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 Project. 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;
- Water Pollution Control Ordinance (WPCO, Cap 358);
- Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage System, Inland and Coastal Waters (WPCO, Cap. 358, S.21);
- Hong Kong Planning Standards and Guidelines (HKPSG);
- Practice Note for Professional Persons (ProPECC), Construction Site Drainage (PN1/94)

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 NENT Landfill at Ta Kwu Ling and the proposed site for NENT Landfill Extension lie within Ganges Subzone of Deep Bay WCZ and the Water Sensitive Receivers which may be affected by the Project works are located within the same subzone. **Table 5.1** shows the Water Quality Objectives (WQO) for Ganges Subzone of Deep Bay WCZ.

Table 5.1: Water Quality Objectives for Ganges Subzone of Deep Bay WCZ

Parameter	Water Quality Objectives for Ganges Subzone of Deep Bay WCZ
Aesthetic Appearance	(a) Waste discharges shall cause no objectionable odours or discolouration of the water. (b) Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent. (c) Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam. (d) There should be no recognisable sewage-derived debris. (e) Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent. (f) Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.
Bacteria	The level of *Escherichia coli* should be zero per 100ml, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.
Colour	Waste discharges shall not cause the colour of water to exceed 30 Hazen units.
pH	Waste discharges shall not cause the pH of the water to exceed the range of 6.5-8.5 units.

Parameter	Water Quality Objectives for Ganges Subzone of Deep Bay WCZ
Temperature	Waste discharges shall not cause the natural daily temperature range to change by more than 2.0 degrees Celsius.
SS	Waste discharges shall not cause the annual median of suspended solids to exceed 20 mg/L.
DO	Waste discharges shall not cause the level of dissolved oxygen to be less than 4 mg/L
BOD_5	Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 mg/L.
COD	Waste discharges shall not cause the chemical oxygen demand to exceed 15 mg/L
NH_3-N	The un-ionized ammoniacal nitrogen level should not be more than 0.021mg/L, calculated as the annual average (arithmetic mean).
Toxins	(a) Waste discharges shall not cause the toxins in water to attain such levels as to produce significant toxic carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other. (b) Waste discharge shall not cause a risk to any beneficial uses of the aquatic environment.

5.3 Baseline Conditions

5.3.1 Groundwater Condition

5.3.1.1 Groundwater Condition at Existing NENT Landfill

Regular groundwater monitoring along the boundary of the landfill site has been conducted since the commencement of the existing NENT Landfill in June 1995. The groundwater sampling locations are presented in **Drawing no. 24315/13/301**. Groundwater monitoring data presented in NENT Landfill's monthly reports showed that the results were in compliance with the specified trigger levels except at several occasions of abnormal observations of COD in 1996 and 1997. After detailed assessment by the Independent Consultant, it was concluded that the causes were not originated from landfill leachate.

Groundwater monitoring data from January 2005 to March 2006 are summarised in Appendix 5.1.

5.3.1.2 Groundwater Condition at NENT Landfill Extension Site

The water quality monitoring data for groundwater has been included in Appendix 5.1. It is observed that there is no contamination of leachate to the groundwater during the operation life of the existing landfill. The current engineering design of leachate management system is proven to be effective and the water quality monitoring data measured in the past 10 year were all within the compliance criteria.

Groundwater samplings have been conducted for a period of 7-days on the NENT Landfill Extension site. **Drawing No. 24315/13/302** shows the locations of the boreholes, and **Table 5.2** summarises the results of groundwater monitoring.

Table 5.2: Summary of groundwater monitoring results

Borehole No.	Ground Level (mPD)	Groundwater Level (mPD)	Groundwater Depth from Ground (m)
BH1	51.19	50.12	1.07
BH2	135.06	128.48	6.58
BH3	146.98	141.22	5.76
BH4	144.65	137.22	7.43
BH5	106.21	---	Dry
BH6	151.20	---	Dry
BH7	154.10	146.87	7.23
BH8	119.60	109.04	10.56
BH9	194.88	---	Dry
BH10	198.02	---	Dry
BH11	214.63	193.75	20.88
BH12	211.69	199.66	12.03
BH13	187.31	172.28	15.03
BH14	119.76	---	Dry
BH15	115.60	112.93	2.67
BH16	143.05	128.70	14.35
BH17	141.75	135.30	6.45
BH18	189.23	165.18	24.05
BH19	191.28	183.78	7.50
BH20	183.69	159.38	24.31
BH21	172.51	161.36	11.15
BH22	139.32	123.91	15.41
BH23	98.02	---	Dry
BH24	143.46	138.67	4.79
BH25	207.62	---	Dry
BH26	62.20	---	Dry
BH27	62.58	50.6	11.98
ABH1	73.74	59.52	14.22
ABH2	48.85	47.17	1.68
ABH3	63.99	52.04	11.95
ABH4	64.78	60.50	4.28
ABH5	83.60	79.00	4.60
ABH6	121.99	106.25	15.74
ABH7	123.59	116.34	7.25
ABH8	137.26	111.61	25.65
ABH9	171.63	139.48	32.15
ABH10	72.96	71.57	1.39
ABH11	97.47	90.26	7.21
ABH12	99.99	97.28	2.71
ABH13	127.78	111.17	16.61
ABH14	150.93	134.98	15.95
ABH15	189.75	162.20	27.55

From the above groundwater monitoring data and the spatial distribution of the borehole locations, it could be observed that all groundwater flows within the site are directed towards the Ping Yuen River Catchment and will not fall into the Lin Ma Hang Stream Catchment.

5.3.2 River Water and Sediment Quality

5.3.2.1 River Water Quality

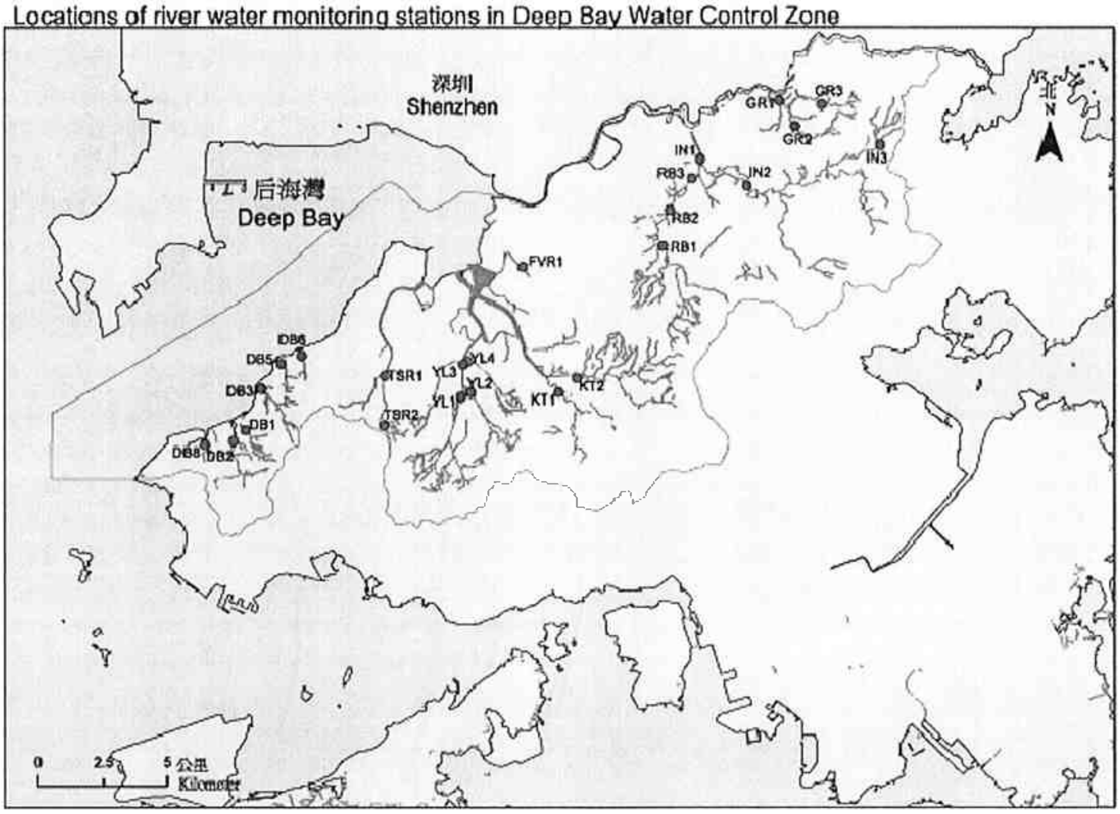
At present, the routine monitoring programme conducted by EPD provides the most comprehensive spatial and temporal river water quality data, and these data may be used to represent the baseline water quality condition of the concerned water system. The nearest EPD water quality monitoring sampling point located around the existing NENT Landfill is "GR3" on a tributary of Ping Yuen River. The river water quality monitoring results, as extracted from the "Annual River Water Quality Reports" published by EPD, are summarised in Table 5.3.

Table 5.3: Summary of monthly water quality monitoring results at upper stream of Ping Yuen River (GR3)

Year	Annual Average Concentration								
	DO (mg/L)	pH	Conduct-ivity (µS/cm)	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	*E. coli* * (cfu/100ml)	NH_3-N (mg/L)	TOC (mg/L)
1998	7.8	7.3	191.2	199.8	5.6	12.6	1,070	0.1	6.4
1999	8.0	7.3	197.7	52.8	6.3	15.5	5,360	0.2	4.8
2000	7.6	7.0	188.8	41.4	3.5	10.9	5,870	0.2	3.3
2001	7.7	6.9	153.0	11.0	2.8	7.3	5,960	0.1	2.2
2002	6.3	7.1	172.0	38.7	5.6	9.8	1,840	0.2	3.3
2003	7.4	7.0	149.1	11.7	2.8	5.9	910	0.2	2.3
2004	7.3	7.0	141.8	11.2	4.9	7.9	840	0.1	2.3
2005	7.7	7.1	143.3	48.0	1.5	6.7	2,610	0.1	2.5
Max. Value	10.9	7.6	401	1200	20	110	410000	0.54	33
Min. Value	4.3	6.5	93	2.1	1	2	10	0.016	1
Std. Dev	1.21	0.25	49.8	177	4.20	13.2	63600	0.10	4.14

* - Geometric mean value

后海灣水質管制區河水水質監測站位置圖
Locations of river water monitoring stations in Deep Bay Water Control Zone



EPD's Annual River Water Quality Reports showed that the Water Quality Indexes (WQI) at GR3 from 1998 to 2004 were either "Good" or "Excellent", the mean *E. coli* concentration at GR3 in 2004 was 840 cfu/100mL.

EPD's monitoring data suggested that there was no sign of river water contamination at upstream of Ping Yuen River by any leachate leaking from the existing NENT Landfill, given the low concentrations of NH_3-N and COD.

A stream water quality survey was conducted in early 2006 by Arup to obtain baseline condition of the streams in the vicinity of the existing NENT Landfill and to identify if there is any sign of leachate seepage from the landfill site to the surrounding water bodies.

Seven samples were taken from the existing stream nearby. Samples were taken from streams running through Lin Ma Hang (WS1, WS2, WS3 and WS4) and those within the boundary of the existing NENT Landfill (WS5, WS6 and WS7). **Drawing No. 24315/13/303** shows the locations of the sampling points. The samplings and testing are conducted by accredited laboratory under the HOKLAS. Table 5.4 summarises the sampling results.

Table 5.4: Summary of stream water analysis results

Parameter	Unit	Rep Limit	Lin Ma Hang Stream				Ping Yuen River		
			WS1	WS2	WS3	WS4	WS5	WS6	WS7
pH @25°C	---	0.1	6.6	6.9	6.3	6.7	6.2	7.1	7.3
Conductivity @ 25°C	µS/cm	1	76	59	42	49	24	67	175
SS	mg/L	0.5	0.8	4.7	7.3	6.7	46.7	162	12.8
$CaCO_3$	mg/L	1	<1	<1	<1	<1	<1	<1	<1
Chloride	mg/L	0.5	5	4	4	3	3	4	5
Zinc	µg/L	10	<10	<10	<10	<10	<10	<10	<10
Iron	µg/L	50	280	340	230	310	70	170	<50
Magnesium	µg/L	50	690	520	290	510	120	620	2470
Ammonia-N	µg/L	10	< 10	< 10	11	19	40	52	34
Nitrite-N	µg/L	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrate-N	µg/L	10	< 10	< 10	< 10	29	10	42	62
TKN-N	mg/L	0.1	0.2	<0.1	0.2	0.2	0.2	0.6	0.5
TOC	mg/L	1	2	2	<1	<1	<1	2	<1
DO	mg/L	0.1	5.6	10.1	7.8	8.5	10.7	10.1	7.0
COD	mg/L	2	9	3	4	3	3	15	7
BOD_5	mg/L	1	3	3	4	2	3	5	4

Note: The "<" sign denotes that the actual value was below reporting limit.

It could be observed from the above table that the sampled streams were free from leachate contamination at the moment of monitoring given the low concentrations of Ammonia-N, BOD_5 and COD recorded, as landfill leachate is usually characterised by high concentrations of these parameters. Previous groundwater and surface water monitoring records were also compared. The data also indicates that there is no contamination on the nearby water body from existing landfill.

The possible reason for the high SS concentration at WS6 is that it is at the downstream locations. Sediments from upstream due to soil erosion are being carried downstream hence resulting in a higher concentration of SS at this point. Measures to prevent pollution of nearby stream water during the construction and operation of the landfill extension are described in 5.8.

5.3.2.2 Sediment Quality

Measurement of river sediment quality was not covered by EPD's river monitoring programme; therefore no past record on river sediment quality was obtained from EPD's monitoring data.

During the water quality survey in early 2006, samples of sediment from the bottom of the streams were also taken and analysed. The analysed results are presented in Table 5.5.

Table 5.5: Summary of sediment analysis results

Parameter	Unit	Rep. Limit	LCEL	UCEL	Lin Ma Hang Stream				Ping Yuen River		
					WS1	WS2	WS3	WS4	WS5	WS6	WS7
Redox Potential	mV	1	--	--	228	235	220	205	230	209	228
Silver	mg/kg	0.1	1	2	<0.1	<0.1	0.4	0.2	0.4	<0.1	<0.1
Arsenic	mg/kg	0.1	12	42	4.6	4.6	5.6	18.2	19.9	9.7	4.4
Cadmium	mg/kg	0.02	1.5	4	0.07	0.10	0.31	1.43	0.21	0.17	0.16
Chromium	mg/kg	0.2	80	160	11.8	6.1	8.2	7.5	7.6	3.3	5.2
Copper	mg/kg	0.2	65	110	3.3	4.7	8.0	14.0	3.4	2.8	3.3
Nickel	mg/kg	0.1	40	40	0.6	0.8	1.8	5.3	1.6	1.9	0.8
Lead	mg/kg	0.1	75	110	21.6	28.3	60.4	24	76.1	20.2	42.9
Zinc	mg/kg	0.1	200	270	24.0	35.5	56.2	155	39.6	37.3	65.4
Mercury	mg/kg	0.02	0.5	1	0.02	0.03	0.33	<0.02	0.04	<0.02	<0.02
TOC	%	0.05	--	--	0.12	<0.05	0.66	0.47	1.23	0.22	0.18
COD	mg/kg	2	--	--	5530	3060	22400	26700	26700	27500	4130
Total PCB	mg/kg	0.05	23	180	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Category of Sediment					L	L	L	M	M	L	L

Note: The "<" sign means the actual value was below detection limit.

Pollution of streambed sediment would be of concern only when they were disturbed. In normal condition, stream water quality would not be directly affected by sediment quality so long as dredging or filling of sediment is not involved. Nonetheless, the sediment samples from the above monitoring points were assessed against the Environment Transport & Works Bureau Technical Circular (TC) No 34/2002 Management of Dredged/Excavated Sediment to determine whether the concentrations of various key parameters in the sediment sample would be a cause of concern.

Table 5.5 above shows that the sediments from most of the sampling locations were of the least contaminated sediment category (Category L), with the exception of sediments at WS4 and WS5 which were of Category M. It means that one or more contaminant levels has exceeded the Lower Chemical Exceedance Level (LCEL) but not exceeded the Upper Chemical Exceedance Level (UCEL).

5.4 Water Sensitive Receivers

Water sensitive receivers (WSRs) under this Project include:

- Lin Ma Hang Stream to the northeast of the site;
- Shenzhen River to the north of the site; and
- Ping Yuen River to the southwest of the site.
- WSD Flood Pumping Station at Ping Yuen River

The beneficial use of Ping Yuen River is mainly water abstraction for irrigation on the surrounding agricultural lands. The flow direction of Ping Yuen River is towards River Indus, then Shenzhen River, and ultimately to Deep Bay while Lin Ma Hang Stream drains directly to Shenzhen River. **Drawing no. 24315/13/303** shows the locations of the WSRs.

5.5 Assessment Methodology

5.5.1 Groundwater Flow

The ground conditions of the study area have been identified from the results of past and recent ground investigation works. The surface water movements in the catchment areas have also been studied.

A hydrogeological model of the Project site has been developed based on available records and monitoring data of existing ground water levels and distribution across the Project site. In order to obtain reasonable estimations of various quantities of each parameter, the following input data have been collated:

- Rainfall
- Evaporation
- Effective Rainfall
- Surface Runoff
- Infiltration and Aquifer Recharge
- Groundwater Flow
- Groundwater Storage
  - Surface Water in Streams and Channels
  - Soil Moisture in Vadose Zone
- Outflow through Extraction Wells

5.6 Identification and Evaluation of Water Quality Impacts

5.6.1 Pollution Sources 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.

5.6.1.1 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 SS 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.

5.6.1.2 Sewage Effluent from Workforce on Site

Sewage effluents will be generated from the sanitary facilities provided for on-site construction workforce. The characteristics for such sewage are its high BOD_5, Ammonia and *E. coli* levels.

5.6.1.3 Drainage Diversion

The potential water quality impact associated with drainage diversion will be from the run-off and erosion from site surfaces and earthwork areas. All existing upstream channel will be diverted off site and discharged to the downstream river.

5.6.1.4 Groundwater Seepage

Ground investigation has been carried out to determine the groundwater levels within the Project site. Groundwater seepage would not be an issue for the project of NENT Landfill Extension as deep excavation, tunnel boring or other underground works are not anticipated.

5.6.2 Environmental Risk Due to Seepage of Leachate

5.6.2.1 Theory

The composite liner system for the NENT Landfill Extension forms a critical component of the landfill design for protection of groundwater and the surrounding environment.

The assessment of leachate seepage is based on the properties of liner materials as shown in Table 5.6.

Table 5.6: Properties of liner materials

Material	Thickness	Hydraulic Conductivity (m/s)
HDPE	2.0 mm	10^{-15}
Bentonite Matting	6.0 mm	10^{-9}

A geomembrane has an extremely low permeability, and therefore, the rate of seepage due to permeability is negligible as compared to the rate of seepage through defects (Giroud and Bonaparte 1989) or due to accidental damage during landfill operation. Therefore, seepage through defects or due to accidental damage will be the dominant source. Accidental damage of liner during landfill operation may potentially cause significant leakage of leachate but this could be minimized by good practice, management and regular inspection on site. In case of leachate leakage due to accidental damage of lining system, the Contingency Plan in place, as described in Section 5.8.2.1 would help prevent any contamination of the surrounding natural environment. Therefore only seepage of leachate due to defect in geomembrane will be assessed.

If there is a defect in the geomembrane, it will flow laterally for some distance between the geomembrane and the bentonite matting, and finally infiltrate in the low permeability soil. The flow between geomembrane and the bentonite matting is referred to as the interface flow, which is highly dependent upon the quality of contact between the two components. If the geomembrane is laid with as few wrinkle as possible on top of a bentonite matting layer that has been adequately compacted and has a smooth surface, it is considered to have good contact condition. In the case of the liner system at NENT Landfill Extension site, which will consist of geomembrane and bentonite, good contact conditions can be assumed because the bentonite slurry that may exude from a hydrated geosynthetic clay liner (GCL) contributes to establishing a close contact between geomembrane and the GCL.

There are mainly two types of defects; namely: manufacturing defects and installation defects. Typically geomembranes may have about 1 to 2 pinholes per hectare from manufacturing defect (pinholes are defects with a diameter equal or smaller than the geomembrane thickness). The frequency of occurrence of installation defects is a function of the quality of installation, testing, material, surface preparation, equipment and QA/QC programme.

Studies by Giroud and Bonaparte (1989) have shown that geomembrane liners installed with strict construction quality assurance could have one to two defects per 4000m^2 with a typical defect diameter of 2mm.

When assessing the potential seepage of leachate across a composite liner (made up of a 2mm geomembrane on a layer of 6mm bentonite), the following assumptions have been made:

- The GCL has a saturated hydraulic conductivity of 1X10^{-9}m/s, which is the minimum requirement in the existing NENT Landfill. (The minimum requirements in USEPA 40 CFR Part 258 is 1 x 10^{-7} cm/s).
- 4 defects are assumed in every hectare, which represents "Good" installation quality. (Schroeder et al., 1994)
- 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)
- Giroud et al. (1997)'s equation for calculating the flow through a composite liner having circular defect with diameter of 2mm.

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

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 component of the composite liner (m)
d= Diameter of circular defect (m)
k_s= Conductivity of liner

There are two limitations in applying the above equation to predict seepage of leachate through a defect (Giroud et al. 1997):

- The diameter of the circular defect should not be less than 0.5mm or greater than 25mm
- The liquid head on top of the geomembrane should be equal to or less than 3m

5.6.2.2 Assessment Results

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^{-9}m/s, the rate of seepage would be 7.73 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" (Schroeder et al., 1994). A conductivity of 1x10^{-11} m/s should generally be adopted for bentonite in a modern landfill. (SENT landfill has been adopting lining system with bentonite of the conductivity of 1x10^{-11} m/s.)

The potential amount of leaked leachate from the NENT Landfill Extension site reaching the groundwater collection layer would be 0.26 litres per hectare per day, if bentonite conductivity of $1x10^{-11}$ m/s is assumed. The depth of leaked leachate mixing with groundwater would be 0.0019mm per year. The "Working Paper on Assessment of Existing Groundwater Regime and Potential Changes Resulting from Future Landfill Operation" has predicted the depth of water that will infiltrate into the groundwater system to be 126mm. For leachate with typical COD and NH_3-N concentrations of 4,485mg/L and 2,863mg/L[5-1] , the increase in COD and NH_3-N concentrations of the groundwater will be 0.33mg/L and 0.21mg/L respectively, which are negligible and well within the respective trigger levels of 30mg/L and 5mg/L. Table 5.7 shows the potential impact on groundwater quality under various defect conditions.

Table 5.7: Potential impacts of leachate seepage on groundwater quality

No. of Defects /ha	Conductivity (m/s)	Rate of seepage (l/h/d)	Depth infiltrated (mm/yr)	Groundwater Quality	
				COD (mg/L)	NH_3-N (mg/L)
4	$1 x10^{-11}$	0.26	0.0093	0.33	0.21
3	$1 x10^{-11}$	0.19	0.0070	0.25	0.16
2	$1 x10^{-11}$	0.13	0.0047	0.17	0.11
1	$1 x10^{-11}$	0.06	0.0023	0.08	0.05

In practice, an average of 4 defects per ha of liner could be easily achieved by good manufacturing quality and QA/QC programme (Girond and Bonaparte, 1989). The impact on groundwater quality, in particular COD and NH_3-N concentrations, due to seepage of leachate will then be less than 0.33mg/L and 0.21mg/L respectively, which is negligible.

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.

5.6.2.3 Risk Due to Accidental Leakage of Leachate

The selected layout (Option 4) will have no encroachment on the Lin Ma Hang Stream and its catchment as well as Shenzhen River, the landfill extension works will have no impact on these rivers and the environmental risk to these water bodies due to seepage of leachate or other wastewater is considered unlikely. Nevertheless, the potential impacts of accidental leakage of leachate due to rupture of leachate pipelines, failure of pipe joint sealing and damage of geomembrane are catered in the contingency plan to be discussed in Section 5.8.2.1. With the prompt and effective implementation of the contingency plan, no adverse impact on groundwater quality of the Project site is anticipated.

5.6.3 Potential Impacts on Groundwater Regime

5.6.3.1 General

A separate hydrogeology assessment had been carried out to assess the existing groundwater regime in the region and to evaluate the potential changes resulting from future landfill operation. The assessment results are summarised in the following sub-sections.

5.6.3.2 Site Geology

A separate ground investigation was carried out to obtain the existing ground conditions of the site.

[5-1] Data from NENT Monthly Reports, 2001 - 2005.

For superficial geology, fill deposits were encountered within a number of drill-holes during the recent ground investigation. The nature of the deposits was mainly gravel. It is apparent that these deposits have been formed as a result of stockpiling by the existing NENT Landfill site. Thin layers of colluvium were identified during the ground investigation. The typical nature of the deposits was silt. It is apparent that the colluvium is mostly located within natural drainage channels / topographic depressions and is typically of thickness of not exceeding 2.0m. Weathered tuff was also identified at some drill-holes during field inspections.

For solid geology, volcanic tuff rock or metamorphosed tuff was identified in most of the drill-holes. Metasedimentary rock in the form of sandstone was identified in only one drill-hole during the recent ground investigation.

For structural geology, a number of faults were identified based on aerial photograph interpretation. Desktop study, visual inspections of the site and the recent ground investigation work have confirmed the following:

- The first fault (Fault 1) was located along the northern boundary of the study area and was striking approximately west-northwest.
- The second fault (Fault 2) strikes north-northeast through the study area, most likely extending through the existing waste reception area to the south of the site and then following the topographic valley northeast from this.
- The third fault (Fault 3) follows the approximate alignment of the existing haul road through the centre of the site, trending west-northwest to east-southeast, and extends beyond the site boundaries.
- The fourth fault (Fault 4) is most likely a large splay fault associated with Fault 2.

5.6.3.3 Catchment Areas

The proposed NENT Landfill Extension is located at the north-eastern end of a large catchment area surrounding a low-lying alluvial valley running from Ta Kwu Ling to Pak Hok Shan. The catchment area is bound on its north-eastern side by the major topographic ridgelines running between Wong Mau Hang Shan, Wo Keng Shan and Cheung Shan, and along its south-western side by the ridges between Cham Shan, Wa Shan and Tsung Shan. The catchment has a total area in the order of 1,250 ha.

The existing catchment areas in the vicinity of the NENT Landfill Extension are shown in **Drawing No. 24315/13/304**. As shown in the drawing, the landfill extension will not encroach into the catchment for Lin Ma Hang Stream.

The NENT Landfill Extension area is located at the upstream catchments of Ping Yuen River. The topography within Catchment Area GE01A where the majority of the site area will be located consists largely of relatively steep sided hill slopes that are likely to result in higher occurrence of run-off than infiltration of rainfall. The two downstream catchments, namely GE02A and GE03A are mainly low-lying areas with shallow gradient. The potential for direct run-off of groundwater will be the infiltration of rainfall into the groundwater system. This means that these two downstream catchments potentially form a larger recharge resource for the groundwater table than the area within the proposed landfill extension site and thus the impact on groundwater flow would unlikely be significant.

Since there is no encroachment into the Lin Ma Hang Stream Catchment, the landfill extension works will have no impact on the groundwater level within and downstream of the Lin Ma Hang catchment.

5.6.3.4 Groundwater Resources

There is no available record showing the past yields of ground water extraction wells within any vicinity villages. Investigation has been conducted to identify the number of villages in the vicinity of the NENT Landfill Extension site that are relying on extraction wells to provide groundwater supply. According to the water main record plan from WSD, most of the villages in the vicinity areas are supplied with fresh water supply. The number of villages potentially affected by the Project would be minimal.

5.6.3.5 Groundwater Model

A conceptual groundwater model for the study area was established in accordance with the procedures described in Section 5.5.2 to predict the potential impact to the future groundwater flow pattern of the site. The prediction results are presented in the following sub-sections.

5.6.3.6 Impact on Surface Water Runoff

For the purpose of this study, the most substantial impact on stream flow would be during the landfill operation period, during which time all surface runoff flow generated from the active tipping face would require collection and discharge to the leachate treatment plant for preliminary treatment prior to disposal at Shek Wu Hui Sewage Treatment Works while the remaining surface runoff within the site will be collected by surface drainage channels and discharged into downstream watercourses. The quality of surface runoff discharged to downstream watercourses from the existing NENT Landfill is monitored on a quarterly basis. Table 5.7a summarises the surface water monitoring results in 2005.

Table 5.7a: Quarterly surface water monitoring results in 2005

Parameters	Annual Average (Range)			
	SP1 (near waste reception area with the Stockpile & Borrow Area at upstream)		SP2 (near leachate treatment works with the existing landfill at upstream)	
Sample Temperature, °C [3]	22.5	(18.3-26.1) SD=3.5	27.5	(24-30) SD =26
pH	7	(6.6-7.2) SD=0.27	7.5	(6.9-8) SD = 0.45
E. C., μS/cm	145	(123-186) SD =28	589.8	(440-839) SD=187
SS, mg/L	7.5	(4-12) SD = 4.1	4.5	(4-5) SD=0.96
Alkalinity, mg/L	35.8	(29-40) SD=4.8	138.5	(102-165) SD=26.7
COD, mg/L	4	(2-6) SD=2	5	(2-8) SD=3.46
BOD_5 , mg/L	2	SD = NA [1]	2	SD = NA [1]
TOC, mg/L	1	SD = NA [1]	<1	SD = NA [1]
Ca, mg/L	16.8	(11.6-26.6) SD=6.7	96.1	(62.1-140) SD=36.9
Mg, mg/L	2.0	(1.6-2.7) SD=0.49	4.8	(3.3-5.9) SD =1.08
Na, mg/L	5.1	(3.7-5.9) SD=0.99	13.8	(11.8-18.6) SD =3.23
Cu, mg/L [4]	<0.01	SD = NA [1]	<0.01	SD = NA [1]
Fe, mg/L	1.8	(0.42-3.8) SD=1.7	0.30	(0.19-0.42) SD=0.17
Mn, mg/L	1.0	(0.002-1.86) SD=0.88	0.79	(0.002-1.79) SD=0.84
Ni, mg/L [4]	<0.01	SD = NA [1]	<0.01	SD = NA [1]
Zn, mg/L	0.04	(0.022-0.06) SD =0.024	<0.01	SD = NA [1]
Pb, mg/L	0.001	(0.001- 0.01) SD=0.005	<0.001	SD = NA [1]
Cd, mg/L	<0.001	SD = NA [1]	<0.001	SD = NA [1]
Cr, mg/L [4]	<0.01	SD = NA [1]	<0.01	SD = NA [1]
Cl^-, mg/L	6.5	(2-13)	8.8	(4-12) SD=3.6
SO_3^{2-}, mg/L	<2	SD = NA [1]	<2	SD = NA [1]
SO_4^{2-}, mg/L	22.3	(7-60) SD=25.3	119.5	(50-199) SD=64.6
PO_4^{3-}, mg/L	0.02	(0.01-0.03) SD=0.01	0.01	SD=NA1
NH_3, mg/L	0.11	(0.05-0.17) SD=0.051	0.16	(0.08-0.27) SD=0.09
NO_3^- , mg/L	0.19	(0.17-0.23) SD=0.053	0.63	(0.4-0.72) SD=0.15
TKN, mg/L	0.27	(0.2-0.4) SD=0.13	0.3	(0.2-0.4) SD=0.08
Total Coliform, CFU/100ml [2]	67	(13-660) SD=5.3	119	(26-4600) SD=11.6

Note [1] : SD=NA indicates that standard derivation is not applicable due to the monitoring data is lower than the detection limit

[2] : Geometric mean and standard derivation are performed for Total Coliform

[3]: SP1 and SP2 are under different catchments, the sources of the water and the flow conditions are different. Therefore, there is a difference in parameters for the two different drainage systems.

[4]: The Yr 2004 and part of Yr 2005 sampling data were carried out by two different laboratories with different instruments and the detection limit for the two instruments was not the same.

Table 5.7b: Quarterly surface water monitoring results in 2004

Parameters	Annual Average (Range)			
	SP1 (near waste reception area with the Stockpile & Borrow Area at upstream)		SP2 (near leachate treatment works with the existing landfill at upstream)	
Sample Temperature, °C[3]	21	(16.4 –25.9) SD = 4.8	25.9	(22.2 – 29.7) SD = 3.3
pH	7.0	(6.9 – 7.3) SD = 0.2	8.0	(7.6 – 8.2)SD = 0.3
E. C., μS/cm	114	(78 – 130) SD= 24	465	(446 - 477) SD = 13
SS, mg/L	6.8	(4 – 10) SD = 2.5	6.0	(3 – 11) SD = 3.6
Alkalinity, mg/L	38	(32 – 46) SD = 6	132	(107 – 154) SD = 20
COD, mg/L	2.3	(2 – 3) SD = 0.5	< 2	SD = NA[1]
BOD_5 , mg/L	< 2	SD = NA[1]	< 2	SD = NA[1]
TOC, mg/L	1.3	(1- 2)SD = 0.5	< 1	SD = NA[1]
Ca, mg/L	12.9	(8.9 – 16.4) SD = 3.2	76.7	(72 – 84.5) SD = 5.8
Mg, mg/L	1.6	(1 – 2) SD = 0.4	4.1	(4.0 – 4.6)SD = 0.33
Na, mg/L	5.4	(4.7 – 5.9)SD = 0.5	12.2	(9.5 – 13.6) SD = 2.0
Cu, mg/L	< 0.001	SD = NA[1]	0.0013	(0.001 – 0.002) SD = 0.0005
Fe, mg/L	2.1	(0.06 – 3.2) SD = 1.4	0.28	(0.05 – 0.71) SD = 0.31
Mn, mg/L	1.5	(1.2 – 1.9) SD = 0.4	1.0	(0.273 – 1.7) SD = 0.62
Ni, mg/L	< 0.001	SD = NA[1]	< 0.001	SD = NA[1]
Zn, mg/L	0.012	(0.01 – 0.016) SD = 0.003	< 0.001	SD = NA[1]
Pb, mg/L	< 0.001	SD = NA[1]	< 0.001	SD = NA[1]
Cd, mg/L	< 0.0002	SD = NA[1]	0.0003	(0.0002 – 0.0006) SD = 0.0002
Cr, mg/L	< 0.001	SD = NA[1]	< 0.001	SD = NA[1]
Cl^-, mg/L	5.3	(4 – 7) SD = 1.5	8.5	(4-13) SD = 3.9
SO_3^{2-}, mg/L	< 2	SD = NA[1]	< 2	SD = NA[1]
SO_4^{2-}, mg/L	13	(3 –20) SD = 8.4	102	(58 –181)SD = 55
PO_4^{3-}, mg/L	0.015	(0.01 – 0.03) SD = 0.01	0.01	SD = NA[1]
NH_3, mg/L	0.14	(0. – 0.19) SD = 0.06	0.22	(0.12 – 0.3)SD = 0.1
NO_3^-, mg/L	0.18	(0.1 – 0.25)SD = 0.08	0.50	(0.35 – 0.7) SD = 0.15
TKN, mg/L	0.18	(0.1 – 0.2) SD = 0.05	0.38	(0.2 – 0.6) SD = 0.2
Total Coliform, CFU/100ml[2]	156	(72 – 320)SD = 112	1005	(100 – 3300) SD = 1535

Note [1] : SD=NA indicates that standard derivation is not applicable due to the monitoring data is lower than the detection limit

[2] : Geometric mean and standard derivation are performed for Total Coliform

[3]: SP1 and SP2 are under different catchments, the sources of the water and the flow conditions are different. Therefore, there is a difference in parameters for the two different drainage systems.

Table 5.7c: Quarterly surface water monitoring results in 2003

Parameters	Annual Average (Range)			
	SP1 (near waste reception area with the Stockpile & Borrow Area at upstream)		SP2 (near leachate treatment works with the existing landfill at upstream)	
Sample Temperature, °C[3]	22.3	(17.6 – 25.3) SD = 3.4	26.6	(24 – 29) SD = 2.6
pH	7.1	(6.8 – 7.3) SD = 0.2	7.7	(7.2 – 7.9) SD = 0.3
E. C., μS/cm	124	(112 – 156) SD = 21.4	440	(388 – 527) SD = 63.0
SS, mg/L	7.6	(1.5 – 14) SD = 5.5	6.5	(5 – 8) SD = 1.29
Alkalinity, mg/L	36.5	(35 – 38) SD = 1.3	135	(111 – 151) SD = 17.1
COD, mg/L	2.8	(2 – 4) SD = 1.0	2.8	(2-4) SD = 1.0
BOD_5, mg/L	2.3	(2-3) SD = 0.5	2.3	(2-3) SD = 0.5
TOC, mg/L	1.3	(1 – 2) SD = 0.5	< 1	SD = NA[1]
Ca, mg/L	26.3	(10.7 – 63.1) SD = 24.7	42.2	(12.5 – 77.3)SD = 34.3
Mg, mg/L	2.5	(1.5 – 4.7) SD = 1.5	3.6	(1.8 – 5.1) SD = 1.4
Na, mg/L	16.5	(5.0 – 43.1) SD = 18.1	9.2	(5.5 –11.8) SD = 3.0
Cu, mg/L	< 0.001	SD = NA[1]	< 0.001	SD = NA[1]
Fe, mg/L	1.3	(0.025 – 2.85) SD = 1.3	1.07	(0.025 – 2.55) SD = 1.1
Mn, mg/L	1.8	(1.1 – 2.77) SD = 0.7	2.1	(1.49 – 2.56) SD =0.5
Ni, mg/L	< 0.001	SD = NA[1]	< 0.001	SD = NA[1]
Zn, mg/L	< 0.01	SD = NA[1]	< 0.01	SD = NA[1]
Pb, mg/L	0.0013	(0.001 – 0.002) SD = 0.0005	< 0.001	NA[1]
Cd, mg/L	0.00023	(0.0002 – 0.0003) SD = 0.00005	0.0004	(0.0002 – 0.001) SD = 0.0004
Cr, mg/L	< 0.001	SD = NA[1]	< 0.001	SD = NA[1]
Cl^-, mg/L	7.5	(5 – 10) SD = 2.4	9	(7 – 13) SD = 2.7
SO_3^{2-}, mg/L	< 2	SD = NA[1]	< 2	SD = NA[1]
SO_4^{2-}, mg/L	12.3	(9 – 20) SD = 5.2	58.8	(42 – 85)SD = 18.5
PO_4^{3-}, mg/L	< 0.01	SD = NA[1]	< 0.01	SD = NA[1]
NH_3, mg/L	0.19	(0.07 – 0.33)SD = 0.12	0.4	(0.32 – 0.5)SD = 0.08
NO_3^-, mg/L	0.16	(0.1 – 0.21) SD = 0.05	0.33	(0.22 – 0.51)SD = 0.14
TKN, mg/L	0.3	(0.2 – 0.4) SD = 0.1	0.48	(0.4 – 0.6) SD = 0.1
Total Coliform, CFU/100ml[2]	212	(48 – 540) SD = 223	66	(13 –120) SD = 52

Note [1] : SD=NA indicates that standard derivation is not applicable due to the monitoring data is lower than the detection limit.

[2] : Geometric mean and standard derivation are performed for Total Coliform

[3]: SP1 and SP2 are under different catchments, the sources of the water and the flow conditions are different. Therefore, there is a difference in parameters for the two different drainage systems.

Drops in stream flow within surface drainage system at Wo Keng Shan are anticipated during the operation stage as the landfill extension site forms a major portion of upstream catchment for this village. Further downstream in Ta Kwu Ling valley, streams will also be substantially fed by run-off from other catchments in the vicinity. The degree of impact on the stream flow in Ta Kwu Ling will be significantly less than that of Wo Keng Shan.

Upon completion of the landfill works, the Project site will be capped for afteruse. Any surface runoff generated over the area will then be collected within surface drainage channels and discharged into downstream river systems. New drainage channel will be provided along the site boundary to convey all surface runoff to Ping Yuen River. Water quality monitoring will be continued during restoration and aftercare periods.

Given that there will be no deep infiltration of groundwater after capping; all precipitation will be entered into the hydraulic system as either surface runoff or interflow through the topsoil material. The resultant surface water flow for the Ping Yuen Catchment will therefore be comparable to the existing condition prior to the landfill extension development.

5.6.3.7 Impact on Groundwater Regime

Local Impact at Project Site

The formation of a fully-lined and capped landfill within the proposed landfill extension area will mean that any infiltration that currently occurs within the stockpile and borrow area 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.

A conservative assessment had been carried out, the calculated depth of aquifer recharge that would be lost to the hydrogeological system is about 126mm per year. It means that the groundwater level beneath the extension site may potentially fall up to 1.5m during the operational lifetime of the landfill extension, which is estimated to be 10 to 12 years. After completion of waste filling, a permanent final capping layer will be installed and the sites will be recharged.

Regional Impact on Surrounding Area

Only two of the villages downstream of the landfill extension area, namely Wo Keng Shan and Ping Yeung, are located in areas where a large portion of their catchments are formed by the landfill extension site.

While the reduction in ground water level in the downstream areas will not be as significant as those directly beneath the landfill extension site, some resultant draw down of groundwater can be anticipated. It is estimated that ground water levels at Wo Keng Shan could fall by 0.5m to 1m over the operational lifetime of the landfill extension whereas a drop of 0.6m can be expected at Ping Yeung over the period. This estimation is considered to be conservative as the groundwater table downstream will be recharged by adjacent catchments. In view of the minimal impact anticipated on these areas (only 1 m fall in Wo Keng Shan Village), a full-scale hydrogeological investigation for the entire catchment (1,250 ha) is considered not necessary at the feasibility study stage but will be included in the NENT Landfill Extension Contract.

5.6.3.8 Recommendations

A number of measures to mitigate the potential loss of groundwater yields to Ping Yeung and Wo Keng Shan areas, where necessary, have been proposed as follows:

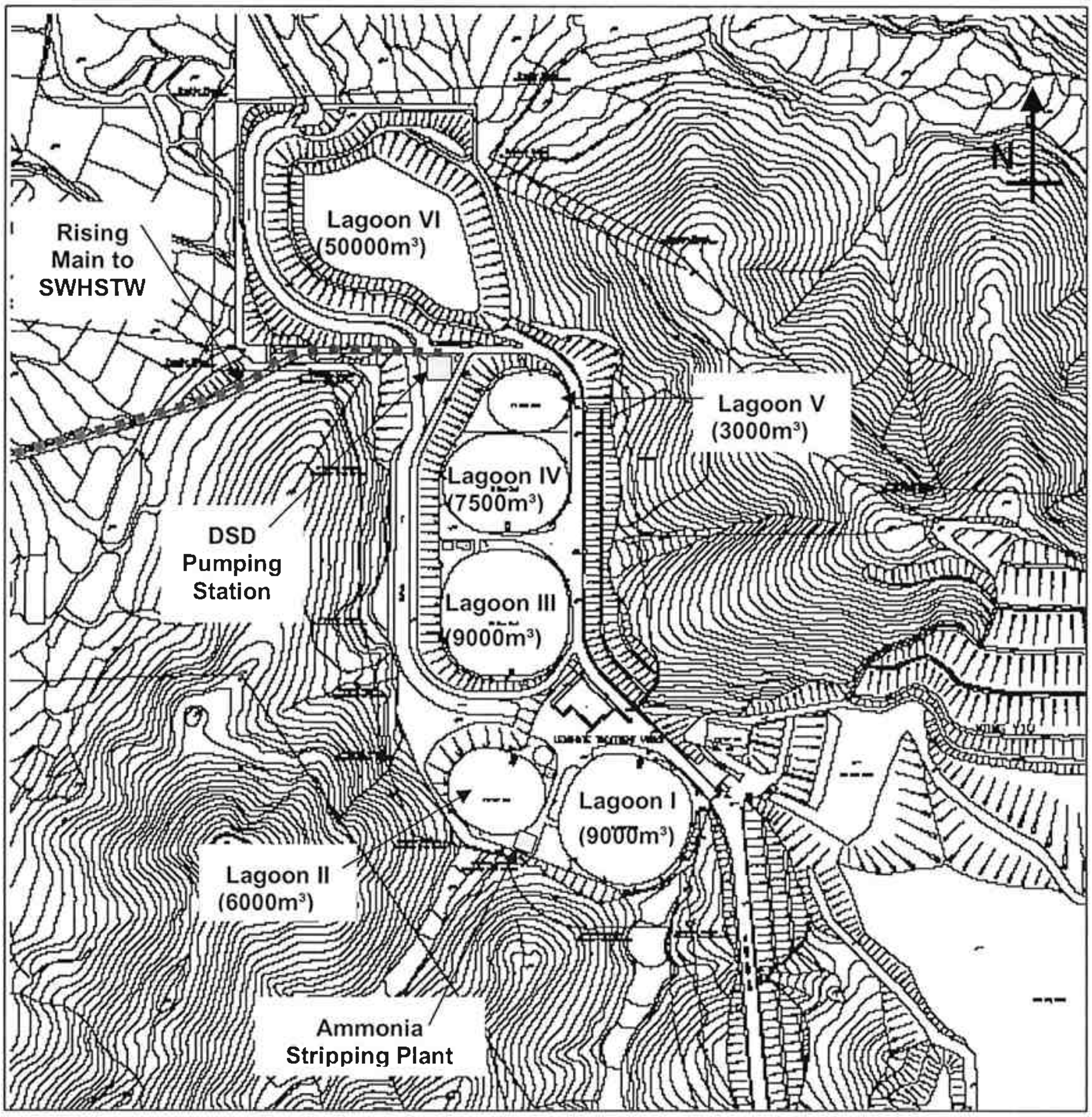
- Provision of adequate water supply for irrigation purposes to the affected villages downstream during the operational lifetime of the landfill extension, i.e. 10 to 12 years. Such provision should be included in the landfill extension contract document;
- Installation of a network of monitoring stations to keep track of the stream flow volumes. Should monitoring of stream flow indicate insufficient quantities to provide sufficient water for irrigation downstream, a contractual requirement for the DBO Contractor to "tank in" water from an external source could be imposed. This is the system currently in place for the existing NENT Landfill;
- Diversion of flow from other catchments outside the site boundary. The surface runoff generated in the catchments with abandoned agricultural lands could be collected and conveyed to the active agricultural lands;
- Formation of new extraction wells that extend deeper down within the aquifer; and

- Artificial recharge by surface spreading, spray irrigation or pumping water directly into the ground via vertical shafts.

5.6.4 Leachate Collection and Treatment System

5.6.4.1 Background

Raw leachate is collected and conveyed to the existing on-site leachate treatment plant for treatment. The existing leachate treatment plant consists of six leachate lagoons and an ammonia stripping plant for nitrogen removal. The design capacity of the leachate treatment plant is about 1,200m³/day. The total storage capacities of the existing leachate lagoons are about 84,500m³. Treated leachate is pumped to the existing DSD Pumping Station and then conveyed to the Shek Wu Hui Sewage Treatment Works for further treatment. The layout of existing leachate treatment plant is shown below.



According to the existing monitoring data, the characteristics of raw leachate entering the leachate treatment plant are shown in Table 5.8.

The Water Discharge Licence W5/2G32/5 granted to the existing leachate treatment plant at NENT Landfill has specified the discharge limits on various parameters as well as the maximum effluent flow rate (Table 5.9).

Table 5.8: Characteristics of raw leachate at existing NENT Landfill in 2004 and 2005

Parameters	Average[1] (Range)	
	2004	2005
Leachate Temperature (°C)	23.2 (16.7 – 30.1), SD=5.5	25.0 (19.1 – 30.1), SD=4.9
pH	8.4 (8.4 – 8.5), SD=0.05	8.3 (8.2 – 8.4), SD=0.1
BOD_5 (mg/L)	814 (780 – 840), SD=25	1665 (900 – 2940), SD=957
COD (mg/L)	3418 (2700 – 4050), SD=554	4485 (3610 – 4970), SD=623
SS (mg/L)	30 (21 – 44), SD=10.7	84 (39 – 157), SD=51
NH_3-N (mg-N/L)	3395 (2800 – 4060), SD=552	2863 (2000 – 4560), SD=1187
Nitrate (mg-N/L)	<0.1, SD=NA[2]	<0.1, SD=NA[2]
TN (mg-N/L)	3685 (3100 – 4120), SD=445	2980 (2000 – 4620), SD=1171

Note: [1] monitoring was conducted on a quarterly basis.
[2] SD=NA indicates that standard derivation is not applicable due to the monitoring data is lower than the detection limit

Table 5.9: Discharge limits on effluent from NENT Landfill Leachate Treatment Plant

Parameters	Limit	Average Effluent Quality (Range)	
		2004	2005
Daily Flow Rate	800 m^3/day (Nov to May) 1,200 m^3/day (June to Oct)	626 (345 - 1251), SD=188 852 (460 – 1577), SD=244	696 (455 – 1196), SD=195 1293* (1009 – 1552), SD=245
BOD_5	400 mg/L	10 (3 – 25), SD=4.5	14 (3 – 34), SD=8.6
COD	2,000 mg/L	1205 (940 – 1720), SD=359	987 (424 – 1620), SD=388
NH_3-N	5 mg/L	0.8 (0.5 – 1.05), SD=0.23	0.9 (0.45 – 3.6), SD=0.86
TN	200 mg/L	121 (100 – 149), SD=20.6	121 (57 – 193), SD=43

Note: 1. Monitoring was conducted on a monthly basis.
2. * Buffer storage lagoons had been provided on site to store the treated-effluent before discharging to the DSD SWHSTW. There is no exceedance of discharge limit in the past.

According to monitoring data from the existing NENT Landfill (see Table 5.9), abnormalities in flow rate were recorded during extremely bad weather in wet season. Nevertheless, sufficient on-site storage lagoons have been provided to cater for the worst-case weather condition, and there is no overflow or discharge of leachate to Ping Yuen River and its tributaries during the operation life of the existing landfill.

5.6.4.2 Leachate Generated from NENT Landfill Extension

The leachate generated by the NENT Landfill Extension has been estimated. Under normal meteorological condition (i.e. with an average annual rainfall of 1,875 mm, data taken from Ta Kwu Ling Station from 1999 to 2005), the peak leachate flow rate from restored NENT Landfill and NENT Landfill Extension (under fully operation in Year 10) is estimated to be (265+860 =) 1,105 m^3 /day in wet season, which is within the design capacity of the existing leachate treatment plant (i.e. 1,200 m^3 /day).

Under severe meteorological condition with an ultimate annual rainfall of 2,503 mm in Year 2001 (the worst-case scenario from 1999 to 2005), the peak leachate flow rate could reach a max of (350+1,150 =) 1,500m^3 /day in wet season (during the Year 10 of the operation). To minimise the impact to the downstream infrastructure (including the DSD pumping station, downstream rising main and SWHSTW), the excess leachate of (1,500 – 1,200=) 300m^3/day will be temporarily stored on site. Similar to the existing NENT Landfill (Table 5.9), storage tanks / lagoons will be provided to store the excess leachate flow for detention before on-site treatment. Temporary leachate storage lagoons will be constructed to cater for the abnormalities in flow rate due to extremely severe storm in wet season, and will be designed with sufficient detention time to control the outflow to comply with the Discharge Licence.

As discussed in the previous section, the peak leachate generation rate from both landfill sites will be about 1,500 m^3/day under severe storm events, including 1,150 m^3/day from the NENT Landfill Extension and 350 m^3/day from the restored NENT Landfill. Nonetheless, the maximum leachate flow of 1,150m^3/day will only be generated during full-scale operation of NENT Landfill Extension. Prior to the full-scale operation, the amount of leachate generated will be much less.

After restoration of existing NENT Landfill, a maximum leachate flow of 350m^3/day from the restored NENT Landfill is anticipated during the initial period of aftercare. With the full development of final impermeable capping, rainwater infiltration will be much reduced leading to reduction in leachate amount. In reality, the full-scale operation of NENT Landfill Extension will not coincide with the initial aftercare phase of the existing NENT Landfill. The peak leachate flow of 1,500m^3/day for the two landfills is therefore only a theoretical maximum.

5.6.4.3 Leachate Minimization

The proposed 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 landfill extension. In order to minimise leachate generation, the phasing of 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.

5.6.4.4 Leachate Treatment Schemes

Various options for future treatment of the leachate have also been considered. Due to the close proximity and similar applications (similar catchment area, similar waste quantity per day, similar waste composition) of the two landfills, qualities of leachate generated from the two sites are expected to be similar.

Two leachate treatment scenarios have been considered. The first option is to deploy the existing treatment facility for both sites while the second option is to build a new plant for the NENT Landfill Extension.

Utilization of the existing leachate treatment plant and building a new storage lagoon to store any excess leachate under the severe storm event is considered the preferred treatment option. This will minimise further impact to the existing DSD Pumping Station and the downstream Shek Wu Hui Sewage Treatment Works.

The raw leachate generated from the NENT Landfill Extension will be conveyed to the existing treatment plant fully utilising its remaining capacity. Temporary storage lagoons will also be provided to cater for the period of peak leachate generation rate on the excess leachate under the severe storm event. The total outflows to DSD Pumping Station as well as to the SWHSTW will be kept to 1,200 m^3/day to minimise the impact to downstream network.

Under the worst-case contractual scenario, a new leachate treatment plant with a capacity of 1,200 m^3/day is planned to cater for the flows from the NENT Landfill Extension, while the existing treatment plant will continue to serve the restored landfill. The new leachate treatment plant will consist of an ammonia stripping plant and a sequencing batch reactor (SBR). The treated leachate from the new treatment plant would then be pumped to the existing DSD pumping station within the existing leachate treatment plant for subsequent conveyance to the SWHSTW for further treatment.

The new leachate treatment plant for the NENT Landfill Extension will be located near the waste reception area of the existing NENT Landfill due to the topography constraints for gravity leachate collection system. The proposed locations are indicated in **Drawing No. 24315/01/005**. Approximately 2 ha of land area is required for the construction of new leachate treatment plant. If more advanced treatment technology is available at the time of implementation, the area of the leachate treatment plant could be much reduced.

Treated leachate discharged from the two leachate treatment plants will be collected in storage lagoons before connecting to DSD's existing discharge point. The discharge limit of 1,200 m^3/day will remain unchanged (i.e. the total amount of treated leachate to be discharged to DSD's sewerage network will not exceed 1,200 m^3/day). Regular leachate flow monitoring will be conducted. Impact on the capacity of the downstream sewerage infrastructure system due to the NENT Landfill Extension is not expected.

5.6.5 Implication of IWMF Implementation

If the IWMF would be commissioned around the same time as the NENT Landfill Extension, NENT Landfill Extension will be receiving residues from IWMF. The waste as well as the leachate characteristics will vary significantly from the existing ones. Due to its low biodegradable content, residue from IWMF usually generates less leachate than common municipal waste, although it may however contain higher concentrations of heavy metal and toxic substances. Given that the final cover will consist of an impermeable mineral layer, a drainage layer of at least 0.5 metre and at least one metre of top soil, the leakage of the IWMF waste is not anticipated.

Table 5.10 presents the characteristics of the leachate generated from a typical landfill in Japan which contains over 75% of incinerated residue (K Ushikoshi et al., 2002).

Table 5.10: Characteristics of raw leachate from landfill with mainly incinerated residue

Parameters	Range
pH	7.1 - 10.5
Turbidity, turb. unit	2.8 - 39.9
Colour, colour unit	14 - 80
Electric conductivity, mS/m	237 - 2,980
M-alkalinity, mg $CaCO_3$/L	30.1 - 101
Total hardness, mg $CaCO_3$/L	642 - 8,961
Ca, mg/L	232 - 3,560
Mg, mg/L	2.5 - 78
Na, mg/L	167 - 2,760
K, mg/L	104 - 2,470
Free CO_2, mg/L	0 - 15.7

Parameters	Range
Cl, mg/L	655 - 11,700
SO_4, mg/L	31.1 - 207
SiO_2, mg/L	2.4 - 26.3
Mn, mg/L	0.6 - 4.77
Fe, mg/L	0.01 - 5.3
Ba, mg/L	0.18 - 6.08
Sr, mg/L	1.1 - 17.6
B, mg/L	0.06 - 8
Total Salinity	2,190 - 27,300
BOD_5 , mg O_2/L	<5 - 155
COD, mg O_2/L	7.9 - 97.4
Total-N, mg N/L	2.2 - 82
NH3-N, mg N/L	0.96 - 33.7
SS, mg/L	9 – 67
Dioxins + Furans, pg-TEQ/L	2.2
Coplanar PCBs, pg-TEQ/L	0.15

It can be observed from the above table that leachate generated from waste consisting of mainly incinerated residue was characterized by its very low concentrations in COD and NH_3-N but relatively high concentrations in salinity and persistent organics, such as dioxins and endocrine disrupting chemicals.

Given the low BOD_5, COD and NH_3-N concentrations, leachate treatment methods being currently adopted in NENT Landfill, namely aerobic biological treatment and ammonia stripping, may no longer be suitable for treating leachate from IWMF residue. As a worst-case scenario, the leachate from the residues may not be suitable to the bacteria in the aerobic biological treatment. Other treatment technologies such as chemical precipitation, ion exchange, reversed osmosis and membrane process should be considered instead. Similar to other IWMF overseas, suitable engineering design and precautionary measures (such as liner and treatment facility) will be provided in the market such that the effluent can fulfill the current discharge criteria. With the anticipated development in advance technology in the next 10 years, more options for advanced treatment facilities can be made available.

Given the uncertainty of the implementation programme for IWMF and on the exactness of data on compositions/volume and final disposal location for the residue, the impact on the future leachate treatment plant at NENT Landfill Extension will be assessed when the actual framework is better defined. If NENT Landfill Extension is finally considered as a suitable site for the disposal of IWMF residues, pilot and bench-scale tests are recommended (to be included in the NENT Landfill Extension Contract) before any full-scale operation. Leachate test for any hazardous waste/ash, such as Toxicity Characteristic Leaching Procedure (TCLP), should be conducted before dumping on the NENT Landfill Extension.

5.6.6 Hazardous Waste Diverted from Other Landfills

In 2005, HK generated a total waste of 17,679 tonnes per day (tpd) with 95 tpd (0.5%) classified under hazardous wastes. Leachate generated from hazardous waste will therefore not have significant impact on the treatment capacity of the treatment works.

The NENT Landfill Extension and the leachate treatment works have also been designed to handle the hazardous wastes and the associated leachate. As a worst-case scenario, other than construction waste and municipal waste, NENT Landfill Extension may also receive hazardous waste (e.g. animal carcasses, asbestos waste, stabilised chemical waste, clinical waste, CWTC stabilised residue and dewatered sludge) diverted from other landfills (e.g. SENT) after their closure. The handling and disposal of these special wastes will follow the Waste Disposal Ordinance (Cap. 354). The amount of hazardous wastes from other landfills is anticipated to be small and co-disposal with typical municipal waste will be adopted. In addition, an impermeable mineral layer, a drainage layer of at least 0.5 m and at least 1m top soil will form the capping. Hence, the leakage of the hazardous wastes is not anticipated.

The leachate generated from the hazardous wastes will be mixed with those of municipal waste in the landfill cell. Leachate generated from the landfill may also contain hazardous material and would be diluted by the leachate from domestic waste as well as the contaminated surface water. Leachate will then be transported to the leachate treatment plant for treatment. The collected leachate will be temporarily stored in buffer lagoons as equalization tanks, and then diverted to thermally driven ammonia stripping process for the removal of high ammonia concentration. After the stripping process, the leachate will be diverted to SBR basin for COD, BOD_5 and SS removal. After completing these treatment processes, the effluent will be discharged to the buffer lagoon for onward pumping to Shek Wu Hui Sewage Treatment Works. Given that the discharge limit of the leachate treatment works will be maintained, the impact of leachate on the environment will be minimal.

5.6.7 Sewage Impact

5.6.7.1 Construction Phase

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. Temporary sanitary toilets will be specified in the contract requirements.

5.6.7.2 Operation Phase

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 public sewerage network leading to the SWHSTW. The DBO Contractor will provide temporary sanitary toilets for their own staff. 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.

5.6.7.3 Restoration and Aftercare Phases

Sewage will be generated from staff working on the site and site office during restoration and aftercare phases. 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.

5.6.7.4 Impact on Existing Sewerage Infrastructure System

Given that the existing NENT Landfill will be closed prior to the operation of the NENT Landfill Extension, increase in leachate generation rate is not expected (ceiling rate kept at $1200m^3$/day as stated in 5.6.4.3). Therefore, the existing leachate treatment works as well as the sewerage infrastructure system downstream will not be overloaded.

5.7 Cumulative Impacts

Under the current design, the NENT Landfill Extension will not be in operation before the existing NENT Landfill is full (i.e. the two landfills will not receive waste at the same time). Cumulative impact due to concurrent operation of the two landfills will therefore not be an issue.

Due to the topography of the existing landfill and the future extension, the two landfills are situated in two different catchments. The surface runoff generated in the existing landfill will fall toward Kong Yiu River while surface runoff generated in the extension site will fall toward Ping Yuen River. Cumulative impact due to surface water will therefore consider unlikely.

Cumulative impact on leachate treatment would, however, occur during the restoration of the existing landfill and operation of the landfill extension. 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 in compare with an active landfill. See Appendix 5.2 for the estimation of leachate. In the landfill extension, given the fact that the landfill extension will be developed in phases, leachate generated in the early stage of the landfill extension would be small. The existing leachate treatment system and new on-site treatment facilities (if any) will be designed to cater leachate from both existing landfill and its extension. Cumulative impact during the restoration of existing landfill and operation of landfill extension is considered minimal.

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.

During the restoration of existing landfill, regular monitoring on leachate flows will be carried out, excess leachate generated in the restored landfill is not anticipated. Hence the cumulative impact will be minor.

The fact that no adverse cumulative water quality impact arising from the phased development of the existing NENT Landfill has been recorded. It is suggested that cumulative water quality impact resulting from concurrent construction and operation activities at NENT Landfill Extension will not be an issue, given the proper implementation of the site drainage management system as mentioned in Sections 5.8.1.1 and 5.8.2.3 below.

In addition, given a proper management and containment of the surfacing water runoff at the NENT Landfill Extension will be provided, no cumulative impact on the WSRs (in particular Lin Ma Hang – with no physical encroachment in catchment area) is expected.

5.8 Precautionary Measures

5.8.1 Construction Phase

5.8.1.1 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 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 temporary 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.
- The overall slope of the site will be kept to a minimum to reduce the erosive potential of surface water flows, and all trafficked areas and access roads protected by coarse stone ballast.
- 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.
- In order to prevent the pollution risks arising from works area (waste reception area) and haul roads of NENT Landfill, intercepting bund or barrier along the roadside will be constructed.

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 to Shek Wu Hui Sewage Treatment Works.

5.8.1.2 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.

5.8.1.3 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.

5.8.2 Operation Phase

5.8.2.1 Contingency Plan on Accidental Leakage of Leachate

Existing Contingency Plan for Groundwater Contamination

Under the existing contingency plan (under Landfill Monitoring Plan) for NENT 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	5 mg/L
COD	30 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 extension site.

Proposed Modifications to Contingency Plan for Groundwater Contamination

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:

- Ammonia nitrogen: 0.5 mg/L
- COD: 30 mg/L
- suspended Solid: 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.

5.8.2.2 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.

5.8.2.3 Surface Water Drainage System

A temporary surface water drainage system to manage runoff will be adopted during construction and operation. 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 public drainage system.

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 to the Shek Wu Hui Sewage Treatment Works.

5.8.2.4 Monitoring

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.

In addition, monitoring of the surface water quality at the upstream of Lin Ma Hang Catchment is also recommended in order to ensure there is no leachate leakage during operation phase.

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

5.8.3 Restoration and Aftercare Phases

A permanent surface water drainage system is designed to convey the water running through the final restoration slopes to perimeter channel as quick as possible.

The design of the diversion channels located on the final cover is such that their construction involves no disturbance below the cap cover soil.

5.9 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 NENT 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.

The declination of groundwater table within and downstream of the site is considered the only residual hydrological impact. The declination in groundwater level may affect the supply of irrigation water. However, it will not induce insurmountable water quality impact. With the implementation of the measures recommended in Section 5.6.3.8, the impact on irrigation water will be minimized.

5.10 Conclusion

The potential water quality impacts of the Project have been assessed. No overflow or discharge of raw leachate, treated leachate and contaminated surface runoff from the tipping face to Ping Yuen River and its tributaries will be allowed under any circumstances.

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

Under normal installation condition, the rate of leachate seepage is potentially 0.06 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.

Assessment results on groundwater flow impact shows that the groundwater level beneath the site may potentially fall by 1.5m over the operational lifetime of the landfill extension. Ground water levels at Wo Keng Shan could fall by 0.5m to 1m over the operational lifetime of the landfill extension whereas a drop of 0.6m can be expected at Ping Yeung over the same period. However, it should be noted the groundwater table downstream will be recharged by adjacent catchments and therefore the potential impact predicted above would be conservative. A number of measures to mitigate the potential loss of groundwater yields have also been proposed (including provision of water supply for irrigation to affected downstream villages). The draw down of groundwater level will not induce insurmountable water quality impact.

The amount of leachate generated from the NENT Landfill Extension has been estimated. The average peak leachate generated from both landfills is estimated to be 1,200 m^3/day, which is within the treatment capacity of the existing leachate treatment plant. The maximum peak leachate generated from both landfills during a severe storm event is estimated to be 1,500m^3/day, and new temporary storage lagoons will be constructed to store the additional leachate for further treatment. It is therefore concluded that no adverse impact on the downstream sewerage network is expected.

Sewage will be generated by workforce on site throughout the construction, operation, restoration and aftercare stages. Adverse impact is not anticipated as both portable toilets and permanent toilets at the site office will be provided to collect all sewage generated.

If IWMF would be commissioned around the same time as the NENT Landfill Extension, NENT Landfill Extension will be receiving residues from IWMF. The waste as well as the leachate characteristics will vary significantly from the existing ones. Given the uncertainty of the implementation programme for IWMF and on the exactness of data on compositions/volume and final disposal location for the residue, the impact on the future leachate treatment plant at NENT Landfill Extension will be assessed when the actual framework is better defined. If NENT Landfill Extension is finally considered as a suitable site for the disposal of IWMF residues, pilot and bench-scale tests are recommended (to be included in the NENT Landfill Extension Contract) before any full-scale operation. Leachate test for any hazardous waste/ash, such as Toxicity Characteristic Leaching Procedure (TCLP), should be conducted before dumping on the NENT Landfill Extension. The leachate generated from the hazardous wastes will be mixed with those of municipal waste in the landfill cell. Leachate generated from the landfill may also contain hazardous material and would be diluted by the leachate from domestic waste as well as the contaminated surface water. Leachate will then be transported to the leachate treatment works for NH_3, COD, BOD_5 and SS removal. After completing these treatment processes, the effluent will be discharged to the buffer lagoon for onward pumping to Shek Wu Hui Sewage Treatment Works. These processes are similar to the treatment process being adopted by the existing NENT Landfill. Given that the discharge limit of the leachate treatment will be maintained, the impact of leachate on the environment will be minimal.

Given that the landfill extension will only be in operation after the closure of the existing landfill, no cumulative water quality impact due to the construction / 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. As the two landfills fall into different drainage catchments (NENT Landfill Extension falls within Ping Yuen River Catchment while the existing NENT Landfill falls within Kong Yiu River Catchment), with the proper implementation of leachate management system as proposed in this chapter, no adverse cumulative impact is anticipated. The leachate management system includes :

- Contract provision to provide leachate storage tank for flow balancing and for detention before on-site leachate treatment.
- Sizing of the storage tank to be sufficient to cater the contaminated surface water for corrective action.
- Design capacity of the leachate treatment plant shall be planned to accommodate the worst-case scenarios and cater for treating leachate from both landfills and contaminated surface water as stated in the Contingency Plan on Accidental Leakage of Leachate.
- Perimeter bund shall be provided around the tipping face to prevent overflow during extreme rainfall.

5.11 Reference

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