5 WATER QUALITY IMPACT ASSESSMENT

5.1 Introduction

A water quality impact assessment has been undertaken to define the nature and scale of potential environmental impacts associated with the Project specifically in terms of the effects in the vicinity of sensitive receivers in accordance with the requirements of the Study Brief and *Annexes 6 and 14* of the *Technical Memorandum to the EIAO*. Both construction and operational phase impacts have been assessed and mitigation measures have been identified to reduce any residual impacts to acceptable levels.

5.2 Legislation, Standards, Guidelines and Criteria

Legislation, Standards, Guidelines and Criteria relevant to the consideration of water quality impacts under this study include the following:

- Water Pollution Control Ordinance;
- Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems Inland and Coastal Waters;
- Environmental Impact Assessment Ordinance (Cap. 499) and Technical Memorandum on Environmental Impact Assessment Process;
- Technical Memorandum for Effluent Discharges.

Apart from the above statutory requirements, the Practice Note for Professional Persons, Construction Site Drainage (ProPECC PN 1/94), issued by ProPECC in 1994, also provide useful guidelines on the management of construction site drainage and prevention of water pollution associated with construction activities and are referred to in this report.

Water Pollution Control Ordinance

The *Water Pollution Control Ordinance* (WPCO) is the legislation for the control of water pollution and water quality in Hong Kong. Under the WPCO, Hong Kong waters are divided into 10 Water Control Zones (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 maintain the water quality within the WCZs. The ultimate discharge point for the Outfall is to the Western Buffer Water Control Zone as shown on **Figure 5.1.** The WQOs are applicable as evaluation criteria for assessing compliance of any effects from the construction and operation of the Project.

Technical Memorandum for Effluent Discharges

All discharges during both the construction and the operational phases of the Project are required to comply with the *Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM)* issued under Section 21 of the WPCO. The TM defines discharge limits to different types of receiving waters. Under the TM, effluents discharged into the drainage and sewerage systems, inshore and coastal waters of the WCZs must comply with the pollutant concentration standards for particular discharge volumes. Any new discharges within a WCZ are subject to licence conditions and the TM acts as a guideline for setting discharge standards for the licence.

Environmental Impact Assessment Ordinance and Technical Memorandum on Environmental Impact Assessment Process

Under Section 16 of the EIAO, Environmental Protection Department (EPD) issued the *Technical Memorandum on Environmental Impact Assessment Process* (TMEIA) which specifies the assessment methods and criteria for environmental impact assessment. This Study follows the TMEIA to assess the potential water quality impacts that may arise during the construction and operational phases of the Project. Sections in the TMEIA relevant to the water quality impact assessment are: Annex 6 - Criteria for Evaluating Water Pollution; and Annex 14 - Guidelines for Assessment of Water Pollution.

Practice Note for Professional Persons (ProPECC Note PN1/94) on Construction Site Drainage

The *Practice Note for Professional Persons (ProPECC Note PN1/94) on Construction Site Drainage provides guidelines for the handling and disposal of construction discharges*. This ProPECC Note is generally applicable for control of site runoff and wastewater generated during the construction phase of the Project.

Technical Memorandum (TM), "Standards for Effluent Discharge into Drainage and Sewerage Systems, Inland and Coastal Water

The Technical Memorandum (TM), *"Standards for Effluent Discharge into Drainage and Sewerage Systems, Inland and Coastal Waters"*, issued under Section 21 of the WPCO defines acceptable effluent discharge limits to different types of receiving waters. With regard to inland waters, there is no distinction between different zones and the beneficial use of the inland waters is the only factor governing the quality and quantity of the effluent that should be met. Under the TM, inland waters are classified into four groups. These are given below in **Table 5.1**.

Table 5.1 Different Groups of Inland Water Specified in the TM

Inland Water Grouping	Beneficial use
Group A	Abstraction for potable water supply
Group B	Irrigation
Group C	Pond fish culture
Group D	General amenity and secondary contact recreation

(Source: Adopted from Technical Memorandum of Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters)

For this Project both Group A and Group D waters prevail, as the Project encroaches on the Water Gathering Grounds as well as inland waters which are within the Study Area. The WQOs which prevail are given in **Table 5.2** and **Table 5.3**.

Table 5.2 Standards for Effluents Discharged into Group A Inland Waters (All units in mg/L unless otherwise stated; all figures are upper limits unless otherwise indicated)

Flow rate (m^3/day) Determinand	≤ 10	> 10 and ≤ 100	> 100 and ≤ 500	> 50 and ≤ 1000	> 1000 and ≤ 2000
pH (pH units)	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Temperature (°C)	35	35	30	30	30
Colour (lovibond units) (25mm cell length)	1	1	1	1	1
Conductivity (µg/c, at 20°C)	1000	1000	1000	1000	1000
Suspended solids	10	10	5	5	5
Dissolved oxygen	≥ 4	≥ 4	≥ 4	≥ 4	≥ 4
BOD	10	10	5	5	5
COD	50	50	20	20	10
Oil & Grease	1	1	1	1	1
Boron	2	2	1	0.5	0.5
Barium	2	2	1	0.5	0.5
Iron	2	2	1	0.5	0.5
Arsenic	0.05	0.05	0.05	0.05	0.05
Total chromium	0.05	0.05	0.05	0.05	0.05
Mercury	0.001	0.001	0.001	0.001	0.001
Cadmium	0.001	0.001	0.001	0.001	0.001
Selenium	0.01	0.01	0.01	0.01	0.01
Copper	0.2	0.2	0.2	0.2	0.1
Lead	0.1	0.1	0.1	0.1	0.1
Manganese	0.5	0.5	0.5	0.5	0.5
Zinc	1	1	1	1	1
Other toxic metals individually	0.1	0.1	0.1	0.1	0.1
Total toxic metals	0.3	0.3	0.2	0.2	0.15
Cyanide	0.05	0.05	0.05	0.05	0.02
Phenols	0.1	0.1	0.1	0.1	0.1
Hydrogen sulphide	0.05	0.05	0.05	0.05	0.05
Sulphide	0.2	0.2	0.1	0.1	0.1
Fluoride	1	1	1	1	0.5
Sulphate	800	600	500	400	200
Chloride	800	500	500	200	200
Total reactive phosphorus	1	0.7	0.7	0.5	0.5
Ammonia nitrogen	1	1	1	1	0.5
Nitrate + nitrite nitrogen	15	15	15	10	10
E. coli (count/100ml)	< 1	< 1	< 1	< 1	< 1

(Source: Adopted from *Technical Memorandum of Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*)

Table 5.3 Standards for Effluents Discharged into Group D Inland Waters

Flow rate (m^3/day) Determinand	≤200	>200 and ≤400	>400 and ≤600	>600 and ≤800	>800 and ≤1000	>1000 and ≤1500	>1500 and ≤2000	>2000 and ≤3000
pH (pH units)	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10
Temperature (°C)	30	30	30	30	30	30	30	30
Colour (lovibond units) (25mm cell length)	1	1	1	1	1	1	1	1
Suspended solids	30	30	30	30	30	30	30	30
BOD	20	20	20	20	20	20	20	20
COD	80	80	80	80	80	80	80	80
Oil & Grease	10	10	10	10	10	10	10	10
Iron	10	8	7	5	4	2.7	2	1.3
Boron	5	4	3.5	2.5	2	1.5	1	0.7
Barium	5	4	3.5	2.5	2	1.5	1	0.7
Mercury	0.1	0.05	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.1	0.05	0.001	0.001	0.001	0.001	0.001	0.001
Other toxic metals individually	1	1	0.8	0.8	0.5	0.5	0.2	0.2
Total toxic metals	2	2	1.6	1.6	1	1	0.5	0.4
Cyanide	0.4	0.4	0.3	0.3	0.21	0.1	0.1	0.05
Phenols	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Sulphide	1	1	1	1	1	1	1	1
Sulphate	800	600	600	600	600	400	400	400
Chloride	1000	800	800	800	600	600	400	400
Fluoride	10	8	8	8	5	5	3	3
Total phosphorus	10	10	10	8	8	8	5	5
Ammonia nitrogen	20	20	20	20	20	20	20	10
Nitrate + nitrite nitrogen	50	50	50	30	30	30	30	20
Surfactants (total)	15	15	15	15	15	15	15	15
E. coli (count/100ml)	1000	1000	1000	1000	1000	1000	1000	1000

(Source: Adopted from Technical Memorandum of Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters)

(All units in mg/L unless otherwise stated; all figures are upper limits unless otherwise indicated)

Water Quality Objectives (WQOs)

The *Water Pollution Control Ordinance* (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 whole Hong Kong waters are divided into ten Water Control Zones (WCZs). Water Quality Objectives (WQOs) were established to protect the beneficial uses of water quality in WCZs. WQOs relevant to this Project are given in **Table 5.4**.

Table 5.4 Marine Water Quality Objectives Relevant to the Western Buffer Water Control Zone

Parameter	Water Quality Objective
PH	to be in the range 6.5 – 8.5, and change due to waste discharge not to exceed 0.2
Salinity	Change due to waste discharge < 10% of natural ambient level
Temperature	Change due to waste discharge < 2 ^{o}C
Suspended Solids (SS)	Waste discharge not to raise the natural ambient level by 30% nor cause the accumulation of suspended solids which may adversely affect aquatic communities
Toxicants	Not to be present at levels producing significant toxic effect
Dissolved Oxygen (DO) (Bottom)	Not less than 2 mg/L for 90% samples
Dissolved Oxygen (Depth-averaged)	Not less than 4 mg/L for 90% samples
Nutrients	Annual mean depth averaged inorganic nitrogen not to exceed 0.4mg/L
Unionised ammonia	Annual mean not to exceed 0.021 mg/L
E. coli	Annual geometric mean not to exceed 610cfu/100mL (secondary contact recreation subzones and fish culture subzones)
Aesthetic Appearance	There should be no objectionable odours or discoloration of the water; tarry residues, floating wood, articles made of glass, plastic and rubber should be absent; mineral oil should not be visible; 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; water should not contain substances which settle to form objectionable deposits.

Source EPD, 2003: Marine Water Quality in Hong Kong 2003, WPCO (Version date 30/06/1997)

5.3 Assessment Methodology

The assessment area for the water quality assessment is 5km from the project boundary and according to the Study Brief includes the Fish Culture Zone at Ma Wan. In order to assess the impacts on receiving water during and following construction it is first necessary to define what activities will take place which could potentially affect water quality.

Construction of the Project will commence close to the outfall location. Essentially a platform will be created to receive a Tunnel Boring Machine (TBM) which will be used to drive the 5.13km tunnel, uphill. A cascade will be formed (shown on **Figure 5.2)** to attenuate the energy from the water prior to discharge via the outfall. The outfall will be formed and the discharge point will be 4.5mPD (well above top water level). This means that the stormwater will be discharged into the receiving water vertically, rather than as a horizontal jet which would be the case if the outfall was located below water level. The combination of cascade and above water level outfall combine to attenuate velocity of the discharge and minimise impacts on the receiving waters (in terms of turbulence, energy propulsion i.e. waves and disturbance to marine vessels). The outfall will also be visible and thus acts as a warning to marine users (in the event water is discharging from the outfall).

The 5.13km tunnel will be driven uphill which means that water generated at the face of the TBM (for cooling the cutter heads) , and any groundwater ingression to the tunnel will drain back out towards the outfall. No bentonite will be used so the water will not be contaminated with bentonite but may pick up fragments of rock debris and fine materials which will need to be screened out before discharge to the marine environment.

Two interceptor shafts and a tunnel inlet will be formed at the locations shown on **Figure 5.1.** The TBM will be driven from the outfall to Intakes I3, I2, and will emerge at Intake I1. Intake structures will be excavated using hand dug means until to a depth, whence drill and blast techniques would be used without causing undue impacts to the surface structures. The associated interceptor works at the Intake structures have been designed to intercept the flow only when the rainfall exceeds 30mm/hr. The design maintains streamflow at all other times and has no deleterious effect on downstream water quality or quantity. This is particularly important to note as the catchment supports local agricultural practices. The tunnel will be permanently lined and the drawdown of ground water table is envisaged to be insignificant if any. Moreover, since the majority of the tunnel will be driven through grade III or better rock of low permeability, water ingress during construction will be mainly from the rock joints and faults. With proper pre-grouting ahead of TBM driving, the drawdown of groundwater can be effectively controlled and the groundwater regime can be reinstated shortly after the tunnel is lined. The tunnel is therefore not expected to affect groundwater levels or the ecological resources above the tunnel. The sequencing of the construction works are illustrated on **Figures 5.3-5.6**. Reinstatement of the streamcourses is designed to be a progressive activity to minimise ecological and water quality impacts during construction.

No concrete batching is required on site. All concrete will be brought in precast segments (linings etc. for the tunnel) or as ready mixed concrete. There will be no washing out of concrete trucks permitted at the works sites (for ecological protection and space constraints).

Space constraints preclude the inclusion of wheelwashers at the outfall site, instead all vehicles will be washed down manually before returning to the main roads.

Stockpiling areas have been proposed for the three intake structures, as shown on **Figure 5.7**. It is envisaged that materials will be removed on a daily basis (due to site constraints and to minimise the extent of dust suppression measures i.e. water). Stockpiling will take place at the outfall structure between 7pm and 7am. An area of 800m^2 has been identified as working space for the stockpiling of overnight tunnel spoil. Adjacent to that area will be a sediment tank with a grille to catch/trap rocks and fragments conveyed by groundwater ingression and cooling water from the (cutter head) tunnelling works (see **Figure 5.8**).

Wastewater will also be generated by the workers on site, and as the sites are remote chemical toilets will be required.

Table 5.5 Potential Activities which could generate Water Quality Issues During Construction.

Summary Construction Activities with the Potential to Affect Water Quality	
Activity	**Effects**
Formation of platform to receive TBM	No reclamation required. No dredging. Offsite runoff generating aesthetic effects.
Tunnelling	Potential increases in suspended solids in receiving waters, aesthetic effects due to runoff of cooling waters, and ground water.
Interceptor structures	Offsite runoff and potentially increased suspended solids, oils/greases. Minimal disturbance to streambed which is generally rocky.
Streamcourse Diversion	Streams flows will be maintained to an acceptable standard throughout construction phase to maintain flows downstream to agricultural areas. Construction method proposed is pipe piles to provide diversion.
Stockpiling	Potential runoff from site during stockpiling dust suppression (ie wetting).
Washdown of Plant and Equipment	Change in pH, aesthetic quality and suspended solids.
Domestic effluent	*E. coli*, suspended solids, BOD etc.

Once operational, the outfall will convey stormwater from the upper reaches of the catchment to the Rambler Channel and discharge via the outfall cascade. The peak flow rate for the stormwater will be 210m^3/s. In general, the discharge flow rate is just about 72.5m^3/s. The flow will be attenuated via the cascade channel, and ultimately the rip rap which will be laid on the seabed. The velocity at the point of entry to the marine environment will be approximately 2.5m/s for 1 in 200-year design flow and will be discharged at 4.5 mPD. The majority of the energy will dissipate within less than 10m of the point of entry and the effects on the marine environment will be dissipated in close proximity to the entry point. Salinity changes in the immediate proximity of the point of entry will be rapidly diluted. In the vicinity of the outfall the seabed will be protected by rip rap (to avoid erosion). Potential changes to flows, sediment regimes and water quality impacts downstream are considered to be negligible, and thus no hydrodynamic or water quality modelling has been undertaken. An assessment of the potential effects on receiving water quality has been made using the rainfall data in Tsuen Wan area and the baseline monitoring statistics (refer to *Section 5.6.2*).

The assessment methodology adopted has been to define the construction and operational aspects which could affect receiving waters, to determine the baseline conditions and sensitive receivers, and to determine the extent of impacts on the receiving environment and sensitive receivers. The assessments will be quantified as far as practical and will follow the requirements of the Study Brief discounting any issues with reasons as appropriate.

5.4 Baseline Conditions/ Sensitive Receivers

5.4.1 Baseline Conditions

The marine aspects of the Study Area include in the nearfield the Rambler Channel which is encompassed by the Western Buffer Water Control Zone and the Victoria Harbour Water Control Zone. Within the Study Area water quality is dominated by the disposal of treated effluent from the Stonecutters Island Sewage Treatment Plant, the activities at the container terminals, the shipyards, typhoon shelter activities and the Tsuen Wan beaches (which are closed for bathing) which are located within the 5km radius of the project boundary. (Refer to **Figure 5.1**).

5.4.2 Water Quality Monitoring

The baseline Water Quality Monitoring Report is attached as **Appendix E** which was conducted under normal weather conditions. There were 8 monitoring tests in total, in which 6 tests were in dry weather conditions while another 2 events were carried out after rain. In accordance with the Study Brief water quality sampling (such as Temperature, pH value, Electrical Conductivity, Dissolved Oxygen Content, Turbidity, Flow Rate, Suspended Solids, Total Nitrogen Content, Biochemical Oxygen Demand and Escherichia Coli Count) was carried out under different conditions to characterise the streams in the Study Area. The Intake I1 is characterised by urban runoff, with much debris and refuse (refer to Part V of **Appendix E**). At Intakes I2, I3 the water quality appears to be better, although there is evidence of human activity (sewage discharges) in the water body (refer to Part V of **Appendix E**). A summary of water quality parameters tested at the intakes is given in **Table 5.6**.

Table 5.6 Water Quality at Intake Structures

Wet										
Intake	***TSS***	***BOD_5***	***TN***	***E. Coli***	***Temp***	***Conduct***	***DO***	***Turbidity***	***pH***	***Flowrate***
I1	**23** (3-42)	**5** (3-6)	**2.2** (1.7-2.7)	**7.9x10^4** (2.8x10^4-1.3x10^5)	**21.5** (19.8-23.2)	**142.6** (141.8-144.1)	**8.4** (7.9-8.9)	**18.5** (3.2-33.9)	**7.8** (7.7-8)	**47.5** (26.6-68.4)
I2	**<2**	**<3**	**1.3** (1.2-1.4)	**3.6x10^4** (7.4x10^3-6.5x10^4)	**21.8** (19.9-23.7)	**118.3** (105.8-130.5)	**7.4** (6.9-7.9)	**2.2** (1.8-2.7)	**7.5** (7.4-7.5)	**221.0** (198-244)
I3	**<2**	**<3**	**1.0** (0.8-1.2)	**6x10^5** (1.6x10^2-1.2x10^6)	**21.6** (19.5-23.7)	**98.0** (95.2-100.4)	**8.3** (8.1-8.5)	**2.0** (0.9-3.2)	**7.6** (7.5-7.7)	**311.5** (254-369)
Dry										
Intake	***TSS***	***BOD_5***	***TN***	***E. Coli***	***Temp***	***Conduct***	***DO***	***Turbidity***	***pH***	***Flowrate***
I1	**30** (2-160)	**<3**	**2.4** (1.8-3.4)	**4.4x10^4** (8.9x10^3-1.2x10^5)	**22.5** (20.3-23.4)	**133.0** (114.6-166.2)	**8.9** (8.4-10)	**21.3** (2.4-110)	**7.9** (7.2-8.5)	**32.4** (28.3-37.6)
I2	**<2**	**<3**	**2.1** (1.3-5.8)	**3.7x10^4** (9.4x10^3-1.2x10^5)	**23.3** (21.7-23.8)	**115.2** (107.4-132.4)	**8.3** (7.5-9.3)	**2.1** (1.4-3.1)	**7.4** (7-7.7)	**142.8** (46.6-236)
I3	**<2**	**<3**	**1.0** (0.4-1.4)	**1.1x10^3** (3.4x10^2-4.3x10^3)	**22.7** (21.4-23.5)	**92.5** (86.5-101.3)	**8.7** (8.3-10)	**1.7** (1.1-2.4)	**7.5** (6.9-8)	**362.8** (283-453)
Compliance										
Intake	***TSS***	***BOD_5***	***TN***	***E. Coli***	***Temp***	***Conduct***	***DO***	***Turbidity***	***pH***	***Flowrate***
I1	✗	✓	✓	✗	✓	✓	✓	NA	✓	NA
I2	✓	✓	✓	✗	✓	✓	✓	NA	✓	NA
I3	✓	✓	✓	✗	✓	✓	✓	NA	✓	NA

Notes: TSS = Total Suspended Solids, mg/l
BOD_5 = Biochemical Oxygen Demand, mg/l

TN = Total Nitrogen Content, mgN/l
E. Coli = Escherichia coli count, cfu/100ml
Temp = Temperature, ºC
Conduct = Conductivity, μmhos/cm
DO = Dissolved Oxygen, mg/L
Turbidity = Turbidity, NTU
pH = pH, unit
Flowrate = Flowrate, m^3/hr
NA = Not applicable, no standard for the parameter.
Data presented in bold are average values and the ranges are shown in brackets.

It is noted that *E. coli* exceeds the permitted standards for all intake points and TSS exceeds the standard at Intake I1. As noted from site visits the water quality at I1 was characterised by urban runoff and evidence of sewage deposits.

5.4.3 Marine Water Quality

The EPD marine water quality monitoring data routinely collected in the vicinity of the site, which documents the water quality in Western Buffer and Victoria Harbour WCZs have been used. The EPD monitoring stations of most relevance (i.e. in the vicinity of outfall) include WM4, VM12 and VM14, as shown in **Figure 5.1**. A summary of the most recently published EPD monitoring data (for the year 2003) collected at these stations are presented in **Table 5.7**.

Table 5.7 Baseline Marine Water Quality Data 2003

Parameter	Tsing Yi West		Rambler Channel			
	WM4		VM12		VM14	
Number of Samples	12		12		12	
Temperature	23.5	(17.4 - 28.0)	23.6	(17.5 - 28.0)	24.0	(17.6 - 28.3)
Salinity	31.4	(27.6 - 33.5)	31.1	(25.3 - 33.3)	29.3	(15.4 - 33.3)
Dissolved Oxygen (mg/L)	5.2	(3.1 – 6.9)	5.1	(3.8 - 6.3)	5.5	(4.6 - 6.5)
(bottom)	4.9	(1.9 – 7.0)	4.8	(2.2 - 6.4)	5.2	(3.3 - 6.6)
Dissolved Oxygen (% Saturation)	73	(45 - 88)	71	(54 - 86)	78	(69 - 85)
(bottom)	69	(29 - 88)	67	(32 - 87)	73	(47 - 87)
pH	8.1	(7.9 – 8.3)	8.1	(7.8 - 8.2)	8.1	(7.9 - 8.3)
Secchi Disc Depth (m)	2.2	(1.4 – 4.1)	2.0	(1.2 - 3.5)	1.9	(0.9 - 3.9)
Turbidity (NTU)	11.9	(6.6 – 19.2)	11.6	(5.8 - 15.9)	11.4	(5.4 - 20.7)
Suspended Solids (mg/L)	9.6	(2.7 – 18.5)	10.5	(4.8 - 16.2)	7.1	(3.4 - 10.0)
5-day Biochemical Oxygen Demand (mg/L)	0.7	(0.4 – 1.0)	0.8	(0.7 - 1.1)	0.9	(0.6 - 1.3)
Ammonia Nitrogen (mg/L)	0.10	(0.01 – 0.23)	0.17	(0.04 - 0.29)	0.14	(0.03 - 0.27)
Unionised Ammonia (mg/L)	0.005	(<0.001 - 0.008)	0.008	(0.002 - 0.013)	0.006	(0.002 - 0.010)
Nitrite Nitrogen (mg/L)	0.04	(<0.01 - 0.11)	0.04	(0.01 - 0.12)	0.06	(0.01 - 0.18)
Nitrate Nitrogen (mg/L)	0.16	(0.02 – 0.40)	0.17	(0.03 - 0.53)	0.25	(0.03 - 0.83)
Total Inorganic Nitrogen (mg/L)	0.29	(0.13 – 0.50)	0.39	(0.25 - 0.68)	0.44	(0.20 - 1.04)
Total Kjeldahl Nitrogen (mg/L)	0.21	(0.15 – 0.31)	0.31	(0.20 - 0.40)	0.28	(0.23 - 0.35)
Total Nitrogen (mg/L)	0.40	(0.19 – 0.64)	0.53	(0.35 - 0.84)	0.58	(0.31 - 1.27)
Orthophosphate Phosphorus (mg/L)	0.022	(0.02 – 0.03)	0.032	(0.02 - 0.04)	0.029	(0.02 - 0.04)
Total Phosphorus (mg/L)	0.04	(0.03 – 0.06)	0.05	(0.04 - 0.06)	0.04	(0.03 - 0.06)
Silica (as SiO2) (mg/L)	1.1	(0.5 – 2.7)	1.2	(0.5 - 3.1)	1.5	(0.5 - 4.7)
Chlorophyll-a (μg/L)	2.6	(0.4 – 8.9)	2.4	(0.3 - 7.8)	3.9	(0.4 - 15.0)
E .coli (cfu/100mL)	1400	(200 - 7700)	5400	(2400 - 14000)	1700	(470 - 12000)
Faecal Coliforms (cfu/100mL)	2900	(420 - 17000)	12000	(4600 - 33000)	3400	(770 - 25000)

Source: EPD (2003) – Marine Water Quality in Hong Kong in 2003

Unless otherwise specified, data presented are depth-averaged (A) values calculated by taking the means of three depths: Surface (S), Mid-depth (M), Bottom (B).
Data presented are annual arithmetic means of the depth-averaged results except for *E. coli* and faecal coliforms which are annual geometric means.
Data in brackets indicate the ranges.

The Harbour Area Treatment Scheme Stage 1 was commissioned in 2002 with the consequential influences in receiving water quality. In 2002 the Western Buffer WCZ exhibited a slight increase in dissolved oxygen (DO) by 0.2-0.5mg/L (4-9%) was observed although the level of ammonia nitrogen (NH_4-N) was similar to the previous year. By comparison orthophosphate phosphorus and total phosphorus showed a substantial decrease in 2002, reaching their lowest levels in recent years in 2003.

The levels of suspended solids (SS) remain high (with the exception of WM1). As the sand abstraction in the northern part of East Lamma Channel Marine Borrow Area has ceased in 2002, the SS at WM1 dropped by some 40% and returned to the normal level which is largely due to the abstraction of sand from the South Tsing Yi Marine Borrow Area and the dumping of mud at two marine disposal sites at South Tsing Yi. The Study Area is also influenced by the Public Filling Area of North Tsing Yi.

From the data reviewed and presented in **Table 5.7** it is apparent there is full compliance with the water quality objectives. Furthermore, to reduce pollution around the Tsuen Wan area, the Government constructed a new Sewage Treatment Works at Sham Tseng with new sewerage planned along the Castle Peak Road to serve the unsewered villages and developments in Tsuen Wan, Sham Tseng and Tsing Lung Tau (this would be expected to reduce the background pollution load at Intake I1). While this will improve water quality locally, the effluent discharged from the Stonecutters Island STW under the HATS Stage 1 has been observed to cause elevated bacterial counts in the marine waters of Tsuen Wan beaches.

5.4.4 Bathing Beach Water Quality

Eight gazetted beaches are located within the Tsuen Wan District. It is of note that this is the only district where gazetted beaches do not meet the WQO’s due to pollution loadings from unsewered villages (plans are in place to remedy this) and the Sham Tseng Nullah. Apart from the Ma Wan Tung Wan beach all other beaches have been closed to the public (the latest closures being in 2003). A general deterioration of water quality at all beaches in the district has been observed and although EPD continues to monitor the beaches it is unlikely these will open unless a significant improvement can be observed. **Figure 5.9** shows the water quality of these gazetted beaches.

The poor water quality of the Tsuen Wan beaches is attributed to pollutants discharged from their unsewered hinterland, the polluted Sham Tseng Nullah and the relatively high bacterial level in the marine water off the Tsuen Wan coast. These are all important aspects to consider in the current context,

5.4.5 River Water Quality

The main river within the Study Area which is monitored by EPD is the Sam Dip Tam Stream (refer to **Table 5.8**). It has a catchment area of 4.5 km^2, runs through Tsuen Wan and drains into Rambler Channel through an underground box culvert.

Since the declaration of the Victoria Harbour Water Control Zone (Phase I), the Water Quality Objective (WQO) compliance of Sam Dip Tam Stream has improved steadily from 72% in 1994 to 98% in 2001, 96% in 2002 and 95% in 2003. A significant improvement has been noted in dissolved oxygen (EPD, 2003).

The Water Quality Index (WQI) of Sam Dip Tam was upgraded to "excellent" in 2003 for the middle reaches of the stream although high *E. coli* levels were counted mainly due to the sewage from unsewered villages in the catchment. EPD "stepped up enforcement measures against polluters" to the Sam Dip Tam Stream (EPD, 2003). **Figure 5.10** shows the water quality index of Sam Dip Tam Stream and its tributaries.

Table 5.8 Baseline River Water Quality Data 2003

Parameter	Unit	Sam Dip Tam Stream		
		TW1	TW2	TW3
Dissolved Oxygen	mg/L	7.0 (6.4 – 8.3)	8.3 (7.6 – 9.5)	7.9 (7.1 – 9.7)
PH		7.4 (7.1 – 7.8)	7.9 (7.5 – 8.2)	7.5 (7.2 – 7.8)
Suspended Solids	mg/L	4 (1 – 56)	2 (1 – 5)	5 (2 – 23)
5-day Biochemical Oxygen Demand	mg/L	3 (1 – 120)	5 (1 – 7)	2 (1 – 5)
Chemical Oxygen Demand	mg/L	6 (2 – 24)	8 (2 – 13)	6 (2 – 16)
Oil & grease	mg/L	0.5 (0.5 – 1.1)	0.5 (0.5 – 1.3)	0.5 (0.5 – 1.2)
Faecal Coliforms	(cfu/100mL)	190,000 (54,000 – 4,600,000)	410,000 (57,000 – 3,000,000)	44,000 (11,000 –3,200,000)
E. coli	(cfu/100mL)	8,100 (1,600 – 18,000)	100,000 (39,000 – 330,000)	17,000 (6,500 – 120,000)
Ammonia Nitrogen	mg/L	0.04 (0.01 – 0.34)	0.27 (0.08 – 0.88)	0.20 (0.07 – 0.38)
Nitrate Nitrogen	(mg/L)	0.62 (0.42 – 1.70)	1.10 (0.88 – 1.90)	1.50 (1.00 – 2.20)
Total Kjeldahl Nitrogen, SP	(mg/L)	0.20 (0.06 – 1.80)	0.55 (0.11 – 1.20)	0.42 (0.18 – 0.73)
Orthophosphate	(mg/L)	0.05 (0.02 – 0.07)	0.20 (0.07 – 0.37)	0.18 (0.11 – 0.28)
Total Phosphorus, SP	(mg/L)	0.09 (0.06 – 0.13)	0.24 (0.07 – 0.40)	0.22 (0.17 – 0.38)
Sulphide, SP	(mg/L)	0.02 (0.02 – 0.04)	0.02 (0.02 – 0.02)	0.02 (0.02 – 0.02)
Aluminium	µg/L	60 (50 – 2,600)	65 (50 – 240)	95 (50 – 220)
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 – 3)	1 (1 – 1)	1 (1 – 1)
Copper	µg/L	2 (2 – 7)	4 (2 – 8)	4 (3 - 11)
Lead	µg/L	1 (1 – 11)	2 (1 – 10)	4 (1 - 12)
Zinc	µg/L	20 (10 – 50)	20 (10 – 30)	20 (10 - 40)

Parameter	Unit	Sam Dip Tam Stream		
		TW1	TW2	TW3
Flow	L/s	NM	23 (15 – 150)	NM

Notes: 1. Data presented are in annual medians of monthly samples; except those for faecal coliforms and *E. coli* which are in annual geometric means.
2. Figures in brackets are annual ranges.
3. NM indicates no measurement taken.
4. cfu - colony forming unit.
5. SP - soluble and particulate fractions i.e. total value.
6. Values at or below laboratory reporting limits are presented as laboratory reporting limits.
7. Equal values for annual medians (or geometric means) and ranges indicate that all data are the same as or below laboratory reporting limits.

5.5 Sensitive Receivers

5.5.1 Definitions

Sensitive receivers have been identified in these potentially affected areas under the broad designations of gazetted and non-gazetted bathing beaches, water intakes, fish culture zones (also refer to *Section 10*), sites of ecological value (also refer to *Section 7*), water recreational areas as well as the water gathering grounds. The identified sensitive receivers in each of these categories are as follows:

5.5.2 Bathing Beaches

There are 8 gazetted bathing beaches and 2 non-gazetted bathing beaches in the vicinity of the Study Area (as shown in **Figure 5.1**); Ma Wan Tung Wan Beach (gazetted); Gemini Beach (gazetted); Ho Mei Wan Beach (gazetted); Casam Beach (gazetted); Lido Beach (gazetted); Ting Kau Beach (gazetted); Approach Beach (gazetted); Anglers' Beach (gazetted); Dragon Beach and Tsing Lung Tau Beach. Approach Beach is the nearest bathing beach 650m from the proposed outfall O1.

The only beach which remains open is the Tung Wan Beach on Ma Wan. The others have been closed progressively and most recently have been affected by the discharge of effluent from the Harbour Area Treatment Scheme (HATS) 1 Outfall. The treatment provided to effluent at Stonecutters Island is not specifically intended to remove *E. coli* and while there are improvements in water quality due to removal of other pollutants, *E. coli* remains a problem. This situation will only improve with the introduction of later stages of HATS.

5.5.3 Fish Culture Zone

The Ma Wan Fish Culture Zone (FCZ) has an area of 46 300 m^2, is a Water Sensitive Receiver (WSR) in relation to the current Project as defined in the Study Brief and is located some 4.4km from the project Boundary. During construction the water discharged to the receiving environment will be from cooling the cutters of the TBM and any groundwater ingression to the tunnel. This will be screened prior to discharge to remove any silt and debris, and given the distance between the FCZ and the outfall location it is not expected that the effects would be perceived at the latter. No dredging or reclamation is required for the construction of the outfall, and the only seabed activity will be the placing of rip rap and thus no water quality modelling was undertaken as there is no disturbance or modification to the seabed.

5.5.4 Water Recreational Areas

The closest water recreation areas are the bathing beaches which are discussed above. The Rambler Channel is not an area renowned for other secondary contact recreational sports.

5.5.5 Water Gathering Grounds

The boundary of the Water Gathering Grounds (WGG) is illustrated on **Figure 5.1** which indicates that all works are downstream of this sensitive receiver. No works will be carried out in the WGG and thus this aspect is not considered further.

5.5.6 Future Planned Water Sensitive Receivers

There are no future planned sensitive receivers in the vicinity of the Project, although reference is made to a "proposed ecological park". From discussions with Government it has been established that there are no details yet for the proposed ecological park, its function or the timing of the facility. No details other than the proposed boundary are known. As such it is more prudent for this EIA to acknowledge the future use and recognise the constraints in the LVIA (i.e. reduce the scale of built facilities as far as possible).

5.6 Impact Assessment

5.6.1 During Construction

The preliminary designs have been progressing with the intention of avoiding environmental impacts wherever possible. The assessments for the construction phase are by default qualitative rather than quantitative. **Table 5.9** provides a summary of the construction activities and potential impacts. From that a series of mitigation measures have been defined.

Table 5.9 Summary of Construction Activities and Potential Impacts

Summary Construction Activities with the Potential to Affect Water Quality			
Activity	**Assessments**	**Mitigation Measures**	**Monitoring**
Formation of platform to launch TBM	Established that the site is already formed. No reclamation required. No dredging. Impacts relate to potential off-site runoff. Minor impact	Sandbags or other measures to provide bunds around the perimeter.	Visual as part of routine audits
Tunnelling	Potential effects if not controlled could include discharge of a plume with suspended materials. Water generated by cooling cutterheads and ingress from groundwater, visual/aesthetic impacts.	Provision of a sedimentation tank at the 800m^2 working area. Provision of grille to trap coarse fragments, water floors over grille, sediments drop out, clear water discharged	Required to check frequently of sediment runoff from the sedimentation tank
Interceptor structures	Assessments undertaken to ensure avoidance of direct works within the streamcourses. Once the shaft is created the works are confined within the shaft/adit tunnel and impacts on streamcourses are	Designed to minimise impacts	Visual as part of routine audits

Summary Construction Activities with the Potential to Affect Water Quality			
Activity	**Assessments**	**Mitigation Measures**	**Monitoring**
	avoided. Moderate impact		
Streamcourse Diversion	Designs developed to maintain the flows, minimise the temporary and permanent land disturbance, no direct impact on flows which will be maintained. Moderate impact	Designs mitigate impacts	Visual as part of routine audits
Stockpiling	Assessments focussed on identifying the locations of the stockpiles, the potential impact such as runoff, and providing a suite of measures to avoid or minimise impacts. Site runoff generated as a result of daily activities and exacerbated during rainstorms would result in high levels of suspended sediments being discharged into the streams and receiving waters. Pretreatment of such wastewaters is required before discharge to receiving waters and as a minimum would need sedimentation tanks to be established at each intake/outfall where the dewatering activities take place. Moderate impact	Provision of tarpaulins or similar over stockpiles wetting with minimal water. Sandbags around the perimeter to prevent off site runoff. See also Section 5.9.1 for precautions/actions prior to and during rainstorms. Also note that the ProPECC Note PN 1/94 on construction site drainage must be strictly adhered to.	Visual as part of routine audits
Washdown of Plant and Equipment	Will be carried out offsite. Small quantities of wastewaters from maintenance and repair of equipment could be generated at each intake structure. This is likely to generate very small quantities of wastewater which should be collected, contained and disposed of as chemical waste to avoid discharge to the receiving water. To this case the Contractor would need to register as a Chemical Waste User. Minor impact due to small quantities	An area for this activity should be provided with and covered.	Visual as part of an site audits
Domestic effluent	Provision of chemical toilets required. Domestic Wastewater will be generated at each intake structure, outfall and any other worksite. Provision shall be made at each worksite for mobile toilets, should there be no convenient public facilities (only possible at Intake 1). These should be provided under agreement with a reputable wastewater collection service. Negligible impact	Chemical toilets to be provided.	Monitor to determine frequency of collection /disposal. As part of routine site audits. If potential problems occur, increase frequency.

5.6.2 During Operation

As described at the beginning of this EIA the justification for this project is based on minimising the effects of flooding. The interceptor systems and conveyance tunnel have been designed to come into effect once the rainfall exceeds 30 mm/hr. This is the basis of design. This means that:

- For the majority of the year the streams in the Study Area will be flowing normally. This assumption has been based on the interpolation of rainfall data for Tsuen Wan and Kwai Chung. Rainfall records for Tsuen Wan and Kwai Chung in 1999 – 2001 have been interrogated and the number of days the rainfall exceeded 30mm/hr was ascertained refer to **Table 5.10**. These 3-consecutive-year data have been used in the development of the drainage tunnel design, and more than normal rainfall was recorded in these 3 years, so the adopted value is considered to be conservative and in line with the design. These data were then interpolated and an annual estimated volume of rainwater entering the tunnel was calculated and used as the basis for design of the tunnel (size). This annual rainfall has been estimated on the basis of Tsuen Wan and Kwai Chung rainfall records to be 0.622Mm^3. Taking the average frequency of tunnel usage to be 28 days this equates to an estimated 22,214m^3 discharge per event.

Table 5.10 No. of Days Rainfall Exceeds 30mm/hr 1999 - 2001

Year	No. of Days
1999	20
2000	29
2001	35
Average over 3 years (basis of tunnel design)	28

- It should be noted that the quantity of water in the streams is not affected except on those occasions where a rainstorm of >30 mm/hr occurs. At all other times the stream flows are maintained. The streamflow maintained to the downstream rivers/ channels under various rainfall events are shown in **Table 5.11**. Compared with the EPD monitoring results in Sam Dip Tam (Intake I-2) and other flow data taken during the water quality monitoring (summarized in **Table 5.12**), under rainfall events with intensities equal 30mm/hr, the stream flow maintained to the downstream rivers/ channels are still larger than the normal ranges of flow and only excessive streamflow will extracted from the rivers/ channels by the drainage tunnel. No effect will be experienced by downstream agricultural uses except the benefits of protection from erosion when the rainfall exceeds 30mm/hr. There will be no drawdown effect on the water table, and a programme of monitoring is included to demonstrate this.

Table 5.11 Streamflow Maintained to the Downstream Rivers/ Channels

	Intake I-1		**Intake I-2**		**Intake I-3**	
Rainfall events	Existing flow (m^3/s)	Remaining flow to downstream (m^3/s)	Existing flow (m^3/s)	Remaining flow to downstream (m^3/s)	Existing flow (m^3/s)	Remaining flow to downstream (m^3/s)
200-yr	62.79	3.42	80.38	26.98	252.47	155.38
50-yr	48.40	3.57	62.05	23.55	194.90	123.08

	Intake I-1		Intake I-2		Intake I-3	
10-yr	36.09	3.33	46.32	20.32	145.48	98.46
2-yr	19.95	2.98	25.69	15.46	80.69	59.41
30mm/hr	2.25	1.98	10.29	10.26	14.38	14.37

Table 5.12 Range of Streamflow under Normal Conditions

Location	Streamflow maintained to downstream rivers/ channel when rainfall intensities = 30mm/hr	Streamflow recorded during water quality surveys (October to December 2003)	EPD's montoring (extracted from River Water Quality in Hong Kong in 2003)
Intake I-1	1.98 m^3/s	0.007 - 0.019 m^3/s	-
Intake I-2	10.26 m^3/s	0.016 - 0.068 m^3/s	0.015 - 0.15 m^3/s
Intake I-3	14.37 m^3/s	0.071 - 0.126 m^3/s	-

- There will be no deleterious effect on the downstream uses of the stream (agriculture or irrigation) as the tunnel will only take surplus stormwater, following a rainstorm of >30 mm/hr. At all other times the streams will flow unimpeded. Also, water for the agricultural activities is extracted from the adjacent stream. It could be said that the tunnel protects the downstream areas not only in the urban areas but also protects agricultural users from washout/erosion of crops (refer to **Figures 5.11** to **5.12**).

- The tunnel will discharge water as it is received ie no stagnation of water which could lead to potential vector breeding grounds or malodors.

- In terms of water quality impacts, the design of the interceptors and collection systems are such that screening of silts and debris (e.g. floating materials, vegetation) will take place before the water enters the tunnel. **Figure 5.13** shows the details of trash grills to be installed at intakes. The trash grill has a spacing of 200mm x 200mm which can screen debris with the minimum size of 200mm, and the sand traps at Intakes I2 and I3 are estimated to screen off the particles larger than 2.06mm and 14.92mm respectively in 200-year design.

- To minimise maintenance works and to protect receiving water quality the shaft designs have been developed to avoid ingress of silt and debris rats/rodents and other vermin into the tunnel. The fact that stormwater will flow by gravity will also prevent ponding of stormwater within the tunnels thereby minimising breeding grounds for vectors.

Estimation of Pollution Loads

The quantity of the water entering the tunnels has been estimated using the information obtained from the rainfall events and the baseline monitoring and site inspections used to predict water quality. The estimated quantity of water conveyed in the tunnels each event is estimated to be on average 22,214m^3. To assess the quality of the rainwater the monitoring data collected has been interpreted to estimate the average pollution loads at each intake (taking the concentrations, mg/l or cfu/100ml, and flow data, m^3/hr, from the monitoring data which is contained in **Appendix E**). From the baseline data provided the average pollution loads in the stream at present are presented in **Table 5.13**.

Table 5.13 Estimated Average Pollution Loads

	Total Suspended Solid	BOD_5	Total Nitrogen Content	E. Coli
Average Pollution Loads at Intake I1	819 g/hr	119 g/hr	80 gN/hr	$1x10^{10}$ cfu/hr
Average Pollution Loads at Intake I2	325 g/hr	487 g/hr	270 gN/hr	$6x10^{10}$ cfu/hr
Average Pollution Loads at Intake I3	700 g/hr	1,050 g/hr	360 gN/hr	$5x10^{9}$ cfu/hr

It is reasonable to assume that not all the current pollution loads in the streams will be conveyed via the tunnels (some will be discharged via the stream courses prior to the tunnel becoming operational, some will be screened out by the mechanisms designed into the intake structures as mentioned earlier).

The portion of the pollution load may be conveyed is assumed to be the same as average design rate for the interception at intake. The pollution loads are therefore assumed to be 88%, 50% and 30% of the average pollution loads at Intakes I1, I2 and I3, respectively. The total pollution loads have then been used in concert with the estimated volume of water per event to obtain a predicted concentration at outfall (refer to **Table 5.13**). Using the worst case assumption that the three intake structures operate at the same time for the full duration of the rainstorm event, the concentration of the discharge at the outfall has been estimated and shown in **Table 5.13**. Since the predicted pollution concentration of discharge is significantly lower than that of the background receiving water (Rambler Channel), the tunnel discharge would indeed dilute the pollution concentration in Rambler Channel. Take account of the average discharge flowrate and the flowrate of Rambler Channel together with the baseline water quality (data obtained from Rambler Channel monitoring station VM14 in 2003), then the diluted concentration and associated dilution percentage to baseline could be predicted as shown in **Table 5.14**. A sample calculation is presented below:

Take the calculation of total suspended solid as an example:

- Total Pollution Load from all 3 Intakes = 88% x 819g/hr +50% x 325g/hr + 30% x 700g/hr
= 1,093g/hr
- Predicted Pollution Concentration at Outfall = 1,093g/hr x 1hr / 22,214 m^3
= 0.05 mg/l
- Diluted Concentration in Rambler Channel
= (0.05 mg/l x 72.5m^3/s + 7.1 mg/l x 2,280m^3/s) / (72.5m^3/s + 2,280m^3/s)
= 6.9 mg/l
- Dilution Percentage to Baseline = 6.9 mg/l / 7.1 mg/l x 100%
= 97%

Table 5.14 Estimated Pollution Concentration

	Total Suspended Solid	BOD_5	Total Nitrogen Content
Total Pollution Loads from all 3 Intakes	1,093 g/hr	663 g/hr	314 gN/hr
Predicted Pollution Concentration at Outfall	0.05 mg/l	0.03 mg/l	0.01 mgN/l

	Total Suspended Solid	**BOD_5**	**Total Nitrogen Content**
Baseline Concentration in Rambler Channel	7.1 mg/l	0.9 mg/l	0.58 mgN/l
Diluted Concentration in Rambler Channel	6.9 mg/l	0.9 mg/l	0.56 mgN/l
Dilution Percentage to Baseline	97%	97%	97%

Notes: 1 Assuming all 3 intakes will be operating at the same time.
2 Using the average interception rate at Intakes I1, I2 and I3 which are 88%, 50% and 30%, respectively.
3 The estimated average volume of water is 22,214m^3 per event.
4 Assuming the duration of rainfall is 1 hour on average for each event.
5 The baseline data was taken from Rambler Channel monitoring station VM14 in 2003.
6 The average discharge flowrate is 72.5m^3/s.
7 The flowrate of receiving water (Rambler Channel) is about 2,280m^3/s.

The above estimation shows the general scenario that the pollution concentration of the tunnel discharge during rainfall events is significantly lower than the background receiving water quality (refer to **Tables 5.7** and **5.14**) and would not compromise Water Quality Objectives (WQO). In case of the 1 in 200-year rainstorm event, the interception rates at Intakes I1, I2 and I3 relate to 94%, 66% and 38% of the design capacity. Although larger pollution loads would be conveyed from the streams via the tunnel, the pollution concentration would be, at the same time, diluted by the heavy rainfall such that the pollution concentration at outfall would be indeed lower than the above estimation and also far below the WQO discharge effluent standards.

Pollution Dispersion

Reference to **Table 5.6** indicates TSS of up to 30mg/L, however this load will not be fully conveyed in the tunnel but rather ‘screened out or flushed downstream’ at the beginning of the rainstorm event. The predicted TSS in tunnel discharge is 0.05mg/l (refer to **Table 5.14**) which is minimal and the discharge would in fact dilute the pollution concentration in Rambler Channel. Also having consideration of the dispersion effect, the water quality of the nearest bathing beach (Approach Beach) 650m away from outfall will be improved by the stormwater discharge. It should be stressed that there are plans to improve the pollution loads generated in the catchment area through implementation of sewerage improvement schemes.

Moreover, the tunnel is only operational on average 28 times per annum. Even if the Approach Beach was open to public for swimming there would be no visible effect from the drainage tunnel as there are mechanisms in place to screen out pollutants. The portion of the stormwater which is intercepted is also natural stormwater generated when the rainfall exceeds 30mm/hr. The aesthetic WQO will therefore be complied with, and charges in salinity will be confined to the immediate point of discharge (which will disperse rapidly), thus the effects on the beaches (closed to swimmers) will be negligible. It is also worthy of note that the water discharged from this outfall will be much less polluted than other drainage outfalls as the project is designed to only pick up natural stormwater and the intakes will screen out debris, vegetation and sediments by the installation of trash grill and sand trap.

Estimation of *E. Coli*

E. coli is a key parameter for the water quality especially in bathing beach. The Water Quality Objectives for the Water Control Zones and bathing beaches in terms of the annual geometric mean of *E. coli* are not exceeding 610cfu/100ml and 180cfu/100ml respectively, while the standard for effluents discharged into Rambler Channel and Group D inland waters should be less than 1,000cfu/100ml.

The same approach of estimating other parameters (TSS, BOD_5 and total nitrogen content) has been adopted to predict the *E. coli* concentration at outfall and the dilution. The estimated results are presented in **Table 5.15**.

Table 5.15 Estimated E. Coli Concentration

	E. Coli
Total Pollution Loads from all 3 Intakes	$4x10^{10}$ cfu/hr
Predicted Pollution Concentration at Outfall	181 cfu/100ml
Baseline Concentration in Rambler Channel	1,700 cfu/100ml
Diluted Concentration in Rambler Channel	1,653 cfu/100ml
Dilution Percentage to Baseline	97%

Notes: 1 Assuming all 3 intakes will be operating at the same time.
2 Using the average interception rate at Intakes I1, I2 and I3 which are 88%, 50% and 30%, respectively.
3 The average duration of rainfall is 1 hour per event.
4 The estimated average volume of water is $22,214m^3$ per event.
5 The data was taken from Rambler Channel monitoring station VM14 in 2003.
6 The avearge discharge flowrate is $72.5m^3/s$.
7 The flowrate of receiving water at Approach Beach is about $2,280m^3/s$.

The discharged level of *E. coli* at outfall is only about 181cfu/100ml on average which is well below the WQO of 1,000cfu/100ml. The source of *E. coli* is mainly due to the discharge from unsewered villages in the catchment which create a relatively high background count for *E. coli* in the streams.

The *E. coli* concentration predicted at outfall is significantly lower than the WQO standard and the background concentration, so the stormwater discharge would provide dilution in Rambler Channel. It should be noted that the nearest sensitive receiver Approach Beach has already been closed since 1996 due to the very poor water quality. The geometric mean of *E. coli* recorded at Approach Beach over last 10 years is around 663 cfu/100ml (refer to **Table 5.16** and **Figure 5.9**). By proportional method, the *E. coli* count at Approach Beach is estimated to be reduced to 645 cfu/100ml (= 663 cfu/100ml x 97%) when the tunnel is in operation.

Table 5.16 Annual Geometric Mean *E. Coli* Level at Approach Beach 1995 - 2004

Approach Beach	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
E. Coli (cfu/100ml)	977	1164	1009	435	387	316	411	696	762	470

Similarly, other gazetted beaches in the Tsuen Wan District except Ma Wan Tung Wan beach have been closed to the public because of the poor water quality with the pollution loads from unsewered villages and the Sham Tseng Nullah.

To improve the water quality and reduce the pollution loads generated in the catchment area, sewerage improvement schemes are planned. It is anticipated that coliforms counts will be significantly reduced once the sewerage improvement schemes including HATS 2 are in place.

Minimisation of Impacts on Flow Regime

The design of the outfall structure has been critically reviewed and modified to minimise the potential adverse impacts of the flow from the outfall to the marine facilities and vessels in the vicinity of the outfall area, the design of the culvert section of the outfall has been revised to further reduce the outflow velocity to 2.5m/s. More importantly, the invert level of the outfall has now been raised to approximately 4.5mPD which is above the tide level of the sea. The flow from the outfall at this invert level will drop into the open water instead of shooting out horizontally in a submerged condition. The majority of the energy of the flow will be dissipated locally adjacent to the outfall where a rip rap apron will be provided to prevent scouring and erosion of seabed. Further away from this local turbulent area, the flow will be transformed into a series of small waves with a much reduced velocity compared to the outflow velocity. It is not expected that these waves will cause perceptible effects to the vessels using the nearby marine waters. The exposed outfall below the upgraded Castle Peak Road will also serve as a warning sign itself when flow starts coming out from it compared to the previous low level design which might be submerged during high tide condition. Please note that the chance of occurrence of having a 2.5m/s flow from the outfall is only 1 in 200 years. Under "normal circumstances", it is only expected that discharge from the outfall will only occur on average 28 times each year and with a flow (72.5m^3/s on average) far smaller than the 1 in 200-year events.

Pollution Inventory

The circumstances surrounding the collection of water, ie when rainfall exceeds 30mm/hr, implies that the stormwater will have picked up the debris and silts, sediments (pollutants generally known as the "first flush") and washed them downstream. By the time the water is intercepted it will be fast flowing and the debris load will be negligible compared to the initial period of the rainstorm event. The screens and silt traps (refer to **Figure 5.13**) in the interceptor chambers will collect any materials, thereby only allowing the less polluted waters to flow into the tunnel. There will be no organic water directly discharged into the tunnel and malodours are not expected. The design of the tunnel is such that there is no stagnant water. The pollution load associated with this portion of the flood will therefore be minimal compared to that at the beginning of the rainstorm. Other potential sources of pollution relate to domestic generated sewage from village houses and squatter areas particularly in the vicinity of Intake I3. Using the same reasoning as that for the debris and silt/sediment, it may be considered that domestic wastes which are discharged into the receiving streamcourses will be significantly diluted by the first two hours of the rainstorm and undetectable upon entry into the marine environment.

Modification of the Seabed resulting in Changes to Flows and Sedimentation Regimes

No modifications are proposed to the seabed other than to place rip rap for scour protection. According to Protection of Harbour Ordinance (CAP.531), 'reclamation' means any works carried out or intended to be carried out for the purpose of forming land from the sea-bed or foreshore. Since only a layer of rip rap will be laid on the seabed and no land will be formed in the Project, no reclamation will be involved in the context of the Protection of Harbour Ordinance. Moreover, no dredging is required for this Project. No changes to the hydrodynamic and sedimentation regimes as a result of this Project. Water quality will not be adversely affected in the receiving waters nor at the bathing beaches.

5.7 Mitigation of Impacts

5.7.1 During Construction

Mitigation measures have been proposed and are included in **Table 5.9**. In addition to which a spill control and response plan has been prepared for works at the intakes and work sites as shown in **Table 5.17**.

Table 5.17 Spill Control and Response Plan

1. Prevention and Precaution Measures

General Precautions

No discharge of silty water into watercourses.

All materials to be used during construction and operation shall be identified and their hazard potential evaluated.

Maintenance of vehicles and equipment involving activities with potential for leakage and spillage shall only be undertaken with the areas appropriately equipped to control these discharges.

Any soil contaminated with chemicals/oils shall be removed from site and the void created shall be filled with suitable materials.

Any construction plant which causes pollution to catchwaters or water gathering ground due to leakage of oil or fuel shall be removed off-site immediately.

Suitable containers shall be used to hold the chemical wastes to avoid leakage or spillage during storage, handling and transport.

Chemical waste containers shall be suitably labelled to notify and warn the personnel who are handling the wastes to avoid accidents.

Storage areas shall be selected at safe locations on site and adequate space shall be allocated to the storage area.

Prevent obstructions and tripping hazards.

Storage Precautions

All chemical storage containers shall be correctly labelled.

Solid and impermeable enclosure walls or storage shelves shall be used.

Only compatible chemical wastes shall be stored in the same storage area.

The storage areas shall be inspected to detect any leakages or defective containers on a regular basis.

The condition of the storage containers shall be checked regularly.

Suitable notices warning of hazards, emergency response plans, telephone numbers etc shall be posted around the site, including storage areas.

Large and heavy containers shall be stored at ground level.

Chemical waste containers shall be stored below eye level.

Adequate space for handling of the containers shall be provided.

Spill response kits shall be located adjacent/near to the storage areas.

A log of chemical wastes shall be maintained.

Incompatible chemicals shall be stored separately.

2. Responses/Action Plan

All Workers shall be made aware of emergency telephone numbers and the location of all relevant pollution control equipment. Training be given in emergency response/action plans. The action include the following steps:

- Only trained personnel who are equipped with protective clothing and equipment shall be allowed to enter the spillage area for clean up.
- Wherever appropriate, spills shall be transferred appropriate back into containers using suitable equipment.
- Absorbent materials shall be used to clean up the spills and shall be disposed of as chemical wastes.
- Where appropriate suitable solvents may be used to clean the contaminated area after removal of all contaminated materials.
- All necessary protective devices, safety equipment, containers and clean up materials for emergency use shall be maintained to a high standard.

3. Spill Clean Up and Disposal

Effect the response plan.

Control the leakage and absorb the spillage using suitably absorbent materials.

Provide safety equipment and personal protective equipment for handling of chemical wastes would be similar to that for handling of chemicals.

Safety equipment includes but is not limited to:

- Fire extinguishers.
- Spades, brushes, dustpan, mop and bucket (or similar readily available on site).
- Absorbent material such as dry sand, tissues and toweling (all materials readily available on-site).
- Containers including plaster bags, drums, etc.
- Absorbing materials.
- Pumps.

Personal protective equipment includes as appropriate:

- First-aid kits.
- Safety helmet and goggles.
- Gloves which can resist chemical reaction.
- Protective boot and clothing.
- Respirators and gas masks.
- Face visor and masks.

In addition to the foregoing precautions to be taken at any time of year when rainstorms are likely:

- Temporarily exposed surfaces should be covered e.g. by tarpaulin.
- Temporary access roads should be protected by crushed stone or gravel.
- Trenches should be dug and backfilled in short sections. Measures should be taken to minimize the ingress of rainwater into trenches.

Actions to be taken when a rainstorm is imminent or forecast:

- Silt removal facilities, should be checked to ensure that they can function properly.
- Open stockpiles of construction materials on site should be covered with tarpaulin or similar fabric.
- All temporary covers to slopes and stockpiles should be secured.

Actions to be taken during or after rainstorms:

- Silt removal facilities should be checked and maintained to ensure satisfactory working conditions.

5.7.2 *Emergency Responses to Spillages*

Emergency plans and clean up procedures will need to be provided by the Contractor recognising his specific working methods and construction programme, activities and sequences and specifically because the Intakes I2 and I3 are in areas of requiring specific water/ecological protection. Agreement must be sought prior to commencement of the construction work but the following principles should be considered. The emergency plans should include the procedures for:

- spill prevention and precaution;
- response actions; and
- spill clean up and disposal.

Spill prevention and precaution embraces good site practice and covers:

- good housekeeping practices;
- chemical storage requirements; and
- chemical transfer and transport.

5.7.3 During Operation

Erosion control during the operational phase has been incorporated into the design of the tunnel intakes and outfalls, and includes the construction of sand traps, grills and boulder traps at the three intake locations, side weirs at Intakes I2 and I3, while at the outfall O1 there will be cascades and rip rap. Regular inspection of the tunnels is essential to monitor the structural integrity and proper functioning of the drainage tunnel, which allows repairing of structural deterioration when it begins to develop. It is recommended that routine inspection shall be carried out at least two times per year for the drainage tunnel at the beginning and end of wet season from April to September.

The first inspection (inspection at the beginning of wet season) is to enable the drainage tunnel is at a good condition for operation to discharge the intercepted upland flow in the wet season. Any obstructions entered the tunnel that will reduce the hydraulic capacity of the tunnel will need to be removed prior to the operation of the tunnel during wet season. The second inspection (inspection after the wet season) aims to check any damage caused to the tunnel during the wet season period and identify the necessary repair works to be undertaken in the following dry season. This inspection frequency will be subject to change based on the findings of the first few inspections.

5.8 Residual Impacts

Taking note of the potential issues identified for construction it is considered that residual impacts will be controlled to acceptable level, with strict adherence to the mitigation or pollution prevention measures proposed. No residual impacts are expected as a result of constructing or following the construction of the project.

5.9 Cumulative Impacts

No cumulative impacts are expected.

5.10 Environmental Monitoring and Audit

There is no requirement for a formal monitoring procedure to be established for this Project (especially as there is no dredging or reclamation). However, a program of monitoring is proposed to confirm the mitigation measures are protecting the water bodies during the construction. In the operational phase, water quality monitoring is also recommended to be carried out at the outfall during the wet season (April to September) in the first operational year. The monitoring and audit details are stated in the EM&A Manual.

In order to ensure the water levels in the stream courses and thus on the surrounding habitats will not be affected, the groundwater levels along the tunnel will also be measured throughout the construction and maintenance period. In addition, a drainage monitoring and audit plan has been proposed in the Drainage Impact Assessment. The water levels, sediment levels, flow rate and the dimensions of stream courses, channel, culverts and pipe within the site boundary shall be regularly monitored under this plan during the construction.

5.11 Conclusions

With appropriate mitigation and precautions measures in place during construction there should be relatively minor impacts associated with this project during or following construction. In the operational phase, the impacts from stormwater discharge are anticipated to be negligible.

5.12 References

Environmental Protection Department (2002), *Beach Water Quality Report 2002*.

Environmental Protection Department (2002) *Marine Water Quality in Hong Kong 2002*.

Environmental Protection Department (2002) *River Water Quality in Hong Kong 2002*.

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