5. WATER QUALITY IMPACT

5.1 Introduction

5.1.1 This section presents the results of the water quality impact assessment conducted for construction and operation phases of the Project.

5.1.2 The water quality impact assessment was conducted in accordance to the criteria and guidelines stated in Annexes 6 and 14 of the EIAO-TM for evaluation and assessment of water quality impact. It covered the scope of work outlined in Section 3.4.4 of the EIA Study Brief for the Project.

5.2 Relevant Legislations, Standards & Guidelines

Environmental Impact Assessment Ordinance (EIAO)

5.2.1 The Environmental Impact Assessment Ordinance (EIAO) provides a legislative framework to safeguard the environment by reducing and minimizing adverse environmental impacts from Designated Projects.

5.2.2 Annexes 6 and 14 of the EIAO Technical Memorandum (TM) on Environmental Impact Assessment Process specify the general and project-specific criteria and guidelines for water quality impact assessment.

Practice Note for Professional Persons

5.2.3 The Practice Note for Professional Persons (ProPECC Note PN1/94) on construction site drainage provides guidelines on good practice for dealing with discharges from construction sites. This Practice Note is applicable to this study for control of site runoff and wastewater generated during the construction phase of the Project.

5.2.4 The water quality assessment followed this Practice Note to recommend mitigation measures to minimise the potential water quality impact arising from construction activities.

Water Pollution Control Ordinance & Water Quality Objectives

5.2.5 The Water Pollution Control Ordinance (WPCO) (Cap. 358) enacted in 1980 is the principal legislation to safeguard water quality in Hong Kong. Under the WPCO, the Hong Kong waters are classified into 10 Water Control Zones (WCZs). Water Quality Objectives (WQOs) are specified for each WCZ. The WQOs set the limits for different water quality parameters for maintaining good quality of water within each of the WCZs.

5.2.6 The North Western WCZ and the North Western Supplementary are marine water zones that may be potentially impacted by the effluent from the Tai O STW. The WQOs for the North Western WCZ and North Western Supplementary are listed in **Table 5.1**.

Table 5.1 : Summary of Water Quality Objectives (WQOs) for North Western Water Control Zone (WCZ) and North Western Supplementary

Parameters	Objectives	Sub-Zone
Offensive Odour, Tints	Not to be present	Whole zone (including North Western Supplementary Zone)
Visible foam, oil scum, litter	Not to be present	Whole zone (including North Western Supplementary Zone)
Dissolved Oxygen (DO) within 2 m of the seabed	Not less than 2.0 mg/L for 90% of samples	Marine waters (including North Western Supplementary Zone)
Depth-averaged DO	Not less than 4.0 mg/L	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones, Water Gathering Ground Subzones and other inland waters
	Not less than 4.0 mg/L for 90 % sample	Marine waters (including North Western Supplementary Zone)
pH	To be in the range of 6.5 – 8.5, change due to human activity not to exceed 0.2	Marine waters (including North Western Supplementary Zone), excepting Bathing Beach Subzones
	To be in the range of 6.5 – 8.5	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
	To be in the range of 6.0 – 9.0	Other inland waters
	To be in the range of 6.0 – 9.0 for 95% samples	Bathing Beach Subzones
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(including North Western Supplementary Zone)
Suspended solids (SS)	Not to raise the ambient level by 30% caused by human activity	Marine waters(including North Western Supplementary Zone)
	Not to cause the annual median to exceed 20 mg/L	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
	Not to cause the annual median to exceed 25 mg/L	Inland waters
Unionized Ammonia (UIA)	Annual mean not to exceed 0.021	Whole zone(including North

Parameters	Objectives	Sub-Zone
	mg/L as unionized form	Western Supplementary Zone)
Nutrients	Shall not cause excessive algal growth	Marine waters(including North Western Supplementary Zone)
Total Inorganic Nitrogen (TIN)	Annual mean depth-averaged inorganic nitrogen not to exceed 0.3 mg/L	Castle Peak Bay Subzone
	Annual mean depth-averaged inorganic nitrogen not to exceed 0.5 mg/L	Marine waters (including North Western Supplementary Zone), excepting Castle Peak Bay Subzone
Bacteria	Not exceed 610 per 100ml, calculated as the geometric mean of all samples collected in one calendar year	Secondary Contact Recreation Subzones and North Western Supplementary Zone
	Should be less than 1 per 100 ml, calculated as the running median of the most recent 5 consecutive samples taken between 7 and 21 days.	Tuen Mun (A) and Tuen Mun (B) Subzones and Water Gathering Ground Subzones
	Not exceed 1000 per 100 ml, calculated as the running median of the most recent 5 consecutive samples taken between 7 and 21 days	Tuen Mun (C) Subzone and other inland waters
	Not exceed 180 per 100 ml, calculated as the geometric mean of all samples collected from March to October inclusive. Samples should be taken at least 3 times in one calendar month at intervals of between 3 and 14 days.	Bathing Beach Subzones
Colour	Not to exceed 30 Hazen units	Tuen Mun (A) and Tuen Mun (B) Subzones and Water Gathering Ground Subzones
	Not to exceed 50 Hazen units	Tuen Mun (C) Subzone and other inland waters
5-Day Biochemical Oxygen Demand (BOD_5)	Not to exceed 3 mg/L	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
	Not to exceed 5 mg/L	Inland waters

Parameters	Objectives	Sub-Zone
Chemical Oxygen Demand (COD)	Not to exceed 15 mg/L	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
	Not to exceed 30 mg/L	Inland waters
Toxins	Should not cause a risk to any beneficial uses of the aquatic environment	Whole zone (including North Western Supplementary Zone)
	Waste discharge shall not cause the toxins in water significant to produce toxic carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms.	Whole zone (including North Western Supplementary Zone)
Phenol	Quantities shall not sufficient to produce a specific odour or more than 0.05 mg/L as C_6H_5OH	Bathing Beach Subzones
Turbidity	Shall not reduce light transmission substantially from the normal level	Bathing Beach Subzones

Technical Memorandum on Effluents Discharge Standard

5.2.7 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), issued under Section 21 of the WPCO, sets limits for permissible effluent discharges based on the type of receiving waters (foul sewers, storm water drains, inland and coastal waters).

5.2.8 The effluent discharge standards are intended to set limits for the physical, chemical and microbial quality of the effluent, and vary with the discharge rate of the effluent flow. The TM effluent standards relevant to this study are shown in **Table 5.2**.

Table 5.2 : Standards for Effluents Discharged into the Inshore Waters of North Western Water Control Zone

Flow rate (m^3/day) Determinant	≤10	>10 & ≤200	>200 & ≤400	>400 & ≤600	>600 & ≤800	>800 & ≤1000	>1000 & ≤1500	>1500 & ≤2000	>2000 & ≤3000	>3000 & ≤4000	>4000 & ≤5000	>5000 & ≤6000
pH (pH units)	6–9	6–9	6–9	6–9	6–9	6–9	6–9	6–9	6–9	6–9	6–9	6–9
Temperature (oC)	40	40	40	40	40	40	40	40	40	40	40	40
Colour (lovibond units) (25mm cell length)	1	1	1	1	1	1	1	1	1	1	1	1
Suspended solids	50	30	30	30	30	30	30	30	30	30	30	30
BOD	50	20	20	20	20	20	20	20	20	20	20	20
COD	100	80	80	80	80	80	80	80	80	80	80	80
Oil & Grease	30	20	20	20	20	20	20	20	20	20	20	20
Iron	15	10	10	7	5	4	3	2	1	1	0.8	0.6
Boron	5	4	3	2	2	1.5	1.1	0.8	0.5	0.4	0.3	0.2
Barium	5	4	3	2	2	1.5	1.1	0.8	0.5	0.4	0.3	0.2
Mercury	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Other toxic metals individually	1	1	0.8	0.7	0.5	0.4	0.3	0.2	0.15	0.1	0.1	0.1
Total toxic metals	2	2	1.6	1.4	1	0.8	0.6	0.4	0.3	0.2	0.1	0.1
Cyanide	0.2	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.03	0.02	0.02	0.01
Phenols	0.5	0.5	0.5	0.3	0.25	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Sulphide	5	5	5	5	5	5	2.5	2.5	1.5	1	1	0.5
Total residual chlorine	1	1	1	1	1	1	1	1	1	1	1	1
Total nitrogen	100	100	80	80	80	80	50	50	50	50	50	30
Total phosphorus	10	10	8	8	8	8	5	5	5	5	5	5
Surfactants (total)	20	15	15	15	15	15	10	10	10	10	10	10
E. coli (count/100 mL)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Notes:

(1) All units in mg/L unless otherwise stated; and

(2) All figures are upper limits unless otherwise indicated.

Assessment Criteria for Specific Sensitive Receivers

Water Supplies Department's Water Quality Criteria

5.2.9 Water Supplies Department (WSD) has specified a set of water quality criteria for water quality at flushing seawater intakes. Water quality parameters relevant to this EIA are listed in **Table 5.3** along with their target limits.

Table 5.3 : WSD Standards For Flushing Water Intakes

Parameter (in mg/L unless otherwise stated)	WSD Target Limit
Colour (Hazen Unit)	< 20
Turbidity (NTU)	< 10
Threshold Odour Number (odour unit)	< 100
Ammoniacal Nitrogen	< 1
Suspended Solids (SS)	*< 10*
Dissolved Oxygen (DO)	> 2
Biochemical Oxygen Demand (BOD)	< 10
Synthetic Detergents	< 5
E. coli (no. / 100 ml)	< 20,000

Assessment Criterion for Cooling Water Intake

5.2.10 The assessment criterion for assessing the impact to cooling water intakes is that the concentration of suspended solids (SS) does not exceed 40 mg/L.

Assessment Criteria for Corals

5.2.11 The assessment criteria for corals are based on both the sedimentation rate and WQO for SS.

5.2.12 With reference to studies by (Pastorok & Bilyard, 1985) and (Hawker & Connel, 1992) on coral reef communities, the recommended sedimentation rate for providing sufficient protection and avoiding unacceptable impacts to corals is less than 0.1 $kg/m^2/day$.

5.2.13 The WQO for SS specifies that human activities or waste discharges shall not raise the ambient SS level by 30% and shall not affect aquatic communities. The ambient SS concentrations at each of the identified WSRs were determined using the 90^{th} percentile (90%ile) of baseline concentrations from water quality model. The level of increase in SS due to the Project was predicted by a sediment plume model.

Assessment Criteria for Dredging Activities

5.2.14 Construction of a new submarine sewage outfall involves dredging of marine sediment and rock/sand filling activities. Key concerned water quality parameters associated with such an activity are Suspended Solids (SS) and Dissolved Oxygen (DO). The WQOs for SS and DO for the relevant WCZs are summarised in **Table 5.4**.

Table 5.4 : WQOs for SS and DO for North Western WCZ

Water Quality Parameter	WQO	Remarks
Depth-averaged Dissolved Oxygen	≥ 4 mg/L for 90% of samples for marine waters except fish culture subzones	Marine waters (including North Western Supplementary Zone)
	≥ 5 mg/L for 90% of samples for fish culture subzones	-
Bottom Dissolved Oxygen within 2m of the Seabed	≥ 2 mg/L for 90% of samples for marine waters	Marine waters (including North Western Supplementary Zone)
Suspended Solids	Waste discharge not to raise the natural ambient level by 30% nor cause the accumulation of SS which may adversely affect aquatic communities for marine waters	Marine waters (including North Western Supplementary Zone)

Assessment Criteria for Contaminant release from Marine Sediment

5.2.15 There are no existing legislative standards or guidelines in Hong Kong for individual heavy metals and micro-organic pollutants (PCBs, PAHs and TBT) for marine waters. International standards were therefore adopted as the assessment criteria in this study. The international standards include the UK Water Quality Standards, Australian Water Quality Guidelines, USEPA Criterion and relevant research studies.

5.3 Assessment Methodologies

Identification of Key Water Quality Issues

5.3.1 The reclamation is in a small scale with a 0.26 ha site formation. Reclamation filling for the Project is scheduled to proceed after construction of the core of seawall and foundation stone to form a temporary seawall which acts as a barrier between the proposed Tai O STW site and the sea. As a result of the seawall acting as a barrier between the site and sea water, the impact to nearby marine water is expected to be extremely small. The works sequences showing the construction of the temporary seawall are presented in **Appendix 2.2** and the general layout of the proposed Tai O STW is presented in **Figure 2.2**.

5.3.2 As confirmed with DSD operation staff, functions of both the Hang Mei and Fan Kwai Tong SPSs would be restored within 4 hours in case of an emergency situation. Retention of sewage flows for at least 4 hours will be provided at the inlet chamber and wet well of both SPSs before any emergency discharge could take place. Therefore, an emergency discharge of sewage overflows from the SPSs is unlikely to occur. The general layouts of the proposed Hang Mei and Fan Kwai Tong SPSs are presented in **Figure 2.4** and **Figure 2.5** respectively.

5.3.3 The key water quality issues during the construction phase of the Project include:

- Dispersion of sediment and fine materials due to dredging of marine sediment for the construction of the sewage submarine outfall;
- Release of contaminants from the marine sediment during dredging;
- Filling related activities;
- Construction site runoff;
- Wastewater generated from general construction activities;
- Sewage effluent generated by workforce; and
- Accidental spillage of chemicals;

5.3.4 A key water quality concern during construction is disturbance to marine bottom sediment during dredging. The disturbance to the marine sediment may result in the following:

- Increased suspension of fine sediment into the water column during dredging activities, with possible consequences of reducing DO levels, increasing nutrient levels and causing non-compliance to the WQOs and other criteria; and
- Release of organic and inorganic constituents such as heavy metals, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and nutrients into the water column.

5.3.5 Potential water quality issues arising from the operation of the Project include:

- Hydrodynamic impact due to land reclamation;
- Discharge of treated effluent into the marine water from Tai O STW; and
- Emergency discharge of untreated sewage from Tai O STW.

5.3.6 During the operational phase, potential water quality impacts will be mainly related to the effluent discharge from the Tai O STW. Key concerns are the water quality effects of effluent discharge and the proposed land reclamation on receiving waters. The effluent discharge may affect water quality in the receiving waterbody and impose potential impacts to nearby water quality sensitive receivers and habitats. Such potential impacts may include salinity impact on halophytes and mangrove, nutrient impact on the Tai O Creek and wetlands, etc.

5.3.7 Impacts could also occur as a result of emergency discharge of untreated sewage due to unexpected events such as interruption of power supply or damage to the effluent pipeline. The emergency events could result in emergency wastewater discharge and could have impacts on the receiving waters with a certain period of duration of impact.

Construction Phase

Marine-Based Impact Assessment

5.3.8 Construction of submarine outfall involves the use of the open trench method. Grab dredgers will be used to excavate seabed to form a trench. Subsequent construction activities include trench trimming, in-situ fabrication, in-situ testing, pipeline laying and backfilling.

5.3.9 A concern on water quality impact associated with the submarine outfall construction is the release of sediment and contaminants into the water column during dredging. Elevation in SS levels could result in increased turbidity and decreased level of penetration of sunlight into the water column. High SS levels could also cause depletion of dissolved oxygen concentration in the water column, which may result in possible suffocation of coral colonies, fish and other aquatic life.

5.3.10 Potential impacts to SS concentrations associated with the dredging works in this study was assessed using a sediment plume model based on the Delft3D model suite. Suspended solids and sedimentation flux were assessed using the sediment plume model.

5.3.11 The degree of depletion in dissolved oxygen concentration was determined using a dissolved oxygen depletion model. The same model was also used in the EIA Study for Development of a 100MW Offshore Wind Farm in Hong Kong for assessing the DO depletion due to sediment dredging.

5.3.12 Effects of release of contaminants into the ambient marine water during dredging works were assessed as well in this study. The results from the laboratory test of elutriate samples were used to evaluate the amount of contaminants that could be released into the water column.

Land-Based Impact Assessment

5.3.13 Land-based construction activities include construction of pumping stations and new sewer systems, expansion and upgrading of the STW, and installation of effluent reuse facilities. Site storm runoff and substances released from construction activities are the major source of terrestrial water quality impact.

5.3.14 Stormwater runoff from the land-based construction activities may contain high levels of suspended solids generated from excavation. It may also contain oil and grease originated from the operation of mechanical equipment. Sewage arising from the construction workforce is another source of water quality impact.

5.3.15 A variety of chemicals used in the construction activities includes petroleum products, spent paints, spent lubrication oil, grease, mineral oil acid solutions/ solvent, alkaline solutions/ solvent and others. Accidental spillage of these chemicals may lead to soil contamination, which may in turn impact nearby water bodies through site runoff.

5.3.16 Water quality impact assessment in this study covers all the identified potential sources during the project construction. The assessment followed the criteria and guidelines for water quality impact assessment as stated in Annexes 6 and 14 of the TM. Mitigation measures were proposed on the basis of the ProPECC Note on the construction site drainage to ensure that any water discharge would comply with the WPCO criteria.

Operational Phase

Hydrodynamic Impact due to reclamation

5.3.17 The expansion and upgrading of Tai O STW will includes 0.26 ha site formation by reclamation. Although the reclamation is in a small scale, the Delft3D-FLOW model was used to evaluate the hydrodynamic impact to the nearby marine waters due to reclamation.

Normal Discharge of the STW Effluent

5.3.18 During the operational phase, some of the raw sewage that is currently discharged into adjacent waters will be collected, treated and discharged via the proposed submarine outfall. As a result, it is expected that the Project will bring environmental benefits and help improve water quality in vicinity of the Tai O marine area.

5.3.19 To address the water quality effects, the Delft3D-WAQ model with 3-dimensional capability was used to simulate the impacts of effluent discharge on water quality conditions of the marine environment.

Emergency Discharge

5.3.20 Under emergency conditions, raw sewage would be directly diverted into adjacent water bodies through the emergency outfall from the storm tank.

5.3.21 The probability of emergency discharge is expected to be low, and the duration of such an emergency discharge, if occurring, is short. Nonetheless, the potential effects of an emergency discharge from the upgraded STW were assessed using the Delft3d-WAQ model as well.

Modeling Development

5.3.22 Computer modelling approach was adopted to assess the potential impact on marine water quality associated with the Project. Delft3D suite of models, namely Delft3D-FLOW, Delft3D-WAQ and Delft3D-SED, developed by Delft Hydraulics, were used as the platform for hydrodynamic, water quality and sediment plume modelling, respectively. Delft3D is a state-of-the-art computer program that simulates three-dimensional flow and water quality processes and is capable of handling interactions between different hydrodynamic and water quality processes.

5.3.23 The existing regional model "**Update Model**" developed for Hong Kong marine waters was applied in this study to simulate effects of the proposed Tai O STW works on hydrodynamics and water quality. The Update Model is a fully calibrated and verified model developed under Update on Cumulative Water Quality and Hydrological Effect of Coastal Developments and Upgrading of Assessment Tool Study (1998) by EPD based on the Delft3D suite of models.

5.3.24 Grid size of the existing Update Model near the Project site is in the order of about 300 m. To cover local areas near the proposed Project, a **Local Fine Grid Model** with finer grids was specifically set up for the Tai O STW to carry out hydrodynamic, water quality and sediment plume simulations. The grid size of the Local Fine Grid Model was set to be around 30 m, which is less than 75 m to meet the modelling requirements specified in the Study Brief.

5.3.25 The Local Fine Grid Model was linked to the regional Update Model for continuity of model input conditions. Open boundary conditions of the fine grid model were transferred from the Update Model. That is, modelling was first carried out using the regional Update Model, and the output from the Update Model at the interface with the Local Fine Grid Model was used as the boundary conditions for input to the Local Fine Grid Model. The cumulative effects from the Pearl River estuary were accounted for in the Update Model, which covers the entire Hong Kong waters and the Pearl River estuary. Details on the model development are provided in **Appendix 5.2** of this report.

Scenario Runs

5.3.26 The upgraded Tai O STW is tentatively scheduled to start commissioning in 2022. The time horizon for water quality assessment was, therefore, set for the year of 2022 and the assessment was conducted for the following scenarios:

- Scenario 1 – Effluent discharge through the submarine outfall without commissioning of the Upgraded Tai O STW ("Without Project Scenario, Baseline Condition in 2022");
- Scenario 2 - Effluent discharge through the submarine outfall under the normal operation conditions upon commissioning of the Upgraded Tai O STW ("With Project Scenario") in 2022; and
- Scenario 3 – Emergency bypass of raw sewage from the Tai O STW.

5.3.27 Scenario 1 represents the future baseline condition without the expansion and upgrading of Tai O STW in 2022. Scenario 2 represents the normal operational condition of the Tai O STW after the project is commissioned in 2022. Scenario 3 is to address the impact from an emergency discharge of untreated effluent under temporary shutdown of the sewage treatment units as a result of unexpected events such as the failure of power supply, equipment malfunction, or other incidents.

Evaluation of Mitigation Measures

5.3.28 Appropriate mitigation measures were identified where necessary to mitigate the potential water quality impact to an acceptable level for both construction and operational phases of the Project. The potential sources of impact for which mitigation measures were considered include:

- SS release from dredging and filling activities;
- Contaminant release from dredging activities;
- Contaminant of construction site runoff;
- Emergency discharge of the STW effluent and raw sewage from SPSs; and
- Options to avoid or minimize reclamation.

Residual Water Quality Impacts

5.3.29 The residual water quality impact with the implementation of recommended mitigation measures was assessed to examine the potential impact to water sensitive receivers in the study area for both the construction and operational phases.

5.4 Study Area and Water Sensitive Receivers

5.4.1 The study area for this EIA study covers the entire Tai O Bay and its surrounding areas to provide a sufficient aerial coverage of potentially affected marine waters as shown in **Figure 5.1** and **Figure 5.2a**. Water sensitive receivers (WSRs) within the study area that could be potentially affected by the Tai O STW Project were identified. The identified WSRs are presented in **Table 5.5a**. **Figure 5.2b** and **Table 5.5b** illustrate the water quality modelling assessment locations and corresponding WSRs.

Table 5.5a : Identified Water Sensitive Receivers

Classes	Water Sensitive Receivers
Marine Water Habitats	• Chinese White Dolphin (Sousa chinensis) and Finless Porpoise (Neophocaena phocaenoides); • Areas with ecological or conservation value; and • Areas which are horseshoe crab nursery sites, habitats of marine mammals, marine benthic communities, intertidal habitats and coral communities.
Inland Waters	• Natural streams and rivers including Tai O Creek and Tai O River. • Ponds
Bathing Beach Zones	• Bathing beaches.
Fish Culture Zones	• Fish spawning and nursery grounds and fish culture zones.
Secondary Contact Recreation Zones	• Secondary contact recreational zones; and • Recreation and tourism related uses,
Others	• Coastal protection areas; • Ecologically important streams and mangroves areas, salt pans and marshland; • Sheltered bay area including the Tai O sheltered boat anchorage; and • Sea water intakes.

Table 5.5b : Water Quality Modelling Assessment Point and Corresponding WSRs

Water Quality Modelling Point	Water Sensitive Receiver
WSR 1	Coral
WSR 2	Coral
WSR 3	Coral
WSR 4	Coral
WSR 5	Coral
WSR 6	Coral
WSR 7	Coral
WSR 8	Chinese White Dolphins
WSR 9	Mudflat
WSR 10	Sheltered Boat Anchorage
WSR 11	Pond
WSR 12	Watercourse
WSR 13	Inner Bay
WSR 14	Inner Watercours

5.5 Baseline Water Quality Conditions and Trend

Regional Marine Water Quality Baseline Conditions

5.5.1 The most recently published monitoring data sampled at the EPD marine water monitoring stations near the proposed Project site were collected and reviewed to assess existing water quality conditions in the study area. The selected EPD marine water monitoring stations in the vicinity of the project area include:

- NM8 and NM6 in the North Western WCZ; and
- SM20 in the Southern WCZ.

5.5.2 The water quality monitoring results collected at these three stations are summarized from **Table 5.6** to **Table 5.8.** Data in the tables were used to establish the existing water quality conditions of the open sea area of Tai O. Station of NM8 is the closest to the Tai O site; it is therefore more representative of the open sea water quality condition around Tai O.

Table 5.6 : Water Quality Monitoring Results at NM6 from 2006-2010

Parameters	2006	2007	2008	2009	2010	Average
Temperature (°C)	24.0	23.8	23.3	24.1	23.6	23.8
	(17.7 - 29.2)	(17.3 - 30.3)	(15.1 - 28.4)	(16.7 - 29.8)	(15.7-30.0)	
Salinity (PSU)	26.0	27.5	26.7	27.9	26.3	26.9
	(10.5 - 33.3)	(12.0 - 33.0)	(9.3 - 32.4)	(16.1 - 33.0)	(13.9 - 32.6)	
Dissolved Oxygen (mg/L)	6.7	6.4	6.5	6.2	7.1	6.6
	(4.8 - 8.7)	(3.2 - 10.0)	(4.4 - 8.2)	(5.0 - 7.6)	(4.7 - 10.4)	
Bottom Dissolved Oxygen (mg/L)	6.6	6.4	6.3	6.1	7.0	6.5
	(4.2 - 8.6)	(2.4 - 10)	(3.3 - 8.5)	(4.8 - 8.0)	(5.0 - 9.9)	
pH	7.9	8.0	8.1	8.0	8.0	8.0
	(7.5 - 8.2)	(7.5 - 8.5)	(7.9 - 8.3)	(7.8 - 8.1)	(7.7 - 8.5)	
Suspended Solids (mg/L)	12.6	10.0	10.3	13.4	9.7	11.2
	(4.1 - 35.9)	(3.5 - 27.7)	(2.8 - 36.3)	(5.2 - 41.3)	(1.9 - 23.0)	
5-day Biochemical Oxygen Demand (mg/L)	0.7	1.1	0.7	0.7	1.0	0.8
	(0.3 - 1.3)	(0.5 - 2.7)	(0.2 - 1.9)	(0.2 - 1.4)	(0.3 - 2.5)	
Ammonia Nitrogen (mg/L)	0.170	0.112	0.130	0.081	0.069	0.112
	(0.010 - 0.500)	(0.050 - 0.240)	(0.030 - 0.370)	(0.033 - 0.143)	(0.021 - 0.160)	
Unionized Ammonia (mg/L)	0.006	0.006	0.006	0.003	0.003	0.005
	(0.002 - 0.022)	(0.001 - 0.012)	(0.001 - 0.011)	(0.001 - 0.005)	(<0.001 - 0.005)	

Parameters	2006	2007	2008	2009	2010	Average
Nitrite Nitrogen (mg/L)	0.093	0.087	0.096	0.069	0.103	0.090
	(0.026 - 0.200)	(0.006 - 0.373)	(0.020 - 0.353)	(0.021 - 0.200)	(0.018 - 0.373)	
Nitrate Nitrogen (mg/L)	0.390	0.379	0.436	0.347	0.459	0.402
	(0.030 - 1.000)	(0.037 - 1.267)	(0.079 - 1.500)	(0.101 - 0.857)	(0.098 - 1.270)	
Total Inorganic Nitrogen (mg/L)	0.66	0.58	0.66	0.50	0.63	0.61
	(0.09 - 1.40)	(0.12 - 1.40)	(0.15 - 2.03)	(0.20 - 1.05)	(0.19 - 1.66)	
Total Kjeldahl Nitrogen (mg/L)	0.36	0.33	0.32	0.26	0.27	0.31
	(0.14 - 0.75)	(0.17 - 0.47)	(0.15 - 0.64)	(0.17 - 0.41)	(0.17 - 0.45)	
Total Nitrogen (mg/L)	0.84	0.79	0.85	0.67	0.83	0.80
	(0.22 - 1.66)	(0.28 - 1.69)	(0.32 - 2.30)	(0.31 - 1.23)	(0.30 - 1.85)	
Orthophosphate Phosphorus (mg/L)	0.020	0.021	0.024	0.020	0.016	0.020
	(<0.010 - 0.050)	(0.002 - 0.059)	(0.012 - 0.041)	(0.007 - 0.041)	(0.009 - 0.032)	
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.04	0.04	0.05
	(0.03 - 0.08)	(0.04 - 0.09)	(0.03 - 0.08)	(0.03 - 0.06)	(0.03 - 0.06)	
Silica as SO_2 (mg/L)	2.4	1.9	2.1	1.5	1.7	1.9
	(0.3 - 7.4)	(0.1 - 5.4)	(0.5 - 5.9)	(0.4 - 4.2)	(0.1 - 5.8)	
E. coli (count/100mL)	64	18	12	19	31	29
	(2 - 1900)	(1 - 1300)	(2 - 160)	(1 - 170)	(2 - 120)	

Table 5.7 : Water Quality Monitoring Results at NM8 from 2006-2010

Parameters	2006	2007	2008	2009	2010	Average
Temperature (°C)	23.8	23.6	23.2	24.0	23.6	23.6
	(17.5 - 28.3)	(17.1 - 30.6)	(14.9 - 27.9)	(16.9 - 29.7)	(15.9-30.1)	
Salinity (PSU)	27.6	28.9	27.6	29.6	27.1	28.2
	(11.9 - 33.4)	(9.7 - 33.5)	(7.4 - 32.4)	(20.0 - 33.4)	(14.3 - 33.6)	
Dissolved Oxygen (mg/L)	6.8	6.8	6.6	6.2	7.6	6.8
	(4.8 - 8.2)	(3.7 - 9.8)	(4.2 - 9.0)	(4.1 - 10.0)	(5.1 - 10.8)	

Parameters	2006	2007	2008	2009	2010	Average
Bottom Dissolved Oxygen (mg/L)	6.7	6.5	6.3	6.0	7.1	6.5
	(4.6 - 8.3)	(2.4 - 9.3)	(3.1 - 9.0)	(3.5 - 10.1)	(5.3 - 10.1)	
pH	7.9	8.1	8.1	8.0	8.1	8.0
	(7.5 - 8.2)	(7.5 - 8.4)	(7.9 - 8.3)	(7.9 - 8.2)	(7.7 - 8.5)	
Suspended Solids (mg/L)	15.8	11.6	10.8	20.6	12.8	14.3
	(2.7 - 56.7)	(3.5 - 27.7)	(4.1 - 28.3)	(6.6 - 59.3)	(1.9 - 43.0)	
5-day Biochemical Oxygen Demand (mg/L)	0.7	1.1	0.7	0.7	1.1	0.9
	(0.3 - 1.9)	(0.4 - 2.1)	(0.3 - 2.2)	(<0.1 - 1.5)	(0.1 - 3.4)	
Ammonia Nitrogen (mg/L)	0.10	0.07	0.07	0.04	0.05	0.07
	(0.01 - 0.35)	(0.02 - 0.24)	(0.01 - 0.15)	(0.01 - 0.08)	(0.01 - 0.10)	
Unionized Ammonia (mg/L)	0.004	0.004	0.004	0.002	0.002	0.003
	(0.001 - 0.019)	(<0.001 - 0.009)	(<0.001 - 0.012)	(<0.001 - 0.003)	(<0.001 - 0.005)	
Nitrite Nitrogen (mg/L)	0.066	0.058	0.080	0.038	0.084	0.065
	(0.009 - 0.150)	(0.006 - 0.193)	(0.019 - 0.377)	(0.009 - 0.088)	(0.004 - 0.357)	
Nitrate Nitrogen (mg/L)	0.280	0.312	0.378	0.215	0.378	0.313
	(0.010 - 0.720)	(0.029 - 1.367)	(0.084 - 1.567)	(0.030 - 0.790)	(0.030 - 1.300)	
Total Inorganic Nitrogen (mg/L)	0.44	0.44	0.53	0.29	0.51	0.44
	(0.06 - 1.20)	(0.07 - 1.48)	(0.13 - 2.09)	(0.07 - 0.89)	(0.08 - 1.67)	
Total Kjeldahl Nitrogen (mg/L)	0.28	0.28	0.25	0.21	0.23	0.25
	(0.11 - 0.57)	(0.16 - 0.40)	(0.12 - 0.47)	(0.15 - 0.28)	(0.13 - 0.45)	
Total Nitrogen (mg/L)	0.62	0.65	0.70	0.46	0.69	0.62
	(0.15 - 1.39)	(0.23 - 1.78)	(0.26 - 2.41)	(0.22 - 1.04)	(0.16 - 1.88)	
Orthophosphate Phosphorus (mg/L)	0.020	0.016	0.018	0.013	0.012	0.016
	(<0.010 - 0.040)	(0.003 - 0.036)	(0.009 - 0.040)	(0.005 - 0.027)	(0.005 - 0.037)	
Total	0.04	0.04	0.04	0.03	0.04	0.04

Parameters	2006	2007	2008	2009	2010	Average
Phosphorus (mg/L)	(0.02 - 0.06)	(0.03 - 0.07)	(0.02 - 0.07)	(0.02 - 0.05)	(0.02 - 0.05)	
Silica as SO2 (mg/L)	2.0	1.6	1.9	1.2	1.5	1.6
	(0.5 - 6.0)	(0.1 - 5.8)	(0.4 - 6.2)	(0.5 - 4.3)	(0.2 – 6.0)	
E. coli (count/100mL)	5	5	3	2	2	4
	(1 - 420)	(1 - 170)	(1 - 77)	(1 - 4)	(<1 - 12)	

Table 5.8 : Water Quality Monitoring Results at SM20 from 2006-2010

Parameters	2006	2007	2008	2009	2010	Average
Temperature (°C)	24.1	23.9	22.7	24.1	23.1	23.6
	(17.7 - 27.9)	(19.3 - 28.1)	(14.0 - 27.0)	(16.6 - 29.1)	(17.2 - 28.2)	
Salinity (PSU)	31.0	31.1	30.4	31.0	30.3	30.8
	(22.7 - 33.2)	(23.6 - 34.0)	(21.9 - 33.1)	(26.1 - 33.7)	(18.1 - 33.8)	
Dissolved Oxygen (mg/L)	6.9	6.1	6.4	5.8	5.9	6.2
	(5.3 - 8.2)	(3.4 - 8.4)	(3.9 - 9.5)	(3.9 - 7.6)	(2.2 - 7.9)	
Bottom Dissolved Oxygen (mg/L)	6.7	6.0	6.1	5.7	5.8	6.1
	(5.0 - 8.4)	(3.1 - 7.9)	(2.0 - 9.7)	(2.9 - 7.6)	(1.9 - 8.0)	
pH	8.1	8.1	8.1	8.1	7.9	8.1
	(7.8 - 8.3)	(7.5 - 8.4)	(7.7 - 8.3)	(7.8 - 8.3)	(7.7 - 8.3)	
Suspended Solids (mg/L)	13.4	10.4	12.4	11.0	10.2	11.5
	(3.5 - 29.3)	(1.9 - 45.3)	(3.5 - 36.3)	(3.2 - 33.0)	(3.9 - 20.2)	
5-day Biochemical Oxygen Demand (mg/L)	0.6	0.8	0.7	0.7	0.7	0.7
	(0.1 - 1.4)	(0.4 - 2.0)	(0.2 - 1.3)	(0.2 - 1.5)	(0.4 - 1.1)	
Ammonia Nitrogen (mg/L)	0.040	0.050	0.050	0.028	0.029	0.039
	(0.010 - 0.070)	(0.020 - 0.100)	(0.010 - 0.120)	(0.008 - 0.062)	(0.008 - 0.073)	
Unionized Ammonia (mg/L)	0.002	0.003	0.002	0.002	0.001	0.002
	(<0.001 - 0.005)	(<0.001 - 0.007)	(<0.001 - 0.007)	(<0.001 - 0.004)	(<0.001 - 0.003)	
Nitrite Nitrogen	0.027	0.036	0.034	0.031	0.042	0.034

Parameters	2006	2007	2008	2009	2010	Average
(mg/L)	(0.002 - 0.049)	(0.004 - 0.130)	(0.005 - 0.071)	(0.005 - 0.113)	(0.003 - 0.203)	
Nitrate Nitrogen (mg/L)	0.130	0.172	0.196	0.135	0.187	0.164
	(<0.010 - 0.500)	(0.025 - 0.577)	(0.019 - 0.853)	(0.037 - 0.367)	(0.008 - 0.620)	
Total Inorganic Nitrogen (mg/L)	0.20	0.26	0.28	0.19	0.26	0.24
	(0.02 - 0.59)	(0.08 - 0.75)	(0.06 - 1.03)	(0.07 - 0.43)	(0.04 - 0.84)	
Total Kjeldahl Nitrogen (mg/L)	0.18	0.20	0.24	0.16	0.16	0.19
	(0.12 - 0.24)	(0.14 - 0.35)	(0.16 - 0.35)	(0.12 - 0.23)	(0.11 - 0.22)	
Total Nitrogen (mg/L)	0.34	0.41	0.47	0.32	0.39	0.39
	(0.17 - 0.76)	(0.18 - 1.05)	(0.19 - 1.27)	(0.20 - 0.56)	(0.17 - 1.00)	
Orthophosphate Phosphorus (mg/L)	0.010	0.012	0.013	0.009	0.013	0.011
	(<0.010 - 0.010)	(0.004 - 0.021)	(0.005 - 0.026)	(0.004 - 0.014)	(0.004 - 0.032)	
Total Phosphorus (mg/L)	0.030	0.040	0.030	0.030	0.030	0.032
	(0.020 - 0.050)	(0.020 - 0.050)	(0.020 - 0.040)	(<0.020 - 0.040)	(<0.020 - 0.060)	
Silica as SO_2 (mg/L)	0.95	1.10	1.30	0.90	1.16	1.08
	(0.20 - 3.00)	(0.10 - 3.10)	(0.10 - 4.40)	(0.17 - 1.53)	(0.34 - 3.13)	
E. coli (count/100mL)	1	1	2	1	1	1
	(1 - 11)	(1 - 2)	(1 - 75)	(1 - 1)	(<1 - 9)	

5.5.3 The annual average pH level varied within 7.9-8.1 from 2006 to 2010 at Station NM8. This indicates that pH is in compliance with the WQO standard in the open sea area of Tai O. The pH level also stayed very stable at the stations NM6 and SM20 since 2006.

5.5.4 Salinity level ranged from 14.3 to 33.6 PSU at NM8 in 2010. Salinity was between 13.9 and 32.6 PSU at NM6 and in a range of 18.1-33.8 PSU at SM20 in 2010. The annual average salinity maintained to be at a stable level at NM8, NM6 and SM20 since 2006.

5.5.5 The annual average UIA at NM8 was in a range of 0.002-0.004 mg/L from 2006 to 2010, which was in good compliance of WQO standard (0.021 mg/L) without significant change in its annual average value. Similar water quality condition occurred at NM6 and SM20, where UIA level was relatively low and complied well with the WQO standard.

5.5.6 Depth-average DO ranged from 5.1 to 10.8 mg/L at NM8 in 2010 and it has complied with the WQO for DO since 2006 in the open sea area of Tai O. No significant changes in the annual average DO have been detected at NM8, NM6 and SM20 since 2006.

5.5.7 The SS concentration monitored in 2010 ranged within 1.9-43.0 mg/L at NM8, 1.9-23.0 mg/L at NM6 and 3.9-20.2 mg/L at SM20, respectively. A relatively wider range of variation for SS was observed in 2006, 2009 and 2010 at NM8.

5.5.8 The total inorganic nitrogen (TIN) level exceeded WQO in 2008 and 2010 at NM8 by a marginal level. The average TIN concentration at NM8 in the open sea area of Tai O was observed to be 0.44 mg/L, which is close to the WQO standard (0.5 mg/L). On the other hand, total inorganic nitrogen (TIN) monitored at Stations NM6 (as shown in **Table 5.6**) and SM20 frequently exceeded the water quality objective (WQO) for TIN.

5.5.9 Monitored *E. coli* level ranged from 1 to 12 count/100mL in 2010 at NM8 and from 2 to 120 count/100mL at NM6 respectively in 2010, which was in compliance to the WQO standard. The *E. coli* level at NM8 and NM6 (as shown in **Table 5.6** and **Table 5.7**) has decreased gradually since 2006, which indicates a water quality improvement with respect to *E. coli*.

5.5.10 In summary, water quality at Stations NM8, NM6 and SM20 was observed to be in a good condition, except for TIN. The TIN level at these stations has been frequently higher than the WQO limit for TIN since 2006. The monitoring station NM8 is located close to the Tai O STW and is considered to represent a typical water quality condition for the open sea area of Tai O.

Water Quality Baseline Conditions within the Tai O Area

Validity of Water Quality Survey Results

5.5.11 In addition to the EPD data regularly monitored at stations NM8, NM6 and SM20, water quality data for Tai O Bay and Tai O Creek were also collected under two previous EIA studies: Tai O Sheltered Boat Anchorage, and Ngong Ping Sewage Treatment Works and Sewerage.

5.5.12 Water quality sampling locations adopted in the Tai O Sheltered Boat Anchorage EIA and Ngong Ping STW EIA are shown in **Figure 5.3**. The data were collected at each monitoring station for the high high water (HHW) and low low water (LLW) snapshots. The availability of the field data from these two EIAs is summarized in **Table 5.9**. Integration of data from these two EIAs provides the baseline water quality condition that covers both flood and ebb tides, under both dry and wet seasons, respectively.

Table 5.9 : Availability of Field Water Quality Data in the Tai O Bay Area under Two Previous EIAs

EIA Project	Dry Season		Wet Season		References
	Ebb	Flood	Ebb	Flood	
Ngong Ping STW	One set of water quality data collected at Tai O Creek in March 2000		√ (July-August, 2001)	√ (July-August, 2001)	Ngong Ping STW EIA Report
Tai O Sheltered Boat Anchorage	√ (February 1999)	√ (February 1999)			Appendix 3 of Tai O Sheltered Boat Anchorage EIA report

5.5.13 Water quality data collected under the Tai O Sheltered Boat Anchorage EIA are summarized in **Table 5.10** and **Table 5.11**. Water quality data collected under the Ngong Ping Sewage Treatment Works and Sewerage EIA are summarized in **Table 5.12** and **Table 5.13**.

Table 5.10 : In-Situ Water Quality Data Collected in Tai O Sheltered Boat Anchorage EIA (February 1999)

Location	Water Depth (m)	Speed (cm/s)	Direction (°)	Tempera ture (°C)	Salinity (ppt)	D.O. (mg/L)	pH	Silt (NTU)
HHW								
1	1	6.3	60	19.35	32.04	8.73	8.16	13.83
2	6.5	6.3	58.9	18.79	32.04	8.85	8.12	14.74
3	4.5	10.5	90	18.3	32.23	8.52	8.09	3.99
4	3.6	9.4	72	18.52	32.23	8.8	8.1	6.2
5	4.6	9	260	18.56	32.13	8.16	8.1	3.18
6	2.3	14	79	18.6	32.13	8.67	8.09	2.78
7	2	5	100	18.92	32.04	8.22	8.17	4.69
8	-	-	-	20.72	32.46	-	-	-
10	0.8	<1	-	19.02	31.86	7.64	8.22	15.21
LLW								
1	2.6	6	330	18.09	31.09	5.6	7.75	5.9
2	1.9	7.5	25	18.06	31.76	7.01	7.87	11.92
3	3.1	7.5	125	17.79	32.23	7.36	7.93	6.8
4	1.4	6.3	160	17.9	32.23	7.3	7.94	6.3
5	2.6	2.5	20	17.5	32.23	7.29	7.92	8.61
6	0.5	3.5	105	18.1	31.76	6.87	7.9	10.82
7	0.3	5.5	150	17.94	31.85	6.75	7.92	17.05
8	-	-	-	17.84	31.94	-	-	-
10	0	-	-	-	-	-	-	-

Table 5.11 : Marine Water Quality Data for Tai O Bay Collected in Tai O Sheltered Boat Anchorage EIA (February 1999)

	1		2		3		4		5		6		7	
	HHW	LLW	HHW	LLW	HHW	LLW	HHW	LLW	HHW	LLW	HHW	LLW	HHW	LLW
SS (mg/L)	18	16	13	10	8	8	10	6	6	10	6	9	10	78
E. coli (count/100mL)	410	390	16	3400	9	14	22	19	13	7	2	1900	25	1600
Cd (µg/L)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cr (µg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cu (µg/L)	10	10	10	10	10	55	10	10	10	10	10	10	10	10
Ni (µg/L)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pb (µg/L)	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5	<5
Zn (µg/L)	5	10	5	10	5	30	5	5	10	5	<5	5	5	5
COD (mg/L)	<10	12	15	<10	<10	10	12	<10	<10	14	16	12	13	<10
BOD (mg/L)	<1	<1	<	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hg (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
NH4 (mg/L)	<0.01	0.03	<0.01	0.02	0.01	0.06	0.02	0.02	0.06	0.02	<0.01	0.03	0.01	0.06
TN (mg/L)	0.3	0.5	0.3	0.4	0.3	0.4	0.3	0.3	0.5	0.4	0.6	0.5	0.3	0.5
TIN (mg/L)	0.01	0.05	<0.01	0.04	0.02	0.06	0.03	0.02	0.06	0.02	0.02	0.05	0.02	0.08
TP (mg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

**Table 5.12 : Water Quality Data Collected in Ngong Ping
Sewage Treatment Works and Sewerage EIA (July - August 2001)**

Location	pH	DO	*E. coli*	SS	NH4	TIN	BOD	Salinity
Spring Ebb								
A	7.95	5.49	2947	32	0.0782	0.3909	1	10.77
B	8.02	5.08	702	12	0.09	0.34	1	10.9
C	7.73	4.97	1533	13	0.0533	0.3333	1	7.23
D	7.75	5.05	1740	23	0.0775	0.3	1	8
E	8	4.83	1650	15	0.1167	0.2667	1	11.07
F	7.8	5	1476	10	0.06	0.22	1	7.7
G	7.99	4.94	966	11	0.08	0.2714	1	13.39
H	7.99	5.19	1133	15	0.0771	0.2714	1	12.57
I	8.08	4.93	495	19	0.0763	0.3	1	12
Spring Flood								
A	7.84	5.17	783	21	0.0871	0.2857	1	9.74
B	7.73	4.4	5750	13	0.1025	0.3	1	7.73
C	7.68	5.38	1300	18	0.085	0.275	1	6.95
D	7.83	5	2173	20	0.1033	0.3	1	9.77
E	7.75	4.28	4125	27	0.105	0.375	1	9.53
F	7.73	4.55	1300	13	0.0725	0.325	1	7.98
G	7.93	4.83	288	44	0.1043	0.3	1	10.33
H	7.84	4.69	332	23	0.0929	0.2143	1	9.31
I	7.79	4.73	135	14	0.1063	0.3625	1	10
Neap Ebb								
A	8.26	7.05	1408	20	0.0475	0.3563	1	12.05
B	8.53	8.9	613	20	0.0433	0.41	1.33	9.9
C	8.33	8.1	440	14	0.0233	0.3533	1.67	9.13
D	8.4	7.77	2067	17	0.0267	0.42	1.33	11

Location	pH	DO	*E. coli*	SS	NH4	TIN	BOD	Salinity
E	8.37	7.73	3300	10	0.0533	0.3933	1.33	9.87
F	8.26	7.82	216	22	0.04	0.374	1.4	9.34
G	8.47	8.34	187	14	0.0267	0.3656	1.44	13.24
H	8.47	8.38	343	17	0.0333	0.3467	1.5	12.85
I	8.57	9.69	20	17	0.0257	0.4443	2.29	13.51
Neap Flood								
A	8.12	5.98	1248	19	0.0633	0.4633	1	13.53
B	8.03	5.93	1928	16	0.07	0.39	1	9.4
C	7.86	5.88	1524	11	0.068	0.372	1	8.56
D	8.13	6.08	1560	24	0.0575	0.4	1	12.23
E	7.85	5.98	9800	15	0.0925	0.425	1	8.75
F	7.87	5.53	1510	10	0.07	0.4	1.33	9.13
G	8.37	7.4	503	15	0.0657	0.3114	1.29	13.69
H	8.3	6.94	1512	9	0.0486	0.2571	1.29	12.31
I	8.33	7.53	28	14	0.0643	0.29	1.14	12.9

Table 5.13 : Water Quality Data Collected in Ngong Ping Sewage Treatment Works and Sewerage EIA (March 2000)

Parameter	Sampling Location					
	C	K	L	E	B	J
E. coli (count/100mL)	4000	5500	1000	2800	5500	5900
pH	8	8	8.2	8.2	8	8.1
NH4(mg/L)	0.1	0.1	0.1	0.1	0.2	0.2
COD (mg/L)	40	40	30	30	40	30
BOD (mg/L)	< 2	< 2	< 2	< 2	< 2	< 2

5.5.14 As the two EIA studies concluded, the impact of the sheltered boat anchorage development and the Ngong Ping STW to water quality is very small and negligible. It is therefore considered that the water quality data sampled under these two EIAs are still representative of the baseline water quality conditions in the Tai O Creek and Tai O Bay.

Baseline Water Quality Conditions of the Tai O Area

5.5.15 Within the Tai O Bay and Tai O Creek, pH is generally in compliance to the WQO standard except for one occasion where a pH value of 8.57 was measured at Station I in the wet season. However, the pH value only marginally exceeded WQO limit (6.5-8.5).

5.5.16 Salinity ranges from 31.1 to 32.2 ppt during the dry season and from 7.23 to 13.69 ppt during the wet season. Salinity in the Tai O Creek is relatively lower than that in the Tai O Bay.

5.5.17 Dissolved oxygen (DO) ranges from 4.3 to 9.7 mg/L in the Tai O Bay and Tai O Creek, which is in compliance to the WQO standard (4mg/L for 90% depth-averaged samples).

5.5.18 The ammonia levels are below 0.2 mg/L. Unionised ammonia (UIA) levels are below 0.0065 mg/L, which is within the UIA WQO limit of 0.021 mg/L).

5.5.19 Total inorganic nitrogen (TIN) concentration ranges from 0.01 to 0.46 mg/L. The background TIN is in compliance to the WQO of 0.5 mg/L in the local Tai O Bay and Tai O Creek area.

5.5.20 The SS concentration is in a typical range of 10 to 20 mg/L in the local Tai O Bay and Tai O Creek area.

5.5.21 *E. coli* varies from 2 to 9800 count/100mL. As referenced in the two EIA studies, the *E. coli* level in the outer Tai O Bay is generally lower than that in the mid and inner portions of the Tai O Bay, and Tai O Creek is subject to relatively higher *E. coli* levels than the Tai O Bay as Tai O Creek receives sewage discharges from nearby residential dwellings.

5.5.22 In summary, the concentrations of nutrients, DO and salinity are relatively low in the Tai O Bay and Tai O Creek. While episodic events may result in higher concentrations, the SS concentration maintains to be relatively low most of the time. The *E. coli* concentration is relatively higher in the inner and mid part of Tai O Bay than outer part of Tai O Bay.

5.6 Water Quality Impact Assessment

Construction Phase

Site Runoff

5.6.1 Site runoff from construction sites that are subject to excavation or earth works might lead to surface erosion and would carry a high level of sediment. Sediment in runoff may be eventually carried to adjacent marine waters near the Tai O STW, Tai O Creek and Tai O Bay areas through drainage channels.

5.6.2 With the implementation of site mitigation measures to control site runoff from working areas, and with the provision of sediment removal facilities, no adverse water quality impacts from site runoff are anticipated to occur in the adjacent marine waters or drainage systems.

General Construction Activities

5.6.3 Wastewaters generated from construction activities may contain high SS concentrations. They may also contain a certain amount of grease and oil. Potential impacts due to such site wastewaters can be minimized if construction and site management practices are implemented to ensure that litter, fuels, and solvents do not enter public drainage systems. With implementation of good management practices, no adverse impacts are expected to occur to drainage systems and receiving waters.

Domestic Sewage from Workforce

5.6.4 Domestic sewage generated from the workforce during construction is forbidden to directly discharge into public drainage systems or adjacent water bodies. Portable chemical toilets should be installed within construction sites. Wastewaters generated from kitchens should be discharged to public foul sewers or collected in a temporary storage tank. With a good control of domestic sewage, no adverse water quality impacts from the workforce swage are anticipated to occur.

Accidental Spillage of Chemicals

5.6.5 Accidental spillage and illegal disposal of chemicals within the site area would cause soil contamination. This could have potential to impact the groundwater. It could also impose pollution to nearby channels or water bodies through leaching to site runoff.

5.6.6 The Code of Practice on Packaging, Labelling and Storage of Chemical Wastes published under the Waste Disposal Ordinance should be used as a guideline for handing chemical wastes. Chemical wastes should be disposed of following the rules stipulated in the Waste Disposal Ordinance.

5.6.7 With effective control through good operation and management practices, no adverse impacts to water quality are anticipated to occur due to accidental spillage of chemicals from construction activities.

Release of Suspended Sediment during Dredging

5.6.8 Grab dredgers are to be used to excavate the seabed during construction. The dredging rate of a grab dredger for the construction of the sewage submarine outfall under the Tai O STW project is designed to be 62.5 m^3/hr [Assume each grab size is about 8 m^3, 7 times per hour, i.e. = 56 m^3/hr (~62.5 m^3/hr)] for 8 hours during a work day (500 m^3/day). To determine the rate of sediment loss into the water column during dredging, two previous study reports were reviewed: Contaminated Spoil Management Study (MacDonald, 1991), and Environmental Impact Assessment: Dredging an Area of Kellett Bank for Reprovisioning of Six Government Mooring Buoys - Working Paper on Design Scenarios (ERM,1997). The two reports indicated that sediment loss is at a rate of 20~25 kg/m^3 for areas with significant amounts of debris on the sea bed, and of 12~18 kg/m^3 for areas where debris is less likely to hinder the operations. For the project area in this study, it is unlikely that a significant amount of debris is present on the seabed. An average loss rate of 18 kg/m^3 was therefore adopted in this study. Consequently, the sediment release rate into the water column was estimated to be 0.313 kg/s during dredging.

5.6.9 Simulated contour of elevated SS, maximum SS non-compliance zone, and time-series of sedimentation rate are given in **Appendix 5.3**. Predicted elevated SS and sedimentation rate at identified WSRs are shown in **Table 5.14** and **Table 5.15**.

5.6.10 Predicted sedimentation rate at identified WSRs are far smaller than the criterion of 100 g/m^2/day, which indicate the sedimentation impact to coral communities is not significant.

5.6.11 For assessing the environmental impacts of release SS, the background SS level is derived from the calibrated model. As shown in **Appendix 5.3**, SS concentrations at the bottom layer are much higher than those at both the surface and the middle layer. To be conservative, the maximum bottom SS concentrations were referenced in this EIA for both the dry and wet seasons, respectively. Predicted non-compliance zone indicates that the size of impacted area where allowable SS limit of increase would be exceeded is within about 550m from the dredging site during the dry season, and about 520 m during the wet season.

Table 5.14 : Predicted Elevated Concentration of SS and Sedimentation Rate (Dry Season, Unmitigated)

Water Sensitive Receivers	Background SS Level (mg/L)	Increase in SS Concentration at Bottom Layer (mg/L)			Sedimentation (g/m^2/day)		
		Criterion (30% of Mean SS Level)	Mean	Maximum	Criterion	Mean	Maximum
Coral (WSR 1)	6.14	1.84	2.67	10.03	<100	0.75	9.11
Coral (WSR 2)	6.07	1.82	0.89	4.00	<100	0.12	2.55
Coral (WSR 3)	6.23	1.87	1.05	3.99	<100	0.74	3.88
Coral (WSR 4)	6.05	1.81	0.54	2.21	<100	0.11	1.82
Coral (WSR 5)	6.28	1.88	0.49	2.22	<100	0.35	1.88
Coral (WSR 6)	6.30	1.89	0.39	1.57	<100	0.30	1.40
Coral (WSR 7)	5.97	1.79	0.29	0.90	<100	0.02	0.83
Chinese White Dolphins (WSR 8)	6.01	1.80	0.09	0.25	<100	0.01	0.13
Mudflat (WSR 9)	7.44	2.23	0.13	0.20	<100	0.13	0.20
Sheltered Boat Anchorage (WSR 10)	5.97	1.79	0.18	0.30	<100	0.15	0.30
Pond (WSR 11)	7.20	2.16	0.15	0.22	<100	0.14	0.22
Watercourse (WSR 12)	7.50	2.25	0.09	0.14	<100	0.08	0.14
Inner Bay (WSR 13)	6.10	1.83	0.54	1.99	<100	0.51	1.90
Inner Watercourse (WSR 14)	7.55	2.27	0.05	0.07	<100	0.05	0.07

Note: number in shade exceeded WQO standards.

Table 5.15 : Predicted Elevated Concentration of SS and Sedimentation Rate (Wet Season, Unmitigated)

Water Sensitive Receivers	Background SS Level (mg/L)	SS Elevation in Bottom Layer (mg/L)			Sedimentation ($g/m^2/day$)		
		Criterion (30% of Mean SS Level)	Mean	Maximum	Criterion	Mean	Maximum
Coral (WSR 1)	9.52	2.86	3.64	11.06	<100	1.34	9.87
Coral (WSR 2)	9.76	2.93	0.95	6.16	<100	0.20	3.59
Coral (WSR 3)	9.13	2.74	1.70	5.90	<100	1.23	5.69
Coral (WSR 4)	9.68	2.90	0.53	2.85	<100	0.18	2.09
Coral (WSR 5)	9.03	2.71	0.78	2.83	<100	0.52	2.82
Coral (WSR 6)	8.98	2.69	0.47	2.04	<100	0.34	2.02
Coral (WSR 7)	9.81	2.94	0.27	1.38	<100	0.03	1.24
Chinese White Dolphins (WSR 8)	10.04	3.01	0.06	0.42	<100	0.01	0.10
Mudflat (WSR 9)	7.83	2.35	0.08	0.14	<100	0.07	0.14
Sheltered Boat Anchorage (WSR 10)	9.12	2.74	0.10	0.18	<100	0.05	0.16
Pond (WSR 11)	8.92	2.68	0.09	0.15	<100	0.08	0.15
Watercourse (WSR 12)	9.12	2.74	0.06	0.11	<100	0.06	0.11
Inner Bay (WSR 13)	9.04	2.71	0.70	2.23	<100	0.56	2.01
Inner Watercourse (WSR 14)	8.46	2.54	0.05	0.09	<100	0.05	0.09

Note: number in shade exceeded WQO standards.

Dissolved Oxygen Depletion during Dredging

5.6.12 The dredged marine sediment may contain organics and chemical contaminants. The following formula was used to determine the potential dissolved oxygen depletion:

$$DO_{dep} = C \times SOD_{20} \times K \times 10^{-6}$$

Where DO_{dep} = Dissolved Oxygen Depletion (mg/L)

C = SS elevation (mg/L)

SOD_{20} = Maximum 20-day sediment oxygen demand (mg/kg)

K = daily oxygen uptake factor

5.6.13 The above equation was also adopted in the following two EIA Studies:

- Central Kowloon Route & Widening of Gascoigne Road Flyover – Investigation, Central Kowloon Route; and
- Kai Tak Development Engineering Study, cum Design and Construction of Advance Works – Investigation, Design and Construction.

5.6.14 Due to the lack of SOD_{20} information for the project area, a desktop study was conducted. Value of 12,400 mg/kg was used at NS3 which is near the Pillar Point STW outfall as a basis for the DO depletion prediction, as indicated in the Marine Water Quality Annual Report of 2014..

5.6.15 A K value of 1.0 was used in the above two EIAs, and was therefore also adopted in this EIA. The predicted depletions of dissolved oxygen during both dry and wet seasons are shown in **Table 5.16** and **Table 5.17**.

5.6.16 The predicted results indicate that even without mitigation, the resultant DO concentrations are still higher than 4 mg/L for the depth-averaged DO WQO, and higher than 2 mg/L for the bottom within 2 m of the seabed. It is therefore concluded that no significant DO depletion would occur at all the identified WSRs during both the dry and wet seasons.

Table 5.16 : Predicted Depletion of Dissolved Oxygen (Dry Season, Unmitigated)

Water Sensitive Receivers	Maximum Predicted SS Elevation (mg/L)	Max. DO Depletion (mg/L)	Background DO (mg/L)	Resultant DO (mg/L)	Depletion in Background DO (%)
Coral (WSR 1)	10.03	0.12	7.21	7.09	1.72%
Coral (WSR 2)	4.00	0.05	7.20	7.15	0.69%
Coral (WSR 3)	3.99	0.05	7.25	7.20	0.68%
Coral (WSR 4)	2.21	0.03	7.19	7.16	0.38%
Coral (WSR 5)	2.22	0.03	7.24	7.21	0.38%
Coral (WSR 6)	1.57	0.02	7.25	7.23	0.27%
Coral (WSR 7)	0.90	0.01	7.19	7.18	0.16%
Chinese White Dolphins (WSR 8)	0.25	0.00	7.17	7.17	0.04%
Mudflat (WSR 9)	0.20	0.00	7.21	7.21	0.03%
Sheltered Boat Anchorage (WSR 10)	0.30	0.00	7.24	7.24	0.05%
Pond (WSR 11)	0.22	0.00	7.22	7.22	0.04%
Watercourse (WSR 12)	0.14	0.00	7.22	7.22	0.02%
Inner Bay (WSR 13)	1.99	0.02	7.22	7.20	0.34%
Inner Watercourse (WSR 14)	0.07	0.00	7.22	7.22	0.01%

Table 5.17 : Predicted Depletion of Dissolved Oxygen (Wet Season, Unmitigated)

Water Sensitive Receivers	Maximum Predicted SS Elevation (mg/L)	Max. DO Depletion (mg/L)	Background DO (mg/L)	Resultant DO (mg/L)	Depletion in Background DO (%)
Coral (WSR 1)	11.06	0.14	5.78	5.64	2.37%
Coral (WSR 2)	6.16	0.08	5.74	5.66	1.33%
Coral (WSR 3)	5.90	0.07	5.88	5.81	1.24%
Coral (WSR 4)	2.85	0.04	5.75	5.71	0.61%
Coral (WSR 5)	2.83	0.04	5.98	5.94	0.59%
Coral (WSR 6)	2.04	0.03	5.99	5.96	0.42%
Coral (WSR 7)	1.38	0.02	5.76	5.74	0.30%
Chinese White Dolphins (WSR 8)	0.42	0.01	5.63	5.62	0.09%
Mudflat (WSR 9)	0.14	0.00	5.81	5.81	0.03%
Sheltered Boat Anchorage (WSR 10)	0.18	0.00	5.81	5.81	0.04%
Pond (WSR 11)	0.15	0.00	5.81	5.81	0.03%
Watercourse (WSR 12)	0.11	0.00	5.81	5.81	0.02%
Inner Bay (WSR 13)	2.23	0.03	5.81	5.78	0.48%
Inner Watercourse (WSR 14)	0.09	0.00	5.82	5.82	0.02%

Release of Contaminants during Dredging

5.6.17 The release of contaminants during dredging may result in adverse water quality impacts. Thus, an elutriate test was conducted for this Tai O STW EIA to investigate the possible release of contaminants from dredged sediments. Sampling locations for the elutriate test are illustrated in **Figure 5.4**, and the test results are summarized in **Table 5.18** (detailed lab testing results are provided in **Appendix 5.1**).

Table 5.18 : Elutriate Test Result and Water Quality Standards

Location	Sampling Depth (m)	Metal Concentration (µg/L)									Organic Compounds Concentration (µg/L)			Inorganic Nonmetallic Parameters				
		Ag	Cd	Cu	Ni	Pb	Zn	Cr	As	Hg	Total PCBs	Low M.W. PAHs	TBT	Ammonia as N	Nitrite as N	Nitrate as N	TIN	UIA(7)
Water Quality Standards		2.3(2)	2.5(2)	5(2)	30(2)	25(2)	40(2)	15(2)	25(2)	0.3(2)	0.03(3)	3.0(4)	0.1(5)	-	-	-	0.5(6)	0.021
D11	All Depth	<1	<0.2	2	1	<1	<10	<1	<10	<0.1	<0.01	<2.2	<0.015	9.55	0.03	0.20	9.78	0.467
D10	All Depth	<1	<0.2	<1	<1	<1	<10	<1	<10	<0.1	<0.01	<2.2	<0.015	5.34	0.03	0.21	5.58	0.262
D9	All Depth	<1	<0.2	<1	1	<1	<10	<1	<10	<0.1	<0.01	<2.2	<0.015	1.63	0.03	0.22	1.88	0.080
D8	All Depth	<1	<0.2	<1	1	<1	<10	<1	<10	<0.1	<0.01	<2.2	<0.015	0.83	0.03	0.21	1.07	0.041
Blank	All Depth	<1	<0.2	<1	<1	<1	<10	<1	<10	<0.1	<0.01	<2.2	<0.015	0.33	0.02	0.24	0.59	0.016

Notes:
1) Values in yellow indicate the exceedance of the Water Quality Standard.
2) UK Water Quality Standard.
3) USEPA Salt Water Criteria.
4) Australian Water Quality Guidelines for Fresh and Marine Waters.
5) Michael H. Salazar and Sandra M. Salazar (1996). "Mussels as Bioindicators: Effects of TBT on Survival, Bioaccumulation, and Growth under Natural Conditions" in Organotin, edited by M. A. Champ and P. F. Seligman. Chapman & Hall, London.
6) WQO for North Western WCZ and North Western Supplementary.
7) UIA is derived by calculation:

SALTWATER FORMULAS

Un-ionized Ammonia in Saltwater

$$f_{NH_3} = \frac{1}{1 + 10^{\left[pK_a + 0.0324(298-T) + \frac{(0.0415)P}{T} - pH\right]}}$$

where,

f_{NH_3} = fraction of un-ionized ammonia

$$I = \frac{19.9273 \times S}{1000 - 1.005109 \times S}$$ (from EPA 1989, formula 5, p. 2)[1]

$$pK_a = 9.245 + 0.116 \times I$$

S = salinity (ppt)

T = temperature (°K)

P = pressure (assumed to be 1 atm)

References: i) Bower C.E. and Bidwell J.P. (1978), Ionization of ammonia in seawater: Effect of temperature, pH and salinity. J. Fish. Res. Board Can. Vol.35, pp.1012-1016; ii) K., Russo R.C. & et. al. (1975), Aqueous ammonia equilibrium calculations: effect of pH and temperature. J. Fish. Res. Board Can. Vol.32, pp.2379-2383

5.6.18 As there is no existing local legislation to stipulate the standards or guidelines for individual heavy metal contents in the Hong Kong marine waters, the water quality standards presented in **Table 5.18** were used for assessment in this EIA. The same standards in **Table 5.18** were also used in other EIA studies including the EIA study for Kai Tak Development Engineering Study cum Design and Construction of Advance Works – Investigation, Design and Construction Kai Tak Development.

5.6.19 As shown in **Table 5.18**, concentrations of heavy metals and organic compounds from the elutriate test are all below the respective standards and do not show any levels higher than the blank sample. Adverse water quality impacts from the release of organic compounds and heavy metals are unlikely to occur during dredging.

5.6.20 The distances from nearest WSR coral community (WSR1) to D8, D9 & D10 are 70 m, 100 m and 145 m, respectively. Concentration of TIN at locations of D8, D9, D10 and D11 have exceed the WQOs of 0.5 mg/L. Concentration of Blank is 0.59 mg/L, which exceeded WQOs either. As stated in **Table 5.7**, the total inorganic nitrogen (TIN) level exceeded WQO in 2008 and 2010 at NM8 by a marginal level. The average TIN concentration at NM8 in the open sea area of Tai O was observed to be 0.44 mg/L, which is close to the WQO standard (0.5 mg/L).

5.6.21 The required dilution factor, which enables TIN at location of D11 (9.78mg/L) to be compliant with WQO (0.5mg/L), was calculated to be 19.56. Desktop reviews were conducted to determine the related dilution factor:

- *CE 83/2001 (DS) Peng Chau Sewage Treatment Works Upgrade – Investigation, Design and Construction*: The dilution factor 98 was achieved with downstream distance 4m at low velocity during wet season. The dilution factor 219.2 was achieved with downstream distance 5 m at low velocity during dry season.
- *Agreement No. CE 20/2005(DS), Review Report on EIA Study*: The dilution factor at a distance of 300m was from 2,284 to 2,908 for ambient velocity from 0.05 m/s to 0.5 m/s.

5.6.22 Thus, it is considered that the required dilution factor of 21 to meet the WQOs could be easily achieved, in a very short distance (less than 5 m). It's concluded that no significant adverse impact would be caused due to TIN concentration.

5.6.23 The required dilution factor, which enables UIA at location of D11 (0.467mg/L) to be compliant with WQO (0.021mg/L), was calculated to be 22.2. Similarly, it's considered that the required dilution factor of 22.2 to meet the WQOs could be easily achieved in a very short distance (less than 5m).

5.6.24 On the other hand, as shown in **Figure 5.4**, locations of D10 and D11 are not in the area of dredging zone. Thus, no significant adverse impact would be caused.

Operational Phase

Hydrodynamic Impact due to reclamation

5.6.25 The expansion and upgrading of Tai O STW will include a site formation of 0.26 ha by reclamation. A time-series comparison of the magnitude and direction of tidal flow currents near the project area are shown in **Appendix 5.4** for the pre- and post-reclamation scenarios. The comparison shows that the hydrodynamic change due to the reclamation is not significant.

Scenario 1 – Baseline Condition

5.6.26 Simulated marine water quality for the year of 2022 with the existing Tai O STW effluent discharge was used as the baseline condition for assessing the potential water quality impact arising from the operation of the upgraded Tai O STW.

5.6.27 The existing flow rate and water quality characteristics of the sewage influent to the Tai O Sewage Treatment Works (STW) are shown in **Table 5.19**. The influent data were compiled from the recent wastewater monitoring results from 2010 to 2011.

5.6.28 Currently, sewage is treated in the Tai O STW through a primary treatment unit without disinfection. **Table 5.20** lists the treatment efficiencies for Tai O STW for different water quality constituents. **Table 5.21** shows the effluent loading from Tai O STW.

Table 5.19 : Characteristic of Wastewater Inflow to Tai O STW (2010-2011)

Flow	pH	CBOD	TSS	COD	NH_3-N	TKN	TP	Cl	SO_4^{2-}	E. coil
m^3/d	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	cfu/100mL
1,054	7.0	67	54	143	13	21	2.0	1,407	306	21,971,429

Table 5.20 : Typical Treatment Efficiencies for Tai O Sewage Treatment Work

Type of Treatment Plant	CBOD	TSS	NH_3-N	Org-N	OrthoP	TotP	Cu	E.coli
Primary Treatment (no disinfection)	32.5%	55%	0%	15%	0%	15%	26%	50%

Table 5.21 : Current Pollutant Loading from Tai O STW (2010-2011)

Flow	CBOD	TSS	NH_3-N	TKN	TP	E. coil
m^3/d	kg/d	kg/d	kg/d	kg/d	kg/d	cfu/d
1,054	47.68	25.81	13.85	18.81	1.82	1.16E+14

5.6.29 Background DO values represent 10%ile value which extracted from the calibrated and validated water quality model. The 10%ile depth-averaged DO, 10%ile bottom DO, depth-averaged TIN, UIA, SS and geometric-mean E.coli for the baseline condition at the identified WSRs are shown in **Table 5.22** and **Table 5.23**.

Table 5.22 : Baseline Water Quality (Scenario 1) at Identified WSRs in Dry Season

Water Sensitive Receivers	Depth-Averaged DO (mg/L)	Bottom DO (mg/L)	SS (mg/L)	UIA (mg/L)	TIN (mg/L)	E. coli (count/100mL)
	>4	>2	Not increase 30%	<0.021	<0.5	<610
Coral (WSR 1)	7.21	7.19	6.14	0.002	0.181	45
Coral (WSR 2)	7.20	7.18	6.07	0.002	0.179	78
Coral (WSR 3)	7.25	7.21	6.23	0.002	0.182	37
Coral (WSR 4)	7.19	7.18	6.05	0.002	0.179	45

Coral (WSR 5)	7.24	7.21	6.28	0.002	0.182	28
Coral (WSR 6)	7.25	7.21	6.30	0.002	0.183	23
Coral (WSR 7)	7.19	7.19	5.97	0.002	0.177	25
Chinese White Dolphins (WSR 8)	7.17	7.15	6.01	0.002	0.181	5
Mudflat (WSR 9)	7.21	7.19	7.44	0.002	0.180	9
Sheltered Boat Anchorage (WSR 10)	7.24	7.15	5.97	0.002	0.180	10
Pond (WSR 11)	7.22	7.19	7.20	0.002	0.180	8
Watercourse (WSR 12)	7.22	7.19	7.50	0.002	0.180	6
Inner Bay (WSR 13)	7.22	7.19	6.10	0.002	0.180	3
Inner Watercourse (WSR 14)	7.22	7.19	7.55	0.002	0.180	3

Table 5.23 : Baseline Water Quality (Scenario 1) at Identified WSRs in Wet Season

Water Sensitive Receivers	Depth-Averaged DO (mg/L)	Bottom DO (mg/L)	SS (mg/L)	UIA (mg/L)	TIN (mg/L)	E. coli (count/100mL)
	>4	>2	Not increase 30%	<0.021	<0.5	<610
Coral (WSR 1)	5.78	5.66	9.52	0.005	0.474	20
Coral (WSR 2)	5.74	5.62	9.76	0.005	0.474	53
Coral (WSR 3)	5.88	5.79	9.13	0.005	0.474	9
Coral (WSR 4)	5.75	5.64	9.68	0.005	0.473	36
Coral (WSR 5)	5.98	5.86	9.03	0.005	0.476	13
Coral (WSR 6)	5.99	5.86	8.98	0.005	0.478	11
Coral (WSR 7)	5.76	5.63	9.81	0.005	0.472	21
Chinese White Dolphins (WSR 8)	5.63	5.49	10.04	0.005	0.475	2
Mudflat (WSR 9)	5.81	5.69	7.83	0.005	0.475	7
Sheltered Boat Anchorage (WSR 10)	5.81	5.69	9.12	0.005	0.475	12
Pond (WSR 11)	5.81	5.69	8.92	0.005	0.475	6
Watercourse (WSR 12)	5.81	5.69	9.12	0.005	0.475	5
Inner Bay (WSR 13)	5.81	5.69	9.04	0.005	0.475	5
Inner Watercourse (WSR 14)	5.82	5.70	8.46	0.005	0.475	3

Scenario 2 – Normal Operation (Year 2022 with the proposed expansion and upgrading works)

5.6.30 **Table 5.24** shows the flow and quality of the upgraded Tai O STW effluent upon commissioning. The resultant pollutant loads into the marine water under the normal condition are summarized in **Table 5.25**.

5.6.31 In line with the conservative assumption of approved EIA "Outlying Islands Sewerage Stage 2 - Upgrading of Cheung Chau Sewage Collection, Treatment and Disposal Facilities", it's assumed that no pollution reduction in the stormwater system after implementation of upgrading. That is, stormwater load remain constant which extracted from Update Model for conservative assessment purpose, before and after upgrading of Tai O STW.

5.6.32 The simulated water quality concentrations at the identified WSRs are summarized in **Table 5.26** and **Table 5.27** for Scenario 2 of normal of the upgraded Tai O STW. Incremental changes in concentration of the water quality constituents between Scenario 2 and Scenario 1 are presented in **Table 5.28** and **Table 5.29** for the identified WSRs. **Appendix 5.5** shows the contour plots of the simulated parameters for both the baseline and normal operation conditions.

5.6.33 Both the predicted depth-averaged and bottom DO concentrations would be in compliance with the WQO at all the identified WSRs. The DO difference between the normal operation and baseline conditions is very minimal. A slightly DO increase was predicted for both the dry and wet seasons.

5.6.34 The predicted UIA concentration is very low and is in compliance with the WQO for both the dry and wet seasons. No significant UIA changes would were predicted between the normal operational and baseline conditions.

5.6.35 With the commissioning of the Tai O STW, TIN concentration was predicted to decrease by around 1.11% in the Tai O area during the dry season and by around 0.05% during the wet season.

5.6.36 *E.coli* levels were predicted to reduce significantly upon commissioning of the Tai O STW. During the dry season, an average reduction of about 50 cfu/100ml is achieved near the submarine outfall, and a reduction of about 5 cfu/100ml is obtained in the Tai O Bay. During the wet season, an average reduction of about 30 cfu/100ml is achieved near the submarine outfall, and a reduction of about 4 cfu/100ml is obtained in the Tai O Bay.

5.6.37 An improvement in water quality with respect to *E.coli* was predicted in the vicinity of the Tai O area under both the dry and wet weather conditions. The improvement is mainly attributable to the enhanced treatment efficiency of the upgraded STW, which would significantly reduce the *E.coli* loading into the marine water. No adverse water quality impacts are anticipated to occur under the normal operation of the upgraded Tai O STW as far as *E.coli* is concerned.

5.6.38 Overall, upon commissioning of the upgraded Tai O STW, a relative improvement in water quality is expected to occur to the marine water near the Project area. The proposed Project is expected to result in a reduction in concentrations of a number of water quality constituents including TIN, UIA and *E.coli,* and result in a certain level of improvement to DO concentration near the Project area. As shown in **Table 5.28** and **Table 5.29,** the predicted SS concentration during normal operation is slightly lower than baseline condition. Thus, sedimentation is anticipated to be smaller than baseline conditions. The upgraded Tai O STW is predicted with water quality modelling to bring environmental benefits to the nearby marine waters.

Table 5.24 : Design Flow and Effluent Quality of Upgraded Tai O STW

Flow (m^3/d)	CBOD (mg/L)	TSS (mg/L)	NH_3-N (mg/L)	TotN (mg/L)	E. coil (CFU/100mL)
2,750	20	30	5	10	1,000

Table 5.25 : Estimated Pollutant Loading from Upgraded Tai O STW

Flow (m^3/d)	CBOD (kg/d)	TSS (kg/d)	*E. coil* (CFU/d)	NH_3-N (kg/d)	TotN (kg/d)
2,750	55	82.5	2.80×10^{10}	13.8	27.5

Table 5.26 : Water Quality (Scenario 2) at Identified WSRs in Dry Season

Water Sensitive Receivers	Depth-Averaged DO (mg/L)	Bottom DO (mg/L)	SS (mg/L)	UIA (mg/L)	TIN (mg/L)	E. coli (count/100mL)
	>4	>2	Not increase 30%	<0.021	<0.5	<610
Coral (WSR 1)	7.22	7.20	6.11	0.002	0.180	1
Coral (WSR 2)	7.20	7.18	6.04	0.002	0.177	1
Coral (WSR 3)	7.25	7.21	6.20	0.002	0.179	1
Coral (WSR 4)	7.20	7.18	6.02	0.002	0.177	1
Coral (WSR 5)	7.24	7.21	6.25	0.002	0.180	1
Coral (WSR 6)	7.25	7.21	6.27	0.002	0.181	1
Coral (WSR 7)	7.19	7.19	5.94	0.002	0.175	1
Chinese White Dolphins (WSR 8)	7.17	7.15	5.98	0.002	0.179	1
Mudflat (WSR 9)	7.22	7.19	7.41	0.002	0.178	1
Sheltered Boat Anchorage (WSR 10)	7.24	7.15	5.94	0.002	0.178	4
Pond (WSR 11)	7.22	7.19	7.17	0.002	0.178	2
Watercourse (WSR 12)	7.22	7.19	7.44	0.002	0.178	2
Inner Bay (WSR 13)	7.22	7.19	6.07	0.002	0.178	1
Inner Watercourse (WSR 14)	7.22	7.19	7.48	0.002	0.178	3

Table 5.27 : Water Quality (Scenario 2) at Identified WSRs in Wet Season

Water Sensitive Receivers	Depth-Averaged DO (mg/L)	Bottom DO (mg/L)	SS (mg/L)	UIA (mg/L)	TIN (mg/L)	E. coli (count/100mL)
	>4	>2	Not increase 30%	<0.021	<0.5	<610
Coral (WSR 1)	5.78	5.66	9.52	0.005	0.474	1
Coral (WSR 2)	5.74	5.62	9.76	0.005	0.474	1
Coral (WSR 3)	5.88	5.79	9.13	0.005	0.473	1
Coral (WSR 4)	5.75	5.64	9.68	0.005	0.473	1
Coral (WSR 5)	5.98	5.86	9.03	0.005	0.476	1
Coral (WSR 6)	5.99	5.86	8.98	0.005	0.478	1
Coral (WSR 7)	5.76	5.64	9.81	0.005	0.472	1
Chinese White Dolphins (WSR 8)	5.63	5.49	10.04	0.005	0.475	1
Mudflat (WSR 9)	5.81	5.70	7.83	0.005	0.474	1
Sheltered Boat Anchorage (WSR 10)	5.81	5.70	9.12	0.005	0.474	7
Pond (WSR 11)	5.81	5.70	8.92	0.005	0.474	1
Watercourse (WSR 12)	5.81	5.70	9.11	0.005	0.474	2
Inner Bay (WSR 13)	5.81	5.70	9.04	0.005	0.474	1
Inner Watercourse (WSR 14)	5.82	5.71	8.46	0.005	0.474	3

Table 5.28 : Differences in Water Quality Conditions Between Baseline and Scenario 2 (Dry Season)

Water Sensitive Receivers	Depth-Averaged DO (mg/L)	Bottom DO (mg/L)	SS (mg/L)	UIA (mg/L)	TIN (mg/L)	E. coli (count/100mL)
Coral (WSR 1)	0.04%	0.03%	-0.49%	0.00%	-0.83%	-44
Coral (WSR 2)	0.02%	0.00%	-0.54%	0.00%	-1.12%	-77
Coral (WSR 3)	0.03%	0.00%	-0.55%	0.00%	-1.65%	-36
Coral (WSR 4)	0.03%	0.00%	-0.52%	0.00%	-0.84%	-44
Coral (WSR 5)	0.00%	0.01%	-0.45%	0.00%	-1.10%	-27
Coral (WSR 6)	0.00%	0.00%	-0.54%	0.00%	-1.09%	-22
Coral (WSR 7)	0.00%	0.00%	-0.51%	0.00%	-1.13%	-24
Chinese White Dolphins (WSR 8)	0.01%	0.00%	-0.42%	0.00%	-1.10%	-5
Mudflat (WSR 9)	0.03%	0.01%	-0.41%	0.00%	-1.11%	-8
Sheltered Boat Anchorage (WSR 10)	0.00%	0.00%	-0.45%	0.00%	-1.11%	-6
Pond (WSR 11)	0.02%	0.01%	-0.48%	0.00%	-1.11%	-6
Watercourse (WSR 12)	0.02%	0.01%	-0.81%	0.00%	-1.11%	-4
Inner Bay (WSR 13)	0.02%	0.01%	-0.47%	0.00%	-1.11%	-2
Inner Watercourse (WSR 14)	0.02%	0.00%	-0.92%	0.00%	-1.13%	0

Note: (1) All percentages are calculated as (Scenario 2 – Scenario 1)/(Scenario 1) x 100%
(2) E.coli is calculated as (Scenario 2 – Scenario 1)

Table 5.29 : Differences in Water Quality Conditions Between Baseline and Scenario 2 (Wet Season)

Water Sensitive Receivers	Depth-Averaged DO (mg/L)	Bottom DO (mg/L)	SS (mg/L)	UIA (mg/L)	TIN (mg/L)	E. coli (count/100mL)
Coral (WSR 1)	0.02%	0.00%	-0.04%	0.00%	0.00%	-20
Coral (WSR 2)	0.02%	0.02%	-0.04%	0.00%	0.00%	-52
Coral (WSR 3)	0.02%	0.02%	-0.04%	0.00%	-0.21%	-8
Coral (WSR 4)	0.03%	0.02%	-0.03%	0.00%	0.00%	-36
Coral (WSR 5)	0.02%	0.02%	-0.05%	0.00%	0.00%	-12
Coral (WSR 6)	0.02%	0.03%	-0.04%	0.00%	0.00%	-10
Coral (WSR 7)	0.02%	0.02%	-0.03%	0.00%	0.00%	-20
Chinese White Dolphins (WSR 8)	0.02%	0.02%	-0.04%	0.00%	0.00%	-1
Mudflat (WSR 9)	0.02%	0.02%	-0.05%	0.00%	-0.03%	-6
Sheltered Boat Anchorage (WSR 10)	0.02%	0.02%	-0.03%	0.00%	-0.03%	-6
Pond (WSR 11)	0.02%	0.02%	-0.02%	0.00%	-0.03%	-5
Watercourse (WSR 12)	0.02%	0.02%	-0.06%	0.00%	-0.03%	-3
Inner Bay (WSR 13)	0.02%	0.02%	-0.05%	0.00%	-0.03%	-4
Inner Watercourse (WSR 14)	0.02%	0.02%	-0.05%	0.00%	-0.03%	0

Note: (1) All percentages are calculated as (Scenario 2 – Scenario 1)/(Scenario 1) x 100%
(2) E.coli is calculated as (Scenario 2 – Scenario 1)

Scenario 3 – Emergency Bypass of Raw Sewage from Tai O STW

5.6.39 Raw sewage discharge into the marine water could occur in case of a temporary failure of treatment units. Though an emergency event would be rare with the incorporation of the standby STW units, the worst case of discharge of the raw sewage via the emergency outfall was evaluated in this EIA.

5.6.40 According to the past operational record by DSD, it normally takes about 6 hours to resume to the normal operation of a STW in case of an operational failure. Owing to travelling time from centre of Hong Kong to the Tai O STW site is around 2 hours, a 10-hour duration of emergency discharge was therefore conservatively considered to assess the potential impact of an emergency discharge of untreated sewage from the Tai O STW.

5.6.41 The Project area is located in the North-western WCZ, which is close to the Pearl Delta Estuary (PRE), and is significantly influenced by a large flow from the Pearl Delta River (PRD) during the wet season. A higher level of dilution may occur due to mixing with the high flows from the PRD. However, the Pearl River discharge is less dense than oceanic water and can cause water stratification result in less dilution effect. To completely cover the different season scenarios, both the dry and wet seasons for the emergency bypass of raw sewage from the STW will be assessed.

5.6.42 As indicated in **Figure 5.2a** and **Figure 5.2b**, key Water Sensitive Receivers concerned in the area are Chinese White Dolphins, Mudflat, and Tai O Inner bay. To cover the different conditions of tidal movement, the following scenarios were assessed for the emergency discharge of the raw STW effluent:

- Scenario 3a – emergency discharge occurs at the beginning of a flood tide during the spring tide cycle in the dry season;
- Scenario 3b – emergency discharge occurs at beginning of an ebb tide during the spring tide cycle in the dry season;
- Scenario 3c – emergency discharge occurs at the high water slack tide during the neap tide cycle in the dry season;
- Scenario 3d – emergency discharge occurs at the low water slack tide during the neap tide cycle in the dry season;
- Scenario 3e – emergency discharge occurs at the beginning of a flood tide during the spring tide cycle in the wet season;
- Scenario 3f – emergency discharge occurs at beginning of an ebb tide during the spring tide cycle in the wet season;
- Scenario 3g – emergency discharge occurs at the high water slack tide during the neap tide cycle in the wet season;
- Scenario 3h – emergency discharge occurs at the low water slack tide during the neap tide cycle in the wet season.

5.6.43 The water quality of raw sewage influent to the Tai O STW is shown in **Table 5.30**. Time-series comparisons of simulated water quality concentrations between Scenario 2 (normal operation) and Scenario 3 (emergency discharge) are shown in **Appendix 5.6**. Contour plots comparison of key water quality indicators between both normal operation and emergency discharge are shown in **Appendix 5.7**.

Table 5.30 : Water Quality of Raw Sewage Influent to Tai O STW

ADWF	2,750 m^3/day
BOD	176 mg/L
SS	153 mg/L
TKN	30 mg/L
NH3-N	17 mg/L
TN	38 mg/L
TIN	25 mg/L
E. coli	2.2. ×10^7 Count/100mL

Scenario 3a (Flood Tide + Spring Tide Cycle + Dry Season)

5.6.44 An emergency discharge was assumed to occur at 01:00:00 27-Jul-1996 (beginning of a flood tide). As shown in **Figure 5E-1** of **Appendix 5.6**, high E.coli concentrations would start to appear at around 06:00 at WSR2 that is to the west of the Tai O STW, and would increase to a maximum of 800 cfu/100ml at around 08:00, which exceeds the WQO of 610 cfu/100ml.

5.6.45 On the other hand, the E.coli concentration would decrease gradually from its peak and would have returned to it's the normal background level by 13:00. The impact duration lasts for about 7 hours after the emergency discharge is ceased.

5.6.46 The maximum E.coli concentration at WSR8 (Chinese White Dolphins) is predicted to be 178 cfu/100ml with an impact duration of about 5 hours. For WSR13 that is located in south-east of the Tai O STW, the E.coli concentration starts to increase at about 02:00, reach to the maximum of 190 cfu/100ml, then sharply decrease to its normal background by 16:00. The impact duration at WSR13 is predicted to be around 14 hours. At other more distant locations such as WSR10, no obvious impacts to the E.coli concentration were simulated to occur during a flood tide.

5.6.47 **Figure 5F-1** of **Appendix 5.7** illustrates the E.coli comparison of both normal operation and emergency discharge (snapshot of maximum concentration during emergency). **Figure 5F-2** shows the E.coli concentration 1 hour, 5 hours, 9 hours and 13 hours after emergency discharge commencement. The simulation shows that impact area is limited to local marine water. The E.coli concentration would decrease gradually from its peak and would have returned to it's the normal background level after 13 hours after emergency commencement.

5.6.48 As shown in **Figure 5F-3** to **Figure 5F-5** in **Appendix 5.7**, and **Figure 5E-2** to **Figure 5E-4** in **Appendix 5.6**, no obvious changes would be predicted at each identified WSRs for parameters of NH3, DO and TIN.

5.6.49 As shown in **Figure 5E-17** of **Appendix 5.6**, no obvious concentration change would be predicted at WSR14.

Scenario 3b (Ebb Tide + Spring Tide Cycle + Dry Season)

5.6.50 An emergency discharge was assumed to occur at 20:00 26-Jul-1996 (beginning of an ebb tide). As shown in **Figure 5E-5**, E.coli concentration starts to increase at around 20:00 WSR2, and reach to the maximum of 1650 cfu/100ml at 01:00, which exceeds the WQO of 610 cfu/100ml. Nonetheless, E.coli concentration would decrease sharply from its peak and return to its normal background at around 12:00. The duration of impact is about 16 hours after the emergency discharge is ceased.

5.6.51 The maximum E.coli concentration at WSR8 (Chinese White Dolphins) was predicted to be 100 cfu/100ml, which is lower than the WQO of 610 cfu/100ml. The impact duration was predicted to be 11 hours. At WSR13, E.coli concentration starts to increase at 02:00, and reach to the maximum of 170 cfu/100ml, which is lower than the WQO of 610 cfu/100ml. E.coli concentration then sharply decreases to its normal background at 17:00. Impact duration at WSR13 is around 15 hours. At other more distant locations such as WSR10, no obvious impacts to E.coli concentration were predicted to occur.

5.6.52 **Figure 5F-6** and **Figure 5F-7** show that impact area is limited to local marine water adjacent emergency outfall. The E.coli concentration would decrease gradually from its peak and would have returned to it's the normal background level after 13 hours.

5.6.53 As shown in **Figure 5F-8** to **Figure 5F-10**, and **Figure 5E-6** to **Figure 5E-8,** no obvious changes to parameters of NH3, TIN and DO were predicted at the identified WSRs.

5.6.54 As shown in **Figure 5E-18**, no obvious concentration change would be predicted at WSR 14.

Scenario 3c (High Water Slack Tide + Neap Tide Cycle + Dry Season)

5.6.55 An emergency discharge was assumed to occur at 02:00:00 5-Aug-1996 (high water slack tide during the neap tide cycle). As shown in **Figure 5E-9**, high E.coli concentrations would start to appear at around 02:00 at WSR2 that is to the west of the Tai O STW, and would increase to a maximum of 600 cfu/100ml at around 09:00, which complies with the WQO of 610 cfu/100ml.

5.6.56 Low flow velocity conditions at high water slack tide during the neap tide cycle, which led to temporal relative high concentration of E.coli near Tai O STW. However, E.coli concentration would decrease gradually from its peak and would have returned to its normal background level by 20:00. The impact duration lasts for about 18 hours from beginning of emergency.

5.6.57 The maximum E.coli concentration at WSR8 (Chinese White Dolphins) is predicted to be 210 cfu/100ml with a total impact duration of about 18 hours. The predicted maximum value exceeds 180 cfu/100ml but far below 610 cfu/100ml. For WSR13 that is located in south-east of the Tai O STW, the E.coli concentration starts to increase at about 09:00 (around 7 hours time-lag from emergency), reach to the maximum of 100 cfu/100ml, then sharply decrease to its normal background by 04:00. The impact duration at WSR13 is predicted to be around 18 hours. At other more distant locations such as WSR10, slight increase of E.coli would be predicted with maximum value of 100 cfu/100ml. The duration is predicted to be around 18 hours.

5.6.58 Contour plots of **Figure 5F-11** and **Figure 5F-12** illustrate that impact area is limited to local marine waters. The high E.coli concentration would return to its normal background after about 18 hours after emergency commencement.

5.6.59 As shown in **Figure 5E-10** to **Figure 5E-12**, and **Figure 5F-13** to **Figure 5F-15**, no obvious changes would be predicted at each identified WSRs for parameters of NH3, DO and TIN.

5.6.60 As shown in **Figure 5E-19**, no obvious concentration change would be predicted at WSR 14.

Scenario 3d (Low Water Slack Tide + Neap Tide Cycle + Dry Season)

5.6.61 An emergency discharge was assumed to occur at 08:00:00 5-Aug-1996 (low water slack tide during the neap tide cycle). As shown in **Figure 5E-13**, high E.coli concentrations would start to appear at around 08:30 at WSR2 that is to the west of the Tai O STW, and would increase to a maximum of 2,100 cfu/100ml at around 15:00, which exceeds the WQO of 610 cfu/100ml significantly. This is because low flow velocity conditions at low water slack tide during the neap tide cycle, which led to temporal high concentration of E.coli near Tai O STW.

5.6.62 However, E.coli concentration would decrease gradually from its peak and would have returned to its normal background level by 20:00. The total impact duration lasts for about 12 hours from the beginning of emergency.

5.6.63 The maximum E.coli concentration at WSR8 (Chinese White Dolphins) is predicted to be 350 cfu/100ml with a total impact duration of about 15 hours (from 14:00 to 05:00, 6 hours time-lag from beginning of emergency). For WSR13 that is located in south-east of the Tai O STW, the E.coli concentration starts to increase at about 09:00 (around 1 hour's time-lag from emergency), reach to the maximum of 120 cfu/100ml, then sharply decrease to its normal background by 08:00. The impact duration at WSR13 is predicted to be around 20 hours. At other more distant locations such as WSR10, slight increase of E.coli would be predicted with maximum value of 80 cfu/100ml. The duration is predicted to be around 14 hours.

5.6.64 **Figure 5F-16** to **Figure 5F-17** shown that high E.coli concentration would limit to local area, and would return to the normal background about 18 hours after emergency commencement.

5.6.65 As shown in **Figure 5E-14** and **Figure 5E-16**, slight increase of NH3 and TIN would be predicted at WSR2 near the Tai O STW. The duration time is last only 3 hours. No obvious changes would be predicted at other identified WSRs.

5.6.66 For the parameter of DO, no obvious concentration change between emergency and normal operation would be predicted.

5.6.67 As shown in **Figure 5E-20**, no obvious concentration change would be predicted at WSR 14.

Scenario 3e (Flood Tide + Spring Tide Cycle + Wet Season)

5.6.68 Similar with dry season, both contour plots and time-series plots indicate the parameter of DO, NH3 and TIN would not have obvious change between normal operation and emergency, as shown in **Appendix 5.6** and **Appendix 5.7**. Thus, emphasis would be focused on E.coli in the following sections.

5.6.69 As shown in **Figure 5E-21**, the maximum E.coli concentration would be about 2,200 cfu/100ml in WSR2 which is close to the STW. **Figure 5F-21** and **Figure 5F-22** illustrate high E.coli concentration would limit to local marine waters. The potential affected WSRs are WSR1, WSR2, WSR4, WSR7, WSR3, WSR13. However, the affected area and concentration are temporary. High concentration would sharply decrease to normal background after cease of emergency discharge immediately (11 hours after emergency commencement). This is because high flow velocities capacity during spring tide in wet season.

Scenario 3f (Ebb Tide + Spring Tide Cycle + Wet Season)

5.6.70 As shown in **Figure 5E-25**, the maximum E.coli concentration would be about 2,100 cfu/100ml in WSR2 which is close to the STW.

5.6.71 **Figure 5F-26** and **Figure 5F-27** indicate high E.coli concentration would limit to local marine waters. High concentration would decrease to normal conditions about 14 hours after emergency commencement.

Scenario 3g (High Water Slack Tide + Neap Tide Cycle + Wet Season)

5.6.72 Similarly, **Figure 5F-31** to **Figure 5F-32** illustrate that high E.coli concentration would be limited to local marine waters adjacent emergency outfall. High concentration would return to normal background about 15 hours after emergency commencement.

Scenario 3h (Low Water Slack Tide + Neap Tide Cycle + Wet Season)

5.6.73 Similarly, **Figure 5F-36** to **Figure 5F-37** illustrate that high E.coli concentration would be limited to local marine waters adjacent emergency outfall. High concentration would return to normal background about 15 hours after emergency commencement.

5.6.74 The above eight scenarios 3a, 3b, 3c, 3d, 3e, 3f, 3g and 3h show that the impact of emergency discharge from the upgraded Tai O STW would be limited only to local areas near the emergency outfall. The total impact duration is less than 20 hours from the beginning of the emergency. The high concentration such as E.coli would disappear rapidly and return to their normal background levels for the WSRs are in the vicinity of the project site after the emergency discharge is ceased. The potential impact to more distant WSRs would be extremely small and insignificant.

5.7 Water Pollution Mitigation and Management

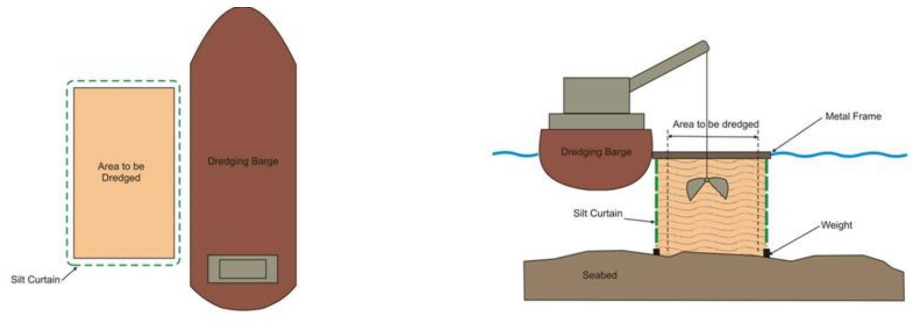
Construction Phase

Dredging

5.7.1 Mitigation measures are recommended to minimize the water quality impact, which include the use of closed grab dredgers and installation of silt curtains. Suspended solids are expected to be reduced by approximately 75% with the incorporation of silt curtains (MacDonald, 1991). The justifications and past references of silt curtains adoption are list below:

- Peng Chau Sewage Treatment Works Upgrade – Investigation, Design and Construction, Environmental Impact Assessment Report;
- Mott MacDonald (1991). Contaminated Spoil Management Study, Final Report, Volume 1, for EPD, October 1991; and
- Central Kowloon Route & Widening of Gascoigne Road Flyover – investigation - Environmental Impact Assessment Report.

5.7.2 The above projects all reported the deployment of cage type silt curtains around the dredging location with an effectiveness of about 75% reduction in sediment release. Silt curtains would be deployed surrounding the dredging site to avoid the generation of sediment plumes and elevation of SS in the water column outside of the dredging site. A sketch for illustrating the use of silt curtains is shown below.



(a) Cage Type Silt Curtain Arrangement for Grab Dredging

(b) Cross-secton of Cage Type Silt Curtain Arrangment

5.7.3 With the implementation of above mitigation measures, potential incremental changes in SS concentration and related sedimentation rate are predicted and the results are shown in **Table 5.31** and **Table 5.32**. The simulated contour of elevated SS, maximum SS non-compliance zone are given in **Appendix 5.3**.

5.7.4 Predicted non-compliance zones indicated that the size of impacted area where allowable SS limit of increase would be exceeded is within about 200 m from the dredging site during dry season, and 190 m during wet season. The simulated results indicated that with mitigation measures implemented, the elevation of suspended solids concentration would be greatly decreased compared to that without mitigation measures.

5.7.5 According to the recent dive surveys, the seabed of the dredging area site was found to be mainly composed of muddy and sandy bottom and of low habitat quality.

Limited marine life was seen except only some small and isolated patches of single species of hard coral (Echinomuricea and Balanophyllia) were found in the Tai O area and this species is common in Hong Kong waters and known to tolerate more turbid and harsh environment.

5.7.6 As indicated in **Table 5.33** and **Table 5.34**, the DO depletion is very minimal and negligible. The resulting DO is in good compliance to the WQO standard.

Table 5.31 : Predicted Elevated Concentration of SS and Sedimentation Rate (Dry Season, mitigated)

Water Sensitive Receivers	Background SS Level (mg/L)	SS Elevation in Bottom Layer (mg/L)			Sedimentation ($g/m^2/day$)		
		Criterion (30% of Mean SS Level)	Mean	Maximum	Criterion	Mean	Maximum
Coral (WSR 1)	6.14	1.84	0.67	2.51	<100	0.19	2.28
Coral (WSR 2)	6.07	1.82	0.22	1.00	<100	0.03	0.64
Coral (WSR 3)	6.23	1.87	0.26	1.00	<100	0.18	0.97
Coral (WSR 4)	6.05	1.81	0.14	0.55	<100	0.03	0.46
Coral (WSR 5)	6.28	1.88	0.12	0.55	<100	0.09	0.47
Coral (WSR 6)	6.30	1.89	0.10	0.39	<100	0.08	0.35
Coral (WSR 7)	5.97	1.79	0.07	0.23	<100	0.01	0.21
Chinese White Dolphins (WSR 8)	6.01	1.80	0.02	0.06	<100	0.00	0.03
Mudflat (WSR 9)	7.44	2.23	0.03	0.05	<100	0.03	0.05
Sheltered Boat Anchorage (WSR 10)	5.97	1.79	0.04	0.08	<100	0.04	0.07
Pond (WSR 11)	7.20	2.16	0.04	0.06	<100	0.04	0.06
Watercourse (WSR 12)	7.50	2.25	0.02	0.04	<100	0.02	0.04
Inner Bay (WSR 13)	6.10	1.83	0.13	0.50	<100	0.13	0.48
Inner Watercourse (WSR 14)	7.55	2.27	0.01	0.02	<100	0.01	0.02

Note: (1) number in shade exceeded WQO standards.
(2) According to AFCD's (prepared by City U in year 2005) Final Report for Establishing threshold tolerance of local corals to sedimentation, in western waters, the recommended threshold value is 20 mg SS/L or +30% of ambient level, whichever is larger. Therefore the exceedance (in WQO standards) of WSR1 can meet this recommended value.

Table 5.32 : Predicted Elevated Concentration of SS and Sedimentation Rate (Wet Season, mitigated)

Water Sensitive Receivers	Background SS Level (mg/L)	SS Elevation in Bottom Layer (mg/L)			Sedimentation ($g/m^2/day$)		
		Criterion (30% of Mean SS Level)	Mean	Maximum	Criterion	Mean	Maximum
Coral (WSR 1)	9.52	2.86	0.91	2.77	<100	0.34	2.47
Coral (WSR 2)	9.76	2.93	0.24	1.54	<100	0.05	0.90
Coral (WSR 3)	9.13	2.74	0.42	1.47	<100	0.31	1.42
Coral (WSR 4)	9.68	2.90	0.13	0.71	<100	0.05	0.52
Coral (WSR 5)	9.03	2.71	0.19	0.71	<100	0.13	0.71
Coral (WSR 6)	8.98	2.69	0.12	0.51	<100	0.09	0.51
Coral (WSR 7)	9.81	2.94	0.07	0.34	<100	0.01	0.31
Chinese White Dolphins (WSR 8)	10.04	3.01	0.02	0.11	<100	0.00	0.03
Mudflat (WSR 9)	7.83	2.35	0.02	0.04	<100	0.02	0.03
Sheltered Boat Anchorage (WSR 10)	9.12	2.74	0.03	0.05	<100	0.01	0.04
Pond (WSR 11)	8.92	2.68	0.02	0.04	<100	0.02	0.04
Watercourse (WSR 12)	9.12	2.74	0.02	0.03	<100	0.01	0.03
Inner Bay (WSR 13)	9.04	2.71	0.18	0.56	<100	0.14	0.50
Inner Watercourse (WSR 14)	8.46	2.54	0.01	0.02	<100	0.01	0.02

Note: (1) number in shade exceeded WQO standards.
(2) According to AFCD's (prepared by City U in year 2005) Final Report for Establishing threshold tolerance of local corals to sedimentation, in western waters, the recommended threshold value is 20 mg SS/L or +30% of ambient level, whichever is larger. Therefore the exceedance (in WQO standards) of WSR1 can meet this recommended value.

Table 5.33 : Predicted Depletion of Dissolved Oxygen (Dry Season, mitigated)

Water Sensitive Receivers	Maximum Predicted SS Elevation (mg/L)	Max. DO Depletion (mg/L)	Background DO (mg/L)	Resultant DO (mg/L)	Depletion in Background DO (%)
Coral (WSR 1)	2.51	0.03	7.21	7.18	0.43%
Coral (WSR 2)	1.00	0.01	7.20	7.19	0.17%
Coral (WSR 3)	1.00	0.01	7.25	7.24	0.17%
Coral (WSR 4)	0.55	0.01	7.19	7.18	0.09%
Coral (WSR 5)	0.55	0.01	7.24	7.23	0.09%
Coral (WSR 6)	0.39	0.00	7.25	7.25	0.07%
Coral (WSR 7)	0.23	0.00	7.19	7.19	0.04%
Chinese White Dolphins (WSR 8)	0.06	0.00	7.17	7.17	0.01%
Mudflat (WSR 9)	0.05	0.00	7.21	7.21	0.01%
Sheltered Boat Anchorage (WSR 10)	0.08	0.00	7.24	7.24	0.01%
Pond (WSR 11)	0.06	0.00	7.22	7.22	0.01%
Watercourse (WSR 12)	0.04	0.00	7.22	7.22	0.01%
Inner Bay (WSR 13)	0.50	0.01	7.22	7.21	0.09%
Inner Watercourse (WSR 14)	0.02	0.00	7.22	7.22	0.00%

Table 5.34 : Predicted Depletion of Dissolved Oxygen (Wet Season, mitigated)

Water Sensitive Receivers	Maximum Predicted SS Elevation (mg/L)	Max. DO Depletion (mg/L)	Background DO (mg/L)	Resultant DO (mg/L)	Depletion in Background DO (%)
Coral (WSR 1)	2.77	0.03	5.78	5.75	0.59%
Coral (WSR 2)	1.54	0.02	5.74	5.72	0.33%
Coral (WSR 3)	1.47	0.02	5.88	5.86	0.31%
Coral (WSR 4)	0.71	0.01	5.75	5.74	0.15%
Coral (WSR 5)	0.71	0.01	5.98	5.97	0.15%
Coral (WSR 6)	0.51	0.01	5.99	5.98	0.11%
Coral (WSR 7)	0.34	0.00	5.76	5.76	0.07%
Chinese White Dolphins (WSR 8)	0.11	0.00	5.63	5.63	0.02%
Mudflat (WSR 9)	0.04	0.00	5.81	5.81	0.01%
Sheltered Boat Anchorage (WSR 10)	0.05	0.00	5.81	5.81	0.01%
Pond (WSR 11)	0.04	0.00	5.81	5.81	0.01%
Watercourse (WSR 12)	0.03	0.00	5.81	5.81	0.01%
Inner Bay (WSR 13)	0.56	0.01	5.81	5.80	0.12%
Inner Watercourse (WSR 14)	0.02	0.00	5.82	5.82	0.00%

5.7.7 In order to alleviate potential water quality impacts from the construction of submarine outfall, the following mitigation measures are recommended during construction:

- Dredging is to be undertaken using closed grab dredgers with a total production rate of 62.5 m^3/hr;
- Cage type silt curtains must be deployed with an efficiency of 75% or higher for reduction of sediment release from the dredging location while dredging works is in progress;
- All vessels be sized such that adequate clearance (i.e. minimum clearance of 0.6 m) is maintained between vessels and the sea bed at all states of the tide to ensure that undue turbidity is not generated by turbulence from vessel movement or propeller wash;
- Excess materials be cleaned from the decks and exposed fittings of barges before the vessel is moved;
- Adequate freeboard (i.e. minimum of 200 m) be maintained on barges to ensure that decks are not washed by wave action;
- All barges be fitted with tight fitting seals to their bottom openings to prevent leakage of material;
- Construction activities not cause foam, oil, grease, scum, litter or other objectionable matter to be present on the water within the site or dumping ground;
- Loading of barges and hoppers be controlled to prevent splashing of dredged material to the surrounding water, and barges and hoppers not be filled to a level which would cause the overflow of materials or sediment laden water during loading or transportation; and
- Decks of all vessels be kept tidy and free of oil or other substances that might be accidentally or otherwise washed overboard.

5.7.8 In summary, temporary residual impacts after implementation of the proposed mitigation measures are unavoidable, and based on their extent of influence and estimated magnitude, temporary residual impacts are considered acceptable in terms of SS and DO during the construction of the new submarine outfall.

Construction Site Runoff

5.7.9 The practices outlined in ProPECC PN 1/94 Construction Site Drainage are recommended to be adopted to minimize potential water quality impacts from construction site runoff and other construction activities. Design of mitigation measures should be submitted by the Contractor to the Engineer for approval. The mitigation measures should cover, but not limited to the following practices:

- Perimeter channels are provided in the works areas to intercept runoff at site boundary prior to the commencement of any earthwork. Surface runoff should be discharged into storm drains via adequately designed sand/ silt removal facilities;
- Work programmes should be designed to minimize the size of work areas to minimize the soil exposure soil and reduce the potential for increased siltation and runoff;
- Silt removal facilities, channels and manholes should be maintained and cleaned regularly to ensure the proper function;
- Careful programming of the works to minimize soil excavation during the rainy season;

- Earthwork surfaces should be well compacted and the subsequent permanent work or surface protection should be carried out immediately after the final surfaces are formed;
- Trench excavation should be avoided in the wet season, and if necessary, it should be carried out and backfilled in short sections;
- Open stockpiles of construction materials on site should be covered with tarpaulin or similar fabric during rainstorms.

General Construction Activities

5.7.10 Good site practices should be adopted to clean the rubbish and litter on construction sites to avoid the rubbish, debris and litter from entering to nearby water bodies. It is recommended to clean the construction sites on a regular basis.

Sewage arising from Workforces

5.7.11 The domestic sewage generated by the workforce on construction sites should be collected and discharged to the STW for proper treatment. Portable toilets should be provided by the Contractor, where necessary, to handle sewage from the workforce. The Contractor should also be responsible for the waste disposal and maintenance practices.

Spillage of Chemicals

5.7.12 Illegal disposal of chemicals should be strictly prohibited. Registration to EPD as a CWP (Chemical Waste Producers) is required if chemical wastes are generated and need to be disposed of. Disposal of chemical wastes should be carried out in compliance with the Waste Disposal Ordinance (WDO). The Code of Practice on Packaging, Labelling and Storage of Chemical Wastes published under the WDO should be used as a guideline for handing chemical wastes.

5.7.13 Oils and fuels should only be used and stored in designated areas which have pollution prevention facilities. To prevent spillage of fuels and solvents to any nearby storm water drains, fall 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.

Operational Phase

Emergency Overflow from Tai O STW

5.7.14 Emergency discharge of raw sewage from the Tai O STW would be caused by the failure of electrical power supply or treatment units. The mitigation measures should cover, but not limited to the following practices:

- Relevant governmental departments, likely EPD, LCSD and DSD should be noticed by the STW operator immediately under possibility of any emergency raw sewage discharge;
- The STW operators should maintain good communications with various relevant parties;
- Standby facilities for the main treatment units and standby pumps, accessories/ equipment parts should be installed to avoid the occurrence of an emergency discharge. Storm Tanks would also be incorporated to provide temporary storage of flow under extremely high flow conditions and hence reduce the

chance of emergency bypass. Dual power supply or standby power sources should also be implemented to minimize the possibility of power failure;

- The proposed STW should be designed, managed and operated properly to minimize the chance of emergency discharge of raw sewage from the STW;
- In case of damages to the submarine outfall, the treated effluent will be diverted to the emergency outfall. Off-line tanks will be implemented to provide a buffer zone for influent or effluent storage. The treated effluent from the emergency outfall will likely meet the effluent standard for this project. Thus, the emergency outfall serves as a standby unit to the submarine outfall.

5.7.15 It is extremely remote that the treatment unit of the STW, electricity supply and the submarine outfall all fail simultaneously; and it is very unlikely that the event will last for a long time.

5.7.16 Nevertheless, a contingency plan should be developed to deal with emergency discharge during the operation of the STW, which include the following:

- Locations of the sensitive receivers in vicinity of the emergency discharge;
- A list of relevant governmental bodies to inform of and to ask for assistance in the event of an emergency discharge, including key contact persons and telephone numbers;
- Reporting procedures required in the event of an emergency discharge;
- Responsibility and procedure for clean-up of the affected water body/sensitive receivers after the emergency discharge; and
- Procedures listing the most effective means in rectifying the breakdown of the pumping station to minimize the discharge duration.

Sewage Overflow from the SPSs

5.7.17 As confirmed by DSD operation staff, considering for emergency situations, labour could be mobilized from Siu Ho Wan STW around the clock and the functions of the proposed Hang Mei and Fan Kwai Tong SPSs could be restored within 4 hours. A retention of sewage flows for at least 4 hours would be provided at both the SPSs in case of emergency overflow. Therefore, an emergency overflow from the SPSs would be unlikely.

5.7.18 Nonetheless, mitigation measures are recommended below in order to reduce the possibility of emergency overflow of sewage:

- A standby pump should be provided to cater for breakdown and maintenance of the duty pumps in order to avoid sewage bypass;
- An alarm should be installed to signal high water levels in the wet well to the control station of the nearest manned station or plant where the operator can take immediate rectification action;
- Standby power supply will be provided at the two SPSs;
- Twin sewer rising mains should be provided wherever technically feasible to minimize the shutdown of SPS for pipeline repairing; and
- Regular maintenance and checking of plant equipment be practiced to prevent equipment failure.

5.7.19 With the implementation of measures stated above, emergency overflow from the pumping stations would be unlikely to happen.

5.8 Cumulative Impacts

Construction Phase

5.8.1 The EIA report on Hong Kong-Zhuhai-Macao Bridge (HZMB) Hong Kong Link Road (HKLR) and Hong Kong Boundary Crossing Facilities (HKBCF) stated that the dredging and filling construction activities would have no water quality impacts to Tai O Mangrove and Horseshoe Crab Habitat (without mitigation measures).

5.8.2 No other cumulative impacts are found from other concurrent projects. No cumulative impact would then be anticipated.

Operational Phase

5.8.3 Given that no water quality impacts were identified during the operation of other projects such as HZMB, HKLR and HKBCF, no operational cumulative impacts are anticipated for water quality.

5.9 Evaluation of Residual Impacts

5.9.1 A certain level of residual actual water quality impact is expected to arise from the dredging activities for the construction of the sewage submarine outfall. Temporary residual impacts after implementation of the proposed mitigation measures may be still present. Nonetheless, by making reference to the recommended threshold value in western waters as stated in AFCD's Final Report for Establishing threshold tolerance of local corals to sedimentation, these residual impacts are considered to be minimal and acceptable based on the estimated extent and magnitude of the impact.

5.10 Environmental Monitoring and Audit Requirements

5.10.1 Monitoring and auditing for marine water quality during construction would be necessary. A monitoring and audit programme aims to ensure that the released SS concentrations from the dredging activities would not adversely affect the sensitive receivers. This monitoring programme would be used to assess the effectiveness of mitigation measures during construction. If the monitoring results indicate that the dredging activities have resulted in exceedence of the predicted elevated SS concentrations even after the implementation of the recommended mitigation measures, the construction programme should be carefully reviewed to reduce the impact.

5.11 Conclusion

Construction Phase

5.11.1 Dredging activities for construction of the submarine outfall would result in an increase in SS concentration the water column in vicinity of the construction site. It was predicted the allowable SS increase would be exceeded within 550 m and 520 m from the dredging site if no mitigation measures are taken, during dry and wet season, respectively. With the use of closed grab dredgers and silt curtains, only a minor exceedance of WQO criteria was predicted within 200 m and 190 m from the dredging location, during dry and wet season, respectively. The corresponding depletion of dissolved oxygen due to dredging is negligible when mitigation measures are implemented.

5.11.2 The release of organic compounds, heavy metals and nutrients during dredging was predicted to be negligible. No adverse impacts to water quality are anticipated during dredging.

5.11.3 Site runoff, general construction activities, sewage arising from the workforce, and spillage of chemicals are not expected to cause adverse impacts to the marine water environment, provided that proper mitigation measures are implemented.

Operational Phase

5.11.4 The expansion and upgrading of Tai O STW will not bring significant hydrodynamic change to the marine water.

5.11.5 With commissioning of the upgraded Tai O STW, improvement in water quality is expected to occur to the marine water near Project area. The proposed Upgrading Project would result in a reduction in concentrations of a number of water quality parameters including TIN, UIA and E.coli, and would result in a certain level of improvement in DO concentration near the Project area. The upgraded Tai O STW would bring environmental benefit to the nearby marine waters.

5.11.6 When emergency happens in Tai O STW, no obvious changes were predicted for parameters of NH3, TIN and DO at identified WSRs. The simulations show that the impact of emergency discharge would be limited only to local areas. The total impact duration is less than 20 hours from the beginning of the emergency. The high concentration such as E.coli would disappear rapidly and return to their normal background levels for the WSRs are in the vicinity of the project site after the emergency discharge is ceased. The potential impact to more distant WSRs would be extremely small and insignificant.

5.11.7 As confirmed with DSD operation staff, functions of both the Hang Mei and Fan Kwai Tong SPSs could be restored within 4 hours in case of an emergency situation. A retention of sewage flows for at least 4 hours would be provided at both SPSs before any emergency discharge. Therefore, emergency overflows from the SPSs would be unlikely.

5.11.8 In general, normal operation of the upgraded Tai O STW will be beneficial to the marine water near Project area. Nonetheless, in order to protect the adjacent marine environment, the recommended mitigation measures should be well implemented.

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