5. Water Quality Impact

5.1 Introduction

This section presents an assessment of potential water quality impacts which may arise from the construction and operational stages of WKCD. Recommendations for mitigation measures have been made, where necessary, to minimise the identified water quality impacts to an acceptable level.

5.2 Water Quality Legislations, Standards and Guidelines

The criteria for evaluating water quality impacts include the following:

- Water Pollution Control Ordinance (WPCO) Cap. 358;
- Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM-DSS);
- Water Supplies Department (WSD) Water Quality Criteria;
- Practice Note for Professional Persons on Construction Site Drainage (ProPECC Note PN 1/94); and
- District Cooling Water System (DCWS) Cooling Water Intakes Water Quality Criteria.

5.2.1 Water Pollution Control Ordinance (WPCO)

The Water Pollution Control Ordinance (WPCO) (Cap. 358) provides the statutory framework for the protection and control of water quality in Hong Kong. According to the WPCO and its subsidiary legislation, Hong Kong waters are divided into ten Water Control Zones (WCZs). Water Quality Objectives (WQOs) were established to protect the beneficial uses of water quality in WCZs. Specific WQOs are applied to each WCZ. The proposed WKCD development is located within the Victoria Harbour, Western Buffer and Eastern Buffer WCZs and their corresponding WQOs are listed in **Tables 5.1, 5.2** and **5.3** respectively. The WQOs for the aforementioned WCZs had been used as the basis for assessment of water quality impacts.

Table 5.1: Water Quality Objectives for Victoria Harbour WCZ

Parameters	Objectives	Sub-Zone
Offensive Odour, Tints	Not to be present	Whole zone
Colour	Not to exceed 50 Hazen units, due to human activity	Inland waters
Visible foam, oil scum, litter	Not to be present	Whole zone
E. coli	Not to exceed 1000 per 100mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days	Inland waters
Dissolved Oxygen (DO) within 2 m of the seabed	Not less than 2 mg L^{-1} for 90% of the sampling occasions during the whole year	Marine waters
Depth-averaged DO	Not less than 4 mg L^{-1} for 90% of the sampling occasions during the whole year; values should be calculated as the annual water column average (expressed normally as the arithmetic mean of at least 3 measurements at 1m below surface, mid depth and 1m above the seabed. However in water of a depth of 5m of less the mean shall be that of 2 measurements – 1m below surface and 1m above seabed, and in water of less than 3m the 1m below surface sample only shall apply.)	Marine waters

Parameters	Objectives	Sub-Zone
Dissolved Oxygen (DO)	Not less than 4 mg L^{-1}	Inland waters
pH	To be in the range of 6.5 - 8.5, change due to human activity not to exceed 0.2	Marine waters
Salinity	Change due to human activity not to exceed 10% of ambient	Whole zone
Temperature	Change due to human activity not to exceed 2 ^{o}C	Whole zone
Suspended Solids (SS)	Not to raise the ambient level by 30% caused by human activity	Marine waters
	Annual median not to exceed 25 mgL^{-1} due to human activity	Inland waters
Unionised Ammonia (UIA)	Annual mean not to exceed 0.021 mg L^{-1} as unionised form	Whole zone
Nutrients	Shall not cause excessive algal growth	Marine waters
	Annual mean depth-averaged inorganic nitrogen not to exceed 0.4 mg L^{-1}	Marine waters
BOD_5	Not to exceed 5 mg L^{-1}	Inland waters
	Not to exceed 30 mg L^{-1}	Inland waters
Toxic substances	Should not attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms.	Whole zone
	Human activity should not cause a risk to any beneficial use of the aquatic environment.	Whole zone

Source: Statement of Water Quality Objectives (Victoria Harbour (Phases One, Two and Three) Water Control Zone).

Table 5.2: Water Quality Objectives for the Western Buffer WCZ

Parameters	Objectives	Sub-Zone
Offensive Odour, Tints	Not to be present	Whole zone
Colour	Not to exceed 30 Hazen units, due to human activity	Water gathering ground subzones
	Not to exceed 50 Hazen units, due to human activity	Other inland waters
Visible foam, oil scum, litter	Not to be present	Whole zone
E. coli	Not to exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in a calendar year	Secondary contact recreation subzones and Fish culture subzones
	Not to exceed 180 per 100 mL, calculated as the geometric mean of all samples collected from March to October inclusive in 1 calendar year. Samples should be taken at least 3 times in 1 calendar month at intervals of between 3 and 14 days	Recreation subzones
	Less than 1 per 100 mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days	Water gathering ground subzones
	Not to exceed 1000 per 100 mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days	Other Inland waters
Depth-averaged Dissolved Oxygen (DO)	Not less than 4 mg L^{-1} for 90% of the sampling occasions during the whole year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed)	Marine waters except Fish culture subzones

Parameters	Objectives	Sub-Zone
	Not less than 5 mg L^{-1} for 90% of the sampling occasions during the year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed)	Fish culture subzones
Dissolved Oxygen (DO) within 2 m of the seabed	Not less than 2 mg L^{-1} for 90% of the sampling occasions during the whole year	Marine waters and Fish culture subzones
Dissolved Oxygen (DO)	Not less than 4 mg L^{-1}	Water gathering ground subzones and other inland waters
pH	To be in the range of 6.5 - 8.5, change due to human activity not to exceed 0.2	Marine waters
	Not to exceed the range of 6.0 – 8.5 due to human activity	Water gathering ground subzones
	Not to exceed the range of 6.0 - 9.0 due to human activity	Other inland waters
Salinity	Change due to human activity not to exceed 10% of ambient	Whole zone
Temperature	Change due to human activity not to exceed 2 ^{o}C	Whole zone
Suspended Solids (SS)	Not to raise the ambient level by 30% caused by human activity and shall not accumulate to affect aquatic communities	Marine waters
	Annual median not to exceed 20 mg L^{-1} due to human activity	Water gathering ground subzones
	Annual median not to exceed 25 mg L^{-1} due to human activity	Other inland waters
Unionised ammonia (UIA)	Annual mean not to exceed 0.021 mg L^{-1} as unionised form	Whole zone
Nutrients	Shall not cause excessive algal growth	Marine waters
	Annual mean depth-averaged inorganic nitrogen not to exceed 0.4 mg L^{-1}	Marine waters
5-day biochemical oxygen demand (BOD_5)	Not to exceed 3 mg L^{-1}	Water gathering ground subzones
	Not to exceed 5 mg L^{-1}	Other inland waters
Chemical Oxygen Demand (COD)	Not to exceed 15 mg L^{-1}	Water gathering ground subzones
	Not to exceed 30 mg L^{-1}	Other inland waters
Toxic substances	Should not attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms.	Whole zone
	Human activity should not cause a risk to any beneficial use of the aquatic environment.	Whole zone

Source: Statement of Water Quality Objectives (Western Buffer Water Control Zone).

Table 5.3: Water Quality Objectives for the Eastern Buffer WCZ

Parameters	Objectives	Sub-Zone
Offensive Odour, Tints	Not to be present	Whole zone
Visible foam, oil scum, litter	Not to be present	Whole zone
Dissolved oxygen (DO) within 2m of the seabed	Not less than 2 mg L^{-1} for 90% of the sampling occasions during the whole year	Marine waters and Fish culture subzones
Depth-averaged DO	Not less than 4 mg L^{-1} for 90% of the sampling occasions during the	Marine waters excepting

Parameters	Objectives	Sub-Zone
	whole year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed)	fish culture subzones
	Not less than 5 mg L^{-1} for 90% of the sampling occasions during the year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed)	Fish culture subzones
	Not less than 4 mg L^{-1}	Water gathering ground subzone and other inland waters
5-day biochemical oxygen demand (BOD_5)	Not to exceed 3 mg L^{-1}	Water gathering ground subzones
	Not to exceed 5 mg L^{-1}	Other inland waters
Chemical oxygen demand (COD)	Not to exceed 15 mg L^{-1}	Water gathering ground subzones
	Not to exceed 30 mg L^{-1}	Other inland waters
pH	To be in the range of 6.5 – 8.5, change due to human activity not to exceed 0.2	Marine waters
	To be in the range of 6.5 – 8.5	Water gathering ground subzones
	To be in the range of 6.0 – 9.0	Other inland waters
Salinity	Change due to waste discharges not to exceed 10% of ambient	Whole zone
Temperature	Change due to waste discharges not to exceed 2 ^{o}C	Whole zone
Suspended solids (SS)	Not to raise the ambient level by 30% caused by human activity and shall not accumulate to affect aquatic communities	Marine waters
	Change due to human activity not to exceed 20 mg L^{-1} of annual median	Water gathering ground subzones
	Change due to human activity not to exceed 25 mg L^{-1} of annual median	Other inland waters
Unionized ammonia (UIA)	Annual mean not to exceed 0.021mg L^{-1} as unionized form	Whole zone
Nutrients	Shall not cause excessive algal growth	Marine waters
	Annual mean depth-averaged inorganic nitrogen not to exceed 0.4 mg L^{-1}	Marine waters
Toxic substances	Should not attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms.	Whole zone
	Human activity should not cause a risk to any beneficial use of the aquatic environment	Whole zone
E. coli	Not exceed 610 per 100mL, calculated as the geometric mean of all samples collected in one calendar year	Fish culture subzones
	Less than 1 per 100mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days	Water gathering ground subzones
	Not exceed 1000 per 100mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days	Other inland waters
Colour	Change due to human activity not to exceed 30 Hazen units	Water gathering ground
	Change due to human activity not to exceed 50 Hazen units	Other inland waters

Source: Statement of Water Quality Objectives (Eastern Buffer Water Control Zone).

5.2.2 Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM-DSS)

Discharges of effluents are subject to control under the WPCO. The *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* (TM-DSS) sets limits for effluent discharges. Specific limits apply for different areas and are different between surface waters and sewers. The limits vary with the rate of effluent flow. Sewage from the proposed construction activities should comply with the standards for effluent discharged into foul sewers, inshore waters or marine waters of the Victoria Harbour, Western Buffer and Eastern Buffer WCZs, as shown in Tables 9a, 9b, 10a and 10b of the TM-DSS.

5.2.3 Water Supplies Department (WSD) Water Quality Criteria

A set of water quality criteria for flushing water at seawater intakes specified by WSD as shown in **Table 5.4** would be followed during construction and operation of the proposed WKCD development.

Table 5.4: WSD's Water Quality Criteria for Flushing Water at Sea Water Intakes

Parameter (in mg/L unless otherwise stated)	Target Limit
Colour (HU)	< 20
Turbidity (NTU)	< 10
Threshold Odour Number (odour unit)	< 100
Ammonia Nitrogen (NH3-N)	< 1
Suspended Solids (SS)	< 10
Dissolved Oxygen (DO)	> 2
5-day Biochemical Oxygen Demand (BOD5)	< 10
Synthetic Detergents	< 5
E. coli (no. per 100 mL)	< 20,000

5.2.4 Practice Note for Professional Persons on Construction Site Drainage (ProPECC Note PN 1/94)

A practice note for professional persons was issued by the EPD to provide guidelines for handling and disposal of construction site discharges. The *Practice Note for Professional Persons on Construction Site Drainage* (ProPECC Note PN 1/94) provides good practice guidelines for dealing with various types of discharge from a construction site. Practices outlined in ProPECC Note PN 1/94 should be followed as far as possible during construction to minimize the water quality impact due to construction site drainage.

5.2.5 District Cooling Water System (DCWS) Cooling Water Intakes Water Quality Criteria

The warmed seawater of district cooling water system (DCWS) would be discharged to the sea through the outfalls. The discharges are called thermal discharges as the cooling water discharges that causes thermal plumes will lead to a temperature rise in the seawater. As detailed in **Table 5.1,** the WQO for the Victoria Harbour WCZ stipulated that the temperature change due to human activity should not exceed 2^{o}C.

Chlorine is added to the DCWS as antifouling agent or biocide to inhibit the growth of marine organisms in the seawater intake system. However, residual chlorine discharging to the receiving water is toxic to marine life and potentially harmful to the environment. EPD has commissioned a study[1] on total residual chlorine (TRC) using local species. The lowest No Observation Effect Concentration (NOEC) value from that study was 0.02mg/L, meaning that the total residual chlorine concentration is recommended to be no more than 0.02mg/L at the water sensitive receivers which are exposing to the thermal discharges with added chlorine as biocide. Nevertheless, a review of other EIAs suggested that the TRC limit of 0.01 mg/L (for average value) could be adopted for conservativeness and therefore TRC limit of 0.01 mg/L will be used as the assessment criterion.

During operation of the DCWS, the release of residual chlorine and thermal plumes in seawater would lead to deterioration in water quality. Other than the WQOs, a licensing system under WPCO is implemented by EPD for DCWS discharge. A discharge license should be granted and approved by the Director of Environmental Protection (DEP) prior to operation of DCWS. The temperature and residual chlorine concentration should be designed at level which complies with the stringent licensing conditions.

5.3 Assessment Area, Water Sensitive Receivers and Baseline Conditions

5.3.1 Assessment Area

Water quality impact assessment had been carried out in the Victoria Harbour, Western Buffer and Eastern Buffer Water Control Zones (WCZs) and all areas within 500m from the proposed WKCD development boundary. Locations of the water control zones are shown in **Figure 5.1**.

5.3.2 Water Sensitive Receivers

Key water sensitive receivers that may potentially be affected by the proposed WKCD development include:

- Yau Ma Tei Typhoon Shelter;
- WSD Flushing Water Intakes;
- Cooling Water Intakes; and

Locations of the key water sensitive receivers are shown in **Figure 5.2**.

5.3.3 Baseline Conditions

5.3.3.1 Marine Water Quality in Victoria Harbour

A summary of marine water quality data for EPD monitoring stations at Victoria Harbour (VM6 and 7), and Stonecutters Island (VM15) extracted from EPD's publication "Marine Water Quality in Hong Kong 2010" are presented in **Table 5.5**. Locations of these monitoring stations are shown in **Figure 5.1**.

[1] CEST, 2000. Provision of Service for Ecotoxicity Testing of Marine Antifoulant – Chlorine in Hong Kong. Final Report. Tender Reference WP 98-576. Submitted to the EPD by Centre for Coastal Pollution and Conservation. City University of Hong Kong. Centre for Environmental Science and Technology.

Table 5.5: Marine Water Quality at Victoria Harbour and Stonecutters Island in 2010

Parameter	Monitoring Station		
	Victoria Harbour (Central)	Victoria Harbour (West)	Stonecutters Island
	VM6	VM7	VM15
Temperature (^{o}C)	23.2 (16.6 – 27.7)	23.0 (17.9 – 27.2)	23.4 (16.8 – 27.6)
Salinity	31.4 (28.8 – 33.4)	31.2 (26.1 – 33.3)	31.0 (26.7 – 33.5)
Dissolved Oxygen (mg/L)	5.2 (3.6 – 6.5)	5.8 (4.5 – 7.5)	5.5 (3.9 – 6.3)
Dissolved Oxygen (Bottom) (mg/L)	4.2 (1.9 – 5.2)	5.6 (3.4 – 7.0)	4.8 (1.3 – 6.4)
pH	7.9 (7.6 – 8.2)	7.9 (7.6 – 8.2)	7.9 (7.6 – 8.2)
Secchi Disc Depth (m)	2.7 (1.0 – 5.2)	2.7 (1.7 – 4.0)	2.4 (1.2 – 3.6)
Turbidity (NTU)	3.1 (1.0 – 5.5)	3.5 (1.0 – 6.6)	3.7 (1.3 – 7.5)
Suspended Solids (mg/L)	3.5 (1.0 – 6.9)	3.8 (1.6 – 5.6)	4.2 (1.3 – 8.7)
BOD_5 (mg/L)	1.0 (0.6 – 1.7)	1.0 (0.5 – 1.8)	0.9 (0.5 – 2.0)
Ammonia Nitrogen (mg/L)	0.177 (0.109 – 0.310)	0.163 (0.090 – 0.293)	0.199 (0.114 – 0.333)
Unionised Ammonia (mg/L)	0.006 (0.002 – 0.018)	0.005 (0.002 – 0.014)	0.007 (0.002 – 0.021)
Nitrite Nitrogen (mg/L)	0.031 (0.009 – 0.053)	0.034 (0.016 – 0.078)	0.034 (0.012 – 0.057)
Nitrate Nitrogen (mg/L)	0.141 (0.051 – 0.270)	0.157 (0.068 – 0.347)	0.147 (0.046 – 0.307)
Total Inorganic Nitrogen (mg/L)	0.35 (0.19 – 0.51)	0.35 (0.20 – 0.49)	0.38 (0.18 – 0.62)
Total Kjeldahl Nitrogen (mg/L)	0.32 (0.23 – 0.47)	0.35 (0.25 – 0.48)	0.34 (0.23 – 0.47)
Total Nitrogen (mg/L)	0.49 (0.30 – 0.67)	0.55 (0.45 – 0.65)	0.53 (0.29 – 0.73)
Orthophosphate Phosphorus (mg/L)	0.030 (0.017 – 0.048)	0.025 (0.008 – 0.039)	0.031 (0.016 – 0.046)
Total Phosphorus (mg/L)	0.05 (0.03 – 0.06)	0.05 (0.04 – 0.06)	0.05 (0.04 – 0.06)
Silica (SiO_2) (mg/L)	0.91 (0.36 – 1.80)	0.81 (0.13 – 2.13)	0.93 (0.16 – 1.87)
Chlorophyll-a (µg/L)	3.3 (0.3 – 15.6)	5.0 (0.4 – 13.7)	4.1 (0.2 – 21.8)

Parameter			Monitoring Station
	Victoria Harbour (Central)	Victoria Harbour (West)	Stonecutters Island
	VM6	VM7	VM15
E.coli (count/100mL)	4400 (550 – 13000)	2800 (520 – 16000)	1800 (430 – 5900)
Faecal Coliforms (count/100mL)	11000 (1300 – 29000)	6100 (1000 – 28000)	4600 (880 – 28000)

Notes:

Unless otherwise specified, data represented are depth-averaged (A) values calculated by taking the means of three depths: Surface (S), Mid-depth (M), Bottom (B)

Data presented are annual arithmetic means the depth-averaged results except for E.coli and faecal coliforms which are annual geometric means.

Data in brackets indicated the ranges.

5.3.3.2 Marine Water Quality in Yau Ma Tei Typhoon Shelter

A summary of marine water quality data for EPD monitoring stations at Yau Ma Tei Typhoon Shelter (VT10) extracted from EPD's publication "Marine Water Quality in Hong Kong 2010" are presented in **Table 5.6**. Location of this monitoring station is shown in **Figure 5.1**.

Table 5.6: Marine Water Quality at Yau Ma Tei Typhoon Shelter in 2010

Parameter	Yau Mei Tei
	VT10
Temperature (^{o}C)	23.6 (18.2 – 27.9)
Salinity	30.8 (29.1 – 31.8)
Dissolved Oxygen (mg/L)	4.1 (1.6 – 5.1)
Dissolved Oxygen (Bottom) (mg/L)	4.5 (3.1 – 5.6)
pH	7.7 (7.5 – 7.8)
Secchi Disc Depth (m)	1.8 (1.0 – 2.7)
Turbidity (NTU)	5.9 (1.3 – 13.6)
Suspended Solids (mg/L)	6.9 (2.8 – 15.5)
BOD_5 (mg/L)	1.3 (1.0 – 1.8)
Ammonia Nitrogen (mg/L)	0.309 (0.193 – 0.450)
Unionised Ammonia (mg/L)	0.006 (0.003 – 0.011)

Parameter	Yau Mei Tei
	VT10
Nitrite Nitrogen (mg/L)	0.038 (0.023 – 0.050)
Nitrate Nitrogen (mg/L)	0.147 (0.097 – 0.200)
Total Inorganic Nitrogen (mg/L)	0.49 (0.37 – 0.64)
Total Kjeldahl Nitrogen (mg/L)	0.50 (0.41 – 0.66)
Total Nitrogen (mg/L)	0.68 (0.59 – 0.85)
Orthophosphate Phosphorus (mg/L)	0.040 (0.024 – 0.051)
Total Phosphorus (mg/L)	0.06 (0.04 – 0.07)
Silica (as SiO_2) (mg/L)	0.83 (0.12 – 1.23)
Chlorophyll-a (µg/L)	6.6 (0.8 – 21.3)
E.coli (count/100mL)	2800 (1500 – 35000)
Faecal Coliforms (count/100mL)	7400 (2700 – 71000)

Notes:

Unless otherwise specified, data represented are depth-averaged (A) values calculated by taking the means of three depths: Surface (S), Mid-depth (M), Bottom (B)

Data presented are annual arithmetic means the depth-averaged results except for E.coli and faecal coliforms which are annual geometric means.

Data in brackets indicated the ranges.

5.4 Identification of Water Quality Impact

5.4.1 Construction Phase

Potential sources of water quality impact associated with the construction activities for the proposed WKCD development had been identified. These include:

- Construction site runoff and drainage;
- Modification of seawall and Construction of landing steps and possible piers/viewing platform;
- Barging facilities and activities;
- Sewage effluent from construction workforce; and
- General construction activities.

5.4.2 Operation Phase

Potential sources of water quality impact associated with the operation activities for the proposed WKCD development had been identified. These include:

- Road and surface runoff;
- Sewage and wastewater effluents from the proposed WKCD development;
- Marine piles of possible piers;
- Emergency effluent from optional sewage pump sump;
- Improvement works for New Yau Ma Tei Typhoon Shelter for odour mitigation
- Water reuse facilities; and
- Thermal/cooled water discharge from district cooling system.

5.5 Assessment Methodology

5.5.1 General

Pollutants from point discharges and non-point sources to surface water runoff, sewage from workforce and polluted discharge generated from the proposed WKCD development and spent thermal/cooled water discharge that could affect the quality of surface water runoff and marine waters were identified. All identified sources of potential water quality impact were then evaluated and their impact significance was determined. The need for mitigation measures to reduce any identified adverse impacts in water quality to acceptable levels was determined.

5.5.2 Thermal/cooled water discharge from district cooling system

5.5.2.1 Modelling Tools

During operation phase, seawater would be drawn into the proposed district cooling water system (DCWS) and two independent cooling systems for the 1) Freespace; and 2) the Mega Performance Venue and Exhibition Centre and the proposed hotel and retail/dining/entertainment developments on top of the Western Harbour Crossing portal (hereafter called “MPV/EC & Hotel”). The seawater, which carries heat from the cooling systems, would be discharged back to the sea through the outfalls. The Delft3D model suite, developed by Delft Hydraulics, would be used to assess the potential impact on water quality due to the operation of the proposed DCWS, and independent cooling systems for the Freespace and the MPV/EC & Hotel.

In the present study, the basis for modelling of the harbour waters is the existing, validated Western Harbour Model developed by Deltares. This model covers the relevant part of the Hong Kong waters, including the Pearl Estuary and the Dangan (Lema) Channel. A locally refined domain in the project area was inserted to obtain the higher resolution by means of a technique called “Domain Decomposition” in the model to obtain a resolution between 100m and 200m in the project area. The grid mesh was modified to generate higher resolution (about 40 m x 50 m) in the vicinity of West Kowloon. The details of the grid at the concerned area are provided in **Appendix 5.1**.

To ensure that an accurate coastline profile was used in the modelling, the existing model was updated with the most recently available information of proposed development from sources such as designated projects under the EIAO including the Central and Wan Chai Developments and 600m gap opening at the Kai Tak Airport Runway. The bathymetry set up was also updated based on the latest Admiralty Chart.

5.5.2.2 Thermal Plume

To simulate the thermal plume dispersion in the marine environment, the Excess Temperature Model in Delft3D-FLOW model would be employed. The model simulates the evaporation process (i.e. the heat transfer from water surface to the atmosphere at the sea/air surface). The total heat flux is proportional to the excess temperature at the surface while the rate of heat transfer depends on the temperature difference and wind speed.

The water quality model Delft3D-WAQ in the Delft3D model suite would then be employed to simulate the surplus temperature directly resulting from the discharge of seawater from the DCWS and the independent cooling systems for the Freespace and the MPV/EC & Hotel. A time history temperature elevation at each intake locations can be obtained from the model output.

In accordance with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM-DSS)*, effluent discharge from the proposed cooling water systems of WKCD would not be allowed in any typhoon shelter, or within 100m of any seawater intake point including the seawater intake points of the DCWS and the independent cooling system for the Freespace and MPV/EC & Hotel.

As shown in **Appendix 5.1**, there are two intake points and three outfalls for the proposed DCWS, Freespace and the MPV/EC & Hotel in WKCD development. The existing intake and pump cells at WKCD will be utilized as the intakes for DCWS and Freespace. The outfall location for the proposed DCWS was proposed to be at the seawall at about 160m east of the WKCD intake while the outfall for the independent cooling system serving the Freespace will be located at about 100m west of existing MTRC Kowloon Station outfall and is at least 300m away from the closest seawater intake point. For the independent cooling system for the MPV/EC & Hotel, since the design for the intake and outfall is not available, the locations shown in the figure in **Appendix 5.1** are assumed based on the 100m minimum separation from any seawater intake point requirement. Modelling would be conducted to confirm the suitability of the outfall locations and determine the potential recirculation impact.

The total cooling load demand was estimated based on the cooling load from the proposed communal facilities, residential buildings, hotels, offices and other facilities. A total of less than 20,000 Tons of refrigeration (TR) cooling load was estimated for the full development of WKCD and another less than 300 TR cooling load was required for the independent cooling system serving the Freespace[2] . On the other hand, the cooling load for the MPV/EC & Hotel was predicted to be less than 6,300 TR. To allow for full capacity of the existing pump cells, a maximum cooling load of 26,000 TR for the DCWS while based on

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[2] Mott MacDonald 2012, Project Consultancy Study for West Kowloon Cultural District Development Plan – Technical Report No.12 Design Memorandum and Preliminary Designs of Infrastructures Proposed in the Development Plan, West Kowloon Cultural District Authority.

the design cooling load of the Freespace and MPV/EC & Hotel, 1,000 TR and 8,000 TR respectively as the worst case assessment scenario for the Freespace and MPV/EC & Hotel would be simulated through the proposed intakes and outfalls as shown in **Appendix 5.1**.

The design excess temperature at the proposed outfalls of the DCWS and independent cooling system would be 5°C. A recirculation factor would be added to the temperatures at the intakes to address the potential short circuit issue due to recirculation of water with elevated temperature. This follows the methodology in the approved EIA Report for Express Rail Link (XRL) (EIAO Register No.: AEIAR-143/2009) and the intake temperatures would be multiplied by a factor of (1/(1-E/k), where E is the maximum of the mean temperature elevations predicted at the intakes and k is the excess temperature of cooling system (i.e. 5°C). The parameters to be adopted for the thermal plume model are summarized in **Table 5.7**.

Table 5.7: Summary of Parameters for Thermal Plume Model (Delft3D-FLOW)

Delft3D-FLOW Excess Temperature Model Parameters		
Temperature of spent cooling water (°C)*	5°C above ambient temperature	Dry Season Wet Season
Flow rate (worst case for 26,000 TR, 1,000 TR and 8,000 TR for DCWS, Freespace and the MPV/EC & Hotel respectively) (l/s)**	5,500 l/s, 212 l/s and 1,692 l/s	Dry Season Wet Season
Wind Speed (m/s)	5 m/s	Dry Season (north-east direction) and Wet Season (south-east direction)
Ambient Water Temperature (°C)***	23°C 30°C	Dry Season Wet Season

Note:
* It is conservatively assumed that the spent cooling water discharge have an excess temperature of 5°C with reference to the background seawater temperature.
** The sea water flow rate is estimated from the following equation: $Q = H/(\rho c \Delta T)$; where
Q is the sea water flow rate (m^3/s); H is the heat rejection (kW) which is estimated as the cooling load multiplied with the heat rejection rate of 120% to 130%; ρ is the density of sea water (kg/m^3); c is the specific heat capacity of sea water (kJ/kg/K); and ΔT is the temperature difference between sea water intake and discharge (K).
The cooling load is 26,000TR (or 91,442 kW) and the temperature difference is 5K for the DCWS. It should be noted that the cooling load of 26,000 TR is a rough estimate based on a heat rejection rate of 120%. It can be estimated from the above that the sea water flow rate is around 5.3 m3/s or 5,300 L/s (to be conservative in the model, a sea water flow rate of 5.500 m3/s or 5,500 L/s would be simulated). Similarly, a sea water flow rate of 212 L/s and 1,692 L/s will be adopted for simulation for the 1,000 TR and 8,000 TR cooling load for the independent cooling systems of the Freespace and the MPV/EC & Hotel respectively.
*** The ambient water temperature follows the original setting of the Western Harbour Model developed by Deltares.

For a realistic estimation of the temperature elevation, the diurnal pattern of the cooling load demand for the proposed WKCD DCWS and the independent cooling systems for the FreeSpace and the MPV/EC & Hotel were studied. **Table 5.8** below showed the estimated diurnal pattern of the cooling water discharge for the proposed WKCD development. As the temperature difference for inflow and outflow of the seawater cooling system is set to 5K and only the flow rate will vary with time. The flow rate input into the thermal model at any time of a day follows this formula:

Flow Rate at Hr T = 5,500 l/s x (% full cooling load at Hr T shown in **Table 5.8**)

On the other hand, the flow of the proposed seawater cooling system of XRL follows its own diurnal pattern as mentioned in Section 11.57 of the XRL EIA Report. The hourly diurnal flow of XRL seawater cooling system adopted in XRL EIA Report was input into the model for this project.

Table 5.8: Diurnal pattern of cooling water discharge for proposed WKCD DCWS and the independent cooling systems

Hours	% of full cooling load for the proposed DCWS*	% of full cooling load for Freespace^	% of full cooling load for MPV/EC & Hotel^
00:00 – 02:00	62	70	71
02:00 – 04:00	51	40	55
04:00 – 06:00	51	40	52
06:00 – 08:00	58	50	58
08:00 – 10:00	62	50	62
10:00 – 12:00	71	60	70
12:00 – 14:00	74	65	74
14:00 – 16:00	78	75	79
16:00 – 18:00	84	85	82
18:00 – 20:00	84	100	88
20:00 – 22:00	79	100	87
22:00 – 00:00	74	100	88

Note: *The %full cooling load at different times of the day are estimated by summing up the anticipated cooling demand of recreational, residential, commercial, hotel, retails uses at different times of the day in WKCD. Full cooling load demand was not predicted to happen as the cooling requirement varies for different types of buildings at different hours of the day.
^The design cooling load profile for CACF is adopted for the Freespace; whilst a composite pattern derived from design cooling load profile for CACF, hotel, office, retail, dinning and entertainment is adopted for the MPV/EC & Hotel.

The existing and proposed seawater cooling systems near the proposed WKCD development have been considered. From the approved EIA Report for Express Rail Link (XRL) (EIAO Register No.: AEIAR-143/2009), the locations, flow rates and the typical diurnal flow pattern for the XRL intake and outfall were referenced. Information on other private systems was sought from property operators. Assumptions on the flow rates were made from the available information where appropriate. The cooling water discharge of the proposed WKCD development and other systems would be modelled to assess the cumulative impact. The approximate distances of these intakes and outfall from the WKCD DCWS proposed outfall (excluding the outfall of the independent cooling systems) were presented in **Table 5.9** and their locations are shown in **Appendix 5.1**.

Table 5.9: Approximate distances of existing cooling water intakes and outfalls from the WKCD DCWS proposed Outfall

Existing cooling systems	Distances to proposed WKCD DCWS Outfall (m)	
	Intake	Outfall
Ocean Centre	740	830
Harbour City	700	630
Ocean Terminal	830	830
West Kowloon Terminus (under construction)	370	270
China H.K. City	360	550
Elements	190	460
MTRC Kowloon Station	330	510

Due to the existing site constraints including the location of the existing seawater and cooling water intakes, the outfall of the proposed WKCD DCWS is limited to the location shown in **Appendix 5.1**.

5.5.2.3 Residual Chlorine

The water quality model Delft3D-WAQ in the Delft3D model suite was employed for assessing the residual chlorine discharged from the cooling water. Other anti-fouling chemical agent (e.g. C-treat-6) would not be used at the proposed DCWS. With confirmation on the engineering design, a residual chlorine concentration of 0.2 mg/L has been adopted for the proposed WKCD development.

The discharge of residual chlorine would be represented by a decayable tracer in the WAQ model. As the WAQ model was coupled to the FLOW model with a “communication file” between the two models, diffusion and dispersion of the chlorine would be based on the flow determined in the hydrodynamic model. Each flow simulation would cover a complete spring-neap tidal cycle (approximately 15 days).

Following the approved XRL EIA Report, the T90 factor (time to decay by 90%) adopted in the approved XRL EIA Report for the project *Tai Po Sewage Treatment Works Stage V* (EIAO Register No.: AEIAR-081/2004) is the most conservative value among the past EIA studies. Therefore the chlorine decay value (T90 = 8289s) used under these two studies would be adopted. Conversion of the unit to suit the parameter in the WAQ model was done and the calculated decay rate was 24/d. Summary of parameters to be used in the Delft3D-WAQ model is presented in **Table 5.10**.

Moreover, due to the high decay rate of chlorine in marine waters, the ambient chlorine level is assumed to be negligible. As no background chlorine would be included in the water quality model, only the elevation of residual chlorine would be evaluated.

Table 5.10: Summary of Parameters for Modelling of Residual Chlorine (Delft3D-WAQ)

Particle Track Model Parameters		
Vertical Dispersion Coefficient (m^2/s)*	5×10^{-3} 1×10^{-5}	Dry Season Wet Season
Residual Chlorine of seawater cooling discharge (mg/L)	0.2	Dry Season Wet Season
Decay rate (/d)	24	Dry Season Wet Season
Flow Rate (m^3/s)	Equivalent to flow rates in the thermal model	Dry Season Wet Season

Note:
*Values presented are commonly adopted and in line in the XRL EIA.

The impacts from other existing seawater cooling systems near the proposed WKCD development would be included in the model to assess the cumulative impact, similar to the thermal plume modelling.

5.6 Prediction and Evaluation of the Water Quality Impact

5.6.1 Construction Phase

5.6.1.1 Construction site runoff and drainage

Runoff from the surface construction works areas may contain increased loads of sediments, other suspended solids (SS) and contaminants. Potential sources of pollution from site drainage include:

- Runoff from and erosion from site surfaces, drainage channels, earth working areas and stockpiles

- Release of any bentonite slurries, concrete washings and other grouting materials with construction run-off and storm water
- Wash water from dust suppression sprays and wheel wash facilities
- Fuel, oil, solvents and lubricants from maintenance of construction vehicles and mechanical equipment

Sediment laden runoff particularly from works areas subjected to excavation or earth works, if uncontrolled, may carry pollutants (adsorbed onto the particle surfaces) into any nearby storm water drains. Bentonite and chemical grouting may be required for diaphragm walling works and as a result may pollute surface runoff.

As a good site practice, mitigation measures should be implemented to control construction site runoff and drainage from the works areas, and to prevent runoff and drainage water with high levels of SS from entering any nearby storm water drains. With the implementation of adequate construction site drainage and provision of sediment removal facilities, unacceptable water quality impacts are not anticipated. The construction phase discharge would be collected by the temporary drainage system installed by the Contractor and then treated or desilted on-site before discharge to storm water drains. The Contractor would be required to obtain a license from EPD under the WPCO for discharge to the public drainage system.

5.6.1.2 Modification of seawall and Construction of landing steps and possible piers/viewing platform

The tentative location of marine features including landing steps, possible piers and viewing platform for the proposed WKCD development are shown in **Figure 5.3**.

Construction of cooling water discharges/outfalls to the south and west of the proposed WKCD development would involve minor seawall modification. Typical cross section of drainage pipe outfall is shown in **Figure 5.7**. Detailed design of the cooling water discharges/outfalls would be available at the detailed design stage. In general, the construction sequence is that a temporary cofferdam in the form of sheet-pile wall outside the cooling water discharge/outfall would be constructed prior to the construction of the cooling water discharge/outfall. Excavation of fill material from the existing seawall above the existing seabed would be carried out. The outfall pipe would be positioned in temporary open cuts in the existing seawall well above the existing seabed. Once the outfall pipe have been installed and checked for alignment, the seawall would be reinstated by backfilling to match the existing condition. Dredging operation would not be anticipated and dredging of marine sediment would not be required for the construction of cooling water discharges/outfalls. Nevertheless, this might still results in small amount of suspended solids released from the surface of the seawall. Silt curtain should be deployed to completely enclose the seawall modification for construction of the cooling water discharges/outfalls.

Construction of landing steps at the south and south west of the proposed WKCD development would also involve minor seawall modification. Detailed design of the landing steps would be available at the detailed design stage. In general, the landing steps are anticipated to be founded on piles. The pile foundation would be fixed into the seabed either by driving or drilling. Part of the rockfill of the seawall where the landing steps are located would be removed. Precast steps would be installed to form the landing steps. The seawall would be reinstated by backfill with rocks and gravels to match the existing condition. The proposed landing steps are designed for public amenity purpose and as an integrated part of the waterfront promenade and WKCD landscaped space. They would not be designed to serve any marine traffic. Formation of basins for marine access is therefore not anticipated. No dredging of marine sediment would be required. Dredging operation would not be anticipated for the construction of landing steps. Nevertheless, this might still results in small amount of suspended solids released from the surface of the seawall. Silt curtain should be deployed to completely enclose the seawall modification and construction of the landing steps.

By adopting this preventive measure, it is considered that the seawall modification for construction of the cooling water discharge/outfalls and landing steps would not cause adverse impact to the aquatic life and environment.

Installation of marine piles would be required for the possible piers. The tentative general and piling arrangement of the possible pier are shown in **Figures 5.4** and **5.5** respectively. Detailed design of the possible piers would be available at the detailed design stage. In general, the footing of the piles would mainly be in place on the seabed adjacent to the under-water seawall. In order to support the deck of the possible pier and provide sufficient space for visitors for boarding, there are a total of about 26 piles (each with a diameter of about 0.7m diameter) to form an array with at least about 2m gap between each pile. The pier deck has its length of about 50m and width of about 6 to 7m.The installation of the piles would include driving the piles mainly into the seabed adjacent to the under-water seawall. Part of the rockfill of the seawall where part of the possible piers are located would be removed. Socked H-piles are installed by inserting H-piles into pre-bored holes sunk into bedrock and subsequently grouting the holes with cementitious materials. A temporary casing passing through the soil layer would be provided in the pre-boring process to prevent collapse of the seabed and sediment from falling into the pre-bored hole. Conventional drilling system should be employed to drill through all materials above the rock head level. The seawall would be reinstated by backfill with rocks and gravels to match the existing condition. Excavation of marine sediment is therefore not expected. As the possible piers are proposed for visitors or leisure activities, installation of piles with large diameters are not necessary. Formation of basins for marine access is also not anticipated as the water depth to the south and west of the proposed WKCD development is at least 7m. No dredging of marine sediment is expected. Nevertheless, this might still results in small amount of suspended solids released from the surface of the seabed. Silt curtain should be deployed to completely enclose the pile installation works. By adopting this preventive measure, the impacts of the marine pile installation works on water quality is expected to be minimal.

The viewing platform is an extension of the waterfront promenade, possibly composed of cantilever structure on top seabed and foreshore only. Therefore, the construction of viewing platform is not expected to cause adverse impact on water quality.

5.6.1.3 Barging facilities and activities

Barging point facilities of the Hong Kong Section of Guangzhou - Shenzhen - Hong Kong Express Rail Link project at the West Kowloon seafront would be used for handling of spoil generated from excavation works for the proposed WKCD development. Barging activities might cause adverse impact on water quality if not handled properly. Mitigation measures are recommended to control any pollutant discharge into the sea due to barging activities. Impact due to barging activities is expected to be insignificant provided all recommended mitigation measures are properly implemented.

5.6.1.4 Sewage effluent from construction workforce

Domestic sewage would be generated from the workforce during construction phase. However, portable chemical toilets should be installed within the construction site. The Contractor have the responsibility to ensure that chemical toilets are used and properly maintained, and that licensed Contractors are employed to collect and dispose of the waste off-site at approved locations. Therefore, water quality impact is not anticipated.

5.6.1.5 General construction activities

On-site construction activities may result in water pollution from the following:

- Uncontrolled discharge of debris and rubbish such as packaging, construction materials and refuse; and
- Spillages of liquids stored on-site, such as oil, diesel and solvents etc.

Good construction and site management practices should be observed to ensure that litter, fuels and solvents do not enter the public drainage system.

5.6.2 Operation Phase

5.6.2.1 Road and surface runoff

Surface runoff from the local road network proposed under the WKCD development may be contaminated by oils leaked from passing vehicles. It is considered that impacts upon water quality would be minimal provided that the proposed WKCD development and associated local road network are designed with adequate drainage systems and appropriate oil interceptors, as required in accordance with *Highways Department Guidance Notes RD/GN/035 – Road Pavement Drainage Design*.

5.6.2.2 Sewage and wastewater effluents from the proposed WKCD development

The Development Plan for WKCD proposes a number of Core Art and Cultural Facilities (CACF) combined with commercial, catering and retail facilities. A park is also proposed to be located at the south western portion of the WKCD. Under the development plan, the total pollution of WKCD is about 120,000.

Sewage and wastewater effluents generated from the proposed WKCD development would be connected to the proposed foul sewerage system as detailed in **Section 6**.

Hydraulic assessment had been conducted and the results had concluded that adverse sewerage impact to the existing 1350mm trunk sewer, the sewer along Austin Road West and Lin Cheung Road and the sewer along Canton Road in which the sewage form the proposed WKCD development will be discharged to are not predicted. The local sewerage network should therefore have sufficient capacity to cater for the sewage flow generated from the proposed WKCD development.

Recommendations for the design, operation and maintenance for the sewerage system are detailed in **Section 6**.

5.6.2.3 Marine piles of possible piers

The presence of the marine piles would create forces on the tidal flow which result in energy loss of the flow and eventually impact the flushing capacity within the vicinity of the possible piers. In view of the orientation of the piles and their sizes as indicated in **Figures 5.4** and **5.5**, potential impacts of the provision of the marine piles on flushing capacity in the vicinity of the possible piers is expected to be insignificant.

5.6.2.4 Emergency effluent from optional sewage pump sump

The optional sewage pump sump would be located at the basement of the Freespace and the proposed installed capacity is estimated to be approximately 580 m^3 per day.

Potential water quality impact associated with the optional sewage pump sump include occasional overflow of sewage effluent during storm event under normal operation and emergency sewage effluent discharge as a consequence of pump failure or interruption of power supply. A two hour emergency storage capacity would be provided within the optional sewage pump sump according to EPD's Environmental Guidance Note for Sewage Pumping Stations which is NOT a Designated Proejct. Pump sets would be provided with 100% standby of the operational capacity. Emergency over pumping utilising temporary pumps and emergency power supply to convey sewage to the gravity sewerage system would be arranged in the event all pumps duty and standby were to fail. Provision of standby pumps and dual power supply with sufficient capacity (100% standby of the operational capacity) would mean there would not be occurrence of such effluent discharge. No emergency effluent overflow or bypass is to be provided from the optional sewage pump sump located within the deep basement of the Freespace. Water quality impact as a result of overflow of sewage effluent is therefore not anticipated.

With the implementation of the aforesaid design measures, adverse water quality impact associated with emergency effluent bypass from the optional sewage pump sump is not anticipated.

5.6.2.5 Improvement works for New Yau Ma Tei Typhoon Shelter for Odour Mitigation

It has been ascertained that malodour emissions from New Yau Ma Tei Typhoon Shelter (NYMTTS) are localized at the areas in the vicinity of outfalls from the Cherry Street and Jordon Road Box Culverts and are mainly due to effluent discharges from these two Box Culverts. The most effective way to mitigate the malodour emissions is to stop or prevent the effluent discharges from entering the NYMTTS via the Cherry Street and Jordon Road Box Culverts. To achieve this, the short term measures of rectifying any identified expedient connections and desilting of sediments at the two Box Culverts have been in-progress by the relevant government departments. In addition, relevant dry weather flow interceptors (DWFI) improvement measures including improvement in interception of effluent discharge were proposed for NYMTTS. In order to help mitigate the odour emission from NYMTTS, it has been recommended to implement the project to construct a new DWFI at the outlet of the Cherry Street Box Culvert as well as the proposed upgrading works for the existing DWFIs upstream of the Cherry Street Box Culvert and/or the Jordon Road Box Culvert so that the malodour emissions due to effluent discharge from the Box Culverts could be effectively reduced. Details of these improvement measures are given in **Section 3.7.3.1**.

5.6.2.6 Water reuse facilities

Options to be considered for the optional water reuse facilities include green building initiatives such as rainwater harvesting and reuse of condensate from air conditioning systems. Water collection and treatment system would be installed for reuse of the reclaimed water which is being considered for potential uses such as irrigation. The Architectural Services Department (ASD) has guidelines for design of rainwater recycling installations, which recommend standards for recycled rainwater quality as shown in **Table 5.11**.

Table 5.11: Recommended Standard of Recycled Rainwater Quality

Parameter	Unit	Recommended Water Quality Standards
E. Coli	cfu/100ml	Non Detectable
Total Residual Chlorine	mg/L	≥ 1 exiting treatment system; ≥ 0.2 at user end
Dissolved Oxygen in Reclaimed Water	mg/L	≥ 2
Total Suspended Solid (TSS)	mg/L	≤ 5
Colour	Hazen Unit	≤ 20
Turbidity	NTU	≤ 5
pH	/	6 - 9
Threshold Odour Number (TON)	/	≤ 100
5-day Biochemical Oxygen Demand (BOD_5)	mg/L	≤ 10
Ammoniacal Nitrogen	mg/L as N	≤ 1
Synthetic Detergents	mg/L	≤ 5

Source: Water Supplies Department, The Government of the HKSAR.

Note:

1. Apart from total residual chlorine which ahs been specified, the water quality standards for all parameters shall be applied at the point-of-use of the system.
2. Where recycled water is treated for immediate usage, the level of total residual chlorine may be lower than the one specified in this table.
3. Immediate usage means the collected grey water / rainwater is drawn into the treatment process immediate before a particular round of usage and the treated water will be depleted after that round of usage is completed.

Rainwater can be directly harvested from rooftop installations. It may contain trace amounts of particulates, but is otherwise considered to be a safe and clean source of water for non-potable use. Provided that the rainwater harvesting installation is well maintained, no adverse impact is anticipated from reuse of rainwater for irrigation. Condensate from air conditioning can be collected as part of the system and delivered to a disinfection unit to remove microorganisms prior to reuse for irrigation. Provided that the disinfection system is adequately designed and implemented, no adverse impact is anticipated from reuse of condensate for irrigation. Demand for reclaimed water is significant and discharge of surplus reclaimed water is not anticipated. Water quality impact as a result of discharge of surplus reclaimed water is therefore not anticipated. Discharge of surplus reclaimed water, if deemed necessary, would be required to comply with requirements specified in the WPCO.

5.6.2.7 Thermal/cooled water discharge from district cooling system

In accordance with the methodology as presented in Section 5.5.2.2, the thermal plume model was run for the proposed cooling load demand for the project with other existing cooling water discharges.

Temperature Elevation

In the WQO, it was stipulated that the temperature increase in the water column due to human activity should not exceed 2°C. Since the intakes of the cooling water system will be located at around -3.15 mPD, the temperature elevations near the mid-depth of the water column are taken from the model. The summary of results of the aforesaid scenario is shown in **Table 5.12**. The temperature elevations at the surface level of the water column at different tidal conditions in dry and wet seasons are shown in the plots in **Appendix 5.2**.

Table 5.12: Temperature elevations at cooling water intakes

Water sensitive receivers	Temperature elevation at cooling water intakes in ◦C			
	Dry season		Wet season	
	Mean	90 percentile	Mean	90 percentile
MTRC Kowloon Station (C1)	0.17	0.29	0.47	1.05
West Kowloon Terminus (under construction) (C2)	0.59	0.75	0.85	1.48
China H.K. City (C3)	0.38	0.50	0.48	0.73
Harbour City (C4)	0.21	0.27	0.22	0.37
Ocean Centre (C5)	0.30	0.45	0.55	1.07
Ocean Terminal (C6)	0.15	0.25	0.12	0.22
The Elements (C7)	0.19	0.38	0.69	1.54
WSD Intake (WSD1)	0.08	0.11	0.04	0.09
Existing Intake for WKCD DCWS (including Freespace)	0.20	0.38	0.71	1.55
Proposed Intake of Independent Cooling System for MPV/EC & Hotel	0.10	0.15	0.08	0.20

Note: Bold number indicates exceedance of relevant criteria.

The predicted 90-percentile temperature increases at all the intakes ranged from 0.11°C to 1.55°C. Therefore, no unacceptable cumulative impact due to temperature elevation is predicated at all seawater intakes including the WSD flushing water intakes.

Residual Chlorine Model

The 0.01 mg/L criterion for residual chlorine has been defined for protection of marine life. The residual chlorine has no impact on the cooling water systems or the flushing water intakes. Therefore, specific values of chlorine at these receivers are not taken. Instead the predicted depth-averaged chlorine concentration in the dry and wet season over the project area is plotted. Together with the results of the residual chlorine for the sensitivity test, the map plots of chlorine concentration are shown in **Appendix 5.3**.

The model has included all the existing cooling water discharge and their potential contributions to the residual chlorine in the marine environment. The results indicated that there are potentially a few mixing zones near the proposed and existing cooling water system outfalls. However, it should be noted that the actual chlorine level should be lower since a worst-case 0.2 mg/L dosage and a conservative decay rate of chlorine was assumed. Moreover, the assumed flow rates of the existing cooling water systems were at the conservative side.

Outside the limited mixing zone there is no non-compliance with the criterion of 0.01 mg/L for residual chlorine. Therefore, no unacceptable impact is anticipated due to residual chlorine from the cooling water discharge from this Project and the other existing cooling water systems.

The discharge of spent cooling water discharge is subject to the control of the WPCO. The discharge limits for temperature, residual chlorine and others would be specified on the WPCO discharge license.

5.7 Mitigation of Adverse Water Quality Impact

5.7.1 Construction Phase

5.7.1.1 Construction site runoff and drainage

The site practices outlined in ProPECC Note PN 1/94 should be followed as far as practicable in order to minimise surface runoff and the chance of erosion. The following measures are recommended to protect water quality and sensitive uses of the coastal area, and when properly implemented should be sufficient to adequately control site discharges so as to avoid water quality impacts:

- At the start of site establishment, perimeter cut-off drains to direct off-site water around the site should be constructed with internal drainage works and erosion and sedimentation control facilities implemented. Channels, earth bunds or sand bag barriers should be provided on site to direct storm water to silt removal facilities. The design of the temporary on-site drainage system should be undertaken by the WKCDA's Contractors prior to the commencement of construction;
- Sand/silt removal facilities such as sand/silt traps and sediment basins should be provided to remove sand/silt particles from runoff to meet the requirements of the TM standards under the WPCO. The design of efficient silt removal facilities should be based on the guidelines in Appendix A1 of ProPECC Note PN 1/94. Sizes may vary depending upon the flow rate. The detailed design of the sand/silt traps should be undertaken by the WKCDA's Contractors prior to the commencement of construction.
- All drainage facilities and erosion and sediment control structures should be regularly inspected and maintained to ensure proper and efficient operation at all times and particularly during rainstorms. Deposited silt and grit should be regularly removed, at the onset of and after each rainstorm to ensure that these facilities are functioning properly at all times.
- Measures should be taken to minimize the ingress of site drainage into excavations. If excavation of trenches in wet periods is necessary, they should be dug and backfilled in short sections wherever practicable. Water pumped out from foundation excavations should be discharged into storm drains via silt removal facilities.
- All vehicles and plant should be cleaned before leaving a construction site to ensure no earth, mud, debris and the like is deposited by them on roads. An adequately designed and sited wheel washing facility should be provided at construction site exit where practicable. Wash-water should have sand and silt settled out and removed regularly to ensure the continued efficiency of the process. The section of access road leading to, and exiting from, the wheel-wash bay to the public road should be paved with sufficient backfall toward the wheel-wash bay to prevent vehicle tracking of soil and silty water to public roads and drains.
- Open stockpiles of construction materials or construction wastes on-site should be covered with tarpaulin or similar fabric during rainstorms. Measures should be taken to prevent the washing away of construction materials, soil, silt or debris into any drainage system.
- Manholes (including newly constructed ones) should be adequately covered and temporarily sealed so as to prevent silt, construction materials or debris being washed into the drainage system and stormwater runoff being directed into foul sewers.
- Precautions should be taken at any time of the year when rainstorms are likely. Actions should be taken when a rainstorm is imminent or forecasted and actions to be taken during or after rainstorms are summarized in Appendix A2 of ProPECC Note PN 1/94. Particular attention should be paid to the control of silty surface runoff during storm events, especially for areas located near steep slopes.

- Bentonite slurries used in piling or slurry walling should be reconditioned and reused wherever practicable. Temporary enclosed storage locations should be provided on-site for any unused bentonite that needs to be transported away after all the related construction activities are completed. The requirements in ProPECC Note PN 1/94 should be adhered to in the handling and disposal of bentonite slurries.

5.7.1.2 Modification of seawall and Construction of landing steps and possible piers/viewing platform

To minimise any adverse water quality impact during modification of seawalls for construction of cooling water discharges/outfalls and landing steps and installation of marine piles for construction of the possible piers, silt curtains should be deployed to completely enclose the modification of seawalls and marine pile installation works. The WKCDA's Contractors should be responsible for the design, installation and maintenance of the silt curtains to minimize the impacts on water quality. The design and specification of the silt curtains should be submitted by the WKCDA's Contractors to the Engineer for approval.

5.7.1.3 Barging facilities and activities

Adverse impacts related to marine water quality are not expected to arise from operation of the proposed barging point, provided that good site practices are strictly followed. Recommendations for good site practices during operation of the proposed barging point include:

- all vessels should be sized so that adequate clearance is maintained between vessels and the seabed in all tide conditions, to ensure that undue turbidity is not generated by turbulence from vessel movement or propeller wash;
- loading of barges and hoppers should be controlled to prevent splashing of material into the surrounding water. Barges or hoppers should not be filled to a level that will cause the overflow of materials or polluted water during loading or transportation;
- all hopper barges should be fitted with tight fitting seals to their bottom openings to prevent leakage of material; and
- construction activities should not cause foam, oil, grease, scum, litter or other objectionable matter to be present on the water within the site.

5.7.1.4 Sewage effluent from construction workforce

Temporary sanitary facilities, such as portable chemical toilets, should be employed on-site where necessary to handle sewage from the workforce. A licensed contractor should be employed to provide appropriate and adequate portable toilets and be responsible for appropriate disposal and maintenance.

5.7.1.5 General construction activities

Construction solid waste, debris and refuse generated on-site should be collected, handled and disposed of properly to avoid entering any nearby storm water drain. Stockpiles of cement and other construction materials should be kept covered when not being used.

Oils and fuels should only be stored in designated areas which have pollution prevention facilities. To prevent spillage of fuels and solvents to any nearby storm water drain, all fuel tanks and storage areas should be provided with locks and be sited on sealed areas, within bunds of a capacity equal to 110% of the storage capacity of the largest tank. The bund should be drained of rainwater after a rain event.

5.7.2 Operational Phase

5.7.2.1 Road and surface runoff

For operation of the proposed WKCD development and associated local road network, a surface water drainage system would be provided to collect road and surface runoff. It is recommended that the road drainage should be provided with adequately designed silt trap and oil interceptors, as necessary. The design of the operation phase mitigation measures for the proposed WKCD development and associated local road network should take into account the guidelines published in the *Practice Note for Professional Persons on Drainage Plans Subject to Comment by the Environmental Protection Department* (ProPECC Note PN 5/93) and *Highways Department Guidance Notes RD/GN/035 – Road Pavement Drainage Design*.

5.7.2.2 Sewage and wastewater effluents from the proposed WKCD development

Domestic sewage generated during operation phase of the proposed WKCD development should be diverted to the foul sewer. Sewage and sewerage impact assessment had identified that the proposed WKCD development would not cause adverse impact to the local sewerage network which should have sufficient capacity to cater for the sewage flow generated from the proposed WKCD development. No mitigation measures and upgrading works to the existing local sewer are necessary for the proposed WKCD development. Recommendations for the design, operation and maintenance for the sewerage system are detailed in **Section 6**.

5.7.2.3 Marine piles of possible piers

As the potential impacts of the provision of the marine piles on flushing capacity in the vicinity of the possible piers is expected to be insignificant, no mitigation measures would be required.

5.7.2.4 Emergency effluent from optional sewage pump sump

The following mitigation measures are proposed to be incorporated in the design of the optional sewage pump sump:

- A two hour emergency storage capacity should be provided within the optional sewage pump sump accordingly to EPD Environmental Guidance Note for Sewage Pumping Stations which is NOT a Designated Project;
- Dual power supply or emergency generator with sufficient capacity (100%) should be provided to the optional sewage pump sump to secure electrical power supply;
- Standby pumps with sufficient capacity (100%) should be provided to the optional sewage pump sump to ensure smooth operation of the optional sewage pumping station during maintenance of the duty pumps;
- An alarm should be installed to signal emergency high water level in the wet well of the optional sewage pump sump; and
- Should the optional sewage pump sump is unmanned, a remote monitor system connecting the optional sewage pump sump with the control station through telemetry system should be provided to ensure swift actions to be taken in case of malfunction of the optional sewage pump sump.

With the implementation of the aforesaid design measures, emergency effluent bypass from the optional sewage pump sump is not anticipated.

5.7.2.5 Improvement works for New Yau Ma Tei Typhoon Shelter for Odour Mitigation

To help mitigate the malodour emissions from NYMTTS, effluent discharges should be stopped or prevented from entering the NYMTTS via the Cherry Street and Jordon Road Box Culverts. The short term measures of rectifying any identified expedient connections and desilting of sediments at the two Box Culverts have been in-progress by relevant government departments. Implementation of the project to construct a new DWFI at the outlet of the Cherry Street Box Culvert as well as the proposed upgrading works for the existing DWFIs upstream of the Cherry Street Box Culvert and/or the Jordon Road Box Culvert was recommended to help reduce the malodour emissions due to effluent discharge from the Box Culverts.

5.7.2.6 Water reuse facilities

Regarding collection and treatment of rainwater, individual venue operators should follow Architectural Services Department (ASD) Design Guideline for Rainwater Recycling Installation with typical schematic design of a rainwater recycling installation and recommended recycled rainwater standard with reference to the international standards, such as EPA of USA etc. as detailed in **Table 5.11** during design and operation of the facilities. Disinfection by chemical treatment and monitoring should be implemented for reuse of condensate from air conditioning systems. As the demand for reclaimed water is significant, discharge of surplus reclaimed water is not anticipated.

5.7.2.7 Thermal/cooled water discharge from district cooling system

The thermal impact from the DCWS discharge on the harbour water is predicted to be localized and minor as the general flushing capacity in the Victoria Harbour is high. As chlorine would be subject to decay, the impact from any residual chlorine discharge from the DCWS is also predicted to be localized and confined in area close to the outfall. No mitigation measures would be required.

Monitoring for the spent cooling water discharge from DCWS during operation should follow the requirements as specified in the discharge license to be issued under the WPCO.

5.8 Evaluation of Cumulative and Residual Water Quality Impact

Provided that proper mitigation measures would be implemented by each of the concurrent projects such as XRL, no adverse cumulative land-based and marine-based water quality impacts would be expected.

With the implementation of the recommended mitigation measures for the construction and operation phases of the proposed WKCD development, no residual water quality impact is anticipated.

5.9 Water Quality Monitoring and Audit

Adverse water quality impact was not predicted during the construction and operation phases of the proposed WKCD development. Nevertheless, appropriate mitigation measures are recommended to minimize potential water quality impacts.

Water quality monitoring is recommended during the course of marine construction works to obtain a robust, defensible database of baseline information of marine water quality before construction, and thereafter, to monitor any variation of water quality from the baseline conditions and exceedances of WQOs at sensitive receivers during construction and to ensure the recommended mitigation measures are properly implemented.

Regular audit of the implementation of the recommended mitigation measures during the construction phase at the work areas should also be undertaken to ensure the recommended mitigation measures are properly implemented.

Monitoring for the spent cooling water discharge from DCWS during operation should follow the requirements as specified in the discharge license to be issued under the WPCO. Details of the water quality monitoring and audit programme and the Event and Action Plan are provided in the stand-alone EM&A Manual.

5.10 Conclusion

5.10.1 Construction Phase

The key issue in terms of water quality during the construction phase of the Project would be the potential for release of effluent into coastal waters from construction site runoff and drainage and potential for release of suspended solids into the surrounding water from excavation and backfilling for modification of seawall and construction of landing steps and possible piers/viewing platform.

Deterioration in water quality could be minimised to acceptable levels through implementing adequate mitigation measures such as control measures on suspended solids release, on-site runoff and drainage from the works areas to minimise suspended solids spillage and construction runoff prior to discharge. Proper site management and good housekeeping practices would also be required to ensure that construction wastes and other construction-related materials would not enter the public drainage system and coastal waters. Sewage effluent arising from the construction workforce would also be handled through provision of portable toilets.

With the implementation of these recommended mitigation measures, no unacceptable impacts on water quality from the construction works for the Project are anticipated. Water quality monitoring during the course of marine construction works and site inspections during construction phase should be undertaken routinely to inspect the construction activities and works areas to ensure the recommended mitigation measures are properly implemented.

5.10.2 Operation Phase

Surface runoff from the proposed WKCD development and associated local road networks may be contaminated by oils leaked from passing vehicles. It is considered that impacts upon water quality will be acceptable provided that the proposed WKCD development and associated local road networks are designed with adequate drainage systems and appropriate oil interceptors, as required.

Sewage and wastewater effluents generated from the proposed WKCD development would be connected to the proposed foul sewerage system which has sufficient capacity to cater for the sewage flow from the proposed WKCD development. No adverse sewage impact is anticipated resulting from the proposed WKCD development.

As the potential impacts of the provision of the marine piles on flushing capacity in the vicinity of the possible piers is expected to be insignificant, no mitigation measures would be required.

With the optional pump sump with very limited capacity, located at the basement level of WKCD and provision of standby pump facilities and dual power supply with sufficient capacity (100%), there would not be occurrence of emergency discharge event. With the implementation of suitable design measure, there would not be any insurmountable water quality impacts associated with the optional sewage pump sump operation. Discharge from district cooling water system (DCWS) would be controlled under the Water Pollution Control Ordinance (WPCO) discharge licence in which the monitoring for the spent cooling water discharge would be specified.

Water collection and treatment system would be installed for reuse of the reclaimed water via rainwater harvesting and reuse of condensate from air conditioning systems, which is being considered for potential uses such as irrigation. Provided that the rainwater harvesting installation and the condensate collection and disinfection system is well maintained, no adverse impact is anticipated from reuse of rainwater and condensate for irrigation. As the demand for reused rainwater is significant, discharge of surplus reused rainwater is not anticipated. Water quality impact as a result of discharge of surplus reused rainwater is therefore not anticipated. Discharge of surplus reused rainwater, if deemed necessary would be required to comply with requirements specified in the WPCO.

The thermal impact due to sea water discharge from the DCWS and independent cooling systems on the harbour water is predicted to be localized and minor as the general flushing capacity in Victoria Harbour is high. As the chlorine would be subject to decay, the impact from any residual chlorine of the sea water discharge is also predicted to be localized and confined in area close to the outfall. No mitigation measures would therefore be required.