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5. Water Quality Impact

5.1 Legislations, Standards, Guidelines and Criteria

5.1.1 General

5.1.1.1 The relevant legislations, standards, guidelines and criteria applicable to the Project for the assessment of water quality impacts include:

- Environmental Impact Assessment Ordinance (EIAO) (Cap. 499);
- Water Pollution Control Ordinance (WPCO) (Cap. 358);
- Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM-DSS);
- Hong Kong Planning Standards and Guidelines;
- ProPECC PN 1/94 "Construction Site Drainage";
- ProPECC PN 5/93 "Drainage Plans Subject to Comment by the Environmental Protection Department";
- Environment, Transport and Works Bureau (ETWB) Technical Circular (Works) No. 5/2005: Protection of Natural Streams/Rivers from Adverse Impacts Arising from Construction Works; and
- Water Supplies Department's (WSD) Target Values of Sea Water Quality for Flushing Supply at Intake Point of Salt Water Pumping Station.

5.1.2 Environmental Impact Assessment Ordinance (EIAO) (Cap. 499)

5.1.2.1 EIAO (Cap. 499) provides the major statutory framework for the Environmental Impact Assessment (EIA) in Hong Kong. Under Section 16 of the EIAO, EPD issued the Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM) which specifies the assessment methods and criteria for EIA process. Annexes 6 and 14 of the EIAO-TM stipulate the "Criteria for Evaluating Water Pollution" and "Guidelines for Assessment of Water Pollution" respectively.

5.1.3 Water Pollution Control Ordinance (WPCO) (Cap. 358)

5.1.3.1 WPCO (Cap. 358) provides the major statutory framework for the protection and control of water quality in Hong Kong. According to the Ordinance and its subsidiary legislation, the entire Hong Kong waters are divided into ten Water Control Zones (WCZs) and four supplementary WCZs. Each WCZ has a designated set of statutory Water Quality Objectives (WQOs). The WQOs set limits for different parameters that should be achieved in order to protect specific beneficial uses and conservation goals of each of the zones.

5.1.3.2 The Project is situated within the North Western WCZ and the water quality objectives for the North Western WCZ are summarized in **Table 5.1**.

Table 5.1 WQOs for North Western WCZ

Water Quality Objectives (WQO)	Part or Parts of Zone
Aesthetic Appearance	
• Waste discharges shall cause no objectionable odours or discolouration of the water.	• Whole Zone

Water Quality Objectives (WQO)	Part or Parts of Zone
• Tarry residues, floating wood, articles made of glass, plastic, rubber or any other substances should be absent. • Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam. • There should be no recognisable sewage derived debris. • Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent. • Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	
Bacteria	
• The level of *Escherichia coli* should not exceed 610 per 100mL, calculated as the geometric mean of all samples collected in a calendar year	• Secondary Contact Recreation Subzones
• The level of *Escherichia coli* should 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
• The level of Escherichia coli should be less than 1 per 100 mL, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	• Tuen Mun (A) and Tuen Mun (B) Subzones and Water Gathering Ground Subzones
• The level of Escherichia coli should not exceed 1 000 per 100 mL, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	• Tuen Mun (C) Subzone and other inland waters
Colour	
• Waste discharges shall not cause the colour of water to exceed 30 Hazen units.	• Tuen Mun (A) and Tuen Mun (B) Subzones and Water Gathering Ground Subzones
• Waste discharges shall not cause the colour of water to exceed 50 Hazen units.	• Tuen Mun (C) Subzone and other inland waters
Dissolved Oxygen	
• Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg/L for 90% of the sampling occasions during the year; values should be calculated as the water column average (arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth, and 1 metre above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 mg/L within 2 metres of the seabed for 90% of the sampling occasions during the year.	• Marine Waters
• Waste discharges shall not cause the level of dissolved oxygen to be less than 4 mg/L.	• Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones, Water Gathering Ground Subzones and other inland waters
pH	
• The pH of the water should be within the range of 6.5-8.5 units. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.2 units.	• Marine Waters excepting Bathing Beach Subzones
• The pH of the water should be within the range of 6.0-9.0 units.	• Other Inland Waters
• The pH of the water should be within the range of 6.0-9.0 units for 95% of samples. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.5 units.	• Bathing Beach Subzones

Water Quality Objectives (WQO)	Part or Parts of Zone
• Waste discharges shall not cause the pH of the water to exceed the range of 6.5–8.5 units.	• Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
Temperature	
• Waste discharges shall not cause the natural daily temperature range to change by more than 2.0°C.	• Whole zone
Salinity	
• Waste Discharges shall not cause the natural ambient salinity level to change by more than 10%.	• Whole zone
Suspended Solids	
• Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	• Marine Waters
• Waste discharges shall not cause the annual median of suspended solids to exceed 20 mg/L.	• Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
• Waste discharges shall not cause the annual median of suspended solids to exceed 25 mg/L.	• Other Inland Waters
Ammonia	
• The un-ionised ammoniacal nitrogen level should not be more than 0.021 mg/L calculated as the annual average (arithmetic mean).	• Whole Zone
Nutrients	
• Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	• Marine Waters
• Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 mg/L, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed).	• Castle Peak Bay Subzone
• Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.5 mg/L, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed).	• Marine Waters excepting Castle Peak Bay Subzone
5-Day Biochemical Oxygen Demand	
• Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 mg/L.	• Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
• Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 mg/L.	• Other Inland Waters
Chemical Oxygen Demand	
• Waste discharges shall not cause the chemical oxygen demand to exceed 15 mg/L.	• Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
• Waste discharges shall not cause the chemical oxygen demand to exceed 30 mg/L.	• Other Inland Waters

Water Quality Objectives (WQO)	Part or Parts of Zone
Toxins	
• Waste discharges shall not cause the toxins in water to attain such levels as to produce significant toxic carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other. • Waste discharges shall not cause a risk to any beneficial use of the aquatic environment.	• Whole Zone
Phenol	
• Phenols shall not be present in such quantities as to produce a specific odour, or in concentration greater than 0.05 mg/L as C_6H_5OH.	• Bathing Beach Subzones
Turbidity / Light Penetration	
• Waste discharges shall not reduce light transmission substantially from the normal level.	• Bathing Beach Subzones

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

5.1.4.1 Under Section 21 of the WPCO (Cap. 358), TM-DSS was issued to control the physical, chemical, and microbial quality of effluent discharges into foul sewers, stormwater drains, inland and coastal waters. Specific limits apply for different areas and are different between surface waters and sewers, and the limits vary with the rate of effluent flow. Under the TM-DSS , any effluents discharged from the Project must comply with pollutant concentration standards defined by EPD and are specified in license conditions for any new discharge

5.1.5 Hong Kong Planning Standards and Guidelines (HKPSG)

5.1.5.1 Chapter 9 of HKPSG outlines the environmental requirements that need to be considered in land use planning. The recommended guidelines, standards and guidance cover the selection of suitable locations for the developments and provision of environmental facilities, design, layout, phasing, and operational controls to minimise adverse environmental impact. It lists out environmental factors influencing land use planning and recommends buffer distances for land uses.

5.1.5.2 Section 5 under Chapter 9 of HKPSG provides broad guidelines on water quality which includes the principal framework for planning against water pollution. The overall objectives for planning against water pollution are:

- Achieving and maintaining the quality of inland waters, coastal waters, marine waters and groundwaters so that they can be used for their legitimate purposes;
- Providing adequate public sewerage, wastewater treatment and disposal facilities for all wastewaters; and
- Putting in place and enforce water pollution control legislation aimed at safeguarding the health and welfare of the community.

5.1.5.3 With reference to the aforementioned part of HKPSG, a list of potentially polluting and sensitive uses is summarized below in **Table 5.2.**

Table 5.2 Potential Polluting Sources and Water Sensitive Uses

Potential Polluting Sources	Water Sensitive Uses
• Industry and agriculture (including livestock keeping and slaughterhouses); • Sewage disposal (including sewage from private residential developments); • Civil engineering works (including all building works, well boring, ground investigation, dredging, reclamation, excavation of fill, man-made lagoons etc.); and • Transport facilities.	• Bathing; • Aquaculture and fisheries; • Agriculture; • Residential and recreational development; • Typhoon shelters, marinas and boat parks; • Water gathering grounds; • Nature reserves; • Sites of Special scientific Interest; • Marine parks/marine reserves; • Coastal protection areas; • Conservation areas; and • Fish spawning grounds.

5.1.6 ProPECC PN 1/94: "Construction Site Drainage"

5.1.6.1 Professional Persons Environmental Consultative Committee Practice Note (ProPECC PN) 1/94 on construction site drainage provides guidelines for the handling and disposal of construction discharges. This note is applicable for the control of site run-off and wastewater generated during the construction phase of the Project.

5.1.6.2 The types of discharges from construction sites outlined in the ProPECC PN 1/94 include:

- Surface run-off;
- Groundwater;
- Boring and drilling water;
- Wastewater from concrete batching and precast concrete casting;
- Wheel washing water;
- Bentonite slurry;
- Water for testing and sterilisation of water retaining structures and water pipes;
- Wastewater from building construction;
- Acid cleaning, etching, and pickling wastewater; and
- Wastewater from site facilities.

5.1.7 ProPECC PN 5/93: "Drainage Plans subject to Comment by the Environmental Protection Department"

5.1.7.1 ProPECC PN 5/93 issued by EPD provides guidelines on the environmental design and pollution control in drainage plans submitted under Building (standards of Sanitary Fitments, Plumbing, Drainage Work and Latrines) Regulations 40(1), 40(2), 41(1), and 90. Any submitted drainage plans submitted shall be referred to EPD for comment on whether there may be concerns regarding pollution control.

5.1.8 Environment, Transport and Works Bureau (ETWB) Technical Circular (Works) No. 5/2005: "Protection of Natural Streams/Rivers from Adverse Impacts Arising from Construction Works"

5.1.8.1 The ETWB TC (W) No. 5/2005 provides a framework to better protect all natural streams/rivers from the adverse impacts of construction works. The procedures promulgated under the Circular aims to clarify and strengthen existing measures for protection of natural streams/rivers from both government and private projects/developments. The guidelines and precautionary mitigation measures given in the Circular should be followed to the best of abilities to protect inland watercourses at or near the Project area during the construction phase.

5.1.9 Water Supplies Department's (WSD) Target Values of Sea Water Quality for Flushing Supply at Intake Point of Salt Water Pumping Station

5.1.9.1 The criteria for assessing the water quality impact on the WSD's seawater intakes are based on the Target Values of Sea Water Quality for Flushing Supply at Intake Point of Salt Water Pumping Station (at intake point) issued by the WSD and are summarized under **Table 5.3**.

Table 5.3 WSD's Target values of Sea Water Quality at Intake Point of Salt Water Pumping Stations

Parameter	Target Value
Colour	< 20 H.U.
Turbidity	< 10 N.T.U.
Threshold Odour No.	< 100
Ammoniacal Nitrogen	< 1 mg/l
Suspended Solids	< 10 mg/l
Dissolved Oxygen	> 2 mg/l
Biochemical Oxygen Demand	< 10 mg/l
Synthetic Detergents	< 5 mg/l
E. coli	< 20,000 cfu/100 ml

5.2 Baseline Conditions

5.2.1 Marine Water

5.2.1.1 The Project is located within the North Western WCZ, which is located at the western side of Hong Kong and covers the waters around the North and Western side of Lantau Island, Tuen Mun, Sha Chau, and Lung Kwu Chau. According to EPD's Marine Water Quality of Hong Kong 2021 report, the overall WQO compliance rate of the North Western WCZ was 89% in year 2021. The Dissolved Oxygen (DO) and ammonia-nitrogen (NH_3-N) WQOs were fully met. However, for Total Inorganic Nitrogen (TIN), the WQO was 67% under the influence of high background levels in the Pearl River Estuary. For the past 5 years, the WQO compliance rate has fluctuated, and there was an increase from 72% in Years 2017, to 89% in Years 2018 and 2019, before declining to 67% in 2020, and eventually rising back to 89% in 2021. The water quality monitoring data from monitoring stations NM2 and NM3 in 2021 is presented in **Table 5.4** below.

Table 5.4 Summary of EPD's Routine Marine Water Quality Data for North Western WCZ in 2021

Parameters		North Western WCZ[1,2,3,4,5,6]	
		NM2	NM3
Temperature (°C)		24.8 (19.5 - 27.9)	24.1 (18.1 - 27.6)
Salinity (ppt)		29.3 (22.9 - 33.5)	29.1 (24.0 - 33.4)
Dissolved Oxygen (mg/L)	Depth Averaged	4.9 (4.1 – 5.7)	5.1 (4.1 - 6.4)
	Bottom	4.9 (3.3 – 6.7)	4.9 (3.5 - 6.9)
Dissolved Oxygen (% Saturation)	Depth Averaged	70 (59 – 82)	71 (60 - 86)
	Bottom	69 (47 – 90)	68 (51 - 87)
pH		7.5 (7.2 - 7.9)	7.6 (7.2 - 8.0)
Secchi Disc Depth (m)		2.3 (1.7 - 3.5)	2.3 (1.5 - 3.0)
Turbidity (NTU)		6.0 (2.9 - 11.5)	12.2 (3.3 - 78.8)
Suspended Solids (mg/L)		4.9 (1.6 - 9.4)	5.1 (1.5 - 9.6)
5-day Biochemical Oxygen Demand (mg/L)		1.3 (0.2 - 4.9)	1.2 (0.3 - 2.8)
Ammonia Nitrogen (mg/L)		0.090 (0.038 - 0.167)	0.089 (0.048 - 0.170)
Unionised Ammonia (mg/L)		0.001 (<0.001 - 0.003)	0.002 (<0.001 - 0.003)
Nitrite Nitrogen (mg/L)		0.063 (0.004 - 0.117)	0.062 (0.004 - 0.123)
Nitrate Nitrogen (mg/L)		0.280 (0.047 - 0.617)	0.315 (0.062 - 0.787)
Total Inorganic Nitrogen (mg/L)		0.43 (0.21 - 0.76)	0.47 (0.21 - 0.93)
Total Kjeldahl Nitrogen (mg/L)		0.61 (0.35 - 0.95)	0.56 (0.46 - 0.70)
Total Nitrogen (mg/L)		0.78 (0.59 - 1.11)	0.76 (0.64 - 0.92)
Orthophosphate Phosphorous (mg/L)		0.014 (0.003 - 0.027)	0.013 (<0.002 - 0.026)
Total Phosphorous (mg/L)		0.06 (0.04 - 0.09)	0.06 (0.03 - 0.09)
Silica (as SiO_2) (mg/L)		1.29 (0.34 - 2.10)	1.36 (0.30 - 2.67)
Chlorophyll-*a* (µg/L)		4.8 (0.8 - 15.5)	5.1 (0.6 - 12.1)
E. coli (count/100mL)		31 (6 - 350)	25 (4 - 290)
Faecal Coliforms (count/100mL)		59 (14 - 610)	51 (10 - 660)

Notes: 1. Data presented are annual arithmetic means of the depth-averaged results except for E. coli and faecal coliforms which are annual geometric means.

2. Data in brackets indicate the ranges.

3. NM indicates no measurement taken.
4. Values at or below laboratory reporting limits are presented as laboratory reporting limits.
5. Equal values for annual medians (or geometric means) and range indicates that all data are the same as or below laboratory reporting limits.
6. Unless specified otherwise, data presented are depth-averaged value which are calculated by taking the means of three depths (i.e. surface, mid-depth, and bottom).

5.2.2 Tuen Mun Typhoon Shelter

5.2.2.1 Tuen Mun Typhoon Shelter is located at Tuen Mun South and at the mouth of Tuen Mun River, which is at the vicinity of the Project's assessment area. There are no bacteriological WQOs for typhoon shelters as their beneficial use are primarily for vessel mooring. Hence the concerned parameters for typhoon shelter water quality are mainly DO and NH_3-N. Both parameters met the WQO in 2021. In general the long term trend shows an improvement of water quality in Tuen Mun Typhoon Shelter.

5.2.2.2 The water quality monitoring data from monitoring stations NT1 of Tuen Muen Typhoon Shelter is presented in **Table 5.5** below.

Table 5.5 Summary of EPD's Routine Marine Water Quality data for Tuen Mun Typhoon Shelter in 2021

Parameters		Tuen Mun Typhoon Shelter[1,2,3]
		NT1
Temperature (°C)		26.2
		(20.6 - 29.1)
Salinity (ppt)		26.1
		(20.4 - 31.8)
Dissolved Oxygen (mg/L)	Depth Averaged	4.8
		(4.2 – 5.8)
	Bottom Layer	4.7
		(4.0 - 5.2)
Dissolved Oxygen (% Saturation)	Depth Averaged	69
		(58 - 83)
	Bottom Layer	67
		(56 - 75)
pH		7.5
		(7.1 - 7.6)
Secchi Disc Depth (m)		1.7
		(1.4 - 2.4)
Turbidity (NTU)		6.9
		(4.9 - 12.2)
Suspended Solids (mg/L)		7.1
		(3.2 - 10.1)
5-day Biochemical Oxygen Demand (mg/L)		0.9
		(0.5 - 1.3)
Ammonia Nitrogen (mg/L)		0.098
		(0.036 - 0.200)
Unionised Ammonia (mg/L)		0.001
		(<0.001 - 0.003)
Nitrite Nitrogen (mg/L)		0.053
		(0.019 - 0.073)

Parameters	Tuen Mun Typhoon Shelter[1,2,3]
	NT1
Nitrate Nitrogen (mg/L)	0.330
	(0.143 - 0.635)
Total Inorganic Nitrogen (mg/L)	0.48
	(0.25 - 0.74)
Total Kjeldahl Nitrogen (mg/L)	0.63
	(0.58 - 0.68)
Total Nitrogen (mg/L)	0.83
	(0.81 - 0.84)
Orthophosphate Phosphorous (mg/L)	0.011
	(0.005 - 0.021)
Total Phosphorous (mg/L)	0.08
	(0.06 - 0.09)
Silica (as SiO_2) (mg/L)	1.25
	(0.63 - 1.95)
Chlorophyll-*a* (µg/L)	7.0
	(0.8 - 19.5)
E. coli (count/100mL)	33
	(8 - 220)
Faecal Coliforms (count/100mL)	210
	(42 - 990)

Notes: 1. Data presented are annual arithmetic means of the depth-averaged results except for E. coli and faecal coliforms which are annual geometric means.
2. Data in brackets indicate the ranges.
3. Unless specified otherwise, data presented are depth-averaged value which are calculated by taking the means of three depths (i.e. surface, mid-depth, and bottom).

5.2.3 Inland Water

Tuen Mun River

5.2.3.1 Tuen Mun River is a major river located in the western New Territories, which passes through Lam Tei, San Hing Tsuen and Fu Tei in its upstream section, then through the densely populated Tuen Mun Town in its mid-stream before draining into the Tuen Mun Typhoon Shelter at its mouth. This river has experienced improvement in its water quality over the last three decades, with its WQO compliance rate rising significantly from 42% in 1991 to 85% in 2021. Four of the six monitoring stations (i.e. TN3 - TN6) are situated at the middle to lower sections of the river, and maintained a "Good" water quality index (WQI) grading. In 2021, the upstream monitoring station (i.e. TN2) received a "Fair" WQI grading, while another upstream monitoring station (TN1) was graded "Bad", mainly due to discharges from unsewered rural areas. The water quality monitoring data from monitoring stations TN1, TN2, and TN6 in 2021 is presented in **Table 5.6** below.

Table 5.6 Summary of EPD's Routine River Water Quality Data for Tuen Mun River in 2021

Parameters	Tuen Mun River[1,2,3,4,5]		
	TN1	TN2	TN6
Dissolved Oxygen (mg/L)	4.4	8.0	5.4
	(2.0 - 5.9)	(4.3 - 12.9)	(3.6 - 7.9)
pH	7.6	7.9	7.5
	(7.4 - 8.2)	(7.2 - 9.2)	(6.8 - 8.1)

Parameters	Tuen Mun River[1,2,3,4,5]		
	TN1	**TN2**	**TN6**
Suspended Solids (mg/L)	11.0	7.6	3.7
	(3.0 - 16.0)	(3.3 – 6,600.0)	(1.6 - 31.0)
5-Day Biochemical Oxygen Demand (mg/L)	24.0	3.9	3.0
	(11.0 - 47.0)	(2.4 - 66.0)	(1.0 - 9.3)
Chemical Oxygen Demand (mg/L)	32	15	14
	(20 - 54)	(6 - 100)	(8 - 23)
Oil & Grease (mg/L)	0.6	<0.5	<0.5
	(<0.5 - 1.4)	(<0.5 - 2.0)	(<0.5 - <0.5)
E. coli (counts/100mL)	100,000	190,000	2 200
	(44,000 – 230,000)	(49,000 – 1,400,000)	(170 – 45,000)
Faecal Coliforms (counts/100mL)	340,000	290,000	15,000
	(130,000 – 990,000)	(75,000 – 2,000,000)	(1,100 – 300,000)
Ammonia Nitrogen (mg/L)	6.900	2.100	0.480
	(5.400 - 9.700)	(1.200 - 7.800)	(0.150 - 0.960)
Nitrate Nitrogen (mg/L)	0.280	1.100	0.275
	(<0.002 - 0.710)	(0.011 - 7.000)	(0.150 - 0.660)
Total Kjeldahl Nitrogen (mg/L)	11.50	9.00	1.10
	(8.60 - 13.00)	(3.50 - 11.00)	(0.76 - 2.20)
Orthophosphate Phosphorous (mg/L)	0.520	0.260	0.027
	(0.400 - 0.600)	(0.140 - 0.780)	(<0.002 - 0.053)
Total Phosphorous (mg/L)	0.94	0.86	0.12
	(0.69 - 1.00)	(0.39 - 0.96)	(0.07 - 0.16)
Sulphide (mg/L)	0.03	<0.02	<0.02
	(<0.02 - 0.05)	(<0.02 - 0.03)	(<0.02 - <0.02)
Aluminium (µg/L)	<50	<50	60
	(<50 - 442)	(<50 - 140)	(<50 - 163)
Cadmium (µg/L)	<0.1	<0.1	<0.1
	(<0.1 - <0.1)	(<0.1 - <0.1)	(<0.1 - <0.1)
Chromium (µg/L)	<1	<1	2
	(<1 - 1)	(<1 - 3)	(<1 - 3)
Copper (µg/L)	1	2	4
	(<1 - 2)	(<1 - 7)	(3 - 6)
Lead (µg/L)	<1	<1	<1
	(<1 - <1)	(<1 - 2)	(<1 - <1)
Zinc (µg/L)	<10	<10	10
	(<10 - 36)	(<10 - 46)	(<10 - 16)
Flow (m^3/s)	0.138	0.017	NM
	(0.072 - 0.328)	(0.006 - 0.059)	

Notes: 1. Data presented are annual arithmetic means of the depth-averaged results except for E. coli and faecal coliforms which are annual geometric means.

2. Data in brackets indicate the ranges.

3. NM indicates no measurement taken.

4. Values at or below laboratory reporting limits are presented as laboratory reporting limits.

5. Equal values for annual medians (or geometric means) and range indicates that all data are the same as or below laboratory reporting limits.

Channel near Lung Mun Road at Pillar Point

5.2.3.2 There is no EPD inland water quality monitoring station at the vicinity of Pillar Point to assess the baseline conditions of the inland waters of that area. Hence, additional water quality sampling was conducted under this EIA to supplement the inland water quality information for both wet season (i.e. between April and October) and dry season (i.e. between November and March). Sampling was conducted at a frequency of 3 sampling days per week over a 2 week period (i.e. 6 sampling days in total).

5.2.3.3 The water quality parameters that were measured and sampled were the same as those used by EPD's river monitoring stations. In addition, other relevant data (i.e. monitoring location, time, weather conditions, river conditions etc.) were also recorded, the samples were then analysed at a Hong Kong Laboratory Accreditation Scheme (HOKLAS) accredited laboratory. The water quality sampling results are summarised under **Table 5.7** below. In-situ monitoring records and laboratory analysis results are also presented in **Appendix 5.1**.

Table 5.7 Water Quality Sampling Results at Channel near Lung Mung Road at Pillar Point

Parameters	**Channel near Lung Mung Road at Pillar Point (R1)[1,2,3,4,5]**	
	Wet Season	**Dry Season**
Dissolved Oxygen (mg/L)	9.5 (9.1 - 9.8)	8.8 (8.1 - 9.3)
pH	9.5 (8.8 - 9.8)	8.2 (8.0 - 8.4)
Suspended Solids (mg/L)	2.1 (1.3 - 2.7)	4.0 (<0.5 - 6.6)
5-Day Biochemical Oxygen Demand (mg/L)	1.3 (<0.1 - 2.2)	2.9 (2.2 - 3.4)
Chemical Oxygen Demand (mg/L)	10 (6 - 12)	18 (13 - 22)
Oil & Grease (mg/L)	<0.5 (<0.5 - <0.5)	<0.5 (<0.5 - 0.9)
E. coli (counts/100mL)	595 (340 – 1,200)	795 (180 – 2,400)
Faecal Coliforms (counts/100mL)	3,167 (900 – 8,800)	2,006 (410 – 4,700)
Ammonia Nitrogen (mg/L)	6.2 (5.0 - 6.8)	40.1 (33.2 - 50.5)
Nitrate Nitrogen (mg/L)	2.72 (2.32 - 3.09)	3.95 (3.59 - 4.16)
Total Kjeldahl Nitrogen (mg/L)	7.6 (5.3 - 12.3)	42.1 (33.9 - 50.8)
Orthophosphate Phosphorous (mg/L)	0.006 (<0.001 - 0.014)	0.008 (0.004 - 0.010)
Total Phosphorous (mg/L)	0.03 (0.02 - 0.03)	0.04 (0.01 - 0.07)
Sulphide (mg/L)	<0.05 (<0.05 - <0.05)	<0.05 (<0.05 - <0.05)
Aluminium (µg/L)	55 (36 - 77)	41 (16 - 94)
Cadmium (µg/L)	<0.1 (<0.1 - <0.1)	<0.1 (<0.1 - <0.1)
Chromium (µg/L)	1.1 (<1.0 - 1.4)	1.0 (<1.0 - 1.3)
Copper (µg/L)	2.4 (1.0 - 6.8)	2.5 (1.3 - 4.1)
Lead (µg/L)	1.0 (<1.0 - 2.9)	<1.0 (<1.0 - 1.1)
Zinc (µg/L)	33 (10 - 140)	172 (10 – 1,330)
Flow (m^3/s)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)

Notes: 1. Data source: Inland water sampling conducted in October 2022 for wet season.

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

3. Data in brackets indicate the ranges.

4. Values at or below laboratory reporting limits are presented as laboratory reporting limits.

5. The sampling period was conducted over 2 weeks, with 3 sampling days for each week, hence, there are a total of 6 sampling days for each season.

5.2.4 Beaches

5.2.4.1 Two beaches in Tuen Mun District (i.e. Butterfly Beach and Castle Peak Beach) are identified within the assessment area. Summaries of EPD's routine beach water quality monitoring data for the past decade (i.e. Years 2012 to 2022) are presented in **Table 5.7**. The beach water quality monitored in Year 2022 for both beaches received a "Fair" ranking.

Table 5.7 Annual geometric mean *E. coli* levels for Beaches of Tuen Mun District (Years 2012 to 2022)

Beach	*E. coli* counts per 100mL										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Butterfly	42	71	38	98	131	81	39	91	129	57	50
Castle Peak	48	78	91	71	106	65	70	128	112	103	162

5.3 Representative Water Sensitive Receivers

5.3.1.1 The assessment area for the water quality impact assessment shall include areas within 500m from the Project boundary, and shall cover the North Western WCZ as stipulated in Clause 3.4.6.2 of EIA Study Brief (ESB-348/2021). The assessment area was extended beyond the 500m assessment area to cover other locations including beaches, water pumping stations, and cooling water intakes etc., to identify other WSRs that may also be affected by the Project and may have a bearing on the environmental acceptability of the Project. The major groupings of WSRs are summarised below:

- Gazetted beaches;
- Cooling water intakes;
- WSD flushing water intakes;
- Typhoon shelters;
- Country Parks;
- Rivers;
- Water gathering ground and reservoirs; and
- Secondary Contact Recreation Subzones.

5.3.1.2 The identified WSRs are summarised in **Table 5.8** and their locations are shown in **Figure 5.1**.

Table 5.8 Summary of identified WSRs

ID	WSR
Gazetted Beaches	
B1	Butterfly Beach
B2	Castle Peak Beach
Cooling Water Intakes	
C1	ASD Tuen Mun Hospital Cooling Water Intake
WSD Flushing Water Intakes	
WSD1	WSD Flushing Water Intake Near Butterfly Beach
Country Park	
CP1	Tai Lam Country Park
Typhoon Shelters	
TS1	Tuen Mun Typhoon Shelter
Rivers	
RIV1	Tuen Mun River
Water Gathering Ground and Reservoirs	
RSV1	Lam Tei Irrigation Reservoir
RSV2	Hung Shui Hang Irrigation Reservoir
WG1	Water Gathering Ground
Secondary Contact Recreation Subzones	
SCZ1	Secondary Contact Recreation Subzone 1
SCZ2	Secondary Contact Recreation Subzone 2

5.4 Identification and Evaluation of Water Quality Impacts – Construction Phase

5.4.1 Summary of Key Construction Activities

5.4.1.1 A review has been conducted on the construction methodologies given in **Section 2**. A summary of the construction methodologies for various tunnel sections is given below. According to the latest design, both Tunnel Boring Machine (TBM) and Drill-&-Blast (D&B) / Drill-&-Break tunnelling methods would be adopted:

Table 5.9 Summary of Construction Methods for Different Alignment Sections

Alignment Section	Construction Method
Lam Tei Interchange to Existing Lam Tei Quarry Site	At-grade works
Lam Tei to Sam Shing Estate	D&B tunnelling
Tuen Mun Typhoon Shelter	TBM tunnelling (underneath seabed)
Tuen Mun West (Tuen Mun Area 44 to Pillar Point)	TBM tunnelling (land based)
Tuen Mun West (Pillar Point to River Trade Terminal)	At-grade works

5.4.1.2 Other than the above tunnel sections, the construction of the Project also requires the following:

Table 5.10 Construction Elements Required for Construction Works

Construction Elements	Location
Magazine sites for the storage of explosives (for shared use with Route 11)	1 no at Lam Tei 1 no at Siu Lam 1 no at Pillar Point
Barging point	1 no at Tuen Mun – Chek Lap Kok Tunnel (TM-CLKT) Northern Connection

Construction Elements	Location
Temporary works areas	1 no at Sam Shing Estate 1 no at Yau Oi Estate 4 nos at TM-CLKT Northern Connection 2 nos at Pillar Point

5.4.1.3 As discussed in **Section 2**, while most of the Project would be in the form of tunnel sections, the Project Profile has not excluded the possibility for Immersed Tube Tunnelling (IMT) within the Tuen Mun Typhoon Shelter. Obviously, IMT would inevitably require dredging which would induce higher water quality impacts during the construction phase.

5.4.1.4 During the subsequent design stage after the submission of Project Profile and issue of the EIA Study Brief, the project team has collated more baseline information and considered different practicable options for the alignment section within the Tuen Mun Typhoon Shelter. After considering all the issues including engineering, environmental etc, it is considered more appropriate to adopt a Tunnel Boring Machine (TBM) to construct the tunnel section within the Tuen Mun Typhoon Shelter. The environmental benefit of adopting TBM tunnelling is that dredging would be avoided and hence the associated water quality impacts within the Tuen Mun Typhoon Shelter are minimised during the construction phase.

5.4.1.5 The potential water pollution sources induced from the construction of the Project are identified and summarised below:

- Construction run-off and general construction activities;
- Tunnelling and underground works;
- Construction for ventilation buildings, satellite building and administration building;
- Sewage due to construction workforce;
- Construction works in close proximity of inland water;
- Groundwater from contaminated areas and contaminated site run-off;
- Operation of barging points;
- Accidental spillage of chemicals; and
- Diversion of watercourses

5.4.1.6 For the construction of sub-sea section of tunnel at Tuen Mun Typhoon Shelter, tunnel boring machine (TBM) tunnelling will be adopted. The tunnel will be passing within the bedrock layer, which will not have disturbance on the waterbodies or seabed. Therefore, adverse water quality on the marine water bodies is not anticipated, and no mitigation measure would be required.

5.4.2 Construction Run-off and General Construction Activities

5.4.2.1 Construction site run-off is generated from construction activities at work sites and has the potential to cause adverse water quality impacts. Potential water pollution sources from construction site run-offs and construction activities may include:

- Run-off and erosion from site surfaces, earth working areas and stockpiles;

- Accidental release of any bentonite slurries, concrete washing and other grouting materials associated with construction run-off, stormwater or groundwater dewatering process;
- Wash water from concrete washing, dust suppression sprays, equipment and wheel washing facilities;
- General site cleaning and polishing; and
- Chemical spillage such as fuel, oil, solvents and lubricants from the maintenance of construction machinery and equipment.

5.4.2.2 In addition, during rainstorm events, site run-off would wash away soil particles on unpaved lands and areas with exposed topsoil. Which generally contains high concentrations of SS, meaning the discharge of uncontrolled site run-off would increase the SS levels and turbidity of the nearby water bodies. Uncontrolled site run-off may also contain concrete and cement-derived materials which may increase the turbidity, discoloration, pH levels of nearby waterbodies. The increased turbidity of water bodies decreases the amount of sunlight penetration, hence reducing the rate of faecal bacteria decay and the rate of photosynthesis. However, the adverse impacts could be minimised with good construction site practices.

5.4.3 Tunnelling and Underground Works

5.4.3.1 As discussed in **Section 5.5.1**, the tunnel sections of the Project would be constructed by either D&B and TBM methods.

Drill-&-Blast (D&B) / Drill-&-Break Tunnelling

5.4.3.2 As discussed in **Section 2**, the majority of the tunnel section underneath Tai Lam Country Park would be in granite. The depth of this tunnel section would vary between 43 – 465m below local ground. After considering the latest geological information, D&B / Drill-&-Break tunnelling is considered the most suitable construction methodology for this tunnel section underneath Tai Lam Country Park.

5.4.3.3 The proposed D&B / Drill-&-Break tunnelling works may result in groundwater infiltration which may increase construction site run-off and lead to potential groundwater table drawdown. Any potential drawdown could result in different degrees of settlement and dewatering of surface waterbodies (i.e. Lam Tei Irrigation Reservoir, Hung Shui Hang Irrigation Reservoir, and nearby streams), and hence groundwater in the vicinity may also be depleted. SS would also be a key concern as infiltrated water could increase the amount of construction site run-off from the site to nearby drainage systems.

5.4.3.4 However, as this D&B/ Drill-&-Break tunnel section would be in granite and with sufficient depth below ground, together with the good practices and mitigation measures as described in **Section 5.8**, adverse impacts from the change in groundwater level and SS would be insignificant.

Tunnelling using Tunnel Boring Machine (TBM)

5.4.3.5 As discussed in **Section 2**, TBM tunnelling would be adopted for the sections within Tuen Mun Typhoon Shelter, and the section from Tuen Mun Area 44 to Pillar Point. The section within Tuen Mun Typhoon Shelter would be approximately 10 – 60m underneath seabed and within bedrock layer, hence only land-based works would be involved.

5.4.3.6 Potential sources of water quality impact from these tunnelling works would be the discharge of tunnelling wastewater from drilling, boring and wash-down. Furthermore, the use of bentonite and grouting materials for the construction of bored tunnels would contaminate the water pumped out from the tunnel. Surface run-off may also be contaminated, and turbid water may enter adjacent watercourses, drainage systems, and waterbodies located downstream as excavated material is conveyed to the surface. Water used for the tunnelling works should also be re-circulated after sedimentation and when the water is due for final disposal, it should be treated to ensure compliance with the standards stipulated in the TM-DSS before being discharged into storm drains.

5.4.3.7 TBM tunnelling may influence the groundwater levels. However, as the works area is located at coastal areas, the groundwater level would be quickly re-balanced by the surrounding marine environments. Also, the TBM tunnelling works within Tuen Mun Typhoon Shelter would take place at the granite layer underneath thick marine deposit and alluvium layers, the disturbance to the marine deposit and alluvium layers of Tuen Mun Typhoon Shelter should be minor. For the section between Tuen Mun Area 44 to Pillar Point, the vertical alignment would also go through both granitic and volcanic layers. Therefore, any change of groundwater level caused by the Project would be insignificant and hence significant changes in underground hydrology, hydrodynamic regime, sediment erosion, and deposition patterns are not anticipated.

5.4.3.8 For the operation of TBM at the vicinity of water sensitive receivers near Tuen Mun Typhoon Shelter, reservation of adequate soil cover (i.e. sufficient buffer distance between seabed and underground works area), and/or sealing up of charted boreholes would be provided to prevent potential accidental seepage or discharge due to excessive pressure of TBM. Sufficient ground investigation and soil testing should be carried out to ascertain that adequate soil cover is achieved, and all charted boreholes should be checked by engineers to ensure proper seal up prior to the TMB passing. It may cause accidental blowout during annulus grouting around the completed segment rings at the back of the TBM. The grouting may penetrate through the voids of the soil above the TBM and reach the seabed and leak into the sea. However, provided that there is adequate soil cover, it will prevent the potential of the blowout from happening.

5.4.4 Ventilation Building, Satellite Building and Administration Building

5.4.4.1 As discussed in **Section 2**, there would be a total of 3 ventilation buildings (at Lam Tei, Wah Fat Playground, and Pillar Point), 1 satellite building (at Lam Tei) and 1 administration building (at Pillar Point) along the entire tunnel section, which are shown in **Figure 2.9**. The construction of these ventilation buildings, satellite building and administration building would adopt an open cut excavation method and followed by construction of superstructure and utilities.

5.4.4.2 These buildings are located at the vicinity of waterbodies including Tuen Mun River, Lam Tei Irrigation Reservoir, marine waters, and existing drainage systems. Potential impacts may occur during rainfall events whilst the excavation works are ongoing, as silt and sandy materials carried by run-off from the excavation may enter nearby watercourses, increasing their SS content and turbidity. Other pollutants, such as oil and grease, chemicals, bentonite, and grouting materials, may also be present in the run-off should it flow over storage or maintenance areas, where it may increase discoloration, turbidity, chemical and pH levels of the nearby water bodies. Additionally, the erosion of soil enriched in organic matter may release excess nutrients into adjacent water bodies, potentially leading to eutrophication.

5.4.4.3 These impacts would require the good practices and mitigation measures as described in **Section 5.8** to ensure any residual impacts would comply with the statutory requirements.

5.4.5 Sewage due to Construction Workforce

5.4.5.1 Sewage will be generated by sanitary facilities (i.e. chemical toilets) provided for the on-site construction workforce. Sewage is characterized by high levels of BOD_5, ammonia and *E. coli* counts. According to Table T-2 of Guidelines for Estimating Sewage Flows for Sewage Infrastructure Planning (GESF) published by EPD, the unit flow factor (UFF) is 0.23 m^3/day/employee (0.08 m^3/day/employee for commercial employee and 0.15 m^3/day/employee for employees of construction activities).

5.4.5.2 According to the current design, there will be a workforce of approximately 450 people which will be working on site at any one time during the construction phase of the Project. Hence, a total sewage load of approximately 103.5 m^3/day will be generated throughout the entire construction phase of approximately 93 months.

5.4.5.3 Adequate chemical toilets should be provided to avoid direct discharge into any nearby watercourse or public drains. With these mitigation measures in place, no adverse water quality impacts are anticipated.

5.4.6 Construction Works in Close Proximity of Inland Water

5.4.6.1 Construction activities may pollute nearby inland waterbodies near Lam Tei, Siu Lun, and Pillar Point (i.e. Tuen Mun River and other streams, Lam Tei Irrigation Reservoir, Hung Shui Hang Irrigation Reservoir, streams and water gathering ground) through the potential release of construction wastes, which are generally characterised by high concentration of SS and elevated pH. With the implementation of adequate construction site drainage as specified in the ProPECC PN 1/94 “Construction Site Drainage” and the provision of mitigation measures as described in the ETWB TC (Works) No. 5/2005 “Protection of natural streams / rivers from adverse impacts arising from construction works”, no adverse water quality impacts are anticipated.

5.4.7 Groundwater from Potential Contaminated Areas and Contaminated Site Run-off

5.4.7.1 As discussed in **Section 2**, the majority of the Project alignment would go through the Tai Lam Country Park which would have no potential for land contamination. The tunnel section from Sam Shing to Pillar Point through Tuen Mun Typhoon Shelter would be mainly within rock layer and hence also has no potential for land contamination.

5.4.7.2 **Section 7** has conducted a comprehensive land contamination study for the entire Project. According to the current findings, potential contaminated areas are identified at Lam Tei, Sam Shing Hui, and Pillar Point areas. Proper land contamination remediation and mitigation measures proposed in **Section 7** should be followed. If the groundwater that is pumped out, or from discharged from the dewatering process during excavation works are located within potential contaminated areas, the water could also be contaminated. Any potential contaminated materials which may be disturbed, or any foreign materials which contacts such contaminated material, could be washed by site run-off into the drainage system, thereby discharging contaminated water into the drainage system. Any potential contaminated groundwater or site run-off should be properly treated and disposed in compliance with the requirements of TM-DSS.

5.4.8 Operation of Barging Point

5.4.8.1 As discussed in **Section 2**, the barging points are located at the eastern coastline of TM-CLKT northern landfall. Given the sufficient water depth, dredging would not be required. This would avoid any disturbance to the seabed and hence the associated water quality impacts.

5.4.8.2 However, activities conducted at the barging points still have the potential to cause adverse water quality impacts. Uncontrolled surface run-off generated at the barging point may contain high concentrations of SS, oil & grease, and chemicals. Additionally, materials may also be splashed into the surrounding water during the transportation of spoil using the barging point. These activities may increase the turbidity, discoloration, pH level of the nearby marine waters. Barges may also increase the turbidity and SS content of the nearby waters as marine deposits on the seabed may be disturbed through vessel movements and propeller wash.

5.4.8.3 With the implementation of the good practices and mitigation measures recommended in **Section 5.8**. any residual water quality impacts would comply with the statutory requirements.

5.4.9 Accidental Spillage of Chemicals

5.4.9.1 The use of chemicals such as engine oil and lubricants, and their storage as waste materials has the potential to cause adverse water quality impacts if spillage occurs and enters the adjacent water bodies. Waste oil may infiltrate the surface soil layer, or discharged into the nearby water environment, increasing hydrocarbon levels. However, adverse impacts can be mitigated by implementing practical mitigation measures and good site practices.

5.4.10 Diversion of Watercourses

5.4.10.1 Due to engineering constraints and geological conditions, it is unavoidable that the Project alignment would require diversion of watercourses to be diverted at some locations, including Lam Tei, near Wah Fat Playground, and Pillar Point. The diversion of water courses would involve excavation and construction works. If not properly controlled, pollutants including excavated materials, chemicals, wastewater or construction materials may be flushed downstream via the watercourse, This may cause water quality impacts and flooding may occur in the downstream areas of the diverted or removed watercourses. This requires the implementation of proper mitigation measures stated in **Section 5.8**, to ensure no adverse water quality impacts.

5.5 Identification and Evaluation of Water Quality Impacts – Operational Phase

5.5.1 General

5.5.1.1 The following potential sources of water quality impacts are identified for the operational phase of the Project:

- Road run-off discharged from paved roads and developments proposed under the Project;
- Sewage generated by satellite building and administration building;
- Tunnel run-off and drainage; and
- Wastewater generated from washing and maintenance operations.

5.5.2 Surface Run-off from Paved Areas of the Project

5.5.2.1 Surface run-offs would typically contain pollutants that are deposited onto paved surfaces including roads, bridges, administration building, satellite building and ventilation buildings which are then discharged to existing waterways during rainfall and storms via drainage systems, and are considered as a non-point source. The key pollutants in concern include sediments, oil and grease, heavy metals, debris, rubber, and fertilizers.

5.5.2.2 Pollutants such as rubber, debris, oil and grease and sediments may be generated by road users (i.e. vehicles), and are accumulated on the roads during dry periods. Most of the accumulation is found in slightly depressed and at-grade road sections where sediment and silt will be carried and deposited. Pollutants deposited on the road surface will be washed away from the roads by run-off generated during rainfall and storms events, where a large proportion of the rainfall landing on road hard surfaces will reach the surface water drainage systems.

5.5.2.3 Factors including climatic conditions and intensity of precipitation, topography, and the degree of urbanisation has a significant influence on the characteristics of road run-off. Following high intensity precipitation, the road surface may be scoured, resulting in an initial run-off that is referred to as the "first-flush", which typically contains a high amount of pollutants, and may include significant water quality impacts on the water bodies. Subsequent run-offs may contain lower levels of pollutants. Overall, with the application of adequate mitigation measures, any water quality impacts can be reduced to an acceptable level.

5.5.3 Sewage Effluent from the Proposed Buildings

5.5.3.1 During the operational phase, the sewage generated from the satellite building near the north ventilation building at Lam Tei and the administration building near the toll plaza of Tuen Mun Chek Lap Kok tunnel at Pillar Point, would be a pollution source. Staff and workers at the satellite building and administration building will generate sewage through toilet and sanitary facilities. To avoid adverse water quality impacts, the sewage should not be discharged to waterbodies. Instead, the sewage should be discharged through public sewers that are connected to public sewerage systems which are located at the vicinity of the buildings.

5.5.3.2 No toiletry facilities are proposed for ventilation buildings at Lam Tei, Siu Lun and Pillar Point. Hence, it is anticipated that no sewage will be generated at the ventilation buildings. Adverse impacts are therefore not anticipated.

5.5.4 Drainage of Road Surface and Tunnel Runoff

5.5.4.1 During or after rainstorm events, rainwater on at-grade roads and viaducts may drain into the drainage system, and seepage of groundwater into the tunnel may generate tunnel run-off. These run-off may contain limited amount of SS, oil and grease. Direct discharge of tunnel run-off into nearby waterbodies may induce adverse water quality impact and should be avoided. No adverse water quality impacts are anticipated with the proper implementation of recommended mitigation measures such as the installation of silt traps and oil/grit interceptors as described in **Section 5.9**.

5.5.5 Wastewater Generated from Washing and Maintenance Operations

5.5.5.1 Wastewater will be generated from washing and maintenance operations associated with work vehicles and the maintenance activities for the tunnel ventilation system. Direct discharge of the generated wastewater to the nearby drainage system and waterbodies will induce adverse water quality impacts and should be avoided. Instead, the wastewater should be discharged to the sewerage system.

5.5.5.2 Wastewater generated by washing and maintenance operations associated with the tunnel system, tunnel surface and the ventilation system may include dusts and undissolved oils, whereas wastewater generated by washing and maintenance activities of work vehicles usually contains hydrocarbon pollutants such as petroleum and diesel.

5.5.5.3 No adverse water quality impact is anticipated with the proper implementation of recommended mitigation measures such as discharging wastewater to the public sewerage system properly, as described in **Section 5.9**.

5.6 Cumulative Impacts from Concurrent Projects

5.6.1.1 The construction of the Project may potentially overlap with the construction period of other nearby concurrent projects as identified in **Section 2**. The identified concurrent projects within the 500m Assessment Area of the Project may induce cumulative water quality impacts, which are evaluated and discussed in **Appendix 5.2**. No cumulative water quality impacts are anticipated for concurrent projects.

5.6.1.2 **Appendix 5.2** also tabulates and evaluates those concurrent projects that are beyond the 500m Assessment Area of the Project. Given the large separation distances, the cumulative impacts from the concurrent projects beyond 500m would not be significant.

5.7 Recommended Mitigation Measures – Construction Phase

5.7.1 Construction Run-off and General Construction Activities

5.7.1.1 Best Management Practices (BMPs) of mitigation measures in controlling water pollution and good site management, as specified in ProPECC PN 1/94, should be followed as applicable to prevent run-off with a high level of SS from entering the surrounding waters. Additionally, all effluent discharged from the construction site should comply with the standards stipulated in the TM-DSS. The following mitigation measures are recommended to protect the water quality of the nearby waterbodies, and should provide sufficient and adequate control to site discharges to minimise adverse water quality impacts when properly implemented.

5.7.1.2 All effluent discharged from the construction site should comply with the standards stipulated in the TM-DSS. The following measures are recommended to protect the water quality of the nearby water, and when properly implemented should be sufficient to adequately control site discharges to avoid water quality impacts:

- At the start of site establishment, perimeter cut-off drains to direct off-site water around the site should be constructed with internal drainage works and erosion and sedimentation control facilities implemented. Channels (both temporary and permanent drainage pipes and culverts), earth bunds or sand bag barriers should be provided on site to direct stormwater to silt removal facilities. The design of the temporary on-site drainage system will be undertaken by the contractor prior to the commencement of construction;
- The dikes or embankments for flood protection should be implemented around the boundaries of earthwork areas. Temporary ditches should be provided to facilitate the run-off activities discharge into an appropriate watercourse, through a silt/sediment trap. The silt/sediment traps should be incorporated in the permanent drainage channels to enhance deposition rates;
- The design of efficient silt removal facilities should be based on the guidelines in Appendix A1 of ProPECC PN 1/94. The detailed design of the sand/silt traps should be undertaken by the Contractor prior to the commencement of construction;
- All areas with exposed earth should be vegetated as soon as possible after earthworks have been completed. If excavation of soil cannot be avoided during the rainy season, or at any time of year when rainstorms are likely, exposed slope surfaces should be covered by tarpaulin or other means. All drainage facilities and erosion and sediment control structures should be regularly inspected and maintained to ensure proper and efficient operation at all times, particularly following rainstorms. Deposited silt and grit should be removed regularly and disposed of by spreading evenly over stable, vegetated areas. Considering the scale of the proposed excavation works, it is not practicable to avoid works during the rainy season as this would significantly affect the overall construction programme. However, for works area that is close to watercourses, excavation works shall avoid the rainy season whenever possible. Excavation works shall be proceeded section by section to reduce the amount of works are with exposed earth;
- Measures should be taken to minimise the ingress of site drainage into excavations. If the excavation of trenches in rainy seasons are necessary, it should be excavated and backfilled in short sections wherever practicable. Water pumped from trenches or foundation excavations should be discharged into storm drains installed with silt removal facilities;

- All open stockpiles of construction materials (i.e. aggregates, sand and fill material etc.) should be covered with tarpaulin or similar fabric during rainstorms. Measures should be taken to prevent the washing away of construction materials, soil, silt or debris into any drainage system;
- Manholes (including newly constructed ones) should always be adequately covered and temporarily sealed to prevent silt, construction materials or debris from being washed into the drainage system and storm run-off being directed into foul sewers;
- Precautions should be taken during rainy seasons, and actions as summarised in Appendix A2 of ProPECC PN 1/94 should be taken when a rainstorm is forecasted or imminent,. Particular attention should be paid to the control of silty surface run-off during storm events;
- All vehicles and plants should be cleaned before leaving construction sites to minimise the deposition of earth, mud, debris and other potentially polluting particles on roads. An adequately designed and sited wheel washing facilities should be provided at every construction site's exit where practicable. Wash water should have sand and silt settled out and removed at least on a weekly basis to ensure the continued efficiency of the process. The section of access road leading to, and exiting from, the wheel-wash bay to the public road should be paved with sufficient back fall towards the wheel-wash bay to prevent vehicles from tracking of soil and silty water to public roads and drains;
- Oil interceptors should be provided in the drainage system downstream of any oil/fuel pollution sources. The oil interceptors should be emptied and cleaned regularly to prevent the release of oil and grease into the storm water drainage system after accidental spillage. A bypass should be provided for the oil interceptors to prevent flushing during heavy rain;
- Construction solid waste, debris and rubbish on site should be collected, handled, and disposed of properly to minimise adverse water quality impacts;
- Water used for tests to check for leakages in structures and pipes should be reused for other purposes as far as practicable. Surplus unpolluted water could be discharged into storm drains;
- Earthworks final surfaces should be compacted, and the subsequent permanent work or surface protection should be carried out immediately after the final surfaces are formed to prevent erosion of earth caused by rainstorms. Appropriate drainage with intercepting channels should be provided where necessary;
- Extracted groundwater from activities such as water pumped from basement or foundation construction, and groundwater seepage pumped from tunnel or cavern constructions should be discharged into storm drains after the removal of silt through silt removal facilities;
- Water used in ground boring and drilling for site investigation or rock/soil anchoring should as far as practicable be recirculated after sedimentation. When there is a need for final disposal, the wastewater should be discharged into storm drains through silt removal facilities; and
- The bentonite should be reconditioned and reused wherever practicable to minimise the disposal volume of used bentonite slurries. Temporary enclosed storage locations should be provided on-site for any unused bentonite that needs to be transported away after the related construction activities are completed.

5.7.1.3 The temporary drainage system during the construction phase could cope with a design return period of 1 in 10 years rainfall as recommended in DSD Technical Circular No. 1/2017 "Temporary Flow Diversions and Temporary Works Affecting Capacity in Stormwater Drainage System" and DSD's practical Notes No. 1/2017 "Design rainfall and profile for temporary works within the Dry Season".

5.7.1.4 Good site practices should be adopted to remove rubbish and litter from construction sites so as to prevent the rubbish and litter from spreading from the site area. It is recommended to clean the construction sites on a regular basis.

5.7.1.5 Requirements to be incorporated in the Project contract document should be established based on the water quality mitigation measures as mentioned above.

5.7.2 Tunnelling and Underground Works

5.7.2.1 Whilst conducting tunnelling works, the Contractor should adopt suitable water control strategies, which are applicable to both TBM tunnelling and D&B tunnelling, as far as practicable, including:

- Face confinement (TBM tunnelling): The confinement pressure to be applied at the TBM front should at least balance the existing groundwater pressure to ensure no seepage flow will occur through the TBM face, and hence no groundwater table drawdown throughout the excavation is anticipated.
- Probing Ahead (D&B Tunnelling): The Contractor should undertake rigorous probing of the ground ahead of tunnel excavation works to identify zones of potential significant water inflow. The probe drilling results should be evaluated to determine where grouting is required in line with the tunnel ahead. In zones where significant water inflow could occur due to discrete, permeable features, grouting should be applied to reduce overall inflow of groundwater;
- Pre-grouting (D&B Tunnelling): Where water inflow quantities are excessive, pre-grouting will be required to reduce the water inflow into the tunnel, which will be achieved via a systematic and carefully specified protocol; and
- In principle, the grout pre-treatment would be designed based on probe hole drilling ahead of the tunnel face.

5.7.2.2 In the event of where there is still excessive drawdown of the groundwater table, even after the implementation of water control strategies, post-grouting should be applied as far as practicable, which is described below:

- Post-grouting: Groundwater drawdown will most likely be caused by inflows of water into the tunnel that have not been sufficiently controlled by pre-grouting measures. Should there be groundwater drawdown, post-grouting should be undertaken before the lining is cast. Whilst post-grouting is unlikely required, it should still be considered as a contingency measure to further reduce the permeability of the tunnel to limit groundwater inflow to acceptable levels.

5.7.2.3 The tunnel sections adopting TBM tunnelling should be constructed using a closed face TBM to limit water inflow into the excavation face. The cutter head for the machine will be sealed during excavation and therefore the water inflow from the face will be kept to a minimum. Precast undrained linings should be installed and back grouted behind the TBM as it advances along the tunnel alignment to minimize the potential inflow of water behind the cutter head.

5.7.3 Ventilation Buildings, Satellite Building and Administration Buildings

5.7.3.1 For underground excavations for the proposed ventilation buildings, satellite building and administration building which will require temporary dewatering during their construction, the following mitigation measures are recommended to minimise the potential adverse effects to the groundwater table during the works:

- Toe grouting should be applied beneath the toe level of the temporary/permanent cofferdam walls as necessary to lengthen the effective flow path of groundwater from outside and thus control the amount of water inflow to the excavation; and

- Recharge wells should be installed as necessary outside the excavation areas. Water pumped from the excavation areas should be recharge back onto the ground.

5.7.4 Sewage Due to Construction Workforce

5.7.4.1 No sewage discharge to the drainage system, watercourses, and marine water will be allowed. Adequate and sufficient portable chemical toilets should be provided in the works areas to handle sewage generated by the construction workforce. Should there be any on-site kitchens or canteens, a temporary storage tank should be provided to collect wastewater. A registered collector should be employed to clean and maintain the chemical toilets on a regular basis.

5.7.4.2 Notices should be posted at conspicuous locations to remind the construction workforce not to discharge any sewage or wastewater into the surrounding environment. Regular environmental audit of the construction site should be conducted to provide an effective control of any malpractices and to achieve continual improvement of environmental performances on site.

5.7.5 Construction Works in Close Proximity of Inland Water

5.7.5.1 The practices outlined in ETWB TC (Works) No. 5/2005 "Protection of natural streams/rivers from adverse impacts arising from construction works" should be adopted where applicable to minimise the water quality impacts. Relevant mitigation measures from the ETWB TC (Works) No. 5/2005 are listed below:

- Construction works close to the inland waters should be carried out in dry season as far as practicable where the flow in the surface channel or stream is low;
- Trenches should be dug and backfilled in short sections. Measures should be taken to minimize the ingress of rainwater into trenches;
- The use of less or smaller construction plants may be specified in areas close to the water courses to reduce the disturbance to the surface water;
- Temporary storage of materials (e.g. equipment, chemicals and fuel) and temporary stockpile of construction materials should be located well away from any watercourses during carrying out of the construction works;
- Stockpiling of construction materials and dusty materials should be covered and located away from any watercourses. Construction debris and spoil should be covered up and / or disposed of as soon as possible to avoid being washed into the nearby water receivers; and

- Proper shoring may need to be erected in order to prevent soil or mud from slipping into the watercourses.

5.7.5.2 In addition, WSD's Conditions for Working within Water Gathering Grounds shall also be complied with. The conditions are provided in **Appendix 5.3**.

5.7.6 Groundwater from Contaminated Areas and Contaminated Site Run-off

5.7.6.1 The remediation of contaminated land should be properly conducted following the recommendations proposed under **Section 7**.

5.7.6.2 Any excavated contaminated material and exposed contaminated surface should be properly housed and covered to avoid generation of contaminated run-off, the open stockpiling of contaminated materials should not be allowed. Any contaminated run-off generated under the construction process should be properly collected and treated as necessary before disposal.

5.7.6.3 The direct discharge of groundwater from contaminated areas is not allowed. Prior to any excavation works within potentially contaminated areas, the baseline groundwater quality in these areas should be reviewed based on the past relevant site investigation data and any additional groundwater quality measurements to be performed with reference to *Guidance Note for Contaminated Land Assessment and Remediation*, the review results should be submitted to EPD for approval. If the review results indicated that the groundwater generated from the excavation works would be contaminated, the contaminated groundwater should be either properly treated or properly recharged into the ground in compliance with the requirements of the TM-DSS.

5.7.6.4 If a water treatment facility is deployed on-site to treat the contaminated groundwater, it should be equipped with suitable instruments (e.g., oil interceptor, activated carbon etc.) to reduce the pollution level to an acceptable standard and remove to any prohibited substances (such as total petroleum hydrocarbon) to an undetectable range. All treated effluent from the wastewater treatment plant shall meet the requirements as stipulated in the TM-DSS and should be either discharged into the foul sewers or tankered away for proper disposal.

5.7.6.5 If the deployment of a treatment facility to treat the contaminated groundwater is not feasible, groundwater recharging wells should be installed as appropriate to recharge the contaminated groundwater back onto the ground. The recharging wells should be selected at places where the groundwater quality will not be affected by the recharge operation as stipulated in TM-DSS. The baseline groundwater quality should be determined before selecting the recharge wells and a working plan should be submitted to EPD for agreement. Pollution levels of the recharged groundwater shall not be higher than pollutant levels of ambient groundwater at the recharge well. Groundwater monitoring wells should be installed near the recharge points to monitor the effectiveness of the recharge wells and to ensure that no there is no increase of groundwater level and the transfer of pollutants beyond the site boundary. Prior to the recharge, oil and grease, if any, should be removed as necessary by installing an oil interceptor. The Contractor should apply for a discharge licence under the WPCO through the Regional Office of EPD for groundwater recharge operation or the discharge of treated groundwater.

5.7.6.6 All exposed earth areas should be completed and vegetated as soon as possible after earthworks have been completed. If excavation of soil cannot be avoided during the rainy season, or at any time of year when rainstorms are likely, exposed slope surfaces should be covered by tarpaulin or other means. All drainage facilities and erosion and sediment control structures should be regularly inspected and maintained to ensure proper and efficient operation at all times and particularly following rainstorms. Deposited silt and grit should be removed regularly and disposed of by spreading evenly over stable, vegetated areas. For works area that is close to watercourses, excavation works shall avoid the rainy season as far as possible, and excavation works shall be proceeded section by section.

5.7.7 Operation of Barging Point

5.7.7.1 To minimise the adverse water quality impacts of the surface run-off generated by the operation of the barging point, the mitigation measures recommended under **Section 5.7.1** should be followed. To minimise the potential adverse water quality impact due to the transportation of spoil using the barging point, the following good site practices should be strictly followed:

- Loading of barges and hoppers should be controlled to prevent the splashing of material into the surrounding water. Barges or hoppers should not be filled to a level that will cause the overflow of materials or polluted water during loading or transportation; and
- All vessels should be sized so that adequate clearance is maintained between vessels and the seabed in all tide conditions, to minimise that undue turbidity is not generated by turbulence from vessel movement or propeller wash.

5.7.8 Accidental Spillage of Chemicals

5.7.8.1 The Contractor must be registered as a chemical waste producer if chemical wastes are produced from the construction activities. The Waste Disposal Ordinance (Cap. 354) and its subsidiary regulations, in particular the Waste Disposal (Chemical Waste) (General) Regulation (Cap. 354C), should be observed and complied with for the control of chemical wastes. The Contractor is also recommended to develop management procedures for the chemicals used and prepare an emergency spillage handling procedure to deal with chemical spillage in case of an accident occurs, a contingency plan for any accidental spillage and heavy rainfall event should also be devised.

5.7.8.2 Any services and maintenance facilities should be located on hard standings within a bunded area, sumps and oil interceptors should be provided. Activities with the potential for accidental leakage and spillage of chemicals, including the maintenance of vehicles and equipment should only be undertaken within areas that are appropriately equipped to control the discharges from these potential accidents. The service and maintenance, and any chemical storage areas should not be positioned near watercourses as a safeguard measure.

5.7.8.3 Disposal of chemical wastes should be carried out in compliance with the Waste Disposal Ordinance. The Code of Practice on the Packaging, Labelling, and Storage of Chemical Wastes published under the Waste Disposal Ordinance details the requirements to deal with chemical wastes. General requirements are given as follows:

- Suitable containers should be used to hold the chemical wastes to avoid leakage or spillage during storage, handling, and transport;

- Chemical waste containers should be suitably labelled, to notify and warn the personnel who are handling the wastes, to avoid accidents; and
- Storage area should be selected at a safe location on-site and adequate space should be allocated to the storage area.

5.7.9 Diversion of Watercourses

5.7.9.1 During diversion of watercourses, precaution measures should be implemented to prevent adverse water quality impact to the surrounding environment and downstream areas. Good site practices as described in ETWB TC(Works) No. 5/2005 "Protection of natural streams/rivers from adverse impacts arising from construction works" and ProPECC PN1/94 "Construction Site Drainage" should be implemented. The following major measures include:

- Cofferdams or impermeable structures should be installed as appropriate to isolate the water flow from the construction works area;
- Dewatering or flow diversion shall be conducted prior to the construction works to prevent water overflow to the surrounding area;
- Watercourse removal and flow diversion should be conducted in dry season as far as practicable when the water flow is low;
- Water drained from the watercourse shall be diverted to new/temporary drainage for watercourse diversion; and
- Any excavated land-based sediment from the diversion of watercourse shall be properly stored at bunded areas away from any watercourses and covered with tarpaulin before transporting out of the site.

5.8 Recommended Mitigation Measures – Operational Phase

5.8.1 Surface Run-off from Paved Areas of the Project

5.8.1.1 Surface run-off is identified as a source of water pollution. The paved and developed areas, especially the new roads, tunnels will increase the quantity of surface run-off. The presence of oil, grease and grit on the paved surfaces could be washed into the nearby drainage systems, or nearby watercourses during rainfall.

5.8.1.2 To minimise the adverse water quality impacts, the road drainages should be equipped with adequate silt traps and oil interceptors. Regular washing of the roads and paved areas are also recommended to prevent the accumulation of pollutants. To maintain the equipment's efficiency, contents collected in silt traps and oil interceptors should be cleared regularly, and transferred to an appropriate disposal facility, or to be collected for reuse if possible. Considering the recommended mitigation measure, the adverse water quality impact generated by surface run-off is kept to a minimum.

5.8.2 Sewage Effluent from the Proposed Buildings

5.8.2.1 Sewage effluent generated should be discharged to the existing sewerage networks identified through public sewer at the vicinity of the proposed satellite building and administration building, the sewerage system at these buildings should be connected properly whilst ensuring that the public networks have a sufficient capacity to handle the sewerage load generated. Toilets and other sanitary facilities should be cleaned and maintained on a regular basis.

5.8.3 Drainage of Road Surface and Tunnel Runoff

5.8.3.1 Tunnel run-off is identified as a non-point water pollution sources. To minimise the adverse water quality impacts, the discharge of road drainage channels should pass through treatment facilities (i.e. silt traps and oil/grit interceptors) to remove oil, grease and sediment content before the run-off is discharged to the public storm drainage system. The treatment facilities including silt traps and oil interceptors should be cleaned and maintained regularly to ensure their continued effectiveness. Oily contents of the oil interceptors should be transferred to an appropriate facility, or where possible, reused. With the proper implementation of the recommended mitigation measures, no adverse water quality impacts are anticipated.

5.8.4 Wastewater Generated from Washing and Maintenance Operation

5.8.4.1 Wastewater generated by washing and maintenance activities of ventilation systems should be collected and treated via an activated carbon filter before being discharged, whereas wastewater generated by washing and maintenance activities associate with work vehicles should be collected and treated by petrol interceptors before being discharged. A Licensed Chemical Contractor should be employed to collect and dispose of spent lubrication oil generated from vehicle maintenance activities in compliance with the Waste Disposal Ordinance. No direct discharge of wastewater into the inland water will be allowed. Instead, wastewater should be discharged to public sewerage system.

5.9 Residual Impacts

5.9.1.1 With the full implementation of the recommended mitigation measures for the construction phase of the proposed Project, no unacceptable residual impacts on water quality are anticipated. It is recommended that regular audit of the implementation of the recommended mitigation measures be carried out during the construction phase.

5.9.1.2 With the full implementation of the recommended mitigation measures for the operational phase of the proposed Project, no unacceptable residual impacts on water quality are anticipated.

5.10 Environmental Monitoring and Audit (EM&A)

5.10.1.1 With the proper implementation of the recommended mitigation measures, no unacceptable water quality impacts are expected during the construction phase of the Project. Detailed approaches and methodology for water quality monitoring during the construction phase are detailed in a separate EM&A Manual.

5.10.1.2 For the construction phase of the Project, EM&A monitoring is recommended for the land-based works to assess the potential water quality impacts on the waterbodies at the vicinity, both baseline monitoring before the commencement of works, and post-project monitoring is recommended. TMB tunnelling would be adopted for the section within Tuen Mun Typhoon Shelter which would be approximately 10 - 60m underneath seabed and within bedrock layer, hence marine water quality monitoring is considered not required. In addition, it is recommended that regular site inspections are undertaken, to ensure that the recommended mitigation measures are properly implemented during construction activities and in the works areas.

5.10.1.3 As no adverse water quality impact is anticipated for the operational phase of the Project, no EM&A activities are required.

5.11 Conclusion

5.11.1.1 The key water quality impacts associated with the Project which could impact the nearby waterbodies and water sensitive receivers is mainly associated with the construction phase of the Project, which includes general construction activities, construction site run-off, tunnelling and underground works, sewage from construction workforce, construction works in close proximity of inland water, groundwater from contaminated areas and contaminated site run-off, and the accidental spillage of chemicals. With the proper implementation of recommended mitigation measures, no adverse water quality impacts would be anticipated during the construction phase of the Project.

5.11.1.2 During the operation phase of the Project, the major sources of potential adverse water quality impact include road run-off discharged from paved roads and developments proposed under the Project, and the sewage generated by the proposed satellite building and administration building. With proper implementation of the recommended mitigation measures, no adverse water quality impacts would be anticipated during operational phase.