ENVIRONMENTAL PROTECTION DEPARTMENT
PRACTICE NOTE FOR PROFESSIONAL PERSONS

Landfill Gas Hazard Assessment for Developments adjacent to Landfills

Introduction

Landfill gas is a generic term used to describe the mixture of gaseous product generated as a result of the waste decomposition in landfills. It is both flammable and asphyxiating, and, as a consequence, it has the potential to cause fire, explosion or asphyxiation. In view of the very nature of landfill gas, it might pose potential hazards to developments adjacent to these landfills. It is prudent, therefore, that special attention be given in respect of the developments adjacent to landfills to ensure that their intended uses are safe. Further information on landfill gas in terms of its characteristics, its generation and movement as well as its hazards are presented in **Appendix I**.

2. The potential hazards of landfill gas and the need for protection measures for developments adjacent to landfills in the Territory have been outlined in section 6.5 of Chapter 9 of the Hong Kong Planning Standards and Guidelines (HKPSG). In line with the advice in the HKPSG, the Environmental Protection Department (EPD) has been requiring, by administrative means, project proponents of relevant developments to carry out a landfill gas hazard assessment and to submit a report on the findings to the EPD for vetting. This requirement is usually incorporated through the landuse planning process, either as conditions of planning permissions, or as special conditions in relevant land-title documents. Based on the experience gained to date, this Practice Note is intended to provide project proponents with specific guidelines for developments adjacent to landfills in the Territory.

3. The objectives of this Practice Note are :

(i) to set out the conditions under which a landfill gas hazard assessment may be required;

(ii) to provide some general guidelines on how a proper landfill gas hazard assessment should be conducted; and

(iii) to outline some typical protection measures that are commonly adopted for protection of developments adjacent to landfills.

For the purposes of assessing the degree of risk associated with developments adjacent to landfills, the landfill gas hazard assessment outlined in this Practice Note will only focus on the safety hazards such as fire and explosion. The potential health hazards associated with landfill gas are beyond the scope of this Practice Note.

Consultation Zone

4. It has been a common approach in many countries to designate a zone around a landfill, within which if development is proposed, the relevant authorities will need to be consulted. This is to ensure that the potential hazards associated with landfill gas are properly considered for developments adjacent to landfills. For similar purpose, a Consultation Zone around each of the landfills in the Territory has been established. There are in total 16 landfills in the Territory and their locations are shown in the appended plan. The Consultation Zone represents the area of land surrounding the landfill boundary as defined by a line running parallel to and 250 m away from the edge of the waste if this can be identified or, if not, the recognized landfill site boundary. Detailed plans delineating such a Consultation Zone for each of the landfills are kept by the EPD and are available for inspection. The extent of the Consultation Zone was established by making reference to international practices and taking into account the local conditions in Hong Kong.

5. It is advisable that the professional persons, who are involved in any development or re-development projects falling in whole or in part within the Consultation Zones, should give attention to the procedures, requirements and guidelines set out below so that the potential hazards associated with landfill gas for the proposed development can be minimized or avoided at an early stage. In this context, the term "development" has the same meaning as that in the Town Planning Ordinance, i.e. "carrying out building, engineering, mining or other operations in, on, over or under land, or making a material change in the use of land or buildings".

Role of the Professional Person

6. If a proposed development is identified to be within a Consultation Zone, the project proponent or professional person responsible for the development is generally required to carry out a landfill gas hazard assessment and submit the report to the EPD for vetting. It should be emphasized, however, that this requirement is not to be applied indiscriminately with no exception. In situations where certain types of developments are

evidenced to have a very low sensitivity to landfill gas impacts, the requirement for the hazard assessment in these instances might be waived even though the proposed developments fall within the Consultation Zones. On the other hand, in some particular exceptional circumstances, a landfill gas hazard assessment might be required despite the proposed developments are located outside the Consultation Zones. These mainly refer to situations where the physical setting between a landfill and the proposed site is identified to have distinct geological features (e.g. fault lines and lineaments) or predominant artificial buried structures (e.g. utility tunnels and conduits) and that these will act as the preferential pathways for gas migration. Such exceptional circumstances might warrant a landfill gas hazard assessment to be carried out to ensure the safety of the proposed development. If the need for a landfill gas hazard assessment is in doubt, advice can be sought from the EPD.

7. When the need for a landfill gas hazard assessment is confirmed, the project proponents and professional persons responsible for the proposed developments or re-developments should :

(i) carry out a landfill gas hazard assessment to evaluate the degree of risk associated with the proposed development;

(ii) design suitable precautionary/protection measures to render the proposed development as safe as reasonably practicable;

(iii) ensure that the precautionary/protection measures will be implemented and constructed in accordance with the design; and

(iv) establish a maintenance and monitoring programme for ensuring the continued performance of the implemented protection measures.

For planning purposes, the proposed buildings and structures should generally be sited at least 10 m away from the edge of the waste in a landfill.

8. The landfill gas hazard assessment should be carried out and completed for submission to the EPD for vetting at the early planning stage of the project. The early completion of the assessment study will ensure that the identified protection measures be considered and incorporated into the overall design process for the proposed development.

Landfill Gas Hazard Assessment

9. In general, a landfill gas hazard assessment entails two main components

comprising a qualitative risk assessment and the design of precautionary/protection measures. Specifically, a proper assessment should include, but is not limited to, the following steps:

(i) review of background information pertaining to the landfill(s) that might have potential impacts on the proposed development (e.g. landfill site history, waste type and age, geological and hydrogeological data and environmental monitoring data);

(ii) evaluation of the nature and extent of the sources, including the likely concentrations and/ or amounts of hazardous emissions which might have the potential for impacts on the proposed development;

(iii) identification of the possible pathways through the ground, underground cavities, utilities and ground water, and the nature of these pathways through which the hazardous emissions must traverse if they were to reach the proposed development;

(iv) identification of the potential targets associated with the proposed development which are sensitive to the impacts of the hazardous emissions (e.g. building basements, underground car parks, unventilated excavations and any other confined spaces);

(v) assessment of the degree of risk which the hazardous emissions may pose to the sensitive targets for each possible source-pathway-target combination, using a qualitative technique;

(vi) formulation of suitable precautionary measures for the safe construction of the proposed development and suitable protection measures for its safe intended use; and

(vii) identification of monitoring requirement for assessing the adequacy and performance of the implemented protection measures.

10. As assessing the degree of risk and designing the appropriate protection measures require special expertise, it is advised that experienced professional persons who have the sound knowledge and experience in this particular field should be engaged for the above-discussed hazard assessment study.

Landfill Gas Protection Measures

11. A wide range of protection measures is available for protection of developments against landfill gas hazards. However, they can be broadly classified as either passive control systems or active control systems. These may include, but are not limited to, the following :

Passive Control Systems :

- passive trench vents or well vents in the ground;
- physical barriers in the ground;
- passive ventilation (vents) systems beneath the building floor; and
- physical barriers beneath or inside the building floor.

Active Control Systems :

- active trench vents or well vents in the ground; and
- active ventilation (vents) systems beneath the building floor.

12. The selection of an appropriate protection measure is site-specific, and is dependent on the degree of risk identified for the proposed development. In some cases, it may be necessary to adopt a combination of protection measures under either or both of the passive and active control systems. A brief description of these protection measures is presented in **Appendix II**.

13. Landfill gas hazards that may arise during the construction phase should not be overlooked. To ensure safe construction of the development, precautionary measures should be clearly laid down and adhered to with respect to, for example, welding and flame-cutting, trenching and excavation as well as creation of confined spaces at, near to or below ground. Periodic monitoring should also be carried out at all works areas, particularly in all excavations and confined spaces created on site.

Advice from the Environmental Protection Department

14. The Environmental Protection Department is presently preparing a Guidance

Note which will provide more detailed guidelines for carrying out the qualitative risk assessment and designing the appropriate protection measures against landfill gas hazards for developments adjacent to landfills. In parallel, the EPD is also developing an electronic database which shall contain information including environmental monitoring data for landfill gas, leachate and groundwater for each of the landfills in the Territory. To facilitate the project proponents in carrying out the landfill gas hazard assessment, access to the Guidance Note as well as the database will be made available to the project proponents when they are completed. Enquiries for further information and specific advice on landfill gas hazard issues can be addressed to: Facilities Development Group, Environmental Protection Department (Attention Mr. Andy King, Telephone No. 2835 1177, Faxline No. 2591 6662).

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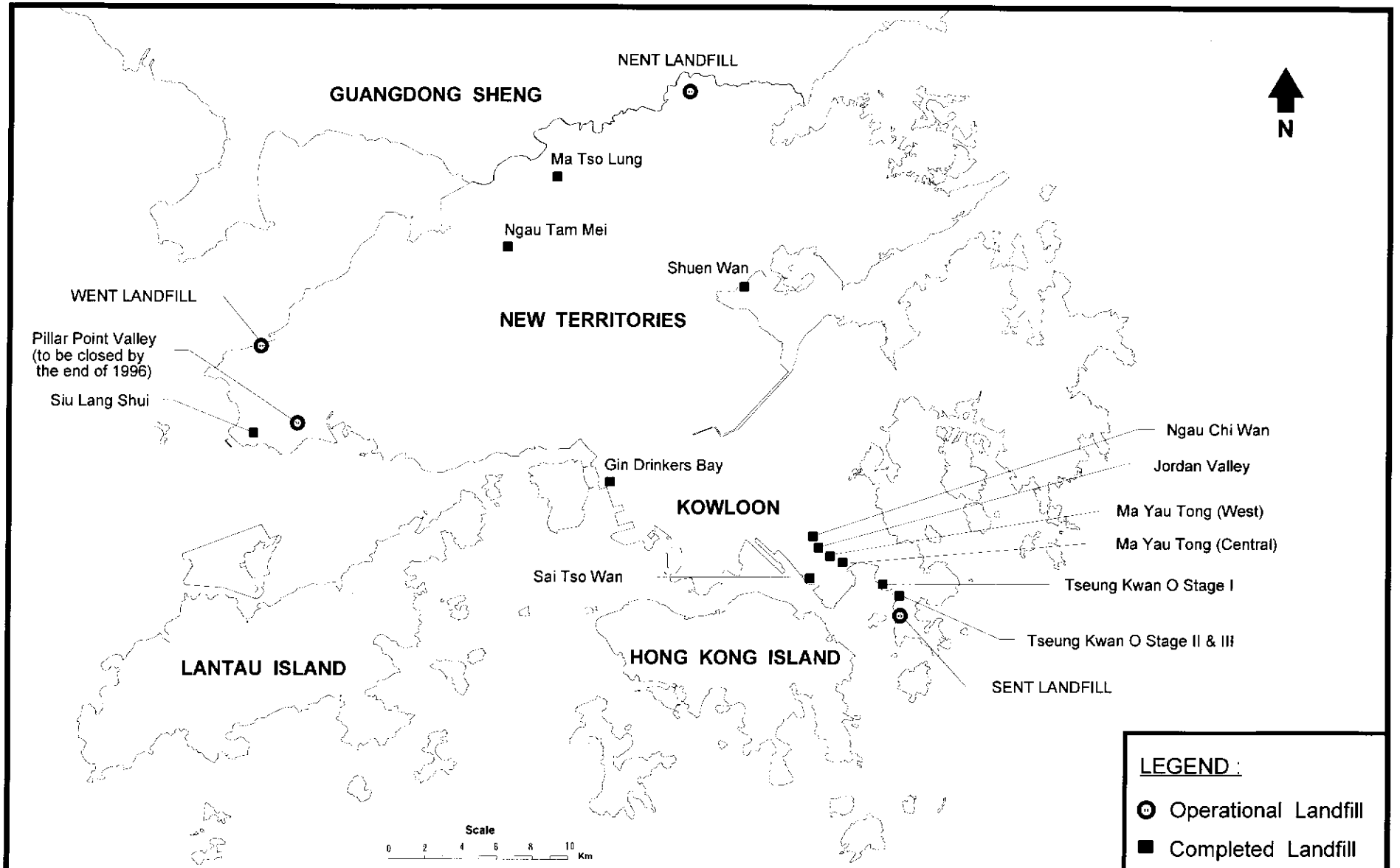

Location of Landfills

Environmental Protection Department

Background Information on Landfill Gas

(I) Landfill Gas Characteristics

Landfill gas is a generic term used to describe the mixture of gaseous by-product generated as a result of the waste decomposition. It consists principally of methane (about 60%) and carbon dioxide (about 35 %) as well as other low levels of compounds, including nitrogen, sulphides and organics. The actual composition of landfill gas varies, depending on the make-up of waste and the various stages of decomposition of waste.

Methane, which is colourless and odourless, is the constituent of most concern. It is highly flammable and can be explosive when all three of the following conditions are met :

(a) its concentration in air is between 5 to 15 % by volume (the Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL), respectively) ;

(b) the gases are in a confined or semi-confined space; and

(c) a source of ignition is present.

Carbon dioxide is colourless, odourless and noncombustible. It is a constituent also of concern because, in the absence of oxygen, it can asphyxiate humans and animals.

(II) Landfill Gas Generation and Movement

Landfill gas is generated as a result of the biological decomposition of organic materials in landfills. In the initial stage of decomposition, waste begins to break down under the aerobic (in the presence of oxygen) condition, producing mainly carbon dioxide and water. As the oxygen is used up within the filled area, the process proceeds to anaerobic (absence of free oxygen) decomposition, where both methane and carbon dioxide are produced. Methane production from landfilled wastes normally reaches a maximum rate at about two years after placement and may continue at this rate for many years. This depends on such factors as waste composition, age, density, temperature and depth; the site operations practice; the position of the water/leachate level as well as local climate.

Landfill gas moves through the subsurface by convection and / or by diffusion. In general, convection is the predominant transport mechanism in dry, coarse-grained soil.

Whereas, in dry, fine-grained soil, diffusion is the likely governing mechanism. However, both convection and diffusion mechanisms will cease to operate when the migrating pathway through which landfill gas tends to move becomes fully saturated. It should be noted, however, that landfill gas may dissolve in and move along with groundwater and may subsequently be released from it.

(III) Landfill Gas Potential Hazards

Landfill gas generated at a landfill site has a tendency to migrate off site, potentially affecting the nearby buildings and structures. Landfill gas has the potential to cause explosion, fire or asphyxiation if it migrates into and accumulates in the confined spaces such as building basements, underground car parks, lift shafts, pumping stations and maintenance chambers. For the same reasons, temporary structures such as site huts and any other unventilated enclosures erected during construction are also exposed to landfill gas hazards. Underground services might also be susceptible to the potential hazards associated with landfill gas as they commonly form the preferential pathways for landfill gas. These include sewer drains, storm drains and service ducts.

Appendix II

Typical Landfill Gas Protection Measures

(I) The landfill gas protection measures should be designed to meet the following objectives :

(a) to prevent landfill gas from entering all buildings, services, ducts and confined air spaces;

(b) to ensure the development is safe for its intended purpose throughout the remaining gas producing lifetime of the landfill; and

(c) to be simple, robust and easy to maintain.

(II) There are a number of protection measures commonly adopted for protection of developments adjacent to landfills. These include both passive and active control systems :

Passive Control Systems :

(a) Passive Trench Vents or Well Vents in the Ground

Passive trench vents or well vents are control measures that provide an engineered escape route for landfill gas, and they are usually installed across the potential migration pathway at the site boundary. Trench vents usually consist of a granular backfilled trench with vertical vent pipes installed along the trench. Well vents are the special case of trench vents, and they are typically perforated piping installed vertically into pre-drilled boreholes with the top of the pipe extending above ground for venting.

(b) Physical Barriers in the Ground

Physical barriers basically comprise low-permeability barriers, which may be constructed of earth, soil bentonite, cement bentonite or geosynthetics, to impede the flow of gas. To ensure effective control of landfill gas, barriers are required to extend below the water table or keyed into a low-permeability zone. These systems are commonly constructed across the potential migration pathway to intercept and prevent migrating gas from entering the development.

(c) Passive Ventilation Systems beneath the Building Floor

Passive ventilation systems simply rely on natural air movements through the clear voids created below the structural slabs of buildings for venting of sub-slab gases. Alternatively, vents are installed within a gravel bedding placed beneath the buildings. These vents typically are connected to risers that ventilate sub-slab gases above the roof of buildings.

(d) Physical Barriers beneath or inside the Building Floor

These physical barriers typically consist of the low-permeability geomembranes incorporated into the building floor slabs to impede sub-slab gases from entering the buildings. Geomembranes such as high density polyethylene (HDPE) are commonly used in these applications because they have good resistance to chemical attack, good strength characteristics, and low gas permeabilities.

Active Control Systems :

(a) Active Trench Vents or Well Vents in the Ground

In these active systems, the trench vents or well vents are manifolded together such that either a negative pressure barrier or a positive pressure barrier can be created by applying a vacuum to the vents or by injecting air to the vents, respectively. Active vents either in the form of a continuous trench or a series of discrete wells are installed across the potential migration pathway at the site boundary to prevent migrating gas from entering the development.

(b) Active Ventilation Systems beneath the Building Floor

These active ventilation systems typically consist of vents placed in a gravel bedding directly beneath buildings. These vents commonly are connected to a blower or blowers which either apply a vacuum to extract sub-slab gases and then ventilate them through a riser or risers above the roof of the building, or inject air beneath the slab to provide a positive pressure barrier to impede sub-slab gases from entering the building.