7 Landfill Gas Hazards

7.1 Introduction

This chapter presents the risk assessment of landfill gas (LFG) hazards arising from the construction, operation, restoration and aftercare phases of the Project. Appropriate protective and precautionary measures will be implemented during various phases of the Project to control the LFG hazards to a minimum and acceptable level. No adverse impact is anticipated.

The landfill gas impact assessment has been conducted in accordance with the requirements in ProPECC PN 3/96 and EPD/TR8/97, and Clause 3.4.5 of the EIA Study Brief for the Project.

7.2 Legislation, Standards and Guidelines

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

- Annex 7 and Annex 19 of the Technical Memorandum on EIAO (TM-EIAO).
- ProPECC PN 3/96 – Landfill Gas Hazard Assessment for Development Adjacent to Landfill
- EPD/TR8/97 Landfill Gas Hazard Assessment Guidance Note (LFG Guidance Note), which sets out the conditions and provide guidance to carry out LFG hazard assessment.

These guidance notes recommend that in general, assessment of LFG hazard will be required for proposed developments within the 250m consultation zone of a landfill. The landfill extension site is located within the 250m consultation zone of the existing NENT Landfill, and the Project site itself is a potential source of landfill gas generation.

7.3 Background Information

7.3.1 Desktop Study

A comprehensive desktop review study of literature information and study reports has been undertaken to appreciate the site characteristics and determine the likelihood of potential LFG impacts on the sensitive receivers. Other sources of information include topographical and geological maps, aerial photographs, utilities plan (gas, electricity, drainage, etc), information from previous ground investigations, engineering and operation details regarding NENT Landfill, gas monitoring data, visual data at landfill extension site, etc. The following documents have been reviewed:

- Development of the North East New Territories Landfill Final Report
- Environmental Review for NENT Landfill
- NENT Landfill: Supplementary Environmental Impact Assessment Final Report
- EP/SP/12/92 Development and Management of North East New Territories (NENT) Landfill monthly and annual reports (1996 to 2005)
- EP/SP/12/92 NENT Landfill – Landfill Monitoring Plan
- NENT Landfill Leachate Treatment Phase I and Village Sewerage – Final Environmental Impact Assessment Update Report
- CE45/99 Extension of Existing Landfills and Identification of Potential New Waste Disposal Sites – Final Strategic Environmental Assessment Report

- EP/SP/12/92 Development and Management of NENT Landfill Contract documents
- FP99/055 Study on the Waste Management Plan – Collection and Forecast of Waste Data – Resource Document
- EP/SP/12/92 Monthly Monitoring of Waste Phase 1, 2 and 4 Reports
- Supplementary Environmental Impact Assessment for NENT Landfill Leachate Treatment Works Final Report
- NENT Landfill Leachate Disposal Study
- CE20/2004 NENT Landfill Extension Feasibility Study – Submission Ref 008: Ground Investigation Desk Study Report
- CE20/2004 NENT Landfill Extension Feasibility Study – Submission Ref 036: Final Ground Investigation Report

7.3.2 History of Existing NENT Landfill

NENT Landfill was commissioned in 1995 and receives waste from the North East New Territories, and Kowloon Bay and Sha Tin Refuse Transfer Stations solely by road, with an overall capacity of 35 Mm^3 occupying about 61 ha of land.

The site was first developed under the former Civil Engineering Department (now as Civil Engineering and Development Department)'s management and formed an initial area of the site ready for waste deposition, and also created a Stockpile and Borrow Area, where spoil from the initial excavation was stored for later re-use. It is being developed in 4 phases with construction, operation, restoration and aftercare occurring concurrently in various periods. Based on the information at the end of Year 2005, the existing landfill is being operated in Phase 2 and will be filled up by Year 2010.

About 3 Mm^3 of soil and rock excavated from the development of the landfill void was stored in the Stockpile and Borrow Area that lies about 1 km to the east of the existing landfill.

The landfill includes a leachate treatment plant in the northwest corner of the site that operates at treatment capacity of 800 m^3/day during the dry season (November to April) and 1,200 m^3/day during wet season (May to October). The system includes six aeration / storage lagoons with associated dosing and desludging facilities, and an ammonia stripping processing plant. After treatment, the effluent is discharged via a dedicated rising main to Shek Wu Hui Sewage Treatment Works (SWHSTW) in Sheung Shui.

A LFG management system is also in place for daily operation. LFG generated from the deposited waste is pumped to a LFG utilisation plant, where the gas is used to generate electricity for site needs. LFG is also utilised as a heat source for the ammonia stripping processing plant used in the leachate treatment process. Surplus LFG will be completely burnt in the flaring system.

The contractor for the existing NENT Landfill and HKCG have conducted a pilot study to utilise methane recovered from LFG as an energy source for town gas production.

In the near future, arrangement will be put in place to export LFG from the existing NENT Landfill to Tai Po Gas plant for use as a fuel source.

7.3.3 Geology

7.3.3.1 Existing NENT Landfill Site

Drawing No. 24315/13/501 is a geological map of the existing NENT Landfill site and surrounding area, which are composed entirely of the Tai Mo Shan Formation of the Upper Jurassic Repulse Bay Volcanic Group. The formation is dominantly a lapilli to coarse-ash crystal tuff with intercalated sedimentary rocks, most of which have been metamorphosed.

The intercalations of sedimentary rocks in the Tai Mo Shan Formation are well exposed on Wong Mau Hang Shan and 200m north of Ngong Tong. These rocks are composed of mainly purple or brown fine-grained sericitic sandstone and greenish grey or reddish brown phyllite. At Heung Yuen Wai, 600m north of Wong Mau Hang Shan, the outcrops are mainly phyllite (siltstone or mudstone if in an unmetamorphosed state).

There are four faults identified in the landfill site area. Both the volcanic tuffs and metasediments contain well defined joint (discontinuity) systems, and the movement of groundwater in the bedrock materials beneath the site is controlled by the discontinuities. The depth of weathering is generally in excess of 22m on the crest of ridges surrounding the site, but the volcanic tuffs in the fault zones may be geochemically more resistant to weathering. The superficial materials comprises colluvium, alluvium and fill, which form local thin infills along the valley floors.

7.3.3.2 NENT Landfill Extension Site

A desktop and ground investigation was undertaken at the landfill extension site currently designated as the Stockpile and Borrow Area for the existing landfill (**Drawing No. 24315/13/501**).

The site has a variable thickness of superficial deposits across the majority of its area, comprising fill, colluvium and soils derived from *in-situ* weathering. The solid geology of the site comprises a mixture of volcanic tuff deposits, slightly metamorphosed volcanic tuff deposits and a small area of meta-sedimentary rock. The rockhead levels within the site are largely reflected by the topography, with low-lying valleys typically having been formed due to the presence of geological faults.

Four major geological faults are present within the site:

- Fault 1 is located along the northern boundary of the study area and striking approximately west-northwest.
- Fault 2 strikes north-northeast through the study area, most likely extending through the existing waste reception area to the south of the site and then following the topographic valley northeast from this. Previous work has recorded this fault as dipping at 80° to the southeast, with the material on the southeastern side having been downthrown.
- Fault 3 follows the approximate alignment of the existing haul road through the centre of the site area, trending west-northwest to east-southeast, and extends beyond the site boundaries.
- Fault 4 is most likely a large splay fault associated with Fault 2. The main trend of the fault is north-northeast along the topographic valley to the east of Fault 2, with a small portion trending east-northeast to the south of the haul road before joining with Fault 2 in the low-lying area within the southern part of the site.

7.4 LFG Hazard Assessment

7.4.1 Approach

Qualitative assessment on the risk of LFG hazards at the receivers has been undertaken for each of the identified source-pathway-receiver combinations. Qualitative LFG hazard assessment was undertaken following the method recommended in the LFG Guidance Note. This method is based on the "Source-Pathway-Receiver" model as described below:

- Source – location, nature and likely quantities/ concentrations of LFG which has the potential to affect the landfill extension.
- Pathway – the ground and groundwater conditions, through which LFG must pass in order to reach the landfill extension.

- Receiver – elements of the development that are sensitive to the effects of LFG.

The LFG sources, pathways and receivers are categorised for the hazard assessment. In accordance with the LFG Guidance Note, an assessment of the overall risk is made based on the risk category as summarised in Table 7.1, following determination of which category of source, pathway and receiver, the combination of existing NENT Landfill and its extension fall into during the construction, operation, restoration and aftercare stages.

For the purpose of categorising the landfill extension site, the category is based upon the highest level of risk determined for any of the potential impacts identified in Table 7.1, in which the general implications fall into different overall risk categories as shown in Table 7.2.

The findings of this LFG hazards are also adopted for the impact assessment of wildlife especially at Lin Ma Hang Stream due to accidental LFG migration from the NENT Landfill Extension site.

Table 7.1: Classification of risk category

Source	Pathway	Receiver Sensitivity	Risk Category
Major	Very Short/ Direct	High	Very high
		Medium	High
		Low	Medium
	Moderately Short/ Direct	High	High
		Medium	Medium
		Low	Low
	Long/ Indirect	High	High
		Medium	Medium
		Low	Low
Medium	Very Short/ Direct	High	High
		Medium	Medium
		Low	Low
	Moderately Short/ Direct	High	High
		Medium	Medium
		Low	Low
	Long/ Indirect	High	Medium
		Medium	Low
		Low	Very low
Minor	Very Short/ Direct	High	High
		Medium	Medium
		Low	Low
	Moderately Short/ Direct	High	Medium
		Medium	Low
		Low	Very low
	Long/ Indirect	High	Medium
		Medium	Low
		Low	Very Low

Table 7.2: Summary of general categorisations of risk

Category	Level of Risk	Implication
A	Very high (undesirable)	The type of development being proposed is very undesirable and a less sensitive form of development should be considered. At the very least, extensive engineering measures, alarm systems and emergency action plans are likely to be required.
B	High	Significant engineering measures will be required to protect the planned development.
C	Medium	Engineering measures will be required to protect the proposed development.
D	Low	Some precautionary measures will be required to ensure that the planned development is safe.
E	Very low (insignificant)	The risk is so low that no precautionary measures are required.

7.4.2 Sources

7.4.2.1 Existing Landfill

According to the EP/SP/12/92 Development and Management of NENT Landfill Monthly Reports in the recent 3 years, the LFG recovery statistics in terms of utilisation (for power generation, Ammonia Stripping Plant and other uses) and flaring processes are tabulated in Table 7.3, indicating a significant quantity of LFG generation.

The contractor of the existing NENT Landfill is required to carry out LFG monitoring during landfill operation from gas wells, boreholes and surface emissions for methane (CH_4), carbon dioxide (CO_2) and oxygen (O_2) as specified in the EP/SP/12/92 NENT Landfill – Landfill Monitoring Plan (LMP). Table 7.4 shows the compliance summary of LFG monitoring between 1996 and 2005 for CH_4, CO_2 and O_2 monitoring data extracted from the relevant EP/SP/12/92 Development and Management of NENT Landfill Monthly Reports.

Table 7.3: Recent LFG recovery statistics of existing NENT Landfill

	LFG Volume (m^3)				
	2001*	2002	2003	2004	2005
GenSet	567,408	2,585,544	2,500,824	2,765,592	2,639,904
Ammonia Stripping Plant	5,604,000	23,862,000	22,828,800	23,590,800	23,001,600
Flaring	144,024	1,797,024	1,201,152	1,318,224	1,556,784
Other Uses	348,000	230,400	1,528,152	1,884,408	38,544
Total recovery (m^3)	6,663,432	28,474,968	28,058,928	29,559,024	27,236,832
Recovery rate (m^3/hr)	3,085	3,595	3,248	3,421	3,152

* Available LFG data only for Aug, Nov & Dec in 2001

Table 7.4: Compliance summary of LFG monitoring

Year	Organic Emission (VOC)	LFG (CH_4, CO_2 and O_2)	
		Borehole	Surface
1996	No exceedance of trigger level (1)	No exceedance of trigger level (2)	No exceedance of trigger level
1997	No exceedance of trigger level	No exceedance of trigger level (2)	**Abnormalities at certain locations** (3)
1998	No exceedance of trigger level (4)	No exceedance of trigger level (2)	No exceedance of trigger level
1999	No exceedance of trigger level (5)	No exceedance of trigger level (2)	No exceedance of trigger level
2000	No exceedance of trigger level	No exceedance of trigger level (2)	No exceedance of trigger level
2001	No exceedance of trigger level	No exceedance of trigger level (2)	No exceedance of trigger level
2002	No exceedance of trigger level (6)	No exceedance of trigger level (2)	No exceedance of trigger level
2003	No exceedance of trigger level (7)	No exceedance of trigger level (2)	No exceedance of trigger level
2004	No exceedance of trigger level	No exceedance of trigger level (2)	No exceedance of trigger level
2005	No exceedance of trigger level	No exceedance of trigger level (2)	No exceedance of trigger level

Notes:

(1) Abnormality of chloroform level was recorded at one location, but it was considered erroneous and not due to landfill activities.

(2) Abnormality of CO_2 levels was recorded in some boreholes, but it was considered due to natural source and not due to landfill activities.

(3) Abnormality of flammable gas was detected at some locations in October, November and December 1997.

(4) Abnormality of methanethiols, ethanethiols and buthanethiol were recorded, but they were considered originating from external sources and not due to landfill activities.

(5) Abnormality of ethyl butanoate at one location was recorded, but it was considered originating from external source and not due to landfill activities.

(6) Abnormality was considered originating from external source and not due to landfill activities.

(7) Abnormality of propyl benzene was recorded at one location, but it was considered originating from external sources and not due to landfill activities.

(8) All the abnormalities had been reviewed by the IC and it was concluded that all of them were not originated from the existing NENT Landfill.

It is acknowledged from the NENT Landfill Monthly Reports that the only justifiable exceedances recorded for surface gas monitoring in October to December 1997 were likely due to the proximities of monitoring locations to the active tipping faces. It was also recorded that the frequency of surface gas monitoring had been increased in accordance with the corrective actions of LMP when exceedances occurred. With reference to the LFG Guidance Note, the source of LFG at the existing landfill is categorised as **Medium**, considering the following reasons:

- Active gas extraction system is an essential element of LFG protection measure at the existing NENT Landfill; and
- Gas control systems have been installed and proven to be effective by comprehensive monitoring which has demonstrated that there is no migration of gas beyond the landfill boundary.

The existing NENT Landfill has been incorporated with an efficient and effective LFG management system (Appendix 7.1), in which a coordinated approach to LFG monitoring, collection, extraction, flaring and utilisation is being implemented to achieve the following requirements:

- To eliminate the risk of explosion or combustion due to the presence of LFG within, below, above and inside the landfill site;
- To eliminate the hazards to flora or fauna due to toxicity or asphyxiation effect of LFG presence external to the landfill site;
- To minimise the effect of odours from LFG causing nuisance in the vicinity of the landfill site;
- To minimise the uncontrolled egress of LFG from the landfill site;
- To eliminate migration of LFG to service ducts or enclosed/confined spaces of any on-site buildings;
- To protect any temporary or permanent structures or chambers on the landfill site;
- To prevent unnecessary air ingress into the landfill;
- To prevent unnecessary build-up of LFG pressure within the landfill;
- To relieve positive pressures of LFG at the landfill boundary and near the surface;
- To facilitate the controlled extraction of LFG from the landfill;
- To facilitate the ultimate flaring and utilisation of LFG; and
- To provide signs designating hazards and precautions to avoid on-site accidents.

LFG barrier

The existing NENT Landfill was designed and constructed as a secure containment facility incorporating multi-layer composite liner systems covering the entire surface area of the site. The liner system and future final cap at the existing NENT Landfill form effective barriers against LFG migration. A final cap will be installed during the restoration stage to minimise uncontrolled egress of LFG from the landfill site, control of LFG arising from the landfill site, and minimise uncontrolled ingress of air into the landfill site and avoid any impact on the quality of potentially exploitable LFG.

LFG collection system

The LFG collection system at the existing NENT Landfill comprises vertical collection wells progressively constructed within the buried waste in conjunction with landfilling activities. The wells have radiant horizontal collection trenches throughout the depth of waste connecting with the extraction wells at regular intervals. The system also includes facilities to fulfil the performance requirements for the overall LFG management system, e.g. components to allow the coordination of LFG collection and extraction systems, prevent unnecessary build-up of LFG pressure within the landfill, relieve positive pressures of LFG at the landfill boundary and near surface, and control migration of LFG off-site.

LFG extraction system

The LFG extraction system at the existing NENT Landfill removes LFG collected from the buried waste for efficient and effective removal and conveyance to the LFG flaring and utilisation facilities. The system includes extraction wells and pipework installed within the landfill cap connecting a pumping station on-site. It also incorporates a separate collection system connected to perimeter extraction wells isolated from the main system so that it is operated independently for migration control. The system also allows LFG to be pumped in a minimum of 2 directions to provide flexibility and security of extraction, chemical duty

isolating valves suitable for flow control with status indication, reservoir-/gravity drainage-type condensate traps at low points on the connecting pipework, and independent pumps for the operation of gas extraction system and perimeter control system.

LFG treatment by flaring

The LFG flaring system in the existing NENT Landfill is used for combustion of the extracted LFG such that it can be efficiently and effectively consumed, which comprises a pumping station with gas flares for heat production. LFG is extracted from the landfill and conveyed by a blower through a pipeline system to create a negative pressure for low emission controlled combustion. The wet saturated LFG is dewatered in a condensate separator so that it can be burnt off in the high temperature flare. The collected condensate is discharged into the on-site leachate treatment plant. The total LFG treated by the flaring system was 1.6 Mm^3 in 2005. When required, a mobile flaring unit will be mobilised for LFG treatment.

LFG utilisation for power generation

A Genset system in the existing NENT Landfill is used for combustion of the extracted LFG such that it can be efficiently and effectively consumed for power generation. The Genset system is a water-cooled, 20-cylinder four-stroke spark ignition engine with mixture turbo-charging and a shaft output of maximum 950kW. The total LFG utilised by the Genset system was 2.6Mm^3 in 2005. The system operates to prevent generation of toxic emissions by admitting especially low fuel gas/air mixture to the combustion chamber.

LFG utilisation at ammonia stripping plant

An ammonia stripping plant has been installed and operated (24 hours per day) at upstream of the biological treatment system of the leachate treatment works for advance removal of ammonia by thermal destruction with LFG as fuel. The thermal destructor thus destroys and renders harmless the LFG and ammonia LFG is introduced into to the burners after passing through a flame arrestor, which is designed to operate at a maximum LFG flow of 6,000m^3 per hour with about 50% methane concentration. Total LFG utilisation at ASP was 23 Mm^3 in 2005.

LFG recovery system

The contractor of the existing NENT Landfill and HKCG have conducted a pilot study to utilise methane recovered from LFG as an energy source for town gas production. The necessary facilities are currently being installed including a 19 km gas pipeline from NENT Landfill to Tai Po Gas Plant and relevant modification works to gas production equipment, and the use of LFG is anticipated to commence in 2007. Similar initiative shall be proposed for implementation in the NENT Landfill Extension Project.

LFG monitoring programme

The results from the routine and long-term LFG monitoring programme for the existing NENT Landfill operation indicate that the landfill has been operating satisfactorily and considered adequate with the proven LFG collection system and control plant in place to minimise any potential impact to the concerned sensitive receivers. The scope of LFG monitoring at the existing NENT Landfill covers the following:

- The quantity and quality of LFG extracted from the existing NENT Landfill site is monitored and the effectiveness of landfill liner system is regularly checked to prevent uncontrolled egress of LFG from the landfill site;
- The quantity of LFG emanating from the landfill site is automatically monitored at the LFG pumping station. The suction pressure at gas pumping station is monitored and the alarm will be activated when the pressure increased above or decreased below acceptable pre-determined levels;

- The well heads are installed with valves, connecting pipework, etc to connect with flow meters for monitoring of LFG extraction rates at individual heads;
- The quality of LFG is monitored by the facilities installed in the LFG pumping station, including CO_2, O_2 , nitrogen and methane concentrations, whilst the LFG composition at the well heads is monitored by gas sampling and laboratory analysis;
- The LFG flaring system is monitored for flare temperature, emissions, and differential pressure across flame arrestors;
- Routine LFG monitoring is conducted at fixed surface and borehole locations along the landfill site boundary and at potential sources of concern to ensure timely implementation of emergency and contingency measures in case LFG migration or exceedance of trigger levels; and
- Implementation of "permit to work" system, monitoring to ensure safe level of LFG concentration, and implementation of sufficient mitigation measures when entering confined spaces within the landfill site.

7.4.2.2 Future Landfill Extension

The future landfill extension itself is a source to generate significant amount of LFG during the operation and aftercare phases. LFG hazards may be prone to front-line workers within the site especially where the LFG are extracted, transported and processed. With the LFG control measures and Waste to Energy Facility in the future NENT Landfill Extension, it is anticipated that the source of LFG will be properly controlled within the site similar to the operation in existing NENT Landfill.

The NENT Landfill Extension will be designed as a containment landfill with LFG collection and management systems to eliminate any off-site migration of LFG. By virtue of the effective control and utilisation of LFG being implemented in the existing NENT Landfill based on the past monitoring data, it is likely that the NENT Landfill Extension will be designed to adopt similar LFG control measures so as to ensure future compliance of environmental and safety requirements. The source of LFG at the future landfill extension was categorised as **Medium**, considering the following reasons:

- Active gas extraction systems will be installed in the future landfill extension; and
- Gas control systems will be installed which are proven to be effective by comprehensive monitoring to demonstrate no migration of gas beyond the landfill boundary and specific control measures.

7.4.3 Pathways

The type of pathways can be broadly classified based on various geological features of the landfill extension site such as permeability of soil; spacing, tightness and direction of fissures/joints; topography; depth and thickness of the medium through which the gas may migrate (also affected by groundwater level); nature of strata over the potential pathway; number of media involved; and depth to groundwater table and flow patterns, etc. In general, the pathway can be broadly classified as follows depending on the distance from the landfill boundary:

- **Very Short/ Direct** for path length less than 50m;
- **Moderately Short/ Direct** for path length of 50-100m; and
- **Long/ Indirect** for path length of 100-250m

7.4.3.1 Within Landfill Extension Site

Natural pathways

The major concern is the presence of Faults 1 and 3 as shown in **Drawing No. 24315/13/501** across the existing NENT Landfill towards the landfill extension site, which as natural pathways for preferential LFG migration. These pathways of fissured rock are less than 50m to the landfill extension site and are categorised as **Very Short/ Direct** according to the LFG Guidance Note.

The superficial deposits located below the formation level to the south of the landfill extension site may act as natural pathways for LFG migration towards the Waste Reception Area of the existing NENT Landfill. These pathways of unsaturated permeable strata are less than 50m to the landfill extension site and are categorised as **Very Short/ Direct**.

Man-made pathways

There are man-made pathways in the vicinity of the site consisting of services routes leading to the existing landfill. These pathways to sensitive receivers are classified as **Very Short/ Direct** towards the landfill extension site, as landfill workers could be the targets during landfill operation, piping/ conduit construction, and/or drilling/boring operation.

7.4.3.2 Outside Landfill Extension Site

Natural pathways

The presence of faults lines in NENT Landfill Extension site are identified as the potential natural pathways for potential LFG migration to the vicinities of sensitive receivers as shown in **Drawing No. 24315/13/501**. Fault 4 is the nearest fault line to Tong To Shan Tsuen at a distance of ~280m which is classified as "**Long/Indirect**" pathway extending from the northern bound of the future landfill extension site. Mitigation measures will include installation of proper liner to act as barriers and sealing of fault line ends to prevent off-site LFG migration.

Man-made pathways

Although there are man-made pathways in the vicinity of the site consisting of services routes leading to the existing landfill, they are far from sensitive receivers and are classified as **Long/ Indirect** towards the adjacent occupied development.

7.4.4 Receivers

7.4.4.1 Within Landfill Extension Site

Potential receivers sensitive to LFG hazards associated with the NENT Landfill Extension include the workers and staff of NENT Landfill Extension site:

Construction Phase

- Excavation for construction of new landfill bowl;
- Deep unventilated excavations e.g. pile shafts, trenches for utility installation and basement excavations; and
- Outbuildings, sheds and temporary structures such as construction site offices.

These receivers are categorised as **High Sensitivity** according to the LFG Guidance Note.

Operation, Restoration and Aftercare Phases

- Services ducts or other confined spaces at basements or ground floor levels;
- External manholes, inspection chambers, ducts or other accessible enclosed spaces under the ground;

- Waste Reception Area of the existing NENT Landfill; and

These receivers are categorised as **High Sensitivity**.

7.4.4.2 Outside Landfill Extension Site

The original consultation zone of the existing NENT Landfill is shown in **Drawing No. 24315/13/502**. It is overlaid with the proposed new demarcation of a 250m consultation zone corresponding to the latest footprint of NENT Landfill Extension site area. In general, the land area encroached by the new consultation zone of the landfill extension site is a steep hilly terrain. The landuse of the area is not defined and the demarcation of consultation zone will impose constraints on any future developments.

According to the Wo Keng Shan Outline Zoning Plan (OZP) S/NE-WKS/7 (draft amendment) extracted from the "Statutory Planning Portal" of Planning Department (PlanD) website at http://www.ozp.tpb.gov.hk/default.aspx, the planned landuse to the south of the landfill extension site consists mainly of "Green Belt" with minor area for "Agriculture" and "Village Type Development" with the landuse governed by the Town Planning Ordinance:

Green Belt

Use always permitted

- Agricultural use; barbecue spot; government use (police reporting centre only); nature reserve; nature trail; on-farm domestic structure; picnic area; public convenience; tent camping ground; wild animal protection area.

Use that may be permitted with/without conditions on application to Town Planning Board

- Animal boarding establishment; broadcasting, television and/or film studio; columbarium (within a religious institution or extension of existing columbarium only); field study/ education/ visitor centre; government refuse collection point; government use (not elsewhere specified); helicopter landing pad; holiday camp; house (New Territories exempted house only, other than rebuilding of NT exempted house or replacement of existing domestic building by NT exempted house permitted under the covering notes); petrol filling station; place of recreation, sports or culture; public transport terminus or station; public utility installation; public vehicle park (excluding container vehicle); radar, telecommunications electronic microwave repeater, television and/or radio transmitter installation; religious institution; residential institution; school; service reservoir; social welfare facility; utility installation for private project.

Agriculture

Use always permitted

- Agricultural use; government use (police reporting centre only); on-farm domestic structure; public convenience; religious institution (ancestral hall only); rural committee/village office.

Use that may be permitted with/without conditions on application to Town Planning Board

- Animal boarding establishment; barbecue spot; field study/ education/ visitor centre; government refuse collection point; government use (not elsewhere specified); house (New Territories exempted house only, other than rebuilding of NT exempted house or replacement of existing domestic building by NT exempted house permitted under the covering notes); picnic area; place of recreation, sports or culture (horse riding school, hobby farm, fishing ground only); public utility installation; religious institution (not elsewhere specified); school; utility installation for private project.

Village Type Development

Use always permitted

- Agricultural use; government use (police reporting centre, post office only); house (New Territories exempted house only); on-farm domestic structure; religious institution (ancestral hall only); rural committee/village office.

Use that may be permitted with/without conditions on application to Town Planning Board

- Eating place; government refuse collection point; government use (not elsewhere specified); house (not elsewhere specified); institutional use (not elsewhere specified); place of recreation, sports or culture; public picnic; public convenience; public transport terminus or station; public utility installation; public vehicle park (excluding container vehicle); religious institution (not elsewhere specified); residential institution; school; shop and services; social welfare facility; utility installation for private project.

The northern part of the consultation zone of NENT Landfill Extension site falls within the Tong To Shan Archaeological Site which also imposes restrictions on any proposed development/ re-developments.

All existing and future planned developments within the newly proposed 250m consultation zone will be the potential targets prone to the risk of LFG migration. As of the submission of this EIA Report, there were no identified proposed/ planned new developments or re-developments within this boundary.

A detailed site survey has revealed 2 nearest LFG receivers outside the NENT Landfill extension site including LFG1 (Wo Keng Shan Tsuen) and LFG2 (Tong To Shan Tsuen), as depicted in **Drawing No. 24315/13/502**. LFG1 lies within the original 250m consultation zone of NENT Landfill site (at ~100m from the landfill site boundary). It is therefore categorised under "**High Sensitivity**".

LFG2 is a village house marginally outside the proposed new demarcation of 250m consultation zone corresponding to the latest footprint of NENT Landfill extension site area (at ~270m from the landfill extension site boundary). Although it is currently abandoned and unoccupied, it will be prudent to pay due attention to the implementation of all necessary protective measures if LFG2 were occupied in future.

7.4.5 Qualitative Risk Assessment

With all the information regarding the sources, pathways and receivers identified in the previous sections, a qualitative risk assessment of LFG hazards is summarised in Table 7.5 based on the criteria in stipulated in Table 7.1. According to the LFG Guidance Note, for the purposes of categorising the site at the planning stage, the category is based upon the highest level of risk nominated for any of the potential impacts identified.

The overall risk level of LFG hazards to receivers within the landfill extension site is categorised as '**High**' (Category B). Significant engineering measures will be required to protect the planned development and activities within. Active gas control system supported by gas barriers and monitoring systems will be required for Category B risk level.

The overall risk level of LFG hazards to receivers outside the landfill extension site is categorised as '**Medium**' (Category C). Adequate engineering measures will be required to protect the proposed development. The use of 'semi-active' or enhanced passive gas controls and detection system (in some situations) will be required for Category C risk level.

Table 7.5: Qualitative risk assessment of LFG hazards associated with NENT Landfill Extension

Source	Pathway	Receiver Sensitivity	Risk
Within NENT Landfill Extension Site			
LFG from existing NENT Landfill and NENT Landfill Extension : Medium	Natural (faults): Very Short/ Direct	Excavation works during construction and landfill operation: High	High
	Man-made (services routes): Very Short/ Direct	Excavation works during construction and landfill operation: High	High
Outside NENT Landfill Extension Site			
From future NENT Landfill Extension : Medium	Natural (faults): Long/ Indirect	Adjacent residents: High	Medium
	Man-made (services routes): Long/ Indirect	Adjacent residents: High	Medium

7.5 Protective and Precautionary Measures

The design of suitable level of precautionary measures and contingency plans for the landfill extension and the potential receivers will be incorporated. Future landfill liner, leachate collection and treatment system, LFG control devices, landfill capping will be designed with reference to the specifications of existing NENT Landfill. An Emergency and Contingency Plan will be devised by the DBO Contractor for implementation of appropriate actions in case any LFG migration detected. Such measures include those currently being adopted in the existing NENT Landfill, e.g. installation of double layer liner, LFG extraction/ collection/treatment/export systems, gas sensors, etc. The protective and precautionary measures proposed would also provide information for the ecological impact assessment on the potential risk on wildlife due to accidental LFG migration.

A comprehensive review of the previous monthly and annual reports of landfill operation for the environmental and operational monitoring data, and operation and incident records of mitigation and protective measures adopted in the existing NENT Landfill (Appendix 7.1) has provided the basis for the following conclusions:

- LFG liner: effective barrier to prevent LFG migration off-site;
- LFG collection and extraction system: effective to convey LFG from buried waste location to treatment and utilisation systems;
- LFG treatment by flaring: effective to convert LFG to harmless CO_2;
- LFG utilisation for power generation: effective to convert LFG to electrical power;
- LFG utilisation at ammonia stripping plant: effective to convert LFG to heat energy for combustion and removal of toxic ammonia; and
- LFG recovery system: effective to deliver LFG off-site for energy source of towngas production.

Based on these review findings, the mitigation and protective measures adopted in the existing NENT Landfill are proposed for the future NENT Landfill Extension site, in consideration of the following key factors:

- The NENT Landfill Extension site has similar geological features to the existing NENT Landfill;

- The NENT Landfill Extension site is anticipated to receive waste of similar nature to the existing NENT Landfill;
- The NENT Landfill Extension site has comparable capacity to the existing NENT Landfill; and
- The existing NENT Landfill operation has demonstrated the capability and success of the implemented mitigation and protective measures as precedent of the NENT Landfill Extension.

In case LFG migration is detected and confirmed, the Emergency and Contingency Plan will be triggered for implementation of the necessary action, which include but not limited to the necessary evacuation of occupants, provision of forced ventilation to the concerned sensitive receiver, investigation of potential source of LFG, increase LFG extraction rate on-site, etc. Details of the procedures will be documented in the Emergency and Contingency Plan.

7.5.1 Within Landfill Extension Site

According to the LFG Guidance Note, engineering measures will be required to protect the planned development with risk category at "**High**" level (Table 7.2). Recommendations for protection and precautionary measures for implementation in NENT Landfill Extension during the various Project phases are discussed as follows.

7.5.1.1 Construction Phase

Special precautions should be taken in all respects of works against the possible presence of LFG due to close proximity of the landfill extension site to the existing NENT Landfill. Potential hazards of exposure to LFG, e.g. ignition, explosion, asphyxiation, toxicity, etc. should be fully aware and alerted.

Prominent LFG safety warning signs should be erected on-site to alert all personnel and visitors of the hazards during excavation works. No smoking or burning should be permitted on-site in the working area, and prominent 'No smoking' and 'No Naked Flames' signs should be erected on-site where appropriate. No worker should be allowed to work alone at any time in excavated trenches or confined areas on-site.

Adequate fire fighting equipment should be provided on-site. Construction equipment should be equipped with a vertical exhaust at least 0.6m above ground installed with spark arrestors. Electrical motors and extension cords should be explosion-proof and intrinsically safe when being used on-site.

'Permit to Work' system should be implemented in accordance with the guidance on entry into confined spaces provided in 'Code of Practice on Safety and Health at Work in Confined Spaces' issued by Labour Department of HKSAR Government. Welding, flame-cutting or other hot works should be conducted only under 'Permit to Work' system following clear safety requirements, gas monitoring procedures and in the presence of qualified persons to oversee the works.

For piping assembly or conduit construction, all valves and seals should be closed immediately after installation to avoid accumulation and migration of LFG. If installation of large diameter pipes (diameter >600mm) is required, the pipe ends should be sealed on one side during installation. Forced ventilation is required prior to operation of the installed pipeline. Forced ventilation should also be required for works inside trenches deeper than 1m.

The frequency and location of LFG monitoring within the excavation area should be determined prior to commencement of works. LFG monitoring in excavations should be conducted at no more than 10mm from the exposed ground surface. For excavation works, LFG monitoring should be conducted (1) at ground surface prior to excavation, (2)

immediately before workers entering excavations, (3) at the beginning of each half-day work, and (4) periodically throughout the working day when workers are in the excavation. Any cracks on ground level encountered on-site should be monitored for LFG periodically. Appropriate action should be taken in accordance with the action plan shown in Table 7.6.

LFG precautionary measures involved in excavation and piping works should be provided in accordance with the LFG Guidance Note and included in the Safety Plan for the construction phase of the Project. Temporary offices or buildings should be located where free LFG has been proven or raised clear of ground at a separation distance of at least 500mm.

For large development such as NENT Landfill Extension, a Safety Officer trained in the use of gas detection equipment and landfill gas-related hazards should be present on-site throughout the groundwork phase. The Safety Officer should be provided with an intrinsically safe portable instrument appropriately calibrated and capable of measuring the following gases:

- Methane (CH_4) 0-100% Lower Explosion Limit (LEL) and 0-100% v/v;
- CO_2 0-100%; and
- O_2 0-21%

Periodically during groundwork construction, CH_4, CO_2 and O_2 should be monitored in the works area by using appropriately calibrated portable gas detection equipment. The monitoring frequency and areas to be monitored should be set down prior to commencement of groundwork either by the Safety Officer or by an appropriately qualified person. Routine monitoring should be carried out at all excavations, manholes and chambers and any other confined spaces that may have been created by the temporary storage of building materials on-site. All measurements in excavations should be made with the monitoring tube located not more than 10mm from the exposed ground surface.

For excavations deeper than 1m, measurements should be conducted:

- At ground surface before excavation commences;
- Immediately before any worker enters the excavation;
- At the beginning of each working day for the entire period the excavation remains open; and
- Periodically throughout the working day whilst workers are in the excavation.

For excavations between 300mm and 1m, measurements should be conducted:

- Directly after the exvation has been completed; and
- Periodically whilst the excavation remains open.

For excavations less than 300mm, monitoring may be omitted at the discretion of the Safety Officer or other appropriately qualified person.

Table 7.6: Action plan for LFG monitoring during construction phase

Parameter	Monitoring Result	Action
O_2	<19%	Ventilate trench/ void to restore O_2 level to >19%
	<18%	Stop works, evacuate personnel/ prohibit entry, and increase ventilation to restore O_2 level to >19%
CH_4	>10% LEL*	Post 'No smoking' signs, prohibit hot works, and ventilate to attenuate CH_4 level to <10% LEL
	>20% LEL	Stop works, evacuate personnel/ prohibit entry, and ventilate to attenuate CH_4 level to <10% LEL
CO_2	>0.5%	Ventilate to attenuate CO_2 level to <0.5%

Parameter	Monitoring Result	Action
	>1.5%	Stop works, evacuate personnel/ prohibit entry, and ventilate to attenuate CO_2 level to <0.5%

* LEL: Lower Explosion Limit

7.5.1.2 Operation, Restoration and Aftercare Phases

Where any service voids, manholes and inspection chambers within the landfill extension site are entered for maintenance and LFG monitoring, all the safety requirements in accordance with the 'Code of Practice on Safety and Health at Work in Confined Spaces' issued by Labour Department of HKSAR Government should be strictly followed.

Buildings onsite should be incorporated with passive system relying on natural air movement to prevent gas build-up and active system requiring energy input to mechanically move air to protect against LFG build-up. Design measures for sub-surface building services should include generic measures such as gas barriers, gas vents and strategic routing of any service utilities away from the potential LFG migration pathways.

Any new-built permanent building structures within the landfill extension site, forced ventilation and gas detection system with audible alarm should be installed. When the internal atmosphere is detected with >10% of CH_4, forced ventilation should be triggered automatically. No person should be allowed to enter or remain in any confined areas when CO_2 levels >1.5%/v or O_2 levels <18%/v is detected. Access to confined spaces in the landfill extension site should be controlled to only authorised persons.

Specific types of gas protection measures which can be applied to building services have been provided in accordance with the LFG Guidance Note as included in Appendix 7.2. They generally include gas barriers, gas vents, location of service entries above ground, and service conduits passing through consultation zone.

7.5.2 Outside Landfill Extension Site

The administrative control on development adjacent to the future NENT Landfill Extension site shall be defined by the 250m consultation zone, which is a line running parallel to and 250m away from the edge of the landfill site boundary. If a proposed development or re-development is to be located within the future 250m consultation zone of NENT Landfill Extension site, the project proponent will be required to conduct an LFG hazard assessment and submit the assessment report to the EPD for consultation and vetting in accordance with ProPECC PN 3/96 and LFG Guidance Note. The project proponent should:

- Carry out an LFG hazard assessment to evaluate the degree of risk associate with the proposed development;
- Design suitable precautionary/ protection measures to render the proposed development as safe as reasonably practicable;
- Ensure that the precautionary/ protection measures to be fully implemented according to the design; and
- Establish a maintenance and monitoring programme to ensure the continued performance of implemented protection measures.

Based on the latest design, a preliminary 250m consultation zone is proposed as depicted in **Drawing No. 24315/13/502**. The final demarcation of this zone should be updated for the LFG Guidance Note with respect to the final footprint of NENT Landfill Extension. This 250m consultation zone acts as a precautionary measure, within which any development or re-development projects falling in whole or in part should give attention to the procedures, requirements and guidelines so that potential hazards associated with LFG for the proposed development can be minimised or avoided at an early stage.

As illustrated in **Drawing No. 24315/13/502**, the extension of the consultation zone will attribute to the additional encroachment of totally ~15 ha of land to the north within the steep hilly terrain near Tong To Shan Archaeological Site and south bound of the landfill extension site near Wo Keng Shan Tsuen. However, these areas are imposed with various extent of development contraints, e.g. their landuse not yet being defined, low development potential due to steep hill slopes and terrain, as part of the Tong To Shan Archaeological Site, etc. The anticipated LFG mitigation and protective measures required for any new developments or re-developments in the extended consultation zone will be similar to those within the original area. Protective measures required will be dependent on the location, distance, landuse, etc relative to the NENT Landfill Extension site. Possible gas protection measures that may be applied to new development in accordance with the LFG Guidance Note are summarised below :

General Protection Measures

Passive systems

The most common way of preventing gas from entering an area of ground is to set a "gas barrier" into the ground which is either keyed into low permeability strata or extended at least 1m below the lowest groundwater level.

The presence of a gas barrier to the movement of gas may lead to a gradual build up of gas on the landfill side of the barrier if the gas migration pathway is covered by low permeability materials. To relieve the potential build up of gas, it may be necessary to install additional measures for venting the gas such as trenches filled with no-fines, granular material, e.g. gravel, connected to venting pipes which will provide a preferential pathway for the release of gas to atmosphere.

Active systems

Active systems for preventing gas entering an area of land usually comprise a series of vertical wells arranged in a line across the route of gas migration. By applying suction to the wells, gas is drawn out of the ground and gas which is migrating horizontally not employed, unless there are substantial volume of gas migrating through the ground.

Gas monitoring

With either passive or active systems, it is usual to install monitoring wells into the ground on the development side of the barrier or extraction wells. These are used to measure the concentrations of CH_4 and CO_2 within the ground and hence determine the effectiveness of the measures in preventing LFG migration.

Building Protection Design Measures

Passive systems

- Gas-resistant polymeric membranes which can be incorporated into the floor or wall construction as a continuous sealed layer. Membranes should be able to demonstrate low gas permeability and resistant to possible chemical attack and may incorporate aluminum wafers to improve performance.
- Other building materials, e.g. dense well-compacted concrete or steel shuttering which provide a measure of resistance to gas permeation.
- Creation of a clear void under the structure which is ventilated by natural structure and provide preferential pathways for release of gas.
- Synthetic composite geotextile which provide a free-venting cellular structure and provide preferential pathways for release of gas.

Passive control measures may be used in low and medium risk situations where gas emissions are expected to be at relatively low rates and concentrations and venting to

atmosphere is unlikely to cause a hazard or nuisance due to the low concentration or high dilution which will occur.

Active systems

- A void under the structure like passive control, but it is continuously ventilated by a fan such that any emissions of gas from the ground are mixed and diluted in the air flow before discharge to atmosphere. The rate of ventilation is usually expressed in terms of the volume of air changes (volume of void) per hour and is designed to ensure that, based on the estimated rate at which gas will enter the void, the LFG will be diluted to safe concentrations. Discharge to atmosphere usually takes place above eaves level of the building.
- Construction of a granular layer incorporating perforated collector pipes which is continually ventilated by a fan, such that any emissions of gas from the ground are drawn towards the end of the pipes and diluted in the air flow before discharge to atmosphere above the eaves level of the building.
- Creation of a positive pressure zone below the building structure by injection of migrated LFG into the granular layer.
- Creation of positive air pressure zones within building structures to counteract possible LFG migration into the building from the ground.

Active control measures should be used in conjunction with passive barriers, e.g. membranes in floors, in order that there is no migration of air / gas flow through a floor or wall into a structure. Gas detection systems should also be used to monitor gas in extracted air flow, and to monitor internal spaces inside buildings. Active systems are normally required for high risk sites where gas has been measured in the ground at or close to the development site, and buildings are close to the source of gas.

Gas detection system

- A series of sensors located in appropriate positions within a structure where gas has the potential to accumulate, e.g. near service entries, inside ventilation basements, cupboards or ducts. The sensors detect flammable gas by catalytic oxidation or infra-red principles, and pass data back to a control panel by electrical cabling. The control panel can be set to have two triggers activating alarms and may also be linked by wirless telemetry or internet off-site.
- A series of sampling tubes which are located in appropriate positions and run back to a single measurement station operating on infra-red measurment principles. A pump automatically draws samples of air/gas along each tube in a pre-set pattern such that measuremens of flammable and/or other gases (e.g. CO_2) can be taken at regular and frequent intervals. Triggers, alarms, wireless telemetry and internet systems can be incorporated.
- Manual monitoring can be conducted using a range of portable instruments. Instruments used in areas where flammable gas may be present should be intrinsically safe.

Gas detection system should only be proposed where there is an organisation involved n the long-term use of the development which can be relied upon to maintain and calibrate the system on a regular basis. Where a detection system is used as a final defence, it must be ensured that appropriate emergency action, to be taken in the event of the trigger levels being exceeded, are specified explicitly in an Emergency and Contingency Plan.

Maintenance of control measures

Fundamental to the success of gas protection measures is the means by which they are monitored, managed and maintained, and thus all designs must be accompanied by a

statement or set of procedures showing how the measures proposed can be confidently expected to operate satisfactorily for the duration of the potential gas-producing lifetime of the landfill.

Design Measures for Sub-surface Building Services

Generic Protection Measures

- As for barriers used to prevent movement of gas through the ground, use may be made of clay (or clay-rich soils), bentonite or polymeric membranes (e.g. HDPE). A gas barrier used to prevent movement of gas through services may form part of a more extensive barrier to prevent general mitigation towards the development. In the case of water pipes and sewers which are not always fully filled, water traps e.g. U-bends, should be provided to effectively seal off the conduit and prevent gas-phase transport.
- Vent pipes or gridded manhole covers may be used to avoid build-up of gas in underground utilities manholes. Venting stacks may be built into inspection chambers or connected to collection pipes within high permeability drainage layers adjacent to gas barriers. Under all circumstances, care should be taken in accessing any manhole chambers especially those which are not fitted with vents and necessary safety procedures must be followed.
- In some cases it is possible to route service entries into a building above ground level, therby providing a discontinuity in the gas migration pathway and thus eliminating the risk of gas entry to the building interior.

Services Conduits Passing through Consultation Zone

- For all service runs, the aim should be to provide a protection barrier located at the point where the trenches passes through the perimeter of the consultation zone.
- The service run through the consultation zone may remain "unprotected" since the risks will be minimised by the protection measures installed at the perimeter of the consultation zone and as the general public may not have access to such underground features.
- The service run should be designated as a "special route" and the utility companies should be informed to that effect so that they may implement precautionary measures.
- Any future works e.g. maintenance or extension should be subject to the recommendations specified in the LFG guidance Note.
- Any above ground (minor) termination features e.g. telecom cabinets should be considered to be "buildings" and should be protected by e.g. membrane barriers to minimise the possibility of gas ingress.

Guidance for Entry into Manholes and Chambers

- Any chamber, manhole or culvert which is large enough to permit access to personnel should be subject to entry safety procedures. Such work in confined spaces is controlled by the Factory and Industrial Undertakings (F&IU) (Confined Spaces) Regulations of the F&IU Ordinance. The key issues with regards to the confined spaces which are at risk of LFG build-up have been addressed in section 7.5.1.1 above.

Further details of these measures have been provided in the LFG Guidance Note.

7.6 Monitoring Requirement

LFG monitoring should be conducted in various phases of NENT Landfill Extension with the following key objectives:

- To ensure the safety and health of workers during the construction stage of landfill extension.
- To determine the performance and effectiveness of LFG mitigation measures and control systems on preventing uncontrolled LFG migration.
- To establish a monitoring regime for buildings within the landfill site services routes and other enclosed areas as a warning system for detection of any potential build-up of hazardous LFG concentrations.
- To ascertain the characteristics of the landfill and estimate the quantity and quality of the LFG production in order to assess the potential for future utilisation.

The LFG monitoring programme of the existing NENT Landfill including the monitoring frequency and location was reviewed to suit the future landfill extension. Detailed LFG monitoring requirements will be established in the EM&A Manual for NENT Landfill Extension including the specifications of monitoring locations, parameters, equipment, procedures, frequency, reporting format, Action and Limit (A/L) Levels, Event and Action Plan (EAP), and Emergency and Contingency Plan, etc. With reference to the monitoring data of the existing landfill operation, monitoring for a suite of LFG parameters will be continued, including:

- Surface gas: CH_4, CO_2, O_2;
- Monitoring holes: Pressure, methane, carbon dioxide, oxygen, flammable gas;
- Well head: Pressure, oxygen, methane, carbon dioxide, flammable gas, volatile organic compounds (VOCs);

As mentioned in Table 7.4, the continuous 'false' exceedances of CO_2 levels measured at some boreholes due to natural sources as reported in the monthly reports should be fully addressed in the future LMP for NENT Landfill Extension. **Drawing No. 24315/13/503** illustrates the monitoring results of background CO_2 levels at 25 boreholes constructed in the ground investigation. As elevated background CO_2 levels were noticeable at certain locations within the landfill extension site, it would be prudent to rationalise the Action and Limit Levels with reference to these geographical/ geological variations of CO_2 levels.

The LFG monitoring locations of the existing NENT Landfill site is shown in **Drawing No. 24315/13/504**. The proposed tentative monitoring locations for the future NENT Landfill Extension site are also shown in **Drawing No. 24315/13/504**, which are subject to changes depending on the design and modification by the DBO Contractor.

In general, the LFG monitoring programme should include on-site and off-site monitoring for the above parameters at frequency specified in the future LMP. Similar to that being practised in the existing NENT Landfill, on-site and off-site monitoring for LFG should be conducted including:

- Quantity and quality of extracted LFG at individual well head;
- Quantity of LFG automatically monitored at LFG pumping station;
- Fixed surface and borehole locations along the landfill site boundary and at potential sources of concern;
- Monitoring safe level of LFG concentration, and implementation of sufficient mitigation measures when entering confined spaces within the landfill site.

- Off-site monitoring for LFG at highly sensitive receivers, e.g. LFG1 Wo Keng Shan Tsuen and LFG2 Tong To Shan (if occupied); and
- Detailed requirements of LFG monitoring shall be defined in the EM&A Manual and LMP.

The measured LFG results will be checked for compliance against the pre-defined A/L Levels established in the EM&A Manual and in the Landfill Monitoring Plan developed by the DBO Contractor. In case exceedance of compliance level is detected at any locations, the EAP will be triggered for necessary action to be taken.

If abnormally high LFG level is detected at any off-site sensitive receivers, the Emergency and Contingency Plan will be strictly followed to trigger the planned action without delay, which may include but not limited to the evacuation of occupants, provision of forced ventilation to the concerned sensitive receiver, investigation of potential source of LFG, increase LFG extraction rate on-site to minimise migration etc. Details of the procedures will be documented in the Emergency and Contingency Plan.

7.7 Implication of IWMF Implementation

If the 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. The LFG generation potential, hence its associated risk to nearby environment, would be anticipated to reduce accordingly.

7.8 Conclusion

The results of this qualitative risk assessment for LFG hazards associated with the construction, operation, restoration and aftercare phases indicate that the overall risks to the receivers within the NENT Landfill Extension would be categorised as 'High' and that to the receivers outside the NENT Landfill Extension would be 'Medium'. The sensitive receivers falling within the newly proposed 250m consultation zone shall be prone to LFG potential risk and appropriate protective and precautionary measures including engineering design and monitoring programme have been proposed to reduce such risk to acceptable levels. With these measures in place, no adverse impact would be anticipated.