3 Air Quality Impact

3.1 Introduction

This chapter presents the impact assessment on potential air quality aspects for the construction, operation and restoration and aftercare stages of the Project. Control measures for construction related activities have been recommended, in accordance with the requirements specified in the Air Pollution Control (Construction Dust) Regulation. Proper emission control limits for stack emissions from ammonia stripping plant, flare and landfill gas (LFG) power generator will be in place for the extension site, similar to the current NENT Landfill operation. Together with the implementation of good site practice for the tipping operation, the air quality impact will be controlled to within Hong Kong Air Quality Objectives (HKAQOs).

The assessment has been conducted in accordance with the requirements of Annex 4 and Annex 12 of the TM-EIAO, as well as the requirements set out under Clause 3.4.1 of the EIA Study Brief.

3.2 Environmental Legislation, Standards and Guideline

The relevant legislation and associated guidance notes applicable to the study for the assessment of air quality implications include:

- Environmental Impact Assessment Ordinance (Cap. 499) and Technical Memorandum on Environmental Impact Assessment Process (TM-EIAO);
- Air Pollution Control Ordinance (APCO) (Cap. 311) Air Pollution Control (Construction Dust) Regulation (Cap. 311R);
- Hong Kong Planning Standards and Guidelines (HKPSG);
- World Health Organisation (WHO); and
- United State Environmental Protection Agency (USEPA) references.

3.2.1 Air Quality Objectives

The principal legislation for controlling air pollutants is the Air Pollution Control Ordinance (Cap. 311) and its subsidiary regulations, which define statutory Air Quality Objectives (AQOs) for 7 common air pollutants. The AQOs for these air pollutants are tabulated in Table 3.1 below.

Table 3.1 : Hong Kong Air Quality Objectives

Pollutant	Concentration in micrograms per cubic metre [1] (Parts per million, ppm in brackets)				
	1 Hour [2]	8 Hour [3]	24 Hours [3]	3 Months [4]	1 Year [4]
Sulphur Dioxide	800 (0.3)		350 (0.13)		80 (0.03)
Total Suspended Particulates (TSP)	500 [7]		260		80
Respirable Suspended Particulates (RSP) [5]			180		55
Carbon Monoxide	30,000 (26.2)	10,000 (8.7)			
Nitrogen Dioxide	300 (0.16)		150 (0.08)		80 (0.04)
Photochemical Oxidants (as ozone) [6]	240				
Lead				1.5	

Notes:
[1] Measured at 298°K and 101.325 kPa.
[2] Not to be exceeded more than three times per year.
[3] Not to be exceeded more than once per year.
[4] Arithmetic mean.
[5] Respirable suspended particulates means suspended particulates in air with a nominal aerodynamic diameter of 10 micrometres or smaller.
[6] Photochemical oxidants are determined by measurement of ozone only.
[7] Not an AQO. TM-EIAO suggested short-term averaging level for 1 hour is 500ug/m^3. There is no exceedance allowance for 1-hour TSP guideline level.

3.2.2 Air Pollution Control (Construction Dust) Regulation

The Air Pollution Control (Construction Dust) Regulation identifies those processes that require special dust control. The Contractor of this Landfill Extension is required to inform the EPD prior to carrying out such processes and to adopt dust reduction measures while carrying out "Notifiable Works" or "Regulatory Works", as defined under the regulation. Works relevant to this Project are the site formation activities, for which TSP concentration shall not exceed 500 ug/m^3.

3.2.3 Odour Criteria

In accordance with Annex 4 of TM-EIAO, the limit of 5 odour units (OU) based on an averaging time of 5 seconds for odour prediction assessment shall not be exceeded at any receivers.

3.2.4 Other Pollutants

Other pollutants that are not covered by the Hong Kong AQOs but may impose a health risk concern have also been considered. The criteria / guideline values related to carcinogenic and non-carcinogenic health risk evaluation are established from the following order of reference:

- World Health Organization (WHO);
- United States Environmental Protection Agency (USEPA); and
- California Environmental Protection Agency (CEPA).

The guidelines for the assessment of carcinogenic health risk from exposure to air toxics are based on the WHO and USEPA Integrated Risk Information System (IRIS)'s acceptable lifetime risk.

Long-term monitoring for 38 species of VOC relating to the landfilling operation is being conducted by NENT Landfill. Nonetheless, emission for 18 species of these VOC is found to be insignificant and below the detection limit. Out of the remaining 20 species of VOC, only 8 species have documentary concern related to carcinogenic and non-carcinogenic health risk. The unit risk factor and reference dosage for the 8 related VOCs are tabulated in Table 3.2.

Table 3.2: Unit factors and reference dosage from available WHO/IRIS/CEPA database on related VOCs

Substance [1]	Molecular Weight g/mol [4]	Unit Factor per µg/m³ [3]	Reference dosage [2,4,5,6,7]
Benzene (CASRN 71-43-2)	78.11	$6x10^{-6}$	Chronic Inhalation Exposure (RfC): 30 µg/m³ (9.4ppbv) (IRIS) Acute: 1.3×10^3 µg/m³ (406.9ppbv) (CEPA)
1,4-Dichlorobenzene (CASRN 106-46-7)	147.01	-	Chronic Inhalation Exposure (RfC): $8x10^2$ µg/m³ (133.1ppbv) (IRIS)
Ethyl Benzene (CASRN 100-41-4)	106.16		Chronic: 22,000 µg/m³ for 1 year averaged All based on WHO (Geneva) Chronic Inhalation Exposure (RfC): 1000 µg/m³ (230.3ppbv) (IRIS)
Toluene (CASRN 108-88-3)	92.14	-	Acute: 1×10^3 µg/m³ for 30min averaged (odour threshold) (265.4ppbv), based on S5.14 of WHO Chronic: 260 µg/m³ (69ppbv) of 1 week, based on S5.14 of WHO
Vinyl chloride (CASRN 75-01-4)	62.5	$1.0x10^{-6}$	Chronic Inhalation Exposure (RfC): 100 µg/m³ (IRIS) Acute: $1.8x10^5$ µg/m³ (70,416ppbv) (CEPA)
Xylenes (CASRN 1330-20-7)	106.16	-	Acute: 4800 µg/m³ for 24 hour averaged Chronic: 870 µg/m³ for 1 year averaged All based on WHO (Geneva) Chronic Inhalation Exposure (RfC): 100 µg/m³ (23.0ppbv) (IRIS)
Tetrachloroethylene (CASRN 127-18-4)	165.8	-	Acute: 8000 µg/m³ for 30 min averaged; 250 µg/m³ for 24 hour averaged based on WHO (Geneva)
Methylene Chloride / Dichloromethane (CASRN 75-09-2)	84.93	-	Acute: 3mg/m³ for 24 hour guideline; Chronic: 0.45mg/m³ for a weekly guideline All based on S5.7 of WHO

Note: [1]. CASRN – Chemical Abstracts Service Registry Number
[2]. RfC – Reference Concentration
[3]. If WHO standard is available, it will be applied first
[4]. $C_{ppbv} = C_{ug/m3} \times 24.45$ / Molecular Weight
[5]. WHO represents Air Qualiy Guideline for Europe, WHO
[6]. WHO (Geneva) represents Guidelines for Air Quality, WHO, Geneva, 2000
[7]. CEPA represents California Environmental Protection Agency

3.2.4.1 Carcinogenic Health Risk Assessment

Emissions pertinent to this Project are benzene and vinyl chloride which are key control parameters from the Ammonia Stripping Plant (ASP), flares and LFG generators. Tables 3.3 and 3.4 show the unit risk factors for non-criteria key pollutants of benzene and vinyl chloride and guidelines for assessment of individual risk.

Table 3.3: Unit risk factors guideline for non-criteria pollutants

Pollutant	Unit Risk ((µgm⁻³) ⁻¹)
Benzene	$6x10^{-6}$
Vinyl Chloride	$1.0x10^{-6}$

Table 3.4: Risk guidelines for carcinogenic health risk assessment

Acceptability of Cancer Risk	Estimated Individual Cancer Risk Level	
	Individual Lifetime Risk (A)	Individual Risk Per Year (B) = (A)/70
Significant	$>10^{-4}$	$>1.4x10^{-6}$
Risk should be reduced to As Low As Reasonably Practicable (ALARP)	$>10^{-6}$ & $<= 10^{-4}$	$>1.4x10^{-8}$ & $<= 1.4x10^{-6}$
Insignificant	$\leq 10^{-6}$	$\leq 1.4x10^{-8}$

3.2.4.2 Non-Carcinogenic Health Risk Assessment

Non-carcinogenic health risk guidelines apply to the assessment of chronic and acute health risks.

Chronic Health Risks

Using the chronic health risk assessment approach, the chronic reference concentrations for benzene and vinyl chloride are summarized in Table 3.5 and their acceptability criteria in Table 3.6.

Table 3.5: Chronic reference concentrations for benzene and vinyl chloride

Pollutant	Chronic Reference Concentration (AC_A) (Annual Average)
Benzene	30 μg/m^3 (9.4ppbv) [a]
Vinyl Chloride	100 μg/m^3 (39.12ppbv) [a]

Note: [a] Yr 2000 updated standard from Integrated Risk Information System (IRIS), USEPA

Table 3.6: Acceptability criteria for chronic non-cancer health risks

Acceptability	Assessment Results [a]
Chronic non-cancer risks are considered "Insignificant"	$AC_A \leq RC_C$
Chronic non-cancer health risks are considered 'Significant". Detailed assessment of the control requirements and further mitigation measures are needed	$AC_A > RC_C$

Note: [a] AC_A and RC_C represent annual average concentration and chronic reference concentration respectively.

Acute Health Risks

Using the acute health risk assessment approach, the acute reference concentrations for benzene and vinyl chloride are summarized in Table 3.7 and their acceptability criteria in Table 3.8.

Table 3.7: Acute reference concentrations

Pollutant	Acute Reference Concentration (AC_{HM}) (1-hour average, μg m^{-3})
Benzene	1.3 x 10^3 [a]
Vinyl Chloride	1.8x10^5 [a]

Note : [a] California Air Resources Board – Air Toxic Hot Spots Program Risk Assessment Guidelines, Part I – Technical Support Document for the Determination of Acute Reference Exposure Levels for Airborne Toxicants, May 2000.

Table 3.8: Acceptability criteria for acute non-cancer health risks

Acceptability	Assessment Results [a]
Acute non-cancer risks are considered "Insignificant".	$AC_{HM} \leq RC_A$
Acute non-caner health risks are considered "Significant". Detailed assessment of the control requirements, and further mitigation measures are needed.	$AC_{HM} > RC_A$

Note: [a] AC_{HM} and RC_A represent maximum hourly average concentration and acute reference concentration respectively.

3.3 Description of the Existing NENT Landfill and the Extension

3.3.1 Existing vehicles trips generated from NENT Landfill

Based on the latest information, daily vehicular trip generation is in the order of 500 veh/day (or max peak hourly flow of 90 veh/hr) travelling to and from the existing NENT Landfill. Owing to the low traffic flow, vehicular emission impact is not a key issue for the existing NENT Landfill operation.

In addition, most of the refuse collection vehicles (RCV) for MSW and sludge are of enclosed-type and odorous gases are well contained during transit under normal circumstances. For sludge vehicles / special vehicles that required admission ticket, special condition can be imposed on the cleanliness of vehicle and disposal period to avoid adverse cumulative impact. With reference to the existing NENT Landfill experience, potential odour impact from RCVs can be adequately controlled and unlikely to be an issue.

3.3.2 Existing plants operation

Current NENT Landfill operation emits gaseous emissions from Ammonia Stripping Plant (ASP), flare system and landfill engine. The flare system operates only when the ASP is not in use or when excessive LFG is pending for treatment. With the development of Landfill Gas Export Scheme (LFGES), the need for flaring over any extensive period would be unlikely in practice. Monthly monitoring at the inlet and outlet of the flaring system is conducted to verify the destruction efficiency. Past monitoring results suggest that emission from flaring system has complied with the control limits.

3.3.3 Existing monitoring and audit findings

EM&A records for TSP and VOCs monitoring over the previous 9 years have been reviewed. TSP monitoring is conducted once every 6 days in three locations (See Drawing 24315/13/504 for existing dust monitoring locations D1 to D3). Whereas, VOC monitoring is conducted once every 3 months in four locations around the site boundary (See Drawing 24315/13/504 for existing VOC monitoring locations V1 to V4), and one location at source within the gas well (See Drawing 24315/13/504 for existing gas wells locations W1 to W30).

The sampling methodology was stipulated in Section 35.10.2 of the NENT Landfill Monitoring Plan. Equipment specified in Method T014/T015 of USEPA and corresponding methods for the determination of Toxic Organic Compounds in ambient air were adopted for monitoring the existing landfill. VOC will be collected in 6L stainless steel canisters coated internally with silica. Methane will be trapped using a low-flow rate pump to a 1L Tedlar bag for direct analysis on a gas chromatography. Analysis will be carried out by a laboratory equipped with a capillary gas chromatography linked to a mass spectrometer.

Key observations from the past monitoring records are summarised in Table 3.9 for TSP and Table 3.10 for VOC. The dust and LFG monitoring locations of the existing NENT Landfill is shown in Drawing No. 24315/13/504. In accordance with the long-term monitoring record, there is no exceedance of TSP since Year 1996. With the implementation of dust control measures and periodic EM&A monitoring, the performance of dust suppression measures are found to be sufficient and no adverse impact would be anticipated.

Table 3.9: Dust monitoring record for existing NENT Landfill operation

Monitoring ID	Location	Monitoring Parameters	Frequency	Observations	Mitigation Measures
D1	beside canteen	TSP/RSP	Once very 6 days. Increase to 3 days cycle in case of exceedance event	No exceedance since 1996	Increase water spraying frequency in tipping area and haul road by water trucks and sweeper trucks Apply automatic water spraying system Minimize the exposure duration of cut slopes and temporary capped areas by early hydroseeding.
D2	grassland beside Lagoon#1			No exceedance since 1996	
D3	near Tung Lo Hang Village			There were 2 abnormalities occurred from 97 until present due to dry weather and high traffic rate of haul road M3. The abnormalities were rectified immediately and Independent Consultant was satisfied with the results.	

Remark : The established EM&A mechanism and good site practice in existing NENT Landfill effectively contain any dust problem on site in a timely manner.

Table 3.10: VOC monitoring information for existing NENT Landfill operation

Monitoring ID	Location	Monitoring Parameters	Frequency	Observations	Mitigation Measures
V1	East of the landfill area	38 VOCs including 8 prominent VOCs: • Benzene; • Dichlorobenzenes; • Dichlorodifluor-methane; • Ethylbenzene; • Methylene Chloride; • Toluene; and • Methane.	Quarterly basis in March, June, September and December at four boundary locations and one gas well. If the monitoring results show abnormality, site inspection and special monitoring will be conducted.	Only one abnormality was observed out of 1440 data (9-year monitoring data) [1]	Site investigation has identified neither potential leakage from the pipelines nor defect in extraction system. No exceedance was identified in subsequent special monitoring.
V2	North of the landfill area			Only four abnormalities were observed out of 1440 data (9-year monitoring data) [1]	
V3	West of the landfill area			Only five abnormalities were observed out of 1440 data (9-year monitoring data) [1]	
V4	South of the landfill area			Only one abnormality was observed out of 1440 data (9-year monitoring data) [1]	

Remark : [1] - VOC monitoring data and emission trend at source (within gas well) were compared with the results at the site boundary. Independent Consultant (IC) confirmed that the handful number of abnormal readings were not caused by / related to landfill operation.

Only 11 abnormalities out of 7200 monitoring data were observed over the past 9 years. For all these 11 abnormalities, the VOC levels at the gas well (source) were lower than that at the site boundary. Special monitoring had been conducted immediately and no exceedance was observed. An Independent Consultant (IC) had reviewed all these monitoring results and the findings for the site inspection by Environmental Team. It was concluded that the abnormal readings of VOC were not due to the operation of existing landfill. There were existing pig farm, recycling workshops and woodland in the nearby area that would also have emission of the same VOC elements. The reasons for the cause of the abnormality were orginated from external sources. The reasons were justified and accepted by the IC, and these IC reports have been sent to EPD for review. Therefore, these abnormalities (i.e. non genuine cases) in VOCs have been discarded in this assessment.

The 9-year VOCs concentrations at the 4 monitoring points of the NENT Landfill site boundary are also tabulated in Table 3.11. It is observed that all VOC levels were within the contractual trigger levels which had been verified by the Independent Consultant.

The nearest ASR is located more than 300m away from the NENT Landfill site boundary. Taking into consideration the dispersion from the boundary to the ASRs, it is envisaged that the VOC level at ASRs will be further reduced significantly. During landfill restoration, the existing NENT Landfill will be capped with plastic sheet together with a thick layer of covering soil similar to other landfill under restoration, the VOC emission will be insignificant.

By the time when the NENT Landfill Extension is in operation, existing NENT will be capped with thick soil and equipped with active LFG extraction system, the surface emission from existing NENT will not be an issue based on the observation from the restored landfills in HK. In order words, the ambient VOC level would be significantly lower than the past monitoring data after restoration of existing NENT.

Table 3.11: 9-year averaged VOC concentration at the site boundary of the existing NENT Landfill (from Year 1997 to Year 2005)

Pollutants	Events	9-year monitoring data at the site boundary (in ppbv except methane) [a]			
		V1	V2	V3	V4
1_2-Dibromoethane (CASRN 106-93-4)	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
1_1_1-Trichloroethane (CASRN 71-55-6)	Monitoring result range	<1 * – 1.2	1	<1 * – 1.2	<1 * – 1.1
	Long-term average	1	1	1	1
Benzene (CASRN 71-43-2)	Monitoring result range	<1 * – 2.8	<1 * – 1.8	<1 * – 8.2	<1 * – 2
	Long-term average	1.2	1.1	1.5	1.1
Butan-2-ol (CASRN 71-36-3)	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Butanethiol	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Butyl acetate	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Butyl benzenes	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Carbon Disulphide (CASRN 75-15-0)	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Chloroform (CASRN 67-66-3)	Monitoring result range	<1 * – 13	<1 * – 1.9	<1 * – 14	<1 *
	Long-term average	1.6	1.1	1.3	<1 *

Pollutants	Events	9-year monitoring data at the site boundary (in ppbv except methane) [a]			
		V1	V2	V3	V4
Decanes	Monitoring result range	<1 *	<1 * – 1.1	<1 *	<1 * – 3.2
	Long-term average	<1 *	1	<1 *	1.1
Dichlorobenzene (CASRN 106-46-7)	Monitoring result range	<1 * – 8.1	<1 * – 16	<1 * – 16	<1 * – 17
	Long-term average	1.4	2.4	2.7	3.4
Dichlorodifluoromethane (CASRN 75-71-8)	Monitoring result range	<1 * – 21	<1 * – 83	<1 * – 82	<1 * – 12
	Long-term average	3.5	12.3	6.4	2.0
Dimethyl sulfide	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Dipropyl ether (CASRN 111-43-3)	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Ethanethiol	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Ethanol	Monitoring result range	<100 *	<100 *	<100 *	<100 *
	Long-term average	<100 *	<100 *	<100 *	<100 *
Ethyl Benzene (CASRN 100-41-4)	Monitoring result range	<1 * – 44	<1 * – 6.4	<1 * – 70	<1 * – 65
	Long-term average	3.4	2.1	6.2	5.1
Ethyl Butyrate	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Ethyl Propionate	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Limonene (CASRN 5989-27-5)	Monitoring result range	<1 *	<1 * 4.2	<1 * – 3.5	<1 * – 2.8
	Long-term average	<1 *	1.5	1.1	1.1
Methane	Monitoring result range in ppmv	0.5 – 32	0.05 – 55	1.8 – 56	0.5 – 57
	Long-term average in ppmv	6.7	7.1	9.0	13.9
Methanethiol	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Methanol (CASRN 67-56-1)	Monitoring result range	<100 *	<100 *	<100 *	<100 *
	Long-term average	<100 *	<100 *	<100 *	<100 *
Methyl Butyrate	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Methyl Propionate	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Methylene chloride	Monitoring result range	<1 * – 53	<1 * – 73	<1* – 230	<1 * – 84
	Long-term average	9.1	12.5	27.8	12.1
n-Heptane (CASRN 142-82-5)	Monitoring result range	<1 * – 5.4	<1* – 900	1 – 95	<1 * – 23
	Long-term average	1.2	44	7.2	2.6
n-Octane	Monitoring result range	<1 *	<1* – 760	<1 * – 54	<1 * – 5.8
	Long-term average	<1 *	37.2	3.5	1.2
Nonane	Monitoring result range	<1 *	1 – 92	1– 18	1– 2.3
	Long-term average	<1 *	5.3	1.8	1.1
Propyl Benzene	Monitoring result range	<1*– 36	<1* – 21	<1* – 6.6	<1* – 28

Pollutants	Events	9-year monitoring data at the site boundary (in ppbv except methane) [a]			
		V1	V2	V3	V4
	Long-term average	3.2	3.5	1.4	3.5
Propyl Propionate	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Terpenes	Monitoring result range	<1* – 1.7	<1* – 1.5	<1* – 1.5	<1* – 2
	Long-term average	1.0	1.0	1.0	1.1
Tetrachloroethylene (CASRN 127-18-4)	Monitoring result range	<1* – 2.6	<1 * – 2.9	<1 * – 2.7	<1 *
	Long-term average	1.1	1.1	1.1	<1 *
Toluene (CASRN 108-88-3)	Monitoring result range	<1* – 120	<1* – 42	<1* – 160	<1* – 78
	Long-term average	15.1	11.1	23.4	18.6
Trichloroethylene (CASRN 79-01-6)	Monitoring result range	<1 *	<1 * – 2.8	<1 *	<1 * – 1.7
	Long-term average	<1 *	1.1	<1 *	1.0
Undecane	Monitoring result range	<1 *	<1 *	<1 *	<1 *
	Long-term average	<1 *	<1 *	<1 *	<1 *
Vinyl chloride (CASRN 75-01-4)	Monitoring result range	<1* – 2.8	<1 *	1 – 13	<1 *
	Long-term average	1.1	<1 *	1.6	<1 *
Xylenes (CASRN 1330-20-7)	Monitoring result range	<1* – 64	<1* – 12	<1* – 110	<1* –120
	Long-term average	5.1	3.6	10.7	8.7

Remark (a) : lowest detection limit is 1ppbv for all pollutants; except for methanol and ethanol which is 100ppbv.
* : Below detection limits (assume to take the lowest detection limit as the monitoring result)

Owing to the lack of background monitoring data at the region/ASR, the long-term monitoring data of benzene and vinyl chloride at the site boundary are taken as the background as a conservative estimation. A background benzene and vinyl chloride concentrations of 1.225ppbv (3.9ug/m^3) and 1.175ppbv (3ug/m^3) are adopted, respectively. In fact, these values have included the contribution from surface gas emission, if any, from the tipping area.

Odour complaint records from existing NENT Landfill site office and EPD Environmental Compliance Division have been checked, and there were only 2 odour complaints in the existing NENT Landfill region in the past 5 years. Detailed investigations were conducted by the Independent Consultant and Environmental Team of the existing NENT Landfill and it was concluded that NENT Landfill was not the source of the odour nuisance.

Benzene, Vinyl Chloride and Non-methane Organic Carbon (NMOC) have also been monitored at the flare of the existing NENT Landfill, and the monitoring results are summarised below.

Table 3.12: Monitoring data from flare system

Pollutants	NMOC		Vinyl Chloride		Benzene	
6-year Monitoring Results	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Max (ppmv)	4800	33	1.6	<0.006	1	<0.006
Min (ppmv)	330	0.03	0.2	<0.001	0.2	<0.001
Average (ppmv)	2182	6.1	0.553 (1413 μg/m^3)	0.0026 (6.646 μg/m^3)	0.493 (1574.98 μg/m^3)	0.0029 (9.265 μg/m^3)
Removal Efficiency [aver value (inlet - outlet)/inlet]	99.7%		99.5%		99.4%	

Owing to the lack of monitoring data for ASP and power generator, reference has been made with the typical control efficiency under Table 2.4-3, AP-42 of USEPA as the best estimate. The typical controlled efficiency of 99.6% and 99.8% are proposed for halogenated species and non-halogenated species for boiler/stream turbine. As compared to the controlled efficiency of 99.5% and 99.4% for halogenated species and non-halogenated species for flare, the efficiency in flare is on a conservative side. Therefore, the controlled efficiency for ASP and power generator will assume to be the same as that for the flare.

3.3.4 Proposed Plant for Landfill Gas Export Scheme in Existing NENT Landfill

The contractor of the existing NENT Landfill has signed an agreement with Hong Kong China Gas Co. (HKCG) for the Landfill Gas Export Scheme (LFGES). Under this LFGES, NENT Landfill shall supply a large quantity of LFG as fuel for production of towngas. The ultimate aim of the scheme is to enhance the environment and utilise as much LFG as possible as fuel. The entire system will extract most of the LFG from gas wells.

In order to maximise the extraction to achieve a cost-effective export scheme, the following practices have been implemented since Year 2007 to improve the extraction efficiency (means higher LFG production rate and higher energy recovery) as much as possible:

- Formulation of a working team to review all processes, control practice and extraction system in order to maximum the efficiency of the system.
- Maintain a slightly negative pressure within the entire tipping area (by suction).
- Increase the number of gas-extraction wells by reducing the radius of the catchment from 50m each to 25m.
- Improve the extraction efficiency by checking/reinstating gas wells with abnormally low extraction rate as a result of blockage/soil movement or sedimentation.
- Increase the coverage of inactive tipping area with HDPE sheet which can enhance the anaerobic decomposition (reduce air getting in).
- Extract LFG at newly-opened active tipping area (the only free opening for surface VOC emission).

At the restoration phase, no surface gaseous emission is anticipated after laying of plastic sheet and thick soil cover based on the observations from other restored landfills in HK.

3.3.5 Ambient air quality from EPD monitoring station

The nearest EPD air quality monitoring station to this Project is the Tai Po Monitoring station at Tai Po Government Office Building. According to EPD's report on "Air Quality in Hong Kong" the area type of NENT Landfill Extension is under the "New Town" category.

Air quality data at the Tai Po Monitoring Station between 2000 to 2005 has been extracted. Table 3.13 below shows the average concentration of major air pollutants at the monitoring station.

Table 3.13: Background pollutant concentrations (5-year annual averaged)

Pollutant/ Year	2000	2001	2002	2003	2004 [(a)]	2005	5-year Averaged Concentration (ug/m^3)
NO_2	47	50	48	52	N.A.	49	49.2
SO_2	12	13	11	14	N.A.	19	13.8
TSP	63	68	61	71	N.A.	61	64.8
RSP	48	50	46	54	N.A.	51	49.8

Note: (a) Annual averaged monitoring data for Tai Po is not available at Year 2004 due to upgrading of system.

3.4 Air Sensitive Receivers

Air sensitive receivers (ASRs) were identified in accordance with the guidelines in Annex 12 of the TM-EIAO. Existing ASRs were confirmed through site visits and review of survey maps. There were no planned ASRs on the latest Outline Zoning Plan. Representative ASRs within a distance of 500m from the Project boundary have been selected for the assessment. Their respective locations are shown in **Drawing No. 24315/13/101** and Table 3.14 below.

Table 3.14: Summary of representative air sensitive receivers

Assessment Point No.	Assessment Point Description	Use	No. of Storey (including roof)	Shortest Horizontal Distance to Waste Boundary, m
ASR1	Wo Keng Shan Tsuen	Residential	3	420
ASR2	Village houses at Junction of Ng Chow Road and Wo Keng Shan Road	Residential	3	1040
ASR3	Cheung Shan Monastery	Religions	1	820
ASR4	Man Uk Pin	Residential	3	1130
ASR5	Man Uk Pin	Residential	3	1200
ASR6	Miu Keng	Residential	3	990
ASR7	Heung Yuen Wai	Residential	3	1240
ASR8	Tsung Yuen Ha	Residential	3	1790
ASR9	Ha Heung Yuen	Residential	3	1330
ASR10	Lin Ma Hang	Residential	3	900
ASR11	Tung Lo Hang	Pig Farm/ Residential	2	800
ASR12	Chuk Yuen	Residential	3	2000
ASR13	Nga Yiu Ha	Residential	3	1080
ASR14	Ping Yeung	Residential	3	960
ASR15	Ping Che	Residential	3	1890
ASR16	Ping Che Kat Tin	Residential	3	1870
ASR17	Kan Tau Wai	Residential	3	2250
ASR18	Tong Fong	Residential	3	2150
ASR19	Fung Wong Wu	Residential	2	2500
ASR20	Lei Uk	Residential	2	2450
ASR21	Chow Tin Tsuen	Residential	2	2750
ASR22	Tai Po Tin	Residential	2	2400
ASR23	Ha Shan Kai Wat	Residential	2	2800
ASR24	Sheung Shan Kai Wat	Residential	2	3000
ASR25	Tai Tong Wu	Residential	2	1650
ASR26	Loi Tung	Residential	2	1700
ASR27	Tong To Shan Tsuen (derelict and vacant)	Derelict and Vacant	3	450

3.5 Identification of Air Pollution Source and Environmental Impact

3.5.1 General Modes of Construction/Operation

Based on the practice in existing NENT Landfill operation and the construction/operational programme for future NENT Landfill Extension operation, the construction and operational events are summarised in Tables 3.15, 3.15a and 3.16 respectively. The existing and future landfill development phasing is illustrated in Appendix 2.2 and Drawing 24315/13/203.

Table 3.15: Summary of general modes of construction / capping activities

Stage	Mode of Construction	Period	Dust Impact	Remark
1	• Operation + Capping of Existing NENT Landfill – from end 2008 (assumed as worst case) • Site clearance - end 2008 to mid 2009 • Excavation & site formation - mid 2009 to end 2009 • Installation of liner, leachate & LFG systems - end 2009 to end 2010	About 24 months	• Existing NENT Landfill : About 3,000m² of active area for capping/stockpiling; including the 40m x 30m operation area. • Phase 1 area of NENT Landfill Extension : About 20% of Phase I area under active site formation works. • Phase 2 area of NENT Landfill Extension : No activity. • Phase 3 area of NENT Landfill Extension : No activity.	• Worst-case scenario with the cumulative impact from existing NENT Landfill and its extension, active site areas in NENT and NENT Extension are closest to ASR. • Need advance work and involve larger construction area during critical period. • Setback distance of Stage 1 is closest to ASR.
2	• Site clearance – early 2010 to end 2010 • Excavation & site formation - end 2010 to mid 2012 • Installation of liner, leachate & LFG systems- mid 2011 to end 2012	About 36 months	• Existing NENT Landfill : Aftercare and no construction activity. • Phase 1 area of NENT Landfill Extension : 40m x 30m operation area. • Phase 2 area of NENT Landfill Extension : About 20% of Phase 2 area under active site formation works. • Phase 3 area of NENT Landfill Extension : No activity.	• More float time for construction and smaller construction area Setback distance of Stage 2 to ASR is further away than Stage 1. • Less impact than Stage 1 and detailed model will not be conducted.
3	• Site clearance - early 2013 to end 2013 • Excavation & site formation - mid 2013 to end 2014 • Installation of liner, leachate & LFG systems – early 2014 to end 2015	About 36 months	• Existing NENT Landfill : Aftercare and no construction activity. • Phase 1 & 2 areas of NENT Landfill Extension : 40m x 30m operation area. • Phase 3 area of NENT Landfill Extension : About 20% of Phase 3 area under active site formation works.	• Less impact than Stage 1 and detailed model will not be conducted.
4	• Installation of final capping - early 2020 to end 2021 • Planting and Landscaping - early 2021 to end 2022	about 24 months for capping and 24 months for planting	• Existing NENT Landfill : Aftercare and no construction activity. • NENT Landfill Extension : About 3,000m² of active excavated area for capping.	• Less impact than Stage 1 and detailed model will not be conducted.

Table 3.15a: Identification of worst-case scenario for construction / capping activities

	Existing NENT Landfill / Landfill Extension	Existing NENT Landfill	Landfill Extension Phase 1 Area	Landfill Extension Phase 2 Area	Landfill Extension Phase 3 Area
Earthwork activities	Operation 0.00018 Mm^3 (40x30x0.15 m^3)	Capping 0.7 Mm^3 (0.7 Mm^3 fill)	Site formation 2.7 Mm^3 (1.5 Mm^3 cut + 1.2 Mm^3 fill)	Site formation 2.8 Mm^3 (1.9 Mm^3 cut + 0.9 Mm^3 fill)	Site formation 2.9 Mm^3 (2.8 Mm^3 cut + 0.1 Mm^3 fill)
Programme	Everyday	24 months	15 months	30 months	24 months
Earthwork activities per month (Dust Impact)	0.0054 Mm^3	0.03 Mm^3	0.18 Mm^3	0.10 Mm^3	0.12 Mm^3

Notes :

1. The earthwork activity in operation is considered negligible in comparison with the site formation activities.
2. In Stage 1 (Existing NENT + Extension Phase 1), total earthwork involved is estimated to be 0.21 Mm^3 per month, and is close (~ 500m) to Wo Keng Shan Village.
3. In Stage 2 (only Extension Phase 2 with dusty construction), total earthwork involved is estimated to be 0.10 Mm^3 per month. Phase 2 have more float time and thus the active construction area can be reduced. Thus the impact will be less than that in Stage 1.

Table 3.16: Summary of general modes of operation activities and identification of worst-case scenario

Stage	Mode of Operation	Period	Gaseous Emission and Odour Impact	Remark
A	• Existing NENT Landfill close down without tipping activities • Waste filling (within Phase 1 area) - end 2010 to end 2012	about 27 months	• Existing NENT Landfill : No operational activity. • Phase 1 area of NENT Landfill Extension : In operation with active tipping area about 40m x 30m. • Phase 2 area of NENT Landfill Extension : No operational activity. • Phase 3 area of NENT Landfill Extension : No operational activity.	• Existing NENT will be capped with no detectable surface gas and odour emission. • Less landfill gas and leachate generation than Stage C due to smaller waste filling volume. • Odour from the same active tipping area.
B	• Waste filling (within Phases 1 and 2 areas) - early 2013 to end 2015	About 36 months	• Existing NENT Landfill : No operational activity. • Phase 1 & 2 areas of NENT Landfill Extension : In operation with active tipping area about 40m x 30m. • Phase 3 area of NENT Landfill Extension : No operational activity.	• Less landfill gas and leachate generation than Stage C due to smaller waste filling volume. • Odour from the same active tipping area.
C	• Waste filling (within Phases 1 to 3 areas) - early 2016 to end 2020	About 60 months	• Existing NENT Landfill : No operational activity. • Phase 1, 2 & 3 areas of NENT Landfill Extension : In operation with active tipping area about 40m x 30m – worst-case with largest area (both active and inactive tipping areas) – can be controlled by good extraction system and coverage by plastic sheet. • Max number of operational plants adopted for the entire lifecycle (LFG, ASP and flares) – in practice with largest amount of gas generation due to cumulative of waste and maturity of the landfilling condition.	• Worst case for gaseous emission assessment. • Odour from the same active tipping area.

Stage	Mode of Operation	Period	Gaseous Emission and Odour Impact	Remark
D	• Aftercare (Landfill gas and Leachate will be reduced) 2023 (for 30 years)	About 30 years	• Very light activities within the capped area. Active control system for landfill gas and leachate will be operational without causing adverse environmental impact. • No detectable surface gas and odour emission will be anticipated based on the observations from other restored landfills in HK.	• Less impact than Stage C. • No odour from restored landfill.

3.5.2 Source Identification

On-site and off-site air pollution sources during construction, operation, restoration and aftercare of the Project are summarised in Table 3.17 and 3.18 below:

Table 3.17: Sources of air pollution from Construction and Restoration Phases

Sources of air pollution
• Various construction activities during daytime
• Wind erosion

Table 3.18: Sources of air pollution from Operation Phase

Sources of air pollution
• Road traffic (insignificant due to very low traffic flow. There is no increase in total flow between the existing landfill and its future extension).
• Potential dust emission arising from daily operations (included in the general construction activities)
• VOC emission from active tipping area.
• Gases emission from flare, LFG power generator and ammonia stripping plants.
• Odour emission from leachate treatment facilities.
• Odour emission and surface gas emission from waste tipping operation.

3.5.3 Construction Phase

Heavy construction activities during daytime include site clearance, ground excavation, cut and fill (i.e. earth moving) operations, construction of the associated facilities and temporary road access within the site. In addition, wind erosion of all open sites including stockpiling will have potential impact.

Quantitative assessment on the impact of the identified sources on the ASRs is conducted.

3.5.4 Operation Phase

3.5.4.1 Vehicles

Current daily vehicular trip generation travelling to and from the existing NENT Landfill site along Wo Keng Shan Road is in the order of 500 veh/day. About 90 veh/hour is predicted from the NENT Landfill Extension during the peak operation hour. Given the more than 5m setback distances between Wo Keng Shan Road and ASRs, it is in compliance with the HKPSG requirements for vehicular emission control. As there will not be any overlapping of operation phases between NENT Landfill and its extension, adverse vehicular emission impact is not anticipated and quantitative assessment is not required.

In general, most of the refuse collection vehicles (RCV) for MSW and sludge are of enclosed-type and odorous gases are well contained during transit under normal circumstances. Sludge vehicles / special vehicles that required admission ticket, and special condition can be imposed on the cleanliness of vehicle and disposal period to avoid adverse cumulative impact. With reference to the existing NENT Landfill experience, potential odour impact from RCVs can be adequately controlled and unlikely to be an issue. Quantitative assessment is therefore not required.

In accordance with the HKPSG requirements, the minimum setback distance from earth moving activities to ASRs is 50m. Since the distance between the NENT Landfill Extension and the nearest ASRs is more than 300m, dust emission impact from landfill will be insignificant. In addition, all vehicles will be cleansed by wheel washing facility up to half of the vehicle height before leaving landfill, and soil brought away from landfill is thus not anticipated. Vehicle containing dusty material will also be covered by sheet to avoid any potential nuisance. Any dusty discharge on road is a violation of the Public Health & Municipal Ordinance. Therefore adverse off site dust impact is not anticipated.

3.5.4.2 Ammonia Stripping Plant, LFG Power Generator and Flaring Systems

The ammonia stripping plant and the thermal destructor at the existing NENT Landfill is an integrated unit (Figure 3.1 for illustrative diagram). When raw leachate passes through the ammonia stripping tower, ammonia dissolved in leachate will be removed. The ammonia laden air is combusted with landfill gas in the thermal destructor. Given particulate matter in the combustion process is negligible, emissions of ASP from the stacks are expected to be insignificant.

In accordance with US Environmental Protection Agency, AP-42 "Compilation of Air Pollutant Emission Factors" data, the thermal destructor is designed to destroy over 99% of VOCs (including methane, vinyl chloride, benzene and other non-methane hydrocarbons) in the landfill gas and exhaust from the ammonia stripping tower. Resulting discharge of benzene and vinyl chloride is reduced to a low limit. Similarly, all gaseous ammonia are completely oxidised to nitrogen and water.

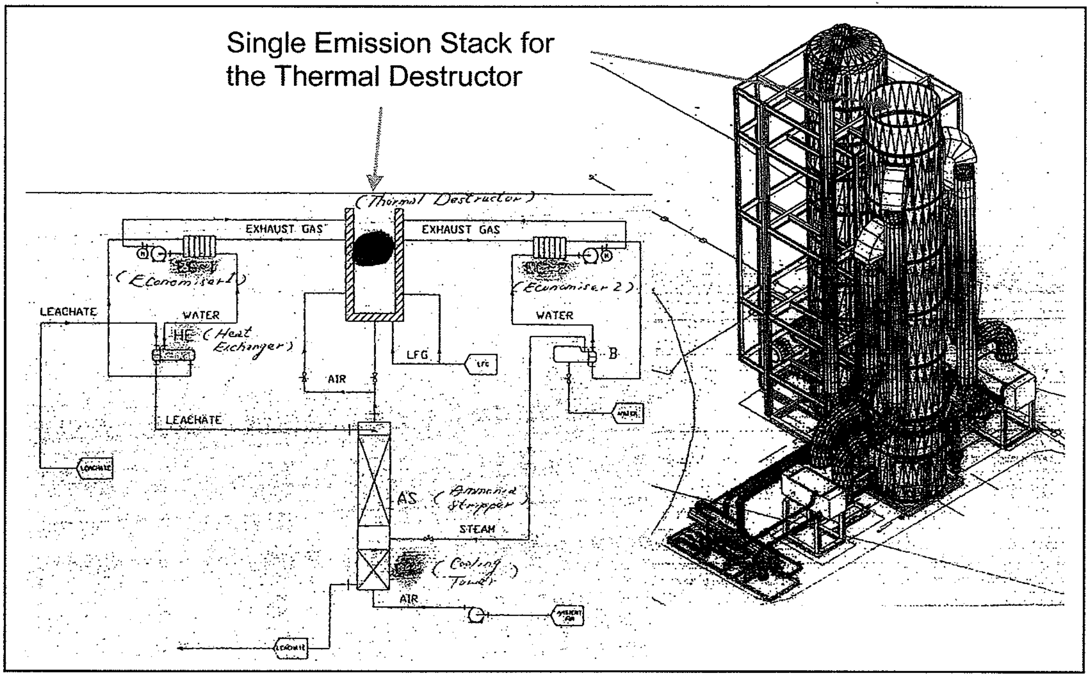

Figure 3.1 Schematic Diagram of the Thermal Destructor (Within Ammonia Stripping Plant)

LFG extracted from NENT Landfill is utilised on site as the fuel source for LFG power generator and will be exported to HKCG for commercial use. The existing LFG power generator plant consists of 2 JGC 320 GS-B21 engine modules which can produce approximately 1.8 MW of electricity. The plant is running in pure isolated operation 24 hours a day because system connection to power grid is not allowed.

An agreement was formed between the contractor of the existing NENT Landfill and The Hong Kong & China Gas Company (HKCG) to export the LFG from NENT Landfill for towngas production. Landfill gas flaring system is installed in the existing NENT Landfill purely for the thermal destruction of surplus landfill gas. Under normal operating condition, all the available LFG will be fully utilised and no surplus LFG will be incinerated in the flaring system. As it is still early stage to formulate a LFG Export Scheme from future NENT Landfill Extension, the following assessment using similar flaring system as the existing landfill will be the worst-case scenario. In fact the flaring system for the extension site would be much smaller than the existing landfill because the total waste volume of the extension site is much less than the existing landfill.

NO_2, SO_2, Vinyl Chloride and Benzene as the key control parameters will be quantitatively modelled to assess their potential impact.

3.5.4.3 Leachate Treatment Facilities

Raw leachate temperature rises as a result of the bacteriological reaction during decomposition of waste. Its temperature is further increased by mixing with the treated effluent from the ammonia stripping plant (heating process). Leachate temperature is therefore well above the atmospheric temperature. Effect of atmospheric temperature variation has little influence on odour emission from leachate treatment plant. Odour samples collected for quantitative analysis is therefore not subjected to temperature adjustment.

To plan for the worst case scenario with cumulative impact from the restored landfill and the NENT Landfill Extension, a new on-site leachate treatment facility is assumed within the NENT Landfill Extension to serve the extension site, while the existing leachate treatment plant is retained to serve the existing landfill under restoration. The new leachate treatment facilities is located at the lowest elevation in order to cater for a gravity leachate collection system. It will be located close to the waste reception area of the existing NENT Landfill and Wo Keng Shan Tsuen. A quantitative assessment model is adopted for the odour impact evaluation of the two leachate treatment plants.

It is also noted that there would be upgrading works under the existing NENT Landfill Project to improve the existing leachate treatment plant. The proposed improvement include:

- Provision of ventilated cover for the existing lagoons and emissions are extracted to suitable odour removal filters with odour removal efficiency of 99%.
- Ferric nitrate or sodium hypochlorite can be added to oxidise the odourous chemical in the leachate. The pH value of leachate can be controlled to a suitable value from future on-site experiment such that the generation of any odourous H_2S and ammonia can be optimised.
- For the gaseous extraction system, the wind speed immediately above the leachate surface should be kept to minimal (in the order of $1E^{-3}$ m/s) such that the odour emission strength from lagoon can be minimised. Suitable treatment system should be provided for odour removal. The ventilated gaseous emission from lagoons should be provided with 5-10 air change per hour for further dilution before discharge.
- The notional centre of the future discharge point (e.g. stack) shall be located at a location with maximum setback distance from the ASRs and further away from the notional centre of the lagoons. The location of discharge point and discharge height should be determined at the detailed design stage to ensure that the odour criterion at the ASRs will not be exceeded.

This will provide an environmental benefit to nearby environment in terms of visual and odour improvement.

As regards the leachate treatment facilities for the Landfill Extension (assuming conservatively that a new plant will be implemented), it is anticipated that the new plant will be built to the improved condition as described above, right from the beginning of its operation. Treatment method such as Sequencing Batch Reactor could be adopted for future lagoon.

Based on the preliminary estimation, owing to the capping of the existing NENT Landfill, leachate generation will be much reduced from currently $800m^3$/day to $350m^3$/day in the future. Most of the existing plants in NENT Landfill will not be operated in full scale. The leachate generation from NENT Landfill Extension will be gradually increased from 0 to about $800m^3$/day when all three phases of the landfill site are fully filled.

3.5.4.4 Waste Tipping Operation

Based on long-term operational practice in existing NENT Landfill, active tipping face during daily operation is normally exercised in a cell of 40mx30m in size while most of the inactive areas are covered by impermeable sheets. Dust emissions from the operation plants are minor and have been included as a cumulative source in the construction dust assessment. Potential odour impact is associated with the prevailing climate condition and is expected to be the worst-case in stable and calm weather. A quantitative assessment model is adopted for the odour impact evaluation of waste tipping operation.

Most of the waste received at NENT Landfill is municipal solid waste, with moisture content varies from 35 to 70%. There are other waste types with extremely high moisture content of 70-85% (e.g. sludge, livestock waste and dredged mud) disposed of at NENT. Waste received in NENT Landfill is wet in nature in particular during humid and wet season in Hong Kong.

Previous waste-statistical data have been reviewed as shown in Table 3.19. Such data on waste composition show that Special-Waste + Sludge amount to approximately 10% or less of the total.

Table 3.19 : Composition of Waste Disposal to NENT Landfill (in tpd)

Year	2000	2001	2002	2003	2004	2005
Landfilled Construction Wastes (LCW) + Municipal Solid Wastes (MSW)	3441	3452	3530	3064	2721	2656
Special-Waste + Sludge	132	144	149	186	215	303
TOTAL	3573	3596	3679	3250	2936	2959
% of LCW + MSW	96.3%	96.0%	96.0%	94.3%	92.7%	89.8%
% of Special Waste + Sludge	3.7%	4.0%	4.0%	5.7%	7.3%	10.2%

Owing to the future implementation of Integrated Waste Management Facilities (IWMF) and Sludge Treatment Facilities, much of the MSW will not be ended up at landfill and some of the sludge will be diverted elsewhere, the current 1:9 (Special-Waste & Sludge) : (LCW & MSW) composition is considered to be the worst-case condition in odour assessment.

3.5.4.5 Surface Gas Emissions

Surface emission is controlled by extracting LFG from the waste mass to the flaring system for final destruction. Active extraction system by pumping will be applied and the inactive tipping area/cell will be mostly sealed and covered by impermeable plastic sheet cover. The edge of plastic sheet cover will be buried and covered underground. For safety reason, the oxygen contents in the LFG need to be controlled to minimum so as to reduce the risk of explosion at the flare. Therefore, the chance of oxygen infiltration or LFG migration at the edge of the covering sheet will be kept to minimum. Periodic monitoring is conducted at the site boundary to ensure the ambient VOCs concentration is within the health and safety limit. In accordance with the site investigation records for the past 9 years, there were no genuine exceedance of VOCs limits at the site boundary.

As discussed in Section 3.3.4, surface emission from existing NENT will not be an issue after capping. For future NENT extension, contractor will enhance the LFG collection and treatment efficiency, a very small portion of VOC would be escaped from the active tipping area.

The additional large separation distance from site boundary of NENT Landfill Extension to ASRs will provide further protection. Subject to future engineering design, the arrangement of the landfill gas collection system and surface covering material for inactive tipping area could be further improved by modern technology. The event action limit for VOC can be lowered such that LFG surface mitigation can be better controlled. Regular VOC monitoring will be conducted during the construction, operation, restoration and aftercare stages of the NENT Landfill Extension. The trend of the VOC emission can be monitored at the site boundary. If there were abnormal building up of VOC at certain locations, special monitoring can be triggered. In order to ensure the surface VOC emission at ASRs can meet the "tightened" long-term chronic criteria from WHO, once every 3 months VOC monitoring at ASRs is recommended before the commissioning of NENT extension (as base-line) and on the 1st year of tipping operation, during the period when the ASP and flare are not in operation. By comparing the monitoring data at the boundary and at ASRs, the cause of VOC and the general downwind dispersion effect from the boundary to the ASRs can be established.

The effects of Alternative Daily Cover Material (ADC), such as membrane daily cover, degradable polyethylene film and ConCover (spray type) on odour and VOCs emission control have been reviewed. As gas infiltration is directly dependant on the porosity of covering material and the porosity of ADC is less than conventional materials, the use of ADC in lieu will have positive effect on surface gas emission control. For the purpose of quantitative assessment, conventional covering method as the worst-case scenario is assumed.

ADC will be adopted as supplementary mitigation measure to be triggered by EM&A Programme on adverse meteorological conditions.

3.5.5 Restoration and Aftercare Phase

In view of the nature and scale of the final capping operation, lesser plant will be employed for dusty operations during the restoration phase for final capping. During aftercare period, only a few number of plant will be required for regular maintenance.

In terms of gaseous emission, there will be very light activities within the capped area. Active control system for landfill gas and leachate will be operational without causing adverse environmental impact. In accordance with the observations from some restored landfills, detectable surface gas and odour emission will not be anticipated.

As both the emission strength and scale of the operation will be less compared to the construction and operation phases, detailed assessment is not required since the impacts from construction and operation phases at the worse case have been assessed.

3.6 Assessment Methodology

3.6.1 Construction Phase

3.6.1.1 Dust Emission

The prediction of dust emissions is based on typical values and emission factors from USEPA, AP-42 "Compilation of Air Pollutant Emission Factors". References of the calculations of dust emission factors for different dust generating activities are listed in Table 3.20.

Table 3.20: References of dust emission factors for different activities

Activities	Reference	Operating Sites	Equations & Assumptions
Heavy construction activities including land clearance, ground excavation, cut and fill operations, construction of the facilities, drill & blast, plant movement and hauling over the site areas	S.13.2.3.3	All construction and excavation sites	E = 1.2 tons/acre/month of activity or = 2.69 Mg/hectare/month of activity
Wind Erosion	S.11.9, Table 11.9.4	All construction sites, and stockpile areas, (all open sites)	E = 0.85 Mg/hectare/yr (24 hour emission)

As all the inactive areas within the landfill will be covered with impermeable sheets, wind erosion and general construction in the active area are the major sources of dust generation from the site. The construction periods are assumed 26 days a month and 12 hours a day. Whereas, there will be a 24 hours emission for wind erosion.

An ISCST3 model is adopted for air impact assessment in accordance with the Study Brief requirement. In accordance with the information from existing NENT Landfill, the area and plant used during construction phases have been identified. The development programme planned for future extension has also been reviewed, and worst-case scenarios has been identified and assessed:

- Worst-case Scenario: Cumulative impact of existing NENT Landfill under capping and Phase 1 site formation of NENT Landfill Extension (i.e. Stage 1 as refer to Table 3.15 and Table 3.15a). At that time, the existing NENT Landfill is almost filled up. To assess the worst-case condition, it is assumed that operation / capping / stockpiling will be occurred at NENT Landfill, whereas, site formation at NENT Landfill Extension will be occurred in Phase 1 area, which is closed to the ASRs at the east.

3.6.1.2 Dispersion Modelling

Dust impact assessment has been undertaken using the ISCST3 model. Table 3.21 gives the list of modelling parameters. Details of the emission rates are listed in Appendix 3.1. Location of dust emission sources are shown in **Drawing No. 24315/13/102**.

Table 3.21: Modeling parameters

Parameters	Input	Remark
Particle size distribution	1.25um = 3.06% 6.25um = 27.55% 20um = 69.39%	Major dominant dust emission source in Landfill is from unpaved road/working area. Owing to the lack of on-site monitoring data for particle distribution, it is the best estimate to assume the particle size distribution is the same as that for unpaved road. Table 13.2.2-2 of Section 13.2, USEPA AP-42, for unpaved road is adopted
Particle density	2.5g/m^3	From Fugitive Dust Model (FDM) Manual
Background Concentration	5-year annual averaged value recorded at EPD's Tai Po monitoring station (64.8µg/m^3)	'TOTAL' Air Quality Guideline
Modeling mode	Rural with terrain effect Dry deposit mode activated	-
Meteorological data	Ta Kwu Ling (TKL) weather station	Mixing height of 500m adopted in accordance with EPD "Guidelines on Choice of Models and Model Parameters"
Emission period	General construction activities during daytime working hours (7am to 7pm) Site erosion over 24-hour period	-
ASR calculating levels	1.5m, 5m and 10m above local ground	-
Good Site Practice – Standard Precautionary Measures	Assume a 50% dust removal efficiency as in general practice based on AP-42 reference.	Periodic watering and covering of inactive construction area with plastic sheet cover. The effectiveness will be monitored in the EM&A.

3.6.2 Operation Phase

3.6.2.1 Emission from the Ammonia Stripping Plant, LFG Power Generator and Flaring Systems

Three operational modes have been considered (see Table 3.22). Monitoring and emission data from existing NENT Landfill has been requested from the existing NENT Landfill contractor and the project proponent; the emission inventory are summarised in Table 3.23 and detailed in Appendix 3.2. New plants have been planned in the future for the Landfill Gas Export Scheme (LFGES).

Referring to the monitoring data from the existing NENT Landfill, emission inventory from NENT Landfill Extension facilities are summarised in Table 3.24 and detailed in Appendix 3.2. For the worst-case scenario, it is assumed that a new LFGES will not be in place for the NENT Landfill Extension.

It is also noted from the existing NENT Landfill operation practices that the flare will only be operated when there is surplus of LFG. During the operation of ASP, the flare will not be operated. There are two set of power generators installed, one duty and one standby.

The locations of emission sources are shown in **Drawing No. 24315/13/103**.

Table 3.22: Modes of operation for various LFG facilities

	Plants (See Appendix 3.2 for details)	Modes of operation		
		Case 1 – ASP On	Case 2 – ASP Off	Case 3 (d) – LFGES Off
Existing NENT (a)	Thermal Destructor in Ammonia Stripping Plant	✓	✗	✓
	Two Existing Landfill Gas Flare (one on duty and one standby)	✗	✗	✓
	Existing LFG Power Generator (Electricity Generation –one on duty and one standby) (b)	✓	✓	✓
	New Landfill Gas Flare at later stage (b)	✗	✗	✓
New LFGES Facilities (a)	Future LFG Power Generator (Only one Electricity Generation)	✓	✓	✓
	New LFG Treatment Unit (LGFTU) from LFGES (2 compressor engines for two parallel processing streams of the LFG TU – purifying methane in LFG)	✓	✓	✗
NENT Extension	Thermal Destructor in Ammonia Stripping Plant	✓	✗	✓
	Two small Landfill Gas Flare at start - one on duty and one standby (b)	✗	✓	✓
	New Landfill Gas Flare at later stage (b) (c)	✗	✓	✓
	LFG Power Generator (Electricity Generation – one on duty and one standby)	✓	✓	✓

Notes:

(a) The LFG Export Scheme aims to utilise all available gas collected from NENT. LFG will not be flared under normal condition. It is anticipated that maintenance of the LFG Export Scheme will occur only a few times in a year and each will last for a few days.

(b) Based on the long-term monitoring data, the flares system was not in operation all the time during the year (utilization rate is not high).

(c) The flare should be a smaller rating than that in the existing NENT Landfill in view of the smaller waste capacity of the landfill extension.

(d) In fact, the peak gaseous emission for existing landfill and the landfill extension will not overlap, due to the different time frame of the project implementation. The assessment is thus on conservative side.

Table 3.23: Pollutants emission rates from plants in Existing NENT Landfill

Source	Operating Conditions (a)	Pollutant	Estimated Emission (µg/m³) (e)	Emission Rates in atmosphere (g/s)
Thermal Destructor in Ammonia Stripping Plant (existing NENT)	1123K (dry condition), stack height= 19.5m, internal chimney diameter =3.5m, flow rate=223,000 m³/hr, gas exit velocity = 6.44m/s	Vinyl Chloride (c,f)	81.8	5.067 x 1E-3
		Benzene (c, f)	64.1	3.97 x 1E-3
		TNMOC as C	13,1926.4	8.172
		NO_x from Thermal Destructor	200,000	12.389
		NO_2 from Thermal Destructor	60,000(b)	3.7167
		SO_2 from Thermal Destructor (d, e)	64,000	3.964
Two Existing Landfill Gas Flares – one duty and one standby(only operated during maintenance period of the LFG Export Scheme and zero emission under normal operation)	Existing (each): 1473K (dry condition), flow rate 138,491m³/hr, stack height= 8.105m, internal chimney diameter =1.835m, gas exit velocity = 14.546m/s	Vinyl Chloride (c)	81.8	3.147 x 1E-3
		Benzene (c)	64.1	2.466 x 1E-3
		TNMOC as C	13,1926	5.075156574
		NOx from Landfill Gas Flare	80,000	3.0776
		NO_2 from Landfill Gas Flare	24,000(b)	0.9233
		SO_2 from Landfill Gas Flare	64,000 (d, e)	2.462
New Landfill Gas Flare (only operated during maintenance period of LFG Export Scheme and zero emission under normal operation)	One new stack: 1473K (dry condition), flow rate 387,774 m³/hr, stack height= 17m, internal chimney diameter =3.25m, gas exit velocity = 12.983m/s	Vinyl Chloride (c)	81.8	8.811 x 1E-3
		Benzene (c)	64.1	6.905 x 1E-3
		TNMOC as C	13,1926	14.21040909
		NOx from Landfill Gas Flare	80,000	8.6172
		NO_2 from Landfill Gas Flare	24,000(b)	2.5852
		SO_2 from Landfill Gas Flare	64,000 (d, e)	6.894
Existing LFG Power Generator (Electricity Generation – one duty and one standby)	853K (dry condition), flow rate 10,839 m³/hr, stack height= 5.5m, internal chimney diameter =0.3m, gas exit velocity = 42.595m/s	Vinyl Chloride (c,f)	81.8	2.46 x 1E-4
		Benzene (c,f)	64.1	1.93 x 1E-4
		TNMOC as C	13,1926.4	0.3972
		NO_x from LFG power generator	500,000	1.5054

Source	Operating Conditions [a]	Pollutant	Estimated Emission ($\mu g/m^3$) [e]	Emission Rates in atmosphere (g/s)
		NO_2 from LFG power generator	150,000[b]	0.4516
		SO_2 from LFG power generator	64,000 [d, e]	0.1927
Future LFG Power Generator (Only One Electricity Generator)	853K (dry condition), flow rate 10,839 m^3/hr, stack height= 5.5m, internal chimney diameter =0.3m, gas exit velocity = 42.595m/s	Vinyl Chloride [c,f]	81.8	2.46 x 1E-4
		Benzene [c,f]	64.1	1.93 x 1E-4
		TNMOC as C	13,1926.4	0.3972
		NO_x from LFG power generator	500,000	1.5054
		NO_2 from LFG power generator	150,000[b]	0.4516
		SO_2 from LFG power generator	64,000 [d, e]	0.1927
New LFG Treatment Unit (LFGTU) of the LFGES (2 compressor engines for two parallel processing streams of the LFG TU) – Will not be operated during maintenance period of LFG Export Scheme	723K (dry condition), flow rate 10,896 m^3/hr each, stack height= 6m, internal chimney diameter =0.5m, gas exit velocity = 15.415m/s [h]	NO_x from LFG power generator	500,000	1.5133
		NO_2 from LFG power generator	150,000[b]	0.454
		SO_2 from LFG power generator	64,000 [d, e]	0.1937
		Vinyl Chloride [c,f]	81.8	2.47 x 1E-4
		Benzene [c,f]	64.1	1.94 x 1E-4
		TNMOC as C	13,1926.4	0.3993

Notes:

(a) Information on NENT Landfill thermal destructor, LFG flare and LFG power generator data are obtained from existing NENT. Real monitoring data is adopted for the model which has taken into account the actual oxygen content, pressure, etc. Modelling has taken a conservative assumption on conversion on molecular volume under high temperature. It is also assumed that oxygen content is sufficient for oxidation/combustion. The effect on the minor change in operating condition will be insignificant due to large margin in results before reaching criteria.

(b) Assuming NOx to NO_2 conversion factor is 30%

(c) Vinyl Chloride and Benzene are major toxic pollutants from ASP (reacted in Thermal Destructor)

(d) Corresponding to monitoring result of 32 mg/m3 for H2S (i.e. 64mg/m3 SO2)

(e) Owing to the lack of monitoring data, assume zero SO2 removal efficiency under the worst-case scenario.

(f) The controlled efficiency for ASP and power generator will assume to be the same as that for the flare.

Table 3.24: Estimated pollutants emission rates from plants in NENT Landfill Extension (Assume no LFG Export Scheme)

Source	Operating Conditions	Pollutant	Estimated Emission (μg/m³) [e]	Emission Rates in atmosphere (g/s)
Thermal Destructor in Ammonia Stripping Plant (NENT Extension)	1123K (dry condition), stack height= 19.5m, internal chimney diameter =3.5m, flow rate=223,000 m³/hr, gas exit velocity= 6.44m/s	Vinyl Chloride [c]	81.8	5.067 x 1E-3
		Benzene [c]	64.1	3.97 x 1E-3
		TNMOC as C	13,1926.4	8.172
		NO_2 from Thermal Destructor	60,000[b]	3.7167
		SO_2 from Thermal Destructor [d, e]	64,000	3.964
Two Landfill Gas Flare – one standby and one duty (NENT Extension)	Each: 1473K (dry condition), flow rate 138,491m³/hr, stack height= 8.105m, internal chimney diameter =1.835m, gas exit velocity = 14.546m/s	Vinyl Chloride [c]	81.8	3.147 x 1E-3
		Benzene [c]	64.1	2.466 x 1E-3
		TNMOC as C	13,1926.4	5.0752
		NOx from Landfill Gas Flare	80,000	3.0776
		NO_2 from Landfill Gas Flare	24,000[b]	0.9233
		SO_2 from Landfill Gas Flare [d, e]	64,000	2.462
Additional Landfill Gas Flare at later stage [f]	1473K (dry condition), flow rate 138,491m³/hr, stack height= 8.105m, internal chimney diameter =1.835m, gas exit velocity = 14.546m/s	Vinyl Chloride [c]	81.8	3.147 x 1E-3
		Benzene [c]	64.1	2.466 x 1E-3
		TNMOC as C	13,1926.4	5.0752
		NO_2 from Landfill Gas Flare	24,000[b]	0.9233
		SO_2 from Landfill Gas Flare [d, e]	64,000	2.462
LFG Power Generator (Electricity Generation – one standby and one duty)	853K (dry condition), flow rate 10,839 m³/hr, stack height= 5.5m, internal chimney diameter =0.3m, gas exit velocity = 42.595m/s	Vinyl Chloride [c]	81.8	2.46 x 1E-4
		Benzene [c]	64.1	1.93 x 1E-4
		TNMOC as C	13,1926.4	0.3972
		NO_2 from LFG power generator	150,000[b]	0.4516
		SO_2 from LFG power generator [d, e]	64,000	0.1927

Notes:

(a) For conservative estimate, LFG flare, LFG power generator and ASP are assumed to be the same as that in existing NENT Landfill. Modelling has taken a conservative assumption on conversion on molecular volume under high temperature. It is also assumed that oxygen content is sufficient for oxidation/combustion. The effect on the minor change in operating condition will be insignificant due to large margin in results before reaching criteria.

(b) Assuming NOx to NO_2 conversion factor is 30%

(c) Vinyl Chloride and Benzene are major toxic pollutants from ASP (reacted in Thermal Destructor)

(d) Corresponding to monitoring result of 32 mg/m³ for H_2S (i.e. 64mg/m³ SO_2)

(e) Owing to the lack of monitoring data, assume zero SO_2 removal efficiency under the worst-case scenario.

(f) The flare should be a smaller rating than that in the existing NENT Landfill in view of the smaller waste capacity of the landfill extension. However, for conservative assessment, the size of flare is assumed to be the same as the existing NENT Landfill.

3.6.2.2 Dispersion Modelling

Gaseous emissions have been assessed by ISCST3 model. The cumulative impacts from both the existing NENT Landfill and its future Extension are taken into account. The modelling parameters are listed in Tables 3.25.

Table 3.25: Modeling Parameters

Parameters	Input	Remark
Background Concentration	5-year annual averaged value recorded from NENT Landfill statistical Data	Follow 'TOTAL' Air Quality Guideline and health risk approach
Modeling mode	Rural with terrain effect	
Meteorological data	Ta Kwu Ling (TKL) weather station; mixing height of 500m adopted in accordance with EPD Guidelines on Choice of Models and Model Parameters	
Emission period	24-hour operation	
ASR calculating levels	1.5m, 5m and 10m above local ground	

Modelling results are compared with the respective criteria. A summary of the relevant criteria is listed in Table 3.26.

Table 3.26: Modeling Criteria

Parameters/ Pollutants	Relevant Criteria/Remark
• NO_2 • SO_2	• 1-hour averaged criteria • 24-hour averaged criteria } (Remark: Adopt AQOs as criteria.) • Annual averaged criteria
• Benzene • Vinyl Chloride	WHO, USEPA (Remarks: • Carcinogenic Risk: Annual average concentrations have been multiplied by the Unit Risk Factors to obtain the maximum individual lifetime risk. The individual annual risk could be obtained from the individual lifetime risk divided by 70 years which is the assumed average lifetime. The calculated individual lifetime risk has been compared with assessment criteria to check the acceptability of the risks at the identified ASRs. • Non-carcinogenic risk: Annual average and maximum 1-hour average concentrations should be directly compared with the chronic reference concentration and the acute reference concentration.)

3.6.2.3 Cumulative Odour Impact from Open Tipping Area and Leachate Treatment Plant

3.6.2.3.1 Critical Weather Condition for Odour Impact Assessment

To determine the reasonably worst case scenario for odour impact assessment, the following steps have been taken:

(i) Meteorological data for the Years 2001 to 2004 from the Ta Kwu Ling (TKL) Weather Station were checked to identify the hours at which the worst stability class (i.e. Class F) tend to occur;

(ii) Odour emission strength measurements were taken for various sources, including daytime sampling for tipped waste not yet covered, lagoons; and night time / early morning sampling for daily cover overlying tipped waste. The odour strength from the highest emission source was identified.

The foregoing steps reveal the following:

(i) As shown in Appendix 3.3A, the vast majority of occurrences of stability Class F were at night or in the early morning hours.

(ii) Table 3.27 shows that odour emission strength measured from the surface of daily cover overlying tipped wastes (i.e. waste deposited for a number of hours) is higher than that from other emission sources.

Table 3.27 : Nominal odour emission rates during day time and night time

Time Period	Odour Sources	Odour Emission Strength $OU/m^2/s$ (extracted from Appendix 3-4)	Active Area (m^2)	Nominal Odour Emission Rate (OU/s)
Night (28°C)	Daily cover overlying tipped waste	5.09	40 x 30	6108
Day (28°C)	Tipped (Aggregated)	4.34	40 x 3	521
	Compacted	3.04	40 x 17	2067
	Manoeuvring	1.41	40 x 10	564
	Equivalent for Day Time = (521+2067+564=) 3152 (i.e. Emission Rate Day time << Night time)			
Day (32°C)	Tipped (Aggregated)	4.34+0.56 = 4.90	40 x 3	588
	Compacted	3.04+0.56 = 3.60	40 x 17	2448
	Manoeuvring	1.41+0.56 = 1.97	40 x 10	788
	Equivalent for Day Time = (588+2448+788=) 3824 (i.e. Emission Rate Day time << Night time			

Notes : 1. Results show that the worst-case occurs at night time or early morning with stable and calm weather.

2. Night time emission source is found to be the worst-case

3. Statistical analysis of the 4 year meteorological data has been conducted. The maximum averaged temperature during operating hours (0700 to 1900 Hour) in the hottest month (Jul to Sept) is found to be 30 deg C. For conservative analysis, sensitivity test has been conducted using a hypothetical odour emission from tipping area at 32 deg C. This emission strength is estimated by linear extrapolation of odour strength from 28 deg C to 32deg C (0.56 OU increment for 4 deg increase in temp). As shown in the table above, the calculated OU/s for 32 degC is much lower than that of the night/early-morning case, with a large margin/difference in between. Even if the OU incremental rate may not exactly be linear, any variance should still be well within the aforementioned large margin. Hence, the worst case scenario should remain as the night-time/early-morning case.

In view of the above, the reasonably worst case scenario for odour impact assessment should be taken at night or early morning hours. The aforementioned meteorological data have also been checked for determining the temperature at such hours. In this regard, relevant average temperature data are tabulated below :

Table 3.27a : Averaged Temperature during night time for the summer months

Year	Average temperature from 1900 till 0700 Hours (from night to early morning hours) for the summer months (July to September)
2001	26°C
2002	26°C
2003	26°C
2004	27°C

To be conservative, the temperature is taken as 28°C for the reasonably worst case scenario. For completeness, the odour impact assessment covers all the hours in the 4 years of the meteorological data for different stability classes. The summary of results is tabulated in Appendix 3.10.

As concluded from the above analysis, the highest odour unit thus calculated correspond to the case of "28°C and stability Class F".

3.6.2.3.2 In-situ Odour Sampling

In-situ odour sampling was adopted to collect odour strength for landfill site in Hong Kong. It is also noted that there is only one accredited laboratory in HK that can conduct such In-situ odour measurement (i.e. Odour Research Laboratory of HKPU).

The odour sampling and subsequent olfactometry tests were conducted by qualified odour panellists from the HKPU. The qualified odour panellists shall have their individual odour threshold of n-butanol in nitrogen gas in the range of 20 to 80 ppb/v as required by the European Standard Method (EN 13725). These panellists also fulfilled the following criteria:

- Odour panellists shall be at least 16 years of age and willing and able to follow instructions.

- Odour panellists shall be free from any respiratory diseases and are not normally working at or living in the area in the vicinity of NENT Landfill Extension.

At the time of sampling in early to mid 2006, the best and the only available apparatus for odour sampling is the wind tunnel hood method which applies blow fan to extract the odorous gas into a sample bag for subsequent olfactometry analysis. It was comprehensively studied in a research paper "Theoretical and Practical Considerations in the Use of Wind Tunnel for Odour Emission Measurement, Jay Witherspoon et al, Jun 2002 Annual Conference & Exhibition Proceedings, AWMA" that this wind tunnel hood technique would overestimate the emission strength due to high suction velocity and will produce very conservative odour results.

Under this wind tunnel hood method for odour emission strength assessment, air samples are taken in-situ by a wind-tunnel hood. The hood, with an internal height of 250mm, is placed over the air-sampling location such that the air to be sampled is drawn and collected from this 250mm high space inside the hood. The odour-strength thus measured therefore represents the odour-strength of an air-sample at an average height of 125mm above ground. Therefore, a reference ground wind speed at 0.125m above ground was adopted for subsequent analysis of the reasonable worst-case scenario to tally with the configuration of the wind tunnel hood used.

3.6.2.3.3 Dispersion Modelling

A total of 17 odour samples from the active tipping areas, inactive areas and the leachate lagoons of the NENT Landfill were collected by Lam Geotechnics and Odour Research Lab of HKPU for the assessment. The ambient surface odour emission fluxes and pollutant concentrations have been measured during the reasonable worst-case temperature. All odour samplings and subsequent olfactometry tests were conducted by qualified specialists and odour panellists. The odour sampling locations are shown in Figure 3.2 below.

Detail of the derivation of odour strength is listed in Table A of Appendix 3.3.

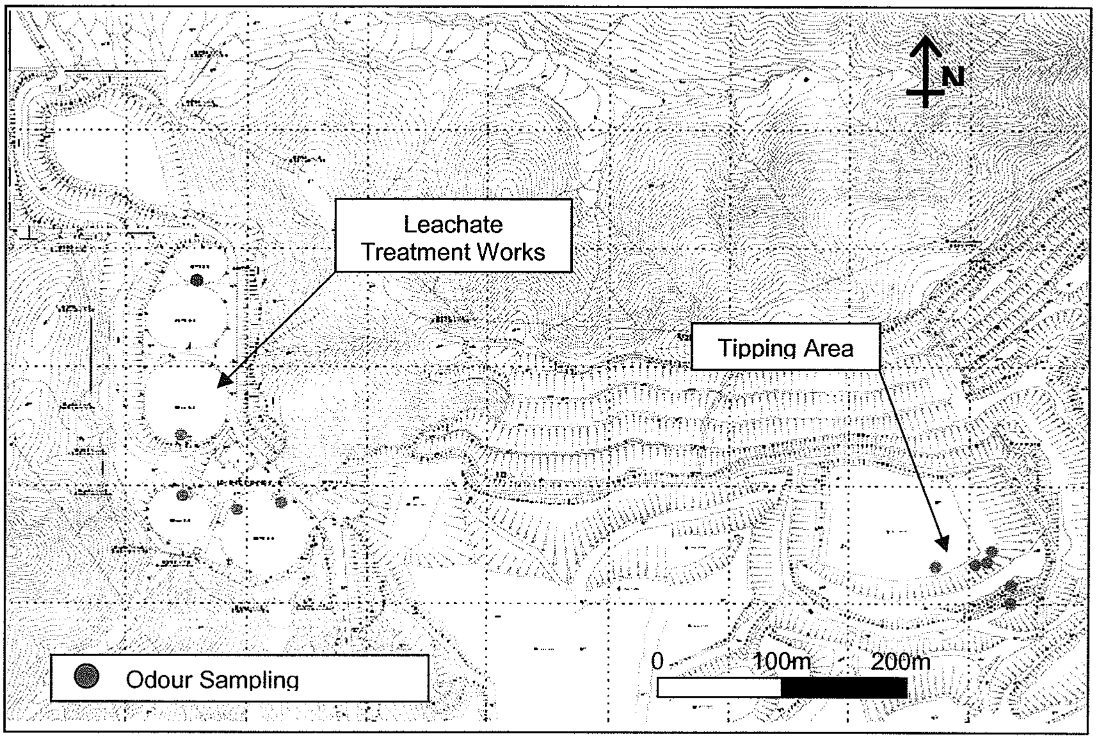

Figure 3.2 Odour Sampling Locations in Existing NENT Landfill

Details of the emission strength and modelling input parameters are listed in Appendix 3.4 and summarised in Table 3.28. For ease of odour modelling, odour emission strengths adopted in the ISCST3 model have been normalised at 0.5m/s.

Table 3.28 : Odour strength applied in the model (Temperature under reasonable worst-case condition)

Sampling Location	Modelled Odour Source Emission Strength normalised at 0.5m/s ground wind speed, OU/m^2 –s
Day time samplings :	
Tipping – Special-Waste + Sludge	8.21
Tipping – MSW	3.91
Tipping – compacted waste	3.04
Tipping – aggregated (90% of MSW and 10% of Special-Waste + Sludge)	4.34
Manoeuvring (at tipping area)	1.41
Raw Leachate Lagoon – before ASP	27.86
Leachate Lagoon – after ASP	10.32
Aeration Lagoon	3.95
Effluent Lagoon	2.83
Night time sampling :	
Daily cover overlying tipped waste	5.09

These air samples for odour assessment were taken at the sampling locations tabulated in Table 3.28 above using a Wind Tunnel Hood, the only method available in Hong Kong then. [The taking of samples, together with the subsequent laboratory assessment, were carried out by Hong Kong Polytechnic University (HKPU), also the only service provider available.]

It has been published in numerous papers that the Wind Tunnel Hood method of sampling is suitable for odour assessment. However, it is also widely published that the odour emission concentration measured from samples taken by a Wind Tunnel Hood will need to be corrected, before being used for odour assessment. This is because the Wind Tunnel Hood utilises a fan to draw-in odorous gas, whereas in reality odorous gas is emitted under natural ground wind.

In this regard, two relevant documents* recommended that the following equation be applied for such correction:

$$SOER_2 = SOER_1 \times \left|\frac{V_2}{V_1}\right|^{0.5}$$ ....Equation (1)

where $SOER_1$ = odour emission concentration under Condition 1, i.e. as measured from samples taken by the Wind Tunnel Hood;
$SOER_2$ = odour emission concentration under Condition 2, i.e. the corrected figure;
V_1 = wind velocity under measurement Condition 1, i.e. the wind speed due to the aforementioned draw-in by fan;
V_2 = wind velocity under Condition 2, i.e. the natural ground wind speed.

[* : The two documents are :

(a) Odour assessment at the NENT Landfill Site, by the Odour Research Laboratory, Hong Kong Polytechnic, 22 March 2006;

(b) Odour emission factors for assessment and prediction of Italian MSW landfills odour impact, by Selena Sironi et al, 25 May 2005]

In particular, Paper (b) above specifically stated that the Wind Tunnel Hood method of sampling, together with the application of Equation (1) above, were applied exactly for odour assessment for landfills in Italy. This renders Paper (b) all the more relevant, in serving as a reference on the applicability of both the Wind Tunnel Hood and Equation (1) above.

The following points should also be noted:

(1) There is one overseas case (Review of Odour Management in New Zealand Technical Report August 2002) stating that different approaches should be adopted for odour assessment on solid and liquid surfaces, with the former based on diffusion consideration instead of adopting Equation (1) above. However, the relevance of this overseas case is doubtful in view of the following points:

(1.1) The aforementioned Paper (b) referred specifically to landfill projects; its relevance to the NENT Landfill Extension project is therefore considered to be stronger than that of the New Zealand case.

(1.2) The odour of landfill wastes is contributed by both the solid and the liquid contents. It would be impracticable to classify the surface precisely as "solid", or "liquid", or "which way in between", for applying the New Zealand case as a reference.

(1.3) As far as the landfill wastes in Hong Kong are concerned, a large proportion of the odour obviously comes from wastes of high moisture contents (see also Section 3.5.4.4). Even if the wastes are overlain by daily cover, the odour sample taken by the Wind Tunnel Hood still predominantly reflects odour originated from high moisture wastes anyway.

(2) Very recently, a new type of odour sampling apparatus namely flux chamber sampling method has become available in Hong Kong, adopting diffusion as the sampling method (instead of using a fan to draw-in a sample). It is widely documented that odour emission rates obtained by wind tunnel hood methodology are grossly over estimates when compared with results obtained by using flux chamber sampling method. In local context, comparison of odour emission rates from waste / landfill obtained by the two methodologies revealed that odour emission rates by the wind tunnel hood method [before applying Equation (1)] is about 10 to 20 times higher than those using flux chamber method [without applying Equation (1)] under similar field conditions. On the other hand, the effect of applying Equation (1) is found to be of a similar order as applying a factor of about $^1/_{10}$ to $^1/_{20}$.

(3) The application of Equation (1) has been limited to a lower bound ground wind velocity of 0.001m/s. In practice, this is equivalent to a maximum wind speed adjustment factor of 1/20, tally with the observation in local context (see (2) above). For cases where the assessed ground wind speed is lower than 0.001 m/s, the value for V_2 will be capped as 0.001 m/s for the purpose of applying Equation (1). It must, however, be noted that the aforementioned [1/10 to 1/20] ratios between wind tunnel hood results (before applying Equation (1)) and flux chamber results refer **STRICTLY** to odour sampling at landfills only.

Owing to the boundary layer effect, the wind velocity near ground level would be very low. With site observations of topographic condition, the surface roughness is estimated to be 0.1245m (see Appendix 3.5). The hourly wind velocities near ground level were estimated using an advanced meteorological equation with reference to the 35,040 hourly (4 years) ground wind speeds from the TKL weather station. The hourly emission concentration is then calculated by the above Equation (1). Details are listed in Appendix 3.6.

Other modelling parameters were determined according to EPD's "Guidelines on Choice of Models and Model Parameters". The 5-second Odour Unit (OU) at the ASRs was assessed by ISCST3 model.

Based on dispersion curve in the ISCST3 manual, the modelling results will be representative for period between 1 hour to 15-minutes averaging time. A conversion factor was applied to convert the average time from 15-minute to 3-minute in accordance with a stability dependent power law relationship as follows:

$$X_l = X_s (t_s / t_l)^P$$

where X_l = concentration for the longer time averaging time;
X_s = concentration for the shorter time averaging time;
t_s= shorter averaging time;
t_l = longer averaging time;
P = power law exponent (Stability Class A: 0.5, B: 0.5, C: 0.333, D: 0.2, E:0.167, F: 0.167)

The 3-minutes averaged value was then converted to a 5-second averaged value, in response to the requirement of the odour level criterion under TM-EIAO. In accordance with the reference papers stated in EPD "Guidelines on Choice of Models and Model Parameters", the conversion factors from 15-minutes to 3-minutes and then 3- minutes to 5-seconds have been determined and tabulated in Table 3.29.

Table 3.29: Multiplying factors for averaging time correction for odour assessment (taking account of EPD's Guideline on Choice of Models and Model Parameters)

Atmospheric Stability Class	Conversion Factor from 1 hour to 15 min	Conversion Factor from 15 min to 3 min	Conversion Factor from 3 min to 5s	Resultant Conversion Factor from 1 hour to 5s
A	1	2.236	10	22.36
B	1	2.236	10	22.36
C	1	1.709	5	8.545
D	1	1.380	5	6.9
E	1	1.308	5	6.54
F	1	1.308	5	6.54

Odour emission has been assessed by ISCST3 air quality model taking into account the Resultant Conversion Factor into account. However, referring to other overseas reference, the Resultant Conversion Factor tabulated above is on the conservative side. For instance, a conversion factor of 3.0 is adopted for Class D condition in Australia. In addition, *"Workbook of Atmospheric Dispersion Estimates"* also stated that ISCST3 results already represent 3 min averaged condition, a resultant Conversion Factor of 10 for A/B and 5 for C to F Classes should have been adopted.

The overall modelling parameters are summarised in Table 3.30 for ease reference.

Table 3.30: Modelling parameters

Parameters	Input	Remark
Background Concentration	No (major source from landfill)	In accordance with the preliminary design information, three scenarios have been assessed (also see Remark below): • Central zone scenario: tipping at the central part of the NENT Landfill Extension site. In view of the existing topography (landfill bowl shape), the central part is the highest occurrence zone during the operation life. • Northern zone scenario: tipping at the northern part of the NENT Landfill Extension site close to Tong To Shan Tsuen. • Western zone scenario: tipping at the western part of the NENT Landfill Extension site close to Wo Keng Shan Tsuen. Owing to the limitation of the ISCST3 model, all circular lagoons are simulated as rectangular area sources with same surface area.
Modeling mode	Rural model with elevated terrain	
Meteorological data	Ta Kwu Ling (TKL) weather station, mixing height of 500m adopted in accordance with EPD Guidelines on Choice of Models and Model Parameters	
Emission period	• Daytime emission from tipping at active cell • Night time emission from daily cover overlying tipped waste • Whole day for emission from leachate treatment works • Effective temporary covers with impermeable plastic sheets will be applied at the inactive tipping areas, and no emission is anticipated. • Active LFG extraction system with an engineering cap will be applied at the restored NENT Landfill and no emission is anticipated.	
ASR calculating levels	1.5m, 5m and 10m above local ground	
Odour strength/results	Input data using odour strength at normalised ground wind speed	The actual odour strength/results are then calculated based on ground wind speed Equation (1) for wind tunnel hood sampling method. $SOER_2 = SOER_1 \times \left\|\frac{V_2}{V_1}\right\|^{0.5}$

Remark: Eastern zone scenario is NOT assessed since there is only steep hill slope in the area. No ASR in the vincity was identified.

The locations of emission sources from existing NENT Landfill and its extension are shown in **Drawing No. 24315/13/104**.

3.7 Prediction and Evaluation of Air Quality Impact

3.7.1 Construction Phase

With the provision of good site practice, such as covering of the inactive area by impermeable sheets and periodic watering, a dust removal efficiency of 50% has been adopted as in other approved EIA reports, such as Kowloon Southern Link. The predicted maximum 1-hour and 24-hour average TSP concentration at the ASRs will be within the 500µg/m^3 and 260 µg/m^3 criterion, respectively. No adverse construction dust impact is anticipated. When the actual construction programme and methodology is finalised by the DBO Contractor, the precautionary measures can be further reviewed and verified by the EM&A monitoring.

Tables 3.31 and 3.32 show the 1-hour and 24-hour averaged TSP levels at the identified ASRs. Details of the assessment results are given in Appendix 3.7. The 1-hour and 24-hour averaged TSP contours at the worst affected level (1.5m above ground) is illustrated in **Drawing 24315/13/105 and 24315/13/106**.

Table 3.31: Predicted TSP levels at various ASRs

ASRID	Predicted 1-hour TSP concentration µg/m^3, when NENT Landfill is under restoration and Phase 1 of NENT Landfill Extension is in site formation (1&2)		
	1.5m	5m	10m
ASR1	230	212	167
ASR2	142	138	128
ASR3	162	157	144
ASR4	185	181	170
ASR5	154	151	143
ASR6	157	154	143
ASR7	180	176	166
ASR8	91	91	89
ASR9	163	161	152
ASR10	138	135	126
ASR11	240	231	205
ASR12	127	126	122
ASR13	175	171	159
ASR14	155	151	139
ASR15	111	111	107
ASR16	114	113	110
ASR17	116	115	112
ASR18	117	116	113
ASR19	101	100	98
ASR20	112	111	109
ASR21	107	106	104
ASR22	106	105	103
ASR23	101	100	99
ASR24	94	94	92
ASR25	124	123	118
ASR26	141	140	135
ASR27	183	174	151

Remark : (1) TSP background of 64.8µg/m^3 has been incorporated.

(2) Adopted good site practice of periodic watering and covering inactive area with plastic sheet as the precautionary measures, a 50% dust removal efficiency is applied as in other approved EIA Reports. This can be verified by subsequent EM&A monitoring.

Table 3.32: Predicted max 24-hour averaged TSP levels at various ASRs

ASRID	Predicted 24-hour TSP concentration μg/m³, when NENT Landfill is under restoration and Phase 1 of NENT Landfill Extension is in site formation (1& 2)		
	1.5m	5m	10m
ASR1	102	99	90
ASR2	82	82	80
ASR3	96	95	92
ASR4	81	81	80
ASR5	80	80	79
ASR6	85	84	83
ASR7	83	83	81
ASR8	72	72	71
ASR9	81	81	80
ASR10	77	77	76
ASR11	103	102	97
ASR12	76	76	76
ASR13	86	85	83
ASR14	82	81	79
ASR15	74	74	73
ASR16	72	72	72
ASR17	74	74	74
ASR18	71	71	71
ASR19	69	69	69
ASR20	71	71	70
ASR21	70	70	70
ASR22	71	71	71
ASR23	70	70	70
ASR24	69	69	69
ASR25	83	82	81
ASR26	77	76	76
ASR27	105	103	97

Remark : (1) TSP background of 64.8μg/m³ has been incorporated

(2) Adopted good site practice of periodic watering and covering inactive area with plastic sheet as the precautionary measures, a 50% dust removal efficiency is applied as in other approved EIA reports. This can be verified by subsequent EM&A monitoring.

3.7.2 Operation Phase

3.7.2.1 AQO Criteria Pollutant

The maximum 1-hour averaged NO_2 and SO_2 concentrations at the ASRs were predicted under three operating modes; namely LFGES Off, ASP On (normal condition with ASP in operation) and ASP Off (with flare in operation). The 1-hour averaged NO_2 and SO_2 contours at the worst affected level (10m above ground) for the Normal Operation with ASP in operation are illustrated in **Drawing 24315/13/107 and 24315/13/108** respectively.

Tables 3.33 to 3.35 show the NO_2 and SO_2 levels at the identified ASRs for various modes of operation. Detailed results are listed in Appendix 3.8. The maximum 1-hour averaged NO_2 and SO_2 concentrations are 120 μg/m^3 and 50 μg/m^3 (during the normal operation with ASP "On"), which would be 40% and 6% of the AQOs. The maximum 24-hour and annual averaged NO_2 and SO_2 concentrations are also well within the AQO. Based on these preliminary results with a large margin, NO_2 and SO_2 emission will not be a concern.

Table 3.33: Predicted NO_2 and SO_2 levels at various ASRs (Case 3 — LFGES Off)

ASRID	Predicted NO_2 concentrations at the worst affected height (all at 10m above ground) (1)			Predicted SO_2 concentrations at the worst affected height (all at 10m above ground) (1)		
	max 1-hr averaged NO_2 (μg/m^3)	max 24-hr averaged NO_2 (μg/m^3)	max Annual Averaged NO_2 (μg/m^3)	max 1-hr averaged SO_2 (μg/m^3)	max 24-hr averaged SO_2 (μg/m^3)	Max Annual Averaged SO_2 (μg/m^3)
ASR1	59.8	52.4	49.6	25.2	15.9	14.1
ASR2	59.5	51.8	49.6	29.7	16.0	14.2
ASR3	62.1	53.4	49.8	32.4	17.5	14.3
ASR4	61.3	53.5	49.4	31.4	17.7	14.1
ASR5	60.8	53.8	49.5	30.4	18.0	14.1
ASR6	61.8	52.1	49.5	31.8	17.3	14.1
ASR7	61.5	51.5	49.4	29.6	15.9	13.9
ASR8	67.0	53.0	49.7	37.6	16.7	14.2
ASR9	63.9	51.5	49.4	32.6	16.0	14.0
ASR10	71.2	57.8	49.6	28.6	19.9	14.2
ASR11	66.3	55.2	50.4	31.1	16.3	14.4
ASR12	65.4	53.1	50.1	35.4	17.1	14.6
ASR13	60.1	51.8	49.7	29.8	16.1	14.2
ASR14	60.0	53.4	49.8	30.5	16.5	14.2
ASR15	57.2	51.8	49.5	25.8	16.6	14.1
ASR16	57.6	52.3	49.5	26.4	16.2	14.1
ASR17	57.8	51.2	49.7	24.7	16.1	14.4
ASR18	57.3	51.0	49.6	24.9	15.7	14.3
ASR19	56.9	50.9	49.7	24.4	16.0	14.4
ASR20	56.5	51.1	49.7	23.8	15.8	14.3
ASR21	56.4	51.1	49.7	24.1	16.1	14.4
ASR22	55.9	51.5	49.5	24.2	16.4	14.1
ASR23	55.8	51.9	49.4	24.0	16.5	14.1
ASR24	55.8	52.0	49.5	24.3	16.9	14.1
ASR25	58.7	51.9	49.6	27.2	17.5	14.2
ASR26	60.0	51.8	49.5	29.5	16.8	14.1
ASR27	91.7	72.3	50.0	47.0	33.8	14.5

Remark : (1) NO_2 background of 49.2μg/m^3 has been incorporated;
(2) SO_2 background of 13.8μg/m^3 has been incorporated; and

Table 3.34: Predicted NO_2 and SO_2 levels at various ASRs (Case 1 — ASP On) – worst-case condition

ASRID	Predicted NO_2 concentrations at the worst affected height (in general 10m above ground unless otherwise stated) (1) & (3)			Predicted SO_2 concentrations at the worst affected height (all at 10m above ground) (1)		
	max 1-hr averaged NO_2 ($\mu g/m^3$)	max 24-hr averaged NO_2 ($\mu g/m^3$)	max Annual Averaged NO_2 ($\mu g/m^3$)	max 1-hr averaged SO_2 ($\mu g/m^3$)	max 24-hr averaged SO_2 ($\mu g/m^3$)	Max Annual Averaged SO_2 ($\mu g/m^3$)
ASR1	70.4	55.7	49.8	23.0	16.6	14.1
ASR2	59.8	54.0	49.7	21.5	16.1	14.1
ASR3	67.5	56.1	49.8	23.7	17.0	14.1
ASR4	64.3	54.2	49.5	22.6	16.5	13.9
ASR5	64.0	55.6	49.6	22.6	17.4	14.0
ASR6	59.1	52.9	49.5	22.9	16.0	14.0
ASR7	69.2	53.2	49.5	23.1	15.6	13.9
ASR8	68.6	54.7	49.9	27.4	16.4	14.1
ASR9	71.1	53.7	49.5	24.0	15.8	14.0
ASR10	87.0	62.9	49.8	33.2	20.8	14.1
ASR11	81.3	57.3	50.5	21.3	15.7	14.2
ASR12	63.9	54.6	50.4	26.5	16.4	14.5
ASR13	68.7	54.2	49.8	22.2	16.0	14.1
ASR14	65.4	57.3	49.9	22.9	17.5	14.1
ASR15	55.8	52.9	49.5	19.5	16.0	14.0
ASR16	60.4	54.5	49.6	19.6	16.3	14.0
ASR17	60.4	51.5	49.8	21.1	15.1	14.2
ASR18	59.1	51.2	49.6	20.8	14.9	14.1
ASR19	59.3	51.5	49.7	20.3	14.9	14.1
ASR20	58.3	51.3	49.6	20.0	14.9	14.1
ASR21	58.2	51.5	49.7	19.9	15.0	14.1
ASR22	59.4	53.6	49.5	19.3	15.7	14.0
ASR23	57.4	52.8	49.5	19.1	15.9	14.0
ASR24	60.0	54.4	49.5	19.0	16.1	14.0
ASR25	57.6	52.8	49.6	21.2	15.6	14.0
ASR26	58.4	52.6	49.5	21.8	15.5	14.0
ASR27	119.6	76.7	50.0	50.4	28.3	14.2

Remark : (1) NO_2 background of 49.2$\mu g/m^3$ has been incorporated;
(2) SO_2 background of 13.8$\mu g/m^3$ has been incorporated; and
(3) Max 1hr NO2 : ASR27 at 1.5m

Table 3.35: Predicted NO_2 and SO_2 levels at various ASRs (Case 2 – ASP Off)

ASRID	Predicted NO_2 concentrations at the worst affected height (in general 10m above ground unless otherwise stated) (1) & (3)			Predicted SO_2 concentrations at the worst affected height (in general 10m above ground unless otherwise stated) (2) & (4)		
	max 1-hr averaged NO_2 (µg/m^3)	max 24-hr averaged NO_2 (µg/m^3)	max Annual Averaged NO_2 (µg/m^3)	max 1-hr averaged SO_2 (µg/m^3)	max 24-hr averaged SO_2 (µg/m^3)	Max Annual Averaged SO_2 (µg/m^3)
ASR1	70.1	55.6	49.8	22.7	16.5	14.1
ASR2	59.2	53.7	49.7	25.8	15.7	14.0
ASR3	67.3	56.0	49.8	25.1	16.8	14.2
ASR4	64.2	53.6	49.4	22.9	16.5	14.0
ASR5	63.9	54.4	49.5	23.1	16.5	14.0
ASR6	58.2	52.7	49.5	24.1	15.5	14.0
ASR7	68.9	53.0	49.5	23.4	15.8	13.9
ASR8	68.7	54.6	49.9	26.8	16.8	14.2
ASR9	70.9	53.6	49.5	25.5	15.7	14.0
ASR10	81.9	61.2	49.7	27.7	19.3	14.1
ASR11	80.9	57.2	50.5	26.4	16.2	14.3
ASR12	64.0	54.5	50.3	25.0	16.7	14.5
ASR13	68.5	54.0	49.7	24.3	15.9	14.2
ASR14	65.4	57.0	49.9	25.4	17.1	14.2
ASR15	55.2	52.1	49.4	21.6	15.1	13.9
ASR16	60.3	54.2	49.5	22.2	15.9	14.0
ASR17	60.1	51.5	49.7	20.5	15.2	14.1
ASR18	58.8	50.9	49.6	21.0	15.2	14.1
ASR19	58.9	51.5	49.6	20.1	15.1	14.1
ASR20	57.8	50.9	49.6	20.5	15.3	14.1
ASR21	58.1	51.4	49.6	20.5	15.3	14.1
ASR22	59.3	53.5	49.5	20.2	15.6	14.0
ASR23	57.3	52.0	49.4	19.9	15.0	13.9
ASR24	60.0	54.3	49.5	20.6	16.0	14.0
ASR25	55.1	52.5	49.5	22.0	16.2	14.0
ASR26	57.6	52.4	49.4	21.5	15.4	14.0
ASR27	110.2	73.0	49.9	42.3	30.1	14.3

Remark : (1) NO_2 background of 49.2µg/m^3 has been incorporated;
(2) SO_2 background of 13.8µg/m^3 has been incorporated;
(3) Max 1hr NO_2 : ASR 19 and ASR 27 at 1.5m; Max 24hr NO_2 : ASR 27 at 1.5m; and
(4) Max 1hr SO_2 : ASR 9; Max 24hr SO_2 : ASR 23 at 1.5m

3.7.2.2 Non-criteria Pollutants

The maximum hourly and annual averaged concentrations of non-criteria pollutants (vinyl chloride and benzene) were predicted. The cumulative cancer risk for benzene and vinyl chloride (i.e. cancer risk of vinyl chloride plus that of benzene) is also within the cancer risk criteria. The contribution from the ASP, flare and generator plants are insignificant. Tables 3.36 to 3.38 show the non-criterion pollutant levels at the identified ASRs. Detailed results for non-criteria pollutants are given in Appendix 3.9. The predicted 1-hour and annual averaged contours for benzene are illustrated in **Drawing Nos. 24315/13/109 and 24315/13/110**; whereas, 1-hour and annual averaged contours for vinyl chloride are illustrated in **Drawing Nos. 24315/13/111 and 24315/13/112**.The emission impacts at the ASR are within the acute and chronic health risk criteria.

Table 3.36: Predicted health risk level for benzene and vinyl chloride at various ASRs (Case 3 – LFGES Off)

ASRID	Predicted max vinyl chloride concentrations at the worst affected height			Predicted max benzene concentrations at the worst affected height		
	max 1-hr and annual averaged vinyl chloride (μg/m³) (with background) (1)	Predicted Individual Risk Level per Year for Vinyl Chloride Chronic Effect	Within Acute and Chronic Reference Conc and Individual Risk Level	max 1-hr and annual averaged benzene level (μg/m³) (with background) (2)	Predicted Individual Risk Level per Year for Benzene Chronic Effect	Within Acute and Chronic Reference Conc and Individual Risk Level
ASR1	~3	5.29E-12	within	~3.9	6.21E-12	within
ASR2	~3	6.57E-12	within	~3.9	7.71E-12	within
ASR3	~3	9.14E-12	within	~3.9	1.071E-11	within
ASR4	~3	4.57E-12	within	~3.9	5.36E-12	within
ASR5	~3	5.86E-12	within	~3.9	6.86E-12	within
ASR6	~3	6.29E-12	within	~3.9	7.29E-12	within
ASR7	~3	2.57E-12	within	~3.9	3.E-12	within
ASR8	~3	7.71E-12	within	~3.9	9.21E-12	within
ASR9	~3	3.71E-12	within	~3.9	4.29E-12	within
ASR10	~3	6.86E-12	within	~3.9	7.93E-12	within
ASR11	~3	1.657E-11	within	~3.9	1.95E-11	within
ASR12	~3	1.529E-11	within	~3.9	1.8E-11	within
ASR13	~3	7.71E-12	within	~3.9	9.E-12	within
ASR14	~3	8.14E-12	within	~3.9	9.43E-12	within
ASR15	~3	5.E-12	within	~3.9	5.79E-12	within
ASR16	~3	4.71E-12	within	~3.9	5.57E-12	within
ASR17	~3	1.014E-11	within	~3.9	1.2E-11	within
ASR18	~3	9.14E-12	within	~3.9	1.071E-11	within
ASR19	~3	1.043E-11	within	~3.9	1.221E-11	within
ASR20	~3	1.0E-11	within	~3.9	1.179E-11	within
ASR21	~3	1.129E-11	within	~3.9	1.329E-11	within
ASR22	~3	6.29E-12	within	~3.9	7.29E-12	within
ASR23	~3	4.57E-12	within	~3.9	5.36E-12	within
ASR24	~3	5.57E-12	within	~3.9	6.43E-12	within
ASR25	~3	7.43E-12	within	~3.9	8.79E-12	within
ASR26	~3	5.86E-12	within	~3.9	6.86E-12	within
ASR27	~3	1.286E-11	within	~3.9	1.5E-11	within

Remark :

(1) Future Vinyl chloride background of 3μg/m³ has been incorporated; and

(2) Benzene background of 3.9μg/m³ has been incorporated

Table 3.37: Predicted health risk level for benzene and vinyl chloride at various ASRs (Case 1 – ASP On) : worst-case condition

ASRID	Predicted max vinyl chloride concentrations at the worst affected height			Predicted max benzene concentrations at the worst affected height		
	max 1-hr and annual averaged vinyl chloride (µg/m³) (with background)(1)	Predicted Individual Risk Level per Year for Vinyl Chloride Chronic Effect (1)	Within Acute and Chronic Reference Conc and Individual Risk Level	max 1-hr and annual averaged benzene level (µg/m³) (with background)(2)	Predicted Individual Risk Level per Year for Benzene Chronic Effect	Within Acute and Chronic Reference Conc and Individual Risk Level
ASR1	~3	5.29E-12	within	~3.9	2.49E-11	within
ASR2	~3	5.14E-12	within	~3.9	2.49E-11	within
ASR3	~3	6.29E-12	within	~3.9	3.E-11	within
ASR4	~3	2.71E-12	within	~3.9	1.29E-11	within
ASR5	~3	3.71E-12	within	~3.9	1.71E-11	within
ASR6	~3	3.57E-12	within	~3.9	1.71E-11	within
ASR7	~3	2.43E-12	within	~3.9	1.11E-11	within
ASR8	~3	6.29E-12	within	~3.9	3.E-11	within
ASR9	~3	2.71E-12	within	~3.9	1.29E-11	within
ASR10	~3	6.14E-12	within	~3.9	2.91E-11	within
ASR11	~3	1.17E-11	within	~3.9	5.49E-11	within
ASR12	~3	1.19E-11	within	~3.9	5.57E-11	within
ASR13	~3	5.43E-12	within	~3.9	2.57E-11	within
ASR14	~3	6.29E-12	within	~3.9	2.91E-11	within
ASR15	~3	3.43E-12	within	~3.9	1.54E-11	within
ASR16	~3	3.86E-12	within	~3.9	1.8E-11	within
ASR17	~3	6.43E-12	within	~3.9	3.E-11	within
ASR18	~3	5.E-12	within	~3.9	2.4E-11	within
ASR19	~3	6.E-12	within	~3.9	2.83E-11	within
ASR20	~3	5.14E-12	within	~3.9	2.4E-11	within
ASR21	~3	6.14E-12	within	~3.9	2.91E-11	within
ASR22	~3	3.57E-12	within	~3.9	1.71E-11	within
ASR23	~3	3.29E-12	within	~3.9	1.54E-11	within
ASR24	~3	3.43E-12	within	~3.9	1.63E-11	within
ASR25	~3	4.14E-12	within	~3.9	1.97E-11	within
ASR26	~3	3.E-12	within	~3.9	1.46E-11	within
ASR27	~3	7.86E-12	within	~3.9	3.69E-11	within

Remark :

(1) Future Vinyl chloride background of 3µg/m³ has been incorporated; and

(2) Benzene background of 3.9µg/m³ has been incorporated

Table 3.38: Predicted health risk level for benzene and vinyl chloride at various ASRs (Case 2 – ASP Off)

ASRID	Predicted max vinyl chloride concentrations at the worst affected height			Predicted max benzene concentrations at the worst affected height		
	max 1-hr and annual averaged vinyl chloride (µg/m³) (with background)(1)	Predicted Individual Risk Level per Year for Vinyl Chloride Chronic Effect	Within Acute and Chronic Reference Conc and Individual Risk Level	max 1-hr and annual averaged benzene level (µg/m³) (with background)(2)	Predicted Individual Risk Level per Year for Benzene Chronic Effect	Within Acute and Chronic Reference Conc and Individual Risk Level
ASR1	~3	4.86E-12	within	~3.9	2.31E-11	within
ASR2	~3	4.43E-12	within	~3.9	2.06E-11	within
ASR3	~3	6.71E-12	within	~3.9	3.17E-11	within
ASR4	~3	3.E-12	within	~3.9	1.37E-11	within
ASR5	~3	3.86E-12	within	~3.9	1.8E-11	within
ASR6	~3	3.71E-12	within	~3.9	1.8E-11	within
ASR7	~3	2.57E-12	within	~3.9	1.2E-11	within
ASR8	~3	7.43E-12	within	~3.9	3.51E-11	within
ASR9	~3	3.57E-12	within	~3.9	1.71E-11	within
ASR10	~3	4.86E-12	within	~3.9	2.31E-11	within
ASR11	~3	1.57E-11	within	~3.9	7.46E-11	within
ASR12	~3	1.23E-11	within	~3.9	5.74E-11	within
ASR13	~3	6.86E-12	within	~3.9	3.26E-11	within
ASR14	~3	7.29E-12	within	~3.9	3.43E-11	within
ASR15	~3	2.57E-12	within	~3.9	1.2E-11	within
ASR16	~3	3.14E-12	within	~3.9	1.46E-11	within
ASR17	~3	6.29E-12	within	~3.9	2.91E-11	within
ASR18	~3	5.71E-12	within	~3.9	2.66E-11	within
ASR19	~3	5.71E-12	within	~3.9	2.66E-11	within
ASR20	~3	6.E-12	within	~3.9	2.83E-11	within
ASR21	~3	6.E-12	within	~3.9	2.83E-11	within
ASR22	~3	3.86E-12	within	~3.9	1.89E-11	within
ASR23	~3	2.14E-12	within	~3.9	1.03E-11	within
ASR24	~3	3.29E-12	within	~3.9	1.54E-11	within
ASR25	~3	4.29E-12	within	~3.9	1.97E-11	within
ASR26	~3	3.29E-12	within	~3.9	1.54E-11	within
ASR27	~3	9.43E-12	within	~3.9	4.46E-11	within

Remarks :

(1) Future Vinyl chloride background of 3µg/m³ has been incorporated; and

(2) Benzene background of 3.9µg/m³ has been incorporated

3.7.2.3 Odour

Based on the assumption that the existing leachate treatment plant will be improved under the existing NENT Landfill Project (as discussed in Section 3.5.4.3) and a proposal that similar odour control measurements will be adopted for the leachate treatment facilities for NENT Landfill Extension.

The proposed leachate treatment facilities include :

- Adopted updated treatment method such as Sequencing Batch Reactor for future leachate treatment. Provision of ventilated cover for the leachate storage lagoons / tanks and emissions extracted to suitable odour removal filters with odour removal efficiency of 99%.
- Ferric nitrate or sodium hypochlorite can be added to oxidise the odourous chemical in the leachate. The pH value of leachate can be controlled to a suitable value from future on-site experiment such that the generation of any odourous H_2S and ammonia can be optimised.
- For the gaseous extraction system, the wind speed immediately above the leachate surface should be kept to minimal (in the order of $1E^{-3}$ m/s) such that the odour emission strength from lagoon can be minimised. Suitable treatment system should be provided for odour removal. The ventilated gaseous emission from lagoons should be provided with 5-10 air change per hour for further dilution before discharge.
- The notional centre of the future discharge point (e.g. stack) shall be located at a location with maximum setback distance from the ASRs and further away from the notional centre of the leachate storage lagoons / tanks. The location of discharge point and discharge height should be determined at the detailed design stage to ensure that the odour criterion at the ASRs will not be exceeded.

The maximum 5-sec averaged odour concentrations at the ASRs were predicted for three representative operating scenarios; namely central tipping, northern tipping and western tipping.

The maximum odour level will only occur at the northern tipping under low wind speed stability condition during night time / early morning. Details are listed in Table 3.39. The predicted maximum odour level is estimated to be 7.4 OU (at ASR27 with only a derelict isolated single house) which will occur during night time with stable and calm condition only.

For the other ASRs, all the assessed odour concentration results are within the 5 OU (5 sec. averaged) criterion.

Table 3.39: Predicted Odour Concentration (OU, 5s averaging) under reasonably worst-case condition

ASR ID	Predicted cumulative odour concentrations for ASRs at height above local ground, OU								
	Central tipping + night time daily cover overlying tipped waste + existing & future (enclosed) lagoons			Western tipping + night time daily cover overlying tipped waste + existing & future (enclosed) lagoons			Northern tipping + night time daily cover overlying tipped waste + existing & future (enclosed) lagoons		
	1.5m	5m	10m	1.5m	5m	10m	1.5m	5m	10m
ASR1	0.5	0.4	0.3	3.7	3.1	1.8	1.4	1.3	1.1
ASR2	0.1	0.1	0.1	2.2	2.1	1.8	1.2	1.2	1.1
ASR3	0.1	0.1	0.1	0.6	0.5	0.5	0.1	0.1	0.1
ASR4	0.1	0.1	0.1	0.2	0.2	0.2	0.9	0.8	0.8
ASR5	0.9	0.9	0.8	0.9	0.9	0.8	0.1	0.1	0.1
ASR6	1.4	1.3	1.2	0.1	0.1	0.1	0.2	0.2	0.2
ASR7	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.1
ASR8	0.5	0.5	0.4	0.8	0.8	0.7	0.1	0.1	0.1
ASR9	0.7	0.7	0.6	1.0	0.9	0.8	1.1	1.1	1.0
ASR10	0.4	0.3	0.3	0.2	0.2	0.1	1.7	1.6	1.2
ASR11	0.6	0.3	0.2	0.6	0.3	0.2	0.9	0.8	0.7
ASR12	0.1	0.1	0.1	0.8	0.8	0.7	0.3	0.3	0.3
ASR13	0.9	0.8	0.7	2.1	2.0	1.7	0.5	0.4	0.4
ASR14	1.6	1.5	1.3	0.3	0.2	0.2	1.5	1.5	1.3
ASR15	0.6	0.6	0.6	0.2	0.2	0.1	0.2	0.2	0.2
ASR16	0.7	0.7	0.6	0.5	0.5	0.5	0.1	0.1	0.1
ASR17	0.1	0.1	0.1	0.2	0.2	0.2	0.6	0.6	0.5
ASR18	0.7	0.6	0.6	0.8	0.8	0.7	0.1	0.1	0.1
ASR19	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1
ASR20	0.2	0.2	0.2	0.1	0.1	0.1	0.3	0.3	0.3
ASR21	0.5	0.5	0.5	0.6	0.6	0.5	0.1	0.1	0.1
ASR22	0.5	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0
ASR23	0.4	0.4	0.4	0.1	0.1	0.1	0.0	0.0	0.0
ASR24	0.1	0.1	0.1	0.5	0.5	0.5	0.4	0.4	0.4
ASR25	0.7	0.7	0.7	0.8	0.8	0.7	0.4	0.4	0.4
ASR26	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1
ASR27	1.8	1.7	1.2	2.4	2.3	1.9	7.4 (on average 8 hours per year)	6.2 (on average 5 hours per year)	3.4
Max:	1.8	1.7	1.3	3.7	3.1	1.9	7.4	6.2	3.4

Residual Odour Impact

As regards the only case in which the 5 OU (5-sec. averaged) criterion is exceeded, i.e. at isolated occasions at ASR 27, the following points should be noted with reference to EIAO-TM Clause 4.4.3 and its Annex 20 Clause 7:

(a) Factors in EIAO-TM Clause 4.4.3:

(i) effects on public health and health of biota or risk to life – Although there is one minor occurrence (occurring at only one ASR, and only on rare occasions) of exceedance, it will not entail any significant health effect, as ASR 27 is a derelict isolated single house. Even in the event that the house is redeveloped, the aforementioned exceedance is readily avoidable because it occurs only at rare occasions (on average 8 hours a year, during night time at stable and calm weather conditions). For the whole operating life of the NENT landfill extension, the tipping face located at the worst "northern tipping" should be much less than 2 years. Landfilling could be planned to operate at locations far enough away from ASR 27 under such rare oaccasions, should the house be redeveloped in the future.

(ii) the magnitude of the adverse environment impacts – The assessed worst case odour concentration is 7.4 OU (5-sec. averaged) does exceed the 5 OU criterion, but as stated above, it occurs only at ASR 27 which is a derelict house.

(iii) the geographic extent of the adverse environmental impacts – The exceedance occurs at only one ASR.

(iv) the duration and frequency of the adverse environmental impacts – As stated above, the exceedance occurs on average 8 hours a year, in other words at a frequency of 0.09% or 1 in 1062, which is obviously a very low frequency.

(v) the likely size of the community or the environment that may be affected by the adverse impacts – ASR 27 is a derelict isolated single house.

(vi) the degree to which the adverse environmental impacts are reversible or irreversible – Odour impact is transient in nature; moreover, as stated above since only one ASR is involved, it is readily practicable to adjust the landfill operation to avoid the exceedance in case the derelict house at ASR 27 is redeveloped.

(vii) the ecological context – The exceedance does not involve ecological context.

(viii) the degree of disruption to sites of cultural heritage – The exceedance does not involve cultural heritage context.

(ix) international and regional importance – The exceedance does not involve international and regional importance.

(x) both the likelihood and degree of uncertainty of adverse environmental impacts – The exceedance does not involve such uncertainty.

(b) Questions in Annex 20 Clause 7:

Have the available standards, assumptions and criteria which can be used to evaluate the impacts been discussed?	Yes
Have the predicted impacts been compared to the available standards and criteria?	Yes
Have the residual impacts, which are the net impacts with the mitigation measures in place, been described and evaluated against the available Government policies, standards and criteria?	Yes
Have the residual impacts been discussed and evaluated in terms of the impact on the health and welfare of the local community and on the protection of environmental resources?	Yes
Have the magnitude, location and duration of the residual impacts been discussed in conjunction with the value, sensitivity and rarity of the resource?	Yes, See (a) above
Where there are no generally accepted standards or criteria for the evaluation of residual impacts, have alternative approaches been discussed and, if so, is a clear distinction made between fact, assumption and professional judgment?	Not applicable
Have the residual impacts, if any, arising from the implementation of the proposed mitigation measures, been considered?	Yes

In view of the rarity or low frequency of occurrence of the exceedance, and the fact that it occurs only at one ASR, which is a derelict house without any inhabitant, the exceedance ought not be considered as an issue of environmental concern.

The predicted 5-sec averaged odour contour for the worst-case scenario at northern tipping and western tipping are shown in **Drawing No. 24315/13/113 and 24315/13/114.**

From a practical point of view, much of the odour would be originated from odorous VOC. In accordance with the long-term VOC monitoring record, the VOC levels at NENT Landfill have been kept at low level as a result of the good site practices and effective control in inactive tipping areas. The odour prediction results are in line with the long-term observation from VOC monitoring data (odorous source). With sufficient setback distance of the nearby ASRs from the NENT Landfill Extension, odour would not be a key issue of the extension site. Nonetheless, good site practices and odour patrol are recommended to monitor the future condition.

3.8 Precautionary Measures

3.8.1 Construction Phase

Dust emission from construction vehicle movement is confined within the worksites area. Watering facilities will be provided at every designated vehicular exit point.

Good site practice is recommended during construction phase. Covering with impermeable sheet should be provided for the inactive tipping area. Periodic dust monitoring at the nearby ASRs should be conducted and detailed in the EM&A manual.

In case of non-compliance, additional mitigation measures in accordance with the EM&A requirements will be implemented.

3.8.2 Operation Phase

3.8.2.1 Stack Discharge from ASP, Flare and LFG Power Generator

Similar to the existing NENT Landfill operation, the maximum allowable discharge limit for ASP, flare and LFG power generator should be specified in the specification. Subject to the subsequent EPD's requirement on chimney installation, once every 3 months regular stack monitoring of vinyl chloride, benzene, TOC, NO_x and SO_2 shall be carried out to demonstrate compliance during the operations.

3.8.2.2 Odour from Leachate Treatment Facilities

As mentioned in Section 3.7.2.3, the proposed leachate treatment facilities in NENT Landfill Extension include :

- Adopted updated treatment method such as Sequencing Batch Reactor for future leachate treatment. Provision of ventilated cover for the leachate storage lagoons / tanks and emissions extracted to suitable odour removal filters with odour removal efficiency of 99%.
- Ferric nitrate or sodium hypochlorite can be added to oxidise the odourous chemical in the leachate. The pH value of leachate can be controlled to a suitable value from future on-site experiment such that the generation of any odourous H_2S and ammonia can be optimised.
- For the gaseous extraction system, the wind speed immediately above the leachate surface should be kept to minimal (in the order of $1E^{-3}$ m/s) such that the odour emission strength from lagoon can be minimised. Suitable treatment system should be provided for odour removal. The ventilated gaseous emission from lagoons should be provided with 5-10 air change per hour for further dilution before discharge.
- The notional centre of the future discharge point (e.g. stack) shall be located at a location with maximum setback distance from the ASRs and further away from the notional centre of the lagoons. The location of discharge point and discharge height

should be determined at the detailed design stage to ensure that the odour criterion at the ASRs will not be exceeded.

- The overall arrangement should be investigated in details by the DBO Contractor and agreed with IEC and EPD. As such, the odour emission from the future leachate treatment facilities will be insignificant.

3.8.2.3 Odour from Waste Transfer and Tipping Activities

The following are some odour precautionary measures that shall be considered by EPD and FEHD as environmental initiatives:

- As an improvement measure to enhance to environmental standard for waste transfer, EPD could take the initiative to recommend others to use enclosed type RCVs (dominantly government vehicles and sludge vehicles).
- Cleaning / watering of the surface and clearing of the waste water receptor of government RCV is recommended before leaving refuse transfer station or government Refuse Collection Point (FEHD).
- The use of alternative daily cover (less permeable layer) instead of inert material should be considered under worst-case weather condition, subject to EM&A Programme.
- The use of immediate daily cover for odorous waste such as sewage sludge, animal waste etc. under critical condition should also be considered, subject to EM&A Programme.
- For the time being, there is no population in the derelict Tong To Shan Tsuen. If there is new residents moving in, thicker daily cover / alternative daily cover should be applied at phase 3 of the extension site such that the emission strength for the night time can be reduced (similar performance as that in the inactive tipping area). Odour patrol at Tong To Shan Tsuen should be arranged during night time / early morning in order to ensure the effectiveness of the measures.
- In accordance with some reference from New Zealand, odour from active tipping area can be much reduced if the waste is covered by sandwich covering material such that it is confined in a solid/semi solid condition. Such covering material will be acted as sandwich protective layers to block the interaction of waste. Only diffusion mode (small scale) will be present. These would be applied during very hot and stable weather condition. Thicker daily cover can be arranged in case odour patrol identify potential odour nuisance, subject to EM&A Programme.
- During stable and calm weather condition and subject to EM&A programme, tipping could be arranged to further increase the setback distance.

3.8.2.4 VOC Surface Emission and Future Ambient Level

- Similar to other restored landfill, the existing NENT Landfill will be capped by plastic covering sheet and a thick layer of soil during restoration period. Surface gas emission from existing restored landfill is insignificant. With the installation of permanent capping, together with the LFG management system, there are double preventive measures against surface emission. Odour and VOC emission from the restored NENT Landfill is not anticipated.
- For the NENT Landfill Extension, with an effective temporary covers, together with LFG management system (active extraction to collect LFG within the landfill cells), natural escape of odourous VOC to the nearby ASRs is negligible.
- EM&A will be conducted to review the future VOC ambient concentration and effectiveness of the extraction system. VOC monitoring at ASRs to be conducted once every 3 month is recommended before the commissioning of NENT Landfill Extension (as base-line) and in the 1st year of tipping operation, during the period when the ASP and flare are not in operation. By comparing the monitoring data at the boundary and at

ASR, the cause of VOC and the general downwind dispersion effect from the boundary to the ASR can be established.

- Development of LFG Export Scheme / energy recovery scheme will be encouraged for the NENT Landfill Extension.

3.8.3 Restoration and Aftercare Phase

Similar measures as in construction and operation phases will be applied.

3.9 Residual Environmental Impact

There is no residual environmental impact during construction phase, operation and aftercare/restoration phases.

3.10 Implication of IWMF Implementation

If the potential of Integrated Waste Management Facility (IWMF) implementation were considered in 2010's, the incoming waste characteristics to the NENT Landfill Extension site would be altered substantially, mainly with inert incinerator ashes. Based on the observation from other similar facilities such as Chemical Waste Treatment Centre at Tsing Yi, the incinerator ashes will be in the form of fused solid sludge. The flying ash issue will not be a concern. The air quality impact (VOC and odour from both active tipping and leachate treatment plant) is anticipated to reduce significantly.

3.11 Conclusion

The potential air quality impacts during construction, operation, restoration and aftercare phases of the NENT Landfill Extension Project have been assessed.

3.11.1 Construction Phase

Construction dust modelling results show that there would be no adverse construction dust impact on the ASRs in the vicinity of the NENT Landfill Extension site. Good site practices, however, are still recommended throughout the construction period to further eliminate any dust problem. Requirements for regular monitoring of dust concentration are detailed in the EM&A Manual.

3.11.2 Operation Phase

3.11.2.1 Stack Gas and Surface Gas Emission

Dispersion modelling results show that gaseous emissions from ammonia stripping plant, LFG power generator and flaring system of the NENT Landfill Extension will have no adverse impact on the ASRs throughout the operational period of the NENT Landfill Extension. Subject to the subsequent EPD's requirement on chimney installation, once every 3 months regular stack monitoring of vinyl chloride, benzene, TOC, NOx and SO_2 shall be carried out to demonstrate compliance during the operations.

By adopting the best practice using effective active extraction system, plastic sheet cover at inactive tipping area plus periodic EM&A monitoring, the surface gas emission can be significant reduced. With the provision of these measures, no adverse health risk impact is anticipated.

Regular emission monitoring of these facilities is recommended to ensure their proper functioning.

3.11.2.2 Odour

Odour assessment results show that there would be no adverse impact on the ASRs during the operational period of the Project, except the derelict and vacant Tong To Shan Tsuen. Residual impact at Tong To Shan Tsuen is considered to be very scarce and transient in nature and can be mitigated with good site practices (including application of thicker daily cover, progressive restoration for inactive tipping face.), as well as periodic odour patrol should be carried out during active tipping period. In case the weather condition is poor (stable and calm weather), tipping should be arranged at area further away from the ASRs as far as practicable, and/or thicker daily cover / alternative daily cover should be applied subject to EM&A programme.

Ventilated cover with emissions extracted to suitable odour removal filters for odour removal has been proposed for existing lagoons. Updated treatment method such as Sequencing Batch Reactor has been proposed for future lagoon. Ventilated cover shall be provided with emissions extracted and diverted to suitable filters with odour removal efficiency of 99%. Ferric nitrate or sodium hypochlorite shall be added to oxidise the odourous chemical in the leachate. The pH value of leachate can be controlled to a suitable value from future on-site experiment such that the generation of any odourous H_2S and ammonia can be optimised.

For the gaseous extraction system, the wind speed immediately above the leachate surface should be kept to minimal such that the odour emission strength from lagoon can be minimised. Suitable treatment system should be provided for odour removal. The ventilated gaseous emission from lagoons should be provided with 5-10 air change per hour for further dilution before discharge.

The notional centre of the future discharge point (e.g. stack) shall be located at a location with maximum setback distance from the ASRs and further away from the notional centre of the lagoons. The location of discharge point and discharge height should be determined at the detailed design stage to ensure that the odour criterion at the ASRs will not be exceeded.

For the time being, there is no population in the derelict Tong To Shan Tsuen. If there is new resident moving into this derelict village, thicker daily cover / alternative daily cover should be applied at phase 3 of the extension site such that the emission strength can be reduced (similar to that in the inactive tipping area). Site walk should be conducted once every three months to the Tong To Shan Tsuen to verify whether there is new resident moving in during the operational stage. Once, there is any new resident, night time / early morning odour patrol at Tong To Shan Tsuen should be arranged to ensure that daily covering material is sufficient without causing odour nuisance. These will be specified in the EM&A manual.

3.11.3 Restoration and Aftercare Phases

The scale of construction activities during the restoration and aftercare phases of the NENT Landfill Extension will be small when compared with the construction phase. Construction dust is therefore not anticipated to be an issue.

The impact of stack gas emissions from treatment facilities will be much reduced during these phases given the gradual reduction in leachate and LFG generation rates over time.

Odour in restored landfill will not be a concern.

Air quality conditions will not be worse than during the operation phase and hence no adverse impact is anticipated.