Environmental Protection Department
The Government of the Hong Kong
Special Administrative Region

Agreement No. CE 2/2008 (EP)

Review and Development of Marine Water Quality Objectives – Feasibility Study

Final Executive Summary

4 February 2014

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Final Executive Summary

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List of Abbreviations

BCF	Bioconcentration Factor
C_6H_5OH	Phenol
CBPs	Chlorination by-products
Chl-a	Chlorophylla-*a*
DDT	A pesticide, Dichlorodiphenyltrichloroethane, CAS 50-29-3
DO	dissolved oxygen
EIA	Environmental Impact Assessment
EIAO	Environmental Impact Assessment Ordinance
EPD	Environmental Protection Department
EU	European Union
GM	geometric mean
HATS	Harbour Area Treatment Scheme
HCB	Hexachlorobenzene
K_{ow}	Octanol-water partition coefficient
L	litre
P	Phosphorus
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PO_4-P	Total orthophosphate-phosphorus
SS	Suspended solids
STW	Sewage Treatment Works
TBT	Tributyltin
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TIN	Total inorganic nitrogen
TM	Technical Memorandum
TN	Total nitrogen
TP	Total phosphorus
TPH	Total petroleum hydrocarbons
UIA	Un-ionized ammonia
US	United States
USEPA	United States Environmental Protection Agency
WCZ	Water Control Zone, statutorily incorporated under the current Water Pollution Control Ordinance
WHO	World Health Organization
WPCO	Water Pollution Control Ordinance
WQOs	Water Quality Objectives
WSD	Water Supplied Department

1 Introduction

1.0.1 Water Quality Objectives (WQOs) are benchmarks of water quality for supporting the ecosystem services provided by a water body. In Hong Kong, WQOs were established in the 1980's and 1990's to protect various beneficial uses in local waters, but have not been updated since their establishment. Given the fact that there have been significant advancements in our scientific understanding, approaches and experience, some of the assumptions and scientific basis used for deriving our current WQOs some two decades ago may not necessarily be valid, and a review is deemed necessary.

1.0.2 The primary objectives of this study are therefore:

a) To characterize the hydrography, ecosystems and beneficial uses of the marine waters of Hong Kong;
b) To review overseas practices and modern approaches on development of water quality objectives;
c) To examine the feasibility of applying appropriate overseas practices and modern approaches in development of water quality objectives in Hong Kong.

1.0.3 This study entails a thorough review on the approach and methodologies on WQOs of nutrients, physical, chemical, microbiological and biological parameters, WQOs for protection of human health and seafood consumption and those for other beneficial uses including flushing, typhoon shelters, navigation, dumping and sewage discharges. Based on the approach and methodologies, appropriate WQOs will be derived. If there is sound scientific justification, the WQOs are then subject to a systematic assessment on their technical attainability, socio-economic impacts, sustainability and added benefits. The public was consulted of the review on the approach and methodologies in 2009.

2 Water Quality Management in Hong Kong

2.0.1 Currently, marine water quality in Hong Kong is protected through the following measures:

a) Planning control: Under the Environmental Impact Assessment Ordinance (EIAO), environmental impact assessments have to be conducted to identify the potential impact of designated project in its planning stages, as well as any alternatives or mitigation measures.

b) Provision of sewerage infrastructure: Currently, about 93% of the local population is served by public sewerage systems, to ensure proper collection and treatment of their sewage before discharge.

c) Source control: Source control of pollution to marine waters is exercised under the Water Pollution Control Ordinance, the Waste Disposal Ordinance and the Dumping At Sea Ordinance.

d) Other legislative and administrative controls: This includes: the Marine Parks Ordinance, for protecting the marine life in marine parks; Hong Kong Planning

Standards and Guidelines and Wild Animals Protection Ordinance, for protecting Sites of Special Scientific Interest; the Marine Fish Culture Ordinance for protecting marine fish culture and the Fisheries Protection Ordinance for promoting the conservation of fisheries and marine ecosystems in general.

3 Water Quality Objectives

3.0.1 The WQOs provide an objective and scientific basis for the formulation and implementation of pollution control strategies, and the planning and development of infrastructure in a suitable and sustainable way. Figure 1 shows the ten WCZs gazetted under the Water Pollution Control Ordinance (WPCO), and Table 3 shows the existing WQOs.

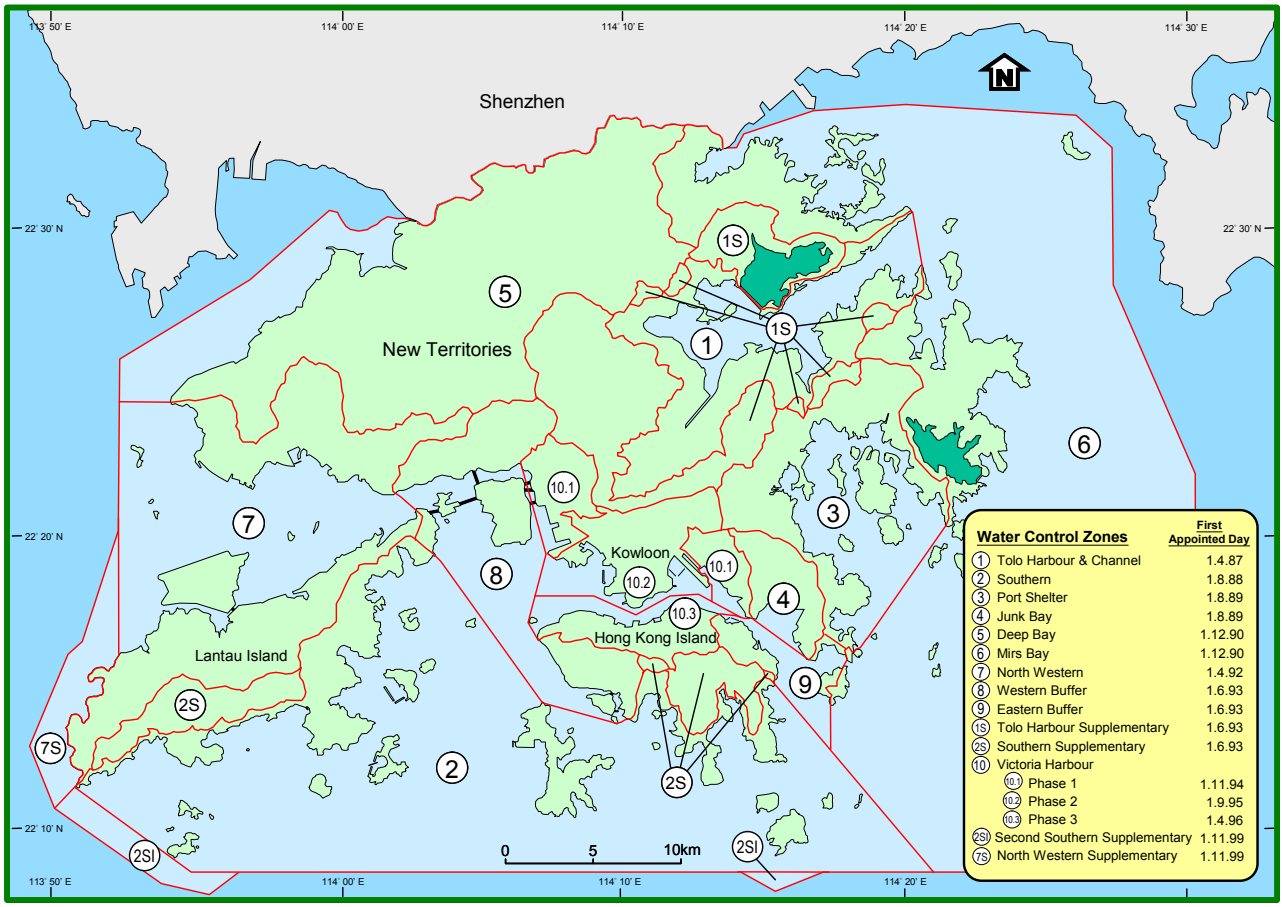

Figure 1. The ten water control zones gazetted under the Water Pollution Control Ordinance

4 Characteristics of our Marine Waters

4.1 Beneficial Uses of Hong Kong waters

4.1.1 A variety of beneficial uses in our coastal environment is shown in Figure 2. In general, waters for more sensitive uses such as mariculture areas and bathing beaches require a higher level of protection, while those for less sensitive uses such as navigation require a relatively lower level of protection. Sensitive water bodies are mostly found in the eastern waters, Deep Bay, and southern waters.

Figure 2. Different beneficial uses of Hong Kong's marine waters

4.2 Hydrography of Hong Kong waters

4.2.1 The hydrography of Hong Kong's territorial water is strongly influenced by the freshwater outflow of the Pearl River in the west and oceanic currents in the east, and the influence of Pearl River outflow is particularly marked during the summer wet season as illustrated in Figure 3. The resulting spatial gradient in physical and chemical parameters are further complicated by the strong seasonality of the Pearl River outflow and local topography, which sometimes make it difficult to differentiate water quality changes resulting from natural variations and anthropogenic activities.

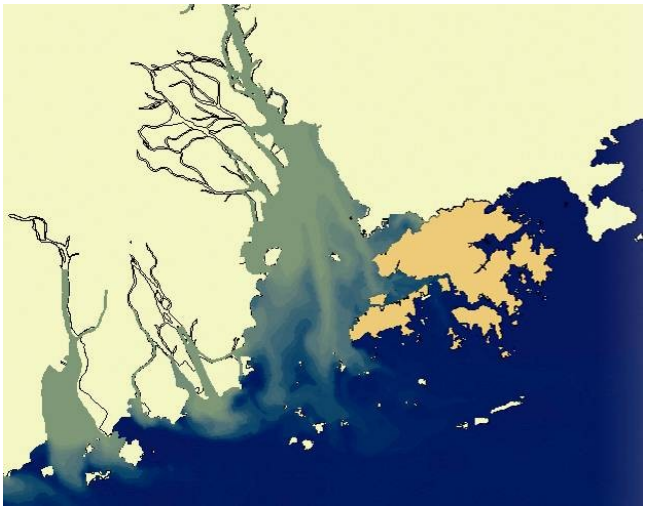

Figure 3. Influence of the Pearl River outflow on Hong Kong marine waters during the wet season

4.2.2 The distribution and abundance of plankton, fish, and benthos in Hong Kong waters are characterized. Marine fauna and flora are strongly influenced by the hydrographic gradient from the west to the east. This general picture is further complicated by pollution derived from various local sources (e.g., Victoria Harbour, Tolo Harbour and Deep Bay). The marked seasonal changes in hydrographic conditions often lead to distinct seasonal abundance and varieties of marine fauna and flora in local waters.

5 Quality of our Marine Waters

5.0.1 Since the late 1980s, EPD has been monitoring the condition of our marine environment. Figure 4 shows the annual WQO compliance rates in Hong Kong and water quality trends from 1986 to 2012. Owing to the continuous government's effort in provision of sewerage infrastructure and various planning and legislative control measures, the water quality has been improving in the past decades. The water quality in Hong Kong waters is generally good, with an overall compliance rates around 80%.

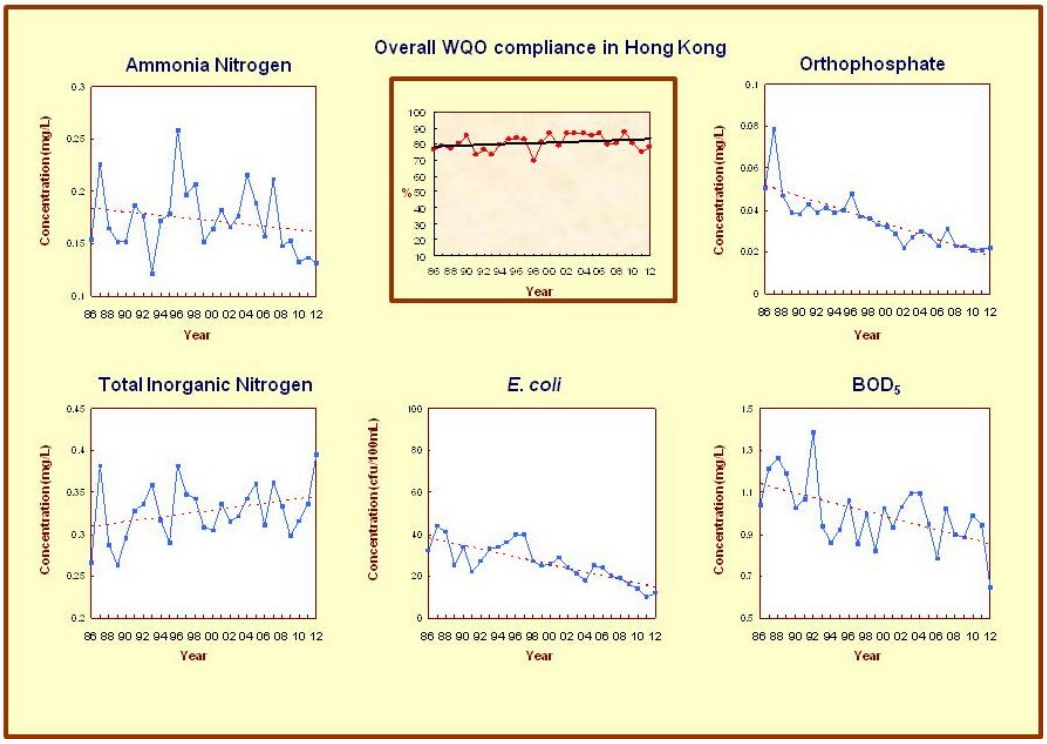

Figure 4. Water quality changes in Hong Kong (1986-2012)

6 Principles and Approaches of the Review

6.1 Promoting conservation and best use of our waters in the public interest

6.1.1 As stipulated in the WPCO, WQOs are intended to promote conservation and best use of our waters in the public interest. Against this background, the review of WQOs is conducted with due regard to the existing uses of our marine waters for various human activities and marine ecosystem services.

6.2 Building upon sound scientific basis

6.2.1 A good database is essential to provide a scientific basis for WQO derivation and to avoid over- or under-protection. Notably, local species may exhibit different responses to water quality changes (such as oxygen deficiency) as compared with their overseas counterparts.

6.3 Drawing reference to overseas practices

6.3.1 The following five approaches are generally adopted to establish WQOs for environmental management in overseas jurisdictions:

1) The technology-based approach: defines limits on discharges based on levels which can be technically and reasonably achievable.

2) The non-degradation approach: WQOs are established based on the natural background levels of WQO at the site, application normally restricted to waters of high environmental value.

3) The use-protection approach: focuses on establishing WQOs for protecting designated uses and ensuring that they are not being adversely affected.

4) The risk assessment approach: This approach predicts the likelihood of the occurrence of undesirable effect due to a chemical or biological agent. Based on the exposure and concentration of the chemical or biological agent, the fraction of species being affected in the ecosystem is estimated. The level of protection can vary according to constraints and weighing of cost and benefit. This approach is widely adopted by USEPA, Australia, New Zealand, Canada and the EU in deriving WQOs for chemicals, and also by WHO in deriving bacterial WQOs in recreational waters.

5) The reference site approach: The water quality at a "clean" site is selected as reference value to represent the undisturbed condition. The departure from the reference site condition would indicate the extent of impairment. This approach is often used for deriving natural physical and chemical factors (e.g., temperature, salinity and nutrients), especially in areas where temporal and spatial variations are significant. This approach is used by the USEPA, Australia, New Zealand, EU and Canada in setting WQOs for nutrients and natural physical parameters.

6.3.2 In practice, however, a mix of approaches is used by most countries depending on the location and situation.

7 WQOs for Hong Kong

7.1 Nutrient WQOs

7.1.1 The primary objective of establishing nutrient WQOs is to prevent eutrophication, harmful algal blooms and subsequently the occurrence of hypoxia and fish kills. Given the large spatial and temporal variations of nutrient levels, as well as the difference in

limiting factors in different water bodies, a risk assessment approach combined with a reference site approach are adopted in deriving site-specific nutrient trigger levels and WQOs in different water bodies. In order to define the natural variations of physical parameters, reference stations are selected for each of the ten water zones. Based on our analysis of the data for Deep Bay, Mirs Bay and other water bodies, the large temporal and spatial variations, as well as the high interactions of natural and anthropogenic factors in local waters make it impractical to attribute changes in water quality parameters specifically to one factor or the others by statistical analysis methods. As such, reference stations that are deemed to be free, or relatively free, from anthropogenic activities, are selected from the water bodies, rather than comparing the level and variability of physical and chemical water quality parameters between different stations. Our analysis also shows that nutrient over-enrichment in some local water bodies (e.g., Victoria Harbour and Deep Bay) may not necessarily lead to eutrophication, since other factors, such as wind and tidal mixing, turbidity, stratification and nutrient ratio, are more important in determining eutrophication and algal blooms in these water bodies.

7.1.2 Water bodies more responsive to nutrient inputs should adopt more stringent WQOs to guard against algal blooms, while water bodies of which algal blooms are controlled by physical factors can adopt a less stringent nutrient standard.

7.1.3 The trigger level of nutrients for eutrophication and algal blooms in different water bodies is derived, taking into account the carrying capacity, seasonality, nutrient concentrations, potential limiting nutrients, the form of nutrients and beneficial uses. Following the approach of Australia, 85^{th} percentile is used for slightly to moderately disturbed zones (e.g., Mirs Bay, Port Shelter, Tolo, and Southern Waters), whereas a less stringent (90^{th} percentile) standard is used for highly disturbed zones (e.g., Deep Bay and western waters) in deriving nutrient WQOs. A new WQO for phosphorus is recommended, especially for estuarine waters which are sometimes P-limiting. On the other hand, we recommend the removal of the existing Chl-a WQO, which is of very limited use. Figure 5 shows the reference sites and percentiles values for the derivation of nutrient WQOs in terms of TIN and PO_4-P.

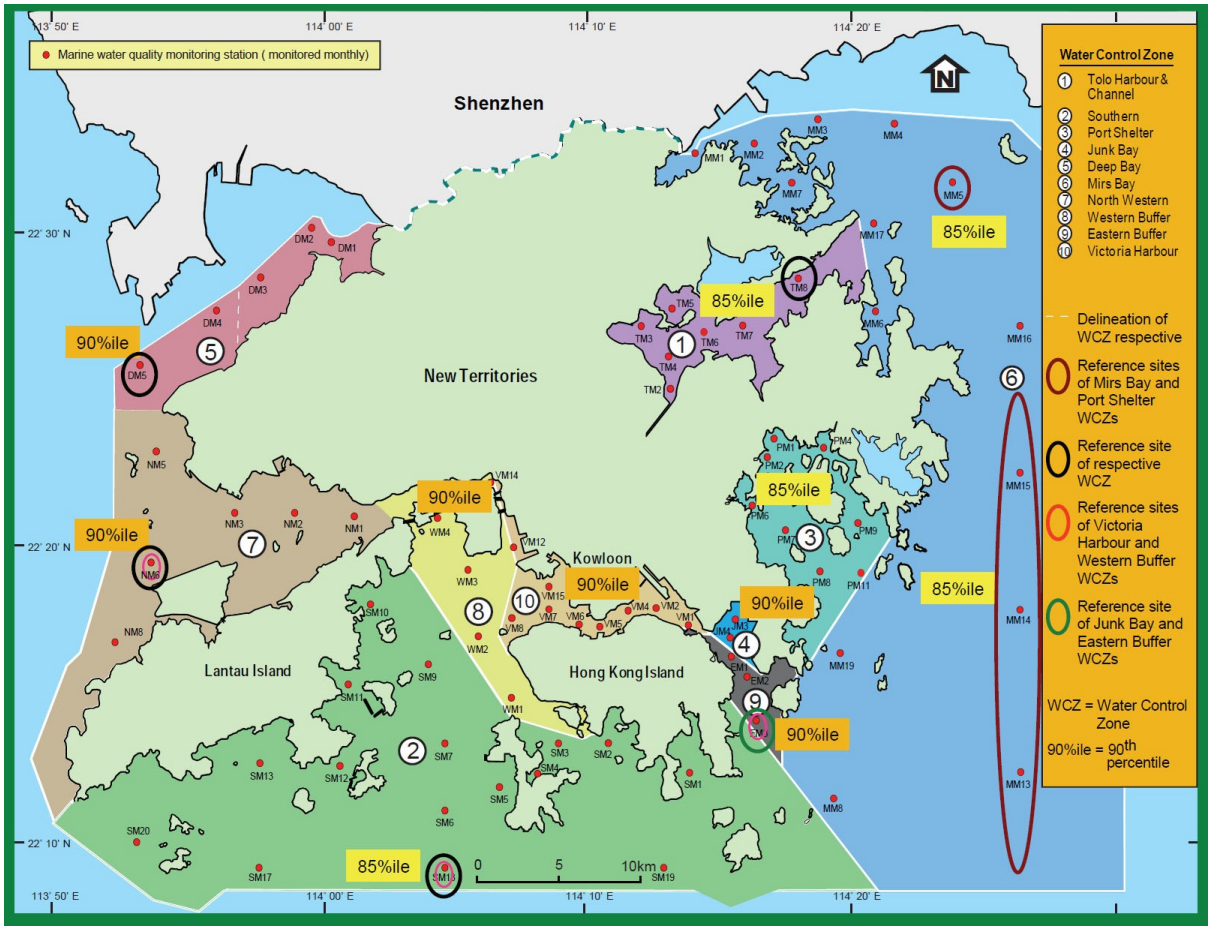

Figure 5. Percentile values and reference sites for setting the proposed nutrient WQOs for the ten water control zones in Hong Kong

7.1.4 The proposed TIN and PO_4-P WQOs are shown in Table 1. They are largely comparable to the criteria adopted by overseas jurisdictions and China.

Table 1. A summary of the existing and proposed nutrient WQOs for the ten water control zones in Hong Kong

n%ile value of the dataset of the reference station	Water Control Zones	TIN		PO_4-P
		Existing WQOs (Annual mean depth-averaged) (mg/L)	Proposed WQO (Annual mean depth-averaged) (mg/L)	Proposed WQO (Annual mean depth-averaged) (mg/L)
85%ile	Tolo Harbour	-	≤ 0.14	≤ 0.010
85%ile	Port Shelter	≤ 0.1	≤ 0.14	≤ 0.013
85%ile	Mirs Bay	≤ 0.3	≤ 0.14	≤ 0.013
85%ile	Southern	≤ 0.1	≤ 0.24	≤ 0.015
90%ile	Junk Bay	≤ 0.3	≤ 0.21	≤ 0.017
90%ile	Eastern Buffer	≤ 0.4	≤ 0.21	≤ 0.017
90%ile	Victoria Harbour	≤ 0.4	≤ 0.79	≤ 0.027
90%ile	Western Buffer	≤ 0.4	≤ 0.79	≤ 0.027
90%ile	North Western	≤ 0.5 except Castle Peak Subzone at ≤ 0.3	≤ 1.36	≤ 0.036
90%ile	Deep Bay (inner)	≤ 0.7	≤ 1.49	≤ 0.048
90%ile	Deep Bay (outer)	≤ 0.5		

Implication of the proposed nutrient WQOs

7.1.5 The implication of the proposed nutrient WQOs is evaluated through model prediction based on the existing and planned treatment facilities. As shown in Table 2, the proposed WQOs are predicted to be attainable for most of water bodies except the Deep Bay WCZs, owing to anthropogenic pollution from both Hong Kong and the mainland. It is noted that measures such as upgrading sewage treatment works (STW) and extending sewer connection are in place to reduce the discharge of nutrients in this WCZ.

7.1.6 Change in TP and TN standards stipulated in the WPCO Technical Memorandum (TM) is not necessary, since the water quality modelling predicts that reasonably good compliance rates can be achieved for most of the WCZs, except Deep Bay and Southern WCZs..

7.1.7 To introduce the proposed nutrient WQOs, there is a need to amend the statements of WQOs established under the WPCO. The introduction of new WQO for phosphorus does not lead to any consequential change to the EIAO or the EIAO TM, since WQOs are quoted in very broad term in Annex 6 and Annex 14 of the EIAO TM. The introduction of the new phosphorus WQO, however, requires assessment of orthophosphate in future EIAO process. There is also a need for transitional arrangement for implementation of the proposed WQOs, if adopted. The details of transitional arrangement including the grace period and implications on EIA studies will be worked out internally by EPD if consensus in the community to pursue the proposed nutrients WQOs can be built up.

Table 2. Predicted compliance rates of the proposed nutrient WQOs

Water Control Zones	Proposed TIN WQO				Proposed Phosphorus WQO (as PO_4-P)			
	2014	2021 (A)	2021 (B)	Ultimate	2014	2021 (A)	2021 (B)	Ultimate
Tolo Harbour and Channel	100%	100%	100%	100%	100%	100%	100%	100%
Port Shelter	100%	100%	100%	100%	100%	100%	100%	100%
Mirs Bay	100%	100%	100%	100%	100%	100%	100%	100%
Southern	88%	69%	63%	63%	94%	88%	94%	94%**
Junk Bay	100%	100%	100%	100%	100%	100%	100%	100%
Eastern Buffer	100%	100%	100%	100%	100%	100%	100%	100%
Victoria Harbour	100%	100%	100%	100%	100%	100%	100%	100%
Western Buffer	100%	100%	100%	100%	100%	100%	100%	100%
North Western	100%	100%	100%	100%	100%	100%	100%	100%
Deep Bay	60%	60%	60%	60%	40%	40%	40%	40%

Notes: 2014 – Early phase of HATS Stage 2A; 2021 (A) – Late phase of HATS Stage 2A; 2021 (B) – Early phase of HATS Stage 2B; and Ultimate – Late phase of HATS Stage 2B. Year 2021 is an assumed reference year for HATS Stage 2B implementation.

**If the ultimate flow is reached before HATS Stage 2B is ready, the compliance rate will drop to 88%.

7.2 WQOs for Physical Parameters

7.2.1 Physical parameters can be influenced by human activities such as wastewater discharge, reclamation, dredging and runoff, as well as non-anthropogenic factors such as hydrographic condition of the water body and weather-related natural fluctuations.

Changes in temperature, salinity, pH and SS in local waters are more affected by natural factors and the current WQOs are adequate in protecting the majority of marine organisms from impact arising from human activities. The WQO for turbidity, light penetration and settleable solid are found redundant, and can be removed since control of these variables can also be exercised through controlling the existing WQO for SS and aesthetic appearance. These existing WQOs are comparable to the water quality criteria of China and jurisdictions such as Australia, Canada and the US. There is no compelling scientific rationale to change these physical WQOs except in Tolo Harbour and Channel WCZ where the SS WQO is recommended to replace the settleable solid WQO. Fluctuation of dissolved oxygen (DO) in most part of Hong Kong waters is largely affected by natural factors such as weather condition and physical stratification rather than anthropogenic pollution. Drawing reference to some overseas jurisdictions which also take into account the natural variation of DO levels, we consider it immature to introduce a new DO criterion derived from limited data on the response of local species and temporal variations (especially diurnal variations) of DO in different water bodies at this stage.

7.3 WQOs for Chemical Substances

7.3.1 Toxic substances have largely been under effective legislative control at source, while the production and input of toxic substances have also reduced significantly in the past decades due to downsizing of industrial activities in Hong Kong. Taking into account the pollution control measures and the low levels of toxic chemicals in local marine waters, and noting the uncertainty and technical difficulties in measuring these chemicals in water, there is no pressing need to introduce numerical WQOs for these toxic chemicals.

7.3.2 The current WQO for un-ionized ammonia (UIA), although stringent, is achievable in the vast majority of local waters. Following the best environmental practice approach, *status quo* is recommended for the existing UIA WQO.

7.3.3 Many metals and persistent organic chemicals typically occur in low, fluctuating concentrations in the marine environment, hence presenting a major challenge to sampling, chemical analyses and monitoring. To address this problem, biological monitoring has been used increasingly instead of, or in addition to, chemical monitoring in many overseas jurisdictions (including the USA, EU and Australia). We recommend further developing the existing EPD biomonitoring programme by including body burden of other heavy metals and trace organics in mussels and barnacles, with a view to developing a more cost-effective monitoring programme. The possibility of using passive samplers to monitor metals (e.g., using the Artificial Mussels) and toxic organic chemicals (e.g., using the Semi-Permeable Membrane Devices) may also be considered.

7.4 Biological WQOs

7.4.1 Ecological responses are often complex in nature, and require a large database for analysis before any meaningful interpretations can be arrived. The Review shows that while local information on certain marine biological communities is available,

longer-term baseline data are generally lacking for setting up scientifically credible "baseline conditions" to compare with the observed change in species composition and community structure, or for understanding "natural variations" in an ecosystem, except for phytoplankton. The lack of longer-term data makes it not practicable to develop narrative or quantitative biological WQOs in Hong Kong at the present stage.

7.5 WQOs for bathing beaches

7.5.1 The existing bacteriological WQO for bathing beaches (annual geometric mean of *E. coli* levels ≤180 counts per 100 mL) was established based on local epidemiological studies conducted by EPD in collaboration with local universities in late 1980s and early 1990s. Its derivation approach is in line with the UNEP/WHO (1977)[1] and overseas practices. Local studies confirm that *E. coli* remains the best bacteriological indicator of sewage contamination of bathing water for Hong Kong. There is no local scientific basis to support changes to the existing bacteriological WQO, noting that the 2003 WHO Guidelines recommend jurisdictions to interpret or modify the guideline values in light of regional and/or local factors. It is recommended (i) to evaluate and study reliable and precise analytical methods in order to obtain reliable enterococci data and their correlation with *E. coli* levels in the local beach environment; (ii) to classify diving as primary contact recreation and (iii) to adopt the existing *E. coli* WQO for bathing as a reference value for this beneficial use.

7.6 WQOs for Mariculture and Capture Fisheries

7.6.1 The paucity of reliable and relevant data, and also the very high degree of uncertainty (contributed by K_{ow}, BCF, species and other confounding factors) make it very difficult, if not impossible, to derive scientifically defendable WQOs for protection of human health through consumption of seafood. Similar to the approach adopted by most overseas jurisdictions (e.g., EU, Scotland, China, Singapore), WQOs target to protect fish production in mariculture areas should aim at supporting the survival, growth, reproduction and development of fish and shellfish species. DO is a key parameter which affects survival and growth of fish. Most fish culture zones in Hong Kong are located in relatively pristine coastal waters remote from major pollution sources and developments. Apart from some non-compliance in summer time mostly due to seasonal factors, the current DO WQO (5 mg/L) which can support normal growth of fish, can be achieved most of the time, and there is no pressing need to change the DO WQOs. In addition to DO, water quality for supporting fisheries and mariculture should carry a low level of contaminants/bacteria, to ensure that there is good chance that public health standards set for human consumption of seafood could be met. Based on the analysis of available scientific data and overseas practices, and taking into consideration the local conditions, we recommend continue to adopt the existing WQO of 610 *E. coli* counts / 100 mL for mariculture waters, to provide basic sanitary protection for culturing seafood, noting that there is existing food surveillance programme in safeguarding food safety. This bacterial WQO is also currently being adopted for secondary contact recreational subzones, and hence is considered appropriate to protect fish farmers from infectious risk associated with contact with waters in the fish culture zones.

[1] UNEP/WHO. 1977. Health criteria and epidemiological studies related to coastal water pollution. United Nations Environment Programme/World Health Organization.

7.7 WQOs for Toxic Substances in Fish and Shellfish Culturing Waters

7.7.1 Aquatic animals may take up and accumulate chemicals directly from the surrounding medium (bioconcentration) and from their food (biomagnification). Theoretically, provided (a) the Maximum Tolerable Tissue Concentrations in fish or shellfish tissues can be defined, and (b) that the contaminants in fish or shellfish tissue have reached equilibrium with the same chemical in the medium, the acceptable concentration of chemicals in the water can be derived using a set of mathematical equations. In reality, however, the degree of chemical bioaccumulation is highly variable and largely dependent on the chemical, species and a variety of confounding factors (e.g., sex, growth, reproductive stages, season and fat content, etc.). The large variations make it impossible to make generalization of WQOs for seafood consumption based on chemical data derived from a single or few species. Furthermore, WQOs for seafood consumption is unlikely to be applicable for non-lipophilic chemicals (e.g., metals) since bioconcentration factors of non-lipophilic chemicals cannot be estimated by lipid partitioning. Indeed, very few jurisdictions have established specific WQO for seafood culture, since most conversion or safe factors are highly variable and not scientifically defensible. Using three metals (mercury, arsenic and cadmium) and three organic chemicals (PAHs, PCBs, DDT) as examples, we demonstrate the large variability and uncertainty in deriving WQOs for application to Hong Kong waters for the protection of human health through seafood consumption. Since acceptability of seafood for human consumption eventually depends on the residue levels of contaminants, it would be much more practical and scientifically sound to set food standards in conjunction with a regular food surveillance programme to protect public health, rather than setting WQOs for seafood.

7.8 Narrative WQOs

7.8.1 There are three existing narrative WQOs which include aesthetic appearance, dangerous substances, and nutrients for the ten WCZs. However, there are some differences between the narrative WQOs for Tolo Harbour and Channel WCZ (which is the first gazetted WCZ) and those for other WCZs. It is recommended to align these narrative WQOs by following those for Victoria Harbour WCZ which was the last declared WCZ.

7.9 WQOs for marine reserve, marine parks, SSSIs, conservation sites, endangered species

7.9.1 Arguably, marine reserve and marine parks and Sites of Specific Scientific Interest are habitats of the highest conservation values in Hong Kong, and naturally there is very high expectation from the general public that maximum protection should be accorded. Our marine parks and reserve are under effective planning and pollution source control, and the overall water quality is generally good and favours healthy growth of marine life. However, some of them, unlike overseas countries, are located in sites with competing beneficial uses in their neighbourhood, and are affected by ambient water quality. Therefore, there may be practical constraints to adopt and implement the non-degradation approach in Hong Kong since our marine environment has to support many beneficial uses in the same location or in the vicinity. Besides, only very few

local scientific data are available regarding response of these specific sensitive receivers (and the marine biota therein) to environmental stresses. As such, the Review recommends no change to the current arrangement.

7.10 Water quality guidelines for abstraction of seawater for toilet flushing

7.10.1 The objective of protecting this beneficial use is to enable Water Supplies Department (WSD) to abstract seawater of appropriate quality for flushing water supply. Seawater used for toilet flushing should be free of debris, floating objects, odour, grease and oil, and has a low turbidity and colour acceptable to the consumers. Bacteria in water should be relatively low and not posing a health hazard in aerosol formed during toilet flushing. Thus, seawater to be abstracted should be of quality that can be handled by WSD's treatment, transfer and storage facilities for meeting the supply needs. The current set of criteria for abstraction of seawater for flushing supply (at intake point) was stipulated by WSD, and has been in use since 1990. Since the criteria have been in use for more than two decades, and scientific justification information is not available to warrant any change of it, it is recommended that the criteria should be kept unchanged and continue be used as administrative guidelines.

8 Recommendations

8.0.1 Table 3 shows the summary of existing and proposed WQOs.

Table 3. Summary of existing and proposed WQOs

WQOs for nutrients

Parameter		Existing WQO		Recommendations
		Details	Applicable to all ten WCZs unless otherwise stated	
1.	Narrative nutrient WQO	Nutrients not to be present in quantities that cause excessive algal growth	All marine waters except Tolo Harbour and Channel WCZ	To retain the WQO, and apply it also to the Tolo Harbour and Channel WCZ.
2.	Total Inorganic Nitrogen (TIN)	≤ 0.1- 0.7 mg/L (annual mean depth-averaged)	All marine waters except Tolo Harbour and Channel WCZ	To introduce the proposed suite of the nutrient WQOs for all ten WCZs (Table 1) under the WPCO.
3.	Phosphorus (as PO_4-P)	No WQO	n/a	
4.	Chlorophyll-*a*	≤6 – 20 μg/L (running mean of 5-d measurement at any single locations and depths)	Marine waters in Tolo Harbour and Channel WCZ only	To remove the existing WQO for Tolo Harbour and Channel WCZ when new WQOs for TIN and Phosphorus are applied.

WQOs for physical parameters

Parameter		Existing WQO		Proposed changes / Suggestion
		Details	Applicable to all ten WCZs unless otherwise stated	
1.	Aesthetic Appearance (narrative)	Offensive odours, tints, colours, visible foam, oil and grease, scum and litter not to be present at levels producing significant visual effects, etc	All marine waters	To retain the existing narrative statement, and to tidy up the differences among the narrative statements of different water control zone.
2.	Settleable Material (narrative)	Discharges not to give rise to bottom deposits or submerged objects, etc	All marine waters in Tolo Harbour and Channel WCZ only	To remove the existing WQO, which is only applicable to Tolo Harbour and Channel WCZ.
3.	Light penetration	≤10% - 20% reduction of normal level	All marine waters in Tolo Harbour and Channel WCZ only	
4.	pH	6.5 – 8.5 and Change ≤ 0.2 due to waste discharge	All marine waters excluding bathing beach subzones in all WCZs, and Tolo Harbour and Channel WCZ	To maintain status quo.
		Change ≤ 0.1 – 0.5 due to waste discharge	All marine waters in Tolo Harbour and Channel WCZ	
		6 – 9 (95% of samples), Change ≤0.5 due to waste discharge	Bathing beach subzones	
5.	Salinity	Change ≤ 10% of ambient level due to waste discharge	All marine waters in all WCZs except Tolo Harbour and Channel WCZ	To maintain status quo.
		Change ≤ 3‰	All marine waters in Tolo Harbour and Channel WCZ	
6.	Suspended Solids	Increase ≤ 30% of ambient level due to discharge nor cause accumulation of SS which may adversely affect aquatic communities	All marine waters except Tolo Harbour and Channel WCZ	To maintain status quo. To apply the existing WQO for suspended solids to Tolo Harbour and Channel WCZ.
7.	Temperature	Change ≤ 2 °C due to waste discharge	All marine waters in all WCZs except Tolo Harbour and Channel WCZ	To maintain status quo.
		Change ≤ 1 °C due to waste discharge	All marine waters in Tolo Harbour and Channel WCZ	
8.	Turbidity	Waste discharge not to reduce light transmission substantially from the normal level	Bathing beach subzones in Port Shelter, Deep Bay (outer part), North Western, Western Buffer WCZs only.	To remove the existing WQO.
9.	Dissolved Oxygen	≥ 4 mg/L (90% samples; depth average)	All marine waters excluding fish culture subzones, and Tolo Harbour and Channel WCZ	To maintain status quo.

Parameter		Existing WQO		Proposed changes / Suggestion
		Details	Applicable to all ten WCZs unless otherwise stated	
		≥ 5 mg/L (90% samples; depth average)	Fish culture subzones except Tolo Harbour and Channel WCZ	
		≥ 4 mg/L (surface to 2m above bottom)	All marine waters in Harbour subzone and Buffer subzone of Tolo Harbour and Channel WCZ	
		≥ 4 mg/L (all depths)	All marine waters in Channel subzone of Tolo Harbour and Channel WCZ	
		≥ 2 mg/L (90% samples, bottom)	All bottom marine waters except Tolo Harbour and Channel WCZ and mariculture subzone, and Inner Marine Subzone of Deep Bay WCZ	
		≥ 2 mg/L (bottom)	All bottom marine waters in Harbour subzone of Tolo Harbour and Channel WCZ	
		≥ 3 mg/L (bottom)	All bottom marine waters in Buffer subzone of Tolo Harbour and Channel WCZ	

(A) WQOs for chemical parameters

Parameter		Existing WQO		Proposed changes / Suggestion
		Details	Applicable to all ten WCZs unless otherwise stated	
1.	Un-ionized Ammonia	≤ 0.021 mg/L (Annual average)	All marine waters except Tolo Harbour and Channel WCZ	To maintain status quo and apply it also to Tolo Harbour and Channel WCZ
2.	Dangerous Substances (narrative)	Toxic substance not to be present at levels producing toxic effect	All marine waters	To retain a narrative statement, and to tidy up differences among the narrative statements of various WCZs.
3.	Phenol	≤ 0.05 mg/L as C_6H_5OH and not present in such quantity to produce a significant odour	Bathing beach subzones in Port Shelter, Deep Bay (outer part) and North Western WCZs	To remove the existing WQO

(B) Other chemical parameters

<table>
<tr><th colspan="2">Parameter</th><th>Current status</th><th>Suggestion</th></tr>
<tr><td>1.</td><td>Metals: Cadmium, Chromium, Copper, Lead, Silver, Zinc, Arsenic, Mercury, Nickel</td><td rowspan="5">A few overseas jurisdictions have established (e.g. US, Australia) water quality criteria or guidelines for some of these chemical parameters. Most of these criteria / guidelines are non-statutory.

Monitoring data show that the levels of these toxic chemicals are mostly below reporting limits or at low levels comparable to the situation of other overseas coastal cities.

The WPCO TM has stipulated effluent standards for heavy metals, and prohibits discharges and deposit of these toxic chemicals into marine environment.

EIA has been making reference to relevant overseas criteria and guidelines for water quality as appropriate.</td><td>To conduct a trial on collecting more toxicity data and determining water effect ratio, before deriving a WQO for individual metals.

To continue monitoring of the levels of these toxic metals in local marine environment.</td></tr>
<tr><td>2.</td><td>Cyanide, Total Residual Chlorine, Polycyclic Aromatic Hydrocarbon (PAHs):
Low molecular weight compounds,
Benzo[a]pyrene,
Phenol,
Nonylphenol,
p.p’-DDT</td><td rowspan="4">To continue monitoring of the levels of these substances in local marine environment.</td></tr>
<tr><td>3.</td><td>Dioxin (as TCDD),
Chlorination-by-products (CBPs),
Hexachlorobenzene (HCB),
Polychlorinated biphenyls (PCBs),
Sulphide ,
Polycyclic Aromatic Hydrocarbon (PAHs): Fluoranthene, Acenaphthene, Phenanthrene, Anthracene, Naphthalene, Total-PAH</td></tr>
<tr><td>4.</td><td>Oil and Grease,
Total Petroleum Hydrocarbon (TPH),
Surfactants:
Alkyl benzene sulfonates (anionic),
Ethoxylates alkyl (neutral/nonionic),
Cationic, Alkyl nitrogen ethoxylates (amphoteric)</td></tr>
<tr><td>5</td><td>Tributyl-tin (TBT)</td></tr>
</table>

(A) Microbiological WQOs

Parameter		Existing WQO		Suggestion
		Details	Applicable to all ten WCZs unless otherwise stated	
1.	*E. coli*	≤180 counts/100 mL (GM of samples from March to October)	Bathing beach subzones	To maintain status quo for the existing WQOs. To apply the existing bacterial WQO for bathing beach as an administrative reference to waters for primary contact recreation.
		≤610 counts/100 mL (Annual GM)	Secondary contact recreation subzones	
			Fish culture subzones and mariculture subzone	To maintain status quo.

(B) Other microbiological parameters

Parameter		Current status	Suggestion
1.	Enterococci	Parameter used in the WHO Guidelines (2003) for classification of recreational water quality	To evaluate and study reliable and precise analytical methods in order to obtain reliable enterococci data and their correlation with *E. coli* levels in the local beach environment.
2.	Faecal streptococci, *Clostridium perfringens,* Faecal coliforms		No proposal to include these parameters into the WQOs.

Biological WQOs

Parameter		Current status	Suggestion
1.	Narrative	A few overseas jurisdictions have established biological criteria, but most of these criteria are non-statutory.	To continue the current biological indicators monitoring programme. To collect relevant data to establish the baseline condition of marine parks and reserve.
2.	Numerical		