10 Landfill Gas Hazard

10.1 Overview

This section gives a brief description of relevant legislation and guidelines for Landfill Gas (LFG) hazard assessment. Ma Tso Lung Landfill (MTLL, close to KTN NDA) is located near the proposed KTN NDA; as shown in **Figure 10.1**.

MTLL is situated in the vicinity of the KTN NDA. A portion of the KTN development falls within the 250m Consultation Zone. A qualitative risk assessment is conducted with landfill gas precautionary/protection design recommenced.

The landfill gas hazard assessment has been conducted in accordance with the requirements of Annexes 7 and 19 of the TM-EIAO as well as the requirements set out under Clause 3.4.11 of the EIA Study Brief.

10.2 Environmental Legislation, Standards and Guidelines

10.2.1 Criteria and Guidelines

The relevant legislations, standards and guidelines applicable to the present study for the assessment of LFG hazards include:

- Section 1.1(f) in Annex 7 of the EIA Technical Memorandum (TM);
- Section 3.3 in Annex 19 of the EIA TM;
- Landfill Gas Hazard Assessment Guidance Note (1997) (EPD/TR8/97); and
- Landfill Gas Hazard Assessment for Development Adjacent to Landfills (ProPECC PN 3/96).

These legislation and guidelines recommend that in general, a qualitative assessment of the risk posed by LFG will be required for a development within the 250m Consultation Zone of a landfill site, to ensure appropriate precautionary measures would be designed and implemented to safeguard the development. For particular sensitive developments and / or where the development is particularly close to the landfill site, it may be necessary to undertake a quantitative risk assessment (QRA). The requirement for a QRA is usually identified during the qualitative assessment.

The KTN NDA developments will encroach into part of the MTLL 250m Consultation Zone. Hence, a qualitative risk assessment is needed for the safety of the developments.

10.2.2 Scope of the Assessment

In accordance with the procedures recommended in Landfill Gas Hazard Assessment Guidance Note, the following tasks have been undertaken to allow a full consideration of the potential risk of LFG from the MTLL to KTN NDA:

- Review of background information (including landfill gas monitoring data, if any) and studies related to the MTLL;
- Identification of the nature and extent of the sources, including the likely concentrations and / or amounts of hazardous emissions which might have the potential impacts on the Project;
- Identification of possible pathways through the ground, underground cavities, utilities or groundwater, and the nature of these pathways through which hazardous emissions must traverse if they are to reach the development;
- Review of design of the proposed developments within the 250m Consultation Zone and identification of the potential receivers which are sensitive to the impacts of the hazardous emissions during both construction and operational phases;
- Qualitative assessment on the degree of risk which the hazardous emissions may pose to the developments taking account of each source-pathway-target combination; and
- Design of suitable level of precautionary measures and contingency plan for the Project and the types of protective measures for safe operations, if needed during both construction and operational phases of the proposed NDA developments.

10.3 Description of the Environment

10.3.1 Ma Tso Lung Landfill and KTN

10.3.1.1 Desktop Study

A number of previous studies have been undertaken at, or involving, the MTLL including Planning and Development Study on North East New Territories; the Feasibility Study on Restoration of North-west New Territories Landfills; North-west New Territories Landfills and Gin Drinkers Bay Landfill Restoration – Contract Arrangements; and the EIA of the Restoration Works under Contract No EP/SP/30/95. The documents which have been used as background material for the preparation of this assessment include the following:

- Landfill gas and surface gas monitoring data for the MTLL and background information regarding the restoration works and landfill gas control measures provided by EPD in 2009 and 2013;
- Agreement No. CE 64/96. Planning and Development Study on North East New Territories: Technical Paper 13 – Environmental Impact Assessment, Maunsell Consultants Asia Ltd, June 2003;
- Agreement No. CE 66/94. North-west New Territories Landfills and Gin Drinkers Bay Landfill Restoration: Further Environment Monitoring Review Report, ERM-Hong Kong, November 1999;

- Agreement No. CE 10/92. Restoration of North-west New Territories Landfills: Initial Environmental Impact Assessment Report, Scott Wilson Kirkpatrick Consulting Engineers, April 1995;
- Agreement No. CE 10/92. Restoration of North-west New Territories Landfills: Final Report, Scott Wilson Kirkpatrick Consulting Engineers, August 1995; and
- Hong Kong Geological Survey Sheet 2, Geology of San Tin.

10.3.1.2 Background Information

The MTLL is located approximately 750m north of Pak Shek Au near the Closed Border Area. The landfill site is at the head of a small valley, surrounded on three sides by higher land (except the east side). The whole site is within the Study Area and is next to the proposed development in KTN NDA.

The landfill site occupies an area of about 2 ha and was operated between 1976 and 1979. About 180,000 tones of domestic, industrial and construction wastes were deposited at the site during this period. Restoration of landfill site has been completed in 2000 and the site is currently for recreational use by Tung Wah Group of Hospitals. EPD is currently implementing "Aftercare" of the landfill which includes operating and maintaining the landfill gas management system and environmental monitoring work. The contract period of the Aftercare Phase lasts for 30 years, from June 2000 to May 2030.

As shown in **Figure 10.2**, the development of KTN NDA will encroach within the MTLL and its 250m Consultation Zone. The developments falling within the Consultation Zone include the Standard Swimming Pool and Sports Centre Zone (E1-5), the Residential Zones (A2-2), Educational Zones (E1-2, E1-4, A3-1 and A3-2), Government Zones (E1-3), Amenity Zones (A2-1), Green Belt Zone (H1-1) and vehicular roads, whilst the developments falling within the MTLL include the District Open Space Zone (E1-1) where recreational area is proposed. There will only be minor construction works required in site E1-1 and the landfill restoration facilities within MTLL will remain unaffected.

10.4 Assessment Methodology

10.4.1 Potential Hazards and Properties of LFG

LFG presents a number of potential hazards and has particular properties of note, as follows:

- Methane is odourless, colourless and typically associated with numerous highly odoriferous compounds in LFG which will give some warning of its presence. However, the absence of odour should not be taken to mean that there is no methane – this can only be confirmed by using appropriately calibrated methane detectors. Methane is a flammable gas and will burn when mixed with air between approximately 5% and 15% by volume, the Lower Explosive Limit

(LEL) and Upper Explosive Limit (UEL) respectively. A mixture of methane and air with a composition between the LEL and UEL ignited in a confined space could lead to an explosion. Methane is also an asphyxiant.

- Carbon Dioxide, which is another major component of landfill gas, could induce asphyxia and adverse health effects. The long-term eight hour Occupational Exposure Limit (OEL) is 0.5% by volume. Similar to methane, it is also odourless and colourless and can only be detected using appropriately calibrated detectors.
- Gas Buoyancy: Methane is lighter than air whereas carbon dioxide is heavier than air. Typical mixtures of LFG are likely to have a density close to or equal to that of air. However, site conditions may result in a ratio of methane to carbon dioxide which may make the gas mixture lighter than air or heavier than air. As a result, LFG may be concentrated in the bottoms of trenches or excavations, or may rise up and accumulate beneath structures and foundations.

10.4.2 Assessment Criteria

In accordance with the Guidance Note, the risk due to LFG may be evaluated based upon the following three criteria:

- Source – the rate and concentration of LFG generated by the landfill
- Pathway – the nature and length of potential pathways through which LFG can migrate and leachate flow, such as geological strata, utility services; and
- Target (Receiver sensitivity) – the level of vulnerability of various elements of the developments to LFG.

Each of these criteria is further described below.

SOURCE

The classification of the Source (i.e. the landfill) is determined as follows:

Major: Recently filled landfill site at which there is little or no control to prevent migration of gas or at which the efficacy of the gas control measures has not been assessed; or any landfill site at which monitoring has demonstrated that there is significant migration of gas beyond the site boundary.

Medium: Landfill site at which some form of gas control has been installed (e.g. lined site or one where vents or barriers have been retrospectively installed) but where there are only limited monitoring data to demonstrate its efficacy to prevent migration of gas; or landfill site where comprehensive monitoring has demonstrated that there is no migration of gas beyond the landfill boundary but where the control of gas relies solely on an active gas extraction system or any other single control system which is vulnerable to failure.

Minor: Landfill sites at which gas controls 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 (or any specific control measures) and at which control of gas does not rely solely on an active gas extraction system or any other single control measure which is vulnerable to failure; or old landfill sites where the maximum concentration of methane within the waste, as measured at several locations across the landfill and on at least four occasions over a period of at least 6 months, is less than 5% by volume (v/v).

PATHWAY

Generally, three types of pathway are considered for the transmission of LFG. They are: man made pathways e.g. utility connections, stormwater channels, etc., natural pathways such as rock jointing planes, fissures and other naturally occurring phenomena which may promote or give rise to the transmission of gas over distances and a combination of the previous categories. An example of the latter may be, for instance, where a specific geological feature promotes gas transmission but which stops short of directly linking the landfill and target. A man made connection, however may also co-exist near the edge of the geological feature, which in combination with the former, may act to link the two sites. In this instance, careful assessment of the likelihood of the mechanism acting to link the two pathways needs to be undertaken before assigning an appropriate pathway classification.

The broad classification of a Pathway is as follows:

Very short / direct: Path length of less than 50 m for unsaturated permeable strata and fissured rock or less than 100 m for man-made conduits

Moderately short / direct: Path length of 50 to 100m for unsaturated permeable soil or fissured rock or 100 to 250 m for man-made conduits

Long / indirect: Path length of 100 to 250 m for unsaturated permeable soil and fissured rock

In classifying the pathway, however, adjustment to the above general guidelines will often be required to take account of other factors which will affect the extent of gas migration including the following:

- Particular permeability of the soils;
- spacing, tightness and direction of the fissures/joints;
- topography;
- depth and thickness of the medium through which the gas may migrate (which may be affected by groundwater level);

- the nature of the strata over the potential pathway;
- the number of different media involved; and
- depth to groundwater table and groundwater flow patterns.

TARGET

Different levels of vulnerability or sensitivity of potential Targets for LFG have been classified as follows:

Highly sensitive: Buildings and structures with ground level or below ground rooms / voids or into which services enter directly from the ground and to which members of the general public have unrestricted access or which contain sources for ignition.

This would include any developments where there is a possibility of additional structures being erected directly on the ground on an ad hoc basis and thereby without due regard to the potential risks.

Medium Sensitivity: Other buildings, structures or service voids where there is access only by authorized, well trained personnel, such as the staff of utility companies, who have been briefed on the potential hazards relating to LFG and the specific safety procedures to be followed.

Deep excavations.

Low Sensitivity: Buildings/ structures which are less prone to gas ingress by virture of their design (such as **those** with a raised floor slab).

Shallow excavations.

Developments which involve essentially outdoor activities but where evolution of gas could pose potential problems.

The above examples of different categories within each criteria are to be used as a general guide only and specific aspects of a development may render it more or less sensitive than indicated. Account needs to be taken of any particular circumstances when assigning a target to one of the three indicated categories.

10.4.3 Classification of Risk Category

Following the determination of the categories of source, pathway and target in which the landfill, pathway and development fall, a qualitative assessment of the overall risk is undertaken with reference to **Table 10.1**, which is extracted from EPD's Guidance Note. The potential implications associated with the various qualitative risk categories are summarized in

Table 10.2. It should be noted that the different levels of risk determine the likely extent of the protection measures required to ensure the safety of a development.

Table 10.1 - Classification of risk category

Source	Pathway	Target 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 10.2 - Summary of general categorizations 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

Category	Level of Risk	Implication
		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.

10.5 Qualitative Risk Assessment

10.5.1 Ma Tso Lung Landfill and KTN

10.5.1.1 The Source

LFG Monitoring Results before Restoration

Various site investigations and monitoring programmes have been undertaken between 1993 and 1999 and provided lots of information on the activities of the landfill. A total of eleven drillholes are installed within the waste and around the periphery of the landfill beyond the waste boundary. These were used for the monitoring of off-site migration of LFG and groundwater quality. The monitoring drillholes located on- and off-site at the landfill are shown in **Figure 10.3** and as follows:

On-site drillholes: DH302 and DH303 (The locations were not provided).

Off-site drillholes: DH304, DH305, DH307, DH308, A351, A352, A353, A354 and A356.

High concentrations of methane and carbon dioxide have been observed in the on-site monitoring drillholes DH302 and DH303. At DH302 the highest concentrations of methane and carbon dioxide recorded were 72.1% v/v in October 1998 and 38.7% v/v in February 1997 respectively. The highest concentrations found at DH303 were 74.8% gas methane in September 1998 and 39.5% gas carbon dioxide in February 1997, respectively. This indicates that the landfill was still actively generating LFG.

The monitoring undertaken during this period revealed no methane in the off-site monitoring drillholes DH304, DH305, DH307, DH308, A352, A353, A354 and A356. The only off-site monitoring drillhole where significant methane concentrations have been detected is A351 located immediately adjacent to the southern landfill boundary. The maximum methane concentration found at A351 throughout the monitoring period was 29% v/v in September 1998. The maximum carbon dioxide concentration in drillhole A351 was 5.2% in March 1998.

Elevated concentrations of carbon dioxide were observed in all of the off-site monitoring drillholes, with the highest concentrations ranging from 3.44% gas in September 1998 in monitoring drillhole DH308 to 32.4%

gas in February 1998 in monitoring drillhole DH304. There have been no obvious trends in the gas concentrations recorded in these drillholes.

Restoration Stage

EPD has commissioned Swire SITA Waste Services Limited in 1999 to undertake a Design, Build and Operate (DBO) Contract (North-west New Territories Landfills and Gin Drinkers Bay Landfill Restoration (Contract No EP/SP/30/95)) to restore the Siu Lang Shui, Ma Tso Lung, Ngau Tam Mei and Gin Drinkers Bay Landfills. The restoration works of the MTLL have been completed in 2000. The following restoration works with respect to LFG and leachate control have been undertaken at the MTLL.

- Installation of a new capping system (comprising an impermeable LLDPE liner, sub-soil drains and surface water drainage systems) for the whole landfill site;
- Installation of a passive LFG venting system;
- Installation of a leachate collection and storage system; and
- Installation of new monitoring wells.

The passive venting system which acts as the primary control will minimize the LFG pressure within the landfill and hence reduce the potential for sub-surface off-site migration. A comprehensive LFG monitoring programme which acts as the secondary control has also been implemented to monitor the effectiveness of the passive venting system and provide an early warning of any off-site migration of LFG.

A number of the existing off-site LFG monitoring drillholes (including DH304, DH305, DH307, DH308, A351, A352, A353, A354 and A356) were adopted by the Landfill Restoration Contractor and used to monitor off-site LFG migration under the restoration contract. One off-site drillhole GG1 which is the downstream of the MTL Landfill was also applied for LFG monitoring (**Figure 10.3**). LFG monitoring results during restoration (1999-2000) are summarized in **Table 10.3**.

Table 10.3 - Summary of MTLL LFG monitoring results (April 1999 to June 2000) (1)

Location	Methane (% v/v)			Carbon Dioxide (% v/v) (3)	
	Range	Average	Compliance Level	Range	Average
DH304	<0.01 - 0.19	0.03	1	1.52 - 28.4	11.8
DH305	<0.01	0.01	1	1.43 - 17.1	8.06
DH307	<0.01 - 0.16	0.02	1	3.3 - 13.5	7.07
DH308	<0.01	0.01	1	1.8 - 8.2	3.84
A351	0.14 - 3.8	0.92	15 (2)	0.71 - 5.95	4.00
A352	<0.01 - 0.03	0.01	1	1.92 - 15.8	5.07
A353	<0.01 - 0.04	0.03	1	1.85 - 19.5	9.14
A354	<0.01 - 0.02	0.01	1	2.26 - 6.64	4.99
A356	<0.01 - 0.21	0.07	1	1.89 - 16.2	5.60

Location	Methane (% v/v)			Carbon Dioxide (% v/v) [3]	
	Range	Average	Compliance Level	Range	Average
GG1	<0.01 - 0.24	0.10	-	4.86 - 18.3	10.71

Note:

1. Information was extracted from the Report of Agreement No. CE 64/96 Planning and Development Study on North East New Territories: Technical Paper 13 – Environmental Impact Assessment, Maunsell Consultants Asia Ltd, June 2003
2. Due to high background level
3. There are no standard compliance levels for carbon dioxide. However, as stated in EPD's Guidance Note, it should be assumed that any concentration of carbon dioxide greater than 5% v/v above background levels in any monitoring well outside the landfill's boundary indicates significant migration.

Low concentrations of methane have been observed in all off-site monitoring drillholes. The only drillhole where significant methane concentrations have been detected is A351 located immediately adjacent to the southern landfill boundary. The maximum methane concentration was 3.8% v/v on June 2000, which is nevertheless significantly lower than that before the restoration. This suggested that the restoration measures have been effectively implemented to control gas migration.

The carbon dioxide concentrations detected in off-site drillholes were similar before and after the restoration work. Maximum gas concentration of 28.4% v/v in drillhole DH304 was recorded in June 1999. The average carbon dioxide concentrations in most of the monitoring wells are above 5% v/v.

Recent Monitoring Results (Aftercare Phase)

Table 10.4 - Summary of MTLL methane monitoring results (January 2008 to December 2012) [1]

Location	Methane (% v/v)			Oxygen (% v/v)	
	Range	Average	Compliance Level	Range	Average
DH304	<0.1	<0.1	1	0.1 - 20.0	14.6
DH305	<0.1	<0.1	1	5.4 - 21.0	17.3
DH307	<0.1	<0.1	1	9.7 - 21.2	15.7
DH308	<0.1	<0.1	1	2.1 - 21.0	18.4
A351	<0.1	<0.1	1	3.3 - 21.3	16.7
A352	<0.1	<0.1	1	5.5 - 20.8	13.6
A353	<0.1	<0.1	1	3.1 - 21.0	17.4
A354	<0.1	<0.1	1	1.8 - 20.2	14.5
A356	<0.1	<0.1	1	5.8 - 19.0	15.2
GG1	<0.1	<0.1	1	1.2 - 20.9	13.9

Notes:

1. All information is provided by EPD.

All monitoring data in past five years tally with the compliance level of 1% methane. No exceedance or abnormal data was detected.

Table 10.5 - Summary of MTLL carbon dioxide monitoring results (January 2008 to December 2012) (1)

Location	Carbon Dioxide (% v/v)			
	Range	Average	Background Level	Compliance Level
DH304	<0.1 – 19.3	5.0	32.4	33.9
DH305	<0.1 – 8.7	2.6	20.5	22.0
DH307	<0.1 - 10.0	3.4	13.5	15.0
DH308	<0.1 - 5.3	1.6	8.2	9.7
A351 (2)	0.1 – 8.6	2.4	7.3	8.8
A352	<0.1 – 13.7	6.0	18.6	20.1
A353	<0.1 – 12.7	3.6	19.5	21.0
A354	0.6 – 12.1	5.4	15.1	16.6
A356	2.1 – 7.1	5.1	16.2	17.7
GG1	<0.1 - 15.9	6.1	18.3	19.8

Notes:

1. All information is provided by EPD.
2. Only one data was detected in drillhole A351 (May 2012, 8.6%) above background level.

Most of the recorded carbon dioxide concentrations were at relatively high level (>5% v/v); however, the carbon dioxide background level for each drillhole is very high too and has corresponding to its high compliance level. Only one data detected in drillhole A351 (May 2012, 8.6%) was higher than background level but not exceeded the compliance levels.

As stated in EPD's Guidance Note, any concentration of carbon dioxide greater than 5% v/v above background levels in any monitoring well outside the landfill's boundary indicated significant migration. The MTLL has potential hazards due to one location (A351, 8.6% CO_2) may still has migration despite the concentration of carbon dioxide is not greater than the 5% v/v above background level of. 7.3%.

Based on surface gas monitoring results of 17 sampling points (**Figure 10.4**) from January 2008 to December 2012, no carbon dioxide was detected and oxygen in all tests were 21.0% (v/v), most methane was 0 ppm, while only few points show slightly elevated results at some time (5-30 ppm).

Classification of Source

A passive landfill gas venting system has been installed at the MTLL under the North-west New Territories Landfills and Gin Drinkers Bay Landfill Restoration Contract. Recent LFG monitoring results (**Tables 10.4 and 10.5**) in Aftercare Phase indicated methane concentrations were at very low level (<1% v/v). Although relatively high carbon dioxide concentrations were recorded, due to the high backgrounds and corresponding high compliance levels, only one data was detected above the background levels. The results indicated that there were no serious LFG migration problems; however, migration might still happen at one

location (i.e. A351). According to Paragraph 3.9 and 3.11 of EPD's Landfill Gas Hazard Assessment Guidance Note, the restored MTLL will be classified as a "**Medium**" Source.

It should be noted that the Landfill Restoration Contractor is required to undertake regular LFG monitoring at the off-site monitoring drillholes. The Restoration Contract specified a stringent compliance level of 1% methane (20% LEL) for the off-site monitoring drillholes.

10.5.1.2 The Pathways

General

The potential pathways through which LFG may enter the KTN NDA site are threefold; namely, through transmission along natural pathways such as fissures or joints in rock, man-made pathways such as through permeable backfill in utilities trenches or a combination of both. The likely potential for each mode of transmission are clearly dependent on the geological and hydrogeological conditions which are discussed below.

Natural Pathways - Geology and Hydrogeology

The occurrence of fissures along the Ma Tso Lung fault (**Figure 10.5**), near the south and south-eastern boundary of the landfill may provide a preferential pathway for LFG migration. The faults are thought to be relatively deep and below the permanent groundwater level. Therefore it is expected that it has little effect on the gas migration potential to the proposed development. In addition, there are no direct connection between the landfill and the fault line.

Migration Potential Due to Natural Pathways

The previous sections have examined the geological and hydrogeological settings of the landfill and the area between the landfill and the proposed development. Taking account of the permeability of the strata between the landfill and proposed development, depth and path length of the unsaturated permeable strata, and the location of the Ma Tso Lung fault, it is considered that this natural pathway for LFG migration from the landfill to the proposed developments within the Consultation Zone should be classified as "**moderately short to long**", whilst that to the proposed development within the MTLL should be classified as "**very short/ direct**".

Man-made Pathways

Utility connections to the proposed NDA site have also been considered as potential pathways for the migration of LFG. It is possible that a preferential route for LFG migration may comprise the permeable backfill in which service utilities are installed and following connection to the site, may allow the direct transmission of LFG to the proposed development. However, the proposed utilities which are connected to the proposed developments within the Consultation Zone are about **50m** away from the MTLL. There is no direct connection between the landfill and these utilities. An access road will be built to provide access to the existing road adjacent to the MTLL from Kwu Tung NDA West Road. The access road

will be formed by filling at the junction connecting the existing road. Shallow utilities and road drainage are proposed along the road.

Therefore it is considered that the man-made pathway for LFG migration from the landfill to the proposed development should be classified as "**moderately short to long**".

For the proposed development within the MTLL, since the future utilities to be installed (if any) will pass directly through the landfill, the man-made pathway for the proposed development within MTLL would be considered as "**very short/ direct**".

Combination (Natural plus Man-made Pathways)

The consideration of this potential pathway allows for a combination of migration through natural strata and subsequently, through man-made sources such as utility connections, as the potential means of LFG affecting the proposed developments at the NDA.

This mode of transmission generally requires a series of events to occur in order for gas to potentially affect the developments. The path length for the transmission of gas by a combination of natural and man-made pathways can generally be assumed too much longer than the direct distance between the landfill and the particular receptor in the development within the Consultation Zone, but still consider direct for the development within MTLL.

10.5.1.3 The Targets

LFG related impacts may occur in areas at/below ground at the proposed development in the NDA during both construction and operational phases.

Construction Phase

The works boundary in KTN NDA is shown in **Figure 10.2**. The construction works to be carried out within the Landfill Consultation Zone include the Standard Swimming Pool and Sports Centre Zone (E1-5), Residential Zone (A2-2), Educational Zones (E1-2, A3-1, A3-2 and E1-4), Government Zones (E1-3), Amenity Zones (A2-1), Green Belt Zone (H1-1) and vehicular roads, whilst the construction works to be carried out within the MTLL will include the District Open Space Zone (E1-1) where recreational area is proposed.

Excavation is expected (though only minor excavation works is expected in site E1-1) and the areas of confined space and trenches are especially at certain level of risk to exposure of LFG. Construction staff working in indoor environment (e.g. site office) may also be at risk to exposure of LFG. In view of the close proximity to the MTLL, construction monitoring of landfill gas at confined spaces and trenches, and general precautionary measures are therefore recommended.

Operational Phase

As described above, proposed developments falls in the Consultation Zone include the Standard Swimming Pool and Sports Centre Zone (E1-5), the Residential Zones (A2-2), Educational Zones (E1-2, E1-4, A3-1

and A3-2), Government Zones (E1-3), Amenity Zones (A2-1), Green Belt Zone (H1-1) and vehicular roads, whilst the proposed developments falling within the MTLL include the District Open Space Zone (E1-1) where recreational area is proposed. There will only be minor construction works required in site E1-1 and the landfill restoration facilities within MTLL will remain unaffected.

To minimize the potential landfill gas hazard to the future occupants of the proposed developments, it is recommended that below ground rooms/voids should be avoided as far as practicable in the developments within the Consultation Zone and should totally be avoided in the recreational developments within the MTLL (i.e. Site E1-1). Avoiding below ground rooms/ voids in the developments within the MTLL will also help to prevent interruption to the landfill restoration facilities.

Although detailed design information is not available at this stage, it is recommended that below ground rooms/voids should be avoided as far as practicable in the detailed design stage. To facilitate the assessment of hazards to the various types of uses at, or below ground, they have been initially grouped into either highly, moderately or low sensitivity categories, based on guidance give in the Guidance Note. This involves a consideration of the following elements:

- Intended use and contents;
- Provision and reliability of ventilation;
- Frequency of use;
- The ability to restrict access by the public; and any other features of the design or specifications which may render the area of more or less sensitivity.

Highly Sensitive

For the developments within MTLL, the uses that would likely fall into this category may include: utility pits and structures into which services enters directly from the ground and to which members of general public have unrestricted access or which contain sources of ignition.

For the developments within the Consultation Zone, the uses that would likely fall into this category may include: underground pump room, utility pits and structures with ground level or below ground rooms/void or into which services enters directly from the ground and to which members of general public have unrestricted access or which contain sources of ignition.

Moderate Sensitivity

The uses that would likely fall into this category may include transformer room, pump room, and telephone / cable rooms at ground level where access only by authorized, well trained personnel who have been briefed on the potential hazards relating to LFG and the specific safety procedures to be followed.

Low Sensitivity

The uses likely to fall into this category may include open playground, car park and security post.

10.5.1.4 Source – Pathway – Target Analysis

On the basis of the source, pathways and targets identified above, two source – pathway – target analysis have been undertaken and is presented in **Table 10.6a** (i.e. for the development within the Consultation Zone) and **Table 10.6b** (i.e. for the development within MTLL) according to EPD's assessment framework. The combination of a medium source term, a pathway of moderately short to long distance between the landfill site and the development sites within the Consultation Zone, and a pathway of very short/ direct between the landfill and the development site within MTLL, results in a range of overall risks depending on the sensitivity of the particular targets.

Table 10.6a indicates the overall risk level of LFG hazards to various targets (receivers) in Construction and Operational Phases within the Consultation Zone is categorized as "Low" (Category D) to "High" (Category B). Similarly, **Table 10.6b** also indicates the overall risk level of LFG hazards to various targets (receivers) in Construction and Operational Phases within MTLL is categorized as "Low" (Category D) to "High" (Category B). According to **Table 10.2**, some precautionary measures will be required for Category D, engineering measures will be required for Category C, and Significant engineering measures will be required for Category B.

Table 10.6a - Qualitative assessment of LFG hazard to the proposed developments within the Consultation Zone

Source	Pathway	Target	Hazard
Ma Tso Lung Landfill A passive LFG venting system has been installed at the MTLL under the Restoration Contract. A comprehensive LFG monitoring programme is being conducted under the Landfill Restoration Contract to provide an early warming and carry out mitigation measures if in case any significant migration of LFG is detected. LFG monitoring results in past five years in MTLL have indicated methane concentrations were at very low level and only one data of carbon dioxide concentration was above the background levels. According to Para 3.10 of EPD's Guidance Note, "any concentration of methane or carbon dioxide greater than 5% v/v above background levels in any monitoring well outside the landfill's boundary indicates significant migration", as a conservative approach for the hazard assessment, the restored MTLL will be classified as a "**Medium**" source. (**Medium source)**	Natural Pathway The proposed development in KTN NDA is close to the south-east of the MTLL. A fault line is present at the south-eastern boundary of the landfill and about 140 m to the south of the landfill. However, there are no direct connections between the fault line and the proposed development within the Consultation Zone. In addition, the fault line is thought to be relatively deep and below the permanent groundwater level. It is expected it will have little effect on the gas migration potential to the proposed development within the Consultation Zone. (**Moderate short/direct**) Man-made Pathway There is no extensive existing under ground utility structures within the Consultation Zone. A telecommunication cable can be found along the northern boundary of the existing community sports centre. The proposed underground utilities which will connect to the proposed development in the NDA within the Consultation Zone includes water mains, power and telecommunication cables. These utilities are running parallel to Kwu Tung NDA West Road and are about 50m away from the landfill. An access road will be built to re-provide access to the existing road adjacent to the MTLL from Kwu Tung NDA West Road. The access road will be formed by filling at the junction connecting the existing road. Shallow utilities and road drainage are proposed along the road. (**Moderate short/direct**) Combination of Natural and Man-made Pathways The combination of natural and man-made pathway may allow potential gas migration to the proposed developments at the NDA. However, this mode of transmission generally requires a series of events to occur in order for gas to potentially affect the developments. (**Moderate short/direct**)	Construction Phase ***Medium Sensitivity*** The construction works to be carried out within the Landfill Consultation Zone include the Standard Swimming Pool and Sports Centre Zone (E1-5), Residential Zone (A2-2), Educational Zones (E1-2, A3-1, A3-2 and E1-4), Government Zones (E1-3), Amenity Zones (A2-1), Green Belt Zone (H1-1) and vehicular roads. Excavation is expected and the areas of confined space and trenches are especially at a higher risk to exposure of LFG. Construction staff working in indoor environment (e.g. site office) may also at risk to exposure of LFG. Nevertheless, during the construction phase all of these development sites would only be accessible by authorised, well trained personnel who would have been briefed on the potential hazards relating to landfill gas and the specific safety procedures to be followed. As such, the risk level of the development sites during the construction phase is considered as Medium Sensitive. Operational Phase ***Highly Sensitive*** The uses that would likely fall into this category may include: underground pump room, utility pits and structures with ground level or below ground rooms/void or into which services enters directly from the ground and to which members of general public have unrestricted access or which contain sources of ignition.	Medium High

Source	Pathway	Target	Hazard
		Medium Sensitivity The uses that would likely fall into this category may include transformer room, pump room, and telephone / cable rooms at ground level where access only by authorized, well trained personnel who have been briefed on the potential hazards relating to LFG and the specific safety procedures to be followed. ***Low Sensitivity*** The uses likely to fall into this category may include open playground, car park and security post.	Medium Low

Table 10.6b - Qualitative assessment of LFG hazard to the proposed developments within MTLL

Source	Pathway	Target	Hazard
Ma Tso Lung Landfill A passive LFG venting system has been installed at the MTLL under the Restoration Contract. A comprehensive LFG monitoring programme is being conducted under the Landfill Restoration Contract to provide an early warming and carry out mitigation measures if in case any significant migration of LFG is detected. LFG monitoring results in past five years in MTLL have indicated methane concentrations were at very low level and only one data of carbon dioxide concentration was above the background levels. According to Para 3.10 of EPD's Guidance Note, "any concentration of methane or carbon dioxide greater than 5% v/v above background levels in any monitoring well outside the landfill's boundary indicates significant migration", as a conservative approach for the hazard assessment, the restored MTLL will be classified as a "**Medium**" source. (**Medium source)**	Natural Pathway For the proposed development within MTLL, since it is located directly above the landfill, a certain degree of gas migration potential to the proposed development would be expected. **(Very short/ direct)** Man-made Pathway For the proposed development within the MTLL, the future utilities to be installed (if any) are likely to be connected directly to the landfill. **(Very short/ direct)** Combination of Natural and Man-made Pathways The combination of natural and man-made pathway may allow potential gas migration to the proposed developments within MTLL. However, this mode of transmission generally requires a series of events to occur in order for gas to potentially affect the developments. (**Very short/ direct**)	Construction Phase ***Medium Sensitivity*** The construction works to be carried out within the MTLL will include the District Open Space Zone (E1-1) where recreational area is proposed. Minor excavation is expected and the areas of confined space and trenches are especially at a higher risk to exposure of LFG. Construction staff working in indoor environment (e.g. site office) may also at risk to exposure of LFG. Nevertheless, during the construction phase the development site would only be accessible by authorised, well trained personnel who would have been briefed on the potential hazards relating to landfill gas and the specific safety procedures to be followed. As such, the risk level of the development site during the construction phase is considered as Medium Sensitive. Operational Phase ***Highly Sensitive*** The uses that would likely fall into this category may include: utility pits and structures into which services enters directly from the ground and to which members of general public have unrestricted access or which contain sources of ignition. ***Medium Sensitivity*** The uses that would likely fall into this category may include transformer room, pump room, and telephone / cable rooms at ground level where access only by authorized, well trained personnel who have been briefed on the potential hazards relating to LFG and the specific safety procedures to be followed. ***Low Sensitivity*** The uses likely to fall into this category may include open playground, car park and security post.	Medium High Medium Low

10.6 Protective and Precautionary Measures

10.6.1 Introduction

The qualitative landfill gas hazard assessment undertaken in **Section 10.5.1** has concluded that the level of risk for KTN development within Consultation Zone during the construction phase is "Medium" and during operational phase is 'Low' to 'High' depending upon the location and nature of the target being considered. Similarly, the level of risk for the developments within MTLL during the construction phase is also "Medium" and during operational phase is 'Low' to 'High' depending upon the location and nature of the target being considered.

This section provides general advice and recommendations for the avoidance of environmental impacts related to LFG during the construction and operational phase. A detailed qualitative LFG hazard assessment (QLFGHA) should be carried out by individual developer during the detailed design stage (such requirement could be included in the lease condition by Lands D) in accordance with the Guidance Notes for Landfill Gas Hazard Assessment. Where applicable, specific measures for handling the hazards identified during the operational phases should be addressed to further reduce the likelihood of incidents and increase the level of safety to the public. These measures should be reviewed taking into account the findings of the detailed QLFGHA to be undertaken by the developers during the detailed design stage as mentioned above.

In addition, the design, construction and operation of the proposed development within the MTLL (i.e. the proposed recreational area in site E1-1) should be fully compatible with the landfill restoration and aftercare works and impose no adverse impact to them. Caution should also be exercised to ensure long term integrity of the capping system and other restoration facilities. Design and Construction of the proposed development within the MTLL should be provided to EPD for agreement in the design stage.

In general, the measures being taken for the restoration of the landfill site and the control of LFG should not be relied upon to ensure the safety of adjoining developments. However, it must also be acknowledged that the works being undertaken would have the effect of lowering the potential for an incident to occur off-site when compared to the historical situation.

10.6.2 General Recommended Precautionary and Protection Measures – Design Phase

At the preliminary assessment stage, it is not practicable to determine detailed protection, but a provisional classification of the site into one of five categories will allow the Professional Person a means of understanding the generic types of protection which would be appropriate. The potential implications associated with the various qualitative risk categories are summarized in **Table 10.2**.

According to the source-path-target analysis in **Tables 10.6a** and **10.6b**, depending upon the locations and nature of the targets being considered, the risk category at the proposed developments within the Consultation Zone and within MTLL are both 'Low' to 'High' during the operational phase. This implied "some precautionary measures" to "significant engineering measures required" by the future site developers to protect proposed development.

For the high risk category, the use of active control of gas, including barriers and detection systems are recommended. These measures include the control of gas by mechanical means e.g. ventilation of spaces with air to dilute gas, or extraction of gas using fans or blowers. For the low risk category, the provision of barriers to the movement of gas is recommended. Measures recommended include the use of membranes in floors or walls, or in trenches, coupled with high permeability vents such as no-fines gravel in trenches or voids/permeable layers below structures. The need and practicality of incorporating such measures should be reviewed in the detailed Qualitative LFG Hazards Assessment (QLFGHA) to be undertaken during the detailed design stage for developments within the Consultation Zone and within MTLL. Detailed precautionary and protection measures should be recommended in the QLFGHA.

Nevertheless, to minimize the risk of landfill gas hazard to the future occupants of the proposed developments, below ground rooms/ voids should be avoided as far as practicable in the developments within the Consultation Zone. For the proposed developments within the MTLL, underground rooms/ voids should totally be avoided not only to minimize the risk of landfill gas hazard to the future occupants, but also to prevent interruption to the landfill restoration facilities. In addition, buildings or structures within the MTLL (i.e. the proposed recreational area in site E1-1) should be at ground level with raised floor slabs which are less prone to gas ingress.

In addition, the design and construction method of the proposed development within MTLL (i.e. the proposed recreational area in site E1-1) should be provided to EPD for agreement in the design stage to ensure compatibility with the landfill restoration facilities and aftercare works within MTLL, such that these facilities and works will not be affected by the construction or operation of the proposed development.

10.6.3 General Recommended Precautionary and Protection Measures – Construction Phase

All contractors participating in the works should be aware that methane and carbon dioxide are always likely to be present in the soil and rock voids and all works should be undertaken on the basis of an "assumed presence of LFG".

Risks in the construction works are mainly resulted from construction workers' contact with LFG. Whilst the risks are not expected to be

significant, owing to the use of powered mechanical equipment to undertake most of the piling and excavation works, there may be still be instances where human exposure may be inevitable when personnel may have to enter confined spaces. Precautionary measures to be adopted by the contractors (for both site formation and infrastructure development) for the period of construction of infrastructure within the landfill Consultation Zone and within the MTLL are outlined in Paragraphs 8.3 to 8.49 of EPD's Landfill Gas Hazard Assessment Guidance Note. The following guidance has been extracted from and appended to this and to ensure a robust and comprehensive set of measures to protect workers are provided.

- During all works, safety procedures should be implemented to minimize the risks of fires and explosions, asphyxiation of workers (especially in confined space) and toxicity effects resulting from contact with contaminated soils and groundwater.
- Safety officers, specifically trained with regard to LFG and leachate related hazards and the appropriate actions to take in adverse circumstances, should be present on all worksites throughout the works.
- All personnel who work on site and all visitors to the site should be made aware of the possibility of ignition of gas in the vicinity of the works, the possible presence of contaminated water and the need to avoid physical contact with it.
- Those staff who work in, or have responsibility for "at risk" areas, including bore pilling and excavation works, should receive appropriate training on working in areas susceptible to LFG.
- Enhanced personal hygiene practices including washing thoroughly after working and eating only in "clean" areas should be adopted where contact may have been made with any groundwater which is thought to be contaminated with leachate.
- Any offices / quarters set up on site should take precautions against LFG ingress, such as being raised off the ground. Other storage premises, e.g. shipping containers, where this is not possible should be well ventilated prior to entry.
- Adequate precautions to prevent the accumulation of LFG under site buildings and within storage shed should be taken by raising buildings off the ground where appropriate and "airing" storage containers prior to entry by personnel and ensuring adequate ventilation at all times.
- Smoking and naked flames should be prohibited within confined spaces. "No Smoking" and "No Naked Flame" notices in Chinese and English should be posted prominently around the construction site. Safety notices should be posted warning of the potential hazards.
- Welding, flame-cutting or other hot works may only be carried out in confined spaces when controlled by a "permit to work" procedure,

properly authorized by the Safety Officer. The permit to work procedure should set down clearly the requirements for continuous monitoring of methane, carbon dioxide and oxygen throughout the period during which the hot works are in progress. The procedure should also require the presence of an appropriately qualified person who shall be responsible for reviewing the gas measurements as they are made, and who shall have executive responsibility for suspending the work in the event of unacceptable or hazardous conditions. Only those workers who are appropriately trained and fully aware of the potentially hazardous conditions which may arise should be permitted to carry out hot works in confined areas.

- During the construction works, adequate fire extinguishers and breathing apparatus sets should be made available on site and appropriate training given in their use.
- Ongoing gas monitoring should be considered for offices, stores etc set up on site.

10.6.3.1 Monitoring

Monitoring should be undertaken when construction works are carried out in confined space within the Consultation Zone and within MTLL. Routine gas monitoring should be undertaken during groundwork construction and in all excavations. Monthly gas monitoring should also be conducted for offices, stores etc set up on site. The monitoring requirements and procedures specified in Paragraphs 8.23 to 8.28 of EPD's Guidance Note are highlighted as follows:

- The monitoring equipment used should be capable of measuring methane, carbon dioxide and oxygen concentrations. The equipment should be intrinsically safe and calibrated according to the manufacturers instructions.
- When portable monitoring equipment is to be used, the frequency and areas to be monitored should be set down prior to commencement of the works either by the Safety Officer or by an appropriately qualified person.
- All measurements should be made with the monitoring tube located not more than 10 mm from the surface.
- A standard form, detailing the location, time of monitoring and equipment used together with the gas concentrations measured, should be used when undertaking manual monitoring to ensure that all relevant data are recorded.
- If methane (flammable gas) or carbon dioxide concentrations are in excess of the trigger levels or that of oxygen is below the level specified in the Emergency Management in the following section, then evacuation should be initiated.

10.6.3.2 Actions in the Event of Abnormal Gas being Detected

Depending on the results of the measurements, actions required will vary and should be set down by the Safety Officer or another appropriately qualified person. As a minimum these should encompass those actions specified in **Table 10.7.**

Table 10.7 - Actions in the event of LFG being detected

Parameter	Monitoring Results	Actions
O_2	<19% v/v	Increase underground ventilation to restore O_2 to >19% v/v
	<18% v/v	Stop works, evacuate all personnel, prohibit entry, and increase ventilation to restore O_2 level to >19%
CH_4	>10% LEL	Prohibit hot works, increase ventilation to restore CH_4 to <10% LEL
	>20% LEL	Stop works, evacuate all personnel, increase ventilation further to restore CH_4 to <10% LEL
CO_2	>0.5% v/v	Increase ventilation to restore CO_2 to <0.5% v/v
	>1.5% v/v	Stop works, evacuate all personnel, increase ventilation further to restore CO_2 to <0.5%

10.6.3.3 Emergency Management

In order to ensure that evacuation procedures are implemented in the event of the trigger levels specified in **Table 10.7** above being exceeded, it is recommended that a person, such as the Safety Officer, is nominated, with deputies, to be responsible for dealing with any emergency which may occur due to LFG.

In an emergency situation the nominated person, or his deputies, shall have the necessary authority and shall ensure that the confined space is evacuated and the necessary works implemented for reducing the concentrations of gas. The following organizations should also be contacted as appropriate:

- Hong Kong Police Force;
- Fire Services Department;
- Environmental Protection Department.

10.6.4 General Recommended Precautionary and Protection Measures – Operational Phase

10.6.4.1 Utility Companies

The developers should make the utility companies aware of the location and features of the site within the Consultation Zone during the respective detailed design stage as part of the QLFGHA. The utilities companies should have a responsibility to train and ensure their staff to

take appropriate precautions at all times when entering enclosed spaces or plant rooms.

Should utility installation be required in site E1-1, the developers should make the utility companies aware of the potential constraints imposed by the landfill restoration facilities and aftercare works to ensure these facilities and works will remain unaffected. Appropriate precautionary measures against landfill gas should also be taken should utility installation be required within the MTLL.

10.6.4.2 Building Management

The management committee of the building estate will hold a special responsibility to ensure that the occupants of the building, its staff and maintenance workers are protected from LFG and that visitors to the site within the Consultation Zone and within the MTLL are also made aware as to the dangers and the precautions required to be taken.

Of primary importance to satisfactorily upholding this responsibility will be to ensure that strict procedures for maintaining control over all temporary and /or permanent works proposed at the site are reviewed with regard to the LFG hazard. This needs to be accompanied by a comprehensive contingency plan in case of incidents, including liaison with EPD officers, Fire Services Department, Landfill Restoration Contractors and others, as necessary.

All construction and maintenance (including utilities) personnel working at the site should be made aware of the hazards of LFG and its possible presence on site. This should be achieved through a combination of posting warning signs in prominent places and also by access to detailed information on LFG hazards and the designs and procedural means by which these hazards are being minimized on site. In addition, entry to confined spaces such as refuse/store rooms, drainage manholes etc. should be preceded by a period of “airing” the space by opening the door widely allowing fresh air to enter. Where appropriate, monitoring of gas should also precede entry.

Any proposed modifications or additions to the building structure should be subject to a further assessment of LFG hazard, particularly in areas where a gas membrane has been installed. Any penetrations of the membrane must be repaired as soon as possible after detection or works completion using similar products.

The building management company should also make arrangement with Landfill Restoration Contractor so that they are advised of all situations which may potentially threaten the safety of the building occupants resulting from any accidents or failures at the landfill site. The building management company should also have available suitable gas monitoring equipment for any ad hoc investigations necessary relating to LFG and be in a position to undertake any future routine monitoring of gas which may be considered necessary soloing completion of the defects correction period.

Precautionary and protection measures recommended for building management should generally be taken up by the developer of the sites.

To ensure that all the above protection and precautionary measures and issues pertaining to LFG are properly and consistently addressed by future users and owners of the site, it is recommended that a comprehensive LFG hazard management system be developed by the owner of the building or its property management agency. The system should be developed as part of the QLFGHA before the occupation of the building and implemented during its operational phase (such requirement could be included in the lease condition by Lands D).

10.6.5 Monitoring Requirement

To protect the site workers and future owners of the developments within the Consultation Zone and within MTLL, it is recommended that monitoring of any LFG which may be migrated to the site should be undertaken during the construction of infrastructure and the development within the Consultation Zone and within MTLL when the works involve confined spaces. Routine gas monitoring should be undertaken during groundwork construction and in all excavations. Monthly gas monitoring should also be conducted for offices, stores etc set up on site. The monitoring requirement has been discussed in **Section 10.6.3.1**.

The requirements of operational monitoring by future site developers should be determined in the detailed QLFGHA during the detailed design stage when the risk potential and mitigation measures, if required, are confirmed.

The design and construction within the sites E1-2 and E1-3 etc should avoid interference or disturbance to the off-site landfill gas, surface water and ground water monitoring wells as part of the landfill restoration facilities of the MTLL. Should it be technically unavoidable, prior approval should be obtained from EPD for the required modification or relocation of the monitoring wells.

10.7 Conclusion

This section has provided a preliminary qualitative assessment on potential hazards associated with LFG migration from MTLL to the proposed development in KTN NDA and within MTLL.

The MTLL is considered as a “Medium” source of gas migration since LFG monitoring results in past five years in MTLL have indicated methane concentrations were at very low level and only one data of carbon dioxide concentration was above the background levels. The risk categories associated with the source-pathway-target have been identified. It is concluded that the potential risk during construction phase for developments within the Consultation Zone is “Medium” and during operational phase is ‘Low’ to ‘High’ depending upon the location and nature of the target being considered. Similarly, the level of risk for the development within MTLL during the construction phase is also “Medium”

and during operational phase is 'Low' to 'High' depending upon the location and nature of the target being considered. Therefore, this implied "some precautionary measures" to "significant engineering measures" required by the future site developers to protect the proposed development.

To minimize the risk of landfill gas hazard to the future occupants of the proposed developments, below ground rooms/ voids should be avoided as far as practicable in the developments within the Consultation Zone. For the proposed developments within the MTLL, underground rooms/ voids should totally be avoided not only to minimize the risk of landfill gas hazard to the future occupants, but also to prevent interruption to the landfill restoration facilities. In addition, buildings or structures within the MTLL (i.e. the proposed recreational area in site E1-1) should be at ground level with raised floor slabs which are less prone to gas ingress. It is also recommended that further LFG monitoring should be carried out prior to the commencement of the detailed design of the developments to provide the latest LFG data for the detailed QLFGHA.

General protection and precautionary measures have been proposed for consideration during the design, construction and operational phases of the developments. In addition, the design, construction and operation of the proposed development within the MTLL (i.e. the proposed recreational area in site E1-1) should be fully compatible with the landfill restoration and aftercare works and impose no adverse impact to them. Caution should be exercised to ensure long term integrity of the capping system and other restoration facilities. The design and construction method of the proposed development within MTLL should also be provided to EPD for agreement during the design stage.

It is expected that with the proposed precautionary measures in place, the potential risk of LFG migration from MTLL to KTN development would be minimal. Nevertheless, a detailed QLFGHA should be undertaken during the detailed design stage of the developments to review the need and practicality of the protection and precautionary measures proposed and provide recommendations on the detailed protection and precautionary measures to be adopted. Such requirement could be imposed on developers by including it in the lease conditions by Lands D.