



**HKRRP**

Hong Kong Resources Recovery Park  
香港資源復育園

Your Ref.: Ax(1) to EP2/N4/G/86 Pt. 11

Our Ref.: WENTX/ACS/LT/ER3/00962

Date: 26 Aug 2024

**Environmental Protection Department**

**By Hand**

**The EIA Ordinance Register Office**

27<sup>th</sup> Floor, Southorn Centre

130 Hennessy Road,

Wan Chai, Hong Kong

Dear Sir,

**Contract No. EP/SP/186/21**

**West New Territories Landfill (WENT) Extension – Environmental Permit (EP) No. EP-393/2010/A and Further Environmental Permit (FEP) No. FEP-01/393/2010/A Condition 2.9 - Detailed Landfill Gas Hazard Assessment Report**

Further to our previous submission on the Detail Landfill Gas Hazard Assessment Report dated 7 Jun 2024 (reference no.: WENTX/ACS/LT/ER3/00645) and your approval letter dated 14 Aug 2024 (reference no.: Ax(1) to EP2/N4/G/86 Pt.11), we are pleased to submit herewith a full set of Detail Landfill Gas Hazard Assessment Report in accordance with the EP condition 2.9.

Should you have any queries, please do not hesitate to contact our Mr. Kenneth Lau at 9315 4944.

Thank you for your kind attention.

Yours faithfully,

for and on behalf of

**Hong Kong Resources Recovery Park**

**Mr. Wu Yick Nam Victor**

**Project Manager**

VW/NC/TW/CNL/KL/shl

Encl.



**HKRRP**

Hong Kong Resources Recovery Park  
香港資源復育園

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Cc:

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**JOB No.: TCS01325/23**

**CONTRACT NO. EP/SP/186/21**

**WEST NEW TERRITORIES LANDFILL EXTENSION**

**DETAILED LANDFILL GAS HAZARD ASSESSMENT  
REPORT**

**SUBMISSION FOR**

**EP-393/2010/A CONDITION 2.9**

**FEP-01/393/2010/A CONDITION 2.9**

**PREPARED FOR**

**HONG KONG RESOURCES RECOVERY PARK**

**Date**

**Reference No.**

**Certified By**

26 April 2024

TCS01325/23/600/R0013r5



Tam Tak Wing  
(Environmental Team Leader)

<b>Revision</b>	<b>Date</b>	<b>Remarks</b>
1	15 January 2024	First Submission
2	5 April 2024	Amended according to EPD's comments
3	15 April 2024	Amended according to EPD's comments
4	17 April 2024	Amended according to EPD's comments
5	26 April 2024	Amended according to EPD's comments

Our Ref: TCS01325/23/300/L0053

**Hong Kong Resources Recovery Park**  
29/F China Overseas Building,  
139 Hennessy Road, Hong Kong

Attn: Mr. Kenneth Lau

7 June 2024  
By email

Dear Sir,

**Re: Contract No. EP/SP/186/21**  
**West New Territories Landfill Extension (WENTX)**  
**Detailed Landfill Gas Hazard Assessment Report (Revision 5)**  
**(Condition 2.9 of EP-393/2010/A and FEP-01/393/2010/A)**

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With reference to the full set of Detailed Landfill Gas Hazard Assessment Report (Revision 5), we hereby certify the report in accordance with Condition 2.9 of EP-393/2010/A and FEP-01/393/2010/A.

Should you have any queries or require further information, please feel free to the undersigned at Tel: 2959-6059 or Fax: 2959-6079.

Yours sincerely,  
For and on Behalf of  
**Action-United Environmental Services & Consulting**



Tam Tak Wing  
Environmental Team Leader

cc

ANewR (IEC)

Mr. James Choi

By e-mail



Environmental Protection Department  
2nd floor, West Wing  
Island West Transfer Station  
88 Victoria Road  
Kennedy Town  
Hong Kong

Your reference:

Our reference: HKEPD259/50/109819

Date: 7 June 2024

Attention: Ms Kins Lo

**BY EMAIL & POST**  
**(email: [wklo@epd.gov.hk](mailto:wklo@epd.gov.hk))**

Dear Sirs

Quotation Ref. 23-02230  
Provision of Independent Environmental Checker Consultancy Services for  
West New Territories Landfill Extension  
Detailed Landfill Gas Hazard Assessment Report (Revision 5)

We refer to email of 6 June 2024 from Hong Kong Resources Recovery Park attaching the full set of Detailed Landfill Gas Hazard Assessment Report (Revision 5) of the captioned.

We have no comment and hereby verify the captioned plan in accordance with Clause 2.9 of the Environmental Permit (EP No.: EP-393/2010/A) and Further Environmental Permit (FEP No. FEP-01/393/2010/A).

Should you have any queries, please do not hesitate to contact the undersigned or our Mr Ricky Lau at 2618 2831.

Yours faithfully  
ANEWR CONSULTING LIMITED

James Choi  
Independent Environmental Checker

CPSJ/LCCR/csym

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## 1 INTRODUCTION

### 1.1 PROJECT BACKGROUND

1.1.1 The West New Territories Landfill Extension (WENTX – the Project) is classified as a Designated Project (DP) requiring an Environmental Permit (EP) under Schedule 2, Part I of the Environmental Impact Assessment Ordinance (EIAO) (Cap. 499). The Environmental Impact Assessment (EIA) Report (AEIAR-147/2009) of WENTX was approved in November 2009 and the respective EP (EP-393/2010) was granted in June 2010. For the WENTX development scheme adopted in the WENTX-EIA in 2009 (hereby referred to the Original Scheme), an area of about 188 hectares of land adjacent to the existing WENT landfill was confirmed to be provided approximately 81 million m<sup>3</sup> (Mm<sup>3</sup>) of additional landfill capacity. Layout of the WENTX of Original Scheme shown in *Figure 1.1*.

1.1.2 Since then, a number of interfacing projects which included T.PARK and Tsang Tsui Columbarium have been proposed and considered in conjunction with the Project. Subsequently, the layout of WENTX was revised and formulated as a reference design in the “Enhanced Scheme” (ES) as lined in the Environmental Review Report (ERR). The changes in the Enhanced Scheme that might have potential implications on Landfill Gas (LFG) hazard are presented in *Table 1-1*.

**Table 1-1 Changes in the Enhanced Scheme that might have potential implications on LFG hazard**

Potential Environmental Implication	Change due to the Enhanced Scheme
Receivers that are sensitive to the effects of LFG	<ul style="list-style-type: none"> <li>Under the ES, the waste boundary has been diminished to 94 ha, from 188 ha in the Original Scheme. Due to the reduced size of the waste boundary, the boundary of 250m consultation zone has been revised. All the receivers outside WENTX will no longer fall within the 250 m consultation zone of the WENTX.</li> </ul>
Pathways through which LFG passes to reach the receivers	<ul style="list-style-type: none"> <li>Due to the reduced size of waste boundary, the physical separation between the revised waste boundary of the WENTX and the receivers has been increased.</li> </ul>

1.1.3 The changes of the design waste filling area and landfill capacity of the ES have been reduced to 94 ha and 76 Mm<sup>3</sup> respectively and are presented in *Table 1-2*.

**Table 1-2 Major design changes between Original Scheme and Enhanced Scheme**

Design Parameters	Original Scheme	Enhanced Scheme
Waste boundary	188 ha	94 ha
Waste capacity	81 Mm <sup>3</sup>	76 Mm <sup>3</sup>

1.1.4 Due to the boundary of WENTX reduced under the Enhanced Scheme, variation of EP (application number VEP-617/2022) was applied by the project proponent and EP-393/2010/A was issued by Environmental Protection Department (EPD) on 29 July 2022 subsequently.

1.1.5 In September 2023, Hong Kong Resources Recovery Park (hereinafter named “HKRRP”) was awarded the Design, Build and Operate (DBO) Contract of WENTX. Pursuant to

Particular Specification (PS) of the Works Contract, HKRRP was required to take up the full responsibility of the Permit Holder of the regarding EP (EP-393/2010/A) before the Contract Works commencement. To fulfill this requirement, HKRRP submitted the application on 18 September 2023 and was granted the Further Environmental Permit (FEP-01/393/2010/A) on 6 October 2023.

## 1.2 LOCATION OF WENTX OF THE PROJECT

- 1.2.1 As shown on **Figure 1.2**, the location of the updated WENTX has no significantly changed and situated on a hillslope to the west of the existing West New Territories (WENT) Landfill. In the vicinity of WENT Landfill, existing T.PARK, Tsang Tsui Columbarium and Black Point Power Station were built at Nim Wan to closer seashore. The eastern part of the site of WENTX is the Tsang Kok Valley, which is a hilly terrain area sparsely vegetated with grass and limited patches of shrubs. The easterly ridge is a boundary to separating the WENTX Landfill and the WENT Landfill. The northern part is the Nim Wan Road and Tsang Tsui Ash Lagoons. The southern area is bounded by the natural topography, with ridgelines rising southwards from the coastline to meet the major east-west trending ridgeline. The southern part of the site encroaches onto the Tsing Shan Firing Range. There are streams within the hillslope, some springs, and water courses of which the flows are mainly seasonal.

## 1.3 PURPOSE OF THE STUDY

- 1.3.1 WENTX will be a new source of landfill gas generation and there are potential risks associated with any development close to a landfill site relating to the generation and sub-surface migration of landfill gas. Therefore, HKRRP shall, at least 1 month before the commencement of construction of the Project, submit to the Director of Environmental Protection for approval a detailed landfill gas hazard assessment, which shall include a review of the preliminary qualitative risk assessment in the approved EIA report, preparation of a detailed qualitative risk assessment, preparation of detailed design of gas protection measures and the establishment of maintenance and monitoring programmes to ensure the continued performance of the proposed control measures in accordance with both Environmental Permits EP-393/2010/A and FEP-01/393/2010/A Condition 2.9 stipulation.
- 1.3.2 AUES was appointed by HKRRP to assist in preparing a detailed landfill gas hazard assessment (DLFGHA). The assessment includes a review of the preliminary qualitative risk assessment as presented in the approved EIA Report and taken into account the design changes of the Enhanced Scheme, to assess the potential risk due to landfill gas migration based on the latest construction methodology and building design at the infrastructure area of WENTX and to recommend appropriate measures to ensure WENTX can be constructed and operated without undue risk to safety. Before submission to the Director of Environmental Protection, the assessment shall be certified by the ET Leader and verified by the IEC.
- 1.3.3 The design of the landfill gas management system and the landfill gas precautionary measures to be adopted on-site would be performed by a landfill gas specialist as appointed by HKRRP, who has comprehensive knowledge on landfill characteristics, potential landfill gas hazards and appropriate precautionary measures to minimise hazards. In addition, the landfill gas management system and landfill gas precautionary measures will be checked and certified by a qualified independent consultant.
- 1.3.4 For the purpose of this DLFGHA Report, the WENTX schemes assessed in the approved

EIA Report and the latest WENTX scheme are referred to as “the Original Scheme” and “the Enhanced Scheme” respectively. The assessment follows the “source-pathway-target” analysis approach adopted in the approved EIA Report and the EPD’s Guidance Note on Qualitative Landfill Gas Hazard Assessment (Guidance Note). It should also be noted that this DLFGHA Report is related to the potential landfill gas hazards due to the operation of the existing WENT Landfill to the construction and operation of the WENTX and the operation of the WENTX to the infrastructure facilities of the WENTX and establishment of the necessary control measures to minimise the risks identified.

## **1.4 ASSESSMENT PROCEDURES AND GUIDELINES**

1.4.1 Under *Annex 7* of the Technical Memorandum on EIA Process (*EIAO-TM*), an evaluation of the potential risk posed by landfill gas is required for any development which is proposed within 250m of the edge of waste, known as Landfill Consultation Zone. The WENTX site is located within the WENT Landfill Consultation Zone (referred to **Figure 1.3 and 1.3a**) and WENTX itself is a potential source of LFG generation.

1.4.2 A Qualitative Landfill Gas Hazards Assessment (QLFGHA) is required to assess the potential risk due to landfill gas migration from the WENT Landfill to the construction and operation of the WENTX. In addition, the operation of the WENTX will generate lower quantities of landfill gas which may pose risk to the operation of the infrastructure facilities of the WENTX. This assessment considered both landfill gas sources (i.e. existing WENT Landfill and WENTX) and the EPD’s guidance notes the “A Practice Note for Professional Persons (ProPECC PN 3/96 “Landfill Gas Hazard Assessment for Development adjacent to Landfills”) and the “EPD/TR8/97 – Landfill Gas Hazard Assessment Guidance Note”.

## **1.5 PREVIOUS STUDIES UNDERTAKEN AT THE SITE**

1.5.1 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, utilities plan (gas, electricity, drainage, etc.), information from previous ground investigations, engineering and operation details, gas monitoring data, visual data at existing WENT Landfill etc. The following documents have been reviewed:

- Annex 7 and Annex 19 of the Technical Memorandum on EIAO (TM-EIAO);
- West New Territories (WENT) Landfill Extension - Feasibility Study: Final Environmental Impact Assessment Report, prepared by Ove Arup & Partners Hong Kong Limited and approved on 20 November 2009;
- West New Territories (WENT) Landfill Extension – Supporting Document for Variation of Environmental Permit (245706-REP-129), by Ove Arup & Partners Hong Kong Limited, July 2022
- Landfill Gas Hazard Assessment: Guidance Note, issued by EPD in 1997 and updated on October 2022.
- ProPECC PN 3/96 “Landfill Gas Hazard Assessment for Development adjacent to Landfills, EPD 1996

## **1.6 SCOPE OF THE STUDY**

1.6.1 The following tasks have been undertaken as part of this assessment:

- review of background information (including landfill gas monitoring data) and studies related to the WENT Landfill and the WENTX;
- identification of the nature and extent of the WENT Landfill and WENTX which

might have potential impacts on the construction and operation of WENTX;

- identification of possible pathways through the ground, underground cavities, utilities or groundwater, and the nature of these pathways through which the landfill gas must traverse if they were to reach the WENTX;
- identification of the potential receivers associated with the WENTX which are sensitive to the landfill gas risk;
- qualitative assessment on the degree of risk which the landfill gas migration may impose on the identified targets for each of the source pathway-target combinations; and
- design of suitable level of precautionary measures and contingency plan for the WENTX and the potential targets, if needed.

## 1.7 REPORT STRUCTURE

1.7.1 Following the introductory description in *Section 1*, the contents of the remainder of this assessment report are presented as follows:

<i>Section 2</i>	Associated Background Information of the Existing WENT Landfill and WENTX
<i>Section 3</i>	Landfill Gas Hazard Assessment Methodology
<i>Section 4</i>	Development of Intercept Landfill Gas
<i>Section 5</i>	Qualitative Assessment of Risk Due to Landfill Gas
<i>Section 6</i>	Protective and Precautionary Measures
<i>Section 7</i>	Landfill Gas Monitoring
<i>Section 8</i>	WENT Landfill Extension Works of Safety Measures
<i>Section 9</i>	Environmental Monitoring and Audit
<i>Section 10</i>	Conclusions and Recommendations

## **2 ASSOCIATED BACKGROUND INFORMATION OF THE EXISTING WENT LANDFILL AND WENTX**

### **2.1 EXISTING WENT LANDFILL HISTORY AND GENERAL DESCRIPTION**

- 2.1.1 Existing WENT Landfill was commissioned in 1993 and receives waste from the North West New Territories by road as well as Island East, Island West, West Kowloon and North Lantau Transfer Stations and Outlying Islands Transfer Facilities by barge, with an overall capacity of 61Mm<sup>3</sup> occupying about 110ha area. Waste intake recorded (mainly municipal and construction waste) is about 6,655 tonnes per day in Year 2022. It has an operation life of about 25 years (subject to the actual waste intake) and an aftercare period of 30 years after the completion of operation.
- 2.1.2 The entire WENT landfill is designed in a “Confined and Contained” approach. Comprehensive landfill gas and leachate collection systems have been operating since day 1 of WENT Landfill operation to collect all the landfill gas and leachate generated from the waste body. A protective lining system is adopted to stop any migration of landfill gas and leachate which forms a barrier on the pathway to nearby development.
- 2.1.3 Monitoring exercise is regularly conducted by the WENT Landfill project team in order to ensure that landfill gas and leachate from the entire landfill are properly collected and treated.
- 2.1.4 A landfill gas management system is also placed 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 uses. LFG is also utilised as a heat source for the ammonia stripping processing plant used in the leachate treatment process. Surplus LFG will be utilized for power generation for both landfill consumption and export to CLP grid, while the remaining will be completely burnt in the flaring system.

### **2.2 HISTORICAL LANDFILL GAS AND LEACHATE CONTROL**

- 2.2.1 The existing WENT Landfill has been equipped with efficient and effective LFG management system which comprises a comprehensive approach to undertake the international best practices for the LFG management including the monitoring, collection, extraction, flaring, and utilisation of the LFG. The LFG management system includes a network of collection pipework connecting the extraction wells installed within the landfill cap to the LFG utilization compound on-site. The existing WENT landfill contractor performs routine inspection and maintenance of the LFG extraction system to ensure the satisfactory operation of the system.
- 2.2.2 The site is lined at the bottom and the LFG and leachate are collected and treated separately by the onsite treatment plants which control effectively to prevent the subsurface off-site migration of landfill gas and leachate. Typical details of the composite liner system installed at the WENT Landfill are presented in *Figure 1.7*.
- 2.2.3 In accordance with the existing contract, the existing WENT landfill contractor will be required to continue the control and monitoring of LFG and leachate following the closure of the landfill for a period of 30 years. The WENT LFG monitoring results from the monitoring wells located along the boundary of WENT Landfill have been reviewed. Locations of the monitoring wells are presented in *Figure 1.8*.
- 2.2.4 Based on the monitoring data of monitoring wells for existing WENT provided by existing WENT landfill contractor, methane was all the time measured of less than the detection limit

(<0.1%) in the year from 2018 to 2022. There is no methane recorded from all monitoring wells along the boundary of WENT Landfill indicates that there was no sub-surface off-site migration of methane from the landfill site.

- 2.2.5 Based on the monitoring data of monitoring wells for existing WENT provided by the existing WENT landfill contractor, the average carbon dioxide concentration detected in the monitoring well ranged from 0.3% to 7.2% while the maximum gas concentrations ranged from 0.3% to 9.1% in the year from 2018 to 2022. The positive carbon dioxide readings but without the presence of methane occurred persistently in most of the monitoring wells could be concluded as a natural phenomenon due to the biological activities and the carbonate cycle in the soil. Such phenomenon is not indicative of a landfill gas presence.

## **2.3 LANDFILL GAS CONTROL FOR THE WENTX**

- 2.3.1 The landfill extension site will be a source to generate LFG during the operation and the aftercare phases. Similar to the operation at the existing WENT Landfill, the source of LFG within the site will be properly controlled under relevant proper control measures and the best practices undertaken by the operator in the WENTX.
- 2.3.2 Extensive measures will be incorporated and undertaken in accordance with the international best practices for the landfill operation in the design of WENTX to contain, collect, and treat the LFG and leachate generated from the site. These include a comprehensive composite liner system, active gas extraction and control systems. With these measures the risk of sub-surface off-site migration of landfill gas and leachate can be effectively controlled. The base liner systems are designed as the LFG barrier to secure contaminant including multi-layer impermeable liners, to contain the LFG and the leachate generated during waste deposition. Details of the base liner system designed for the WENTX is shown in *Figure 1.9*.
- 2.3.3 Comprehensive environmental monitoring programme will be conducted during Construction, Operation, Restoration, and Aftercare of the WENTX to monitor the LFG generated within the WENTX, at the gas monitoring wells along the site boundary of WENTX. The blasting work is scheduled to be carried out in 6 Phases and during Phase 1, HKRRP will utilise the existing WENT's monitoring wells for carrying out landfill gas monitoring as the WENTX landfill gas monitoring boreholes have yet to be completed. However, HKRRP is committed to complete the proposed landfill gas monitoring boreholes along the WENTX waste boundary for both Phase 1 and 2 blasting areas while Phase 1 blasting work is being carried out and so on for subsequent phases. In other words, when the blasting work is completed for Phase 1, the landfill gas monitoring boreholes for subsequent phase (i.e. Phase 2) is also complete and likewise for subsequent Phases. After Phase 1 blasting work is completed, WENT's monitoring wells will no longer be needed as the next phase proposed monitoring wells would have already been constructed. The landfill gas monitoring will be carried out in accordance with the requirement either within 250m consultation zone of the WENT Landfill or within 250m from the waste boundary of the WENT landfill extension site. Comprehensive environmental monitoring programme will be conducted from Construction to Aftercare of the WENTX to monitor the LFG, refers to Fig 7.1, generated within WENTX. When operation commences, landfill gas monitoring will be carried out at gas monitoring wells already installed along the site boundary of WENTX.
- 2.3.4 Based on the terms stipulated in the WENTX contract, HKRRP is required to control the migration of LFG such that the concentration of methane and carbon dioxide at the perimeter LFG monitoring wells shall not exceed 1% by volume and 1.5% by volume above the

background concentration (measured before the operation of the WENTX) respectively. HKRRP will be required to control and monitoring of LFG and leachate during the Operation, the Restoration, and the Aftercare.

- 2.3.5 WENTX itself is one of the LFG sources generated during the Operation, the Restoration, and the Aftercares phases. The other source of LFG is associated with the decomposition of MSW landfilled at the existing WENT Landfill.

## 2.4 LOCATION OF WENT LANDFILL EXTENSION UNDER ENHANCED SCHEME

- 2.4.1 The updated WENTX site covering under Enhanced Scheme is reduced to about 94 hectares (ha) of land and it has been confirmed feasible to be provided approximately 76 million m<sup>3</sup> (Mm<sup>3</sup>) of additional landfill capacity.

- Eastern part of the Site is located in Tsang Kok Valley, which is a hilly terrain site sparsely vegetated with grass and limited patched of shrubs. The easterly ridge forms a boundary with the existing WENT landfill.
- Northern part is the Nim Wan Road and Tsang Tsui Ash Lagoons, T.PARK and Tsang Tsui Columbarium. The southern area is bounded by the natural topography, with ridgelines rising southwards from the coastline to meet the major east-west trending ridgeline.
- Southern part of the Site will be encroached onto the Tsing Shan Firing Range.

- 2.4.2 WENT Landfill Extension site is located within the 250m consultation zone of the existing WENT Landfill.

- 2.4.3 According to construction programme, the extension of tipping covering area will be divided into 6 tipping cells and total tipping volume of 76Mm<sup>3</sup> (refer to **Figure 2.1** for position of the tipping cells) under Enhanced Scheme. Construction period of each extension phase predicted that will take about 2 years, while their operation years will be immediately started afterwards.

## 2.5 GEOLOGY

- 2.5.1 As extracted from the EIA Report, the geological map in **Figure 2.2** indicated that the study area of the Original Scheme is mostly underlain by medium grained granite of the middle Jurassic to the late Cretaceous age, with megacrystic granite recorded in the south-eastern portion. This material has typically been weathered to soil within the upper 10m to 30m of the ground profile.

- 2.5.2 In the Enhanced Scheme shown in **Figure 1.4**, a NE-SW striking fault and associated zone of foliations were mapped along the section of Nim Wan Road between +65 to +55mPD. Several photoalignments were seen along the drainage valleys within along the eastern sides of the waste filling area. The nature of the zones are not revealed in the existing drillholes and may form zones of weaknesses that may have bearing on the intercepting rock slopes.

- 2.5.3 Several ENE-WSW aligning aplite dykes are located the southern portion of the waste filling area of the site. Groups of quartz veins trending NE-SW are also recorded along the southern portion of this part of the site. These features usually have higher resistance to weathering.

- 2.5.4 As shown in **Figure 1.4**, several faults and inferred faults were recorded within the study area. The four major faults are presented below:

- Faults 1 & 2: Another NNW-SSE striking fault lies along the topographic depression near the eastern boundary of the Study Area.
- Fault 3: A NE-SW striking fault running across almost the entire Study Areas. The fault roughly follows the alignment of Nim Wan Road.
- Fault 4: A SEE-NWW striking fault lies along the topographic depression near the western boundary of the Study Area. This fault line is actually outside the 250m LFG consultation zone from the waste boundary.

## 2.6 UTILITIES

2.6.1 The underground utilities (including the LFG collection pipes, electric cables, the telecommunication cables, water mains, sewage drains, stormwater drains, and the leachate pipes etc.) will be laid underground in services ducts within the consultation zone to the northern side of WENTX in Portion 10 of the site. The proposed utility services to WENTX are shown in *Figure 2.3*.

2.6.2 The surface drainage runoffs will be diverted from WENT Landfill to box culverts and will be built at the backfilling in Tsang Kok Stream Outfall.



### 3 LANDFILL GAS HAZARD ASSESSMENT METHODOLOGY

#### 3.1 GENERAL

3.1.1 WENTX site is located within the 250m consultation zone of the existing WENT Landfill, and the Project site itself is a potential source of landfill gas generation. Landfill Gas hazard assessment shall be required for the proposed developments within the 250m consultation zone of a landfill in accordance with “*Landfill Gas Hazard Assessment Guidance Note*”.

#### 3.2 REVIEW OF QUALITATIVE LANDFILL GAS HAZARD ASSESSMENT

3.2.1 The degree of risk of which LFG may create for a particular development is evaluated by adopting the procedure which is based on the “Source–Pathway–Target” method recommended in the Guidance Note on Landfill Gas Hazard Assessment, EPD, 1997 as described below:

- Source – location, nature and likely quantities/ concentrations of LFG which has the potential to affect the WENT Landfill Extension.
- Pathway – the ground and groundwater conditions, through which LFG must pass in order to reach the WENT Landfill Extension.
- Target – elements of the development that are sensitive to the effects of LFG.

3.2.2 The LFG sources, pathways and target 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 3-1**, following determination of which category of source, pathway and receiver, the combination of existing WENT Landfill and its extension fall into during the construction, operation, restoration and aftercare stages.

**Table 3-1 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

Source	Pathway	Receiver Sensitivity	Risk Category
	Long/ Indirect	High	Medium
		Medium	Low
		Low	Very low

3.2.3 For the purpose of categorising the WENT Landfill Extension, the category is based upon the highest level of risk determined for any of the potential impacts identified in *Table 3-1*, in which the general implications fall into different overall risk categories as shown in *Table 3-2*.

**Table 3-2 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.

3.2.4 There may be five generic forms of protection to be used corresponding to the five risk levels as set out in *Tables 3-3* and *3-4*.

**Table 3-3 Generic Protection Measures for Planning Stage Categorisation**

Category	Generic Protection Measures
A	For the planned development active control of gas, supported by barriers and detection systems. Another, less sensitive form of development should also be considered.
B	Active control of gas, including barriers and detection systems <sup>[1]</sup> .
C	Use of 'semi active' or enhanced passive gas controls. Detection systems in some situations
D	Passive control of gas only.
E	No precautionary measures required.

Note: <sup>[1]</sup> The gas protection measures required to allow the safe development of a Category A risk development will need to be more extensive than those for a Category B risk development.

**Table 3-4 Definition of Control Terms**

Term	Definition
Active control	Control of gas by mechanical means e.g. Ventilation of spaces with air to dilute gas, or extraction of gas from the development site using fans or blowers.
Semi active control	Use of wind driven cowls and other devices which assist in the ventilation of gas but do not rely on electricity powered fans.
Passive control	Provision of barriers to the movement of gas eg. 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
Detection systems	Electronic systems based upon, for example, catalytic oxidation or infra-red measurement principles, which can detect low concentrations

Term	Definition
	of gas in the atmosphere and can be linked to alarms and/or telemetry systems.

### 3.3 SOURCES OF LANDFILL GAS (LFG)

3.3.1 Based on the LFG Hazard Assessment Guidance Note, assessment of LFG is required for the proposed developments within the 250m consultation zone of a landfill. Since the WENTX is located within the 250m consultation zone of the existing WENT Landfill, and the WENTX itself is a potential source of LFG generation. Landfill Gas hazard assessment is required to undertake. The classification of the Source (i.e. the landfill) is determined as follows:

- **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 3 months (preferably longer), is less than 5 % by volume (v/v).
- **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.
- **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.

3.3.2 The existing WENT Landfill has implemented efficient and effective LFG management system which includes LFG monitoring, active extraction, collection, utilization, and flaring. The source of the LFG at the existing WENT Landfill should therefore remain the same as the approved WENTX EIA.

3.3.3 The workers within the site may be prone to the LFG hazards especially in those areas LFG is being extracted, transported, and processed. Control measures for the Enhanced Scheme of the proposed WENTX will remain the same as the approved WENTX EIA. The source of LFG will be properly controlled within the site similar to the operation in the existing WENT Landfill. The WENTX will be designed to adopt similar or more advanced LFG control measures to ensure full compliance of the environmental and safety requirements. The source of LFG at the proposed WENTX in the ES will remain the same as the approved WENTX EIA.

### 3.4 PATHWAYS OF LANDFILL GAS (LFG)

3.4.1 The type of pathways can be broadly classified based on various geological features of the landfill extension sites 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: path length of less than 50m for unsaturated permeable strata and fissured rock or less than 100m for man-made conduits;
- Moderately Short / Direct: Path length of 50-100m for unsaturated permeable soil or fissured rock or 100-250m for man-made conduits
- Long / Indirect: Path length of 100-250m for unsaturated permeable soils and fissured rock.

### 3.5 TARGET

3.5.1 Different types of targets that may be broadly classified as follows:

#### High Sensitivity

- 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 of 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 authorised, 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 virtue 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.

3.5.2 The above types of categories should be used as general guide only and particular aspects of a building or development may render it more or less sensitive than indicated. Consideration will be taken for any particular circumstances when assigning a target to one of the three categories.

3.5.3 A qualitative assessment of the overall risk is made based on the risk category as summarised above **Table 3-1**, which is excerpted from Guidance Note. 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 3-1**, in which the general implications fall into different overall risk categories as presented in **Table 3-2**.

## 4 DEVELOPMENT OF INTERCEPT LANDFILL GAS

### 4.1 DETAILED DESIGN

4.1.1 HKRRP has based on the findings and the recommendations of the final EIA report and the environmental review report for WENTX incorporated the relevant control measures in their detailed design of the WENTX infrastructure facilities. The assessment of this review has covered the evaluation of the LFG hazard with reference to the nature and characteristics of the targets, as well as the adequacy of the required relevant control measures. Recommendation will be made in this report for any further control measures required.

#### Description of the Infrastructure Area

4.1.2 According to the EIA and the Specification requirements and, the new site infrastructure areas Portion B1a, to B1c, B9 to B10 of WENTX within 250m consultation zone (refer to **Figure 1.5**). Location of Proposed Infrastructure Buildings and the proposed ground floor plans in the infrastructure area are separately from the existing WENT supporting facilities. As per the Guidance Notes (GN) for the consultation zone, the new site infrastructure area is located within 250m from the WENTX with part of it falls within the consultation zone for WENT waste boundary. As a result, the key risk sources for the new infrastructure area are the WENT and WENTX. The infrastructure area includes the following building/structures are presented as follows:

- Mobile Plant Facilities/ Vehicle Repair
- Crushing Plant – Product Bin, Line 2
- Crushing Plant – Storage Bin, (Final Products)
- Operation & Maintenance Building
- Permanent Office for the Service Manager & Contractor
- Leachate Treatment Works & Landfill Gas Service Building
- Community/Visitor Centre
- Toilet Block & drinking facility near Waste Reception Area (WRA)
- Guard House
- Crushing Plant – Product Bin, Line 1
- Crushing Plant – Surge Bins (Primary Crushed Rock)
- Leachate Treatment Works Facilities (Bioreactor Building)

4.1.3 There are also some other supporting facilities such as the car parking, vehicle maintenance yards, and the vehicle wash bay which are located at Portion B10 which are operated in open space or non-enclosed building. The potential of LFG accumulation within the facilities in this area is very low or unlikely to occur. As a result, they will not be further assessed in this report.

4.1.4 All the new infrastructure facilities will be operated and managed by HKRRP. The approximate distances from the WENTX waste boundary as defined in the GN to each of the target facilities in the new infrastructure area are reviewed and are presented in **Table 4-1** and shown on **Figure 1.6**.

**Table 4-1 Key Target Facilities in the New Infrastructure Area**

Item	Key Facilities	Approximately Distance from the WENTX waste boundary (m)	Distance from WENT Landfill (m)
1	Mobile plant facilities/ Vehicle repair (near Platform E)	39	254
2	Crushing plant – Product bin, Line 2 (25,000 tonnes) (next to WENT)	108	78
3	Crushing plant – Storage bins (Final products) (50,000 tonnes)	308	97
4	Toilet & drinking facility near Waste Reception Area (WRA)	342	61
5	Operation & Maintenance Building	91	264
6	Permanent Offices for the Service Manager & Contractor	208	183
7	LTW & LFG Service Building	318	197
8	Community/ Visitor centre	238	351
9	Weighbridge control room at WRA (inbound)	130	87
10	Weighbridge control room at WRA (outbound)	128	106
11	Guard house	148	188
12	Crushing plant – Product bin, Line 1 (25,000 tonnes) (next to WENTX)	55	123
13	Crushing plant – Surge bins (Primary crushed rock) (50,000 tonnes)	54	118
14	LTW facilities (bioreactor building)	232	313

Remarks: Based on Annex 7 of the Technical Memorandum on EIA Process (EIAOTM) and Landfill Gas Hazard Assessment: Guidance Note, EPD 1997, any development which is proposed within 250m of the edge of the waste, known as the Landfill Consultation Zone (LCZ), should be assessed of the potential risk that may be posed by LFG. The infrastructure areas (listed in **Table 4-1**) proposed for WENTX falls within the WENT Landfill and WENTX LCZ. A Qualitative Gas Hazards Assessment (QLFGHA) is accordingly done to evaluate the potential risk due to the LFG migration from WENT Landfill and WENTX.

## 4.2 CONSTRUCTION METHODOLOGY

4.2.1 Part of the site formation works for the WENTX Landfill area will be done by open face rock excavation methodology to generate the required landfill capacity within the allocated footprint. Extensive blasting and prolonged excavation period including the transportation and processing of significant volume of excavated material will be arranged within the context. The works will be maintained in a prioritised focus of operating in a safe and environmentally responsible manner during the construction stage. The site formation works for the landfill basal liner system will incur open excavation works. Temporary surface water drainage system such as ditches along the perimeter of the excavation locations and the material storage areas.

4.2.2 All blasting works including handling and use of explosives shall comply with the Licence to Possess and Discharge (Blasting) Permit for Schedule 1 Dangerous Goods issued by Mines Division of CEDD in accordance with the conditions outlined in Dangerous Goods

Ordinance, Chapter 295.

**4.3 SENSITIVE TARGET FACILITIES FOR LANDFILL GAS RISK**

Mobile plant facilities/ Vehicle repair (near Platform E)

4.3.1 The Service Manager Office Building is a 1-storey building for mobile plant and vehicle repair work. The ground floor covers a total area of approximate 817 m<sup>2</sup>. The building comprises a vehicle lifting platform, pantry, changing room, female and male toilet rooms which will be designed with mechanical ventilation system. The designed air change for each room is presented in **Table 4-2**.

**Table 4-2 Designed Air Change of the Mobile plant facilities/ Vehicle Repair**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Pantry	10
2	Changing room	15
3	Female toilet room	15
4	Male toilet room	15
5	Vehicle lifting platform	10

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

Crushing plant – Product Bin (Line 2)

4.3.2 The product bin (Line 2) is a steel storage compartment for the crushed rocks with the lateral sides of the compartment enclosed by steel walls of different thickness at different levels. It is installed on ground floor level with an area of approximately 35m x 110m (long) which include a Reclaim Tunnel for transportation of the crushed rocks with passive and active ventilation system installed at regular intervals to prevent accumulation of LFG. The designed protection ventilation measure of Line 2 Product Bin is presented in **Table 4-3**.

**Table 4-3 Designed Air Change of the Crushing Plant – Product Bin (Line 2)**

No.	Room	Protection Measure <sup>(Note 4)</sup>
1	Reclaim Tunnel	Passive and active ventilation system installed inside the Reclaim Tunnel

*Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.*

Crushing plant – Storage Bin (Final Product)

4.3.3 Similar to product bin the Storage Bin (final product) is a steel storage compartment for the crushed rocks with the lateral sides of the compartment enclosed by steel walls of different thickness at different heights. The top of the Storage Bin is installed with passive and active ventilation system for venting of air or in the event methane gas is detected within the Storage Bin. The designed protection ventilation measure of the Storage Bin is presented is presented in **Table 4-4**.

**Table 4-4 Designed Air Change of the Crushing Plant – Storage Bin (Final Product)**

No.	Room	Protection Measure <sup>(Note 4)</sup>
1	Reclaim Tunnel	Passive and active ventilation system installed at the top of the Storage Bin

*Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.*

Toilet & Drinking Facility near WRA

4.3.4 The Toilet and Drinking Facility is a 1-storey building which includes a male toilet and female toilets for the drivers. The building will be provided with mechanical ventilation system. The designed air change of each room is presented in **Table 4-5**.

**Table 4-5 Designed Air Change of the Toilet & Drinking Facility near WRA**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Male driver toilet	15
2	Female driver toilet	15

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

Operation & Maintenance (O&M) Building

4.3.5 The O&M building is 1-storey building with ground floor area around 1,200m<sup>2</sup>. It comprises the Male and Female Toilets, Locker & Changing Rooms, Accessible Toilet, E&M Rooms, Pantry/Mess Room, First Aid Room, Offices for Operation Supervisor, Operation Manager, and Maintenance Manager, Parts, Tool/Storage, Maintenance Workshop, Machine/vehicle Wash Area, and a Container Storage Area. The design air change for each room and the protection measure for the Container Storage are presented in **Table 4-6**.

**Table 4-6 Designed Air Change of the Ground Floor Rooms of the O&M Workshop Building**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Male toilet, shower, locker & changing room	15
2	Convertible shower	15
3	Female toilet, shower, locker & changing room	15
4	Accessible toilet	15
5	Electrical room	10
6	ELV room	10
7	Janitor room	6
8	Accessible toilet	10
9	Pantry. Mess Room	10
10	Reception	1.1L/s/m <sup>2</sup> or 10L/s/person
11	Meeting room 1 & 2	1.1L/s/m <sup>2</sup> or 10L/s/person
12	First Aid room	10
13	Operation Supervisor Room	1.1L/s/m <sup>2</sup> or 10L/s/person
14	Operation Manager Room	1.1L/s/m <sup>2</sup> or 10L/s/person
15	Pantry	10
16	Maintenance Manager	1.1L/s/m <sup>2</sup> or 10L/s/person
17	Parts, tools/Storage	6
18	Maintenance workshop	10
19	Toilet 1	15
20	Toilet 2	15
21	Machine/vehicle wash area	10
22	Container storage area	Natural Ventilation & Raised floor <sup>(Note 2)</sup>



No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
<p><i>Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.</i></p> <p><i>Note 2: Storage Containers will be raised above ground floor level.</i></p>		

Permanent Service Manager & the Contractor Office Building

4.3.6 The Permanent Service Manager and the Contractor Office Building is a 1-storey building. The ground floor covers a total area of approximately 1,200 m<sup>2</sup>. The Ground level rooms include Office Area, Meeting Room, and Plant Room. These areas will be provided with mechanical ventilation system and air conditioning. The designed air change for each room in the Service Manager and the Contractor Office Building is presented in **Table 4-7** and **Table 4-8** respectively.

**Table 4-7 Designed Air Change of Service Manager Office Building**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Staff dining room	10
2	Female washroom	15
3	Male washroom	15
4	Pantry	10
5	Locker & changing room	10
6	Meeting room/Conference room x 3	1.1L/s/m <sup>2</sup> or 10L/s/person
7	Reception	1.1L/s/m <sup>2</sup> or 10L/s/person
8	Interview room	1.1L/s/m <sup>2</sup> or 10L/s/person
9	Multi-purpose room i) Senior inspector room ii) Inspector room iii) Office/Engineer room	1.1L/s/m <sup>2</sup> or 10L/s/person
10	Open office area for Clerical Officers, Environmental Protection Inspectors, Assistant Professional Engineers, Senior Environmental Protection Inspectors, Chief Environmental Protection Inspector, Head of Community Outreach, Community Relations Officer, & the Environmental Protection Officers	1.1L/s/m <sup>2</sup> or 10L/s/person
11	General office furniture & equipment	1.1L/s/m <sup>2</sup> or 10L/s/person
12	Special storage room cum monitoring room	10
13	Central Battery Systems (CBS) room	10
14	Bottle room	10
15	IT LAN/Server room (include bottle room)	10
16	Telecommunications and. Broadcasting Equipment Bedroom (TBE) room	10
17	Private Automatic Branch Exchange (PABX) room	10
18	Uninterruptible Power Supply (UPS) room	10
19	Electrical Room (EL) room	10
20	Extra Low Voltage (ELV) room	10

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
21	File & general storage	10

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 4-8 Designed Air Change of Permanent Contractor Office Building**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	PAU room	10
2	ELV room	10
3	EL room	10
4	UPS room	10
5	PABX room	10
6	TBE room	10
7	CBS room	10
8	Office area	1.1 L/s/m <sup>2</sup> or 10L/s/person
9	Open pantry	10
10	Accessible washroom	15
11	Male washroom & shower	15
12	Male locker & changing room	15
13	PPE/Equipment storage	10
14	Operation file storage	10
15	Bottle room	10
16	LAN server room (include bottle room)	10
17	Lactation room	1.1 L/s/m <sup>2</sup> or 10L/s/person
18	General office & furniture & equipment	10
19	Female toilet & shower	15
20	Female locker & changing room	15

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

LTW & LFG Service Building & Facilities

4.3.7

The Leachate Treatment Works and Landfill Gas (LTW & LFG) Service Building is designed as a 1-storey building, with a ground floor covering a total area of approximately 2,300m<sup>2</sup>. The ground level rooms are separated to sections by a corridor which include Office Room, Laboratory, Female/ Male Toilets, Control Room, Workshop, Pantry, Fire Services Tank and Pump Room, Absorption Chiller Plant Room, Sewage Recycled Treatment Plant/ Rainwater Recycled Treatment Plant/ Irrigation Room, the E&M Rooms, Fuel Tank Room, MCC Room, F.S.I. Genset Room, and the CLP transformer Room etc. There are also 3 Combined Heat and Power landfill gas engines located next to the LTW & LFG Service Building. These engines are housed in specially designed container unit which is equipped with built-in cogeneration module ventilation system. Mechanical ventilation system will be provided for the rooms in this area. The designed air change for each room and the protection cogeneration modular ventilation system are presented in **Table 4-9**.

**Table 4-9 Designed Air Change of the Ground Floor Rooms & the Protection Ventilation Measure of the LTW & LFG Service Building & Facilities**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Male Toilet	15
2	Female Toilet	15
3	Pantry	10
4	FS tank and pump rooms	10
5	FS Control Room & FS inlet	5
6	Workshop	10
7	Absorption Chiller Plant Room	10
8	Sewage Recycled Treatment Plant/Rainwater Recycled Treatment Plant/Irrigation Room	10
9	PV/Elec Room	10
10	ELV Room	10
11	TBE Room	10
12	UPS Room	10
13	Office Room	1.1 L/s/m <sup>2</sup> or 10L/s/person
14	Laboratory	10
15	Master meter room	10
16	Plumbing pump room	10
17	Fuel tank room	10
18	MCC room	10
19	F.S.I genset	10
20	Control room	5
21	CLP transformer room	10
22	CHP Landfill gas generator	Cogeneration module of ventilation system <sup>(Note 3)</sup>
<p><i>Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.</i></p> <p><i>Note 3: Cogeneration module of ventilation system is built-in for the CHP Landfill Gas Generator</i></p>		

Community/ Visitor Centre

4.3.8 The Visitor Centre is a 1-storey building. The ground floor occupies a total area of approximately 500m<sup>2</sup>. The Ground level rooms include Exhibition Room, Meeting Room, and Toilets. These areas will be provided with mechanical ventilation or air conditioning with natural ventilation. The designed air change for each room is presented in **Table 4-10**.

**Table 4-10 Designed Air Change of Visitor Centre**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Male Washroom	15
2	Female Washroom	15
3	Accessible Washroom	15
4	Meeting Room/Multi-purpose Room	1.1 L/s/person and 10 L/s/m <sup>2</sup>
5	Exhibition Room	0.6 L/s/m <sup>2</sup> and 3.8 L/s/person
6	Reception	1.1L/s/m <sup>2</sup> or 10L/s/person
7	Guard House	5

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
<i>Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.</i>		

Weighbridge Control Room in WRA (Inbound and Outbound)

4.3.9 The Weighbridge Control Room is a reinforced concrete structure which is located next to the inbound weighbridges and the outbound weighbridges for monitoring weighing of the refuse collection vehicles. Each weighbridge control room consists of the weighbridge supervisor's office, the pantry, the control room, and the individual waste reception area (WRA) & drinking facility near WRA which is located next to the Control Room. These rooms will be provided with mechanical ventilation or air conditioning with natural ventilation. The designed air change for each room is presented in **Table 4-11**.

**Table 4-11 Designed Air Change of the Weighbridge Control Room (Inbound and Outbound)**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Weighbridge supervisor's office	1.1 L/s/person and 10 L/s/m <sup>2</sup>
2	Pantry	10
3	Toilet	15
<i>Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.</i>		

Guard House

4.3.10 The Guard House is single block building provided with toilet room. The room will be provided with mechanical ventilation or air conditioning with natural ventilation. The designed air change for toilet room is presented in **Table 4-12**.

**Table 4-12 Designed Air Change of the Guard House**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Control room	6
2	Toilet	15
<i>Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.</i>		

Crushing plant – Product Bin, Line 1 (next to WENTX)

4.3.11 Similar to Product Bin Line 2, the Product Bin Line 1 is a steel storage compartment for the crushed rocks with the lateral sides of the compartment enclosed by steel walls of different thickness at different height. It is installed on ground floor level with an area of approximately 35m x 110m (long) which includes a semi-cylindrical Reclaim Tunnel for transportation of the crushed rocks/ Extended conveyor belt is installed through the tunnel to downstream Final Product Bin. The movement of the conveyor belt for conveying the crushed product downstream induces air current in and out of the Reclaim Tunnel. Passive and active ventilation system will be installed at the soffit of the tunnel for air purging in the event that methane gas is detected by the gas alarm system. The protection measure for the Reclaim Tunnel of the Product Bin Line 1 is presented in **Table 4-13**.

**Table 4-13 Designed protection measure of the Reclaim Tunnel in the Product Bin (Line 1)**

No.	Room	Other Protection Measure <sup>(Note 4)</sup>
1	Reclaim Tunnel inside the Product Bin area	Passive and active ventilation system installed inside the Reclaim Tunnel
<i>Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.</i>		

Crushing plant – Surge bins (Primary crushed rock) (50,000 tonnes)

4.3.12 The Surge Bin is a 25m x 53m x 86.5m (Height) reinforced concrete compartment for the crushing plants with the lateral walls covering a total 8-storey. Extended conveyor belt is installed through the tunnel to downstream Product Bin Line 1 and Line 2. The movement of the conveyor belt for conveying the crushed product downstream induces air current in and out of the Reclaim Tunnel. Passive and active ventilation system will be installed at the soffit of the tunnel for air purging in the event that methane gas is detected by the gas alarm system. The protection ventilation measure of the Surge Bin is presented in **Table 4-14**.

**Table 4-14 Designed Protection Ventilation Measure of the Surge Bin**

No.	Room	Other Protection Measure <sup>(Note 4)</sup>
1	Surge bin	Passive and active ventilation system installed inside the Reclaim Tunnel
<i>Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.</i>		

Leachate Treatment Works (LTW) Facilities (Bioreactor Building)

4.3.13 The Leachate Treatment Work Facilities (Bioreactor Building) is a single-storey structure with floor area of approximately 3,500m<sup>2</sup>. Part of the area (approximately 2,600m<sup>2</sup>) is utilized for housing the post-aerobic tank, post-anoxic tank, pre-aerobic tank, pre-anoxic tank, and the air blower system. The remaining area is open top and not bounded, therefore no ventilation system is required. The building will house the plant and equipment for the leachate treatment system and will be provided with mechanical ventilation. The design air change in the LTW Bioreactor Building is presented in **Table 4-15**

**Table 4-15 Designed Air Change of the Bioreactor Building**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Common process room	10
<i>Note 1: A higher air change rate is maintained with air re-circulation.</i>		

## **5 QUALITATIVE ASSESSMENT OF RISK DUE TO LANDFILL GAS**

### **5.1 INTRODUCTION**

5.1.1 This section reviews the information presented in the preceding sections and evaluate the data presented with reference to the assessment definitions provided in the EPD Guidance Note on LFG Hazard Assessment. Conclusion is then presented for the qualitative assessment of the potential hazard from LFG to the proposed targets.

### **5.2 SOURCE**

5.2.1 Both the WENTX and the existing WENT Landfill will be the source of potential risk of LFG migration. They have the same potential for LFG generation. The source of LFG at the existing WENT Landfill and WENTX are classified as Medium. The 250m consultation zones for these sites are presented in *Figure 1.3*.

### **5.3 EXISTING WENT LANDFILL**

5.3.1 The existing WENT Landfill is a large strategic operating landfill of which the potential source for LFG generation is significant. It was designed, constructed to incorporate the international best practices to contain, manage, and control the waste and LFG. It is operated by a specialist waste management contractor which possesses world-wide landfill experiences in design, construction, operation, restoration, and aftercare of landfills.

5.3.2 The potential off-site LFG gas migration information of the existing WENT Landfill is assessed. Given that comprehensive and effective LFG collection and management system that has been installed and is being operated. There is no sign of gas (in terms of methane) migration to date. Given the size of the WENT Landfill and the multiple LFG controls implemented and the WENT Landfill was classified as “Medium” source of the potential landfill gas risk based on the LFG Guidance Note as presented in the EIA Report. This is also applicable to the Enhanced Scheme.

### **5.4 WENT LANDFILL EXTENSION (WENTX)**

5.4.1 WENTX is identified as a source to generate discernible quantities of LFG during the operation, restoration, and the aftercare phases which could be hazardous to the frontline workers within the site. HKRRP will implement effective LFG control measures on the LFG collection and the energy recovery facilities in the WENTX. It is anticipated that the source of LFG could be effectively controlled within the site similar to those that are being operated by the existing WENT Landfill contractor.

5.4.2 Under the Enhanced Schemed WENTX will be designed as a containment site with an area of 94 ha for 76 Mm<sup>3</sup> of void space. In addition to the base and side liners, the leachate and LFG collection and management systems, a final cap will be constructed to minimise the emission of LFG and the surface water infiltration. The final cap will be designed and constructed to facilitate progressively restoration of the landfill in parallel with the operation of the landfill and to eliminate any off-site migration of LFG.

5.4.3 Based on the LFG monitoring records of the WENT Landfill which demonstrate the effectiveness of the control measures on the LFG collection and utilization systems that have been implemented on site, similar LFG control measures will be adopted at WENTX for environmental and safety compliance requirements.

## 5.5 POTENTIAL PATHWAY OF LFG PASS THROUGH THE WENTX SITE

5.5.1 There are three potential pathways through which landfill gas may pass through the WENTX Site. These potential pathways include passing through:

- the natural fissures or joints in rocks;
- the man-made pathways such as the permeable backfill in utilities trenches; or
- a combination of both the above transmissions.

5.5.2 Each type of transmission is dependent upon the geological and hydrogeological conditions. The following sections discussed in detail about the likely potential respect to the above mentioned.

## 5.6 WITHIN THE SITE OF WENTX

### Nature Pathways

#### Within WENTX

5.6.1 The natural pathways that have been identified in the approved WENTX EIA within the waste boundary of WENTX includes the fault 1 and fault 2 that are crossing the existing WENT Landfill toward the eastern part of WENTX as shown in *Figure 1.4*. These are fissure rocks which are prone to LFG migration and are categorized as Very Short/Direct as the path length is less than 50m.

#### Outside WENTX

5.6.2 As mentioned in section 1.2.1 that under the ES, the waste boundary has been diminished to 94 ha, from 188 ha in the Original Scheme. Due to the reduced size of the waste boundary, the boundary of 250m consultation zone has been revised. According to the updated site boundary, I.PARK 2 would be located within the 250m consultation zone of WENTX landfill and it is considered to be a further receiver. Since I.PARK 2 is classified as a Designated Project, a LFG hazard assessment associate with the landfill gas migration from the WENTX Landfills will be conducted. With the implementation of appropriate mitigation measures, adverse impact of landfill gas hazard is not anticipated.

### Man-Made Pathways

5.6.3 During the landfill operations, pipes and conduit laying, drilling and boring operation will be performed. There will be pathways to the sensitive receivers which have been identified as Very Short/Direct towards the WENTX site. The landfill workers could be the targets due to the man-made pathways in the vicinity of the site which have services routes leading to the site. The potential for surface migration of LFG from WENTX waste boundary to the future infrastructure area will include both the reclamation fill and the future utilities connecting the infrastructure area. It is known that the new infrastructure area will be located in area B10 of the WENTX site. Among all utilities, electricity and telecommunications cables will provide a direct man-made pathway for the transmission of LFG. Therefore, LFG control measures such as seal cable duct with bentonite need to be taken to minimise the potential risk.

5.6.4 Based on the information from the detailed design of the distances and the possible migration pathways between the WENTX waste boundary and the proposed individual target in the new infrastructure area, the pathway for LFG migration from the WENTX waste boundary to the individual target will be classified three categories shown in below *Table 5.1*.

- a) <50 m as Very short/ Indirect

- b) 50~100 m as Moderately short/ Indirect
- c) 100~250 m as Long/ Indirect.

## 5.7 OUTSIDE THE SITE OF WENTX

### Nature Pathways

5.7.1 As mentioned in section 1.2.1 that under the ES, the waste boundary has been diminished to 94 ha, from 188 ha in the Original Scheme. Due to the reduced size of the waste boundary, the boundary of 250m consultation zone has been revised. According to the updated site boundary, I.PARK 2 would be located within the 250m consultation zone of WENTX landfill and it is considered to be a further receiver. Since I.PARK 2 is classified as a Designated Project, a LFG hazard assessment associate with the landfill gas migration from the WENTX Landfills will be conducted. With the implementation of appropriate mitigation measures, adverse impact of landfill gas hazard is not anticipated.

### Man-Made Pathways

5.7.2 Although there are man-made pathways in the vicinity of the site consisting of services pipes and trenches leading through the existing landfill, they are far beyond the sensitive receivers and are classified as Long/In direct toward the adjacent occupied development.

**Table 5-1 Classification of Landfill Gas Migration**

No.	Targets	Pathway description	Classification
1	Mobile plant facilities/ Vehicle repair (near Eastern Platform)	Path length of less than 50m for unsaturated permeable strata or less than 100m for man-made conduits	Very Short/ Direct
2	Crushing plant – Product bin, Line 2	Path length of 50m to 100m for unsaturated permeable soil or 100 to 250m for man-made conduits	Moderately Short/ Direct
3	Crushing plant – Storage bins (Final products)		
4	Toilet & drinking facility near WRA		
5	Operation & Maintenance Workshop Building		
6	Permanent offices for Service Manager & Contractor	Path length of 100 to 250m for unsaturated permeable soil	Long/ Indirect
7	LTW & LFG Service building & facilities		
8	Community/ Visitor centre		
9	Weighbridge control rooms (inbound & outbound)		
10	Guard house		
11	Crushing plant – Product bin, Line 1		
12	Crushing plant – Surge bins (Primary crushed rock)		
13	LTW facilities (bioreactor building)		
14	Temporary Site Offices		



## 5.8 TARGETS

### Within the Site of WENTX

- 5.8.1 The LFG hazards may pose related impacts to the workers and staff at below ground or in areas of WENTX. The targets identified in the Enhanced Scheme are presented below.

#### Target 1 - Construction Phase of the WENTX

- 5.8.2 As shown in **Figures 1.5** and **1.6**, part of the WENTX infrastructure site falls within the 250m landfill consultation zone of the WENT Landfill. Blasting works will be incorporated to form cut slope for the construction of the landfill bowl. Excavation for construction of the buildings and site management and the treatment process facilities are expected. The works area includes unventilated trenches for utilities installation, chambers or confined space, if any, are at a higher risk of exposure to LFG. Open cut method will generally be adopted for any excavation works which include the construction of trenches, though deep excavations may be necessary. In the event that any LFG migrated to the site, it will be dispersed and diluted through atmosphere pressure condition. Construction works involving work in confined spaces will be undertaken by workers who have received recognized training.

- 5.8.3 The temporary site offices (location refer to **Figure 1.5**) for both the HKRRP and the Service Manager and his team during the construction phase will be provided with multiple LFG control measures (see **Figures 5.1 & 5.2**). These include the provision of passive ventilation system, penetrating concrete and masonry sealer and the continuous gas monitoring system for all occupied on-site buildings. If combustible gas is detected, it will trigger an alarm signal in the central control room for immediate contingency response. The target is accordingly classified as “Low Sensitivity” for the Enhanced Scheme.

#### Target 2 - Operation Phase of the WENTX (Tipping Face)

- 5.8.4 Part of the waste tipping face will be carried out within the 250m Landfill Consultation Zone of the WENT Landfill. Waste tipping will be in the open air but without any work in confined space. WENTX is also a source of LFG, any migration of LFG to WENTX will either be diluted or dispersed into the open atmosphere or be recovered by the landfill gas collection system at WENTX. Nevertheless, there are also drivers of the refuse collection vehicles (RCV) who will have access to this area for waste tipping from their RCV. LFG safety leaflet will be distributed to Refuse collection vehicle (RCV) drivers and their helpers at the landfill entrance. Other users should receive safety induction training before entering the tipping face which includes the LFG hazards. In view of this scenario, this target is thus classified as “Medium Sensitivity” under the Enhanced Scheme.

#### Target 3 - Operation Phase of the WENTX (Infrastructure Area)

- 5.8.5 Almost all the proposed buildings in the new infrastructure area of WENTX fall within the 250 m landfill consultation zone of WENTX and the existing WENT. Assessments are conducted for those building rooms and structures that are at ground floor level. All services ducts and confined spaces at ground floor level and at the waste reception area of the WENTX were identified as “Medium Sensitivity” in the approved EIA Report.

## 5.9 TARGET OUTSIDE THE WENTX SITE

- 5.9.1 As mentioned that the size of the waste boundary for the Enhanced Scheme has been reduced. According to the updated site boundary, I.PARK 2 would be located within the 250m consultation zone of WENTX landfill and it is considered to be a further receiver. Since I.PARK 2 is classified as a Designated Project, a LFG hazard assessment associate

with the landfill gas migration from the WENTX Landfills will be conducted. With the implementation of appropriate mitigation measures, adverse impact of landfill gas hazard is not anticipated.

5.9.2 Based on the guidance given in EPD’s Guidance Note, the sensitivity of all targets in the infrastructure area is summarised in **Tables 5-2 and 5.3**. All targets are rated as “Low” after incorporation of control measures in detailed design. Multiple options for LFG control measures will be utilised in the detailed design, for example in below.

a. Gas barrier

- impermeable gas membrane to be installed below the base slab of the building; or
- the internal floor slab of the ground floor rooms will be painted with low gas permeability paints; and

b. Ventilation

- ground floor rooms will be provided with mechanical or natural ventilation to prevent potential accumulation of landfill gas; and

c. Gas alarm

- all occupied on-site buildings will be provided with gas alarm;
- check the fixed gas detector by the calibration gas at least once 6 monthly in order to verify the accuracy and alarm function of the fixed gas detector.
- calibration / inspection records will be maintained; and
- 2 levels of gas control will be set up. The first level is the trigger limit of which the set point is 10% LEL. If the trigger limit is activated, the on-site Registered Safety Officer (RSO) will be informed immediately who will then initiate the follow-up actions. The second level is action limit of which the set point is 20% LEL. If the action limit is activated, all personnel within the permanent building will be evacuated.

**Table 5-2 Sensitivity of Target 1 within WENTX consultation zone**

Target	Sensitivity of Infrastructure Area	Sensitivity	
		Preliminary analysis	With incorporation of Control Measures in Detailed Design
1.1	Crushing Plant – (Compartment for detonator storage)	Medium	Low
1.2	Reclaim Tunnel of Crushing Plant - Product Bin (Line 2) (25,000 tonnes)	Medium	Low
1.3	Reclaim Tunnel of Product Bin Line 1 of the Crushing Plant	Medium	Low
1.4	Reclaim Tunnel of the Surge Bin, Crushing Plant	Medium	Low
1.5	Temporary Site Offices	Medium	Low
a) Description / Proposed mitigation measures <ul style="list-style-type: none"> <li>• Above ground room / storage;</li> <li>• With passive and active ventilation system;</li> <li>• With gas-proofing coating applied on top of all ground floor slab or liner protection or raised floor;</li> <li>• With gas alarm; and</li> <li>• Restricted access by authorized personnel</li> </ul> b) Preliminary analysis - sensitivity is Medium c) Incorporation of control measures in detailed design, sensitivity of infrastructure is analysed as low			

**Table 5-3 Sensitivity of Target 3 within WENTX consultation zone**

Target	Sensitivity of infrastructure area	Sensitivity	
		Preliminary analysis	With incorporation of Control Measures in Detailed Design
3.1	a. Pantry, Vehicle Lifting Platform of Mobile plant facilities / Vehicle repair b. Changing room, Female toilet room, Male Toilet Room of Mobile plant facilities / Vehicle repair	Medium to High	Low
3.2	Male & Female Toilet Rooms of Toilet & Drinking Facility Near WRA	Medium to High	Low
3.3	a. Male & Female Toilet/Shower/Locker & Changing Room, Accessible Toilet, Toilet 1 & 2 Rooms of O&M Workshop Building b. Pantry (Mess room), Electrical Room, ELV Room, Pantry/Mess Room, First Aid Room, Pantry, Machine / Vehicle Wash Area, Maintenance Workshop of O&M Workshop Building c. Reception, Meeting Room 1 & 2, Operation Supervisor Room, Operation Manager Room, Maintenance Manager Room of O&M Workshop Building d. Janitor room, Parts/Tools Storage of O&M Workshop Building	Medium to High	Low
3.4.1	a. Female & Male Washrooms of the Service Manager Office Building b. Staff Dining Room, Pantry, Locker & Changing Room, Special storage room cum monitoring room, CBS Room, Bottle Room, IT LAN/Server Room (include Bottle Room), TBE Room, PABX Room, UPS Room, EL Room, ELV Room, File & General Storage of the Service Manager Office Building c. Meeting Room / Conference Rooms, Reception, Interview Room, Multi-purpose Room, Senior Inspector Room, Inspector Rooms, Officer / Engineer Rooms, General Office Furniture & Equipment, Clerical Officers, Environmental Protection Inspectors, Assistant Professional Engineers, Chief Environmental Inspector, Head of Community Outreach, Community Relations Officer, Environmental Protection Officers of the Service Manager Office Building	Medium to High	Low
3.4.2	a. Accessible washroom, Male washroom & Shower room, Male Locker & Changing Room, Female Toilet & Shower & Locker & Changing Room of the Contractor Office Building b. PAU Room, ELV Room, EL Room, UPS Room, PABX Room, TBE Room, CBS Room, Open Pantry, PPE/Equipment Storage, Operation File Storage, Operation File Storage, Bottle Room, LAN Server Room (include Bottle Room) of the Contractor Office Building c. Open Office Area & Cellular Office (General Manager Room), Lactation Room, General Office & Furniture & Equipment of the Contractor Office Building	Medium to High	Low
3.5	a. Male Toilet & Female Toilet of the LTW & LFG Service Building & Facilities b. Pantry, FS Tank & Pump Room, Workshop, Absorption Chiller Plant Room, Sewage Recycled Treatment Plant/Rainwater Recycled Treatment Plant / Irrigation	Medium to High	Low

Target	Sensitivity of infrastructure area	Sensitivity	
		Preliminary analysis	With incorporation of Control Measures in Detailed Design
	Room, PV/Elec Room, ELV Room, TBE Room, UPS Room, Laboratory, Meter Room, Plumbing Pump Room, Fuel Tank Room, MCC Room, FSI Genset Room, CLP Transformer Room of the LTW & LFG Service Building & Facilities c. Office Room of the LTW & LFG Service Building & Facilities d. FS Control Room & FS Inlet, Control Room of the LTW & LFG Service Building & Facilities e. CHP Landfill Gas Generators of the LTW & LFG Service Building & Facilities		
3.6	a. Male Washroom, Female Washroom & Accessible Washroom of the Visitor Centre b. Meeting Room/Multi-purpose Room, Exhibition Room, Reception of the Visitor Centre c. Guard House of the Visitor Centre	Medium to High	Low
3.7	a. Control Room of the Weighbridge Control Room (Inbound) b. Pantry of the Weighbridge Control Room (Inbound) c. Toilet rooms of the Weighbridge Control Room (Inbound)	Medium to High	Low
3.8	a. Control Room of the Weighbridge Control Room (Outbound) b. Pantry of the Weighbridge Control Room (Outbound) c. Toilet rooms of the Weighbridge Control Room (Outbound)	Medium to High	Low
3.9	a. Control room of the Guard House b. Toilet of the Guard House	Medium to High	Low
3.10	Common Process Building of the LTW Facilities (Bioreactor Building)	Medium	Low
3.11	Crushing Plant – (Compartment for detonator storage)	Medium	Low
3.12	Reclaim Tunnel of Crushing Plant - Product Bin (Line 2) (25,000 tonnes)	Medium	Low
3.13	Reclaim Tunnel of Product Bin Line 1 of the Crushing Plant	Medium	Low
3.14	Reclaim Tunnel of the Surge Bin, Crushing Plant	Medium	Low
	a) Description / Proposed mitigation measures <ul style="list-style-type: none"> <li>● Above ground room / storage;</li> <li>● With passive and active ventilation system;</li> <li>● With gas-proofing coating applied on top of all ground floor slab or liner protection or raised floor;</li> <li>● With gas alarm; and</li> <li>● Restricted access by authorized personnel</li> </ul> b) Preliminary analysis - sensitivity is Medium to High c) Incorporation of control measures in detailed design, sensitivity of infrastructure is analysed as low		

## 5.10 SOURCE – PATHWAY – TARGET ANALYSIS

5.10.1 Based on the source, pathways and targets identified in the precedent section, a source-pathway-target analysis for the Enhanced Scheme has been performed and is presented in **Table 5-4** in accordance with the assessment framework described in the LFG Hazard Assessment Guidance Notes. A range of the overall potential hazards results from different

combination of source, pathway, and target.

**Table 5-4 Qualitative Assessment of Landfill Gas Hazard Associated with the WENTX in the Enhanced Scheme**

Source	Pathway	Target	Qualitative Risk
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <i>Category: Medium</i>	<ul style="list-style-type: none"> <li>Fissured rock, Fault 1 and 2 across the WENT Landfill towards the WENTX with potential natural pathways for preferential LFG migration, distance &lt;50m</li> <li>Superficial deposits below the formation level to the south of the landfill extension fill for LFG migration towards the Waste Reception Area of the existing WENT landfill, distance &lt;50m</li> </ul> <i>Category: Very Short/Direct</i>	Target 1a - Construction Phase of the WENTX:- <ul style="list-style-type: none"> <li>Blasting works for slope cutting</li> <li>Excavation for construction of new landfill bowl</li> </ul> <i>Category: High sensitivity</i>	<b>High</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <i>Category: Medium</i>	<ul style="list-style-type: none"> <li>Fissured rock, Fault 1 and 2 across the WENT Landfill towards the WENTX with potential natural pathways for preferential LFG migration, distance &lt;50m</li> <li>Superficial deposits below the formation level to the south of the landfill extension fills for LFG migration towards the Waste Reception Area of the existing WENT landfill, distance &lt;50m</li> </ul> <i>Category: Very Short/Direct</i>	Target 1b – Construction phase of the WENTX:- <ul style="list-style-type: none"> <li>Deep unventilated excavations and trenches for utility installation and underground chamber excavation</li> </ul> <i>Category: High sensitivity</i>	<b>High</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <i>Category: Medium</i>	<ul style="list-style-type: none"> <li>Fissured rock, Fault 1 and 2 across the WENT Landfill towards the WENTX with potential natural pathways for preferential LFG migration, distance about 50-100m</li> <li>Superficial deposits below the formation level to the south of the landfill extension fills for LFG migration towards the Waste Reception Area of the existing WENT landfill, distance about 50-100m</li> </ul> <i>Category: Moderate Short/Direct</i>	Target 1.1 & 1.2 – Construction Phase of the WENTX:- <ul style="list-style-type: none"> <li>Crushing Plant – Product Bins (Line 2), and Final Storage Bins</li> </ul> <i>Category: Low sensitivity</i>	<b>Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation	<ul style="list-style-type: none"> <li>Fissured rock, Fault 1 and 2 across the WENT Landfill towards the WENTX with potential natural pathways for preferential LFG migration, distance about</li> </ul>	Target 1.3 & 1.4 – Construction Phase of the WENTX:- <ul style="list-style-type: none"> <li>Crushing Plant - Product Bins (Line 1), &amp; Surge Bin</li> </ul> <i>Category: Low Sensitivity</i>	<b>Very Low</b>

Source	Pathway	Target	Qualitative Risk
installed. <b>Category: Medium</b>	100-250m <ul style="list-style-type: none"> <li>Superficial deposits below the formation level to the south of the landfill extension fills for LFG migration towards the Waste Reception Area of the existing WENT landfill, distance about 100-250m <b>Category: Long/Indirect</b></li> </ul>		
WENT Landfill - potential for gas generation over time, but proven mitigation and training. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Fill materials between the WENT Landfill and WENTX with potential direct manmade conduits, distance to waste boundary, about 50-100m</li> <li><b>Category: Moderately Short /Direct</b></li> </ul>	Target 2 (Tipping face of WENTX) – <ul style="list-style-type: none"> <li>LFG safety leaflet will be distributed to Refuse collection vehicle (RCV) drivers and their helpers at the landfill entrance. Other users should receive safety induction training before entering the tipping face which includes the LFG hazards. <b>Category: Medium sensitivity</b></li> </ul>	<b>Medium</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conduits, distance to waste boundary, about 50-100m <b>Category: Moderately Short /Direct</b></li> </ul>	Target 3.2 – Infrastructure Area of the WENTX:– <ul style="list-style-type: none"> <li>Male &amp; Female Toilet Rooms of Toilet &amp; Drinking Facility Near WRA <b>Category: Low sensitivity</b></li> </ul>	<b>Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conduits, distance to waste boundary, about 50-100m <b>Category: Moderately Short /Direct</b></li> </ul>	Target 3.7a –Infrastructure area of the WENTX:– <ul style="list-style-type: none"> <li>Control Room of the Weighbridge Control Room (Inbound) <b>Category: Low sensitivity</b></li> </ul>	<b>Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conduits, distance to waste boundary, about 50-100m <b>Category: Moderately Short /Direct</b></li> </ul>	Target 3.7b –Infrastructure area of the WENTX:– <ul style="list-style-type: none"> <li>Pantry of the Weighbridge Control Room (Inbound) <b>Category: Low sensitivity</b></li> </ul>	<b>Low</b>
WENT Landfill - potential for gas generation over	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone</li> </ul>	Target 3.7c –Infrastructure area of the WENTX:– <ul style="list-style-type: none"> <li>Toilet rooms of the</li> </ul>	<b>Low</b>

Source	Pathway	Target	Qualitative Risk
time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 50-100m <b>Category: Moderately Short /Direct</b>	Weighbridge Control Room (Inbound) <b>Category: Low sensitivity</b>	
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b></li> </ul>	Target 3.4.1a – Infrastructure area of the WENTX:– <ul style="list-style-type: none"> <li>Female &amp; Male Washrooms of the Service Manager &amp; Contractor Office Building) <b>Category: Low sensitivity</b></li> </ul>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b></li> </ul>	Target 3.4.1b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Staff Dining Room, Pantry, Locker &amp; Changing Room, Special storage room cum monitoring room, CBS Room, Bottle Room, IT LAN/Server Room (include Bottle Room), TBE Room, PABX Room, UPS Room, EL Room, ELV Room, File &amp; General Storage of the Service Manager Office Building <b>Category: Low sensitivity</b></li> </ul>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b></li> </ul>	Target 3.4.1c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Meeting Room/Conference Rooms, Reception, Interview Room, Multipurpose Room, Senior Inspector Room, Inspector Rooms, Officer/ Engineer Rooms, General Office Furniture &amp; Equipment, Clerical Officers, Environmental Protection Inspectors, Assistant Professional Engineers, Chief Environmental Inspector, Head of Community Outreach, Community Relations Officer, Environmental Protection Officers of the Service Manager Office Building <b>Category: Low sensitivity</b></li> </ul>	<b>Very Low</b>
WENT Landfill - potential for gas	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of</li> </ul>	Target 3.4.2a – (Infrastructure area of the WENTX) –	<b>Very Low</b>

Source	Pathway	Target	Qualitative Risk
generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	<ul style="list-style-type: none"> <li>Accessible washroom, Male washroom &amp; Shower room, Male Locker &amp; Changing Room, Female Toilet &amp; Shower &amp; Locker &amp; Changing Room of the Contractor Office Building</li> </ul> <b>Category: Low sensitivity</b>	
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.4.2b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>PAU Room, ELV Room, EL Room, UPS Room, PABX Room, TBE Room, CBS Room, Open Pantry, PPE/Equipment Storage, Operation File Storage, Operation File Storage, Bottle Room, LAN Server Room (include Bottle Room) of the Contractor Office Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.4.2c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Open Office Area &amp; Cellular Office (General Manager Room), Lactation Room, General Office &amp; Furniture &amp; Equipment of the Contractor Office Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.5a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Male Toilet &amp; Female Toilet of the LTW &amp; LFG Service Building &amp; Facilities</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.5b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Pantry, FS Tank &amp; Pump Room, Workshop, Absorption Chiller Plant Room, Sewage Recycled Treatment Plant/Rainwater Recycled Treatment Plant/Irrigation Room, PV/Elec Room, ELV Room, TBE Room, UPS Room, Laboratory, Meter Meter Room, Plumbing Pump Room, Fuel Tank Room, MCC Room, FSI Genset</li> </ul>	<b>Very Low</b>



Source	Pathway	Target	Qualitative Risk
		Room, CLP Transformer Room of the LTW & LFG Service Building & Facilities <b>Category: Low sensitivity</b>	
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.5c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Office Room of the LTW &amp; LFG Service Building &amp; Facilities</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.5d – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>FS Control Room &amp; FS Inlet, Control Room of the LTW &amp; LFG Service Building &amp; Facilities</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.5e – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>CHP Landfill Gas Generators of the LTW &amp; LFG Service Building &amp; Facilities</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.8a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Control Room of the Weighbridge Control Room (Outbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.8b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Pantry of the Weighbridge Control Room (Outbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic</li> </ul>	Target 3.8c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Toilet rooms of the Weighbridge Control Room (Outbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>

Source	Pathway	Target	Qualitative Risk
installed. <b>Category: Medium</b>	conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>		
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.9a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Control room of the Guard House</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.9b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Toilet of the Guard House</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX Landfill - potential for gas generation over time, but proven mitigation and training. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Fill materials between the WENT Landfill and WENTX with potential direct manmade conduits, distance to waste boundary, about 50-100m</li> <li><b>Category: Very Short /Direct</b></li> </ul>	Target 2 (Tipping face of WENTX) – <ul style="list-style-type: none"> <li>LFG safety leaflet will be distributed to Refuse collection vehicle (RCV) drivers and their helpers at the landfill entrance. Other users should receive safety induction training before entering the tipping face which includes the LFG hazards.</li> </ul> <b>Category: Medium sensitivity</b>	<b>Medium</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about &lt;50m</li> </ul> <b>Category: Very Short/Direct</b>	Target 3.1a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Pantry, Vehicle Lifting Platform of Mobile plant facilities/ Vehicle repair</li> </ul> <b>Category: Low sensitivity</b>	<b>Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about &lt;50m</li> </ul> <b>Category: Very Short/Direct</b>	Target 3.1b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Changing room, Female toilet room, Male Toilet Room of Mobile plant facilities/ Vehicle repair</li> </ul> <b>Category: Low sensitivity</b>	<b>Low</b>
WENTX – potential for gas generation over time, but	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill</li> </ul>	Target 3.3a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Male &amp; Female Toilet/Shower/Locker &amp;</li> </ul>	<b>Low</b>

Source	Pathway	Target	Qualitative Risk
comprehensive and proven mitigation installed. <b>Category: Medium</b>	and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 50-100m <b>Category: Moderately Short/Direct</b>	Changing Room, Accessible Toilet, Toilet 1 & 2 Rooms of O&M Workshop Building <b>Category: Low sensitivity</b>	
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 50-100m</li> </ul> <b>Category: Moderately Short/Direct</b>	Target 3.3b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Pantry (Mess room), Electrical Room, ELV Room, Pantry/Mess Room, First Aid Room, Pantry, Machine/Vehicle Wash Area, Maintenance Workshop of O&amp;M Workshop Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 50-100m</li> </ul> <b>Category: Moderately Short/Direct</b>	Target 3.3c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Reception, Meeting Room 1 &amp; 2, Operation Supervisor Room, Operation Manager Room, Maintenance Manager Room Of O&amp;M Workshop Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 50-100m</li> </ul> <b>Category: Moderately Short/Direct</b>	Target 3.3d – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Janitor room, Parts/Tools Storage of O&amp;M Workshop Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	<ul style="list-style-type: none"> <li>Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m</li> </ul> <b>Category: Long/Indirect</b>	Target 3.10 – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Common Process Building of the LTW Facilities (Bioreactor Building)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.4.1a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Female &amp; Male Washrooms of the Service Manager Office Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas	Sub-surface soil, reclamation fill materials of the unsaturated	Target 3.4.1b – (Infrastructure area of the WENTX) –	<b>Very Low</b>

Source	Pathway	Target	Qualitative Risk
generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	<ul style="list-style-type: none"> <li>Staff Dining Room, Pantry, Locker &amp; Changing Room, Special storage room cum monitoring room, CBS Room, Bottle Room, IT LAN/Server Room (include Bottle Room), TBE Room, PABX Room, UPS Room, EL Room, ELV Room, File &amp; General Storage of the Service Manager Office Building</li> </ul> <b>Category: Low sensitivity</b>	
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.4.1c – (Infrastructure area of the WENTX) <ul style="list-style-type: none"> <li>Meeting Room/Conference Rooms, Reception, Interview Room, Multipurpose Room, Senior Inspector Room, Inspector Rooms, Officer/ Engineer Rooms, General Office Furniture &amp; Equipment, Clerical Officers, Environmental Protection Inspectors, Assistant Professional Engineers, Chief Environmental Inspector, Head of Community Outreach, Community Relations Officer, Environmental Protection Officers of the Service Manager Office Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.4.2a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Accessible washroom, Male washroom &amp; Shower room, Male Locker &amp; Changing Room, Female Toilet &amp; Shower &amp; Locker &amp; Changing Room of the Contractor Office Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.4.2b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>PAU Room, ELV Room, EL Room, UPS Room, PABX Room, TBE Room, CBS Room, Open Pantry, PPE/Equipment Storage, Operation File Storage, Operation File Storage, Bottle Room, LAN Server</li> </ul>	<b>Very Low</b>

Source	Pathway	Target	Qualitative Risk
		Room (include Bottle Room) of the Contractor Office Building <b>Category: Low sensitivity</b>	
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.4.2c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Open Office Area &amp; Cellular Office (General Manager Room), Lactation Room, General Office &amp; Furniture &amp; Equipment of the Contractor Office Building</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.6a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Male Washroom, Female Washroom &amp; Accessible Washroom of the Visitor Centre</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.6b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Meeting Room/Multipurpose Room, Exhibition Room, Reception of the Visitor Centre</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.6c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Guard House of the Visitor Centre</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.7a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Control Room of the Weighbridge Control Room (Inbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.7b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Pantry of the Weighbridge Control Room (Inbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT	Target 3.7c – (Infrastructure area of the WENTX) –	<b>Very Low</b>

Source	Pathway	Target	Qualitative Risk
time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	<ul style="list-style-type: none"> <li>Toilet rooms of the Weighbridge Control Room (Inbound)</li> </ul> <b>Category: Low sensitivity</b>	
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.8a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Control Room of the Weighbridge Control Room (Outbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.8b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Pantry of the Weighbridge Control Room (Outbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.8c – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Toilet rooms of the Weighbridge Control Room (Outbound)</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.9a – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Control room of the Guard House</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 3.9b – (Infrastructure area of the WENTX) – <ul style="list-style-type: none"> <li>Toilet of the Guard House</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENTX – potential for gas generation over time, but comprehensive and proven mitigation installed. <b>Category: Medium</b>	Sub-surface soil, reclamation fill materials of the unsaturated zone between the WENT Landfill and WENTX with potential direct anthropogenic conducts, distance to waste boundary, about 100-250m <b>Category: Long/Indirect</b>	Target 1.5 – (Construction Phase of the WENTX) – <ul style="list-style-type: none"> <li>Temporary Site Offices</li> </ul> <b>Category: Low sensitivity</b>	<b>Very Low</b>
WENT Landfill - potential for gas generation over time, but	<ul style="list-style-type: none"> <li>Fissured rock, Fault 1 and 2 across the WENT Landfill towards the WENTX with potential natural pathways</li> </ul>	Target 3.11 & 3.12 – (Infrastructure area of the WENTX) <ul style="list-style-type: none"> <li>Crushing Plant –Product</li> </ul>	<b>Low</b>

Source	Pathway	Target	Qualitative Risk
comprehensive and proven mitigation installed. <i>Category: Medium</i>	for preferential LFG migration, distance about 50-100m <ul style="list-style-type: none"> <li>Superficial deposits below the formation level to the south of the landfill extension fills for LFG migration towards the Waste Reception Area of the existing WENT landfill, distance about 50-100m</li> </ul> <i>Category: Moderate Short/Direct</i>	Bins (Line 2), and Final Storage Bins <i>Category: Low sensitivity</i>	
WENT Landfill - potential for gas generation over time, but comprehensive and proven mitigation installed. <i>Category: Medium</i>	<ul style="list-style-type: none"> <li>Fissured rock, Fault 1 and 2 across the WENT Landfill towards the WENTX with potential natural pathways for preferential LFG migration, distance about 100-250m</li> <li>Superficial deposits below the formation level to the south of the landfill extension fills for LFG migration towards the Waste Reception Area of the existing WENT landfill, distance about 100-250m</li> </ul> <i>Category: Long/Indirect</i>	Target 3.13 & 3.14 – (Infrastructure area of the WENTX) <ul style="list-style-type: none"> <li>Crushing Plant - Product Bins (Line 1), &amp; Surge Bin</li> </ul> <i>Category: Low Sensitivity</i>	<i>Very Low</i>

## 6 PROTECTIVE AND PRECAUTIONARY MEASURES

### 6.1 GENERAL

- 6.1.1 Landfill liner, landfill gas and leachate collection & treatment system, LFG control devices, landfill capping will be designed with reference to the specifications of existing WENT Landfill. Various control measures have been incorporated in the detailed design for the WENTX infrastructure developments as per the findings and recommendations highlighted in the preliminary QLFGHA. The potential risks due to the possible sub-surface migration of the LFG from WENTX will accordingly be minimized.
- 6.1.2 In case LFG migration is detected and confirmed, HKRRP should implement 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 as prepared by the landfill operator.
- 6.1.3 According to the LFG Guidance Note, significant engineering measures will be required to protect the planned development with risk category at “High” level (See **Table 3.2 of Section 3**). Recommendations for protection and precautionary measures for implementation in WENT Landfill Extension during the various Project phases are discussed as follows.
- 6.1.4 All contractors participating in the works and operational staff should be made aware of the potential of methane and carbon dioxide present in the soil and all works should be undertaken on the basis of an "assumed presence of landfill gas". In addition, the following properties of landfill gas should be noted.
- Methane is odourless and colourless. It is typically associated with numerous highly odoriferous compounds in LFG which may give some warning of its presence. However, the absence of odour or colour should not be considered as the area is free from the methane gas.
  - Methane is a flammable gas and will undergo combustion when mixed with air between approximately 5% and 15% by volume, that is the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL) respectively. A mixture of methane and air with a composition between these two values is ignited in a confined space could lead to combustion of the gas and eventually give rise to an explosion. Methane is also an asphyxiant.
  - Measurement of the methane levels can only be confirmed reliably by using appropriately calibrated portable methane measuring equipment.
  - Carbon dioxide, which is another major component of LFG is an asphyxiating gas which could cause adverse health effects. The long-term Occupational Exposure Limit (OEL) is 0.5% by volume. Similar to methane, it is odourless and colourless and can only be detected by using appropriately calibrated portable measuring equipment.
  - The Gas Buoyancy: Methane is lighter than air and conversely carbon dioxide is heavier than air. Typical LFG comprises a mixture of these two gases and are likely to have a density close to or equal to that of air. However, site conditions may result in a variation of the ratio of methane to carbon dioxide which may subsequently make the gas mixture



lighter or heavier than air. As a result, LFG may accumulate at either the bottom of the trenches or excavation opening, beneath structures and foundations, or may rise up to the top of the confined spaces.

## 6.2 PROTECTIVE AND PRECAUTIONARY MEASURES – DESIGN PHASE

### For the Construction and Operation of the WENTX

- 6.2.1 As the source-path-target assessment conducted in Section 5 shows that the risk during construction and operation (waste tipping) is high significant engineering measures need to be undertaken during the detailed design stage to ensure the safe construction in WENTX. The WENTX will be designed, constructed, and operated by HKRRP, which possesses world-wide experiences in landfill management. HKRRP will identify and implement appropriate engineering measures in accordance with the relevant contract requirements. These include the placement of the liner system and the landfill gas management system to contain, manage, and control the migration and utilization of landfill gas, as well as the relevant environmental and safety training to all the workers on site. These control measures will be reviewed and checked by the Independent Consultant under the WENTX Contract.

### For the Operation of the Infrastructure at the WENTX

- 6.2.2 The risk level of the infrastructure area at WENTX is considered as low with the incorporation of the LFG control measures in the design of the WENTX infrastructure area.
- 6.2.3 Proposed landfill gas monitoring wells (see **Figure 7.1**) will be installed between the WENTX waste boundary and the WENTX infrastructure area to monitor the migration of landfill gas, if any.
- 6.2.4 For the control measures in the detailed design of the WENTX infrastructure area and with continuous landfill gas monitoring, the level of resulting LFG hazards of the identified target will be low. Precautionary measure can be done by incorporating the design drawings as per the EPD Landfill Gas Hazard Assessment Guidance Note.

## 6.3 PROTECTIVE AND PRECAUTIONARY MEASURES – CONSTRUCTION PHASE

- 6.3.1 Special precautions, in accordance with Chapter 8 of LFG Guidance Note (a copy of the Chapter is enclosed in **Appendix A** for reference), should be taken in all respects of works against the possible presence of LFG due to close proximity of the existing WENT Landfill and its extension. Potential hazards of exposure to LFG, e.g. ignition, explosion, asphyxiation, toxicity, etc. should be fully aware and alerted.
- 6.3.2 The LFG risks during the construction phase should be minimised by implementing suitable precautionary measures recommended in Chapter 8 of the LFG Hazard Assessment Guidance Note. Essential measures include the following:
- 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 plants 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.

#### **6.4 PROTECTIVE AND PRECAUTIONARY MEASURES - BLASTING WORKS**

6.4.1 LFG is generated by the decomposition of organic municipal solid wastes. At near steady-state conditions, LFG is typically composed of approximately 55% methane (CH<sub>4</sub>), 40 % carbon dioxide (CO<sub>2</sub>), and the balance 5% nitrogen (N<sub>2</sub>).

6.4.2 Methane is a flammable, potentially explosive gas that is combustible only under specific conditions (i.e., the right combination of CH<sub>4</sub> and O<sub>2</sub> plus a source of ignition). Methane is explosive at concentrations that range from the lower explosive limit (LEL) of 5 percent to the upper explosive limit (UEL) of 15 percent CH<sub>4</sub> per volume of air. At concentrations below the LEL, the CH<sub>4</sub> / air mixture is too dilute (CH<sub>4</sub> concentrations are too low) to ignite. If a source of ignition is available any concentration between the LEL and the UEL will allow combustion. Methane concentrations above the UEL (>15%/v) are too rich (O<sub>2</sub> levels are too low) to support combustion. To sustain a flame, O<sub>2</sub> levels need be at or above 19 percent.

##### Landfill Gas (LFG) Control for Blasting Work

6.4.3 Methane entering a fissures, sub-surface crevices, or tunnel often enters as a localized source at high concentration. In this illustration, methane enters the mine from a crack in the roof. As the methane emerges from the crack, it progressively mixes with the ventilation air and is diluted. In the event that this progressive dilution reduces the concentration from 100% to 1%, Concentration percentage values refer to percent by volume, the methane passes through a concentration range of 5% to 15%, known as the explosive range. In the explosive range, the mixture may be ignited. Above 15%, called the upper explosive limit (UEL), methane-air mixtures are not explosive, but will become explosive when mixed with more air.

6.4.4 Subsurface LFG migration needs to be controlled as the concentration of methane at the landfill boundary is to be maintained below 1%. LFG could migrate/ingress from small cracks or fissures near the crown may produce a methane layer there because methane is

much lighter than air. Any quantity of LFG migrating beyond the blasting zone may result in harmful effects, it is necessary to prevent gas migration. HKRRP will adopt different environmental safety procedure to reduce or eliminate the potential risk that may be posed by the blasting works.

- 6.4.5 Criteria and requirements of blast monitoring shall be:
- I. Landfill Gas Measurement
    - Methane concentration less than 1% by volume
  - II. Ground Vibration Limit Measurement
    - If the blasting works is within the 250m consultation zone of West New Territories (WENT) Landfill, a seismograph recording needs to be installed to record the vibration due to the blasting.
  - III. The seismograph recording system should be installed at or near the closest part of WENT to the blast.
  - IV. Extreme care should be taken during the blasting to control the ground vibrations not to exceed 5 inches per second (approx. 0.13m/s) at the closest part of WENT or WENTX tipping area.

Landfill Gas Monitoring for Blasting Works

- 6.4.6 HKRRP will maintain close liaison with WENT Landfill operator on a weekly basis and provide a two weeks tentative blast schedule at least 1 week before the blasting work. The tentative blast schedule will include the schedule blast date, location of blast works and the approximate separation distance between the blast area and existing WENT Landfill boundary.
- 6.4.7 The frequency and the locations of the LFG monitoring within the excavation area should be determined prior to commencement of the blasting works. The monitoring requirements and procedures specified in *Paragraphs 8.23 to 8.28 of the EPD's Landfill Gas Hazard Assessment Guidance Note* shall be strictly followed.
- 6.4.8 HKRRP will perform landfill gas monitoring for all blasting works within the 250m consultation zone of the WENT Landfill (i.e. plan distance from the edge of the existing waste boundary of WENT Landfill site) at the schedule below.
- a) Before commencement of blast hole drilling
    - HKRRP will inform WENT Landfill operator about the selected perimeter monitoring wells along WENT's landfill boundary for landfill gas monitoring that may be required. When existing WENT's monitoring wells are proposed, permission from WENT's Landfill operator must be obtained.
    - HKRRP will carry out landfill gas monitoring at the nearest monitoring wells (within 250m from WENT boundary) and the results shall be reported to the Service Manager. If the methane concentration is measured and remained to be less than 1%, drilling of blast holes can be proceeded after receiving confirmation from the Service Manager.
    - Drilling of blast holes will take multiple days, thus, landfill gas monitoring shall be carried out every morning the nearest blast hole following the same procedure as mentioned above prior to resume drilling work.
  - b) Drilling of Boreholes
    - Drilling should only proceed with adequate care and precautions against the potential hazards which may be encountered.

- Before site works begin, the drilling contractor should devise a 'method-of-working' statement covering all normal and emergency procedures and the site supervisor and all operatives must be familiar with the Landfill Gas Hazard Assessment Guidance Note (GN) Cl. 8.32.
  - On arrival at site the drilling rig should be set-up up-wind of the borehole location, 'No smoking' signs set out and the working area should be roped or coned-off.
  - When drilling on landfill sites, all spoil obtained from the borehole should be stockpiled alongside the borehole and disposed of (to an appropriately licensed disposal site) at the end of the working day. At the end of the working day all vehicles, the drilling rig and any hand tools should be hosed-down with clean water to remove deposits of excavated spoil. Suitable guards or barriers should be placed around the excavation or borehole to prevent access by unauthorised persons.
- c) Safety Procedures
- A workers should be present at all times during drilling operations, with the sole responsibility of assuring the observance of all safety procedures. This person should be trained in the use of all recommended safety equipment.
  - During the borehole construction, the work areas should be monitored for levels of methane.
  - If the borehole construction works is not completed by the end of the working day, the hole should be covered with a plate of sufficient overlap to prevent access to the hole and sufficient structural strength to support expected loads. The plate should be weighted down to discourage removal and, on landfill sites, the edges of the plate should be covered with sufficient depth of wet soil to prevent escape of gas.
  - All pipes or casings should be capped at the end of each working day.
  - Engine-driven rigs should have vertical exhaust stacks discharging not less than 1.5m above ground level and should have overspeed limits to prevent engine run away on ingested gas.
  - Diesel engine air-intakes should also be located not less than 1.5m above ground level.
  - Any electrical equipment should be intrinsically safe.

6.4.9 The blasting work is scheduled to be carried out in 6 Phases and during Phase 1, HKRRP will utilise the existing WENT's monitoring wells for carrying out landfill gas monitoring as the WENTX landfill gas monitoring boreholes have yet to be completed. However, HKRRP is committed to complete the proposed landfill gas monitoring boreholes along the WENTX waste boundary for both Phase 1 and 2 blasting areas while Phase 1 blasting work is being carried out and so on for subsequent phases. In other words, when the blasting work is completed for Phase 1, the landfill gas monitoring boreholes for subsequent phase (i.e. Phase 2) is also complete and likewise for subsequent Phases. After Phase 1 blasting work is completed, WENT's monitoring wells will no longer be needed as the next phase proposed monitoring wells would have already been constructed. The landfill gas monitoring will be carried out in accordance with the requirement either within 250m consultation zone of the WENT Landfill or within 250m from the waste boundary of the WENT landfill extension site. Comprehensive environmental monitoring programme will be conducted from Construction to Aftercare of the WENTX to monitor the LFG, refers to Fig 7.1, generated within WENTX. When operation commences, landfill gas monitoring will be carried out at gas monitoring wells already installed along the site boundary of WENTX.

On the day of the schedule blast

- HKRRP will carry out landfill gas monitoring inside the nearest blast holes (within 250m from WENT boundary) before charging commences. Portable gas monitoring apparatus will be lower down to the blast holes for methane gas measurements.
- Before charging commence, a walkover survey (Surface Emission Monitoring) for surface gas emission will be carried out within the blast area by a portable gas measurement to detect air condition at about no more than 10mm from the exposed ground surface of the blast hole as far as practical to ensure no LFG is present.
- If the methane concentration is measured to be less than 1%, charging of blast holes can be proceed after received confirmation from the Service Manager.

6.4.10 All gas monitoring works should be carried out by the Safety Officer or by an appropriately qualified person for the following excavation scenarios. The monitoring frequency should be reviewed periodically and adjust as necessary by the Safety Officer based on the measured results.

### ***Contingency Procedure***

#### ***Gas concentration beyond the limits***

6.4.11 In the event that the methane concentration in any of the selected monitoring wells is found to be more than 1%, the following emergency contingency procedure must be activated:

- a) Before blast hole drilling
  - Report to the Service Manager for his record;
  - Re-schedule the blast hole drilling works until the follow up actions are completed;
    - i. Assess the health and safety hazard to all personnel, and take immediate emergency action, including evacuation, if appropriate;
    - ii. Step up the vigilance in monitoring for LFG, including an increase in the frequency of monitoring and an increase in the number of monitoring locations within the zone of influence of the affected area;
    - iii. Investigate appropriate measures/tools to identify the source of LFG and the extent of LFG migration;
    - iv. Design, proposed and implement remedial measures to prevent further gas mitigation; and
    - v. Perform another round of gas monitoring at the selected wells until the methane concentration returns to below 1% by volume.
- b) On the day of scheduled blast
  - Report to the Service Manager for his record;
  - Re-schedule the blast until all follows up actions as mentioned in bullet point a) above are implemented

## 7 LANDFILL GAS MONITORING

### 7.1 REQUIREMENT

- 7.1.1 Periodically during groundworks construction, CH<sub>4</sub>, CO<sub>2</sub> and O<sub>2</sub> 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 groundworks either by the Safety Officer or by an appropriately qualified person.
- 7.1.2 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.

### 7.2 MONITORING PARAMETERS

A suite of LFG monitoring parameters include:

Monitoring Method	Monitoring Parameters	Requirement of Monitoring
• Monitoring borehole:	Methane (CH <sub>4</sub> ), carbon dioxide (CO <sub>2</sub> ), oxygen (O <sub>2</sub> ), flammable gas	If the blasting works are within the 250m consultation zone of WENT Landfill, gas monitoring shall be conducted at the nearest monitoring boreholes <sup>(#)</sup> .
• Surface gas location:	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub>	For excavation works between 300mm and 1m deep and deeper than 1m; and throughout the whole process of the blasting
• Gas well head:	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub> , flammable gas, volatile organic compounds (VOC)	Once the gas well <sup>(#)</sup> is set up
• Off-site location:	VOC	Once WENTX starts receiving waste

*Remark: (#) Monitoring boreholes will be installed for LFG monitoring at the borehole and gas well head. The programme for borehole installation will be synchronized with the construction programme for the blasting work.*

- 7.2.1 The existing WENT Landfill is required to conduct LFG monitoring during landfill operation from drillholes, boreholes, gas probes and piezometers around the perimeter of the Site as specified in their contract. Before setting up the monitoring boreholes for WENTX, HKRRP should refer to the monitoring data collected from the existing WENT Landfill. This data serves as a reference and provides valuable information regarding historical gas levels and trends at the site.

### 7.3 MONITORING LOCATIONS

- 7.3.1 During the construction stage, when excavation of 1m deep or more, surface LFG concentrations should be monitored at before entry and periodically during the progress of works. The blasting work is scheduled to be carried out in 6 Phases and during Phase 1, HKRRP will utilise the existing WENT's monitoring wells for carrying out landfill gas monitoring as the WENTX landfill gas monitoring boreholes have yet to be completed. However, HKRRP is committed to complete the proposed landfill gas monitoring boreholes along the WENTX waste boundary for both Phase 1 and 2 blasting areas while Phase 1 blasting work is being carried out and so on for subsequent phases. In other words, when the blasting work is completed for Phase 1, the landfill gas monitoring boreholes for

subsequent phase (i.e. Phase 2) is also complete and likewise for subsequent Phases. After Phase 1 blasting work is completed, WENT's monitoring wells will no longer be needed as the next phase proposed monitoring wells would have already been constructed. The landfill gas monitoring will be carried out in accordance with the requirement either within 250m consultation zone of the WENT Landfill or within 250m from the waste boundary of the WENT landfill extension site. Comprehensive environmental monitoring programme will be conducted from Construction to Aftercare of the WENTX to monitor the LFG, refers to Fig 7.1, generated within WENTX. When operation commences, landfill gas monitoring will be carried out at gas monitoring wells already installed along the site boundary of WENTX.

- 7.3.2 Throughout the WENT Landfill Extension development, when service voids, manholes or inspection chambers within the project site are entered for maintenance, monitoring and a checklist system of safety requirements should be performed before entry in accordance with the Code of Practice on Safety and Health at Work in Confined Spaces.
- 7.3.3 The proposed LFG monitoring locations including designated boreholes and surface locations, gas wells, and off-site locations for WENT Landfill Extension development are shown in **Figure 7.1**, which are subject to changes depending on the design and modification by HKRRP.

#### **7.4 MONITORING FREQUENCY**

- 7.4.1 The monitoring frequency and areas to be monitored should be set down prior to commencement of groundworks either by the Safety Officer or by an appropriately qualified person. Routine monitoring should be carried out in slope cutting by blasting, in all excavations, manholes and chambers and any other confined spaces that may have been created by, for example, the temporary storage of building materials on the site surface. All measurements in excavations should be made with the monitoring tube located not more than 10mm from the exposed ground surface.
- 7.4.2 HKRRP will maintain close liaison with WENT Landfill operator on a weekly basis and provide a two weeks tentative blast schedule at least 1 week before the blasting work. The tentative blast schedule will include the schedule blast date, location of blast works and the approximate separation distance between the blast area and existing WENT Landfill boundary.
- 7.4.3 The frequency and the locations of the LFG monitoring within the excavation area should be determined prior to commencement of the blasting works. The monitoring requirements and procedures specified in *Paragraphs 8.23 to 8.28 of the EPD's Landfill Gas Hazard Assessment Guidance Note* shall be strictly followed.

##### *A. For blasting works on existing slope*

HKRRP will perform landfill gas monitoring for all blasting works within the 250m consultation zone of the WENT Landfill (i.e. plan distance from the edge of the existing waste boundary of WENT Landfill site) at the schedule below.

- HKRRP will inform WENT Landfill operator about the selected perimeter monitoring wells along WENT's landfill boundary for landfill gas monitoring that may be required. When existing WENT's monitoring wells are proposed, permission from WENT's Landfill operator must be obtained.
- HKRRP will carry out landfill gas monitoring at the nearest monitoring wells (within 250m from WENT boundary) and the results shall be reported to the Service Manager. If the methane concentration is measured and remained to

be less than 1%, drilling of blast holes can be proceeded after receiving confirmation from the Service Manager.

- Drilling of blast holes will take multiple days, thus, landfill gas monitoring shall be carried out every morning at the nearest blast hole following the same procedure as mentioned above prior to resume drilling work.

i) Surface Emission Monitoring

- a walkover survey for surface gas emission to be undertaken within the blasting area, with a portable gas measuring probe to detect the air condition at no more than 10mm from the exposed ground surface of the blast hole as far as practical to ensure no LFG is present.

B. For excavation works deeper than 1m

i) Measurements should be made:

- at ground surface before excavation work 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 through the working day whilst workers are in the excavation.

C. For excavation between 300mm and 1m deep

i) Measurements should be made:

- directly after the excavation has been completed; and
- periodically whilst the excavation remains open.

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

**7.5 ACTIONS IN THE EVENT OF LANDFILL GAS BEING DETECTED**

7.5.1 In the event of the relevant gas concentration deviated from the safety limits, appropriate actions should be determined by the Safety Officer or other appropriately qualified person. These should encompass the actions presented in **Table 7-1**.

**Table 7-1 Action Plan for LFG monitoring during construction phase**

Parameter	Monitoring Result	Action
O <sub>2</sub>	<19%	<ul style="list-style-type: none"> <li>• Ventilate trench/ void to restore O<sub>2</sub> level to &gt;19%</li> </ul>
	<18%	<ul style="list-style-type: none"> <li>• Stop works,</li> <li>• Evacuate all personnel/ prohibit entry,</li> <li>• Increase ventilation to restore O<sub>2</sub> level to &gt;19%</li> </ul>
CH <sub>4</sub>	>10% LEL	<ul style="list-style-type: none"> <li>• Post “No smoking” signs,</li> <li>• Prohibit hot works,</li> <li>• Ventilate to restore CH<sub>4</sub> level to &lt;10% LEL</li> </ul>
	>20% LEL	<ul style="list-style-type: none"> <li>• Stop works,</li> <li>• Evacuate personnel/ prohibit entry,</li> <li>• Ventilate to restore CH<sub>4</sub> level to &lt;10% LEL</li> </ul>
CO <sub>2</sub>	>0.5%	<ul style="list-style-type: none"> <li>• Ventilate to restore CO<sub>2</sub> level to &lt;0.5%</li> </ul>
	>1.5%	<ul style="list-style-type: none"> <li>• Stop works,</li> <li>• Evacuate personnel/ prohibit entry,</li> <li>• increase ventilation to restore CO<sub>2</sub> to &lt;0.5%</li> </ul>



## 7.6 OPERATION, RESTORATION AND AFTERCARE PHASES

- 7.6.1 Where any service voids, manholes and inspection chambers within the landfill extension 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.
- 7.6.2 Buildings on-site 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 LFG barriers, gas vents and strategic routing of any service utilities away from the potential LFG migration pathways.
- 7.6.3 Any new-built permanent building structures within the landfill extension sites, forced ventilation and gas detection system with audible alarm should be installed. No person should be allowed to enter or remain in any confined areas when CO<sub>2</sub> levels >1.5% v/v or O<sub>2</sub> levels <18% v/v is detected. Access to confined spaces in the landfill extension sites should be controlled to only authorised persons.
- 7.6.4 Specific types of gas protection measures which can be applied to building services have been provided in accordance with the LFG Guidance Note (details are appended in *Appendix B*). They generally include LFG barriers, gas vents, location of service entries above ground, and service conduits passing through consultation zone.

### General Protection Measures

#### **Passive systems**

- 7.6.5 Setting a "LFG cut-off trench barrier" is one of the mitigation measures for preventing gas entering an area. With the revised project boundary, the proposed liner and LFG cut-off trench barrier has been adjusted as shown in *Figure 7.2*. According to the EPD Landfill Gas Hazard Assessment Guidance Note, Section 7.13: Since there are no "design equations" for cut-off barrier specifications, it is therefore essential to seek expert recommendation before finalising the design detail of any cut-off barrier.
- 7.6.6 The presence of a LFG cut-off trench 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.

### Gas monitoring

- 7.6.7 With either passive or active systems, it is usual to install monitoring wells into the ground on the development side of the LFG cut-off trench barrier or extraction wells. These are used to measure the concentrations of CH<sub>4</sub> and CO<sub>2</sub> within the ground and hence determine the effectiveness of the measures in preventing LFG migration.

## 7.7 BUILDING PROTECTION DESIGN MEASURES

### Passive systems

- 7.7.1 Passive control measures for buildings include the following:
- 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 aluminium 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 providing preferential pathways for release of gas.
- Synthetic composite geotextile which provide a free-venting cellular structure and provide preferential pathways for release of gas.

7.7.2 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

7.7.3 Active control measures are employed where the rates of gas emission are too high to rely on passive ventilation or in particular circumstances where, for example, there is a sensitive target to protect. Active control measures include the following.

- 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.

7.7.4 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

7.7.5 Gas detection systems include the following:

- 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 wireless 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 measurement principles. A pump automatically draws samples of air/gas along each tube in a pre-set pattern such that measurements of flammable and/or other gases (e.g. CO<sub>2</sub>) 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.

7.7.6 Gas detection system should only be proposed where there is an organisation involved in 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

7.7.7 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.

## 7.8 DESIGN MEASURES FOR SUB-SURFACE BUILDING SERVICES

7.8.1 Generic Protection Measures is following:

- LFG Barrier X 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 LFG 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.
- Gas Vents X 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 LFG 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.
- Location of Service Entry Points Above Ground X In some cases it is possible to route service entries into a building above ground level, thereby 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

7.8.2 In addition to the general guidance given above, the following recommendations apply to service conduits which pass through the Consultation Zone with connections to developments outside the 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 such as maintenance or extensions 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.

## 7.9 OUTSIDE WENT LANDFILL EXTENSION

7.9.1 Due to the reduced size of waste boundary, the extent of 250m consultation zone has been revised. According to the updated site boundary, I.PARK 2 would be located within the 250m consultation zone of WENTX landfill and it is considered to be a further receiver. Since I.PARK 2 is classified as a Designated Project, a LFG hazard assessment associate with the landfill gas migration from the WENTX Landfills will be conducted. With the implementation of appropriate mitigation measures, adverse impact of landfill gas hazard is not anticipated.

7.9.2 Whilst the WENT Landfill Extension will be designed as a containment landfill incorporating multi-layer composite liner systems covering the entire surface area of the site with LFG collection and management systems to eliminate any off-site migration of LFG. Setting a “LFG cut-off trench barrier” is one of the mitigation measures for preventing gas entering an area. With the revised project boundary, the proposed liner and LFG cut-off trench barrier has been adjusted as shown in **Figure 7.2**. According to the EPD Landfill Gas Hazard Assessment Guidance Note, Section 7.13: Since there are no "design equations" for cut-off barrier specifications, it is therefore essential to seek expert recommendation before finalising the design detail of any cut-off barrier.

7.9.3 Moreover, LFG monitoring wells will be installed in the ground on the development side of the barrier to measure the concentration of methane and carbon dioxide and hence to determine the effectiveness of the barrier as preventing LFG migration.

## 7.10 DESIGN OF LFG PROTECTION MEASURES FOR THE WENT LANDFILL EXTENSION

7.10.1 The results from the routine and long-term LFG monitoring programme for the existing WENT 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. It is likely that the WENT Landfill Extension will be designed to adopt similar or more advanced LFG control measures so as to ensure future compliance of environmental and safety requirements.

7.10.2 The design of the landfill gas protection measures to be adopted on-site, e.g. utilities,

buildings, LFG cut-off trench barrier (setting a “LFG cut-off trench barrier” is one of the mitigation measures for preventing gas entering an area. According to the EPD Landfill Gas Hazard Assessment Guidance Note, Section 7.13: Since there are no "design equations' for cut-off barrier specifications, it is therefore essential to seek expert recommendation before finalising the design detail of any cut-off barrier), monitoring wells and facilities related to the WENT Landfill Extension project will be performed by a landfill gas specialist appointed by HKRRP. Moreover, the landfill gas protection measures will be checked and certified by a qualified independent consultant. HKRRP shall ensure that the required protective measures are implemented and constructed in accordance with the design and shall establish a maintenance and monitoring programme for ensuring the continual performance of the implemented protection measures.

## **8 WENT LANDFILL EXTENSION WORKS OF SAFETY MEASURES**

### **8.1 GENERAL REQUIREMENTS**

8.1.1 For general requirements, safety measures during construction shall be following:

- (a) 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 excavations. Safety notices should be posted warning of the potential hazards.
- (b) Those staff who work in, or have responsibility for 'at risk' areas, including all excavation workers, supervisors and engineers working within the Consultation Zone, should receive appropriate training on working in areas susceptible to landfill gas, fire and explosion hazards.
- (c) An excavation procedure or code of practice to minimise landfill gas related risk should be devised and carried out by the project proponent.
- (d) No worker should be allowed to work alone at any time in or near to any excavation. At least one other worker should be available to assist with a rescue if needed.
- (e) Smoking, naked flames and all other sources of ignition should be prohibited within 15m of any excavation or ground-level confined space. 'No smoking' and 'No naked flame' notices should be posted prominently on the construction site and, if necessary, special areas designated for smoking.
- (f) Welding, flame-cutting or other hot works should be confined to open areas at least 15m from any trench or excavation.
- (g) Welding, flame-cutting or other hot works may only be carried out in trenches or confined spaces when controlled by a 'permit to work' procedure, properly authorised by the Safety Officer (or, in the case of small developments, other appropriately qualified person).
- (h) The permit to work procedure should set down clearly the requirements for continuous monitoring for 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, in attendance outside the 'confined area', 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.
- (i) Ground level construction plants should be fitted with vertical exhausts at least 0.6m above ground level and with spark arrestors.
- (j) Any electrical equipment, such as motors and extension cords, should be intrinsically safe.
- (k) During piping assembly or conduit construction, all valves/seals should be closed immediately after installation. As construction progresses, all valves/seals should be closed as installed to prevent the migration of gases through the pipeline/conduit. All piping/conduiting should be capped at the end of each working day.
- (l) Mobile offices, equipment stores, mess rooms etc. should be located on an area which has been proven to be gas free (by survey with portable gas detectors) and ongoing monitoring should be carried out to ensure that these areas remain gas free. The use of permanent gas detectors may be appropriate in some circumstances where there is a relatively high risk but for many developments it will be sufficient to have regular monitoring undertaken manually by the safety officer. The particular arrangements to be adopted at a specific site will need to be determined during the risk assessment/design of protection measures.
- (m) Alternatively, such buildings should be raised clear of the ground. If buildings are raised clear of the ground, a minimum, clear separation distance (as measured from

the highest point on the ground surface to the underside of the lowest floor joist) should be 500mm.

- (n) During construction, adequate fire extinguishing equipment, fire-resistant clothing and breathing apparatus (BA) sets should be made available on site.
- At larger developments, fire drills should be organized at not less than six monthly intervals.
  - The developer should formulate a health and safety policy, standards and instructions for site personnel to follow.

## **9 ENVIRONMENTAL MONITORING AND AUDIT**

- 9.1.1 According to the updated EM&A Manual, HKRRP should undertake regular monitoring of landfill gas within the WENTX and along the WENTX waste boundary, as well as at the start of specific construction works, such as excavation and drilling for blasting, and through the operation, restoration and until completion of aftercare phases. The measured LFG results should be checked for compliance against pre-defined A/L Levels. In case exceedance of compliance level was detected at any locations, the Event and Action Plan should be triggered for necessary action to be taken.
- 9.1.2 LFG monitoring should be conducted in monthly basis at designated monitoring locations and gas monitoring boreholes, supplemented by monthly site surveys of the surrounding environment including natural cracks and fissures, service drains and ducts, area with sign of vegetation death, and any below ground enclosed spaces, which include normal bulk gas using portable instrument verified by gas sampling and laboratory analyses. If the monitoring results indicate evidence of gas migration, the monitoring frequency should be increased accordingly, with the implementation of appropriate mitigation measures under the EAP.



## **10 CONCLUSIONS AND RECOMMENDATIONS**

### **10.1 CONCLUDES OF THE FINDING**

- 10.1.1 The results of qualitative risk assessment for LFG hazards associated with the construction, operation, restoration and aftercare phases in the approval EIA Report indicates that the overall risks to the receivers within the WENT Landfill Extension would be categorised as “Medium” to “High” and that to the receivers outside the WENT Landfill Extension would be “Low” to “Medium”.
- 10.1.2 Under the Enhanced Scheme, the waste boundary area has been reduced from 188 ha to 94 ha. The extent of the 250 m consultation zone has accordingly been revised. The source, pathway, and receiver within the WENTX remain unchanged. For the receivers outside WENTX, I.PARK 2 would be located within the 250m consultation zone of WENTX landfill. Since I.PARK 2 is classified as a Designated Project, a LFG hazard assessment associate with the landfill gas migration from the WENTX Landfills will be conducted. With the implementation of appropriate mitigation measures, adverse impact of landfill gas hazard is not anticipated.
- 10.1.3 Based on the result of the latest Landfill Gas Hazard Assessment, the risk levels associated with the Enhanced Scheme, the risk level is high within WENTX site boundary during the construction and operation phases and the risk posed by WENTX to WENTX infrastructure area ranges from very low to low. With the proposed landfill gas control measures and the precautionary measures including the engineering design (e.g., gas-proof coating applied on top of all ground floor slabs, raised floor, the automatic gas alarm system, together with the air conditioning/ mechanical ventilation/ natural ventilation etc.) in place, the potential multiple risks of LFG migration from WENT and WENTX to the receiver will be minimal.
- 10.1.4 To conclude, the overall risk within the proposed WENTX is anticipated the same whereas no risk is anticipated outside the proposed WENTX. No adverse LFG hazard impact is anticipated during the construction, operation, restoration and aftercare stages of the Project.

### **10.2 RECOMMENDATIONS OF DETAILED LANDFILL GAS HAZARD ASSESSMENT**

- 10.2.1 HKRRP shall be responsible to train and to ensure that their staffs take appropriate precautions at all times when entering enclosed spaces or plant rooms. HKRRP shall also undertake regular monitoring of landfill gas at the perimeter monitoring wells to detect if there are any signs of off-site landfill gas migration. Additional, HKRRP shall be responsible to prepare and implement emergency plan in case off-site landfill gas migration is detected and the trigger levels specified in the EM&A Manual are being exceeded.
- 10.2.2 A continuous permanent gas monitoring system with alarms will be installed and operated in all occupied on-site buildings.
- 10.2.3 Any proposed modifications or additions to the building structure in the infrastructure area should be subject to a further assessment of landfill gas hazard, particularly in areas where a gas membrane has been installed or involving excavation or penetration beneath the floor slab. Any penetrations of the membrane must be repaired as soon as possible after detection or works completion using similar products.
- 10.2.4 HKRRP should implement the best LFG management practices to maintain the LFG

management system which includes developing preventive maintenance programme for the LFG collection and control and the utilization systems. Refurbishment, replacement, or any remedial works should also be undertaken as required to maintain the continued operation of the LFG management facilities to fulfil their required performance criteria.

**Figure (some figures are extracted From EIA Report)**

869000 E  
后海湾 (深圳湾)  
DEEP BAY (SHENZHEN WAN)

870000 E

871000 E

832000 N

830000 N

828000 N



NIM WAN ROAD  
REALIGNMENT

POTENTIAL SITE  
FOR IWMF

PROPOSED STF

TSANG TSUI ASH LAGOONS

EXISTING WEST LANDFILL

WENT LANDFILL  
EXTENSION

EXISTING  
NIM WAN ROAD

BLACK POINT  
POWER STATION

HA PAK NAI

LUNG KWU SHEUNG TAN





TSING SHAN FIRING RANGE

SHA-PO KONG

LUNG KWU TAN

URBASTON ROAD

**LEGEND**

-  BOUNDARY OF EXISTING  
WEST LANDFILL
-  WASTE BOUNDARY OF  
WEST LANDFILL EXTENSION
-  PROJECT BOUNDARY OF  
WEST LANDFILL EXTENSION
-  BOUNDARY OF TSING SHAN  
FIRING RANGE

Consultant

Project title  
**Contract No. EP/SP/186/21  
West New Territories Landfill  
Extension**

Drawing title  
**ORIGINAL SCHEME LAYOUT OF  
WEST NEW TERRITORIES  
LANDFILL EXTENSION**

**FIGURE 1.1**

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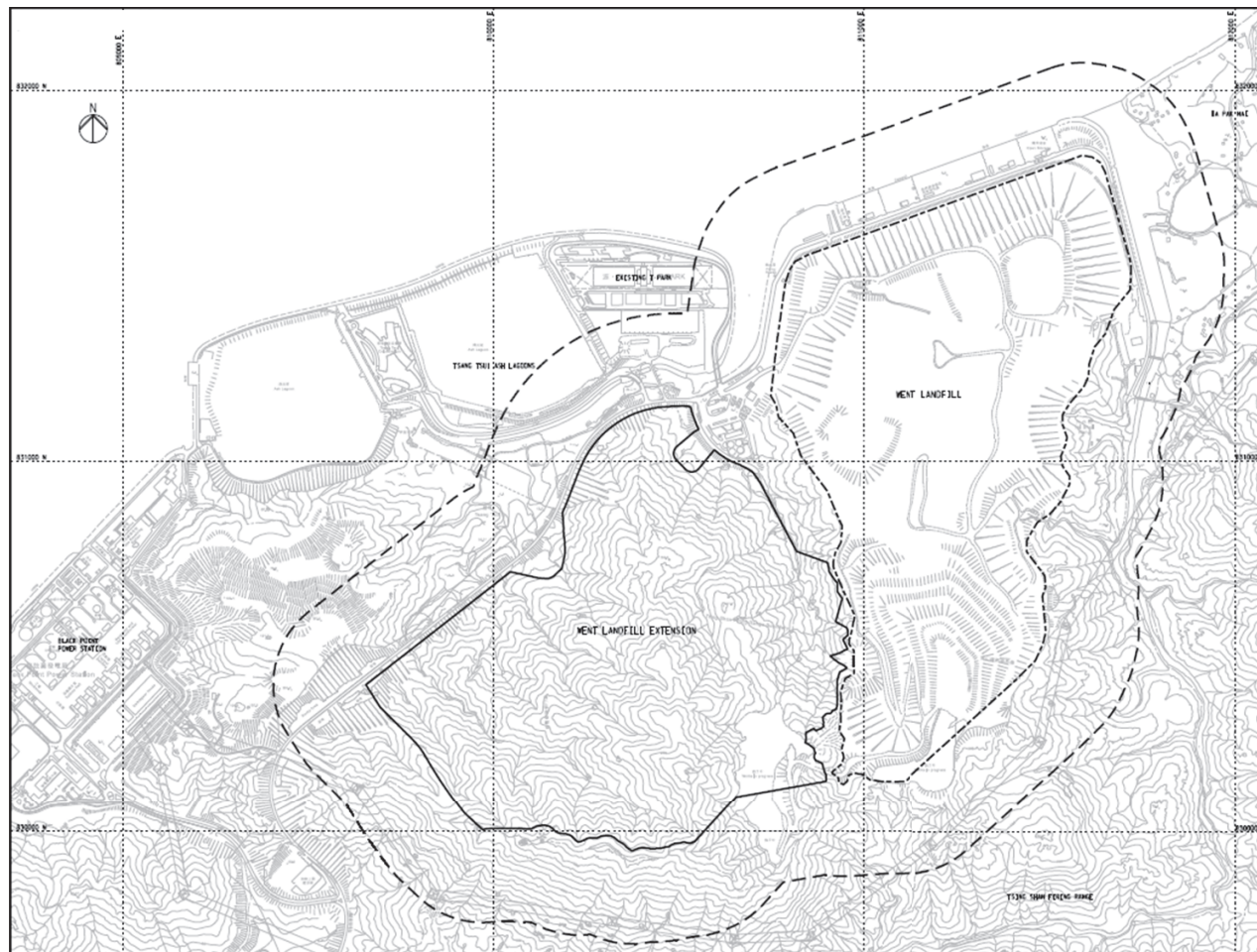
- LEGEND**
- WENT LANDFILL EXTENSION (WENTX) BOUNDARY
  - WENTX WASTE BOUNDARY
  - LANDFILL INFRASTRUCTURE FOR WENTX
  - WENT LANDFILL BOUNDARY
  - TREE PLANTING BUFFER

Project title  
**Contract No. EP/SP/186/21  
 West New Territories  
 Landfill Extension**

Drawing title  
**GENERAL PLAN  
 OF ENHANCED SCHEME**

Drawing no. **FIGURE 1.2**





Scale 1:5000

**Legend:**  
 - - - - WENT Landfill Boundary  
 - - - - WENT Landfill Extension Boundary  
 - - - - Consultation Zone Boundary

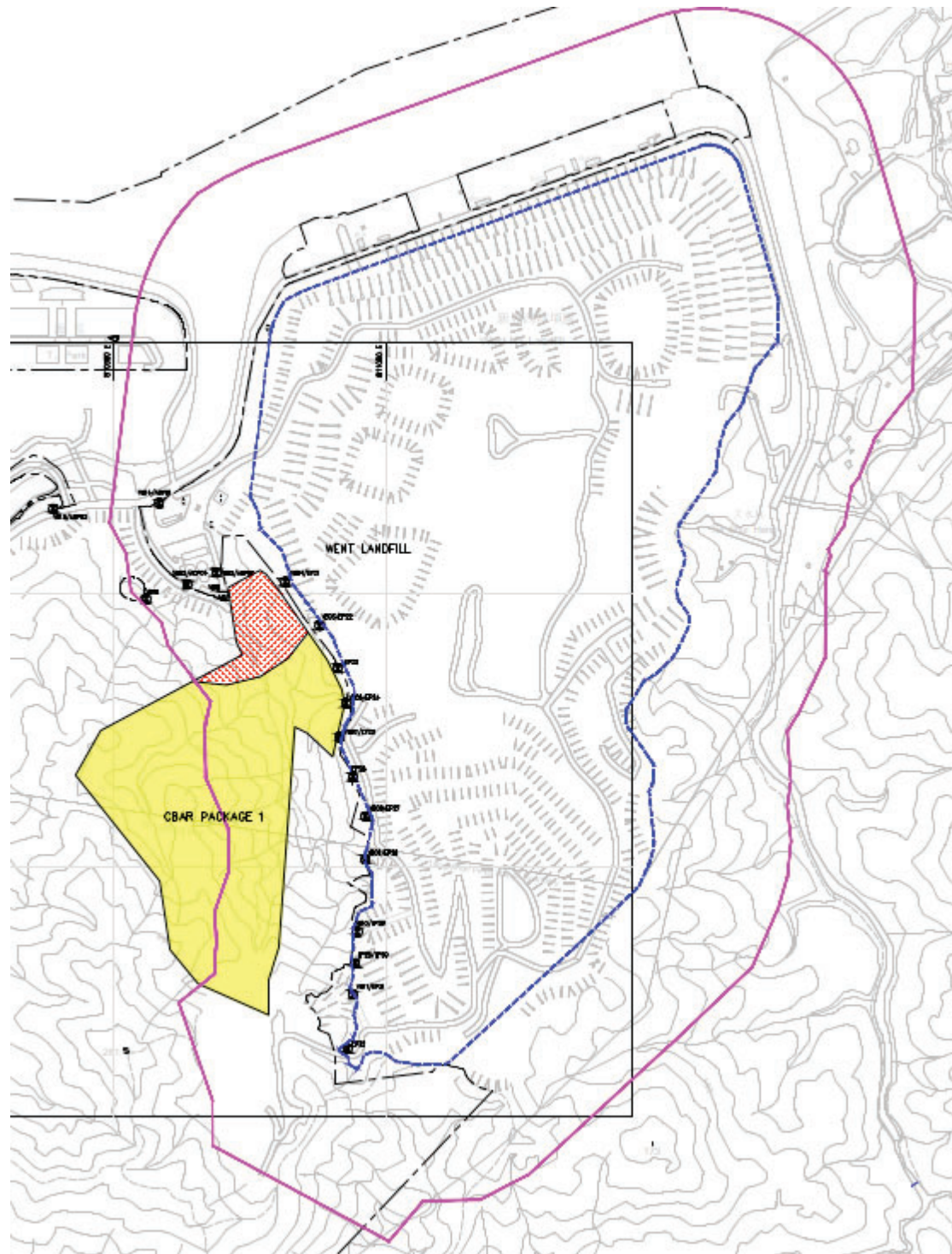
**Note:**  
 More detailed, large scale, plans showing the No Build Zones and Consultation Zones around each landfill site are held by EPD and may be inspected at their offices

**LEGEND:**  
 - - - - WENT LANDFILL WASTE BOUNDARY  
 - - - - WENT LANDFILL EXTENSION WASTE BOUNDARY  
 - - - - CONSULTATION ZONE BOUNDARY

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 EXTENSION 250 METER(M) CONSULTATION  
 ZONE

FIGURE 1.3

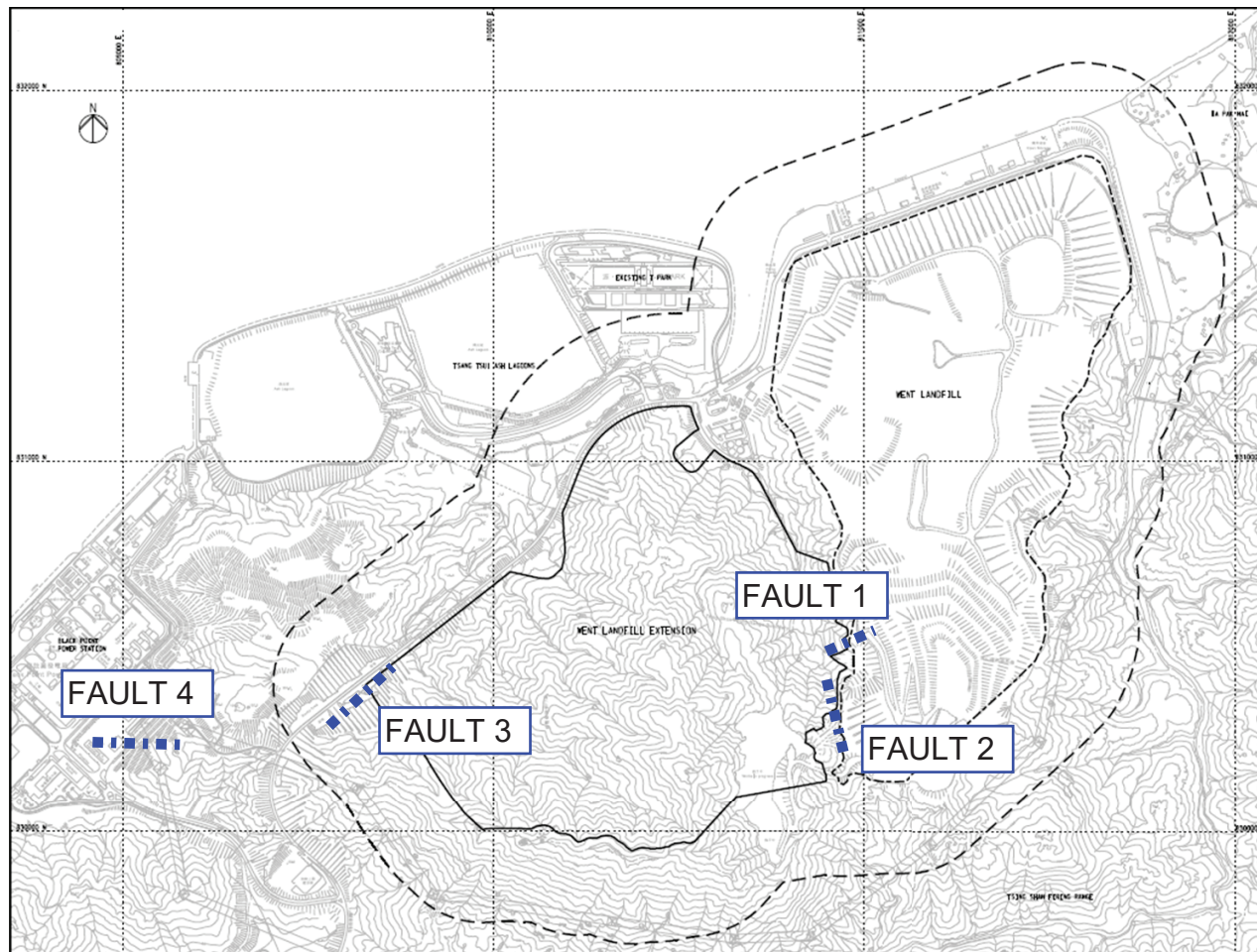


LEGEND:  
 - - - WENT LANDFILL BOUNDARY  
 \_\_\_\_\_ WENT LANDFILL CONSULTATION ZONE BOUNDARY

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 CONSULTATION ZONE

FIGURE 1.3A



- LEGEND:
- WENT LANDFILL WASTE BOUNDARY
  - WENT LANDFILL EXTENSION WASTE BOUNDARY
  - - - CONSULTATION ZONE BOUNDARY
  - - - - - GEOLOGICAL FAULTS

Scale 1:5000

**Legend:**

- - - - - WENT Landfill Extension Boundary
- WENT Landfill Boundary
- - - CONSULTATION Zone Boundary

**Note:**  
 More detailed, large scale, plans showing the No Build Zones and Consultation Zones around each landfill site are held by EPD and may be inspected at their offices

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 EXTENSION GEOLOGICAL MAP

FIGURE 1.4





<p>Scale 1:5000</p> <p><b>Legend:</b></p> <ul style="list-style-type: none"> <li><span style="border-bottom: 1px dashed black; width: 20px; display: inline-block;"></span> WENT Landfill Boundary</li> <li><span style="border-bottom: 1px solid black; width: 20px; display: inline-block;"></span> WENT Landfill Extension Boundary</li> <li><span style="border-bottom: 1px dashed black; width: 20px; display: inline-block;"></span> Consultation Zone Boundary</li> </ul>	<p><b>Note:</b></p> <p>More detailed, large scale, plans showing the No Build Zones and Consultation Zones around each landfill site are held by EPD and may be inspected at their offices</p>
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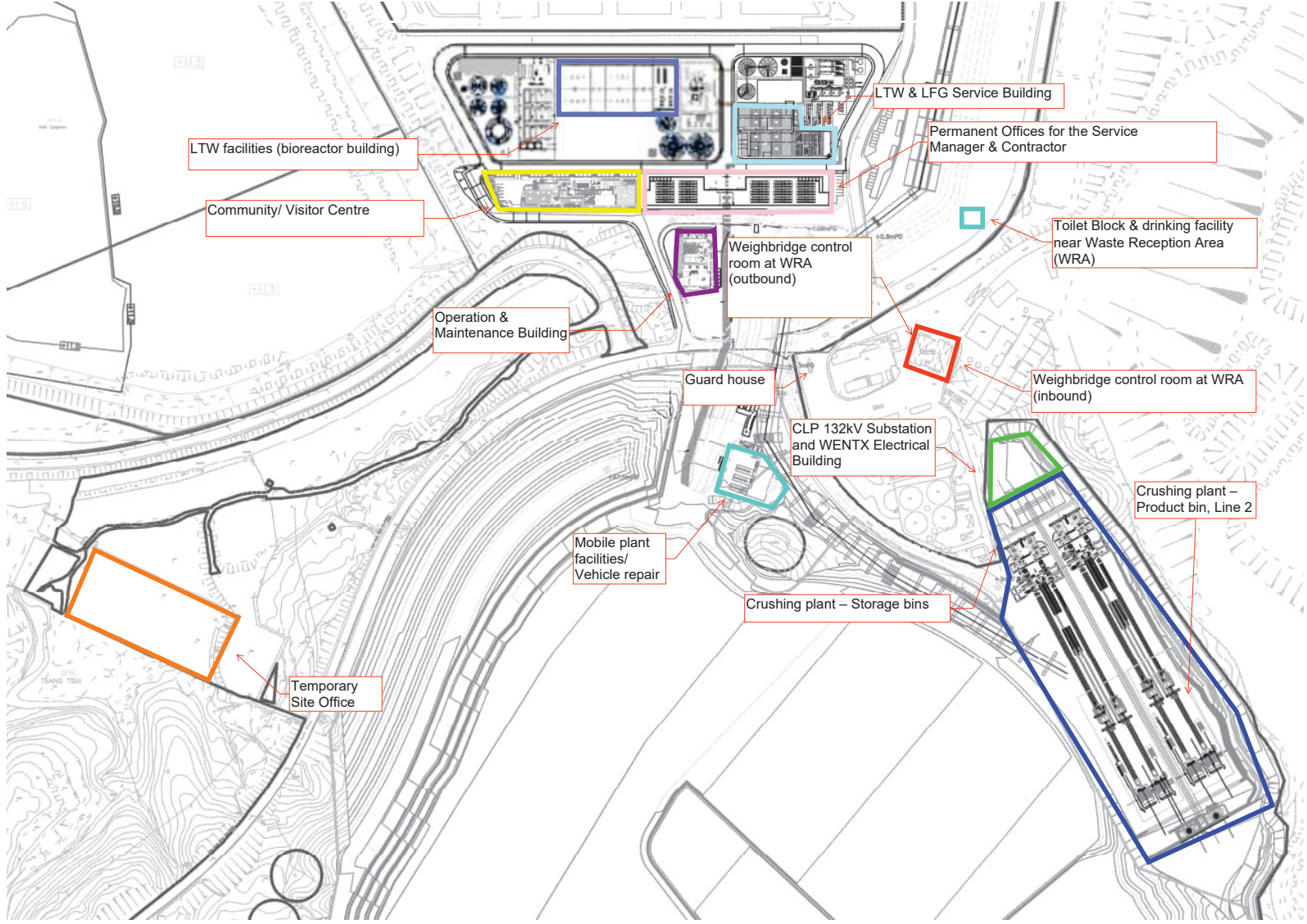
**LEGEND:**

- WENT LANDFILL WASTE BOUNDARY
- WENT LANDFILL EXTENSION WASTE BOUNDARY
- CONSULTATION ZONE BOUNDARY

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

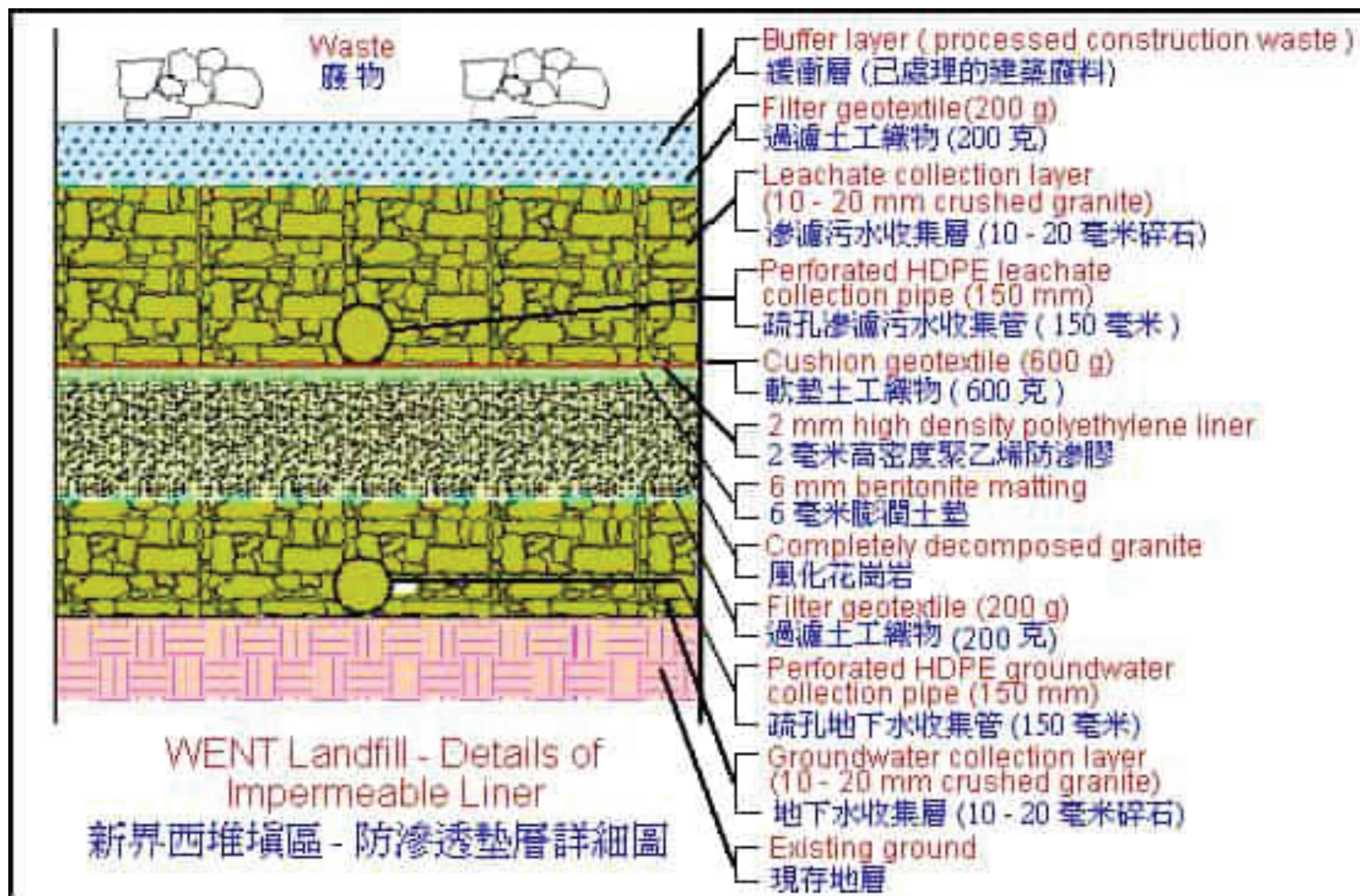
Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 EXTENSION KEY DEVELOPMENT AREA  
 WITHIN CONSULTATION ZONE LAYOUT PLAN

FIGURE 1.5



Drawing title  
WEST NEW TERRITORIES (WENT) LANDFILL  
EXTENSION PRELIMINARY LAYOUT PLAN OF  
BUILDINGS WITHIN WENTX

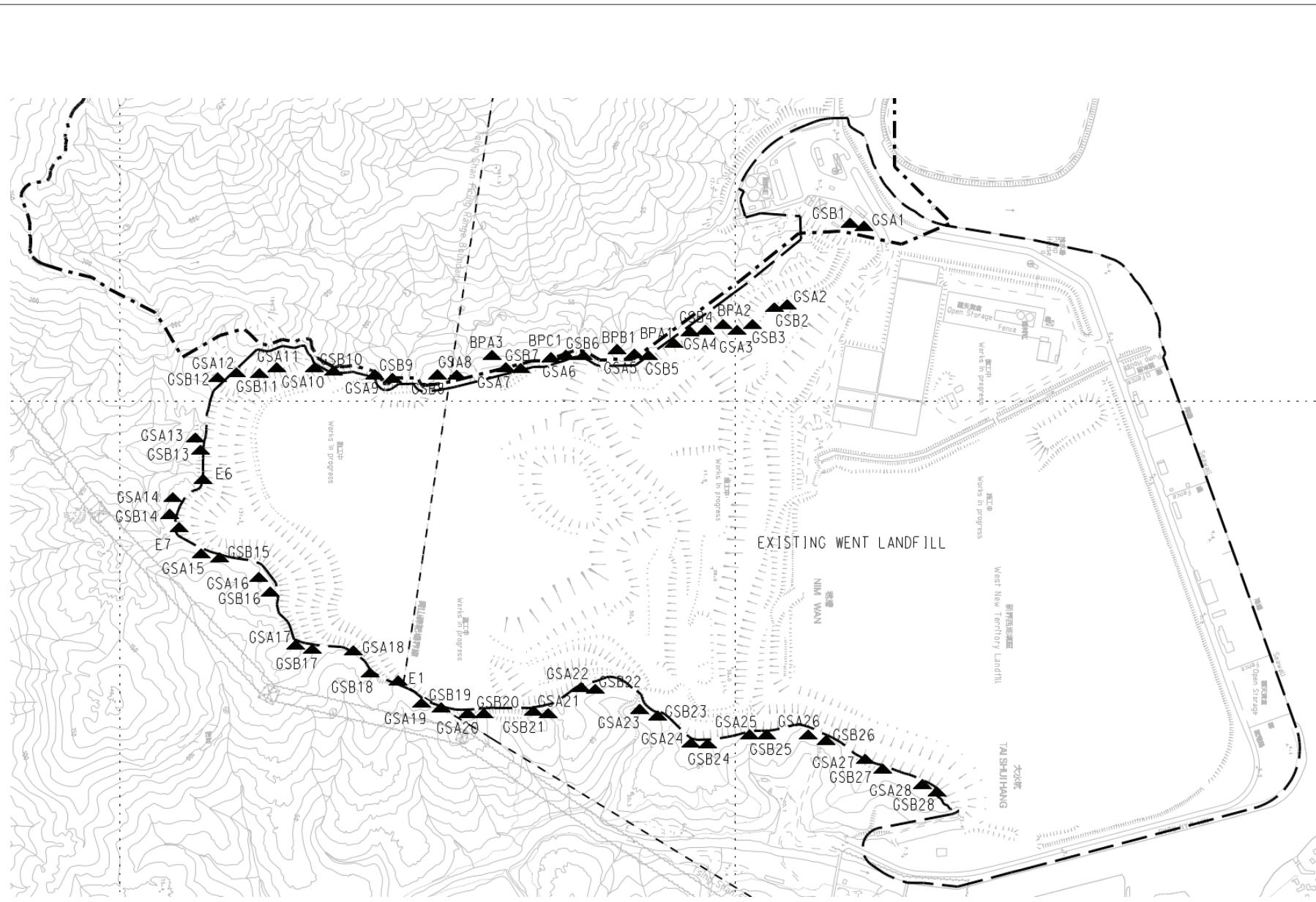
FIGURE 1.6



Project title  
CONTRACT NO. EP/SP/186/21  
WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
WEST NEW TERRITORIES (WENT) LANDFILL  
TYPICAL LINER SYSTEM

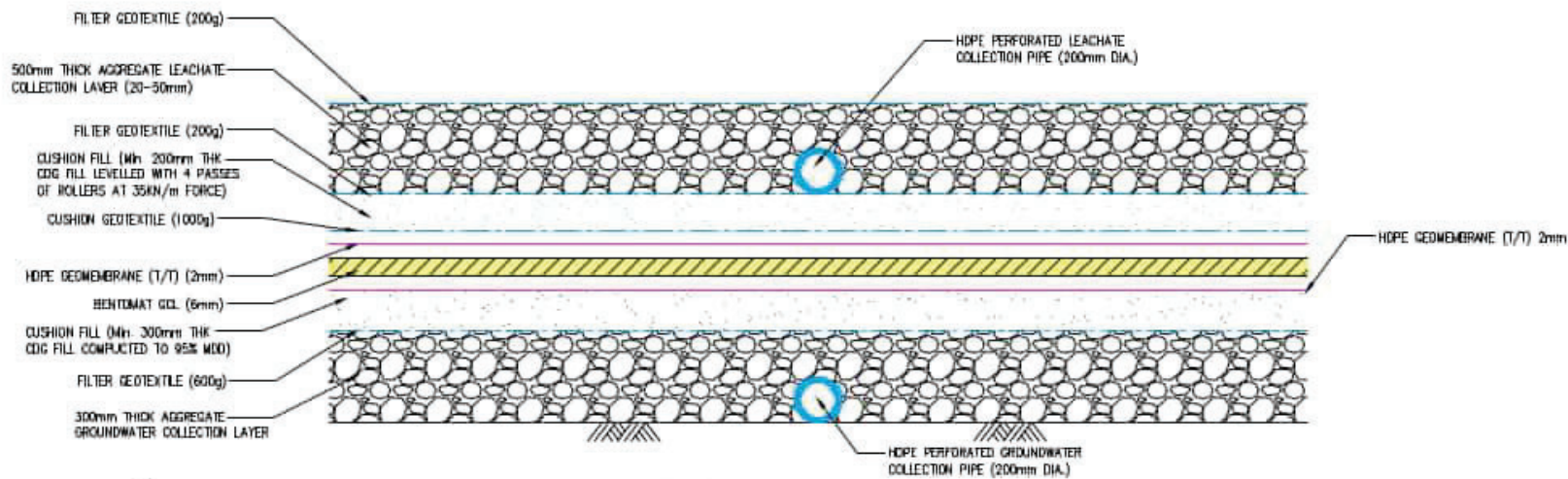
FIGURE 1.7



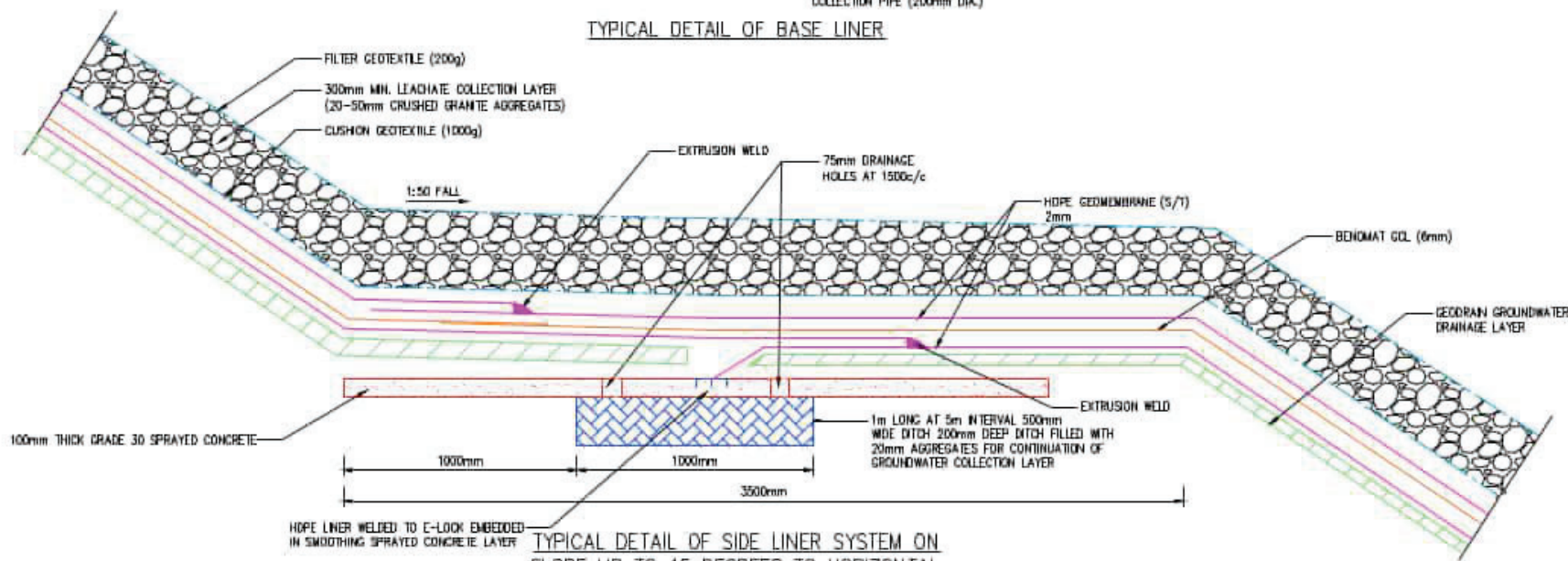
- LEGEND:
- SITE BOUNDARY OF WENT LANDFILL
  - - - WASTE BOUNDARY OF WENT LANDFILL EXTENSION
  - · · · · BOUNDARY OF TSING SHAN FIRING RANGE
  - ▲ GAS MONITORING WELL

LAYOUT PLAN OF WENT LANDFILL LFG MONITORING WELL LOCATION

Project title CONTRACT NO. EP/SP/186/21 WEST NEW TERRITORIES LANDFILL EXTENSION
Drawing title WEST NEW TERRITORIES (WENT) LANDFILL EXTENSION – WENT LFG MONITORING WELL LOCATION
FIGURE 1.8
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TYPICAL DETAIL OF BASE LINER

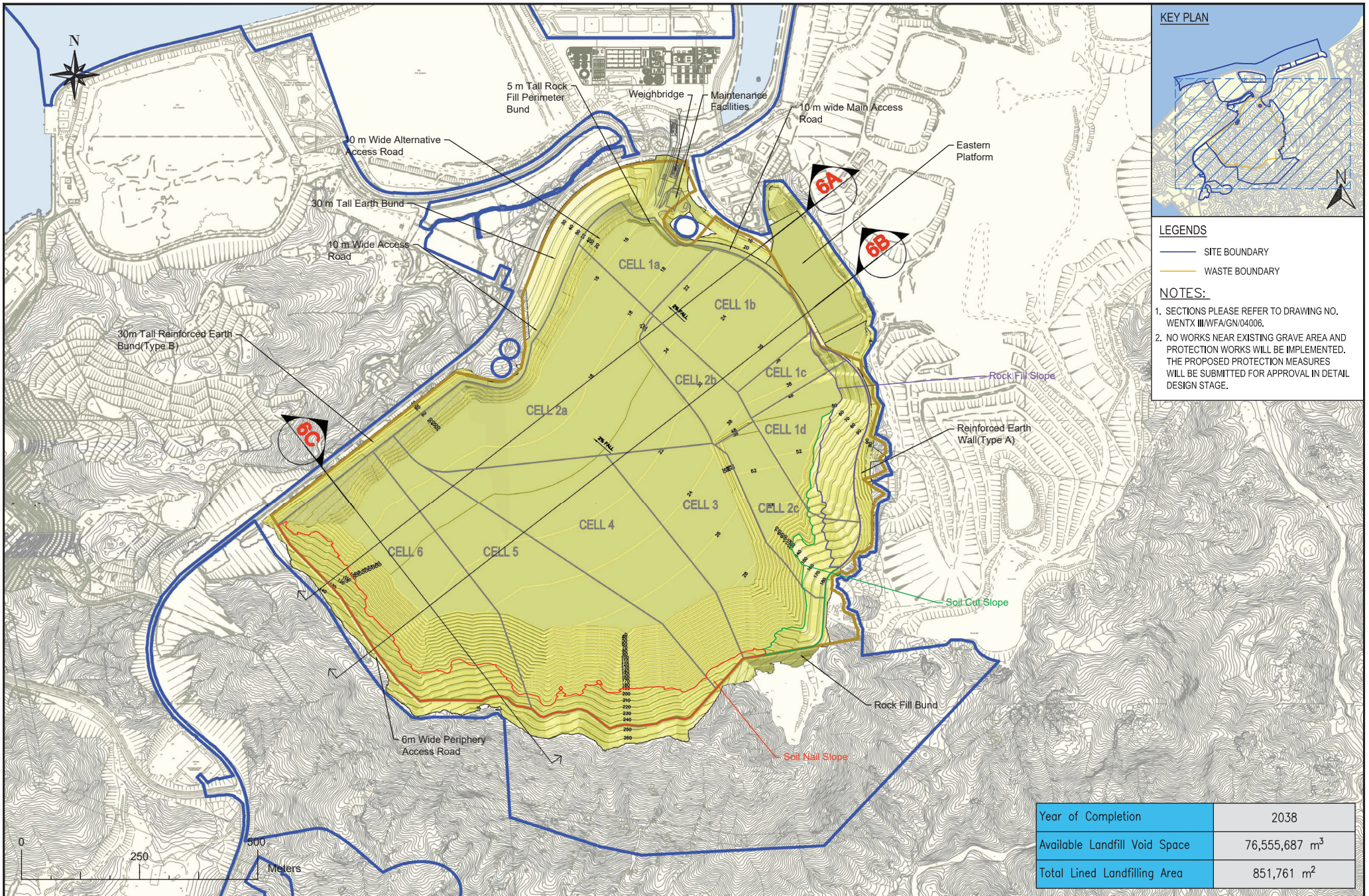


TYPICAL DETAIL OF SIDE LINER SYSTEM ON SLOPE UP TO 45 DEGREES TO HORIZONTAL

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 EXTENSION TYPICAL LINER SYSTEM

FIGURE 1.9



- LEGENDS**
- SITE BOUNDARY
  - WASTE BOUNDARY
- NOTES:**
1. SECTIONS PLEASE REFER TO DRAWING NO. WENTX III/WFA/GN/04006.
  2. NO WORKS NEAR EXISTING GRAVE AREA AND PROTECTION WORKS WILL BE IMPLEMENTED. THE PROPOSED PROTECTION MEASURES WILL BE SUBMITTED FOR APPROVAL IN DETAIL DESIGN STAGE.

Year of Completion	2038
Available Landfill Void Space	76,555,687 m <sup>3</sup>
Total Lined Landfilling Area	851,761 m <sup>2</sup>

PROJECT	TITLE
CONTRACT NO. EP/SP/186/21 WEST NEW TERRITORIES LANDFILL EXTENSION	<b>Position of Tipping Cells</b> FIGURE 2.1

**GEOLOGICAL LINE FEATURE**

- FAULT, INFERRED
- FAULT, OBSERVED
- MINERAL VEIN
- PHOTOLINEAMENT

**METAMORPHOSED GEOLOGY**

- MEGACRYSTIC

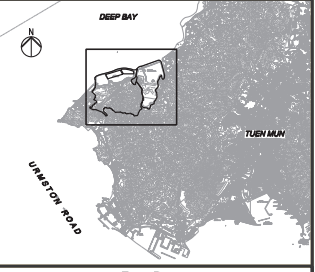
**SUPERFICIAL GEOLOGY**

- FILL
- ms MARINE SAND
- Qa ALLUVIUM
- Qb BEACH DEPOSITS
- Qd DEBRIS FLOW DEPOSITS
- QHH UNDIVIDED, MAINLY MARINE MUD
- Qpa TERRACED ALLUVIUM
- Qpd DEBRIS FLOW DEPOSITS
- Qrb RAISED BEACH DEPOSITS

**SOLID GEOLOGY**

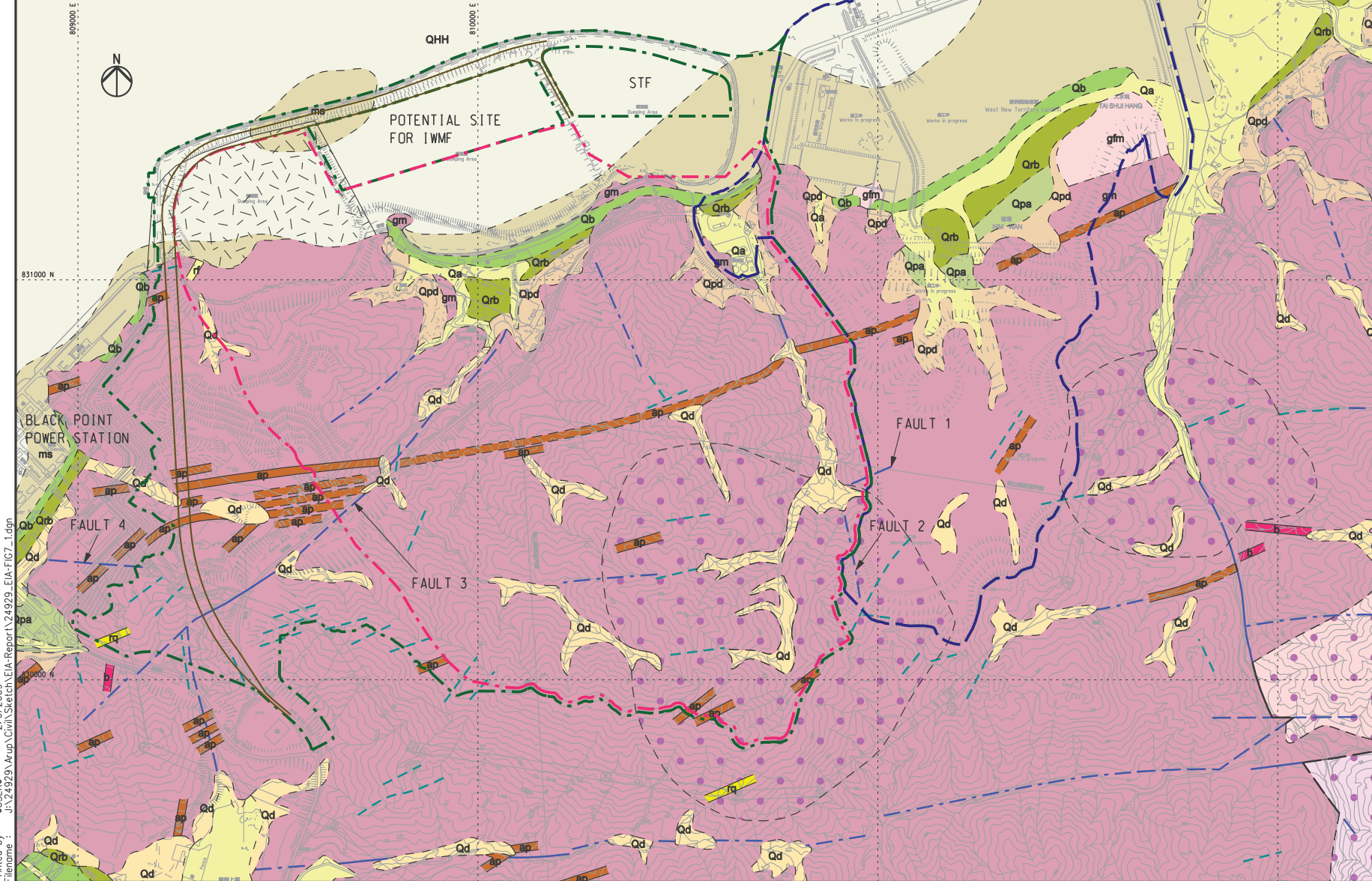
- ap APLITE
- b BASALT
- gf FINE-GRAINED GRANITE
- gfm FINE-TO MEDIUM-GRAINED GRANITE
- gm MEDIUM-GRAINED GRANITE
- l LAMPROPHYRE
- rf FELDSPHRYRIC RHYOLITE
- rq QUARTZPHYRIC RHYOLITE

NOTE: THIS MAP IS REPRODUCED BASED ON DIGITAL GEOLOGY MAP SHEET NO.5 WITH THE PERMISSION OF GEO/PLANNING DIVISION.



**LEGEND**

- BOUNDARY OF EXISTING WENT LANDFILL
- WASTE BOUNDARY OF WENT LANDFILL EXTENSION
- PROJECT BOUNDARY OF WENT LANDFILL EXTENSION
- NIM WAN ROAD DIVERSION



Project title  
**Contract No. EP/SP/186/21**  
**West New Territories Landfill Extension**

Drawing title  
**GEOLOGICAL MAP AS EXTRACTED FROM EIA REPORT**

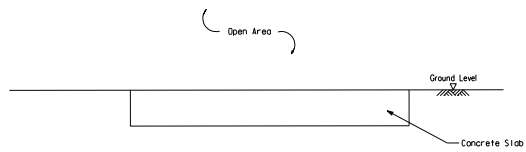
Drawing no. **FIGURE 2.2** Rev. -

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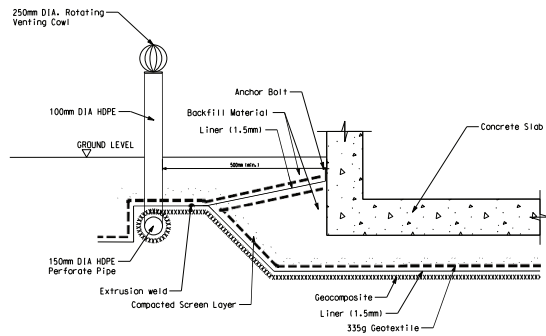
Printed by : \$USER\$  
 Filename : J:\24929\Arup\Civil\Sketch\Report\24929\_EIA-FIG7\_1.dgn  
 2/16/2009



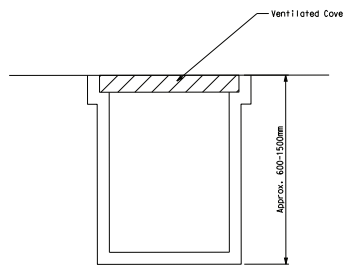




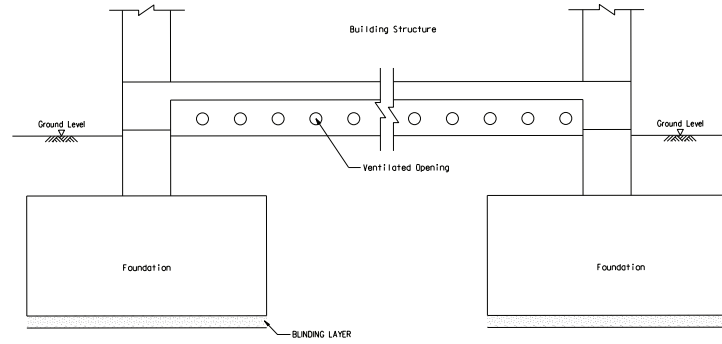
1. Typical Detail of Hardstanding - No Liner (For LTV & LFG Plants)



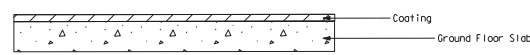
2. Occupied Office Building + Closed Buildings - Liner Protection



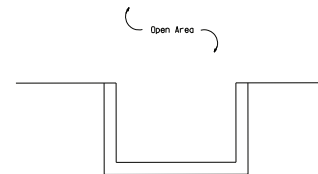
4. Utility Conduit - No Liner



3. Open Sided Building - Raised Floor



2.3 Occupied Office Building + Closed Buildings: Coating Protection



5. Shallow Open Trench

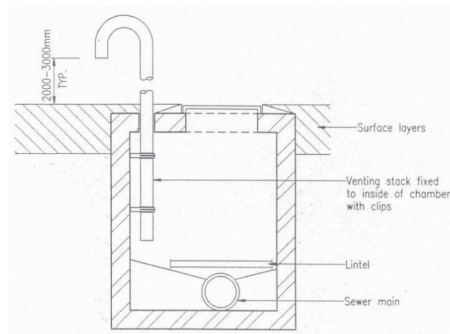
LEGEND:

Project title  
CONTRACT NO. EP/SP/186/21  
WEST NEW TERRITORIES LANDFILL EXTENSION

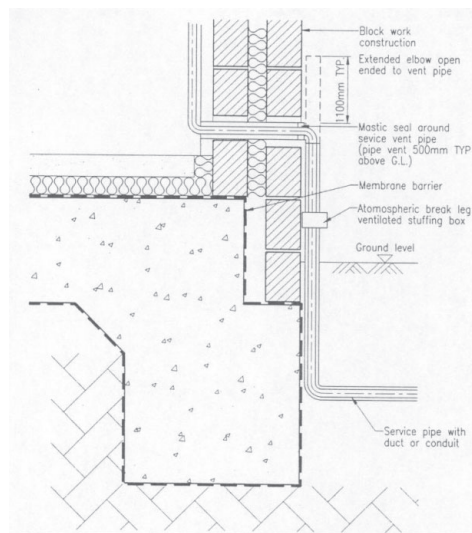
Drawing title  
WEST NEW TERRITORIES (WENT) LANDFILL  
TYPICAL LFG PROTECTION MEASURES

FIGURE 5.1

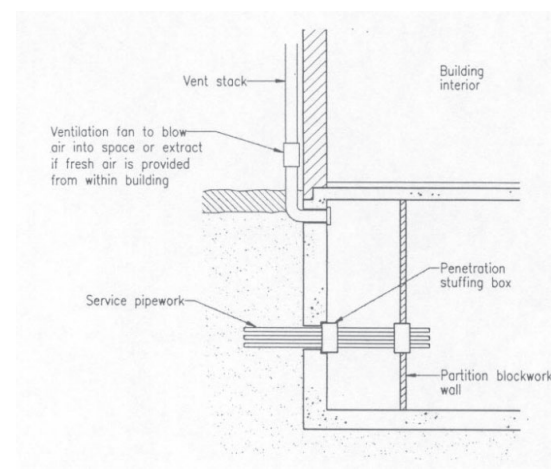
LEGEND:



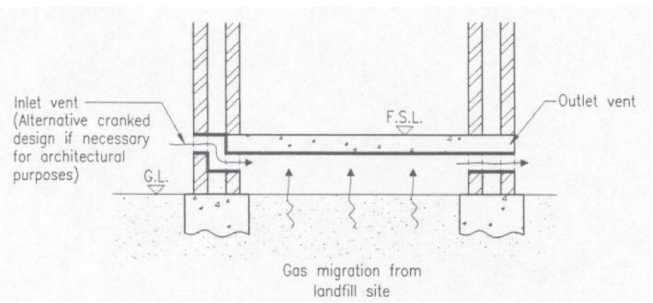
TYPICAL VENTED MANHOLE



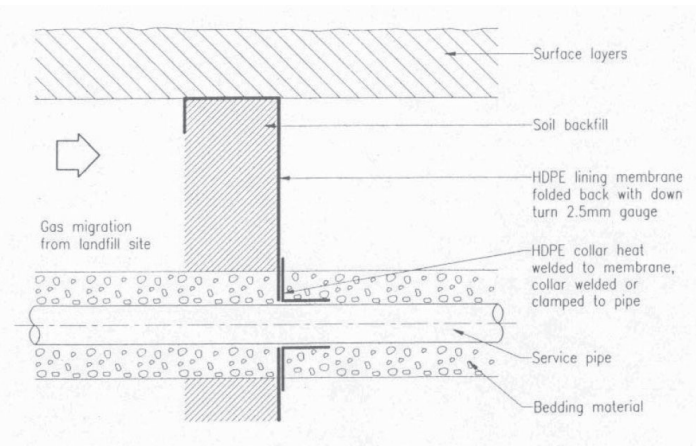
TYPICAL SUBFLOOR VENTING



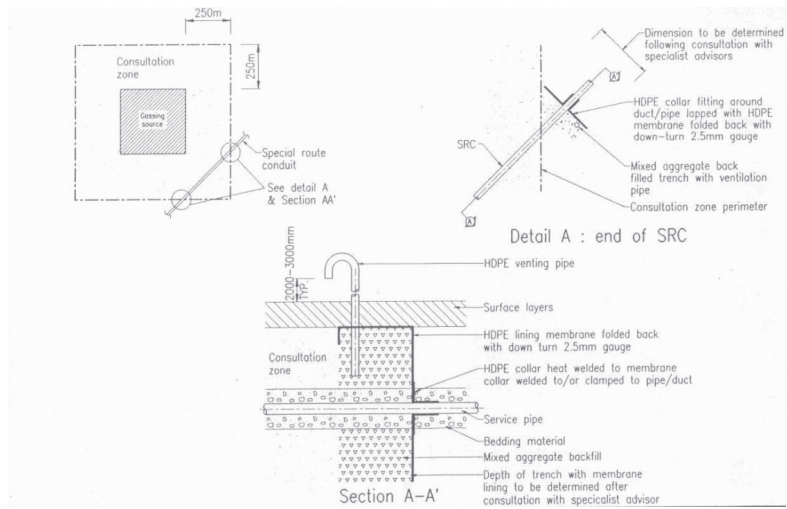
TYPICAL VENTED GAS INTERCEPTOR CAVITY



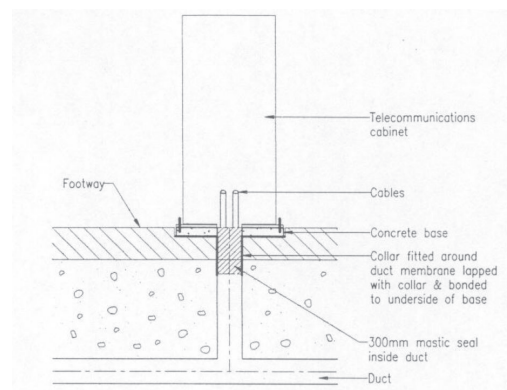
TYPICAL SUBFLOOR VENTING



TYPICAL FLEXIBLE MEMBRANE CUT-OFF



TYPICAL DESIGN FOR SERVICES PASSING THROUGH THE CONSULTATION ZONE

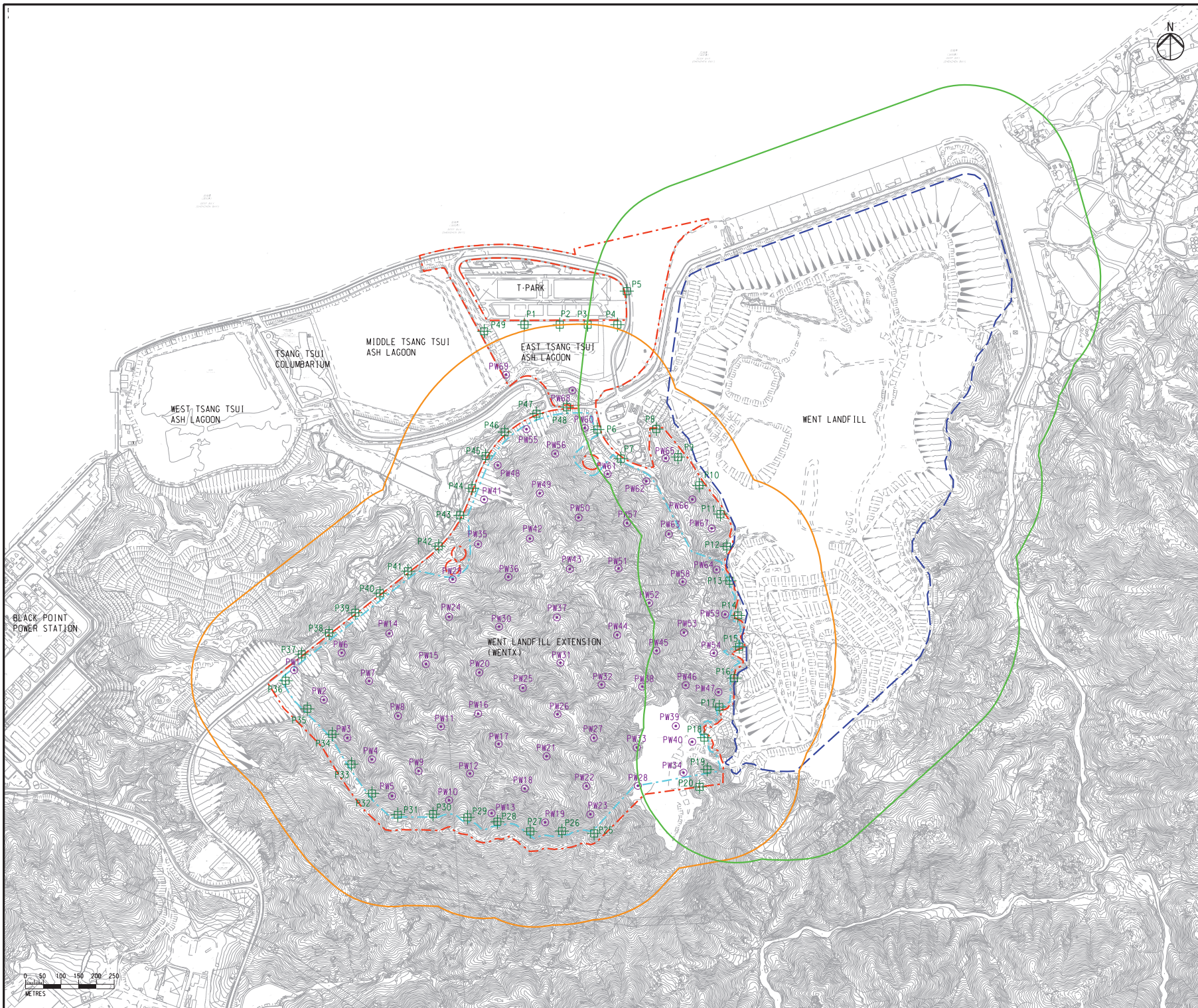


TYPICAL SURFACE DETAIL FOR ABOVE GROUND TERMINATION OF SERVICES WITHIN THE CONSULTATION ZONE

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 TYPICAL LFG PROTECTION MEASURES

FIGURE 5.2

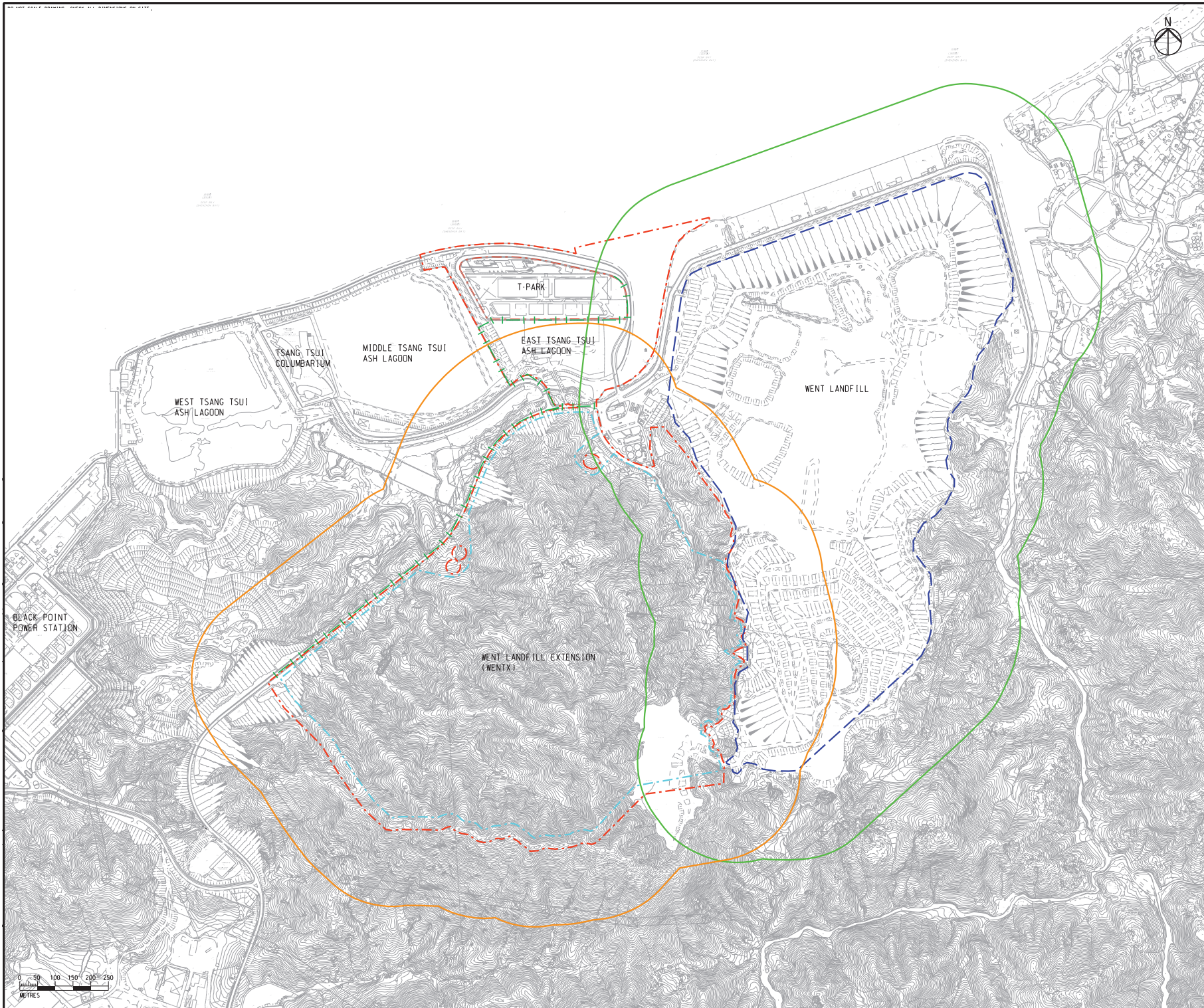


- LEGEND**
- - - WENT LANDFILL EXTENSION (WENTX) BOUNDARY
  - - - WENTX WASTE BOUNDARY
  - — — WENT LANDFILL WASTE BOUNDARY
  - — — PROPOSED NIM WAN ROAD (SOUTH) (BY OTHER PARTIES)
  - — — LANDFILL GAS CONSULTATION ZONE OF WENTX
  - — — LANDFILL GAS CONSULTATION ZONE OF WENT LANDFILL
  - P FIXED LOCATIONS FOR GAS MONITORING PROPOSED P1 - P49
  - PW FIXED LOCATIONS FOR GAS WELLS PROPOSED PW1 - PW69

Project title  
**Contract No. EP/SP/186/21**  
**West New Territories**  
**Landfill Extension**

Drawing title  
**LANDFILL GAS MONITORING**  
**LOCATIONS FOR WENTX**

Figure 7.1



- LEGEND**
- - - WENT LANDFILL EXTENSION (WENTX) BOUNDARY
  - - - WENTX WASTE BOUNDARY
  - - - WENT LANDFILL WASTE BOUNDARY
  - PROPOSED NIM WAN ROAD (SOUTH) (BY OTHER PARTIES)
  - LANDFILL GAS CONSULTATION ZONE OF WENTX
  - LANDFILL GAS CONSULTATION ZONE OF WENT LANDFILL
  - - - LANDFILL GAS CUT-OFF TRENCH BARRIER

Consultant

Project title  
**Contract No. EP/SP/186/21  
 West New Territories  
 Landfill Extension**

Drawing title  
**LANDFILL GAS CUT-OFF  
 TRENCH BARRIER**

Figure 7.2

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## **Appendix A**

### **Chapter 8 of LFG Guidance Note**

*Introduction*

8.1 During the construction phase, hazards may arise which are related either to the flammability of landfill gas or to its potentially asphyxiating properties. In particular cases, it is possible that toxicity effects may be significant. The following sub-sections of the Guidance Note may be used to form the basis of Specification Clauses for incorporation in Contract Documentation for developments within the Consultation Zone.

*General Hazards Which May Be Encountered*

8.2 The developer should be aware of, and should inform construction contractors accordingly, that methane and carbon dioxide are always likely to be present in the soil voids. In addition the developer should be aware of the potential hazards and other properties of landfill gas as described in Section 1.

*Outline of Safety Requirements*

8.3 In all construction work adjacent to landfill sites, safety procedures should be implemented to minimise the risks of:

- fires and explosions;
- asphyxiation of workers; and
- toxicity effects.

8.4 Precautions should be clearly laid down and rigidly adhered to with respect to:

- trenching and excavation; and

- creation of confined spaces at, near to or below ground level.

8.5 In addition to normal site safety procedures, gas detection equipment and appropriate breathing apparatus should be available and used when entering confined spaces or trenches deeper than 1 metre.

#### *Additional General Requirements*

8.6 During the construction phase, the following additional precautions should be followed.

#### *Appointment of Safety Officer*

8.7 For large developments, a Safety Officer, trained in the use of gas detection equipment and landfill gas-related hazards, should be present on site throughout the groundworks phase. The Safety Officer should be provided with an intrinsically safe portable instrument (or instruments), appropriately calibrated and capable of measuring the following gases in the ranges indicated:

methane	0-100% LEL and 0-100 % v/v
carbon dioxide	0-100%; and
oxygen	0-21%

8.8 For smaller developments, if a Safety Officer is not appointed, then expert opinion and advice should be sought on a regular basis.

#### *Safety Measures*

8.9 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 excavations. Safety notices should be posted warning of the potential hazards.

8.10 Those staff who work in, or have responsibility for 'at risk' areas, including all excavation workers, supervisors and engineers working within the Consultation Zone, should receive appropriate training on working in areas susceptible to landfill gas, fire and explosion hazards.

8.11 An excavation procedure or code of practice to minimise landfill gas related risk should be devised and carried out by the project proponent.

8.12 No worker should be allowed to work alone at any time in or near to any excavation. At least one other worker should be available to assist with a rescue if needed.

8.13 Smoking, naked flames and all other sources of ignition should be prohibited within 15m of any excavation or ground-level confined space. 'No smoking' and 'No naked flame' notices should be posted prominently on the construction site and, if necessary, special areas designated for smoking.

8.14 Welding, flame-cutting or other hot works should be confined to open areas at least 15m from any trench or excavation.

8.15 Welding, flame-cutting or other hot works may only be carried out in trenches or confined spaces when controlled by a 'permit to work' procedure, properly authorised by the Safety Officer (or, in the case of small developments, other appropriately qualified person).

8.16 The permit to work procedure should set down clearly the requirements for continuous monitoring for 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, in attendance outside the 'confined area', 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.

8.17 Ground level construction plant should be fitted with vertical exhausts at least 0.6m above ground level and with spark arrestors.

8.18 Any electrical equipment, such as motors and extension cords, should be intrinsically safe.

8.19 During piping assembly or conduiting construction, all valves/seals should be closed immediately after installation. As construction progresses, all valves/seals should be closed as installed to prevent the migration of gases through the pipeline/conduit. All



pipework/conduiting should be capped at the end of each working day.

8.20 Mobile offices, equipment stores, mess rooms etc. should be located on an area which has been proven to be gas free (by survey with portable gas detectors) and ongoing monitoring should be carried out to ensure that these areas remain gas free. The use of permanent gas detectors may be appropriate in some circumstances where there is a relatively high risk but for many developments it will be sufficient to have regular monitoring undertaken manually by the safety officer. The particular arrangements to be adopted at a specific site will need to be determined during the risk assessment/design of protection measures.

8.21 Alternatively, such buildings should be raised clear of the ground. If buildings are raised clear of the ground, a minimum, clear separation distance (as measured from the highest point on the ground surface to the underside of the lowest floor joist) should be 500mm.

8.22 During construction, adequate fire extinguishing equipment, fire-resistant clothing and breathing apparatus (BA) sets should be made available on site.

- At larger developments, fire drills should be organised at not less than six monthly intervals.
- The developer should formulate a health and safety policy, standards and instructions for site personnel to follow.

### *Monitoring*

8.23 Periodically during ground-works construction, the works area should be monitored for methane, carbon dioxide and oxygen using appropriately calibrated portable gas detection equipment.

8.24 The monitoring frequency and areas to be monitored should be set down prior to commencement of ground-works either by the Safety Officer or by an appropriately qualified person.

8.25 Routine monitoring should be carried out in all excavations, manholes and chambers and any other confined spaces that may have been created by, for example, the temporary storage of building materials on the site surface.

8.26 All measurements in excavations should be made with the monitoring tube located not more than 10mm from the exposed ground surface.

8.27 Monitoring of excavations should be undertaken as follows:

**For excavations deeper than 1m,** measurements should be made:

- at the 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 through the working day whilst workers are in the excavation.

**For excavations between 300mm and 1m deep,** measurements should be made:

- directly after the excavation has been completed; and
- periodically whilst the excavation remains open.

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

*Actions in the Event of Gas Being Detected*

8.28 Depending on the results of the measurements, actions required will vary and should be set down by the Safety Officer or other appropriately qualified person. As a minimum these should encompass those actions specified in *Table 8.1*.

**Table 8.1 Actions in the Event of Gas Being Detected in Excavations**

Parameter	Measurement	Action
O <sub>2</sub>	< 19%	Ventilate trench/void to restore O <sub>2</sub> to >19%

Parameter	Measurement	Action
	< 18%	Stop works evacuate personnel/prohibit entry increase ventilation to restore O <sub>2</sub> to >19%
CH <sub>4</sub>	> 10% LEL	Post 'No Smoking' signs prohibit hot works ventilate to restore CH <sub>4</sub> to <10% LEL
	>20% LEL	Stop works evacuate personnel/prohibit entry increase ventilation to restore CH <sub>4</sub> to <10% LEL
CO <sub>2</sub>	>0.5%	ventilate to restore CO <sub>2</sub> to <0.5%
	> 1.5%	Stop works evacuate personnel/prohibit entry increase ventilation to restore CO <sub>2</sub> to <0.5%

#### *Specific Advice Relating to the Drilling of Boreholes*

8.29 As part of the site investigation and subsequent ground works for a development within a Consultation Zone, it will often be necessary to drill exploratory boreholes. Such work should be undertaken following the general advice given above. Specific recommendations relating to the drilling of boreholes within the Consultation Zone are presented below.

#### *Supervision and Safety Management of Drilling Operations*

8.30 Drilling should only proceed with adequate care and precautions against the potential hazards which may be encountered.

8.31 Before site works begin, the drilling contractor should devise a 'method-of-working' statement covering all normal and emergency procedures and the site supervisor and all operatives must be familiar with this statement.

8.32 The method-of-working statement should cover, *inter alia*:

- number of operatives;
- experience and special skills of operatives;

- normal method of operations;
- emergency procedures, including fire fighting;
- supervisors responsibilities;
- storage and use of safety equipment;
- safety procedures; and
- signs, barriers and guarding.

#### *Safety Equipment and Clothing*

8.33 An intrinsically safe, portable methane meter should be available at all times.

Other safety equipment should include:

- no smoking signs, to be placed prominently adjacent to the drilling area;
- portable fire extinguisher;
- high visibility clothing to be worn by all drilling operatives; and
- additional protective clothing should include stout industrial boots (with steel toe cap and insole), plastic hard hats, heavy duty waterproof industrial grooves.

#### *Working Procedures*

8.34 On arrival at site the drilling rig should be set-up up-wind of the borehole location, 'No smoking' signs set out and the working area should be roped or coned-off.

8.35 When drilling on landfill sites, all spoil obtained from the borehole should be stockpiled alongside the borehole and disposed of (to an appropriately licensed disposal site) at the end of the working day. At the end of the working day all vehicles, the drilling rig and any hand tools should be hosed-down with clean water to remove deposits of excavated spoil. Suitable guards or barriers should be placed around the excavation or borehole to prevent access by unauthorised persons.

#### *Safety Procedures*

8.36 One person should be present at all times during drilling operations, with the sole responsibility of assuring the observance of all safety procedures. This person should be trained in the use of all recommended safety equipment.

8.37 Smoking should be prohibited anywhere on a landfill site and within 15 metres of a

boring or excavation at any locations within the Consultation Zone.

8.38 For large diameter boreholes, a working platform should be placed over the hole which will prevent accidental entry into the hole by operatives.

8.39 No worker should be allowed to work alone at any time near the edge of the well under construction. Another worker should always be present, beyond the area considered to be subject to the possible effects of landfill gas or cave-in.

8.40 Periodically during the well construction, the work areas should be monitored for levels of methane.

8.41 If the well construction is not completed by the end of the working day, the hole should be covered with a plate of sufficient overlap to prevent access to the hole and sufficient structural strength to support expected loads. The plate should be weighted down to discourage removal and, on landfill sites, the edges of the plate should be covered with sufficient depth of wet soil to prevent escape of gas.

8.42 All pipes or casings should be capped at the end of each working day.

8.43 Engine-driven rigs should have vertical exhaust stacks discharging not less than 1.5m above ground level and should have overspeed limits to prevent engine run away on ingested gas.

8.44 Diesel engine air-intakes should also be located not less than 1.5m above ground level.

8.45 Any electrical equipment should be intrinsically safe.

8.46 Additional safety advice and guidance may be found in 'Investigation into Establishing an Effective Practical Safe Working Practice When Drilling in Landfill Sites and Adjacent Areas and Contaminated Ground and Adjacent Areas' compiled by the British Drilling Association (1993).

#### *Installation of Vertical Wells*

8.47 To prevent uncontrolled gas release and to protect personnel from the risk of falling into the borehole, the open borehole should be covered with a sheet or plate strong enough to support personnel and having an overlap all round the borehole.

8.48 The drilling rig, boring machine or excavator should remain in place over the borehole and could be used as a support to assist placement of the casing.

8.49 The upper end of the well casing should be sealed, preferably with a fused or screwed end cap or alternatively with an inflatable bag type flow stopper, until the permanent headworks/monitoring tap is fitted. Landfill gas must not be allowed to vent freely at the site surface.

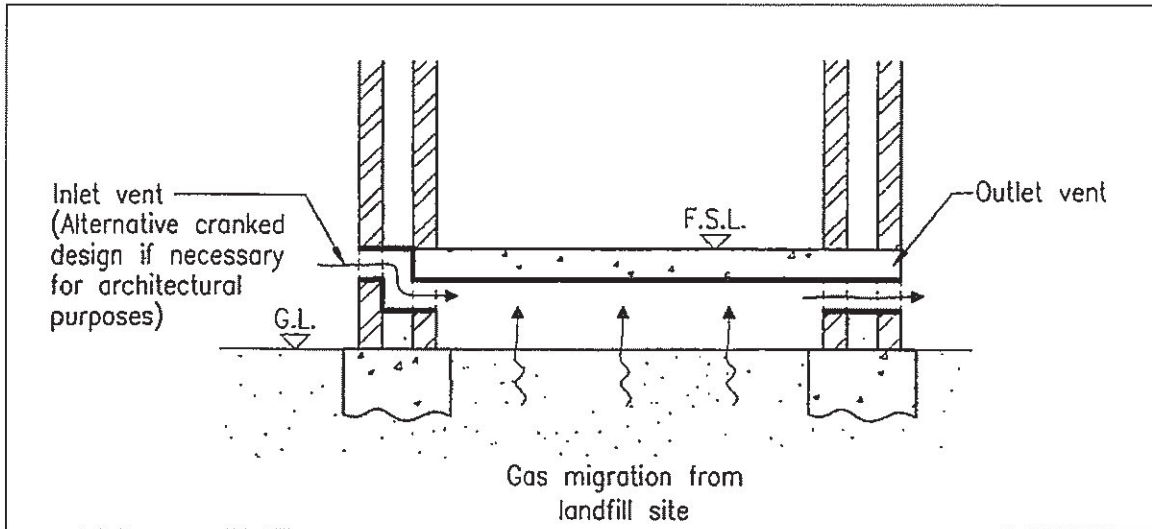
## **Appendix B**

### **Specific Landfill Gas Protection Measures for Building Services**

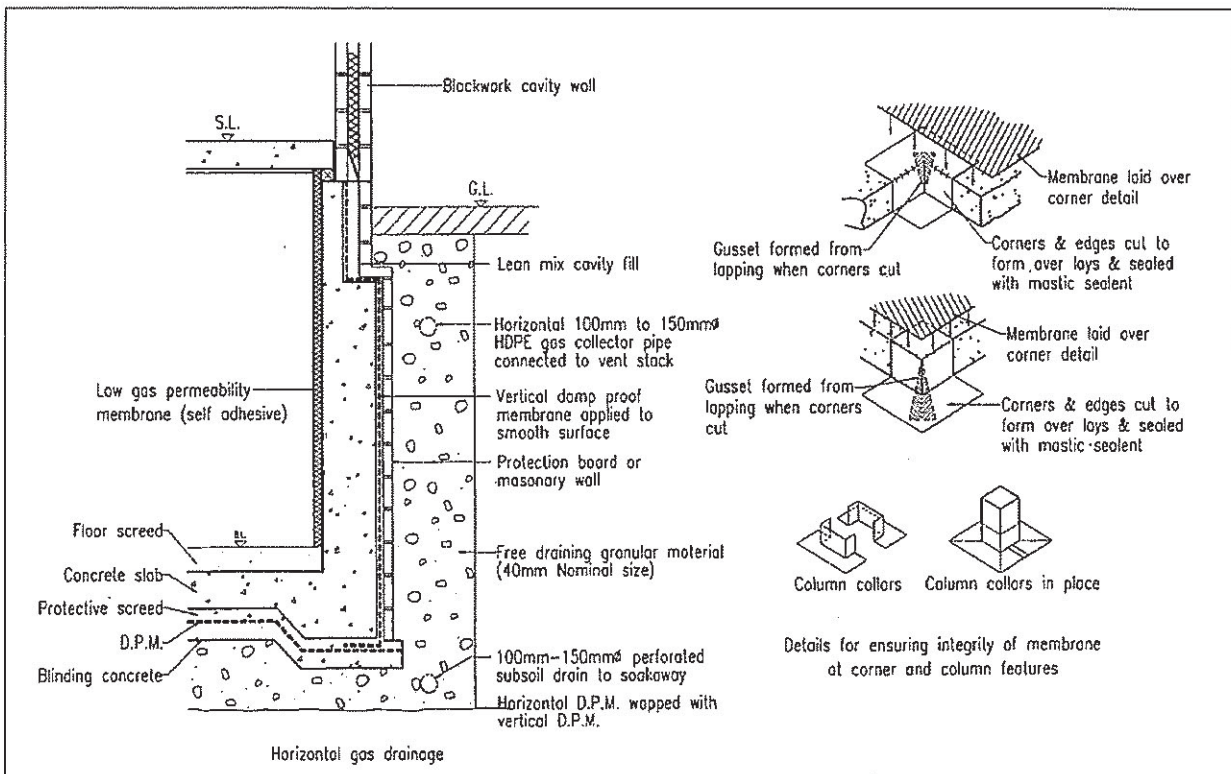
## Building Protection Design Measures

There are a number of protection measures commonly adopted for protection of developments adjacent to landfills. These include both passive and active control system.

### (a) Passive Control Systems :



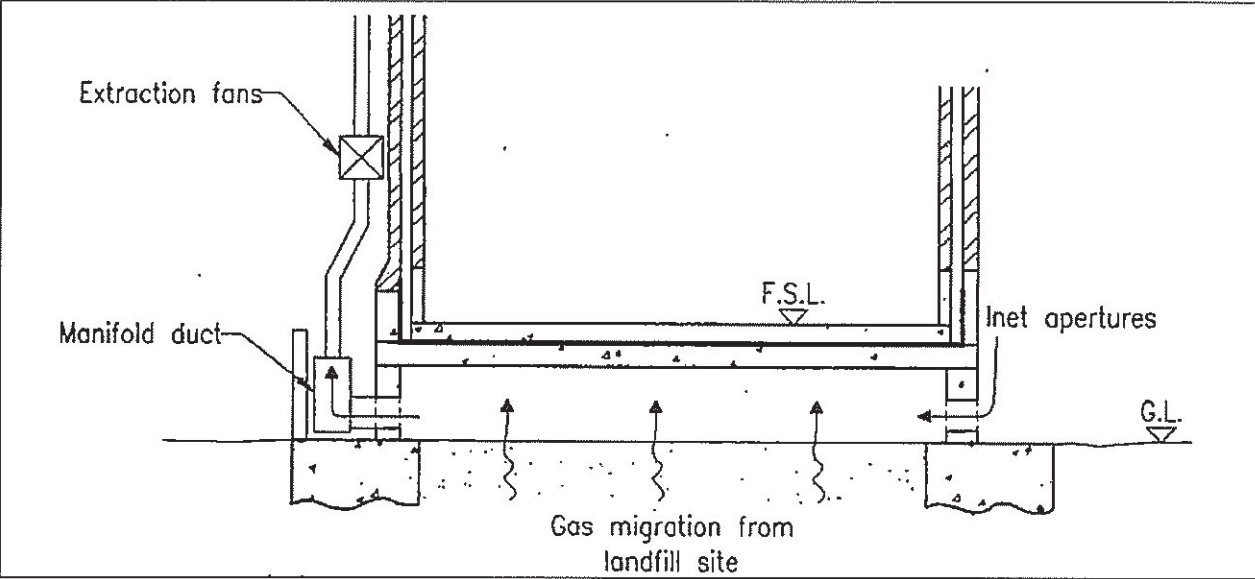
Sub-floor venting system



Typical details for flexible membrane protection measures



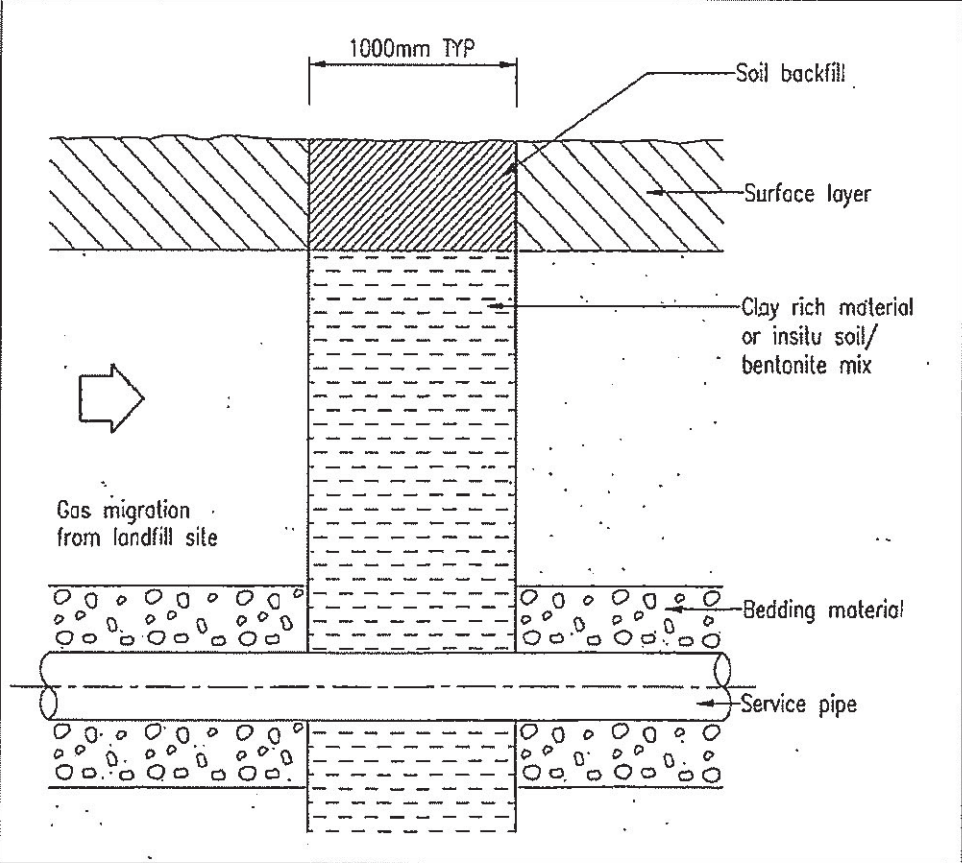
(b) Active Control Systems :



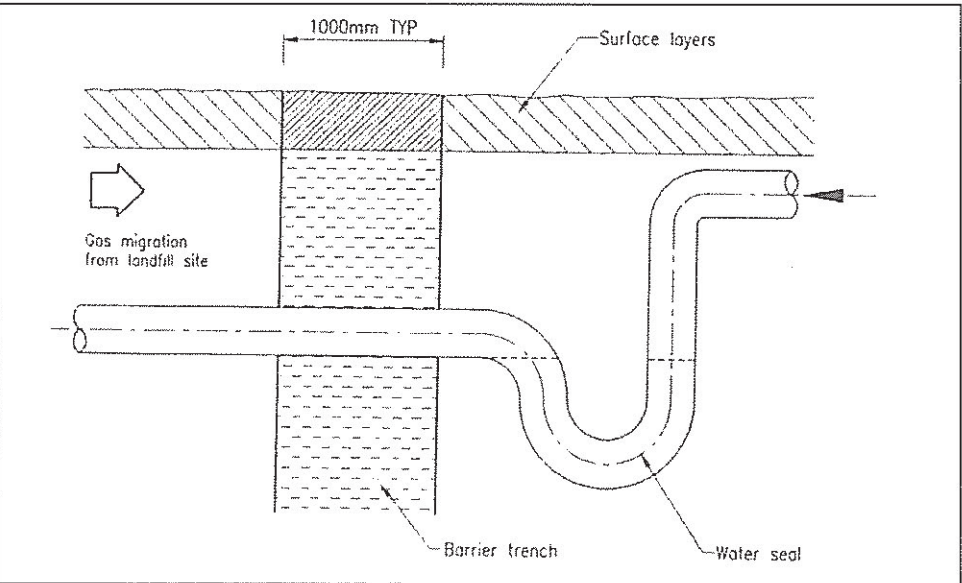
Sub-floor venting system

**Design Measures for Sub-surface Building Services**

**(a) Gas Barriers**

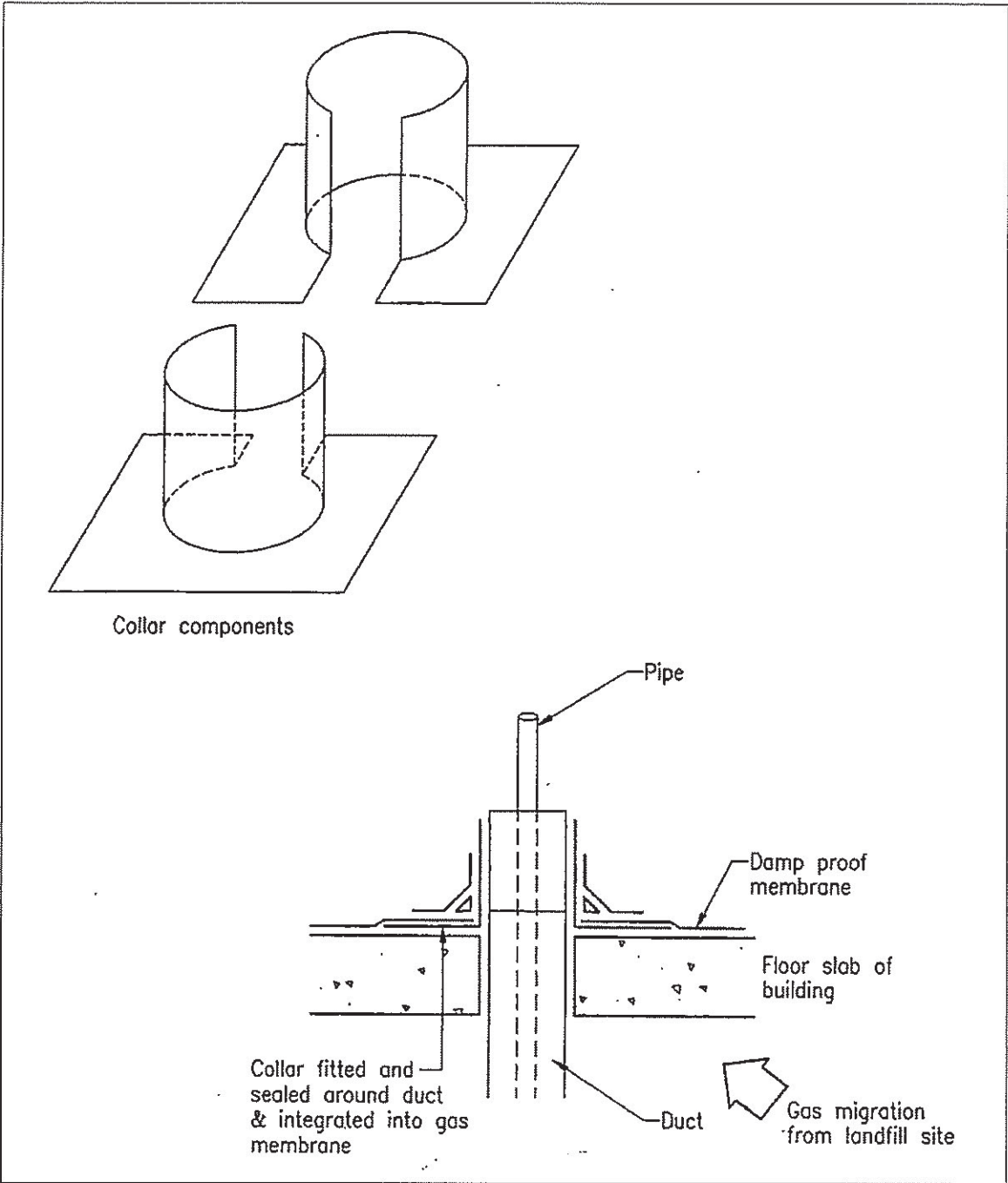


Natural material cut-off barrier

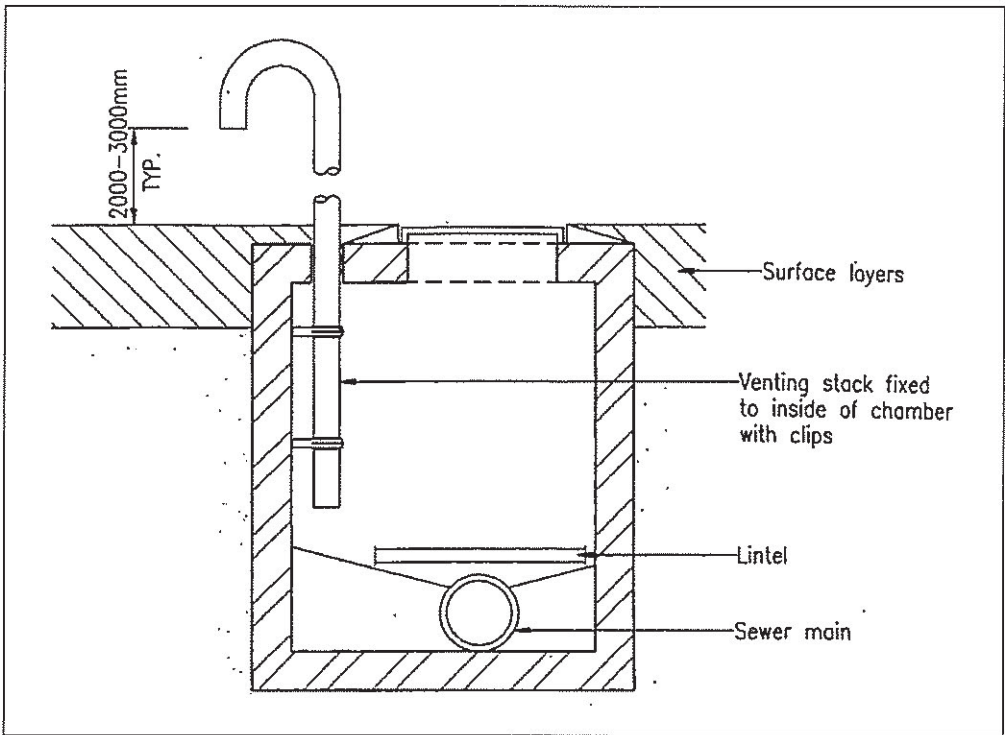


Open conduit protection by water seal

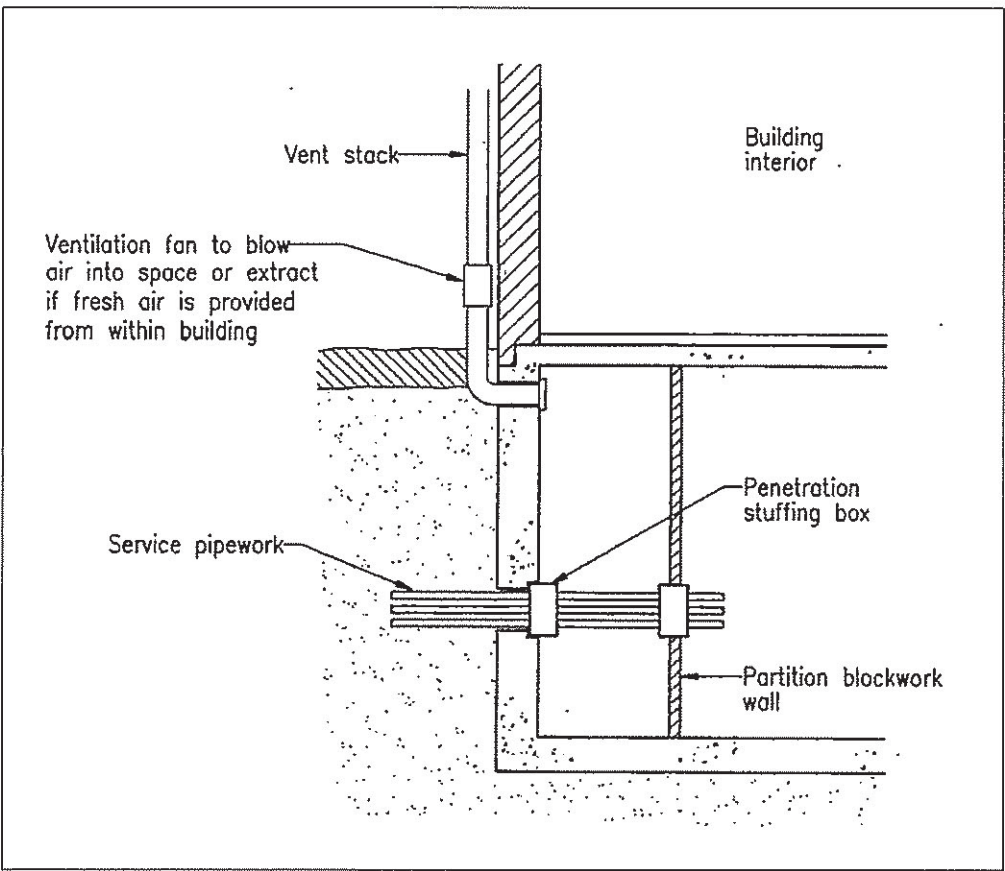
(b) Gas Vents



Typical detail of Collar Seal



Vented manhole



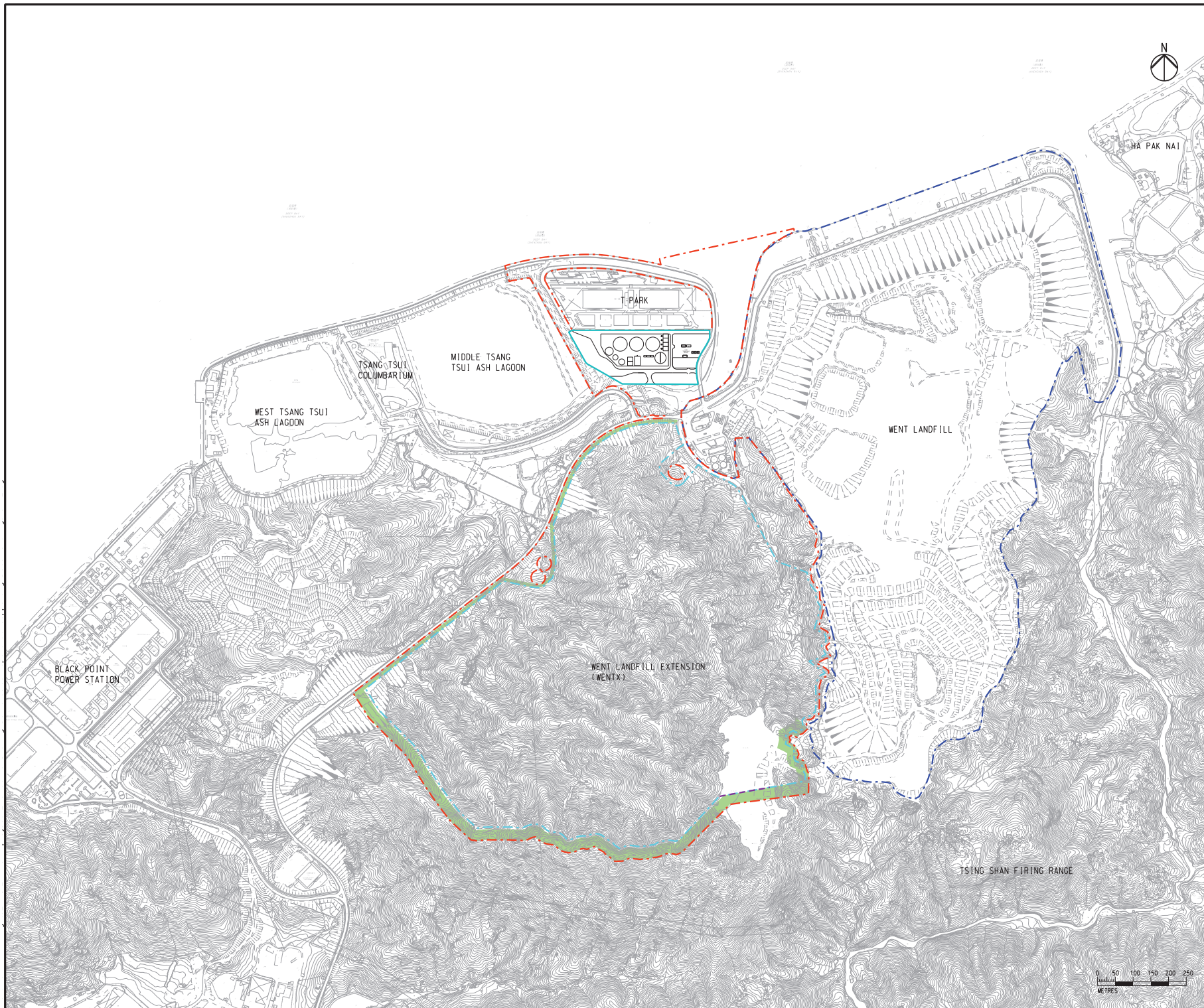
Vented Gas Interceptor Cavity

## **Appendix C**

### **Implementation Schedule**

**Implementation Schedule  
WENT Landfill Extension**

Mitigation Measures ID	Key Mitigation Measures in the Detailed Hazard Assessment Report	Objectives of the Recommended Measures & Main Concerns to address	Who to implement the measures?	Location of the measures	When to implement the measures?	Status
1	Placement of the liner system and the landfill gas management system to contain, manage, and control the migration and utilization of landfill gas. The location and cross section of the liner system and the landfill gas management system are in <i>Figure 1 and Figure 2</i> of this Implementation Schedule.	To ensure that the design of the landfill gas protection measures is in order and appropriate.	Contractor	Entire WENT Landfill Extension site	Construction, Operation, Restoration and Aftercare phases	The liner system will be installed within the WENTX waste boundary in <i>Figure 1</i> of this Implementation Schedule.
2	Landfill gas (LFG) cut-off trench barrier shall be installed at locations as shown in <i>Figure 3</i> of this Implementation Schedule.	To cut off any gas migration from WENT Landfill Extension to the middle lagoon and T Park which falls into the 250m LFG consultation zone of WENT Landfill and its Extension.	Contractor	Along the site boundary of the WENT Landfill Extension	Operation, Restoration and Aftercare phases	Since there are no "design equations" for cut-off barrier specifications, it is essential to seek expert recommendation before finalising the design detail of any cut-off barrier. The design of LFG cut-off trench barrier shall be provided at a later stage.
3	Landfill gas monitoring wells shall be installed at the location as shown in <i>Figure 4</i> between the WENTX boundary and the WENTX infrastructure area to monitor the migration of landfill gas, if any. LFG monitoring shall be conducted on monthly basis.	To ensure that the design of the landfill gas protection measures is in order and appropriate	Contractor	Entire WENT Landfill Extension site	Construction, Operation, Restoration and Aftercare phases	The location of the landfill gas monitoring wells may need to be updated to accommodate ongoing construction work at the site. The final design of the landfill gas monitoring wells should be provided and updated at a later stage.
4	If the monitoring results indicate evidence of gas migration, the monitoring frequency shall be increased accordingly, with the implementation of appropriate mitigation measures under the Contingency Procedure.	Landfill control for blasting work	Contractor	All blasting works within the 250m consultation zone of the WENT Landfill	Construction phase	Refer to <i>Appendix for Mitigation Measures 4</i>
5	In the event of the relevant gas concentration deviates from the safety limits, appropriate actions shall be determined by the Safety Officer or other appropriately qualified person and these shall encompass the action.	To minimise the risk of LFG hazards to personnel in landfill site	Contractor	LFG Consultation zone within WENT Landfill Extension site	Construction, Operation, Restoration and Aftercare phases	Refer to <i>Appendix for Mitigation Measures 5</i>
6	The designed air change for various rooms / facilities or measures shall be implemented.	To minimise the risk of LFG hazards to personnel in landfill site	Contractor	LFG Consultation zone within WENT Landfill Extension site	Construction, Operation, Restoration and Aftercare phases	Refer to <i>Appendix for Mitigation Measures 6</i>
7	Landfill gas protection measures shall be checked and certified by a qualified independent consultant.	To ensure that the design of the landfill gas protection measures is in order and appropriate	Contractor	Entire WENT Landfill Extension site	Construction, Operation, Restoration and Aftercare phases	Landfill gas protection measures shall be checked and certified by the Design Checker.



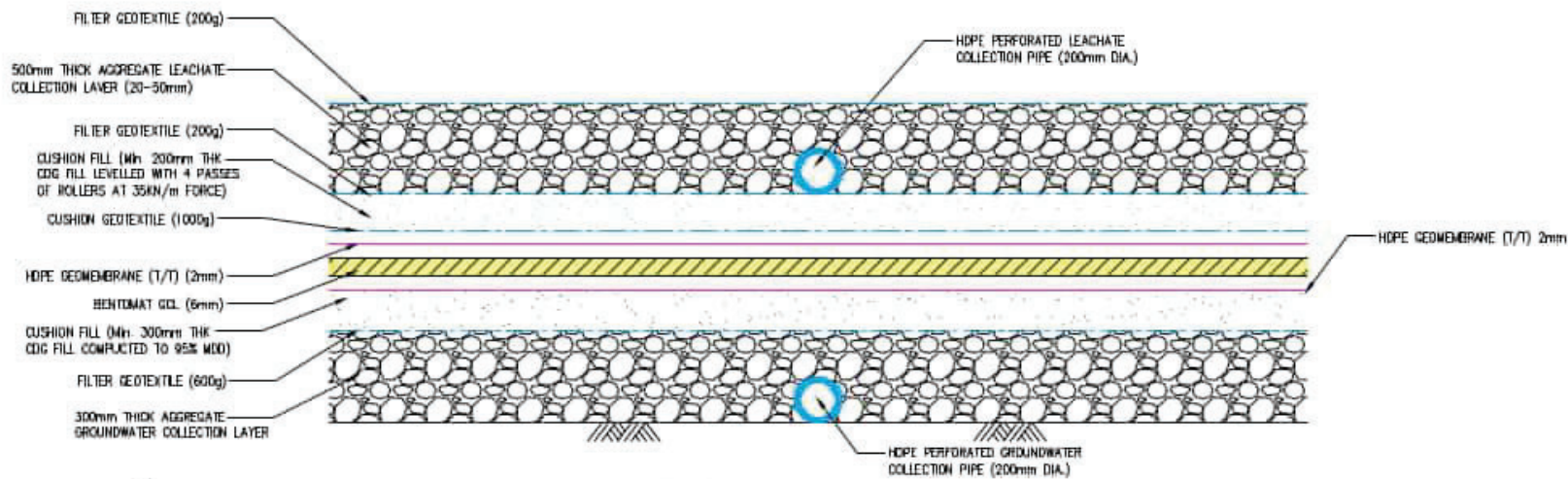
- LEGEND**
- WENT LANDFILL EXTENSION (WENTX) BOUNDARY
  - WENTX WASTE BOUNDARY
  - LANDFILL INFRASTRUCTURE FOR WENTX
  - WENT LANDFILL BOUNDARY
  - TREE PLANTING BUFFER

Project title  
**Contract No. EP/SP/186/21**  
**West New Territories**  
**Landfill Extension**

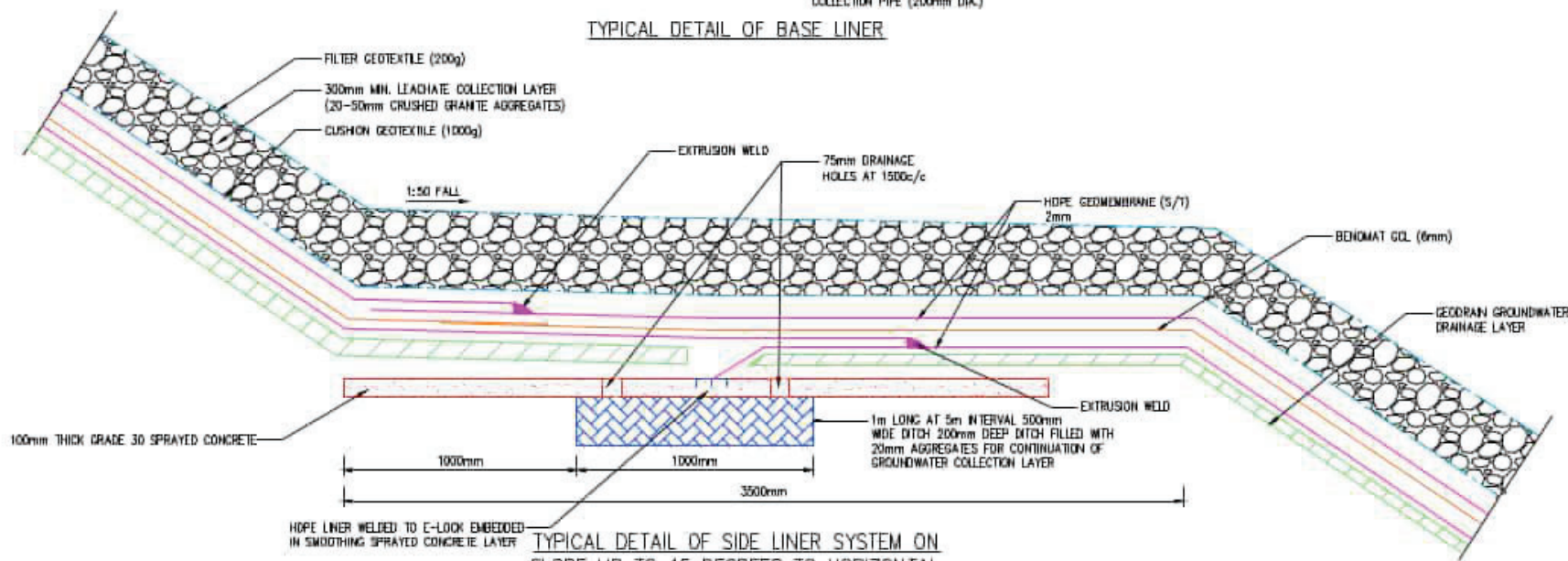
Drawing title  
**GENERAL PLAN**  
**OF ENHANCED SCHEME**

Drawing no. **FIGURE 1**





TYPICAL DETAIL OF BASE LINER



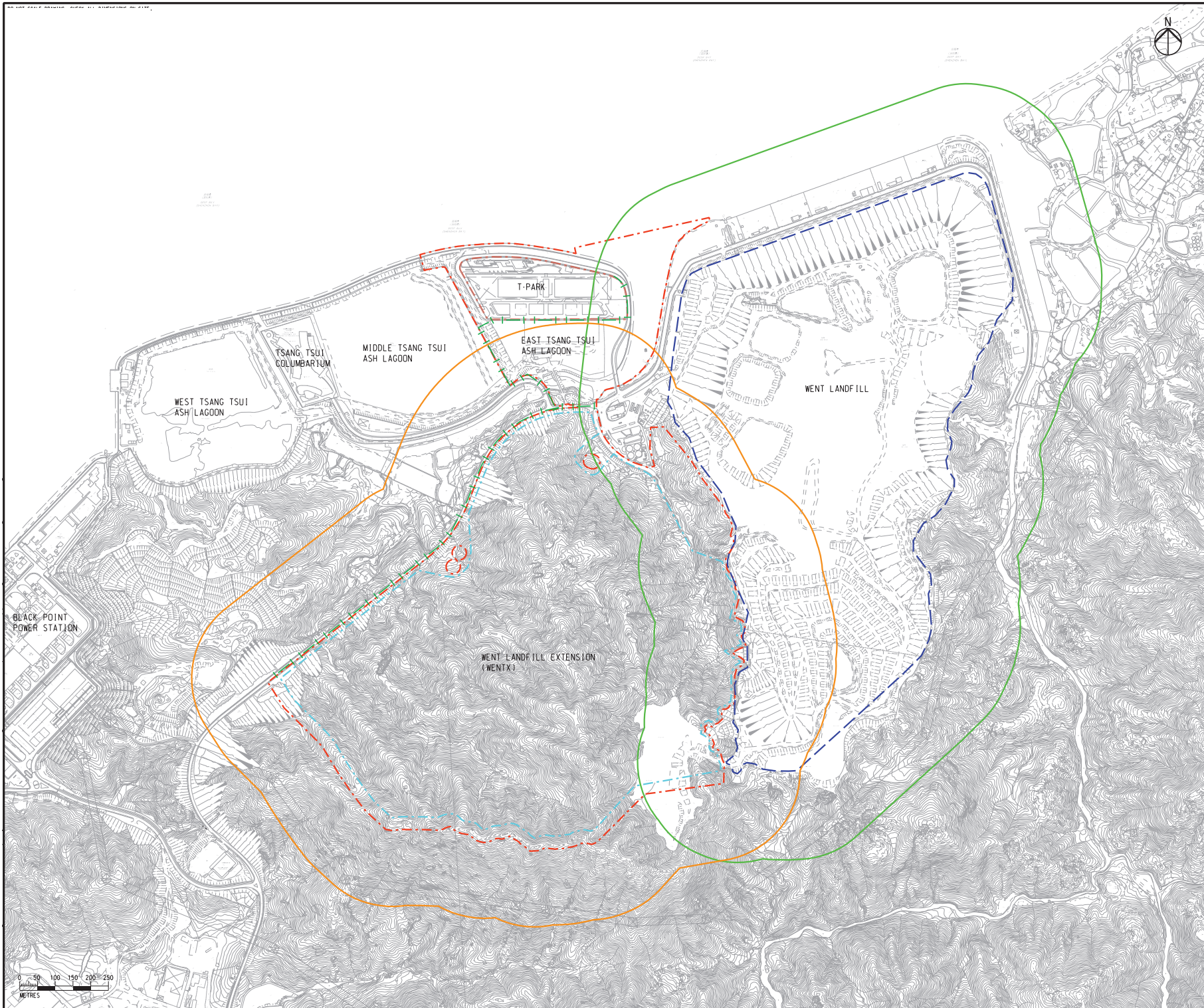
TYPICAL DETAIL OF SIDE LINER SYSTEM ON SLOPE UP TO 45 DEGREES TO HORIZONTAL

Project title  
 CONTRACT NO. EP/SP/186/21  
 WEST NEW TERRITORIES LANDFILL EXTENSION

Drawing title  
 WEST NEW TERRITORIES (WENT) LANDFILL  
 EXTENSION TYPICAL LINER SYSTEM

FIGURE 2





- LEGEND**
- - - WENT LANDFILL EXTENSION (WENTX) BOUNDARY
  - - - WENTX WASTE BOUNDARY
  - - - WENT LANDFILL WASTE BOUNDARY
  - PROPOSED NIM WAN ROAD (SOUTH) (BY OTHER PARTIES)
  - LANDFILL GAS CONSULTATION ZONE OF WENTX
  - LANDFILL GAS CONSULTATION ZONE OF WENT LANDFILL
  - - - LANDFILL GAS CUT-OFF TRENCH BARRIER

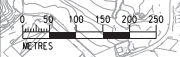
Consultant

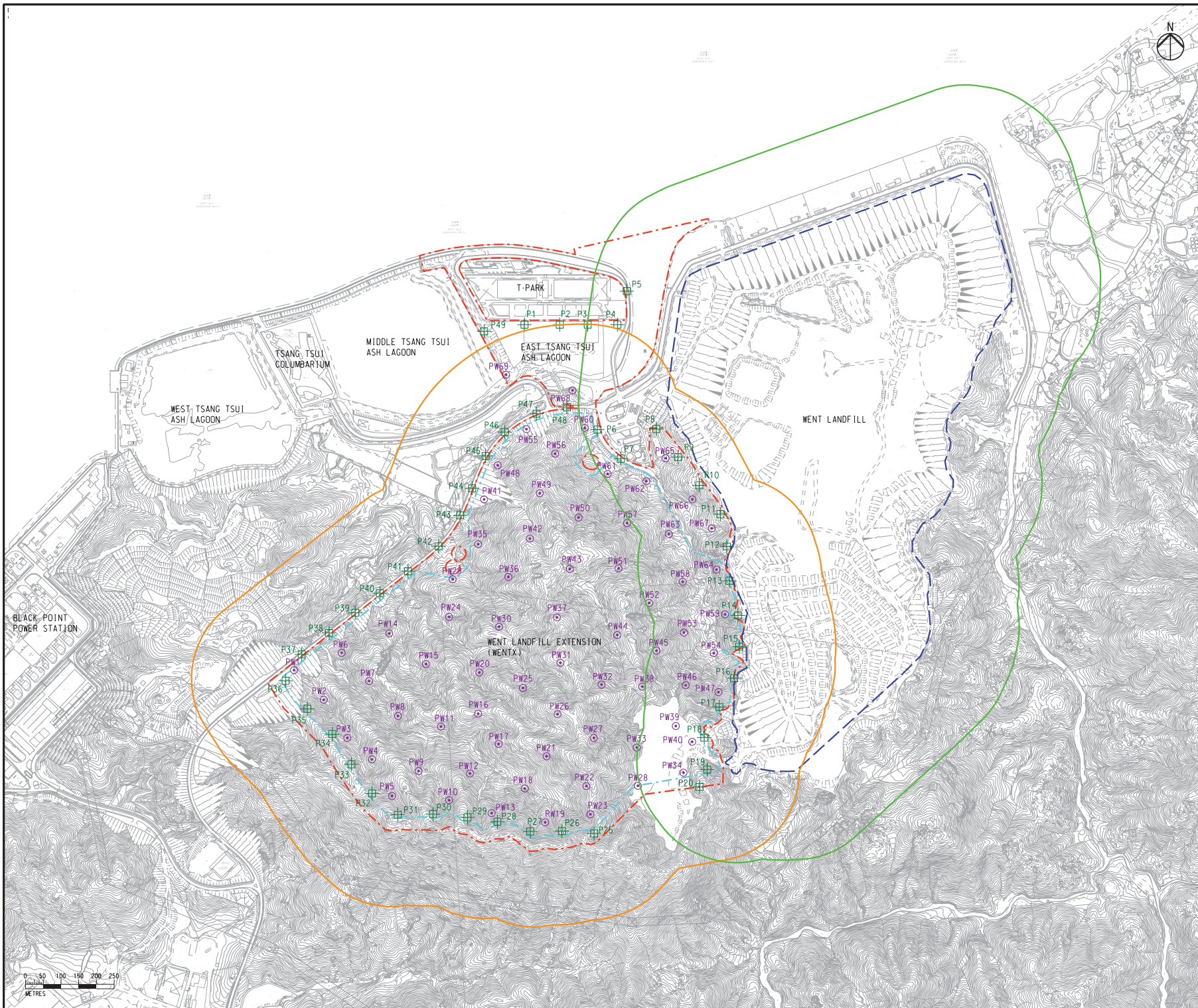
Project title  
**Contract No. EP/SP/186/21  
 West New Territories  
 Landfill Extension**

Drawing title  
**LANDFILL GAS CUT-OFF  
 TRENCH BARRIER**

Figure 3

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- LEGEND**
- - - WENT LANDFILL EXTENSION (WENTX) BOUNDARY
  - - - WENTX WASTE BOUNDARY
  - - - WENT LANDFILL WASTE BOUNDARY
  - PROPOSED NIM WAN ROAD (SOUTH) (BY OTHER PARTIES)
  - LANDFILL GAS CONSULTATION ZONE OF WENTX
  - LANDFILL GAS CONSULTATION ZONE OF WENT LANDFILL
  - P FIXED LOCATIONS FOR GAS MONITORING PROPOSED P1 - P49
  - PW FIXED LOCATIONS FOR GAS WELLS PROPOSED PW1 - PW69

Project title  
**Contract No. EP/SP/186/21**  
**West New Territories**  
**Landfill Extension**

Drawing title  
**LANDFILL GAS MONITORING**  
**LOCATIONS FOR WENTX**

Figure 4

**Implementation Schedule  
WENT Landfill Extension**

**Appendix for Mitigation Measures 4**

If the monitoring results indicate evidence of gas migration, the monitoring frequency shall be increased accordingly, with the implementation of appropriate mitigation measures under the Contingency Procedure as follow:-

***Contingency Procedure***

***Gas concentration beyond the limits***

In the event that the methane concentration in any of the selected monitoring wells is found to be more than 1%, the following emergency contingency procedure must be activated:

- a) Before blast hole drilling
  - Report to the Service Manager for his record;
  - Re-schedule the blast hole drilling works until the follow up actions are completed;
    - i. Assess the health and safety hazard to all personnel, and take immediate emergency action, including evacuation, if appropriate;
    - ii. Step up the vigilance in monitoring for LFG, including an increase in the frequency of monitoring and an increase in the number of monitoring locations within the zone of influence of the affected area;
    - iii. Investigate appropriate measures/tools to identify the source of LFG and the extent of LFG migration;
    - iv. Design, proposed and implement remedial measures to prevent further gas mitigation; and
    - v. Perform another round of gas monitoring at the selected wells until the methane concentration returns to below 1% by volume.
- b) On the day of scheduled blast
  - Report to the Service Manager for his record;
  - Re-schedule the blast until all follows up actions as mentioned in bullet point a) above are implemented

**Implementation Schedule  
WENT Landfill Extension**

**Appendix for Mitigation Measures 5**

In the event of the relevant gas concentration deviates from the safety limits, appropriate actions shall be determined by the Safety Officer or other appropriately qualified person. These shall encompass the action as follow:-

**Action Plan for LFG Monitoring during Construction Phase**

<b>Parameter</b>	<b>Monitoring Result</b>	<b>Action</b>
O <sub>2</sub>	<19%	<ul style="list-style-type: none"> <li>• Ventilate trench/ void to restore O<sub>2</sub> level to &gt;19%</li> </ul>
	<18%	<ul style="list-style-type: none"> <li>• Stop works,</li> <li>• Evacuate all personnel/ prohibit entry,</li> <li>• Increase ventilation to restore O<sub>2</sub> level to &gt;19%</li> </ul>
CH <sub>4</sub>	>10% LEL	<ul style="list-style-type: none"> <li>• Post “No smoking” signs,</li> <li>• Prohibit hot works,</li> <li>• Ventilate to restore CH<sub>4</sub> level to &lt;10% LEL</li> </ul>
	>20% LEL	<ul style="list-style-type: none"> <li>• Stop works,</li> <li>• Evacuate personnel/ prohibit entry,</li> <li>• Ventilate to restore CH<sub>4</sub> level to &lt;10% LEL</li> </ul>
CO <sub>2</sub>	>0.5%	<ul style="list-style-type: none"> <li>• Ventilate to restore CO<sub>2</sub> level to &lt;0.5%</li> </ul>
	>1.5%	<ul style="list-style-type: none"> <li>• Stop works,</li> <li>• Evacuate personnel/ prohibit entry,</li> <li>• increase ventilation to restore CO<sub>2</sub> to &lt;0.5%</li> </ul>

**Implementation Schedule  
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**Appendix for Mitigation Measures 6**

The designed air change for various rooms / facilities or measures shall be implemented as follow:-

**Table 1          Designed Air Change of the Mobile plant facilities/ Vehicle Repair**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Pantry	10
2	Changing room	15
3	Female toilet room	15
4	Male toilet room	15
5	Vehicle lifting platform	10

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 2          Designed Air Change of the Crushing Plant – Product Bin (Line 2)**

No.	Room	Protection Measure <sup>(Note 4)</sup>
1	Reclaim Tunnel	Passive and active ventilation system installed inside the Reclaim Tunnel

*Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.*

**Table 3          Designed Air Change of the Crushing Plant – Storage Bin (Final Product)**

No.	Room	Protection Measure <sup>(Note 4)</sup>
1	Reclaim Tunnel	Passive and active ventilation system installed at the top of the Storage Bin

*Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.*

**Table 4          Designed Air Change of the Toilet & Drinking Facility near WRA**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Male driver toilet	15
2	Female driver toilet	15

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 5          Designed Air Change of the Ground Floor Rooms of the O&M Workshop Building**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Male toilet, shower, locker & changing room	15
2	Convertible shower	15
3	Female toilet, shower, locker & changing room	15
4	Accessible toilet	15
5	Electrical room	10

**Implementation Schedule  
WENT Landfill Extension**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
6	ELV room	10
7	Janitor room	6
8	Accessible toilet	10
9	Pantry. Mess Room	10
10	Reception	1.1L/s/m <sup>2</sup> or 10L/s/person
11	Meeting room 1 & 2	1.1L/s/m <sup>2</sup> or 10L/s/person
12	First Aid room	10
13	Operation Supervisor Room	1.1L/s/m <sup>2</sup> or 10L/s/person
14	Operation Manager Room	1.1L/s/m <sup>2</sup> or 10L/s/person
15	Pantry	10
16	Maintenance Manager	1.1L/s/m <sup>2</sup> or 10L/s/person
17	Parts, tools/Storage	6
18	Maintenance workshop	10
19	Toilet 1	15
20	Toilet 2	15
21	Machine/vehicle wash area	10
22	Container storage area	Natural Ventilation & Raised floor <sup>(Note 2)</sup>

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

*Note 2: Storage Containers will be raised above ground floor level.*

**Table 6      Designed Air Change of Service Manager Office Building**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
1	Staff dining room	10
2	Female washroom	15
3	Male washroom	15
4	Pantry	10
5	Locker & changing room	10
6	Meeting room/Conference room x 3	1.1L/s/m <sup>2</sup> or 10L/s/person
7	Reception	1.1L/s/m <sup>2</sup> or 10L/s/person
8	Interview room	1.1L/s/m <sup>2</sup> or 10L/s/person
9	Multi-purpose room i) Senior inspector room ii) Inspector room iii) Office/Engineer room	1.1L/s/m <sup>2</sup> or 10L/s/person
10	Open office area for Clerical Officers, Environmental Protection Inspectors, Assistant Professional Engineers, Senior Environmental Protection Inspectors, Chief Environmental Protection Inspector, Head of Community Outreach, Community Relations Officer, & the Environmental Protection Officers	1.1L/s/m <sup>2</sup> or 10L/s/person
11	General office furniture & equipment	1.1L/s/m <sup>2</sup> or 10L/s/person
12	Special storage room cum monitoring room	10
13	Central Battery Systems (CBS) room	10
14	Bottle room	10

**Implementation Schedule  
WENT Landfill Extension**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
15	IT LAN/Server room (include bottle room)	10
16	Telecommunications and. Broadcasting Equipment Bedroom (TBE) room	10
17	Private Automatic Branch Exchange (PABX) room	10
18	Uninterruptible Power Supply (UPS) room	10
19	Electrical Room (EL) room	10
20	Extra Low Voltage (ELV) room	10
21	File & general storage	10

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 7      Designed Air Change of Permanent Contractor Office Building**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
1	PAU room	10
2	ELV room	10
3	EL room	10
4	UPS room	10
5	PABX room	10
6	TBE room	10
7	CBS room	10
8	Office area	1.1 L/s/m <sup>2</sup> or 10L/s/person
9	Open pantry	10
10	Accessible washroom	15
11	Male washroom & shower	15
12	Male locker & changing room	15
13	PPE/Equipment storage	10
14	Operation file storage	10
15	Bottle room	10
16	LAN server room (include bottle room)	10
17	Lactation room	1.1 L/s/m <sup>2</sup> or 10L/s/person
18	General office & furniture & equipment	10
19	Female toilet & shower	15
20	Female locker & changing room	15

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 8      Designed Air Change of the Ground Floor Rooms & the Protection Ventilation Measure of the LTW & LFG Service Building & Facilities**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
1	Male Toilet	15
2	Female Toilet	15
3	Pantry	10
4	FS tank and pump rooms	10
5	FS Control Room & FS inlet	5
6	Workshop	10

**Implementation Schedule  
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<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
7	Absorption Chiller Plant Room	10
8	Sewage Recycled Treatment Plant/Rainwater Recycled Treatment Plant/Irrigation Room	10
9	PV/Elec Room	10
10	ELV Room	10
11	TBE Room	10
12	UPS Room	10
13	Office Room	1.1 L/s/m <sup>2</sup> or 10L/s/person
14	Laboratory	10
15	Master meter room	10
16	Plumbing pump room	10
17	Fuel tank room	10
18	MCC room	10
19	F.S.I genset	10
20	Control room	5
21	CLP transformer room	10
22	CHP Landfill gas generator	Cogeneration module of ventilation system <sup>(Note 3)</sup>

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

*Note 3: Cogeneration module of ventilation system is built-in for the CHP Landfill Gas Generator*

**Table 9      Designed Air Change of Visitor Centre**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
1	Male Washroom	15
2	Female Washroom	15
3	Accessible Washroom	15
4	Meeting Room/Multi-purpose Room	1.1 L/s/person and 10 L/s/m <sup>2</sup>
5	Exhibition Room	0.6 L/s/m <sup>2</sup> and 3.8 L/s/person
6	Reception	1.1L/s/m <sup>2</sup> or 10L/s/person
7	Guard House	5

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 10      Designed Air Change of the Weighbridge Control Room (Inbound and Outbound)**

<b>No.</b>	<b>Room</b>	<b>No. of Air Change Per Hour<sup>(Note 1)</sup></b>
1	Weighbridge supervisor's office	1.1 L/s/person and 10 L/s/m <sup>2</sup>
2	Pantry	10
3	Toilet	15

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*



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**Table 11      Designed Air Change of the Guard House**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Control room	6
2	Toilet	15

*Note 1: A higher air change rate is maintained with air re-circulation. A higher air change rate is maintained with air recirculation. The air flow rate of the office area and meeting rooms will be maintained at minimum 1.1 L/s/m<sup>2</sup> or 10L/s/person.*

**Table 12      Designed protection measure of the Reclaim Tunnel in the Product Bin (Line 1)**

No.	Room	Other Protection Measure <sup>(Note 4)</sup>
1	Reclaim Tunnel inside the Product Bin area	Passive and active ventilation system installed inside the Reclaim Tunnel

*Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.*

**Table 13      Designed Protection Ventilation Measure of the Surge Bin**

No.	Room	Other Protection Measure <sup>(Note 4)</sup>
1	Surge bin	Passive and active ventilation system installed inside the Reclaim Tunnel

*Note 4: Axial fans will be activated when the methane concentration is detected by the gas alarm system.*

**Table 14      Designed Air Change of the Bioreactor Building**

No.	Room	No. of Air Change Per Hour <sup>(Note 1)</sup>
1	Common process room	10

*Note 1: A higher air change rate is maintained with air re-circulation.*