5 WATER QUALITY IMPACT

5.1 Introduction

This chapter presents the assessment of potential water quality impacts, which may arise during the construction, operation, restoration and aftercare of the WENT Landfill Extension. Mitigation measures have been proposed to alleviate the potential water quality impact. The residual water quality impact was assessed to be acceptable.

The water quality impact assessment has been conducted in accordance with Annexes 6 and 14 of the TM-EIAO and the EIA Study Brief for the Project.

5.2 Environmental Legislation, Standards and Guidelines

The following relevant legislation and associated guidelines are applicable to the evaluation of water quality impacts associated with the construction, operation, restoration and aftercare of the Project:

- Environmental Impact Assessment Ordinance (Cap.499, S.16), Technical Memorandum on Environmental Impact Assessment Process (TM-EIAO), Annex 6 and 14 [5-1];
- Water Pollution Control Ordinance (WPCO, Cap 358) [5-2];
- Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage System, Inland and Coastal Waters (WPCO, Cap. 358, S.21) [5-3];
- Practice Note for Professional Persons (ProPECC), Construction Site Drainage (PN1/94) [5-4];
- EPD Pollution Control Clauses for Construction Contract [5-5];
- Hong Kong Planning Standards and Guidelines (HKPSG) [5-6];
- Others, e.g., standards of the United Kingdom (UK), European Union (EU), and United States Environmental Protection Agency (USEPA), etc. for those which are not specified in the 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 entire Hong Kong waters are divided into ten Water Control Zones (WCZs) and four supplementary WCZs. The existing WENT Landfill at Nim Wan and the proposed site for WENT Landfill Extension at some 5 km northwest of Tuen Mun overlooking Deep Bay and the Water Sensitive Receivers which may be affected by the Project works are located within the Deep Bay WCZ and the North Western WCZ. Their corresponding WQO are listed in **Table 5.1** and **Table 5.2** respectively.

Table 5.1 Summary of Water Quality Objectives for Deep Bay WCZ

Parameters	Objectives	Sub-Zone
Offensive Odour, Tints	Not to be present	Whole zone
Visible foam, oil scum, litter	Not to be present	Whole zone
Dissolved Oxygen (DO) within 2 m of the seabed	Not less than 2.0 mg/L for 90% of samples	Outer Marine Subzone excepting Mariculture Subzone

Parameters	Objectives	Sub-Zone
Dissolved Oxygen (DO) within 1 m below surface	Not less than 4.0 mg/L for 90% of samples	Inner Marine Subzone excepting Mariculture Subzone
	Not less than 5.0 mg/L for 90% of samples	Mariculture Subzone
Depth-averaged DO	Not less than 4.0 mg/L for 90% of samples	Outer Marine Subzone excepting Mariculture Subzone
	Not less than 4.0 mg/L	Yuen Long & Kam Tin (Upper and Lower) Subzones, Beas Subzone, Indus Subzone, Ganges Subzone, Water Gathering Ground Subzones and other inland waters of the Zone
5-Day Biochemical Oxygen Demand (BOD_5)	Not to exceed 3 mg/L	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	Not to exceed 5 mg/L	Yuen Long & Kam Tin (Lower) Subzone and other inland waters
Chemical Oxygen Demand (COD)	Not to exceed 15 mg/L	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground
	Not to exceed 30 mg/L	Yuen Long & Kam Tin (Lower) Subzone and other inland waters
pH	To be in the range of 6.5 - 8.5, change due to waste discharges not to exceed 0.2	Marine waters excepting Yung Long Bathing Beach Subzone
	To be in the range of 6.5 – 8.5	Yuen Long & Kam Tin (Upper and Lower) Subzones, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	To be in the range of 6.0 –9.0	Other inland waters
	To be in the range of 6.0 – 9.0 for 95% samples, change due to waste discharges not to exceed 0.5	Yung Long Bathing Beach Subzone
Salinity	Change due to waste discharges not to exceed 10% of ambient	Whole zone
Temperature	Change due to waste discharges not to exceed 2 ^{o}C	Whole zone

Parameters	Objectives	Sub-Zone
Suspended solids (SS)	Not to raise the ambient level by 30% caused by waste discharges and shall not affect aquatic communities	Marine waters
	Not to cause the annual median to exceed 20 mg/L	Yuen Long & Kam Tin (Upper and Lower) Subzones, Beas Subzone, Ganges Subzone, Indus Subzone, Water Gathering Ground Subzones and other inland waters
Unionized Ammonia (UIA)	Annual mean not to exceed 0.021 mg/L as unionized form	Whole zone
Nutrients	Shall not cause excessive algal growth	Marine waters
Total Inorganic Nitrogen (TIN)	Annual mean depth-averaged inorganic nitrogen not to exceed 0.7 mg/L	Inner Marine Subzone
	Annual mean depth-averaged inorganic nitrogen not to exceed 0.5 mg/L	Outer Marine Subzone
Bacteria	Not exceed 610 per 100ml, calculated as the geometric mean of all samples collected in one calendar year	Secondary Contact Recreation Subzones and Mariculture Subzones
	Should be zero per 100 ml, calculated as the running median of the most recent 5 consecutive samples taken between 7 and 21 days.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	Not exceed 180 per 100ml, calculated as the geometric mean of the collected from March to October inclusive in one calendar year. Samples should be taken at least 3 times in a calendar month at intervals of between 3 and 14 days.	Yung Long Bathing Beach Subzone
	Not exceed 1000 per 100ml, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days	Yuen Long & Kam Tin (Lower) Subzone and other inland waters
Colour	Not to exceed 30 Hazen units	Yuen Long & KamTin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones
	Not to exceed 50 Hazen units	Yuen Long & KamTin (Lower) Subzone and other inland waters
Turbidity	Shall not reduce light transmission substantially from the normal level	Yuen Long Bathing Beach Subzone

Parameters	Objectives	Sub-Zone
Phenol	Quantities shall not sufficient to produce a specific odour or more than 0.05 mg/L as $C_6 H_5OH$	Yuen Long Bathing Beach Subzone
Toxins	Should not cause a risk to any beneficial uses of the aquatic environment	Whole Zone
	Should not attain such levels as to produce toxic carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms.	Whole Zone

Source: Statement of Water Quality Objectives (Deep Bay Water Control Zone).

Table 5.2 Summary of Water Quality Objectives for North Western WCZ

Parameters	Objectives	Sub-Zone
Offensive odour, tints	Not to be present	Whole zone
Visible foam, oil scum, litter	Not to be present	Whole zone
Dissolved oxygen (DO) within 2 m of the seabed	Not less than 2.0 mg/l for 90% of samples	Marine waters
Depth-averaged DO	Not less than 4.0 mg/l	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) subzones, water gathering ground subzones and other inland waters
	Not less than 4.0 mg/l for 90 % sample	Marine waters
pH	To be in the range of 6.5 - 8.5, change due to human activity not to exceed 0.2	Marine waters excepting bathing beach subzones
	To be in the range of 6.5 – 8.5	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) subzones and water gathering ground subzones
	To be in the range of 6.0 –9.0	Other inland waters
	To be in the range of 6.0 –9.0 for 95% samples	Bathing beach subzones
Salinity	Change due to human activity not to exceed 10% of ambient	Whole zone

Parameters	Objectives	Sub-Zone
Temperature	Change due to human activity not to exceed 2 °C	Whole zone
Suspended solids (SS)	Not to raise the ambient level by 30% caused by human activity	Marine waters
	Change due to waste discharges not to exceed 20 mg/l of annual median	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) subzones and water gathering ground subzones
	Change due to waste discharges not to exceed 25 mg/l of annual median	Inland waters
Unionized ammonia (UIA)	Annual mean not to exceed 0.021 mg/l as unionized form	Whole zone
Nutrients	Shall not cause excessive algal growth	Marine waters
Total inorganic nitrogen (TIN)	Annual mean depth-averaged inorganic nitrogen not to exceed 0.3 mg/l	Castle peak bay subzone
	Annual mean depth-averaged inorganic nitrogen not to exceed 0.5 mg/l	Marine waters excepting castle peak bay subzone
E.coli Bacteria	Not exceed 610 per 100 ml, calculated as the geometric mean of all samples collected in one calendar year	Secondary contact recreation subzones
	Should be less than 1 per 100 ml, calculated as the geometric mean of the most recent 5 consecutive samples taken between 7 and 21 days.	Tuen Mun (A) and Tuen Mun (B) subzones and water gathering ground subzones
	Not exceed 1000 per 100 ml, calculated as the geometric mean of the most recent 5 consecutive samples taken between 7 and 21 days	Tuen Mun (C) subzone and other inland waters
	Not exceed 180 per 100 ml, calculated as the geometric mean of all samples collected from March to October inclusive.	Bathing beach subzones
Colour	Change due to waste discharges not to exceed 30 Hazen units	Tuen Mun (A) and Tuen Mun (B) subzones and water gathering ground subzones

Parameters	Objectives	Sub-Zone
	Change due to waste discharges not to exceed 50 Hazen units	Tuen Mun (C) subzone and other inland waters
5-Day biochemical oxygen demand (BOD_5)	Change due to waste discharges not to exceed 3 mg/l	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) subzones and water gathering ground subzones
	Change due to waste discharges not to exceed 5 mg/l	Inland waters
Chemical oxygen demand (COD)	Change due to waste discharges not to exceed 15 mg/l	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) subzones and water gathering ground subzones
	Change due to waste discharges not to exceed 30 mg/l	Inland waters
Toxins	Should not cause a risk to any beneficial uses of the aquatic environment	Whole zone
	Waste discharge shall not cause the toxins in water significant to produce toxic carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms.	Whole zone
Phenol	Quantities shall not sufficient to produce a specific odour or more than 0.05 mg/l as C_6H_5OH	Bathing beach subzones
Turbidity	Shall not reduce light transmission substantially from the normal level	Bathing beach subzones

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

5.3 Baseline Conditions

5.3.1 Groundwater Condition – Existing WENT Landfill

Regular groundwater monitoring along the boundary of the existing WENT landfill site has been conducted since the commencement of the existing WENT Landfill. Groundwater samplings are currently conducted at groundwater monitoring wells. The groundwater sampling locations are shown in **Figure 5.1**.

According to Development and Management of WENT Landfill Contract Specification Section 35 "Landfill Monitoring", the target levels of ammonia nitrogen (NH_3-N), chemical oxygen demand (COD) and biological oxygen demand (BOD) for groundwater detected through routine monitoring at each groundwater monitoring point of the existing WENT Landfill are listed in the following table:

Table 5.3 Target levels of NH_3-N, COD and BOD

Pollutants	Target Level (mg/l)
NH_3-N	0.5
COD	20
BOD	5

Groundwater monitoring data presented in existing WENT Landfill's monthly reports from 2006 to 2007 are shown in **Appendix 5.1** and summarised below. The results were generally in compliance with the specified trigger levels. It is observed that there is no contamination of leachate to the groundwater during the operation of the existing WENT Landfill. The current engineering design of leachate management system is proven to be effective.

Table 5.3a - Groundwater Monitoring Data (2006 – 2007) for Existing WENT Landfill

Parameters	Unit	2006	2007
EC	mS/cm	0.04 – 25.70	0.04 – 16.60
pH		5.20 – 12.20	3.30 – 13.40
Temp	˚C	22.2 – 29.50	22.00 – 28.30
As	mg/L	0.00 – 0.03	0.00 – <0.01
Cr	mg/L	0.00 – 0.05	0.00 – 0.03
Zn	mg/L	0.00 – 0.14	0.00 – 0.09
Pb	mg/L	0.00 – <0.02	0.00 – <0.02
Cd	mg/L	0.00 – <0.001	0.00 – 0.002
Ni	mg/L	0.00 – 0.02	0.00 – 0.05
Fe	mg/L	0.00 – 0.71	0.00 – 1.20
Mn	mg/L	0.00 – 3.20	0.00 – 2.60
Mg	mg/L	0.01 – 400	0.01 - 180
Ca	mg/L	0.27 – 470	0.26 - 310
Cu	mg/L	0.00 – 0.02	0.00 – 0.01
Ag	mg/L	0.00 – <0.01	0.00 – <0.003

Parameters	Unit	2006	2007
Ba	mg/L	0.00 – 0.52	0.00 – 0.21
Na	mg/L	5.90 – 3600	5.60 - 2900
K	mg/L	1.40 – 110	1.70 - 74
Soluble Hg	mg/L	0.00 – 0.0006	0.00 – <0.0003
BOD	mg/L	0.00 – <3	0.00 – <3
COD	mg/L	0.00 – 19.00	0.00 – 16.00
TSS	mg/L	0.00 - 250	0.00 – 88.00
CN^-	mg/L	0.00 – <0.2	0.00 – <0.2
F^-	mg/L	0.10 – 8.80	0.10 – 9.20
TOC	mg/L	0.00 – 6.00	0.00 – 5.00
CO_3^{2-}	mg/L	0.00 - 110	0.00 - 130
HCO_3^-	mg/L	3.80 - 250	2.00 - 150
Ammonia	mg/L	0.00 – 0.40	0.00 – 0.40
Nitrite	mg/L	0.01 – 0.63	0.02 – 0.93
Nitrate	mg/L	0.02 – 5.80	0.02 – 5.60
TKN	mg/L	0.00 – 1.10	0.00 – 1.00
Cl^-	mg/L	5.00 - 6300	4.00 - 3700
Reactive Phosphorus	mg/L	0.01 – 0.16	0.01 – 0.23
Sulhpide	mg/L	0.00 – 0.00	0.00 – 0.00
Sulphate	mg/L	2.00 - 840	4.00 - 550
E. Coli.	Count/100mL	0.00 - 1300	0.00 - 700

5.3.2 Groundwater Condition –WENT Landfill Extension

Additional groundwater monitoring data within the WENT Landfill Extension had been collected during 2007 and 2008. The monitoring results are presented in **Appendix 5.2** and summarised below.

Table 5.3b - Groundwater Monitoring Data for WENT Landfill Extension

Parameters	Unit	Range
Colour	PtCo	5-60
TSS	mg/L	210-2100
Total LMW PAH	ug/L	0.00-<0.10
Total HMW PAH	ug/L	0.00-<0.10
Total PCB	ug/L	0.00-<0.10
TPH (C6-C9)	ug/L	0.00-<20

Parameters	Unit	Range
TPH (C10-C14)	ug/L	0.00-<25
TPH (C15-C28)	ug/L	0.00-170
TPH (C29-C36)	ug/L	0.00-240
Pesticides	ug/L	0.00-<0.10
Ben	ug/L	0.00-<1.0
Tol	ug/L	0.00-<2
Etb	ug/L	0.00-<2
m,p-Xyl	ug/L	0.00-<4
o-Xyl	ug/L	0.00-<2
BOD5	mg/L	3-23
COD	mg/L	58-460
O&G	mg/L	0.00-23
NH3	mg/L	0.06-0.28
NO3-N	mg/L	0.00-0.43
NO2-N	mg/L	0.00-<0.05
TKN	mg/L	0.00-3.2
PO4-P	mg/L	0.00-<0.01
TP	mg/L	0.00-0.69
SiO_2	mg/L	22-53
T.Surf.	mg/L	0.00-<1
F	mg/L	0.30-63
S^{2-}	mg/L	0.03-5.8
CO_3	mg/L	0.00-<10
HCO_3	mg/L	12-97
SO_4	mg/L	0.00-600
Cl	mg/L	9.8-4100
$TRCl_2$	mg/L	0.00-<0.05
Phenol	mg/L	0.00-<0.1
E.coli	CFU /100mL	30-2800
Tri-Butyl Tin	ug/L	0.00-<0.015
Cyanide	ug/L	0.00-<0.05
TOC	ug/L	0.00-15

5.3.3 Hydrogeological Information

In addition to the ground water quality, the GI has also collected information on other hydrogeological information which is summarised in **Appendix 5.2.**

5.3.4 Marine Water Quality

At present, the routine monitoring programme conducted by EPD provides the most comprehensive spatial and temporal marine water quality data, and these data may be used to represent the baseline water quality condition of the concerned water system. The nearest EPD water quality monitoring sampling point located around the existing WENT Landfill is "DM4 and DM5" within the Deep Bay WCZ and "NM5" within the North Western WCZ for marine water monitoring. **Figure 5.2** shows the locations of the marine monitoring points, and **Table 5.4** shows the results of marine monitoring at the Deep Bay and North Western WCZs in 2007.

Table 5.4 Marine Water Quality of the Deep Bay and North Western WCZs in 2007 [5-7]

Parameter	Water Quality Objective (WQO)	Annual Mean of Monitoring Results at Different Monitoring Stations [1]		
		DM4 (Outer Deep Bay)	DM5 (Outer Deep Bay)	NM5 (Urmston Road)
Dissolved oxygen (depth-averaged) (mg/l)	≥ 4	6.6	6.7	5.7
Dissolved oxygen (bottom) (mg/l)	≥ 2	6.2	6.2	5.4
Total inorganic nitrogen (mg/l)	≤ 0.5	1.16	0.79	0.64
Unionised ammonia (mg/l)	≤ 0.021	0.011	0.007	0.008
pH	6.5 - 8.5	7.6	7.8	8.0
Salinity (ppt)	≤ 10% change due to waste discharge	24.1	26.1	28.6
Temperature (ºC)	≤ 2ºC change due to waste discharge	24.5	24.4	23.4
Suspended solids (mg/l)	≤ 30% increase due to waste discharge	8.1	7.4	11.1
E. coli (cfu/100 ml)	≤ 610	120	180	590

Notes:

[1] Unless otherwise specified, data presented are depth-averaged values calculated by taking the means of three depths, including surface, mid-depth and bottom.

[2] Data presented are annual arithmetic means of the depth-averaged results except for *E. coli* which is annual geometric mean.

5.3.5 River Water Quality

At present, the routine monitoring programme conducted by EPD provides the most comprehensive spatial and temporal river water quality data and these data may be used to represent the baseline water quality condition of the concerned water system. The nearest EPD water quality monitoring sampling point located around the existing WENT Landfill are "DB2" & "DB8" on a tributary of Tai Shui Hang Stream and Tsang Kok Stream inside the Deep Bay WCZ (see **Figure 5.3**). The river water quality monitoring results, as extracted from the "Annual River Water Quality Reports" published by EPD, are summarised in **Table 5.5** and **5.6**.

Table 5.5 Summary of annual water quality monitoring results at Tai Shui Hang Stream (DB2) [5-8]

	Annual Average Concentration						
	DO (mg/L)	pH	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	*E. coli* [1] (cfu/100ml)	NH_3-N (mg/L)
WQO	≥ 4	6.0-9.0	≤ 20	≤ 5	≤ 30	≤ 1000	≤ 0.021
2000	8.2	7	3	1	3	31	0.02
2001	8	7.2	4	1	2	54	0.03
2002	8.2	7.5	6	1	2	37	0.03
2003	8.1	7.3	7	1	3	130	0.04
2004	8.2	7.1	3	1	3	85	0.04
2005	8.4	7.1	5	1	3	120	0.03
2006	8	7.4	4	1	3	190	0.03
2007	8.1	7.5	8	1	3	130	0.03

Note : [1] Geometric mean value

Table 5.6 Summary of annual water quality monitoring results at Tsang Kok Stream (DB8) [5-8]

	Annual Average Concentration						
	DO (mg/L)	pH	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	*E. coli* [1] (cfu/100ml)	NH_3-N (mg/L)
WQO	≥ 4	6.0-9.0	≤ 20	≤ 5	≤ 30	≤ 1000	≤ 0.021
2000	8.0	7.9	6	1	5	50	0.07
2001	8.9	7.6	3	1	3	40	0.03
2002	8.7	7.8	5	1	2	34	0.02
2003	8.8	7.7	4	1	3	87	0.03
2004	9.4	7.8	2	1	4	65	0.03
2005	9.1	7.6	3	1	5	120	0.05
2006	9.5	7.9	4	1	4	310	0.02
2007	10.0	8.4	3	1	3	78	0.03

Note : [1] Geometric mean value

The latest monitoring data in 2007 at Tai Shui Hang Stream and Tsang Kok Stream are generally within the WQOs indicating that the water quality at the stream is relatively good. The river water quality shows no sign of water contamination as indicated by the low inorganic nitrogen level, COD and *E. coli* levels.

5.3.6 Discharge License for Existing WENT Landfill

The discharge from the WENT Landfill Extension leachate treatment plant and other facilities shall not exceed the discharge limits specified in the Water Discharge License (EP760/431/009097/T) for existing WENT Landfill (see **Table 5.7**) issued by EPD under Water Pollution Control Ordinance.

Table 5.7 Discharge limits for effluents

Determinand	Limit for Effluents from EPD Site Office Area, Existing Operator's Offices, Contaminated Surface Water and Grease Trap Waste Treatment Plant and other facilities	Limit for Effluents of Landfill Leachate
Flow Rate (m^3/day)	800	1800
pH (pH units)	6-10 [1]	6-10 [1]
Temperature (˚C)	43	43
Suspended Solids (mg/L)	800	800
Settleable Solids (mg/L)	100	100
Biochemical Oxygen Demand (5days, 20˚C)	800	800
Chemical Oxygen Demand (mg/L)	2000	2000
Oil and Grease (mg/L)	40	40
Mercury (mg/L)	0.001	0.001
Cadmium (mg/L)	0.001	0.001
Copper (mg/L)	1.5	1
Nickel (mg/L)	1	1
Chromium (mg/L)	0.7	0.7
Zinc (mg/L)	1.5	1.5
Silver (mg/L)	1.5	0.7
Other Toxic Metals individually (mg/L) [2]	0.7	0.7
Total Toxic Metals (mg/L)	2	2
Cyanide (mg/L)	0.5	0.2
Phenols (mg/L)	0.5	0.2
Suphide (mg/L)	5	2
Suphate (mg/L)	1000	800

Determinand	Limit for Effluents from EPD Site Office Area, Existing Operator's Offices, Contaminated Surface Water and Grease Trap Waste Treatment Plant and other facilities	Limit for Effluents of Landfill Leachate
Total Nitrogen (mg/L)	200	200
Total Inorganic Nitrogen (mg/L) [3]	-	100
Total Phosphorus (mg/L)	50	25
Surfactants (total) (mg/L)	25	25

Notes :
[1] Range
[2] "Toxic metals" include antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium and any other metals that the EPD specifies.
[3] Include nitrogen-ammonia, nitrogen-nitrate, nitrogen-nitrite.

5.4 Water Sensitive Receivers

Water sensitive receivers (WSRs) under this Project include:

- Tai Shui Hang Stream (WSR-1);
- Sha Chau Lung Kwu Chau Marine Park (WSR-2);
- Area of oyster production (WSR-3);
- A seawater abstraction point for power station cooling (WSR-4); and
- Tsang Kok Stream outfall (WSR-5).

The locations of the WSRs are shown in **Figure 5.4**.

5.5 Potential Impacts of Different Phases

The WENT Landfill Extension will be developed in phases. Site clearance, excavation and slope formation works will be carried out to develop the 'landfill bowl'. The permanent works would comprise cut and fill earthworks, slope formation, earth wall construction and the associated drainage and sewerage works. The temporary works will involve the formation of temporary ditches along the sides of excavations and material storage areas.

During site formation, sediments will be contained in permanent detention ponds/silt traps that will be constructed according to the landfill phasing. The final design and location of sediment traps are yet to be decided, but likely to be down gradient of each landfill phase. Where possible these sediment traps will be maintained during the operation of each phase to ensure the effective control of operational soil erosion problem. As there will be large-scale site formation, any alteration of the existing water courses, natural streams, catchment types or areas, flow regimes and groundwater level will be identified.

As discussed in Chapter 2, the existing Tsang Kok Stream would need to be removed during the construction phase to facilitate a more efficient waste storage capacity. For the existing Tsang Kok Stream outfall, a box culvert as shown in **Figure 5.4a** will be installed. It would be constructed by first installing temporary sheet piles before any de-watering and construction of box culvert is conducted. Hence, construction of the box culvert would not have adverse water quality impacts during the construction phase. During the operation phase, the storm water from the WENT Landfill Extension would be collected and diverted through the box culvert, in a fashion similar to the existing Tsang Kok Stream. The associated ecological impacts have been separately addressed in Chapter 10.

For cost effectiveness, the existing berthing facilities of the existing WENT Landfill will be used for the WENT Landfill Extension. There are no additional berthing facilities / barging points, and thus no capital dredging will be required. Only very infrequent maintenance dredging as the existing WENT Landfill may be required.

The treated leachate from new leachate treatment plant will be pumped to the rising mains running along the realigned Nim Wan Road and connected to the existing gravity sewerage system discharging to the DSD Lung Kwu Sheung Tan Outfall Chamber. It is then discharged via the Urmston Road Submarine Outfall into marine waters. This submarine outfall serves not only the existing effluent from the existing WENT, but all the effluent from other sources including but not limited to the San Wai Sewage Treatment Works (STW). According to the information from DSD, the San Wai STW will be upgraded to a capacity of 246,000m³/day for discharge into the existing NWNT Effluent Tunnel and Urmston Road Submarine Outfall. The quantity of effluent from the existing WENT Landfill (~2,600m³/day) for discharge to the Urmston Road Submarine Outfall only constitutes about 1%. **Table 5.8** summarises the potential water quality impacts during different phases, including construction, operation, restoration and aftercare, of the WENT Landfill Extension.

Table 5.8 Potential Impacts during Different Phases

Impact Source	Potential Impact		
	Construction Phase	Operation Phase	Restoration and Aftercare Phases
Surface runoff	(i) Construction site runoff and stormwater runoff will carry considerable amount of soil due to excavation and filling. (ii) Washwater from dust suppression sprays and wheel washing facilities. (iii) Fuel, oil and chemicals will be generated from maintenance of construction machinery and equipment.	Runoff infiltrated to the active tipping area will result in leachate, which comprises high levels of organics and nutrients arising from the waste materials, particularly during the wet season.	Subject to the nature of aftercare development, runoff should comprise mainly soil in a much smaller-scale than the construction and operation phases.
Capital and maintenance dredging	No capital dredging is involved and thus the impact will be insignificant.	Similar to the current operation, only very infrequent maintenance dredging is anticipated. Hence, the impacts would be similar to those existing and are not anticipated to be significant.	Negligible.
Leachate infiltrated / collected by designated collection systems	No leachate generated and thus negligible impact.	Given the implementation of tipping area control and progressive restoration of landfill, the leachate generated from the landfill extension will be minimised.	During restoration, the landfill will be restored and vegetated to match the surrounding landform. Final capping with impermeable liner will be provided to

Impact Source	Potential Impact		
	Construction Phase	Operation Phase	Restoration and Aftercare Phases
		New leachate treatment works (with adequate design capacity) will be provided to treat the leachate collected. Hence, impact arising from leachate collected should be minimal. Leachate will be treated in the new leachate treatment works and effluent will be discharged to the existing submarine outfall in Urmston Road. The leachate discharge will be under controlled and kept same as the existing Discharge Licence limit for the existing WENT Landfill.	prevent infiltration of surface water and hence minimise the leachate generation. The leachate generated during this period would be much less than the operation phase. The new leachate treatment works have sufficient capacity to treat the leachate and hence impact arising from leachate infiltrated should be in a much smaller-scale than that in operation phase.
Seepage / leakage of leachate	No leachate generated and thus negligible impact.	Seepage of leachate across the geomembrane, and accidental leakage of leachate from ruptured pipeline, failed pipe joint sealing and damaged geomembrane may result in the discharge of pre-treated leachate to the nearby streams and ultimately groundwater.	Similar nature as the operation phase but in a much smaller-scale.
Sewage generation	Sewage generated by the construction workforce.	Sewage generated by staff working at site office during operation phase.	Sewage generated by staff working at site office during restoration and aftercare period.

5.6 Construction Phase

5.6.1 Potential Impacts from Construction Activities

Potential water pollution sources arising from construction activities include sources mainly from land-based activities, such as:

- Construction site runoff;
- Sewage effluent due to workforce on site;
- Drainage diversion; and
- Groundwater seepage

5.6.2 Construction Site Runoff

Construction site runoff comprises:

- Runoff and erosion from excavation areas, drainage channels and stockpiles;
- Wash water from dust suppression sprays and wheel washing facilities;
- Fuel, oil, solvent and lubricants from maintenance of construction machinery and equipment.

Construction runoff may cause physical, biological and chemical impacts. Physical impacts include potential blockage of drainage channels and increase of suspended solids concentration in the receiving drainage channel. Local flooding may occur during heavy rainfall if construction runoff is not properly drained. Chemical and biological effects caused by the construction runoff are highly dependent upon the chemical and nutrient contents of the runoff. Runoff containing significant amounts of concrete and cement-derived material may cause primary chemical effects such as increase in turbidity and discoloration, elevation in pH, and accretion of solids. Secondary impacts, such as toxic effects to water biota due to the elevated pH values, and reduction in decay rate of faecal micro-organisms and photosynthetic rate due to the decreased light penetration may result.

5.6.3 Sewage Effluent from Workforce on Site

Sewage generated due to the presence of site staff and construction workers would have the potential to cause water pollution if it was to be discharged directly into adjacent water bodies without appropriate treatment. The characteristics of sewage include high level of BOD_5, Ammonia and *E. coli* counts.

Sufficient temporary sanitary toilets will be provided for on-site construction workforce and will be specified in the contract requirements. No sewage will be allowed to discharge directly into the surrounding water body without treatment. With this regard, adverse impacts to water quality as a result of handling and disposal of sewage generated by the workforce are not expected.

5.6.4 Drainage Diversion

The potential water quality impact associated with drainage diversion will be from the runoff and erosion from site surfaces and earthwork areas. All existing upstream channel of Tsang Kok Stream will be diverted off site and discharged to the downstream drainage system.

In order to achieve that, a box culvert as shown in **Figure 5.4a** will be installed. It would be constructed by first installing temporary sheet piles before any de-watering and construction of box culvert is conducted. Hence, construction of the box culvert would not have adverse water quality impacts during the construction phase. The associated ecological impacts have been separately addressed in Chapter 10.

5.6.5 Groundwater Seepage

Ground investigation has been carried out to determine the existing groundwater levels within the Project site. Groundwater seepage is not considered as an issue for the project of WENT Landfill Extension as the landfill will comprise a closed system with liner and leachate collection measures. Additionally, no groundwater sensitive receivers or abstraction points are present in the vicinity of the site. As such, any changes in groundwater level resulting from the works will have no notable impact.

5.6.6 Cumulative Impacts

Potential concurrent projects in the vicinity of the WENT Landfill Extension are identified, including the following:

- Sludge Treatment Facilities;

- Integrated Waste Management Facilities; and
- Existing / restored WENT Landfill

Sludge Treatment Facilities

To the north of the east lagoon, a Sludge Treatment Facilities (STF) is planned to be built. According to the best available information, the STF will adopt incineration technology for treating sludge collected from the Stonecutters Island Sewage Treatment Works (STW) and 10 other regional STWs in the territory.

The construction period is tentatively between 2010 and 2012. No reclamation work is required. Hence, potential sources of water quality impact include construction site runoff and drainage, sewage effluent from the construction workforce, and debris, refuse and liquid spillages from general construction activities.

Given that the construction phase is implemented with proper site management and good housekeeping practices, no adverse cumulative water quality impact is anticipated for the STF and therefore no cumulative impact is expected.

Integrated Waste Management Facilities

The other potential concurrent project is the Integrated Waste Management Facilities (IWMF). It is however still undergoing the site selection process, and the detailed design and works programme are yet to be available. Hence, it is not considered as a concurrent project under the EIA for the WENT Landfill Extension.

Even if IWMF is located in the middle lagoon, the construction period is tentatively between 2014 and 2016. Similar to the STF, given that the construction phase is implemented with proper site management and good housekeeping practices, no adverse cumulative water quality impact is anticipated for the IWMF and therefore no cumulative impact is expected.

Existing / Restored WENT Landfill

During the construction of the WENT Landfill Extension, the existing WENT Landfill would still be operating. The leachate generated would be treated by the relocated treatment plant and then pumped to the rising mains running along the realigned Nim Wan Road for discharging to the Lung Kwu Sheung Tan Outfall Chamber and then Urmston Road Submarine Outfall. Even during the operation of the WENT Landfill Extension, the relocated leachate treatment plant would still be operated for the aftercare period of the existing WENT Landfill and hence adverse cumulative water quality impacts are not anticipated.

5.6.7 Precautionary Measures

5.6.7.1 Construction Runoff

In accordance with the Practice Note for Professional Persons on Construction Site Drainage, Environmental Protection Department, 1994 (ProPECC PN 1/94), and DSD Technical Circular TC14/2000, construction phase precautionary measures, where appropriate, will include the following :

- At the start of site establishment, perimeter cut-off drains to direct off-site water around the site will 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 will be provided on site to direct stormwater to silt removal facilities. The design of the temporary as well as the permanent on-site drainage system will be undertaken by the DBO Contractor prior to the commencement of construction.
- The dikes or embankments for flood protection will be implemented around the boundaries of earthwork areas. Temporary ditches will be provided to facilitate the

runoff discharge into an appropriate watercourse, through a silt/sediment trap. The silt/sediment traps will be incorporated in the permanent drainage channels to enhance deposition rates.

- The design of efficient silt removal facilities will be based on the guidelines in Appendix A1 of ProPECC PN 1/94, which states that the retention time for silt/sand traps should be 5 minutes under maximum flow conditions. Sizes may vary depending upon the development phases and associated flow rate, but for a flow rate of 0.1 m^3/s a sedimentation basin of 30m^3 would be provided and for a flow rate of 0.5 m^3/s the basin would be 150 m^3. The detailed design of the sand/silt traps will be undertaken by the DBO Contractor prior to the commencement of construction.
- Construction works will be programmed to minimize surface excavation works during the rainy seasons (April to September). All exposed earth areas will be temporarily covered 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 will be covered by tarpaulin or other means.
- All drainage facilities and erosion and sediment control structures will be regularly inspected and maintained to ensure proper and efficient operation at all times and particularly following rainstorms. Deposited silt and grit will be removed regularly and disposed of by spreading evenly over stable, vegetated areas.
- Measures will be taken to minimise the ingress of site drainage into excavations. If the excavation of trenches in wet periods is necessary, they will be dug and backfilled in short sections wherever practicable. Water pumped out from trenches or foundation excavations will be discharged into storm drains via silt removal facilities.
- Open stockpiles of construction materials (for example, aggregates, sand and fill material) of more than 50m^3 will be covered with tarpaulin or similar fabric during rainstorms. Measures will be taken to prevent the washing away of construction materials, soil, silt or debris into any drainage system.
- Manholes (including newly constructed ones) will always be adequately covered and temporarily sealed so as to prevent silt, construction materials or debris being washed into the drainage system and storm runoff being directed into foul sewers.
- Precaution measures will be taken at any time of year when rainstorms are likely, actions to be taken when a rainstorm is imminent or forecasted, and actions to be taken during or after rainstorms are summarised in Appendix A2 of ProPECC PN 1/94. Particular attention will be paid to the control of silty surface runoff during storm events, especially for areas located near steep slopes.
- All vehicles and plant will be cleaned before leaving the construction site to ensure no earth, mud, debris and the like is deposited on roads. An adequately designed and sited wheel washing facilities will be provided at every construction site 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 will be paved with sufficient back fall toward the wheel-wash bay to prevent vehicle tracking of soil and silty water to public roads and drains.
- Oil interceptors will be provided in the drainage system downstream of any oil/fuel pollution sources. The oil interceptors will be emptied and cleaned regularly to prevent the release of oil and grease into the storm water drainage system after accidental spillage. A bypass will be provided for the oil interceptors to prevent flushing during heavy rain.

- Construction solid waste, debris and rubbish on site will be collected, handled and disposed of properly to avoid water quality impacts.
- All fuel tanks and storage areas will be provided with locks and sited on sealed areas, within bunds of a capacity equal to 110% of the storage capacity of the largest tank to prevent spilled fuel oils from reaching water sensitive receivers nearby.

By adopting the above precautionary measures with Best Management Practices (BMPs) it is anticipated that the impacts of runoff from the construction site will be reduced to satisfactory levels before discharges.

The construction runoff discharged from the landfill site shall fully comply with the standards stated in Section 5.2, otherwise the discharge shall be collected and conveyed to the on-site leachate treatment and eventually discharged via the existing Urmston Road Submarine Outfall.

5.6.7.2 Accidental Spillage of Chemical

Any service workshops and maintenance facilities will be located within a bunding area, and sumps and oil interceptors will be provided. Maintenance of equipment involving activities with potential for leakage and spillage will only be undertaken within the areas appropriately equipped to control these discharges. The fuel and waste lubricant oil from the on-site maintenance of machinery and equipment will be collected by a licensed chemical waste collector.

5.6.7.3 Sewage from Workforce

Portable chemical toilets and sewage holding tanks will be provided for handling the sewage generated by the workforce. A licensed contractor will be employed to provide appropriate and adequate portable toilets and be responsible for appropriate disposal and maintenance.

Notices will be posted at conspicuous locations to remind the workers not to discharge any sewage or wastewater into the nearby environment during the construction phase of the Project. Regular environmental audit on the construction site can provide an effective control of any malpractices and can achieve continual improvement of environmental performance on site. It is anticipated that sewage generation during the construction phase of the Project would not cause water quality impact after undertaking all required measures.

5.6.8 "What if IWMF not proceed"

The feasibility of IWMF is still being conducted and there is no decision on the implementation programme and site selection. In case the IWMF is not located at the middle ash lagoon, the boundary of the proposed WENT Landfill Extension would be further expanded to include the middle lagoon. Since the additional landfill area will be all land based and all the proposed precautionary and mitigation measures will be extended to that area, there would not have additional impacts on the water quality on neighbouring sensitive receivers.

5.7 Operation Phase

5.7.1 Surface Water Management

5.7.1.1 Potential Impacts of Surface Runoff from Site

Surface runoff of the WENT Landfill Extension during its operation phase will be collected through the installation of site drainage system and be discharged through the storm drains and eventually via various new box culverts including the new box culvert at Tsang Kok Stream outfall. The proposed site drainage including the new Tsang Kok Stream box culvert will be designed with adequate capacity. Since the existing Tsang Kok Stream is also carrying stormwater already and the existing downstream has been channelised already, it is anticipated that the surface runoff to be collected and discharged via the new box culvert will not have adverse water quality impact on the environment.

5.7.1.2 Potential Impacts of Surface Runoff from Realigned Nim Wan Road

Surface runoff from the realigned Nim Wan Road may include heavy metals, oil and grease and inorganic matters. Similar to other approved EIA practices on roadwork project (e.g., Deep Bay Link), the most effective mitigation measure to prevent the vehicle-generated pollutants from entering the water bodies is to remove the pollutants from road surface prior to the occurrence of a rainstorm. Vacuum air sweepers/trucks could be deployed to remove the pollutants deposited on the road surface at appropriate time intervals.

Standard road gullies with silt traps could be installed to intercept and enable the removal of residual grit, particulate matters and pollutants in road runoff. Regular cleaning of rubbish and sediments from the drainage system following the normal road maintenance practices is required to maintain the normal operation of the systems at all times.

5.7.2 Groundwater Management

5.7.2.1 Potential Impacts on Groundwater Regime

The formation of a fully-lined and capped landfill within the WENT Landfill Extension will mean that any infiltration that currently occurs within WENT Landfill Extension will be removed from the hydrological system. Although upon completion of the landfill operation this volume of water will be diverted to the surface water, there will be some resultant loss of recharge to the main groundwater body beneath the site area as the main recharge source at upstream will have been lost.

We have carried out groundwater investigation and based on the results from groundwater investigation, the groundwater contours for WENT Landfill Extension have been developed. The direction of groundwater flow, based on the groundwater contours, has been developed and it directs to the sea (see **Figure 5.5**), thus no adverse impact on the downstream watercourses is anticipated.

5.7.2.2 Generation of Leachate due to Groundwater Infiltration

The extension site will be designed and constructed as a containment facility incorporating a multi-layer composite liner system covering the entire land formation of the extension site where waste will be deposited. This will not only prevent infiltration of groundwater into the waste and hence minimising leachate generation, and also prevent off-site migration of leachate and contamination of the groundwater. Construction quality assurance/control procedures will be implemented to ensure that the liner system is proper constructed (ie avoiding puncture of the impermeable HDPE liner by construction equipment during installation, and proper seaming of the joints, etc). It is hence expected that the groundwater will be isolated from the extension site and as a result leachate generation from groundwater infiltration will be negligible.

5.7.2.3 Groundwater Contamination due to Leachate Seepage

A geocomposite groundwater drainage layer will be constructed underneath the lining system. The compacted soil underneath the groundwater drainage layer will inhibit the downward infiltration of leachate into the groundwater and hence the drainage layer (with an adequate gradient) could allow the collected groundwater to flow horizontally by gravity. Since the groundwater drainage layer will also be connected to leachate treatment plant, the operation of the WENT Landfill Extension would not impact the groundwater quality.

5.7.2.4 Groundwater Contamination due to Accidental Leakage

While the WENT Landfill Extension has been installed with precautionary measures such as double-layered geomebranes, there is a possible chance of accidental leaking of leachate from the rupture of the leachate pipeline, failure of the pipe joint and the damage of geomembrane. Based on the historical groundwater monitoring data for the existing WENT Landfill, it is considered such a chance is considered as low. In addition, a contingency plan will also be developed to ensure effective mitigation measures are put in place in a timely manner. Hence any associated impacts are considered insignificant.

5.7.3 Leachate Generation

5.7.3.1 Rainfall Data in Nim Wan, Tuen Mun

Leachate quantity is usually determined using a simple water balance approach taking into account the amount of water entering the landfill (ie precipitation) and the amount of water leaving the landfill (ie water consumed in biochemical reactions and evaporation).

Rainfall data from the Hong Kong Observatory Rain Gauge at Tap Shek Kok and Lau Fau Shan between 1993 and 2007 had been reviewed for estimating the precipitation in Nim Wan.

Table 5.8a Average Monthly Rainfall in Tap Shek Kok and Lau Fau Shan

	Average monthly rainfall in Tap Shek Kok (mm)	Average monthly rainfall in Lau Fau Shan (mm)
Jan	26.6	24.1
Feb	35.8	34.5
Mar	44.4	38.0
Apr	132.4	115.7
May	218.8	181.4
Jun	358.5	291.1
Jul	275.6	258.5
Aug	379.7	313.8
Sep	215.8	181.1
Oct	46.1	40.3
Nov	50.7	39.3
Dec	29.0	30.3
Total	**1813.5**	**1540.4**

It is noted from the above table that the average annual rainfall recorded in Tap Shek Kok is about 20% higher than that of Lau Fau Shan. To plan for the worst, the average rainfall of 1813.5 mm was adopted for the estimation of leachate generation in WENT Landfill Extension.

Reference is also made to ***Table 6.2 of Waste Management Paper 26B, Department of the Environment, London***. Effective rainfall should be adopted for the estimating the leachate flow. It is also noted that the rainfall recorded in Tap Shek Kok Rain Gauge has not taken into account the evaporation effect. Evaporation data from King's Park Meteorological Station had been reviewed as enclosed in **Appendix 5.3**. It is noted that minimum evaporation is recorded in 2006 as 1157mm per year. Thus, the effective rainfall in Tap Shek Kok is estimated to be 902mm/year which is only 50% of the average rainfall. Thus the following leachate estimation based on the average rainfall will be on high side.

5.7.3.2 Estimation of Leachate Flow

The leachate generated from the landfill site in different year can be calculated by :

Leachate generation = runoff coeff. * operation area * effective rainfall

where runoff coefficient for different type of landfill is shown in **Table 5.8b**.

Table 5.8b Runoff Coefficient for Different Type of Landfill

Landfill Type	Runoff coeff.	Remarks
Active tipping face	1.00	100% of surface water infiltrated into leachate collection system of landfill
Temporary restored area	0.30	70% of surface water will be convey to surface channel / stormwater system
Permanent restored area	0.10	90% of surface water will be convey to surface channel / stormwater system

Notes :

1. Reference is made to DSD Stormwater Manual Clause 7.5.2. "The value of C depends on the impermeability, slope and retention characteristics of the ground surface. It also depends on the characteristics and conditions of the soil, vegetation cover, the duration and intensity of rainfall, and the antecedent moisture conditions, etc. In Kong Kong, a value of C =1.0 is commonly used in developed urban areas. In less developed areas, the following C values may be used." Table below extracted from DSD Stormwater Drainage Manual Page 42.

Surface Characteristics	Runoff coefficient, C
Asphalt	0.70 – 0.95
Concrete	0.80 – 0.95
Brick	0.70 – 0.85
Grassland (heavy soil)	
Flat	0.13 – 0.25
Steep	0.25 – 0.35
Grassland (sandy soil)	
Flat	0.05 – 0.15
Steep	0.15 – 0.20

2. As per the recommendation of DSD Manual, a value of C =1.0 is commonly used in developed urban areas, which conveys all the surface face to the adjacent drainage system. Similarly, a runoff coeff. of 1.0 is used for the tippling face in order to convey all leachate to the treatment plant. Runoff coeff. of 0.30 for heavy steep soil is adopted for site formation work. Runoff coeff. of 0.10 for sandy flat soil is adopted for the permanent restored surface with top soil and plantation.

3. The same value had been adopted in the Approved EIA Report for NENT Landfill Extension (Register No. AEIAR-111/2007).

To minimise the leachate generation, it is necessary to control the active tipping area and to start restoration as early as practicable. A Phasing Plan A1 was developed with the following leachate minimisation control measures :

- Operation life of 15 years (with IWMF implemented in mid 2010s);
- active tipping face to be controlled within 3 to 6 ha;
- restoration start in Year 8; and
- leachate recirculation to landfill for leachate storage where necessary.

The proposed phasing sequence for Phasing Plan A1 is shown in **Table 5.8c**. **Table 5.8d** shows the leachate generation for Phasing Plan A1.

Table 5.8c WENT Landfill Extension Phasing Plan A1

Year	Active tipping area (ha)	Temporary working area (ha)	Permanent restored area (ha)	Total Area (ha)
0	0	10	0	10
1	6	20	0	26
2	6	30	0	36
3	6	40	0	46
4	6	50	0	56
5	6	60	0	66
6	6	70	0	76
7	6	80	0	86
8	5	90	0	95
9	5	100	0	105
10	4	90	20	114
11	4	90	40	134
12	3	90	60	153
13	3	80	80	163
14	3	75	100	178
15	3	65	120	188
16	0	48	140	188
17	0	28	160	188
18	0	0	188	188
19	0	0	188	188

Table 5.8d Leachate Generation for Phasing Plan A1

Year	Calculation of Infiltration			Leachate Generation	
	Working Area (m^3/year)	Temporary Restored Area (m^3/year)	Permanent Restored Area (m^3/year)	(m^3/year)	(m^3/day)
1	108,810	108,810	0	217,620	596
2	108,810	163,215	0	272,025	745
3	108,810	217,620	0	326,430	894
4	108,810	272,025	0	380,835	1,043
5	108,810	326,430	0	435,240	1,192
6	108,810	380,835	0	489,645	1,341
7	108,810	435,240	0	544,050	1,491
8	90,675	489,645	0	580,320	1,590
9	90,675	544,050	0	634,725	1,739
10	72,540	489,645	36,270	598,455	1,640
11	72,540	489,645	72,540	634,725	1,739
12	54,405	489,645	108,810	652,860	1,789
13	54,405	435,240	145,080	634,725	1,739

Year	Calculation of Infiltration			Leachate Generation	
	Working Area (m^3/year)	Temporary Restored Area (m^3/year)	Permanent Restored Area (m^3/year)	(m^3/year)	(m^3/day)
14	54,405	408,038	181,350	643,793	1,764
15	54,405	353,633	217,620	625,658	1,714
16	0	261,144	253,890	515,034	1,411
17	0	152,334	290,160	442,494	1,212
18	0	0	340,938	340,938	934
19	0	0	340,938	340,938	934

5.7.3.3 Existing WENT Landfill After Restoration

During the restoration period, a final capping system will be provided to prevent infiltration into the waste body and minimise the leachate generation. After the closure of the existing WENT Landfill, there will still be some leachate generated from the restored landfill. The estimated leachate after closure is about 550m³/day as shown in **Appendix 5.4**.

During the restoration and aftercare period, the workforce in the site office will be significantly reduced, the refuse reception area, vehicle washing facility will also be removed. However, afteruse facilities and visitor centre will be provided during the aftercare period. The wastewater and sewage generated from the restored WENT Landfill will consist of:

(1) Sanitary wastewater from EPD Site Office and Swire-SITA Site Office toilet and canteen, which is estimated to be 32m³/day (say 25% of operation phase).

(2) Sanitary wastewater from aftercare facilities and visitor centre, which is estimated to be 16m³/day (assuming 200 staff/visitors with commercial unit flow rate of 0.08m³/day).

The wastewater and sewage generated from the restored WENT Landfill is estimated to be 50m³/day. Together with the pre-treated leachate flows, the total effluent to be discharged is estimated to be 600m³/day.

5.7.3.4 Other Wastewater from WENT Landfill Extension

Similar to the existing WENT Landfill, there are other wastewater generated from the WENT Landfill Extension during the operation period, which includes :

(1) Sanitary wastewater from EPD Site Office and future operator Site Office including toilet and canteen, which is estimated to be 103m³/day for both dry and wet season, see breakdown below.

Table 5.8e Sewage generated from Site Office in WENT Landfill Extension

Source	Quantity	Unit flow rate	Sewage flows
Staff	500 person	0.08 m³/person/day [a]	40 m³/day
Canteen GFA 600 m² (kitchen area = 21% of Restaurant GFA)	126 m²	0.5 m³/m² kitchen area/day [b]	63 m³/day
		Total	**103 m³/day**

Notes : [a] Unit flow factors of commercial employee extracted from EPD Technical Paper Report No. EPD/TP 1/05.
[b] Unit flow factors for canteen extracted from EPD Guidelines for the design of Small Sewage Treatment Plants Appendix 2.

(2) Wastewater from vehicle wash area, assumed to be 75m³/day.

(3) Wastewater from vehicle maintenance facility, assumed to be 50m³/day.

(4) Wastewater from refuse reception area, assumed to be 50m³/day.

The total wastewater and sewage generated from the WENT Landfill Extension during the operation phase is estimated to be 278m³/day.

During the restoration and aftercare period, the workforce in the site office will be significantly reduced, the refuse reception area, vehicle washing facility will also be removed. However, afteruse facilities and visitor centre will be provided during the aftercare period. The wastewater and sewage generated from the restored WENT Landfill Extension will consist of :

(1) Sanitary wastewater from EPD Site Office and Swire-SITA Site Office toilet and canteen, which is estimated to be 26m³/day (say 25% of operation phase).

(2) Sanitary wastewater from aftercare facilities and visitor centre, which is estimated to be 16m³/day (assuming 200 staff/visitors with commercial unit flow rate of 0.08m³/day).

The wastewater and sewage generated from the restored WENT Landfill Extension is estimated to be 50m³/day.

5.7.3.5 Total Leachate Generated during Operation Phase

During operation of WENT Landfill Extension, the existing WENT Landfill will be restored with total effluent of 600m³/day.

Under the "No Net Increase in Pollution Loads Requirement in Deep Bay", the existing Discharge Licence of 2,600m³/day will be kept remain unchanged. Thus, it is proposed that the restored WENT Landfill will have a Discharge Licence of 600m³/day while the WENT Landfill Extension will have a Discharge Licence of 2,000m³/day.

As the wastewater and sewage generated from the site office and reception area are about 278m³/day, thus the discharge limit for pre-treated leachate will be limited to 1,800m³/day (or 657,000m³/year).

As shown in **Table 5.8d**, exceedance to Discharge Licence limit will not occur during the operation life of the WENT Landfill Extension. The maximum leachate flow generated is estimated to be 1,789m³/day in Year 12. As the leachate estimated is based on an average rainfall data without taking into account the evaporation effect of leachate volume, the actual leachate generated should be less than 1,789m³/day. It is therefore concluded that with the implementation of leachate minimisation control measures, the leachate generated from the WENT Landfill Extension would be within control and no exceedance to the Discharge Licence would be allowed.

5.7.4 Leachate Management

The volume of leachate generated by a landfill depends on the amount of precipitation getting into the landfill. Operating landfills generate more leachate than closed landfills, because closed landfills have been capped and vegetated. This reduces the amount of water getting into the waste body, and thus lesser amount of leachate being produced.

The leachate management system comprises the following components:

- leachate collection system;
- leachate extraction system;
- leachate treatment system; and
- leachate disposal.

5.7.4.1 Leachate Collection

A low permeability composite liner system will be placed at the base of the WENT Landfill Extension to reduce the discharge to the underlying hydrogeologic environment. The liner system will be designed as a barrier to intercept leachate so that the contained leachate can be abstracted for treatment prior to discharge from the WENT Landfill Extension.

The proposed liner system of the WENT Landfill Extension consists of a 2 mm high density polyethylene (HDPE) liner, a 6 mm bentonite matting and a leachate collection system. Similar liner and leachate collection systems had been adopted in the existing WENT Landfill and proven to be effective.

Leachate will be collected by the gravity leachate collection pipe to the proposed leachate treatment works. The treated leachate will be pumped to the rising mains running along the realigned Nim Wan Road and connected to the existing gravity sewerage system discharging to the DSD Lung Kwu Sheung Tan Outfall Chamber. It is then discharged via the Urmston Road Submarine Outfall into marine waters.

5.7.4.2 Leachate Extraction

Leachate will be extracted from the extension via a series of collection sumps around the perimeters of the extension site.

The leachate collection sumps will be constructed of pre-cast concrete and will be equipped with submersible pumps to enable leachate to be pumped from the base of the landfill to the leachate collection main, which will transfer leachate to the new leachate treatment plant near the waste reception area. The leachate collection sumps will be accessed by upslope risers along the toe bund of the extension, and therefore will not be prone to damage due to movements of the waste mass.

5.7.4.3 Leachate Minimisation

The WENT Landfill Extension will adopt even more strengthen operation mode to control the leachate generation. The leachate generation rate is greatly dependent on the meteorological conditions and phasing of the WENT Landfill Extension. In order to minimise leachate generation, the phasing of WENT Landfill Extension will be controlled with detailed planning. The following leachate minimization program will be specified in the DBO Contract for implementation by the DBO Contractor:

- Phased development and closure to minimize the active area footprint;
- Temporary geosynthetic covers to minimize infiltration in active cells;
- Run-on and runoff control systems for active and inactive tipping areas;
- Sub-surface drainage systems to control groundwater seepage;
- Low permeability final cover systems to minimize infiltration during post-closure, and
- Cell construction techniques that promote surface runoff rather than infiltration.

Nevertheless, progressive restoration is encouraged where practicable. With detailed planning on temporary and permanent restored area, leachate generation rate could be under control and greatly reduced. No discharge or overflow of leachate to the adjacent streams, rivers and culverts is anticipated.

5.7.4.4 Leachate Treatment

Leachate from the WENT Landfill Extension will be collected and diverted to a new treatment plant. The collected leachate will be diverted to ammonia stripping plant for the removal of high ammonia concentration. After the stripping process, the leachate will be diverted to SBR plant for COD, BOD and SS removal. The effluent will be discharged off-site to the pumping station for onward pumping to DSD Lung Kwu Sheung Tan Outfall Chamber. A schematic diagram showing the tentative process design is given in **Figure 5.6** for information. The design of the treatment plant has considered the worst case scenario of extreme rainfall incident described in Section 5.7.3.5. Nevertheless, the proposed leachate treatment process will be designed by the future operator to suit its landfill development phasing and sequence. It is up to the future operator to determine which treatment process is preferred to enhance cost-effective.

In general, the objective of leachate treatment at all landfill sites is to attain the required standards for discharge. It is noted that the Discharge License for the existing WENT Landfill EP760/431/009097/T has set out the following limits for the effluent discharge. Due to the 'No Net Increase in Pollution Loads Requirement in Deep Bay', it is reasonable to assume the same standards to be applied for the WENT Landfill Extension.

Table 5.9 Treatment Objectives

Determinand	Limit	
Flow rate for **total effluent**	2,600	m^3/day
pH	6 - 10	
Suspended Solids	< 800	mg/l
Biochemical Oxygen Demand (5 days)	< 800	mg/l
Chemical Oxygen Demand	< 2,000	mg/l
Total Nitrogen	< 200	mg/l

5.7.4.5 Leachate Disposal

Leachate generated from the WENT Landfill Extension will be collected and conveyed to the new leachate treatment plant within the Waste Reception Area. The treated effluent will be pumped to the new rising mains along the realigned Nim Wan Road and connected to the existing gravity sewerage system discharging to the DSD Lung Kwu Sheung Tan Outfall Chamber and then Urmston Road Submarine Outfall.

To facilitate the future maintenance and emergency repair of Lung Kwu Sheung Tan Outfall Chamber and the Urmston Road Outfall, the proposed leachate treatment plant shall be able to have a minimum retention time of 8 hours. The proposed new pumping station and rising main shall equip with gate valve to cut off the leachate flows to downstream system during maintenance / emergency repair period. DSD will notify EPD in case of emergency, a communication channel between DSD / EPD / Landfill Extension Contractor will be set up.

The discharge limit of treated leachate set out in the licence for the existing WENT Landfill is 2,600 m^3/day. To minimise the environmental impacts to surrounding and the drainage impact to downstream DSD Lung Kwu Sheung Tan Outfall Chamber and Urmston Road Outfall, the discharge limit for the combined existing WENT Landfill and its extension will be the same as existing Discharge Licence, ie 2,600 m^3/day.

Under the 'No Net Increase in Pollution Loads Requirement in Deep Bay', the pollution loading currently discharged from the existing WENT Landfill will be kept remain unchanged.

The disposal of treatment effluent, which meets the discharge standards stipulated in the Discharge License, from the leachate treatment plant to the rising mains leading to the Lung Kwu Sheung Tan Outfall Chamber and then Urmston Road Submarine Outfall will not cause adverse water quality impacts to the identified WSRs downstream.

5.7.4.6 Cumulative Impacts

Similar, new pumping station will also be provided at the reprovisioned leachate treatment plant for the restored WENT Landfill. New rising mains will also be provided and connected to the pumping station of the WENT Landfill Extension. The combined leachate with total flows of 2,600m³/day will then be discharged to the proposed rising mains along the realigned Nim Wan Road.

For STF, an on-site wastewater treatment plant would be provided to treat the wastewater generated for reuse at the facility for washdown water and landscape irrigation. In addition, all on-site wastewater will be incinerated and there will be no discharge into the Deep Bay or pose any adverse impact on water quality [5-10]. Hence, no adverse cumulative impact on water quality is expected during its operation.

5.7.5 Potential Impacts from Seepage and Leakage of Leachate

It is assumed that the total leachate generated from the existing WENT Landfill and its extension will be under controlled and within the Discharge License limit as the existing WENT Landfill. Leachate to be collected and treated prior to discharge through the submarine outfall is discussed in Section 5.7.3.

Suitable liner and leachate collection systems of the WENT Landfill Extension will be recommended in accordance with local and international practices to prevent leachate seeping / leaking into the natural groundwater system.

In the assessment of potential seepage of leachate across a composite liner, the following assumptions will be made:

- The bentonite matting has a maximum placed hydraulic conductivity of 1×10^{-10} m/s in any direction, which is the specified performance requirement in the existing WENT Landfill Contract. The HDPE is assumed to have a maximum placed hydraulic conductivity of 1×10^{-11} m/s in accordance to the NENT Landfill Extension EIA Report.
- 4 defects are assumed in every hectare, which represents "Good" installation quality. (Schroeder et al., 1994 [5-11])
- Contact quality factor of 0.21 (i.e. good contact conditions) is assumed. It corresponds to a geomembrane installed, with as few wrinkles as possible, on top of low permeability soil layer that has been adequately compacted and has a smooth surface. (Bonaparte et al., 1989 [5-12])
- Giroud et al. [5-13] (1997)'s equation for calculating the flow through a composite liner having circular defect with diameter of 2mm.

$$\frac{Q}{A} = n \cdot 0.976\, C_{qo} \cdot [1 + 0.1 \cdot (h/t_s)^{0.95}] \cdot d^{0.2} \cdot h^{0.9} \cdot k_s^{0.74}$$

where Q = seepage rate through the considered geomembrane defect (m^3/s)

A = considered geomembrane area (m^2)

n = number of defects per considered geomembrane area (A)

C_{qo} = contact quality factor

h = hydraulic head on top of the geomembrane (m)

t_s = thickness of the low-permeability soil layer of the composite liner (m)

d = diameter of circular defect (m)

k_s = conductivity of liner

It is known that the diameter of circular defect should not be less than 0.5 mm or greater than 25 mm when applying this Giroud's equation to predict seepage of leachate through a defect [5-12] as the limitation.

The liquid head on top of the geomembrane would be in the order of 0.3 m, based on the existing WENT Landfill practice.

Accidental leakage of leachate from the rupture of leachate pipeline, the failure of pipe joint sealing and the damage of geomembrane will cause water quality impact. These may result in the discharge of pre-treated leachate to the nearby streams and ultimately groundwater. There is no known water abstraction of groundwater for drinking, its impact to human health is therefore minimal. The preliminary predicted groundwater flow paths in the vicinity of the site show that the groundwater flows towards the sea (i.e. northward). Hence, it is unlikely that the pre-treated leachate will migrate towards the west to Tai Shui Hang Stream through the natural groundwater transmission path.

Assessment results show that for a composite liner with good contact condition between geomembrane and bentonite matting which has a saturated hydraulic conductivity of $1x10^{-10}$m/s, the rate of seepage would be 1.4 litres per hectare per day. The flow rate could be further reduced by lowering the conductivity of the bentonite matting and the number of defects per unit area through better QA/QC programme to improve the installation quality to "Excellent" [5-11]. According to USEPA 1997 [5-14] ,a conductivity of $1x10^{-11}$ m/s could generally be adopted for bentonite in a modern landfill. This would significantly reduce the seepage rate to 0.26 litres per hectare per day. In addition, composite liner had been proposed for the WENT Landfill Extension (HPDE and Bentonite Mat), thus the resulting conductivity for this composite liner shall be much less then $1x10^{-11}$ m/s.

The potential amount of leaked leachate from the WENT Landfill Extension site reaching the groundwater collection layer would be 0.26 litres per hectare per day, if conductivity of $1x 10^{-11}$ m/s is assumed for the composite liner. The depth of leaked leachate mixing with groundwater would be 0.009mm per year. The groundwater monitoring results show that the groundwater depth outside the site is greater than 5000mm above rock head. As a conservative approach to cater for the fluctuation of the groundwater, 500mm is assumed. For leachate with typical COD, NH_3-N and BOD concentrations of 7,952mg/L, 4,028mg/L and 2,276mg/L [5-1], the increase in COD, NH_3-N and BOD concentrations of the groundwater will be 0.149mg/L, 0.075mg/L and 0.043 respectively, which are negligible and well within the respective trigger levels of 20mg/L, 0.5mg/L and 5mg/L. **Table 5.10** shows the potential impact on groundwater quality under various defect conditions.

Table 5.10 Potential Impacts of Leachate Seepage on Groundwater Quality

No. of Defects (ha)	Conductivity (m/s)	Rate of seepage (l/ha/d)	Depth infiltrated (mm/yr)	Groundwater Quality		
				COD (mg/L)	NH_3-N (mg/L)	BOD (mg/L)
4	$1 x10^{-11}$	0.26	0.0093	0.149	0.075	0.043
3	$1 x10^{-11}$	0.19	0.0070	0.112	0.056	0.032
2	$1 x10^{-11}$	0.13	0.0047	0.074	0.038	0.021
1	$1 x10^{-11}$	0.06	0.0023	0.037	0.019	0.011

In case of seepage / leakage, the leaked leachate will be collected via the groundwater collection layer and will be drained to the on-site leachate treatment plant. The impact on groundwater quality due to seepage / leakage of leachate is therefore assessed to be unlikely.

A network of groundwater boreholes will be established to monitor any leachate leakage. Details of the monitoring, such as locations, frequency and parameters tested, will be proposed in the EM&A Manual. The existing contingency plan, including groundwater

[5-1] Data from WENT Monthly Reports, 2003-2007

extraction, interception and diversion, will also be reviewed and amended to prevent water quality impact on the nearby sensitive receivers, if necessary.

5.7.6 Potential Impacts from Sewage

Sewage will be generated from both staff working on active construction/tipping area and staff working in the site office. Permanent toilet with flushing system will be provided at the site office. The sewage collected will be conveyed to leachate treatment plant for treatment and the treated effluent will be pumped to existing gravity sewerage system for discharging to Lung Kwu Sheung Tan Outfall Chamber and then Urmston Road Submarine Outfall. The DBO Contractor will provide temporary sanitary toilets for their own staff at the landfill development areas. These toilets will be cleaned on a regular basis to comply with the relevant sanitary requirements. For other areas on the site where no temporary toilets are provided, workers on the sites will use the toilets at the site office. The characteristics of the sewage generated during this stage will be very much similar to that generated during construction stage. No sewage impact on the surrounding water systems is anticipated during operation phase.

5.7.7 Cumulative Impacts

Cumulative impact on leachate treatment would occur during the initial operation of the WENT Landfill Extension (Phase 1) and restoration of the existing landfill. During restoration of the existing landfill, small amount of leachate will still be generated due to the decomposition of waste body. However, the amount of leachate generated would be greatly reduced when compared with an active landfill. For the WENT Landfill Extension, given the fact that the WENT Landfill Extension will be developed in phases, leachate generated in the early stage of the WENT Landfill Extension would be small. The new on-site treatment facilities will be designed to cater leachate from both existing WENT Landfill and its extension. Cumulative impact during the restoration of existing WENT Landfill and operation of WENT Landfill Extension is considered minimal. As new leachate treatment plant (reprovision) will also be provided at the restored WENT Landfill. New rising mains will also be provided and connected to the new pumping station of the WENT Landfill Extension. The combined leachate with total flows of 2,600m^3/day will then be discharged to the proposed rising mains along the realigned Nim Wan Road.

For STF, an on-site wastewater treatment plant would be provided to treat the wastewater generated for reuse at the facility for washdown water and landscape irrigation. In addition, all on-site wastewater will be incinerated and there will be no discharge into the Deep Bay or pose any adverse impact on water quality [5-10]. Hence, no adverse cumulative impact on water quality is expected during the operation phase.

If IWMF is proposed in the middle lagoon, it is assumed that similar on-site wastewater treatment plant as STF will be provided and hence no adverse cumulative impact on water quality is expected during the operation phase.

5.7.8 Precautionary Measures

5.7.8.1 Surface Water Management

Erosion Control

There are lots erosion control methods available. The DBO Contractor shall devise a soil erosion control plan during the detailed design stage so as to define the site-specific measures and procedures (including the specific operation plan, implementation frequency, monitoring procedures, maintenance schedules, etc). Such requirement shall be specified in contract documents. The followings summarize the most popular erosion control methods for reference:

a. Preserve Natural Vegetation

This Best Management Practices will involve preserving natural vegetation to the greatest extent possible during the construction process and after construction where appropriate. Maintaining natural vegetation is the most effective and inexpensive form of erosion prevention control.

b. Provision of Buffer Zone

A buffer zone consists of an undisturbed area or strip of natural vegetation or an established suitable planting adjacent to a disturbed area that reduces erosion and runoff. The rooted vegetation holds soils acts as a wind break and filters runoff that may leave the site.

c. Seeding (Temporary/Permanent)

A well-established vegetative cover is one of the most effective methods of reducing erosion. Vegetation should be established on construction sites as the slopes are finished, rather than waiting until all the grading is complete. Besides, Hydroseeding will be applied on the surface of stockpiled soil and on temporary soil covers for inactive tipping areas to prevent soil erosion during rainy season.

d. Ground Cover

Ground Cover is a protective layer of straw or other suitable material applied to the soil surface. Straw mulch and/or hydromulch are also used in conjunction with seeding of critical areas for the establishment of temporary or permanent vegetation. Ground cover provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures.

e. Hydraulic Application

Hydraulic application is a mechanical method of applying erosion control materials to bare soil in order to establish erosion-resistant vegetation on disturbed areas and critical slopes. By using hydraulic equipment, soil amendments, mulch, tackifying agents, Bonded Fiber Matrix (BFM) and liquid co-polymers can be uniformly broadcast, as homogenous slurry, onto the soil. These erosion and dust control materials can often be applied in one operation.

f. Sod

Establishes permanent turf for immediate erosion protection and stabilizes rainageways.

g. Matting

There are numerous erosion control products available that can be described in various ways, such as matting, blankets, fabric and nets. These products are referred as matting. A wide range of materials and combination of materials are used to produce matting including, but not limited to: straw, jute, wood fiber, coir (coconut fiber), plastic netting, and Bonded Fiber Matrix. The selection of matting materials for a site can make a significant difference in the effectiveness of the Best Management Practices.

h. Plastic Sheeting

Plastic Sheeting will provide immediate protection to slopes and stockpiles. However, it has been known to transfer erosion problems because water will sheet flow off the plastic at high velocity. This is usually attributable to poor application, installation and maintenance.

i. Dust Control

Dust Control is one preventative measure to minimize the wind transport of soil, prevent traffic hazards and reduce sediment transported by wind and deposited in water resources.

Apart from above erosion control methods, it should be noted that the greater the volume and velocity of surface water runoff on landfill sites, the more sediment and other pollutants are transported to streams. Diverting runoff away from exposed soils can greatly reduce the amount of soil eroded from a site. Decreasing runoff velocities reduces erosion and the amount of pollutants carried off-site. For the division of run-off from exposed areas, the common practices include the use of pipe slope drains and diversion swales. For the reduction of runoff velocities, the common practices will include check dams and sediment traps.

Surface Water Drainage System

A temporary surface water drainage system to manage runoff will be adopted during construction and operation phases. This system will consist of channels as constructed around the perimeter of the site area. This system will collect surface water from the areas of higher elevations to those of lower elevations and ultimately to the point of discharge. Erosion will therefore be minimised.

The temporary surface water management system will include the use of a silt fence around the soil stockpile areas to prevent sediment from entering the system. Regular cleaning will be carried out to prevent blockage of the passage of water flow in silt fence.

Intermediate drainage system will be installed for filled cell/phase. The major purpose of the intermediate drainage system is to prevent the clean surface water run-off from the filled phases coming into contact with the waste mass in active cell and to prevent excessive surface water infiltration through the intermediate cover, thus contribute to increasing volume of leachate.

The intermediate drainage system will collect the clean surface water run-off and divert it to the permanent discharge channels connected to the proposed box culvert for final discharge.

In addition, surface flow from the haul road (especially near the wheel washing facility) will be collected to a dry weather flow interceptor and conveyed to the leachate treatment plant for further treatment.

The surface flow discharge from the landfill site shall fully comply with the standards stated in Section 5.2, otherwise the contaminated surface flow shall be collected and disposed of to the on-site leachate treatment plant and eventually discharged via the Urmston Road Submarine Outfall.

Inspection and Monitoring

Inspections of the drainage system, sand traps, settlement ponds and surface water channels should be performed regularly to identify areas necessary for maintenance, cleaning or repair. Regular maintenance and replacement, if required, of the HDPE liner should be conducted to prevent degradation from affecting the performance of the capping system.

Monthly monitoring of the surface water discharges will form part of the environmental monitoring programme. The results of the monitoring will show if contamination of surface water by leachate is occurring. If surface water is contaminated, further monitoring will be undertaken to locate the source of contamination, and remediation measures will then be carried out. Once the source of contamination has been identified, various remediation measures will be considered, for example, conveying the contaminated surface water runoff directly to the leachate treatment plant.

Detailed monitoring plan including sampling locations, parameters and frequency will be presented in the EM&A Manual for this Project.

5.7.8.2 Groundwater Management

The groundwater management facilities including the groundwater monitoring wells and the groundwater collection sumps will be inspected regularly during the routine groundwater monitoring programme. Monitoring of groundwater quality will be conducted on a regular basis. Details for the monitoring are given in the EM&A Manual.

5.7.8.3 Leachate Management

Contingency Plan for Accidental Leakage of Leachate

Under the existing contingency plan (under Landfill Monitoring Plan) for existing WENT Landfill, groundwater within and around the site will be monitored in accordance with the groundwater monitoring programme proposed in the EM&A Manual. The parameters to be monitored include groundwater level and groundwater quality. The objective of the monitoring programme is to ensure that the trigger levels in **Table 5.11** below are not exceeded.

Table 5.11 Trigger levels for groundwater monitoring

Parameter	Trigger Level
Ammonia Nitrogen	0.5 mg/L
COD	20 mg/L
BOD	5 mg/L

In the event that the above trigger levels are exceeded, the DBO Contractor will implement a Corrective Action Programme, which shall include:

- Groundwater interception and diversion; and
- Groundwater extraction (by active pumping of leachate from leachate and groundwater collection layers) and treatment prior to discharge.

The existing Contingency Plan is comprehensive and well-developed. It will be used as basis for developing the Contingency Plan for the WENT Landfill Extension.

Potential actions to be taken in case of identification of groundwater contamination should also include:

- Installation of additional ground-water monitoring well;
- Increased frequency of ground-water quality testing;
- Installation of ground-water extraction wells to remove contaminated groundwater for treatment;
- Installation of subsurface barriers, such as bentonite;
- Detailed investigation of the potential impact to be performed within six months of the first detection of the justified impact.

Contingency Plan for Surface Water Contamination

Surface water monitoring will be conducted to keep the ammonia-nitrogen and COD below the following trigger levels:

Table 5.11a Trigger levels for surfacewater monitoring

Parameter	Trigger Level
Ammonia nitrogen	0.5 mg/L
COD	30 mg/L
BOD	20 mg/L

In the event that any one of the above parameters was exceeded, the landfill operation should implement a Corrective Action Programme. The key elements shall include:

- Surface water interception and temporary storage of the contaminated surface water;
- Installation of surface barriers, such as sand bund along the surface water channel / site boundary to avoid overflow off-site;
- Active pumping of the contaminated surface water to the leachate lagoons / leachate recirculation system / on-site leachate treatment plant;
- Additional monitoring locations will be selected to determine the pollution source;
- Installation of surface barriers, such as intercepting bund to separate the active and inactive tipping area.
- Change of working methods to prevent surface water contamination; and
- Implementation of diversionary works.

5.7.9 "What if IWMF not proceed"

Similar to the construction phase, since all the proposed precautionary and mitigation measures will be extended to that area, there would not have additional impacts on the water quality on neighbouring sensitive receivers.

5.8 Restoration and Aftercare Phase

Upon completion of final filling and site restoration, the period of aftercare will begin and last for 30 years. During this period, leachate will continue to be generated. The established leachate control measures and treatment will continue to operate throughout the aftercare period.

Subject to the nature and scale of aftercare development, potential sources of water quality impact during the restoration and aftercare phases include surface runoff, seepage/leakage of leachate and sewage generation. Water quality impact in restoration and aftercare phases would be even smaller than those in the operation phase.

In view of the similar nature but smaller scale in water quality impact generated during this phase, water quality assessment methodologies adopted in the construction and operation phases can be made reference to in the restoration and aftercare phases.

5.8.1 Potential Impacts on Surface Runoff

Subject to the nature of aftercare development, surface runoff should comprise mainly soil in a much smaller-scale than the construction and operation phases. Surface runoff from the restored WENT Landfill Extension will be collected to the new stormwater drainage system and discharge to Deep Bay via box culvert outfall. No adverse water quality impact is expected during restoration and aftercare period.

5.8.2 Potential Impacts on Seepage / Leakage of Leachate

Potential risks to groundwater quality will be associated with leakage of leachate from the WENT Landfill Extension through the base liner and side slope lining systems. With the presence of the multi-layer capping and liner systems, proper site maintenance and regular monitoring, the probability of the leachate leakage to groundwater system from the base liner system and containment system is expected to be very low.

During restoration, the landfill will be restored and vegetated to match the surrounding landform. Final capping with impermeable liner will be provided to prevent infiltration of surface water and hence minimise the leachate generation. The leachate generated during this period would be much less than the operation phase. The new leachate treatment works have sufficient capacity to treat the leachate and hence impact arising from leachate infiltrated should be in a much smaller-scale than that in operation phase. Seepage/leakage of leachate for a restored landfill would have less impact than an operating landfill.

5.8.3 Potential Impacts on Sewage Generation

Sewage generated from the after use facilities will be collected by new sewerage system and conveyed to the leachate treatment plant for treatment. The treated effluent will be pumped to the existing gravity sewerage system for discharging to Lung Kwu Sheung Tan Outfall Chamber and then Urmston Road Submarine Outfall. Similar to the operation phase, all site staff will use the permanent toilet provided at the site office. No sewage impact on the surrounding water systems is anticipated.

5.8.4 Cumulative Impacts

As discussed in Section 5.7.7, no adverse cumulative water quality impact is expected from the concurrent projects during the restoration and aftercare phases.

5.8.5 Precautionary Measures

A permanent surface water drainage system will be provided to convey the surface water running through the final restoration slopes to the perimeter channels. The design of the diversion channels located on the final cover is such that their construction involves no disturbance below the cap cover soil.

Regular groundwater quality monitoring should be carried out to monitor the performance of the leachate containment system. Maintenance and replacement of the capping system should be carried out, if necessary, to prevent leachate seepage in the event of a damaged cap.

In addition, long term measures to prevent any surface breakout of leachate include maintaining control of the leachate level through extraction; and/or maintaining the engineered capped system to control infiltration.

5.8.6 "What if IWMF not proceed"

Similar to other phases, since all the proposed precautionary and mitigation measures will be extended to that area, there would not have additional impacts on the water quality on neighbouring sensitive receivers.

5.9 Cumulative Impacts

Two possible potential concurrent projects in the vicinity of the WENT Landfill Extension are identified, including the following:

- Sludge Treatment Facilities; and
- Integrated Waste Management Facilities.

5.9.1 Construction Phase

As discussed in Section 5.6.6, the construction of the STF, IWMF and WENT Landfill Extension will fall into different timeframe, initial development of the WENT Landfill Extension will be after the completion of the above two projects.

Given that the construction phase is implemented with proper site management and good housekeeping practices, no adverse cumulative water quality impact is anticipated.

5.9.2 Operation Phase

Cumulative impact on leachate treatment would, however, occur during the initial operation of the WENT Landfill Extension (Phase 1) and restoration of the existing landfill. During restoration of the existing landfill, small amount of leachate will still be generated due to the decomposition of waste body. However, the amount of leachate generated would be greatly reduced when compared with an active landfill. For the WENT Landfill Extension, given the fact that the WENT Landfill Extension will be developed in phases, leachate generated in the early stage of the WENT Landfill Extension would be small. The new on-site treatment facilities will be designed to cater leachate from both existing WENT Landfill and its extension. Cumulative impact during the restoration of existing WENT Landfill and operation of WENT Landfill Extension is considered minimal. With leachate minimisation control measures to be implemented in the extension site, the combined leachate from restored WENT Landfill and the WENT Landfill Extension will be kept same as the existing discharge limit of existing WENT Landfill (with total flows of 2,600m^3/day). The combined leachate will then be discharged to the proposed rising mains along the realigned Nim Wan Road and finally disposed to Lung Kwu Sheung Tan Outfall Chamber and then Urmston Road Submarine Outfall.

Besides, there is contract provision in the extension site to provide temporary leachate storage to cater one-off event during extreme rainfall incident. The size of the storage tank will be sufficient to cater the contaminated surface water for corrective action. The quantity of leachate discharged to the on-site leachate treatment plant will be controlled and will not overload the treatment system.

As discussed in Section 5.7.7, on-site wastewater treatment plant would be provided in STF to treat the wastewater generated for reuse at the facility for washdown water and landscape irrigation. In addition, all on-site wastewater will be incinerated and there will be no discharge into the Deep Bay or pose any adverse impact on water quality. Hence, no adverse cumulative impact on water quality is expected during the operation phase.

5.9.3 Restoration and Aftercare Phase

During the aftercare phase of the WENT Landfill Extension, leachate will continue to be generated from both restored WENT Landfill and its extension, but the leachate quantity is expected to be sufficiently reduced. The established leachate control measures and treatment will continue to operate throughout the aftercare period of the WENT Landfill Extension.

Proper site maintenance will be undertaken during the aftercare period to ensure that the capping system, leachate collection and treatment systems will be performed to comply with the design requirements. Surface water, groundwater and effluent quality monitoring will also be undertaken during the aftercare period in accordance to the monitoring plan. With the provisions of all these control and monitoring systems, no cumulative impacts are expected to occur during the aftercare phase.

5.10 Residual Impacts

Construction site runoff will be managed in accordance with the guidelines specified in ProPECC PN 1/94, no residual water quality impact during construction phase is anticipated.

All site staff will either use portable toilets provided on site or the permanent toilets provided at the site office. No residual sewage impact on the surrounding water systems is anticipated.

The rate of leachate seepage is assessed to be negligible. With the implementation of the contingency plan on leachate seepage, no residual groundwater quality impact is anticipated.

The surface drainage management system is designed to collect, carry and discharge the clean surface water run-off from WENT Landfill Extension and its immediate surroundings to the public drainage network. The discharge of surface water from the landfill drainage system will not have any adverse impacts on the water quality of the surrounding streams and rivers.

No residual water quality impact is envisaged during the construction, operation, restoration and aftercare of the WENT Landfill Extension.

5.11 Conclusion

The potential water quality impacts of the Project have been assessed.

5.11.1 Construction Phase

With proper implementation of construction site runoff control measures, adverse water quality impact during construction phase is not expected.

Sewage will be generated by workforce on-site during the construction period. Temporary sanitary toilets will be provided for on-site construction workforce. No sewage will be allowed to discharge directly into the surrounding water body without treatment. It is anticipated that sewage generation during the construction phase of the Project would not cause water quality impact after undertaking all required measures.

5.11.2 Operation Phase

Given that the WENT Landfill Extension will only be in operation after the closure of the existing landfill, no cumulative water quality impact due to the operation of the two landfills will occur. Nonetheless, cumulative impact will occur when restoration in existing landfill and operation in the extension take place concurrently.

With the implementation of surface water and groundwater management control measures, adverse water quality impact on surface water and groundwater during operation phase is not expected.

Leachate generated from the landfill will be treated at the leachate treatment plant. The treated leachate will be pumped to the rising mains running along the realigned Nim Wan Road and connected to the existing gravity sewerage system discharging to the DSD Lung Kwu Sheung Tan Outfall Chamber. It is then discharged via the Urmston Road Submarine Outfall into marine waters. Given that the discharge limit of the leachate treatment will be maintained, the impact of leachate on the environment will be minimal.

Under normal installation condition, the rate of leachate seepage is potentially 0.26 litres per hectare per day, which is considered to be insignificant. With the implementation of the measures proposed in the Contingency Plan on Accidental Leakage of Leachate (including active pumping of leachate from leachate and groundwater collection layers to the on-site leachate treatment plant), impact on the groundwater quality is insignificant.

Nevertheless, monthly monitoring of the surface and groundwater discharges will form part of the EM&A programme. If groundwater or surface water is contaminated, further monitoring will be undertaken to locate the source of contamination, and remediation measures will then be carried out.

Sewage will be generated by workforce on site during operation phase. Adverse impact is not anticipated as both portable toilets and permanent toilets at the site office will be provided to collect all sewage generated.

For STF and IWMF, wastewater generated will be reused within the facilities for washdown water and landscape irrigation. Hence, there would be no discharge into the Deep Bay and no adverse cumulative impact on water quality is anticipated.

5.11.3 Restoration and Aftercare Phases

During the restoration and aftercare phases, leachate will continue to be generated but the amount of leachate generated is expected to be sufficiently reduced. The established leachate control measures and treatment will continue to operate throughout the restoration and aftercare periods of the WENT Landfill Extension.

Proper site maintenance will be undertaken during the restoration and aftercare periods to ensure that the capping system, leachate collection and treatment systems will be performed to comply with the design requirements. Surface water, groundwater and effluent quality monitoring will also be undertaken during the restoration and aftercare periods in accordance to the monitoring plan. With the provisions of all these control and monitoring systems, no cumulative impacts are expected to occur during the restoration and aftercare phases.

5.12 Reference

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