Our ref: ASCL-2018009

AECOM Asia Company Limited
8/F., Grand Central Plaza, Tower 2
138 Shatin Rural Committee Road
Shatin, New Territories, Hong Kong

Attention: Mr. Conrad NG

30 October 2018

Dear Sir,

Contract No. NE/2017/07
Cross Bay Link, Tseung Kwan O – Main Bridge and Associated Works
Detailed Qualitative Landfill Gas Hazard Assessment

I refer to your email concerning the captioned Detailed Qualitative Landfill Gas Hazard Assessment (Final Version) which approved on 3 March 2017. We have no further comment on it and verify the captioned according to section 1.9 of Environmental Permit with No.EP-459-2013.

Yours faithfully,

Li Wai Ming Kevin
Independent Environmental Checker

cc. Mr. Tam (ETL)
Simon Wong (CEDD)

Our Ref: TCS00975/18/300/L0047

AECOM Asia Company Limited
8/F, Grand Central Plaza, Tower 2
138 Shatin Rural Committee Road
Shatin, New Territories, Hong Kong

Attn: Mr. Conrad Ng

30 October 2018
By e-mail

Dear Sirs,

Re: CEDD Contract NE/2017/07
Cross Bay Link, Tseng Kwan O, Main Bridge and Associated Works
Detailed Qualitative Landfill Gas Hazards Assessment

With reference to the Final Detailed Qualitative Landfill Gas Hazard Assessment Report prepared by AECOM in March 2017, please note that we have no adverse comments on the captioned submission. We herewith certify the captioned submission pursuant to General Condition 1.9 of the Environmental Permit no. EP-459/2013.

Should you have any queries, please feel free to contact the undersigned at Tel: 2959-6059 or Fax: 2959-6079 or Email: twtam@fordbusiness.com.

Yours Faithfully,
For and on Behalf of
Action-United Environmental Services & Consulting (AUES)

T. W. Tam
Environmental Team Leader
TW/ml

cc	AECOM (ER)	Mr. Jackie Chan	By-email
	Acuity (IEC)	Mr. Kelvin Li	By-email

AECOM Transportation

Final Detailed Qualitative Landfill Gas Hazard Assessment Report

March 2017

土木工程拓展署
CEDD Civil Engineering and Development Department

Agreement No. CE 6/2014 (HY)

Cross Bay Link, Tseung Kwan O – Design and Construction

土木工程拓展署
Civil Engineering and Development Department
New Territories East Development Office

Agreement No. CE 6/2014 (HY)
Cross Bay Link, Tseung Kwan O – Design and Construction

Final Detailed Qualitative Landfill Gas Hazard Assessment Report

March 2017

Reviewed: Helen Leung 3 March 2017

Approved for Issue: Conrad Ng 3 March 2017

AECOM ASIA COMPANY LIMITED

TABLE OF CONTENTS

Figure

Appendices

Tables

1 INTRODUCTION

1.1 Background

1.1.1 The "Cross Bay Link (CBL)" design and construction works (hereinafter referred to as "the Project") is an approximately 1.8 kilometres (km) long dual two-lane road with a cycle track and a footpath across the Junk Bay mainly on viaduct. The CBL is close to the Northern Bridge and planned Southern Bridge, which will be located at the Eastern Channel of TKO and connect with the Tseung Kwan O – Lam Tin Tunnel (TKO-LT Tunnel) interchange to the west and Wan Po Road near Area 86 of Tseung Kwan O (TKO) in the southeastern area of TKO. The Project comprises the following key components:

a) construction of an approximately 1.8 km long dual two-lane road mainly on viaduct with a footpath and a cycle track;

b) construction of a 900mm diameter salt water main to link the trunk salt water supply system along Wan Po Road to those in TKO Town Centre and Tiu Keng Leng (the alignment of the salt water main is subject to investigation); and

c) implementation of the associated civil, structural, marine, electrical and mechanical, landscaping, as well as environmental protection and mitigation works.

1.1.2 The overall layout of the Project is shown in **Figure 1**. An Environmental Impact Assessment (EIA) study for the Project was conducted in accordance with EIA Study Brief No. ESB-196/2008. The EIA study concluded that the Project would be environmentally acceptable with the implementation of recommended mitigation measures.

1.1.3 The EIA Report (Register No.: AEIAR-172/2013) was approved on 11 July 2013 under the Environmental Impact Assessment Ordinance (EIAO). Following the approval of the EIA Report, an Environmental Permit (EP) was granted on 15 August 2013 (EP No.: EP-459/2013) for the construction and operation of the Project.

1.1.4 Based on the EP condition 2.7, a Detailed Qualitative Landfill Gas Hazard Assessment (QLFGHA) will be submitted to EPD as the location of the work site is within the 250m Consultation Zone of Tseung Kwan O (TKO) Stage II/III Landfill.

Landfill gas (LFG) characteristics and general hazards:

1.1.5 Methane is odourless and colourless, although in LFG it is typically associated with numerous highly odoriferous compounds which give some warning of its presence. However, the absence of odour should not be taken to mean that methane is absent. Methane is a flammable gas and will burn when mixed with air at concentrations between 5 and 15% (v/v). If a mixture of methane and air with a composition between these two values is ignited in a confined space, the resulting combustion may give rise to an explosion. Methane is also an asphyxiant.

1.1.6 Carbon dioxide, the other major component of LFG is an asphyxiating gas and causes adverse health effects at relatively low concentrations. The long-term Occupational Exposure Limit (OEL) is 0.5% (v/v). Like methane, it is odourless and colourless and its presence (or absence) can only be confirmed by using appropriately calibrated portable detectors.

1.1.7 Methane is lighter than air whereas carbon dioxide is heavier than air. Typical mixtures of LFG are likely to have a density close to or equal to that of air. However, site conditions may result in a ratio of methane to carbon dioxide which may make the gas mixture lighter or heavier than air. As a result, LFG may accumulate in either the base or top of any voids or confined spaces

1.2 Purpose of the Report

1.2.1 This report presents the detailed hazard assessment using a methodology based on the Landfill Gas Hazard Assessment Guidance Note (EPD/TR8/97).

1.3 Scope of this Study

1.3.1 The following tasks have been undertaken as part of this study:

- Assessment of existing landfill information including engineering, dates of filling and LFG monitoring data provided by the Environmental Protection Department (EPD).
- Identification of the nature and extent of the sources, including the likely concentrations and behaviour of LFG emissions which might have the potential for impacts on the development.
- Identification of possible pathways through the ground, underground cavities, utilities or groundwater, and the nature of these pathways through which the LFG must traverse if they were to reach the development;
- Qualitative assessment of the degree of risk which the LFG emissions may impose on the development for each of the source-pathway-receiver combinations; and
- Design of suitable levels of precautionary measures to be incorporated into the project works (if needed).

2 ENVIRONMENTAL LEGISLATION AND GUIDANCE

2.1.1 EPD has issued two guidance notes regarding LFG hazard assessment

- ProPECC PN 3/96 – Landfill Gas Hazard Assessment for Development Adjacent to Landfill
- EPD/TR8/97 – Landfill Gas Hazard Assessment Guidance Note.

2.1.2 These documents provide an assessment framework to be followed when evaluating the risks related to developments described under Section 6.5, Chapter 9 of the Hong Kong Planning Standards and Guidelines. ProPECC PN 3/96 and the Guidance Note apply to all developments proposed within 250m of the edge of the waste boundary, known as the Landfill Consultation Zone.

2.1.3 **Figure 2** presents the layout of the works area and the consultation zone of the Tseung Kwan O Stage II/III Landfill.

2.1.4 It is a requirement that project proponents of developments adjacent to landfills undertake a LFG hazard assessment and submit the findings to EPD for vetting. As recommended in ProPECC PN 3/96, the project proponent and professionals (Authorised Persons) responsible for the developments adjacent to landfills should:

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

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

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

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

2.1.5 A Landfill Gas Hazard Assessment (LFGHA) within the EIA report was submitted to EPD for comment during the early stage of the Project in order to assess the potential for LFG hazard to affect the Project and to indicate a series of generic engineering measures which may be adopted to mitigate potential LFG impacts.

2.1.6 This Detailed QLFGHA supersedes the LFGHA within the EIA report and updates gas monitoring data and presents specific mitigation measures proposed for incorporation into the detailed design.

3 BACKGROUND INFORMATION

3.1 Principal Characteristics of the TKO Stage II/III Landfill

3.1.1 According to the approved EIA, TKO Stage II/III Landfill is located at TKO Development Area 105 on the eastern shoreline of Junk Bay. It is a valley landfill sited in a coastal location approximately 1km south-east of TKO Stage I Landfill. The site covers an area of about 42 hectares. To the east of the site lies the Clear Water Bay Country Park; to the west lies reclaimed land which contains the comprehensive development area (e.g. LOHAS Park and MTR Depot) and the TKO Industrial Estate.

3.1.2 Engineering preparation works were carried out prior to the start of landfilling in 1988. A permanent seawall on a dredged foundation was constructed to the seaward boundary. There is a 15m wide margin of completely decomposed volcanic (CDV) material behind the seawall, and between this and the waste deposit there is a 3m wide trench constructed in coarse aggregate with a continuous length of perforated pipe. The trench forms a leachate interception and collection zone, together with a vent trench for LFG. Collected leachate flows to TKO Sewage Treatment Works at the northwest of the landfill site.

3.1.3 Inert materials were used to raise the formation of the landfill base above sea level. The site was not totally lined, although discrete areas of low permeability membrane were laid, which drain leachate into the leachate collection system. TKO Stage II/III Landfill actual operation to receive waste began in 1988 and ended in 1994. Deposited waste at this site included municipal, construction, industrial and chemical waste. It is estimated that the landfill has received 17 million tonnes of waste with a density of approximately 1.3tonnes/m^3. The site was temporarily restored by the end of 1995 with an interim cap of 1m of inert cover, hydroseeded, with surface and sub-surface drains installed. Proper LFG and leachate management systems were not established at that time.

3.2 Restoration Works

3.2.1 Based on the approved EIA, the restoration works of TKO Stage II/III Landfill commenced in July 1997 and were completed in January 1999. The restoration works generally included installation of an engineered capping layer, a LFG collection system with flaring and electricity generation, a leachate collection and treatment system, surface and sub-surface drainage systems, and works to improve geotechnical stability and landscaping of the site. A site plan on completion of final cap and the cross sections of TKO Stage II/III Landfill is illustrated in **Appendix A**.

3.2.2 The engineered low permeability capping layer and surface water drainage system are installed to reduce infiltration of rain water into the waste mass thereby reducing the amount of leachate to be treated. Typical details of a restoration capping system are shown in Detail 2 and Detail 5 of **Appendix A**. The components of the landfill restoration capping system include the following (from top to bottom):

- General Cover Layer: A 850 mm thick soil layer comprising CDV material or completely decomposed granite (CDG); an additional 650 mm CDV is also provided in the location where trees or shrubs are provided;
- Filtration Geotextile-Geonet Composites: A subsoil drainage layer comprising a synthetic drainage medium, surrounded by suitable geotextile filters.
- Geomembrane and Cushion Geotextile: An impermeable layer (anchored in CDV at the perimeter) comprising a 1mm thick linear low density polyethylene (LLDPE) geomembrane; and
- Final intermediate Cover: A well compacted 500 mm thick soil, free from stones or other sharp particles, above the waste.

3.2.3 The LFG management system consists of active extraction wells, electricity generation from LFG, flaring system for LFG, passive vent trenches/ pipes, and monitoring of LFG both on and off-site. The gas extraction system is integrated with the leachate management system. LFG is

collected from the landfill by active gas extraction. It is transferred to the on-site gas utilization plants for electricity generation and used for heating in the leachate treatment process. Surplus LFG is flared at the gas flaring plant at the southeast of the landfill for complete destruction. The system aims to control LFG from migrating off-site in sub-surface layer.

3.2.4 Leachate management system comprises a leachate collection system and a leachate treatment works. Leachate generated at TKO Stage II/III Landfill is intercepted by the leachate collection system, which then transfers the collected leachate to the onsite leachate treatment works. Leachate is treated at the treatment plant to meet the discharge standards prior to discharge at the public sewer.

3.2.5 The aftercare period commenced from February 1999 onwards. Environmental monitoring work for the landfill may continue for more than two decades or up to 30 years. The methane content in the LFG remained fairly constant at 44%-48% between 1999 and 2003. Such LFG quantity and methane content levels still require monitoring as the landfill could only be considered as fully restored from the perspective of LFG safety when the methane content is reduced to 1% or below. The site has been an open space / green zone as its tentative afteruse. The Hong Kong Air Cadet Corps has also been using the top platform at TKO Stage II/III Landfill as a model aeroplane training field on weekends and public holidays. It is now jointly used as a training field of Unmanned Aerial Vehicle for land surveying.

3.3 Existing Monitoring Data

3.3.1 A series of monitoring wells are installed adjacent to the landfill boundary (refer to **Figure 2**) in order to facilitate LFG monitoring to provide data confirming (or otherwise) that the designed engineering measures are sufficient to prevent or limit significant migration of gas from the landfill.

3.3.2 Monitoring data from March 1998 and January 1999 and from February 1999 to May 2009 was reported in the approved EIA. Additional monitoring data has been provide by EPD. Concentrations of methane and carbon dioxide present in LFG have been monitored in these monitoring wells on a monthly basis from August 2015 to October 2016.

3.3.3 LFG monitoring data obtained from EPD is summarized in **Table 3-1** and complete records are present in **Appendix B**.

Table 3-1 Landfill Gas Monitoring Result at Tseung Kwan O Stage II/III Landfill (August 2015 – October 2016)

Drillhole	Average Methane %v/v (Range)	Average Carbon Dioxide %v/v (Range)
2/DG1	0.0 (0.0 - 0.0)	1.1 (0.0 - 4.1)
2/DG2	0.0 (0.0 - 0.0)	3.2 (0.0 - 6.9)
2/DG3	0.0 (0.0 - 0.0)	4.3 (0.0 - 13.6)
2/DG4	0.0 (0.0 - 0.0)	2.1 (0.0 - 7.2)
2/DG5	0.0 (0.0 - 0.0)	0.1 (0.0 - 0.9)
2/DG6	0.0 (0.0 - 0.0)	0.9 (0.0 - 3.8)
2/DG7	0.0 (0.0 - 0.0)	1.0 (0.0 - 6.7)

Note:

1. Information provided by EPD.

3.3.4 Based on the TKO Stage II/III Landfill monitoring data, methane is not detected in all down-gradient monitoring wells indicating no migration of methane offsite or production of methane near peripheral monitoring wells therefore flammable/explosive risk associated with methane is insignificant. However, carbon dioxide concentrations ranged from 0.0 to 13.6 % v/v. As possible LFG migration pathways are plausible, elevated carbon dioxide levels have potential to result in asphyxiant risk in the event of accumulation within a poorly ventilated space.

3.4 Ground Investigation

3.4.1 According to ground investigation, geology within Project works area (within the consultation zone) is mainly reclamation fill (typically described as GRAVEL and COBBLES and occasional boulders of rock, concrete, steel and plastic, or silty SAND with gravel and locally sandy CLAY/SILT with gravel) of about 15 to 21.5m from the ground level. Groundwater level near the works area was recorded at +1.7 mPD, which is 3.5m below the ground level. Geological information is provided in **Appendix C**.

4 LANDFILL GAS HAZARD ASSESSMENT CRITERIA AND METHODOLOGY

4.1 Introduction

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

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

4.2 Sources

4.2.1 The classification of the Source (i.e. the landfill) should be undertaken 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.

4.2.2 The 'significance' of migration should be assessed by reference to the concentration, frequency and location at which gas is detected. For guidance, it should be assumed that any concentration of methane or carbon dioxide greater than 5% v/v above background levels in any monitoring well outside the landfill's boundary indicates significant migration. Lower concentrations may still be 'significant' if they are observed in more than one monitoring well, on several occasions or in monitoring wells located some distance from the site boundary. In general, concentrations of greater than 1% v/v methane or 1.5% v/v carbon dioxide (above background levels in each case) indicate less than adequate control of the gas at source.

4.2.3 In classifying the source term, account needs to be taken of the likelihood and probable effect of a failure of the gas controls. Thus, if it has been demonstrated that there is no migration of gas and there is little danger of the gas controls failing (e.g. if these comprise solely of passive measures such as a liner) it can be assumed that the site represents a "Minor" Source. Where there is no gas migration but this may be as a result of a single, "vulnerable" control

measure (e.g. an active extraction system with no warning of failure), the site should be regarded as a "Medium" or even a "Major" Source depending on the other factors (e.g. size of site and age of waste).

4.2.4 Where the effectiveness of the gas controls has not been proven by off-site monitoring or if there is some doubt as to the adequacy of the monitoring, this should be taken into account when considering the impact of the control measures on the Source term. Assessments should always err on the side of caution and, in general, if the effectiveness cannot be demonstrated, the assessment should be undertaken on the same basis as if the controls were not in place.

4.2.5 The reliability of the monitoring, for determining the efficacy of the gas controls, needs to take account of the design, number and location of the monitoring points together with the frequency and duration over which monitoring has been undertaken. Monitoring should have been undertaken under different weather conditions including, in particular, periods of low or falling atmospheric pressure.

4.3 Pathway

4.3.1 The broad classification of the Pathway should be undertaken as follows:

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

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

- Particular permeability of the soils;
- Spacing, tightness and direction of the fissures/joints;
- Topography;
- Depth and thickness of the medium through which the gas may migrate (which may be affected by groundwater level);
- The nature of the strata over the potential pathway;
- The number of different media involved; and
- Depth to groundwater table and flow patterns.

4.3.3 Thus, although there may be permeable soil between the landfill site and a proposed development, if the soil layer is very shallow and thin with its upper surface exposed to the atmosphere, then it will be appropriate to consider this as a long/indirect pathway. This could of course alter if the land between the landfill site and the development was altered in some other way which reduced the potential for gas release. Similarly, if the land is flat, the surface may be prone to water logging which will also effectively seal it at times of heavy rain. In general, a conservative approach should be adopted and it should be assumed that any such permeable surface soils may become less permeable in the future.

4.3.4 If it is known that a conduit (man-made or natural feature such as a fault plane) leads directly from the landfill to the development area, it should be regarded as a "direct/short" pathway even if it is longer than 100m.

4.4 Target

4.4.1 Different types of target 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 authorized, well trained personnel, such as the staff of utility companies, who have been briefed on the potential hazards relating to LFG and the specific safety procedures to be followed. Deep excavations.
Low sensitivity	Buildings/structures which are less prone to gas ingress by 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.

4.5 Risk Categorization

4.5.1 The classification of the above LFG sources, pathway and target are categorized. Having determined which categories of source, pathway, target and the various elements of the development fall, overall assessment of risk may be made.

4.5.2 **Table 4-1** presents classification of risk categories whilst potential implications associated with the various qualitative risk categories are summarized in **Table 4-2**.

Table 4-1 Classification of Risk Category

Source	Pathway	Target Sensitivity	Risk Category
Major	Very short / direct	High	Very High
		Medium	High
		Low	Medium
	Moderately short / direct	High	High
		Medium	Medium
		Low	Low
	Long / indirect	High	High
		Medium	Medium
		Low	Low
Medium	Very short / direct	High	High
		Medium	Medium
		Low	Low
	Moderately short / direct	High	High
		Medium	Medium
		Low	Low
	Long / indirect	High	Medium
		Medium	Low
		Low	Very Low

Source	Pathway	Target Sensitivity	Risk Category
Minor	Very short / direct	High	High
		Medium	Medium
		Low	Low
	Moderately short / direct	High	Medium
		Medium	Low
		Low	Very Low
	Long / indirect	High	Medium
		Medium	Low
		Low	Very Low

Table 4-2 Summary of General Categorization of Risk

Category	Level of Risk	Implication
A	Very High	The type of development being proposed is 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.

4.5.3 Five generic forms of protection will be used in mitigating the hazards to development. These generic forms corresponding to the five risk levels are set out in **Table 4-3**.

4.5.4 The terms used in **Table 4-3** are defined in **Table 4-4**.

Table 4-3 Generic Protection Measures for Planning Stage Categorization

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(1).
C	Use of “semi active” or enhanced passive controls. Detection systems in some situations.
D	Passive Control of gas only.
E	No precautionary measures required.

Note:

(1) 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 4-4 Definition of Control Terms

Terms	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 electrically powered fans.
Passive control	Provision of barriers to the movement of gas e.g. 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 of gas in the atmosphere and can be linked to alarms and/or telemetry systems.

5 ASSESSMENT OF POTENTIAL RISK

5.1 Source

5.1.1 TKO Stage II/III Landfill operated from 1988 to 1994. Restoration works completed in 1999 included a low permeability surface capping system, active extraction wells, flaring system for LFG, passive vent trenches/pipes, leachate management system comprised of leachate collection and treatment system, and monitoring of LFG on-site and off-site.

5.1.2 Given the landfill design, supervised construction and implementation of systems designed to manage LFG and leachate, the likelihood for significant unexpected migration of LFG off site is low. The TKO Stage II/III Landfill has multi-landfill gas control measure (such as vents and active extraction wells) and monitoring wells system.

5.1.3 According to **Table 3-1**, no detection of methane was recorded in all monitoring wells. However, the carbon dioxide concentrations ranged from 0.0 to 13.6 % v/v. It is concluded that possible LFG migration may still occur as over 5% v/v of carbon dioxide concentration was recorded, therefore, the TKO Stage II/III Landfill is classified as "**Medium**".

5.2 Pathway

5.2.1 Potential pathways through which LFG may enter the Project site included both natural pathways such as faults or gas permeable strata and man-made pathways such as underground utilities. Natural pathways are related to the prevailing geology and whether soil or rock is saturated; of key concern is the presence of open fault lines that gas may exploit as a preferential migratory route.

5.2.2 According to the Hong Kong Geological Survey Map (as **Appendix C**), no significant fault lines trend from the landfill towards the project site. The current works area was reclaimed land with fill. A cross section area between TKO Stage II/III Landfill and the works area are provided at **Appendix D**. The groundwater level near the works area are 3.5m below ground. As such, 3.5m of unsaturated material above the groundwater table may permit gas movement. However, provide that the works area is about 170m from the edge of waste in landfill, the natural pathway is considered to be "**Long/Indirect**".

5.2.3 Existing and proposed utility layout plan are provided in **Appendix E**. These underground man-made conduit would be possible pathway for LFG. Since the distance between works area and the edge of waste is about 170m, the man-made pathway are considered to be "**Moderately Short/Direct**"

5.3 Target

5.3.1 The road works at Wan O Road, construction of the CBL E&M Plant Room at the junction of Wan O Road and Wan Po Road are all situated within the landfill Consultation Zone, as such potentially sensitive receivers to LFG hazards include construction workers (during construction phase) and ad-hoc maintenance staff (during operation phase).

<u>During construction</u>

5.3.2 Construction works will be predominantly undertaken in an outdoor environment by workers trained to adopt safe construction methods; as such, construction workers are characterized as "**Low sensitivity**" except where the following conditions are encountered;

5.3.3 Excavation is anticipated during road works at Wan O Road, construction of the raft footing of the CBL E&M Plant Room. Hot works (welding) are also anticipated during construction. The excavations / any confined or poorly ventilated spaces created may be at greater risk via accumulation of LFG due to physical properties described in **Section 1.1.5** to **1.1.7**. However as open excavations are in contact with ambient air, atmosphere dilution should mitigate risk of gas accumulation. In addition, specific safety procedures should be issued to construction workers as such this group is considered "**Medium sensitivity**".

During operation

5.3.4 For road user of Wan O road, no indoor activity is anticipated and they are considered as "**Low Sensitivity**".

5.3.5 During operation the CBL E&M Plant Room will be unmanned. Only trained maintenance workers will grant access to the CBL E&M Plant Room or utility at Wan O road. Specific safety procedures should be issued to maintenance workers. In the absence of any control measures or where buried utility connections enter basement or ground floor rooms and voids are not sealed to prevent gas ingress, LFG can potentially accumulate. In areas where a potential source of ignition exists (e.g. electrical switches) or rooms are not suitably ventilated such that flammable or asphyxiant risk has potential to be present, maintenance staff are considered "**Medium Sensitivity**".

5.4 Summary of Qualitative Source-Pathway-Target Analysis

5.4.1 Based on the information above, Source-Pathway-Target analysis is summarized in **Table 5-1**.

Table 5-1 Classification of Risk Category

Source	Pathway	Target Sensitivity	Assessment of Risk
TKO Stage II/III Landfill with active extraction wells, flaring system for LFG, passive vent trenches/pipes, leachate management system comprised of leachate collection and treatment system, and monitoring of LFG on-site and off-site (**Medium**)	Natural Path Way Via unsaturated fill above groundwater table (Source-target distance = 170m) (**Long/Indirect**)	*Construction Phase*	
		Construction worker predominantly in an outdoor environment (**Low**)	**Very Low**
		Construction worker undertaking excavation and hot works (**Medium**)	**Low**
		Operation Phase	
		Road user of Wan O Road (**Low**)	**Very Low**
		Trained maintenance workers working in the CBL E&M Plant Room or utility at Wan O Road (**Medium**)	**Low**
	Man-made Pathway Via possible man-made conduit as pathway for LFG (Source-target distance = 170m) (**Moderately Short/Direct**)	*Construction Phase*	
		Construction worker predominantly in an outdoor environment (**Low**)	**Low**
		Construction worker undertaking excavation and hot works (**Medium**)	**Medium**
		Operation Phase	
		Road user of Wan O Road (**Low**)	**Low**
		Trained maintenance workers working in the CBL E&M Plant Room or utility at Wan O Road (**Medium**)	**Medium**

5.4.2 According to the Guideline Notes, an overall risk category is based upon the highest level of risk nominated for any of the potential impacts identified.

5.4.3 As two *Medium* risk, four *low* risks and two *very low* risk are identified, the overall risk level for both the construction and operational phases of the Project is "**MEDIUM"**.

6 PROTECTION MEASURES

6.1 Introduction

6.1.1 According to **Section 5.4.3**, for Projects categorized as "Medium" risk, engineering measures will be required to protect the proposed development. Generic protection measures include "use of 'semi-active' or enhanced passive gas control. Detection systems in some situations".

6.2 Protection Measures during Construction

6.2.1 During the construction phase, hazards may arise which are related either to the flammability of LFG or to its potentially asphyxiating properties. In particular cases, it is possible that toxicity effects may be significant. The guidelines and recommendations of Chapter 8 of the *Landfill Gas Hazard Assessment Guidance Note* may be used to form the basis of Specification Clauses for incorporation in Contract Documentation for developments within the site.

General Hazards Which May Be Encountered

6.2.2 The project proponent 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 LFG as described in **Section 1.1.5** to **1.1.7**.

Outline of Safety Requirements

6.2.3 During construction, safety procedures should be implemented to minimize the risks of:

- Fires and explosions;
- Asphyxiation of workers; and
- Toxicity effects.

6.2.4 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.

6.2.5 In addition to normal site safety procedures, gas detection equipment should be available during excavation within the 250m Consultation Zone of (TKO) Stage II/III Landfill.

Additional General Requirements

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

Appointment of Safety Officer

6.2.7 A safety officer, trained in the use of gas detection equipment and LFG-related hazards, should be present on site throughout the ground works phase. The Safety Officer should be provided with an intrinsically safe portable instrument, which is appropriately calibrated and able to measure the following gases in the ranges indicated below:

Methane	0-100% LEL and 0-100%v/v
Carbon Dioxide	0-100%
Oxygen	0-21%

Safety Measures

6.2.8 For staff who work in, or have responsibility for "at risk" area, such as all excavation workers, supervisors and engineers working within the Consultation Zone, should receive appropriate training on working in areas susceptible to LFG, fire and explosion hazards.

6.2.9 An excavation procedure or code of practice to minimize LFG related risk should be devised and carried out.

6.2.10 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.

6.2.11 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 should be designed for smoking.

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

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

6.2.14 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 should be responsible for reviewing the gas measurements as they are made, and who should 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.

6.2.15 Where there are any temporary site offices, or any other buildings located within the TKO Stage II/III Landfill Consultation Zone which have enclosed spaces with the capacity to accumulate LFG, then they should either be located in an area which has been proven to be free of LFG (by survey using portable gas detectors); or be raised clear of the ground by a minimum of 500mm. This aims to create a clear void under the structure which is ventilated by natural air movement such that emission of gas from the ground are mixed and diluted by air. If the offices/buildings are not raised clear of the ground, ongoing monitoring should be carried out to ensure that these areas remain gas free.

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

6.2.17 During piping assembly or conduit construction, all valves/seals should be closed immediately after installation. As construction progresses, all valves/seals should be closed to prevent the migration of gases through the pipeline/conduit. All piping /conduits should be capped at the end of each working day.

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

6.2.19 Fire drills should be organized at not less than six monthly intervals.

6.2.20 The contractor should formulate a health and safety policy, standards and instructions for site personnel to follow.

6.2.21 All personnel who work on the 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 (in Chinese and English) should be posted at prominent position around the site warning danger of the potential hazards.

6.2.22 For staff who work in, or have responsibility for 'at risk' areas, such as all excavation workers, supervisors and engineers working within the TKO Stage II/III Landfill Consultation Zone should receive appropriate training on working in areas susceptible to LFG, fire and explosion hazards.

6.2.23 Service runs within the Consultation Zone should be designated as "special routes"; utilities companies should be informed of this and precautionary measures should be implemented. Precautionary measures should include ensuring that staff members are aware of the potential hazards of working in confined spaces such as manholes and service chambers, and that appropriate monitoring procedures are in place to prevent hazards due to asphyxiating atmospheres in confined spaces. Detailed guidance on entry into confined spaces is given in Code of Practice on Safety and Health at Work in Confined Spaces (Labour Department, Hong Kong).

6.2.24 Periodically during ground-works construction within the 250m Consultation Zone, the works area should be monitored for methane, carbon dioxide and oxygen using appropriately calibrated portable gas detection equipment. The monitoring frequency and areas to be monitored should be set down prior to commencement of ground-works either by the Safety Officer or an approved and appropriately qualified person.

Monitoring

6.2.25 Routine monitoring should be carried out in all excavations, manholes, chambers, relocation of monitoring wells and any other confined spaces that may have been created. All measurements in excavations should be made with the extended monitoring tube located not more than 10 mm from the exposed ground surface. Monitoring should be performed properly to make sure that the area is free of LFG before any man enters into the area.

6.2.26 For excavations **deeper than 1m**, measurements should be carried out:

- 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 throughout the working day whilst workers are in the excavation.

6.2.27 For excavations **between 300mm and 1m deep**, measurements should be carried out:

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

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

6.2.29 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.

6.2.30 As a minimum these should encompass those actions specified in **Table 6-1**.

Table 6-1 Actions in the Event of Landfill Gas Being Detected in Excavations/Confined Areas

Gas	Average Methane %v/v (Range)	Average Carbon Dioxide %v/v (Range)
Oxygen	< 19 %	- Ventilate to restore oxygen to > 19 %
	< 18 %	- Stop works - Evacuate personnel/prohibit entry - Increase ventilation to restore oxygen to > 19 %
Methane	> 10 % LEL (i.e. > 0.5 % by volume)	- Prohibit hot works - Ventilate to restore methane to < 10% LEL
	> 20 % LEL (i.e. > 1 % by volume)	- Stop works - Evacuate personnel/prohibit entry - Increase ventilation to restore methane to < 10 % LEL
Carbon Dioxide	> 0.5 %	- Ventilate to restore carbon dioxide to < 0.5%
	> 1.5 %	- Stop works - Evacuate personnel/prohibit entry - Increase ventilation to restore carbon dioxide to <0.5%

Specific Advice Relating to the Drilling of Boreholes

6.2.31 As part of the site investigation and subsequent ground works for the development, if drilling exploratory boreholes is necessary, such work should be undertaken following the general advice give above. Specific recommendations relating to the drilling of boreholes are presented below.

Supervision and Safety Measurement of Drilling Operation

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

6.2.33 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.

6.2.34 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 firefighting;
- Supervisors responsibilities;
- Storage and use of safety equipment;
- Safety procedures; and
- Signs, barriers and guarding.

Safety Equipment and Clothing

6.2.35 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, and heavy duty waterproof industrial groves.

Working Procedures

6.2.36 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.

Safety Procedures

6.2.37 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.

6.2.38 Smoking should be prohibited anywhere within 15 meters of a boring or excavation at any locations within the Consultation Zone.

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

6.2.40 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 LFG or cave-in.

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

6.2.42 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.

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

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

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

6.2.46 Any electrical equipment should be intrinsically safe.

Installation of Vertical Wells

6.2.47 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.

6.2.48 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.

6.2.49 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. LFG must not be allowed to vent freely at the site surface.

6.2.50 In the operation phase, if it is necessary to carry out construction works, LFG precautionary measures same as those recommended for the construction stage above should be followed.

6.3 Design and Operational Phase Protection Measures

Road at Wan O Road

6.3.1 For maintenance of Wan O Road, resurfacing or other maintenance works will be carried out at open space and any risk from LFG are unlikely. However, if entry into manholes or chambers are undertaken, the procedure detailed in **Section 6.3.11** to **6.3.14** must be followed.

CBL E&M Plant Room at the Junction of Wan O Road and Wan Po Road

6.3.2 Natural pathways for LFG migration are assessed as long/indirect and LFG migration through unsaturated fill open to atmosphere is unlikely. For the CBL E&M Plant Room, the design does not include a basement. The thickness of the base slab and wall will be 800mm and 600mm respectively, as such the structural integrity of the concrete will form an effective gas barrier mitigating risk from the effects of potential LFG accumulation. A waterproof barrier which by nature has low gas permeability will also be incorporated to the base slab, further reducing risk of vapour intrusion into the building. Detailed design of the waterproof membrane has not yet been finalized however typical details are provided in **Appendix F**.

6.3.3 All rooms in the CBL E&M Plant Room will be naturally ventilated via fresh air, exhaust and door louvres and some rooms will be air conditioned, as such risk of potential gas accumulation within all rooms is low. Proposed louvre sizes are provided in **Appendix G**.

6.3.4 Underground services, such as storm drains and cable runs may also act as preferential man-made pathways for LFG. Typical details of the measures required for services shall be provided in accordance with the *Guidance Note Annex B* **(Appendix H**). Mitigation measures should be implemented to prevent gas ingress via the interface between any pipe /conduit and the building. All services penetrating the building floor should be appropriately sealed and the level of workmanship inspected and approved by the engineer representative to assess the effectiveness of this mitigation measure.

6.3.5 A competent professional person representing the project proponent shall confirm in writing to the Director of Environmental Protection that the ventilation and inherent structural measures have been properly incorporated. A copy of the as-built engineering drawings shall be sent to the Director of Environmental Protection for record.

Post Construction Monitoring

6.3.6 Although the Project is categorised a medium risk, realistic risk is likely to be lower, as the active gas extraction continues to operate within the landfill site. The latest monitoring data also demonstrates that no methane is detected in all down-gradient monitoring wells.

6.3.7 Based on this information and upon documentation that the design measures are appropriately constructed / installed and that levels of workmanship are approved by *Supervisor*, further monitoring is not proposed to assess the effectiveness of the implemented protection measures.

6.3.8 To verify the ventilation and inherent structural measures have been properly incorporated post construction monitoring should be conducted by the operator, trained in the use of gas detection equipment and LFG-related hazards using an intrinsically safe portable instrument, which is appropriately calibrated and able to measure the parameters detailed in **Section 6.2.7**.

6.3.9 Post installation monitoring of LFG should be carried out on a monthly basis for six months and the results shall be submitted to EPD for record. Should the monitoring results indicate that the protection measures are effective; the frequency of the monitoring may be terminated upon agreement of EPD.

6.3.10 Depending on the results of the measurements, actions required will vary and should be set down by the appropriately qualified person. As a minimum these should encompass those actions specified in **Table 6-1**.

Guidance for Entry into Service Rooms / Voids, Manholes and Chambers

6.3.11 Works in confined spaces (such as manholes and service voids, etc.) are controlled by the *Factories and Industrial Undertakings (Confined Spaces) Regulation* of the *Factories and Industrial Undertakings Ordinance* and the *Safety Guide to Working in Confined Spaces* should be followed to ensure compliance with the Regulation.

6.3.12 In general, when work is being undertaken in confined spaces, sufficient approved resuscitation equipment, breathing apparatus and safety torches should be made available. Persons involved in or supervising such work should be trained and practiced in the use of such equipment. A permit-to-work system for entry into confined spaces should be developed by an appropriately qualified person and the system should be consistently employed. The safety measures recommended in Chapter 8 of the Landfill Gas Hazard Assessment Guidance Note should also be strictly followed.

6.3.13 All the access to confined spaces should be restricted only to authorized personnel who are aware of the LFG hazard. No general public should be permitted or allowed to access any confined space.

6.3.14 All manholes will have vented covers to avoid build-up of gas. A warning notice in both English and Chinese which states that there is possibility of flammable and asphyxiating gases accumulating within would be put on the cover.

7 CONCLUSIONS

7.1.1 Detailed Landfill Gas Hazard Assessment characterizes overall risk posed by the TKO Stage II/III Landfill to the Project site as "**Medium**" during both construction and operation phases.

7.1.2 Protection measures during the construction phase include adoption of institutional controls and monitoring.

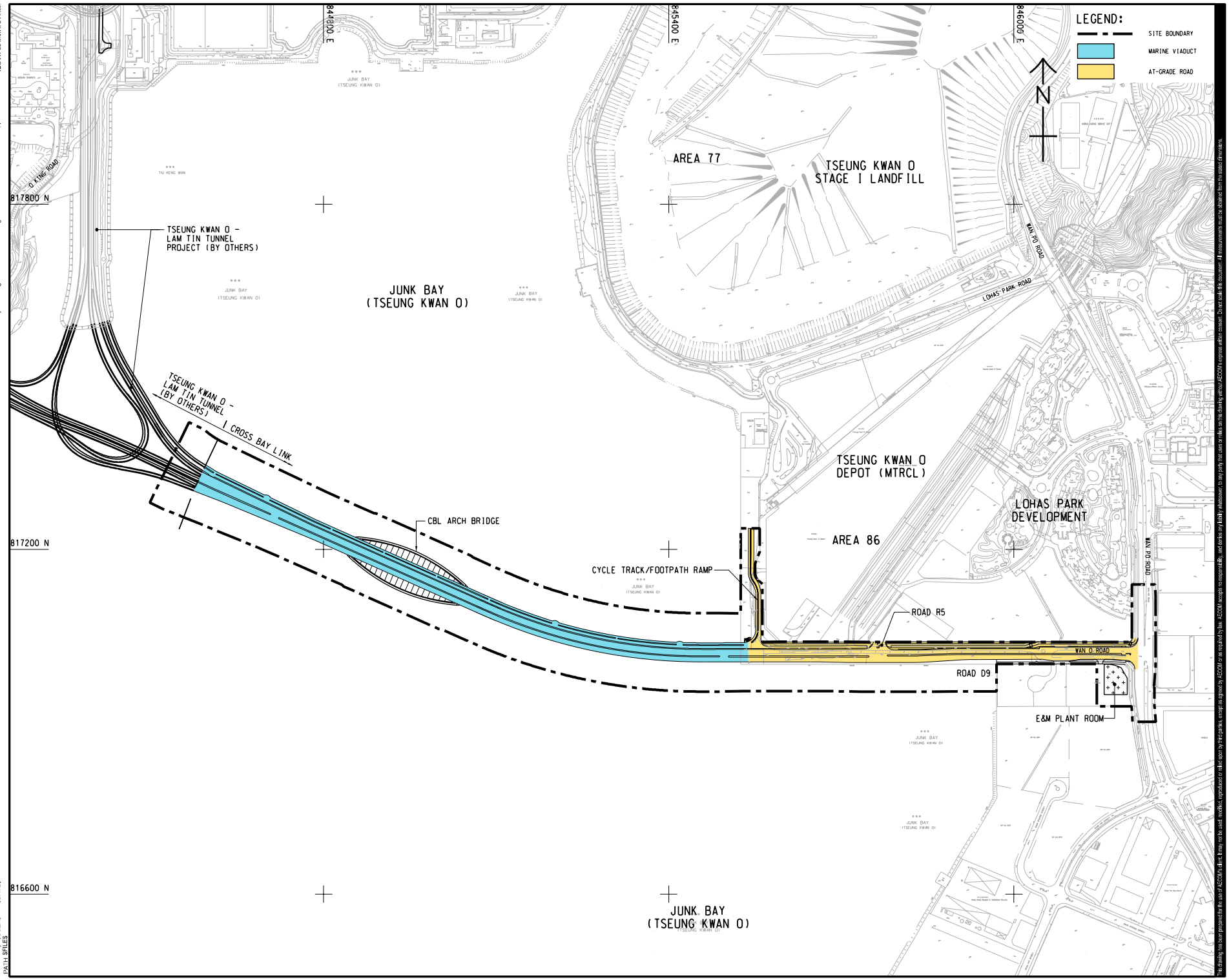
7.1.3 To mitigate risk to the project site, recommended protective measures have been incorporated into the detailed design include the intrinsic protection afforded by the thickness of structural concrete and waterproofing, natural ventilation in CBL E&M Plant Room and sealing of the interface between any pipe /conduit and the building. In addition, no public access to the majority of buildings/potential areas for gas accumulation and adoption of operational safety procedures will reduce risk, thus protect staffing visitors and any future contractor working at the site.

7.1.4 Although the Project is categorised a medium risk, realistic risk is likely to be lower, as active gas extraction continues within TKO Stage II/III Landfill. The latest monitoring data also demonstrates that no methane is detected in all down-gradient monitoring wells.

7.1.5 Based on this information and upon documented confirmation that the proposed design measures are constructed / installed to levels of workmanship approved by the *Supervisor*, post installation monthly monitoring of LFG should be carried out monthly for six months and the results submitted to EPD for record.

7.1.6 Potential hazards associated with LFG shall be effectively mitigated by implementation of the above measures together with operational safety procedures.

FIGURES



ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

Plot File by: $USER$

PATH $FILE$

$DATE$

AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

I/R	DATE	DESCRIPTION	CHK.

STATUS

SCALE

A3 1 : 6000

DIMENSION UNIT

METRES

KEY PLAN

PROJECT NO.

60329339

CONTRACT NO.

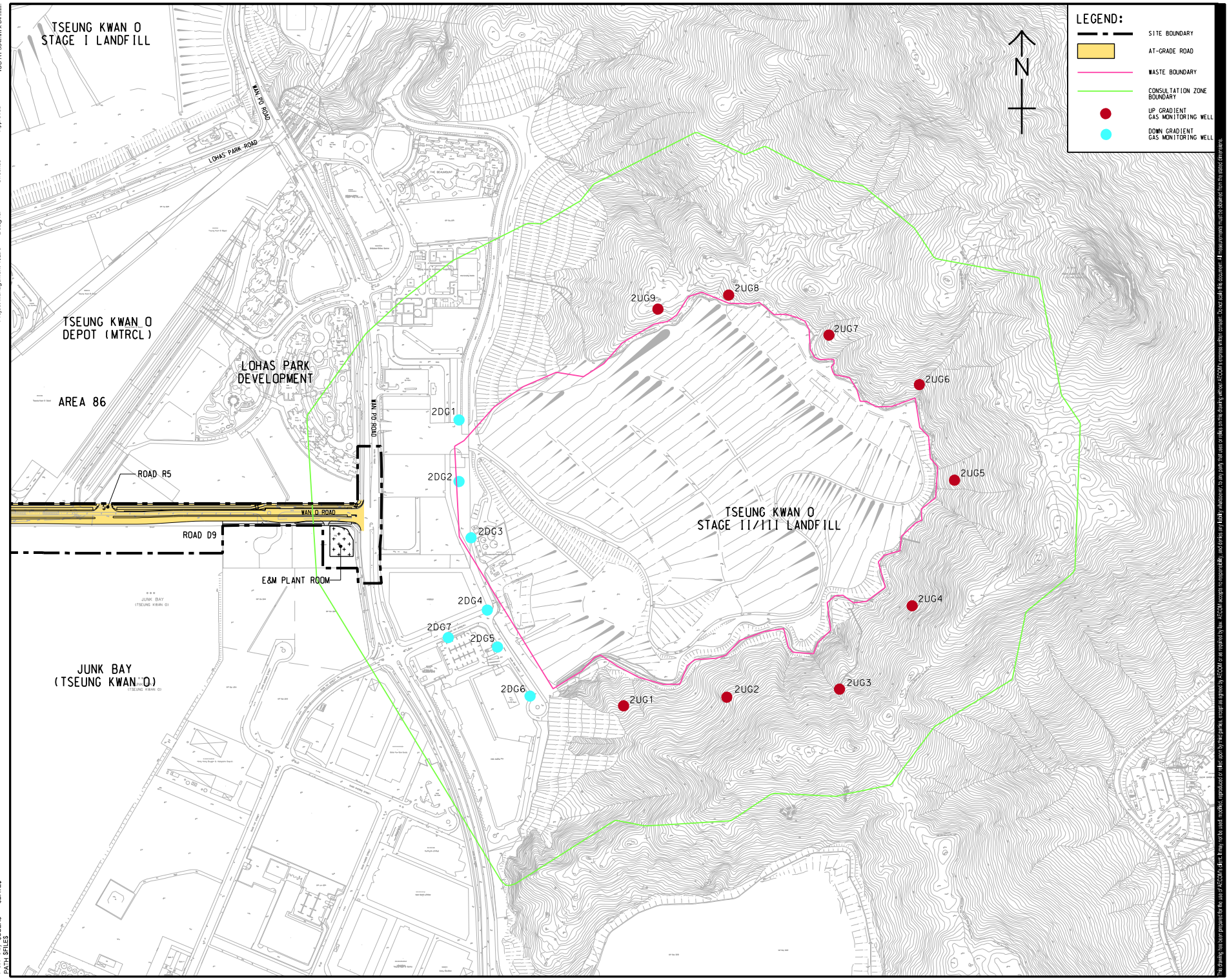
CE 6/2014 (HY)

SHEET TITLE

GENERAL LAYOUT PLAN

SHEET NUMBER

FIGURE 1



ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

Plot File by: $USER$
PATH $FILE$
$DATE$

AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

土木工程拓展署
CEDD Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

I/R	DATE	DESCRIPTION	CHK.

STATUS

SCALE: A3 1 : 6000

DIMENSION UNIT: METRES

KEY PLAN

PROJECT NO.: 60329339

CONTRACT NO.: CE 6/2014 (HY)

SHEET TITLE

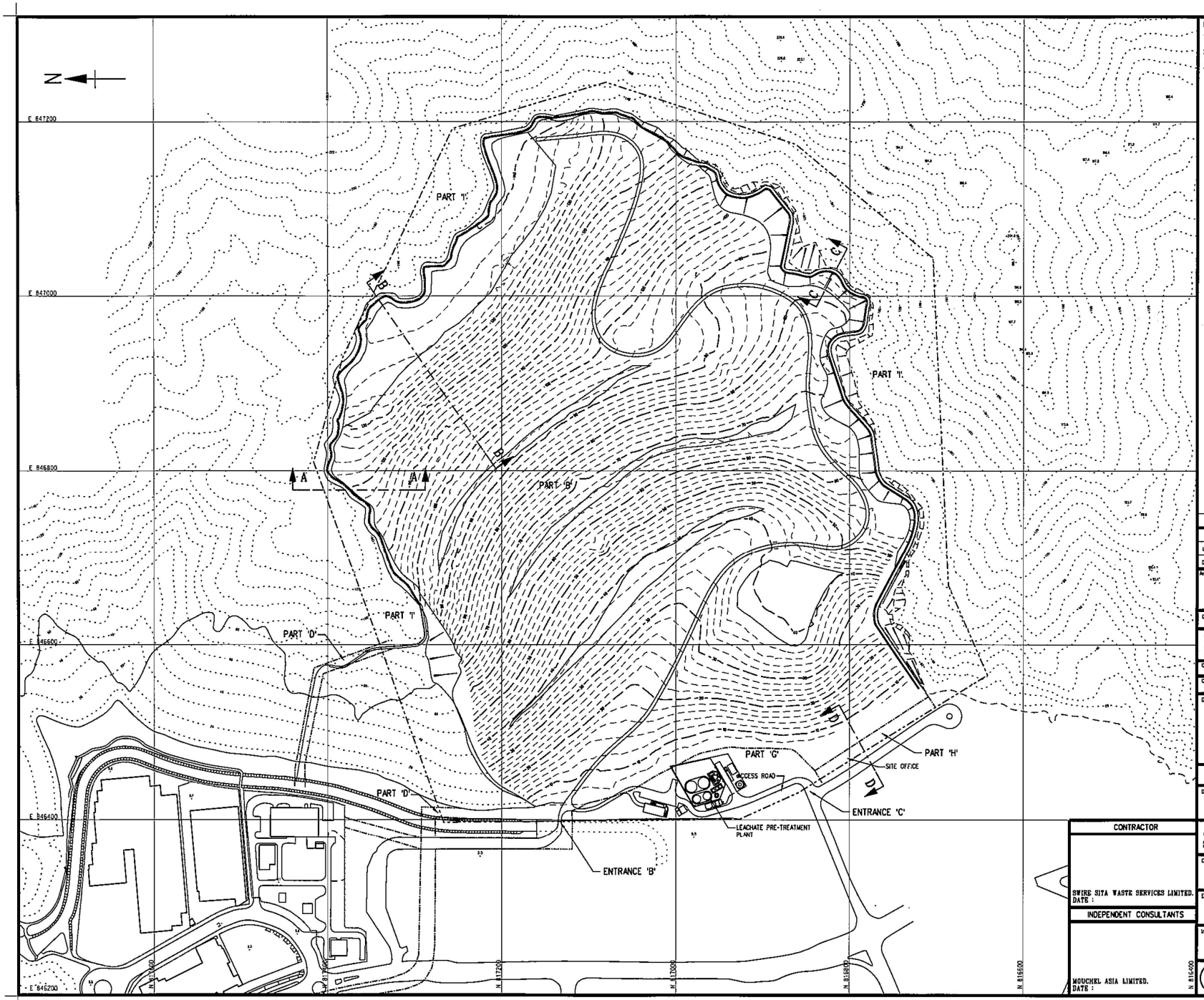
LAYOUT PLAN FOR TSEUNG KWAN O STAGE II/III LANDFILL

SHEET NUMBER

FIGURE 2

APPENDIX A

Restoration of TKO II_III landfill



NOTES:

1. ALL GRIDS ARE HONG KONG GRID 1980.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. FOR SECTIONS REFER TO DRAWING NO. STG2/STE/DRW/021/R.

LEGEND:

- SITE BOUNDARY
- BOUNDARY BETWEEN SITE PARTS
- CONTOURS
- CONTOURS AFTER REPROFILING

Details of Revision			Date
	Designed	Drawn	Checked
Initial			
Date			

Amendment to the Registered Design approved

CAD ref. MAIN: A2STE002.DGN
REF: TK105F-A0, S2-PTRD, S2FCCON & RTKO-ALDGN

ENVIRONMENTAL PROTECTION DEPARTMENT
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

Contract no. EP/SP/29/95

Contract title: TSEUNG KWAN O LANDFILLS RESTORATION

Drawing title:

STAGE II/III SITE PLAN ON COMPLETION OF FINAL CAP

AS CONSTRUCTED RECORD DRAWING

Drawing no. STG2/STE/DRW/002/R

Scale 1:2000

CONTRACTOR

SWIRE SITA WASTE SERVICES LIMITED.
DATE :

INDEPENDENT CONSULTANTS

MOUCHEL ASIA LIMITED.
DATE :

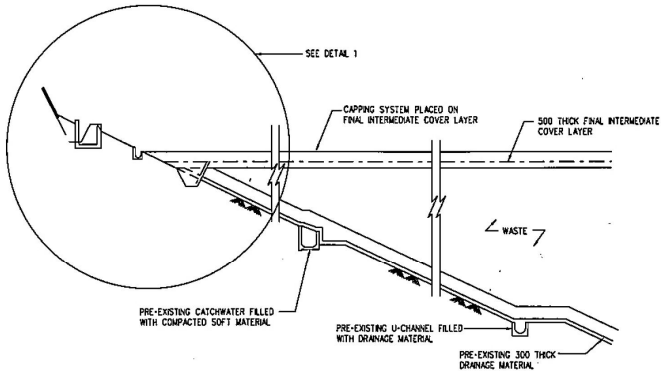
Binnie Black & Veatch Hong Kong Limited

Construction Contractor: CHUN WO CONSTRUCTION & ENGINEERING CO., LTD.

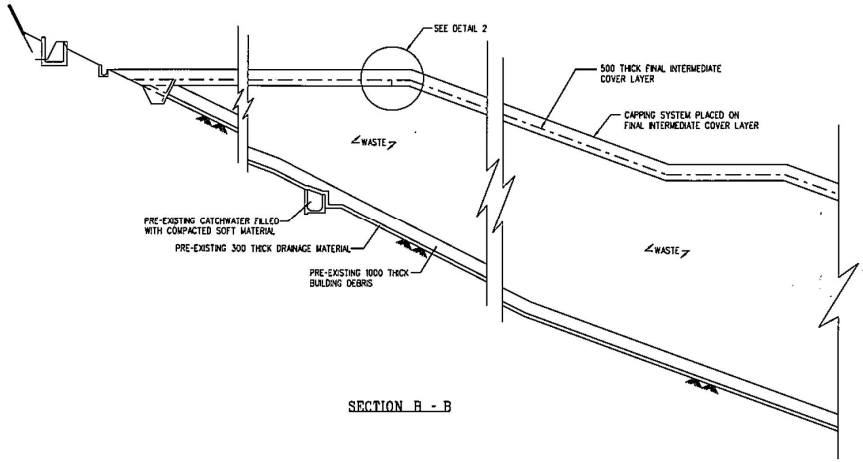
Environmental Consultants: ERM (HK) LTD.

Independent Consultants: MOUCHEL ASIA LIMITED CONSULTING ENGINEERS

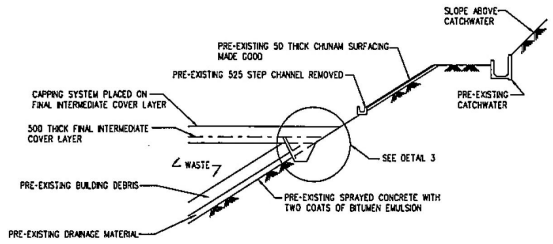
SWIRE SITA WASTE SERVICES LTD.



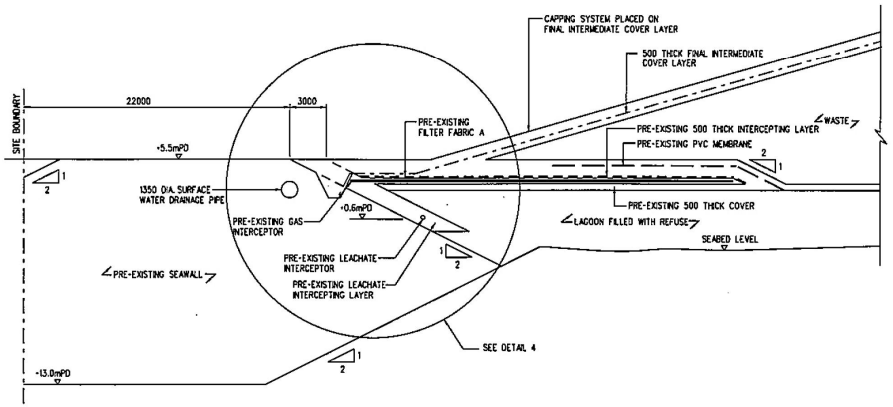
SECTION A - A



SECTION B - B



SECTION C - C



SECTION D - D

NOTES :

1. ALL DIMENSIONS IN MILLIMETRES.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. FOR LOCATIONS OF SECTIONS REFER TO DRAWING NO. STG2/STE/DRW/002/R.
4. FOR DETAILS OF CAPPING SYSTEM, REFER TO DRAWING NO. STG2/STE/DRW/201/R.

LEGEND :

——— FINAL CAP PROFILE

— — — — FINAL INTERMEDIATE COVER LAYER PROFILE

Details of Revision			Date
	Designed	Drawn	Checked
Initial			
Date			

Amendment to the Registered Design approved

CAD ref. MAIN A2STE021.DGN REF:RTKD-A1.DGN

ENVIRONMENTAL PROTECTION DEPARTMENT
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

Contract no. EP/SP/29/95

Contract title: TSEUNG KWAN O LANDFILLS RESTORATION

Drawing title:

STAGE II/III FINAL CAP CROSS SECTIONS

AS CONSTRUCTED RECORD DRAWING

Drawing no. STG2/STE/DRW/021/R

Scale 1 : 200

CONTRACTOR

SWIRE SITA WASTE SERVICES LIMITED.
DATE :

INDEPENDENT CONSULTANTS

MOUCHEL ASIA LIMITED.
DATE :

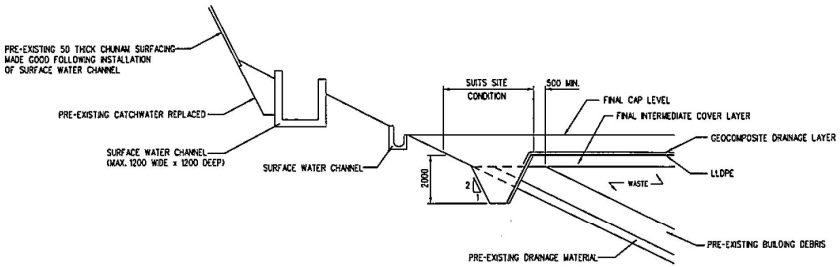
Binnie Black & Veatch Hong Kong Limited

Construction Contractor: CHUN WO CONSTRUCTION & ENGINEERING CO., LTD.

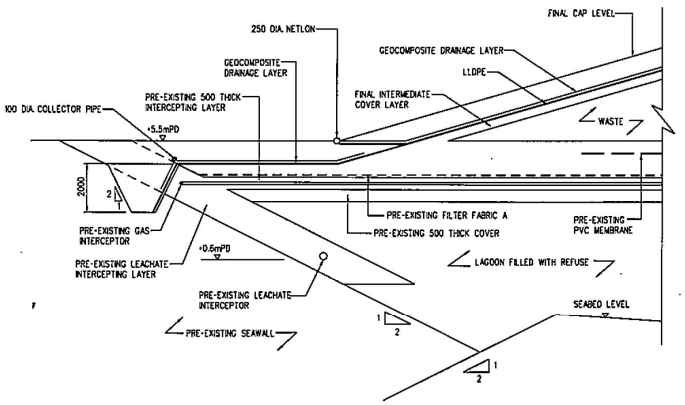
Environmental Consultants: ERM (HK) LTD.

Independent Consultants: MOUCHEL ASIA LIMITED CONSULTING ENGINEERS

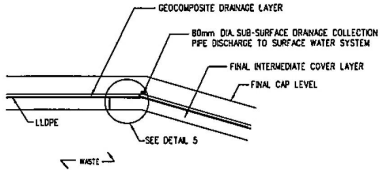
SWIRE SITA WASTE SERVICES LTD.



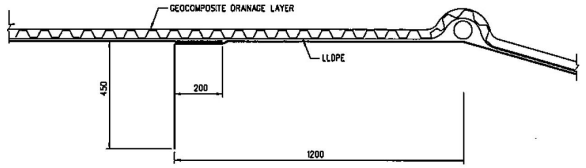
DETAIL 1
1:100



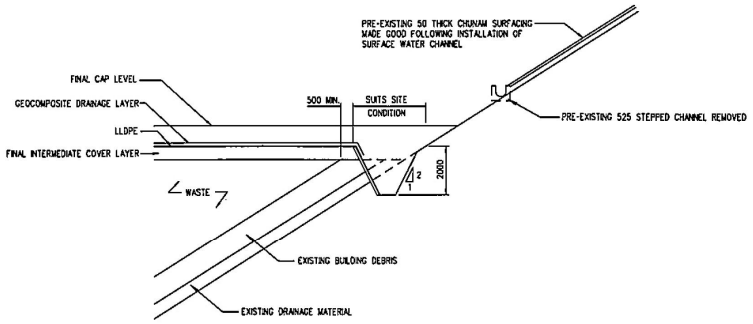
DETAIL 4
1:100



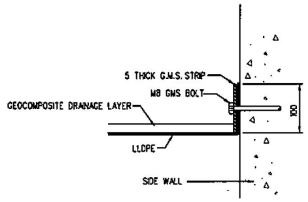
DETAIL 2
1:100



DETAIL 5
NTS



DETAIL 3
1:100



FIXING DETAILS OF LLDPE TO EXISTING CATCHPITS
NTS

NOTES :

1. ALL DIMENSIONS IN MILLIMETRES.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. FOR LOCATIONS OF DETAILS REFER TO DRAWING NO. STG2/STE/DRW/02/R.

Details of Revision			Date
	Designed	Drawn	Checked
Initial			
Date			

Amendment to the Registered Design approved

CAD ref. MAIN A2STE201.DGN
REF: RTE01-A1.DGN

ENVIRONMENTAL PROTECTION DEPARTMENT
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

Contract no. EP/SP/29/95

Contract title: TSEUNG KWAN O LANDFILLS RESTORATION

Drawing title:

STAGE II/III CAP INTERFACE DETAILS

AS CONSTRUCTED RECORD DRAWING

Drawing no.	Scale
STG2/STE/DRW/201/R	AS SHOWN

CONTRACTOR

SWIRE SITA WASTE SERVICES LIMITED.
DATE :

INDEPENDENT CONSULTANTS

MOUCHEL ASIA LIMITED.
DATE :

Binnie Black & Veatch Hong Kong Limited

Construction Contractor: CHUN WO CONSTRUCTION & ENGINEERING CO., LTD.

Environmental Consultants: ERM (HK) LTD.

Independent Consultants: MOUCHEL ASIA LIMITED CONSULTING ENGINEERS

SWIRE SITA WASTE SERVICES LTD.

APPENDIX B

Landfill Gas Monitoring data

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG1

Date	CO_2 (%)	CH_4 (%)	O_2 (%)
1-Nov-14	0.0	0.0	20.2
5-Dec-14	4.1	0.0	16.7
16-Jan-15	1.4	0.0	18.6
24-Feb-15	0.0	0.0	20.6
14-Mar-15	0.0	0.0	20.7
15-Apr-15	0.8	0.0	19.3
6-May-15	1.6	0.0	18.7
3-Jun-15	0.0	0.0	20.3
10-Jul-15	1.2	0.0	18.4
19-Aug-15	4.0	0.0	15.3
8-Sep-15	3.1	0.0	17.2
5-Oct-15	0.0	0.0	20.3
5-Nov-15	0.4	0.0	20.0
21-Dec-15	0.0	0.0	20.8
4-Jan-16	2.0	0.0	18.6
18-Feb-16	1.1	0.0	19.4
1-Mar-16	2.6	0.0	15.2
6-Apr-16	0.9	0.0	18.8
9-May-16	2.3	0.0	17.5
20-Jun-16	0.3	0.0	19.8
11-Jul-16	0.0	0.0	20.4
6-Aug-16	1.2	0.0	18.6
19-Sep-16	0.1	0.0	20.2
7-Oct-16	0.0	0.0	20.3

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG2

Date	CO_2 (%)	CH_4 (%)	O_2 (%)
4-Nov-14	0.2	0.0	20.0
5-Dec-14	0.3	0.0	20.0
16-Jan-15	6.1	0.0	14.3
9-Feb-15	5.6	0.0	15.3
14-Mar-15	3.7	0.0	17.3
15-Apr-15	0.0	0.0	20.3
6-May-15	0.2	0.0	20.3
3-Jun-15	3.6	0.0	16.4
10-Jul-15	0.7	0.0	19.7
4-Aug-15	5.8	0.0	13.6
8-Sep-15	0.3	0.0	20.5
5-Oct-15	6.8	0.0	11.3
26-Nov-15	6.9	0.0	13.2
1-Dec-15	3.3	0.0	17.0
26-Jan-16	5.0	0.0	17.8
2-Feb-16	4.3	0.0	16.6
1-Mar-16	2.3	0.0	17.4
6-Apr-16	1.5	0.0	19.6
9-May-16	0.0	0.0	20.7
28-Jun-16	0.0	0.0	20.6
11-Jul-16	4.3	0.0	15.3
6-Aug-16	5.3	0.0	13.9
19-Sep-16	4.7	0.0	14.7
7-Oct-16	5.2	0.0	15.2

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG3

Date	CO_2 (%)	CH_4 (%)	O_2 (%)
24-Nov-14	11.4	0.0	8.2
5-Dec-14	2.3	0.0	18.4
16-Jan-15	6.5	0.0	13.3
9-Feb-15	0.0	0.0	20.8
11-Mar-15	0.1	0.0	20.6
15-Apr-15	0.8	0.0	19.2
22-May-15	0.8	0.0	18.8
3-Jun-15	6.4	0.0	10.5
10-Jul-15	1.0	0.0	18.8
4-Aug-15	4.6	0.0	14.8
10-Sep-15	6.4	0.0	11.5
5-Oct-15	4.0	0.0	13.5
26-Nov-15	9.8	0.0	11.7
1-Dec-15	6.6	0.0	14.4
26-Jan-16	6.3	0.0	3.2
1-Feb-16	3.0	0.0	16.0
16-Mar-16	0.4	0.0	20.1
6-Apr-16	4.4	0.0	15.2
9-May-16	2.4	0.0	17.8
16-Jun-16	1.9	0.0	18.6
26-Jul-16	13.6	0.0	5.2
6-Aug-16	4.1	0.0	12.3
6-Sep-16	0.3	0.0	20.1
7-Oct-16	6.3	0.0	10.4

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG4

Date	CO_2 (%)	CH_4 (%)	O_2 (%)
24-Nov-14	5.4	0.0	16.4
5-Dec-14	3.1	0.0	17.5
16-Jan-15	4.5	0.0	16.8
24-Feb-15	3.8	0.0	17.5
11-Mar-15	2.7	0.0	18.7
17-Apr-15	0.1	0.0	20.5
6-May-15	0.0	0.0	20.7
3-Jun-15	0.0	0.0	20.1
10-Jul-15	3.2	0.0	16.9
4-Aug-15	3.5	0.0	16.3
8-Sep-15	0.0	0.0	20.9
7-Oct-15	1.2	0.0	20.0
5-Nov-15	0.2	0.0	20.6
1-Dec-15	2.3	0.0	18.2
4-Jan-16	4.5	0.0	16.7
18-Feb-16	3.6	0.0	17.1
1-Mar-16	3.0	0.0	17.3
11-Apr-16	1.3	0.0	19.1
9-May-16	0.0	0.0	20.8
16-Jun-16	0.0	0.0	20.8
11-Jul-16	0.0	0.0	20.8
6-Aug-16	0.3	0.0	20.0
19-Sep-16	0.4	0.0	20.0
7-Oct-16	7.2	0.0	13.5

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG5

Date	CO_2 (%)	CH_4 (%)	O_2 (%)
4-Nov-14	0.1	0.0	20.4
5-Dec-14	0.0	0.0	20.5
16-Jan-15	0.0	0.0	20.5
9-Feb-15	0.0	0.0	20.7
11-Mar-15	0.0	0.0	20.8
15-Apr-15	0.0	0.0	20.3
22-May-15	0.0	0.0	21.3
3-Jun-15	0.1	0.0	19.8
10-Jul-15	0.0	0.0	20.3
4-Aug-15	0.0	0.0	20.8
10-Sep-15	0.1	0.0	20.6
5-Oct-15	0.0	0.0	20.5
13-Nov-15	0.0	0.0	20.6
1-Dec-15	0.1	0.0	20.2
4-Jan-16	0.1	0.0	20.5
1-Feb-16	0.0	0.0	20.8
16-Mar-16	0.0	0.0	20.6
6-Apr-16	0.0	0.0	20.3
9-May-16	0.0	0.0	20.7
16-Jun-16	0.0	0.0	20.7
26-Jul-16	0.4	0.0	20.0
6-Aug-16	0.2	0.0	20.1
6-Sep-16	0.0	0.0	20.7
7-Oct-16	0.9	0.0	19.0

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG6

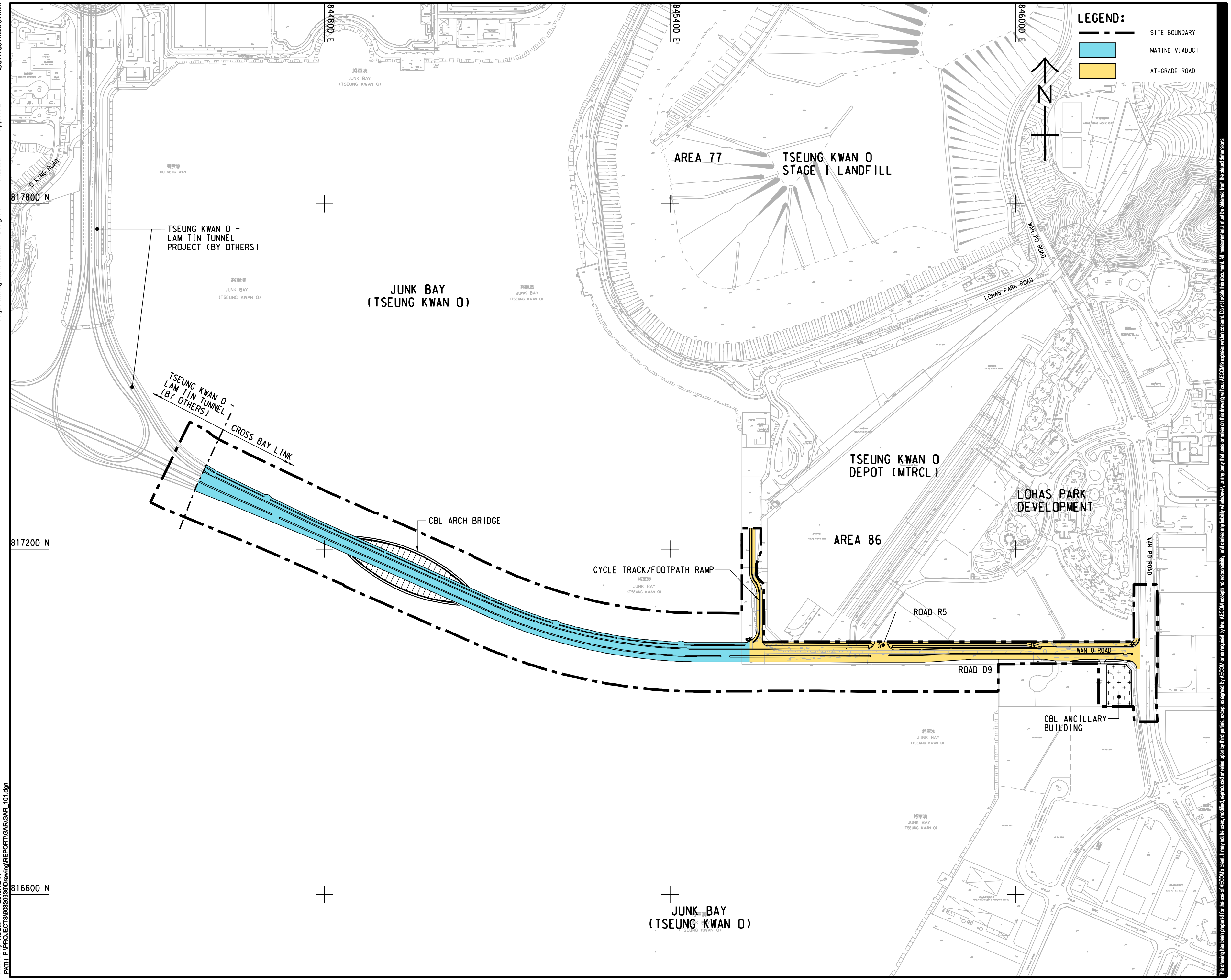
Date	CO_2 (%)	CH_4 (%)	O_2 (%)
1-Nov-14	0.8	0.0	19.5
5-Dec-14	0.9	0.0	19.6
16-Jan-15	0.4	0.0	20.4
9-Feb-15	1.2	0.0	20.0
11-Mar-15	0.4	0.0	20.4
15-Apr-15	0.6	0.0	19.6
6-May-15	0.4	0.0	20.0
19-Jun-15	0.2	0.0	20.0
10-Jul-15	1.2	0.0	17.9
19-Aug-15	0.5	0.0	20.2
8-Sep-15	1.4	0.0	18.5
5-Oct-15	1.5	0.0	16.4
5-Nov-15	0.9	0.0	19.3
21-Dec-15	0.4	0.0	20.5
4-Jan-16	0.7	0.0	19.7
1-Feb-16	0.7	0.0	20.1
1-Mar-16	0.6	0.0	19.3
6-Apr-16	0.6	0.0	19.5
5-May-16	0.0	0.0	20.4
20-Jun-16	1.1	0.0	19.5
11-Jul-16	3.8	0.0	14.8
12-Aug-16	1.5	0.0	18.5
19-Sep-16	0.0	0.0	20.5
7-Oct-16	1.8	0.0	18.0

Restoration of TKO Stage II/III Landfill
Migration Gas Wells Monitoring Data - 2/DG7

Date	CO_2 (%)	CH_4 (%)	O_2 (%)
1-Nov-14	0.1	0.0	19.8
5-Dec-14	0.6	0.0	19.8
16-Jan-15	0.2	0.0	20.1
9-Feb-15	0.7	0.0	20.1
11-Mar-15	0.0	0.0	20.8
17-Apr-15	0.0	0.0	20.3
6-May-15	1.4	0.0	18.9
19-Jun-15	0.4	0.0	19.9
10-Jul-15	0.1	0.0	20.7
4-Aug-15	2.5	0.0	17.5
8-Sep-15	0.1	0.0	20.7
7-Oct-15	1.6	0.0	19.5
5-Nov-15	1.9	0.0	18.9
1-Dec-15	0.6	0.0	19.4
4-Jan-16	0.1	0.0	20.5
1-Feb-16	0.0	0.0	20.8
1-Mar-16	0.0	0.0	20.5
11-Apr-16	0.0	0.0	20.5
5-May-16	1.0	0.0	19.0
16-Jun-16	0.0	0.0	20.6
11-Jul-16	2.5	0.0	15.3
12-Aug-16	2.0	0.0	16.0
19-Sep-16	2.2	0.0	16.0
7-Oct-16	6.7	0.0	6.5

APPENDIX C

Geological Map & Geotechnical Cross Section



AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 複核

STATUS 階段

SCALE 比例 A1 1 : 3000

DIMENSION UNIT 尺寸單位 METRES

KEY PLAN 索引圖

PROJECT NO. 項目編號 60329339

CONTRACT NO. 合約編號 CE 6/2014 (HY)

SHEET TITLE 圖紙名稱

GENERAL LAYOUT PLAN

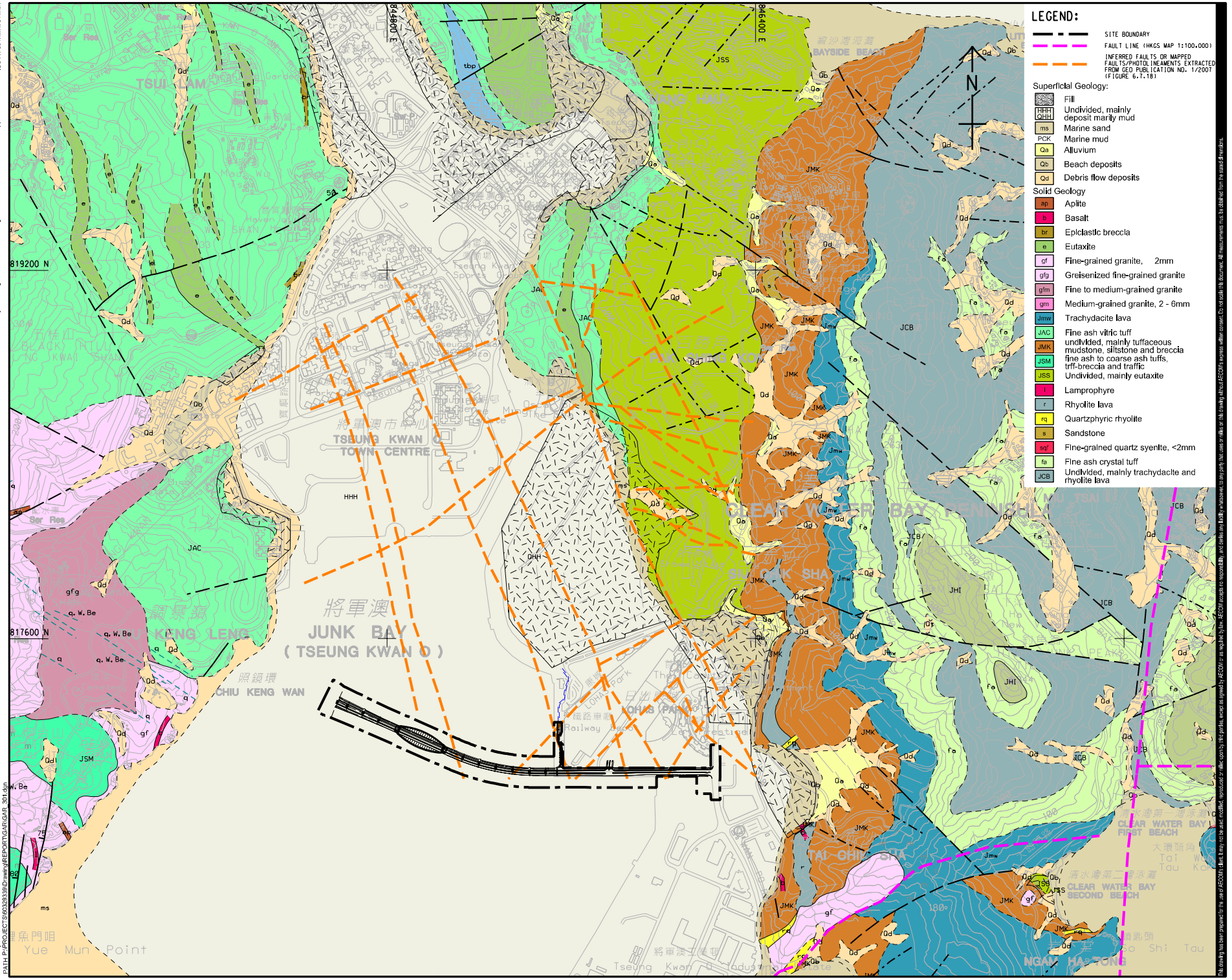
SHEET NUMBER 圖紙編號

60329339/GAR/FIGURE 1.1

Plot File by: XUCM 2015/10/14
PATH P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_101.dgn

Project Management Initials: Designer: Checked: Approved:

ISO A1 594mm x 841mm



ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

Plot File by: XIEYZ
PATH P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_3011.dgn
2015/10/15

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

I/R	DATE	DESCRIPTION	CHK.

STATUS

SCALE
A1 1 : 7500

DIMENSION UNIT
METRES

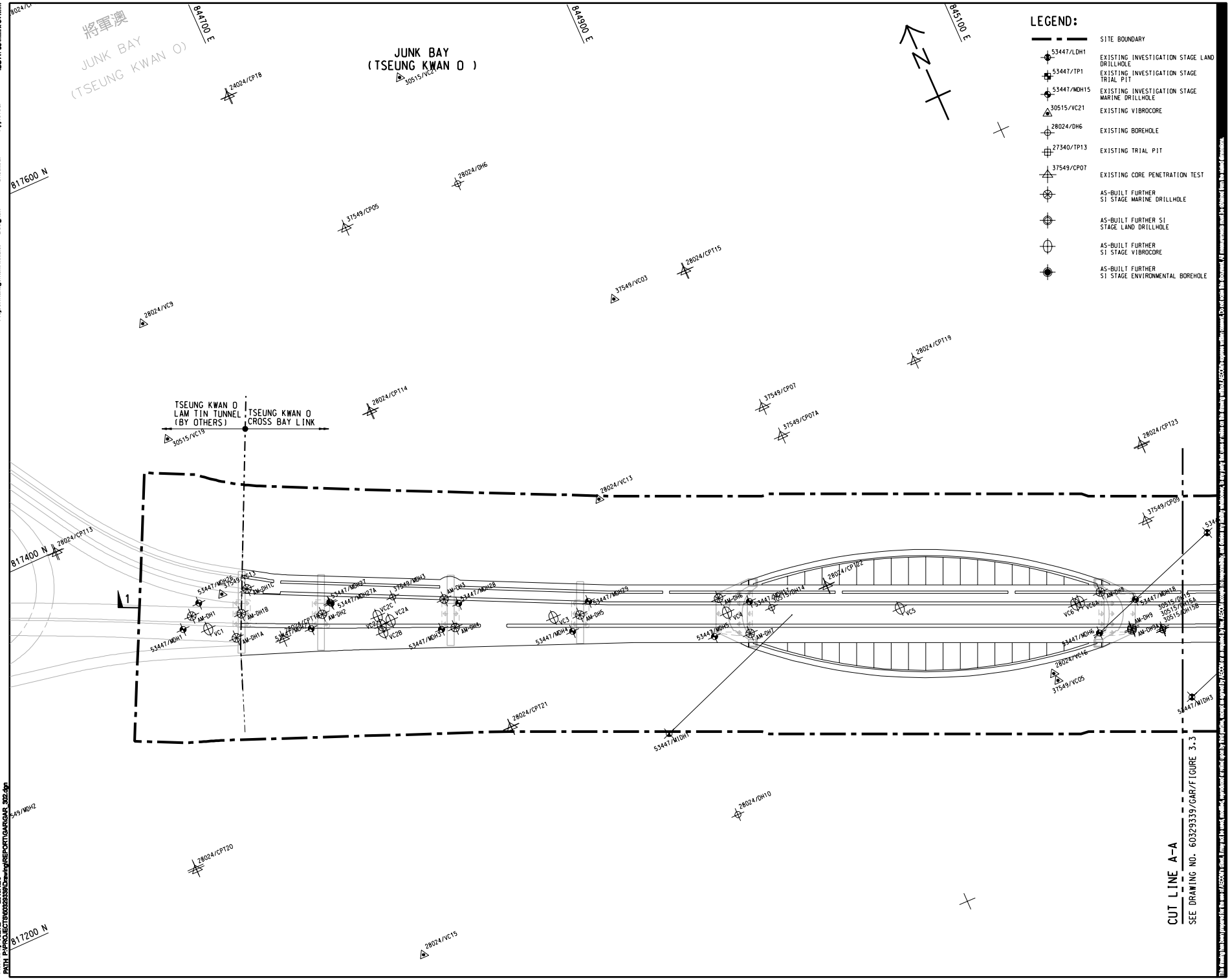
KEY PLAN

PROJECT NO.
60329339

CONTRACT NO.
CE 6/2014 (HY)

SHEET TITLE
REGIONAL GEOLOGICAL MAP (EXTRACTED FROM GEOLOGICAL MAP SHEETS 11 AND 12)

SHEET NUMBER
60329339/GAR/FIGURE 3.1



AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

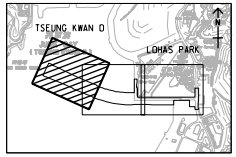
REF	DATE	DESCRIPTION	CHK

STATUS

SCALE A1 1 : 1000

DIMENSION UNIT METRES

KEY PLAN A1 1 : 30000



PROJECT NO. 60329339

CONTRACT NO. CE 6/2014 (HY)

SHEET TITLE

EXISTING GROUND INVESTIGATION (GI) LOCATION PLAN

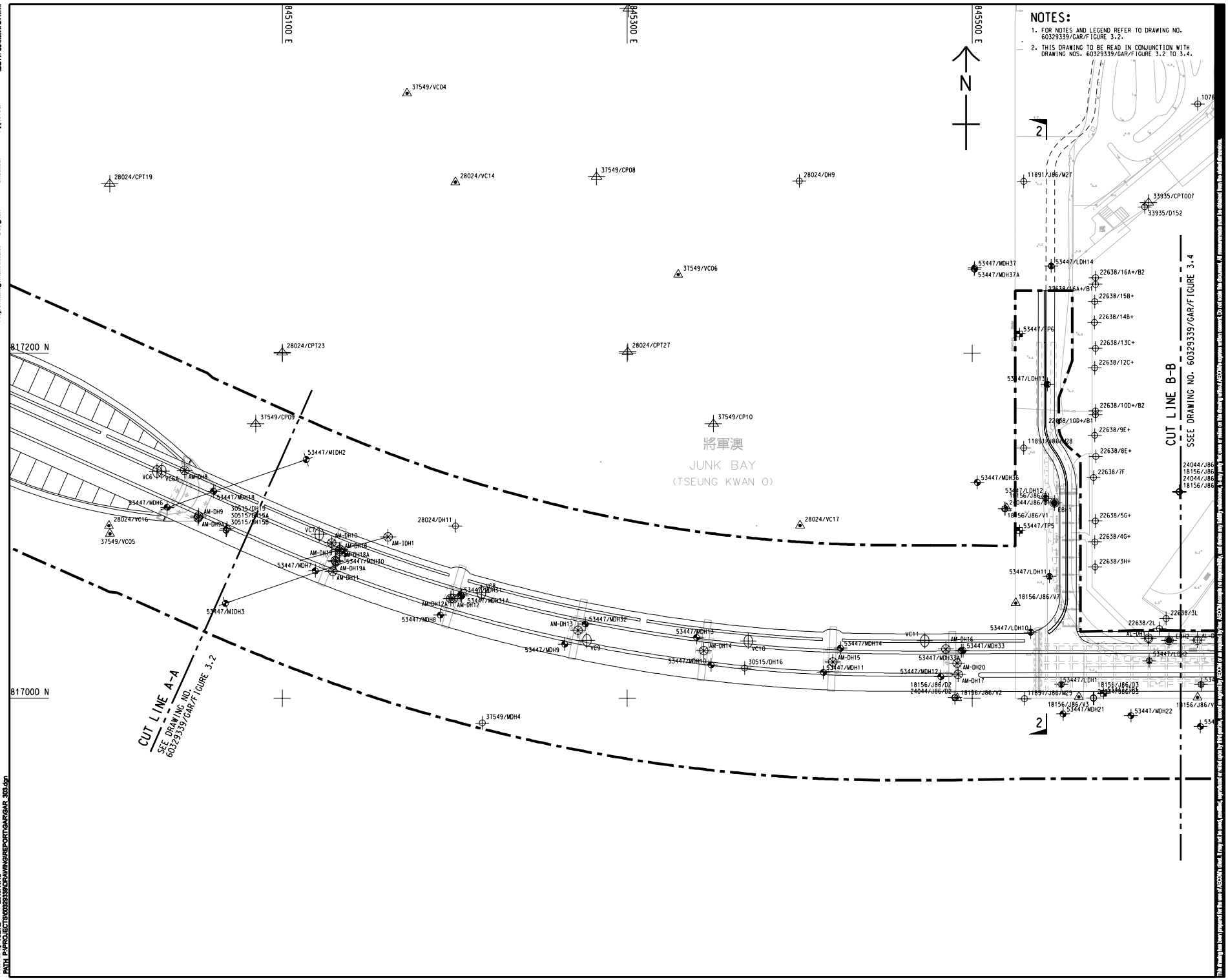
SHEET 1 OF 3

SHEET NUMBER

60329339/GAR/FIGURE 3.2

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Plot File by: XIEYZ 2016/1/29
PATH: P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_302.dgn



Approved:
Checked:
Designer:
Project Management Initials:
ISO A1 594mm x 841mm

Plot File by: XIEYZ 2015/11/12
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_303.dgn

AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

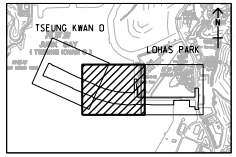
NO.	DATE	DESCRIPTION	CHK.

STATUS

SCALE A1 1 : 1000

DIMENSION UNIT METRES

KEY PLAN A1 1 : 30000



PROJECT NO. 60329339

CONTRACT NO. CE 6/2014 (HY)

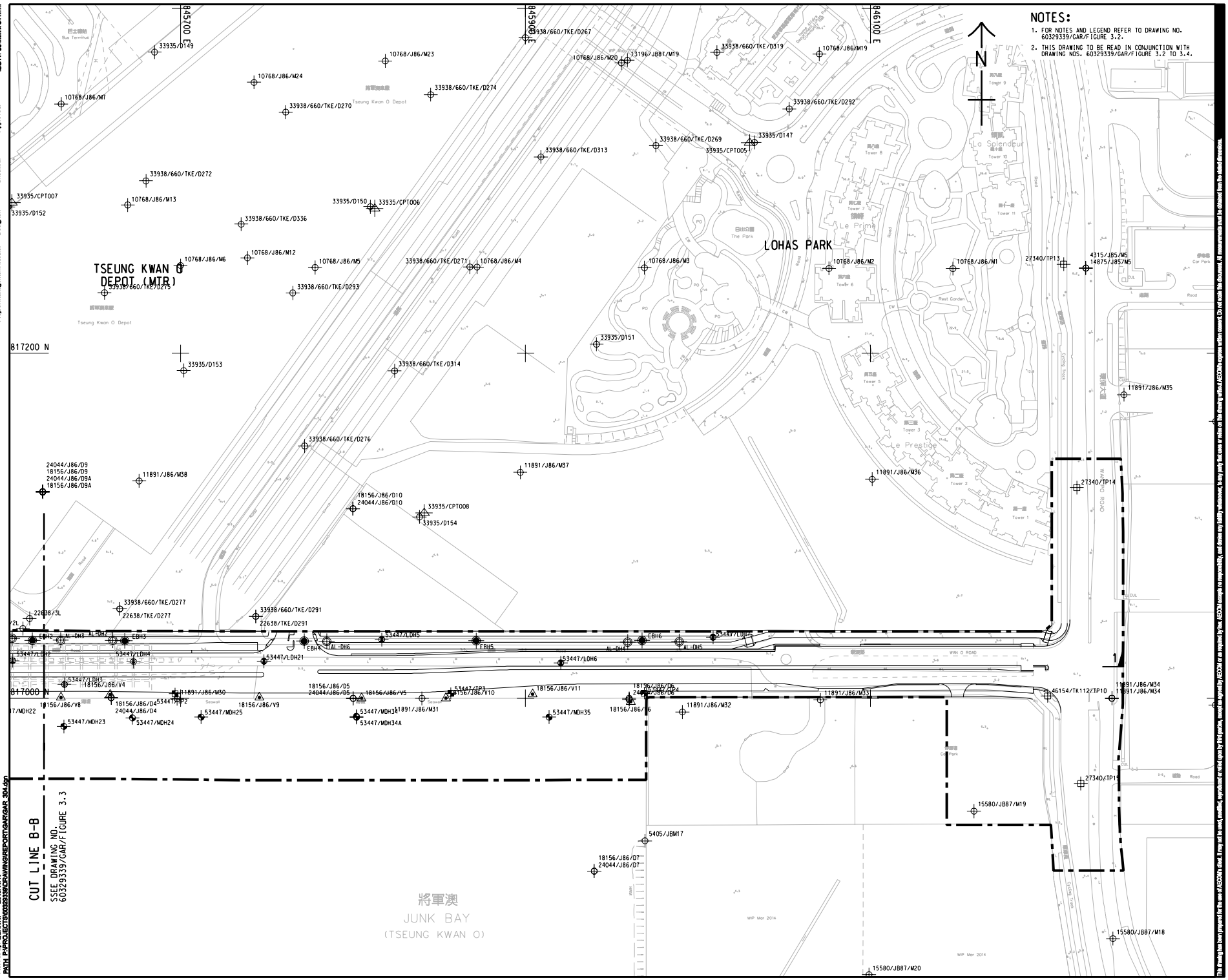
SHEET TITLE

EXISTING GROUND INVESTIGATION (GI) LOCATION PLAN

SHEET 2 OF 3

SHEET NUMBER

60329339/GAR/FIGURE 3.3



ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

Plot File by: QUANWF 2015/11/1
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_304.dgn

AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

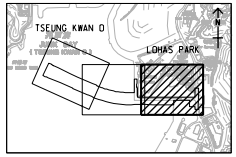
RE	DATE	DESCRIPTION	CHK

STATUS

SCALE: A1 1 : 1000

DIMENSION UNIT: METRES

KEY PLAN A1 1 : 30000



PROJECT NO. 60329339

CONTRACT NO. CE 6/2014 (HY)

SHEET TITLE

EXISTING GROUND INVESTIGATION (GI) LOCATION PLAN

SHEET 3 OF 3

SHEET NUMBER

60329339/GAR/FIGURE 3.4

GEOLOGICAL SECTIONS NOTES:

GENERAL:

1. ANY INFORMATION PERTAINING TO THE GEOLOGICAL, GEOTECHNICAL, HYDROGEOLOGICAL AND FOUNDATIONS PRESENTED ON ANY PLAN AND SECTION IS ESTABLISHED BASED ON THE AVAILABLE GEOTECHNICAL INVESTIGATION AS FOUND AND IT IS INDICATIVE AND IS GIVEN FOR REFERENCE ONLY. THE ACTUAL GROUND CONDITION WILL BE VERIFIED BY ADDITIONAL GI.

GROUND PROFILE:

1. THE GROUND PROFILE SHOWN HAS BEEN DERIVED USING THE PUBLISHED TOPOGRAPHIC MAP.

DRILLHOLE DETAILS:

1. FOR DETAILS OF INDIVIDUAL DRILLHOLE RECORDS REFERENCE SHOULD BE MADE TO THE SPECIFIC DRILLHOLE LOG.

2. A SIMPLIFIED VERSION OF THE DRILLHOLE DETAILS HAS BEEN SHOWN IN THE SECTIONS.

3. THE OFFSET DISTANCE FOR INCLINED DRILLHOLES ARE THE OFFSET DISTANCE AT THE GROUND/SEABED/WORKING PLATFORM LEVEL.

GEOLOGICAL LAYERS:

1. ANY GEOLOGICAL INTERPRETATION SHOWN ON THE DRAWINGS IS DERIVED FROM THE EXISTING DRILLHOLE RECORDS.

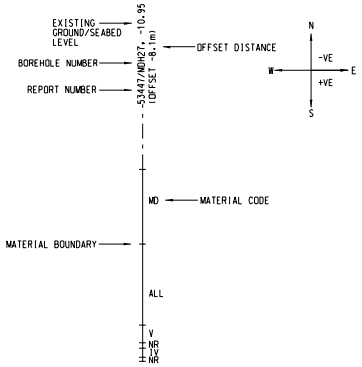
2. THE ACTUAL GROUND CONDITIONS MAY VARY FROM THAT SHOWN ON ANY INTERPRETED GEOLOGICAL SECTIONS.

3. UNLESS OTHERWISE SHOWN ON THE GEOLOGICAL SECTIONS, THE ROCK DECOMPOSITION GRADES (I.E. GRADES I, II, III, IV, V, IV) SHALL REFER TO GEOGUIDE 3.

4. ROCKHEAD LEVELS SHOWN ON THE GEOLOGICAL SECTIONS HAVE BEEN ESTIMATED FROM THE AVAILABLE GROUND INVESTIGATION DATA.

5. IT SHOULD BE NOTED THAT THE LOCATION, EXTENT, SIZE, DEPTH, ORIENTATION (DIP ANGLE AND DIP DIRECTION) OF THE INFERRED POSSIBLE FAULTS/SHEAR ZONES SHOWN ON THIS SECTION ARE INDICATIVE AND FOR REFERRENCE ONLY. THE ACTUAL CONDITIONS OF THE POTENTIAL FAULTS/SHEAR ZONES ARE TO BE VERIFIED BY THE ADDITIONAL GI.

6. "I-STAGE" SHOWN ON THE GEOLOGICAL SECTIONS STANDS FOR "INVESTIGATION STAGE"



TYPICAL SECTION FOR GEOLOGICAL CROSS SECTION

LEGEND FOR GEOLOGICAL SECTIONS:

WB	WASH BORING
NR	NO RECOVERY
FILL	FILL
MD	MARINE DEPOSIT
ALL	ALLUVIUM
V	COMPLETELY DECOMPOSED TUFF
IV	HIGHLY DECOMPOSED TUFF
III	MODERATELY DECOMPOSED TUFF
II	SLIGHTLY DECOMPOSED TUFF
— ? — ? —	INFERRED GEOLOGICAL BOUNDARY
	ROCKHEAD

AECOM

PROJECT
項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
客戶

CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
土木工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS
分判土木工程顧問公司

ISSUE/REVISION
修訂

I/R 修訂	DATE 日期	DESCRIPTION 內容簡述	CHK. 核對

STATUS
狀況

SCALE 比例 -

DIMENSION UNIT 尺寸單位 -

KEY PLAN
索引圖

PROJECT NO. 項目編號 60329339

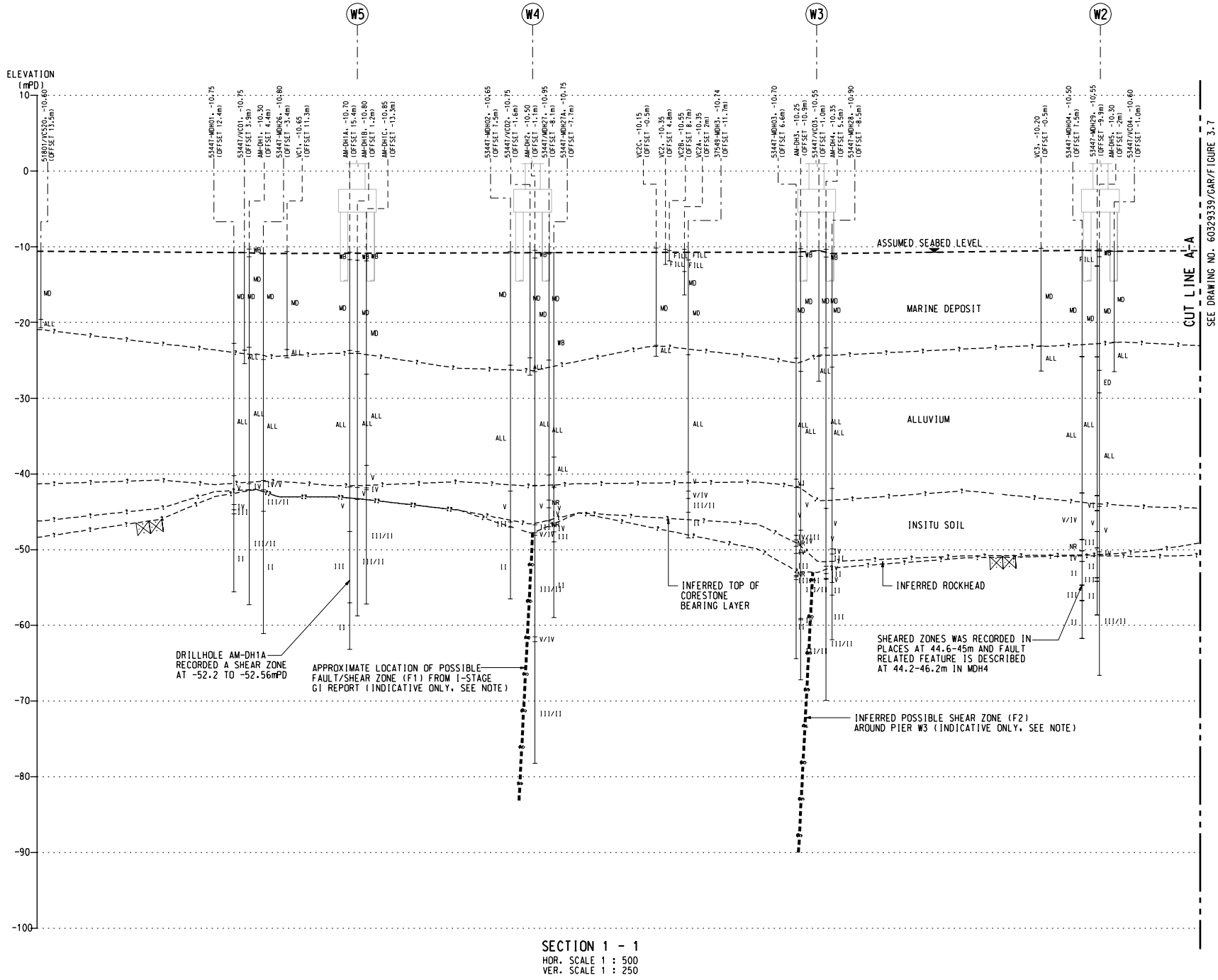
CONTRACT NO. 合約編號 CE 6/2014 (HY)

SHEET TITLE
圖紙名稱

NOTES AND LEGEND FOR GEOLOGICAL SECTIONS

SHEET NUMBER
圖紙編號

60329339/GAR/FIGURE 3.5



SECTION 1 - 1
HOR. SCALE 1 : 500
VER. SCALE 1 : 250

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

NO.	DATE	DESCRIPTION	CHK.

STATUS

SCALE
A1 AS SHOWN

DIMENSION UNIT
METRES

KEY PLAN

PROJECT NO.
60329339

CONTRACT NO.
CE 6/2014 (HY)

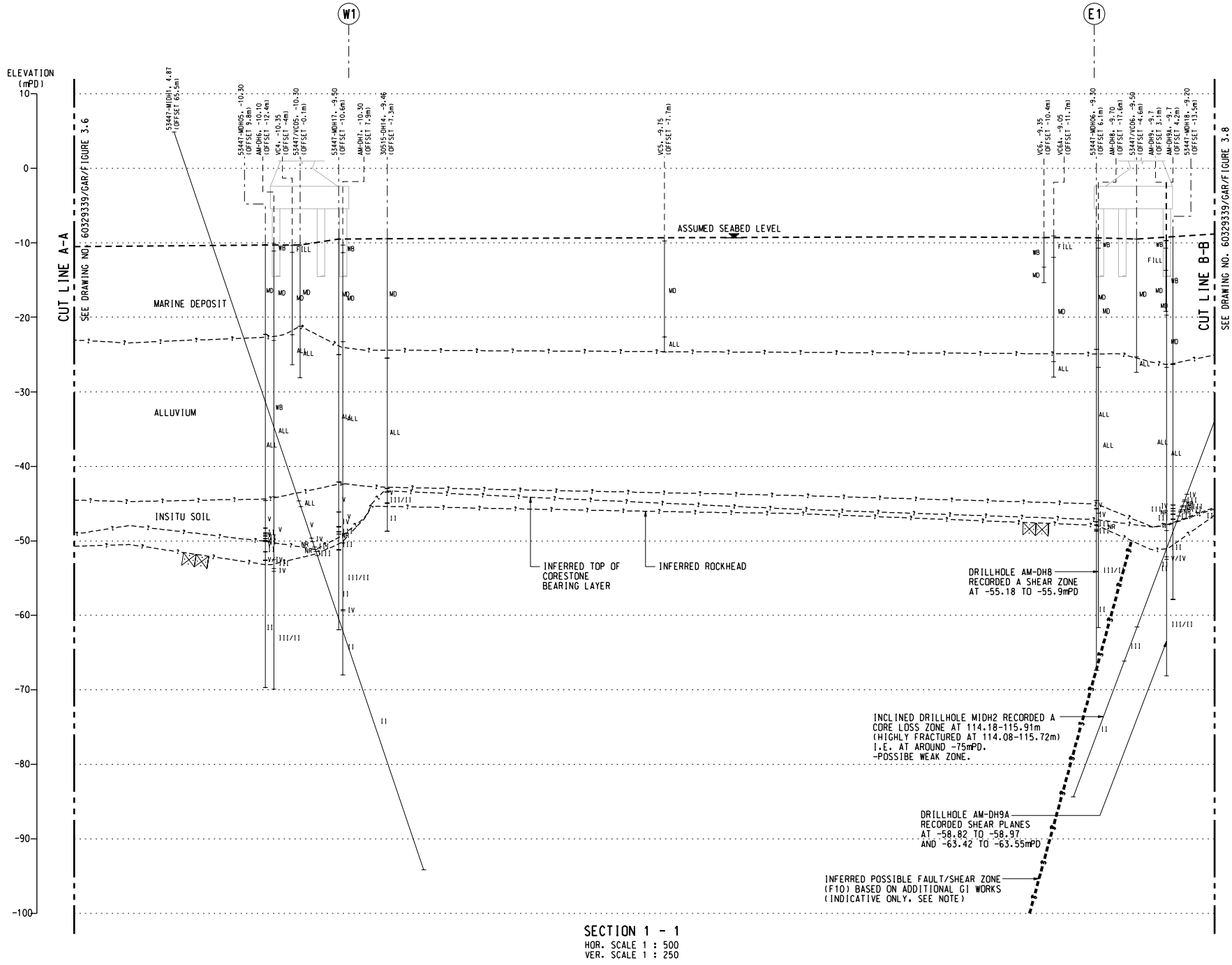
SHEET TITLE
GEOLOGICAL SECTION 1 - 1

SHEET 1 OF 6

SHEET NUMBER
60329339/GAR/FIGURE 3.6

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Plot File by: XIEYZ 2015/11/23
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_306.dgn



SECTION 1 - 1
HOR. SCALE 1 : 500
VER. SCALE 1 : 250

Plot File by: XIEYZ 2018/11/24
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_307.dgn

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

NO.	DATE	DESCRIPTION	CHK.

STATUS

SCALE: A1 AS SHOWN
DIMENSION UNIT: METRES

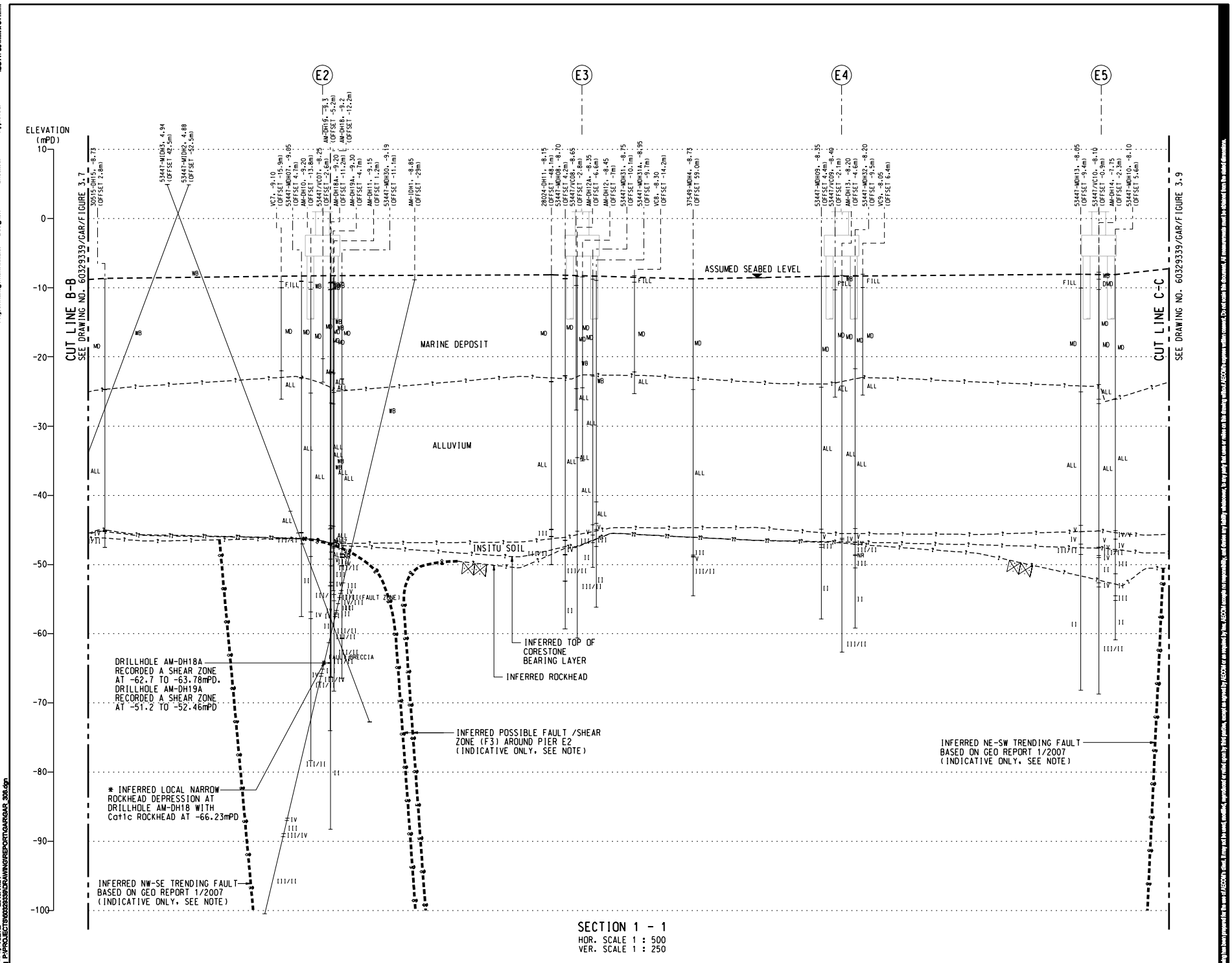
KEY PLAN

PROJECT NO.: 60329339
CONTRACT NO.: CE 6/2014 (HY)

SHEET TITLE
GEOLOGICAL SECTION 1 - 1

SHEET 2 OF 6

SHEET NUMBER
60329339/GAR/FIGURE 3.7



SECTION 1 - 1
HOR. SCALE 1 : 500
VER. SCALE 1 : 250

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Plot File by: XIEYZ 2015/11/24
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_306.dgn

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
土木工程拓展署
Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

NO.	DATE	DESCRIPTION	CHK.

STATUS

SCALE: A1 AS SHOWN
DIMENSION UNIT: METRES

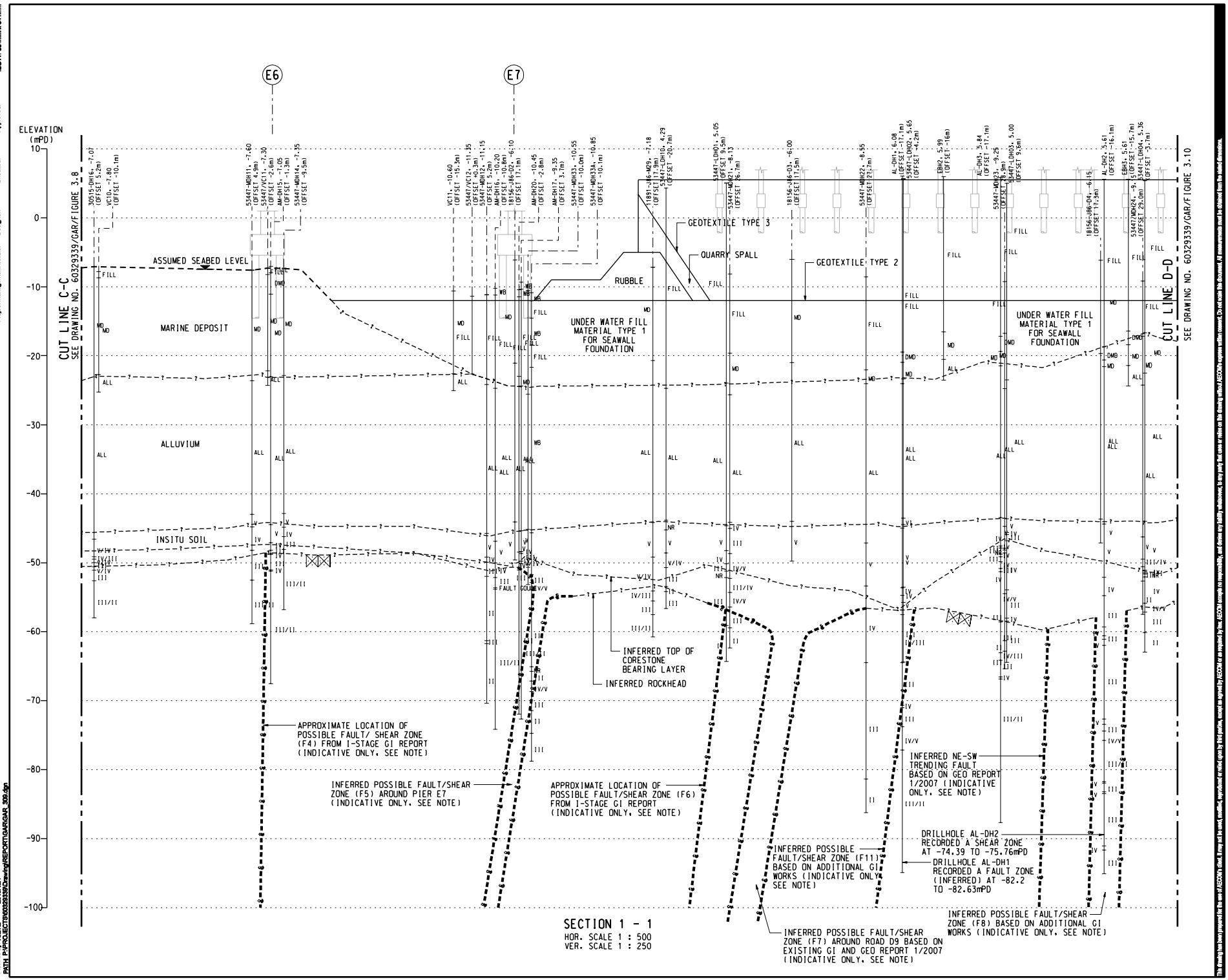
KEY PLAN

PROJECT NO.: 60329339
CONTRACT NO.: CE 6/2014 (HY)

SHEET TITLE
GEOLOGICAL SECTION 1 - 1

SHEET 3 OF 6

SHEET NUMBER
60329339/GAR/FIGURE 3.8



Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Plot File by: XIEYZ 2018/12/27
PATH: P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_309.dgn

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

REF	DATE	DESCRIPTION	CHK

STATUS

SCALE: A1 AS SHOWN
DIMENSION UNIT: METRES

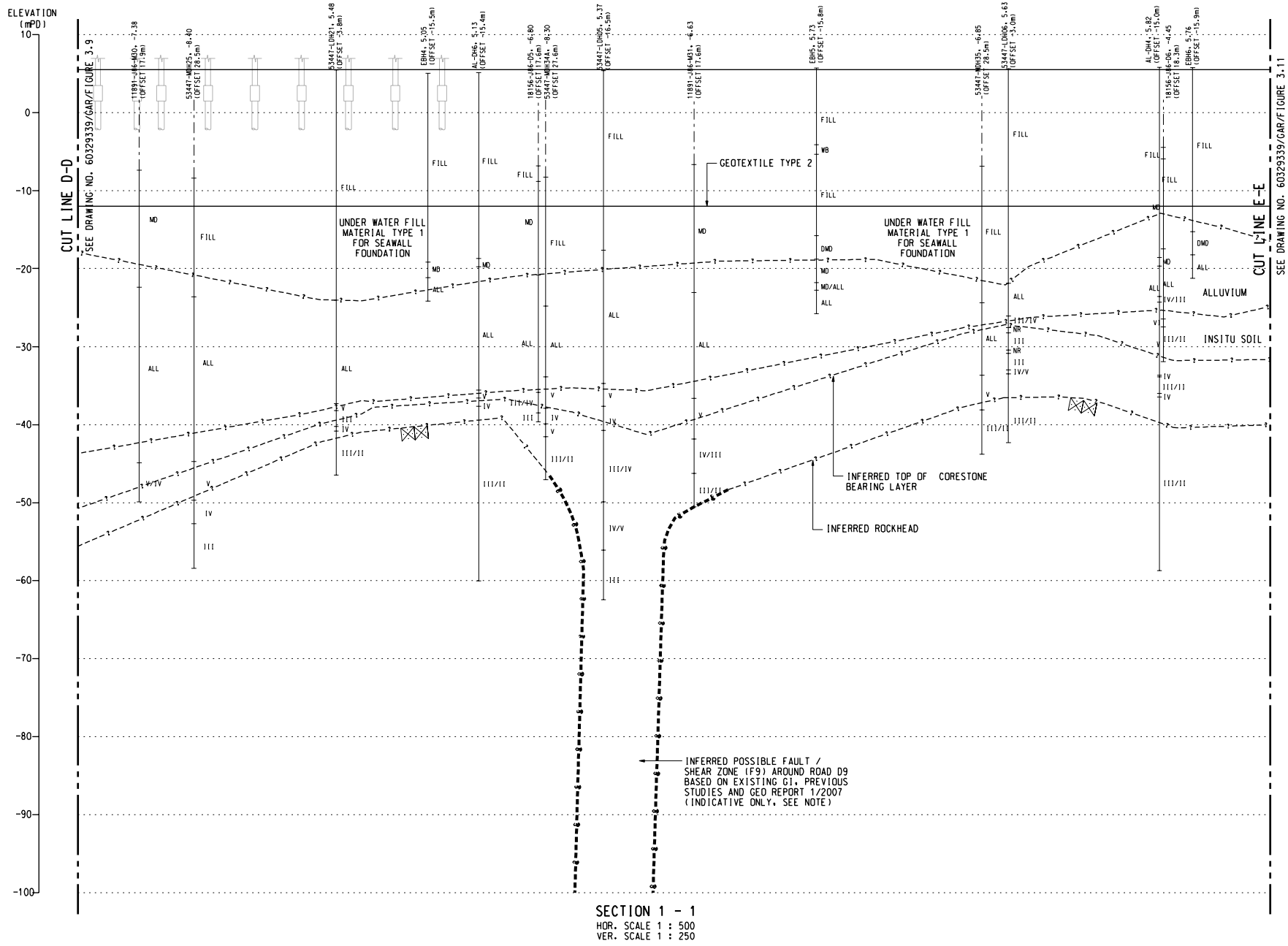
KEY PLAN

PROJECT NO.: 60329339
CONTRACT NO.: CE 6/2014 (HY)

SHEET TITLE
GEOLOGICAL SECTION 1 - 1

SHEET 4 OF 6

SHEET NUMBER
60329339/GAR/FIGURE 3.9



SECTION 1 - 1
HOR. SCALE 1 : 500
VER. SCALE 1 : 250

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

NO.	DATE	DESCRIPTION	CHK.

STATUS

SCALE
A1 AS SHOWN

DIMENSION UNIT
METRES

KEY PLAN

PROJECT NO.
60329339

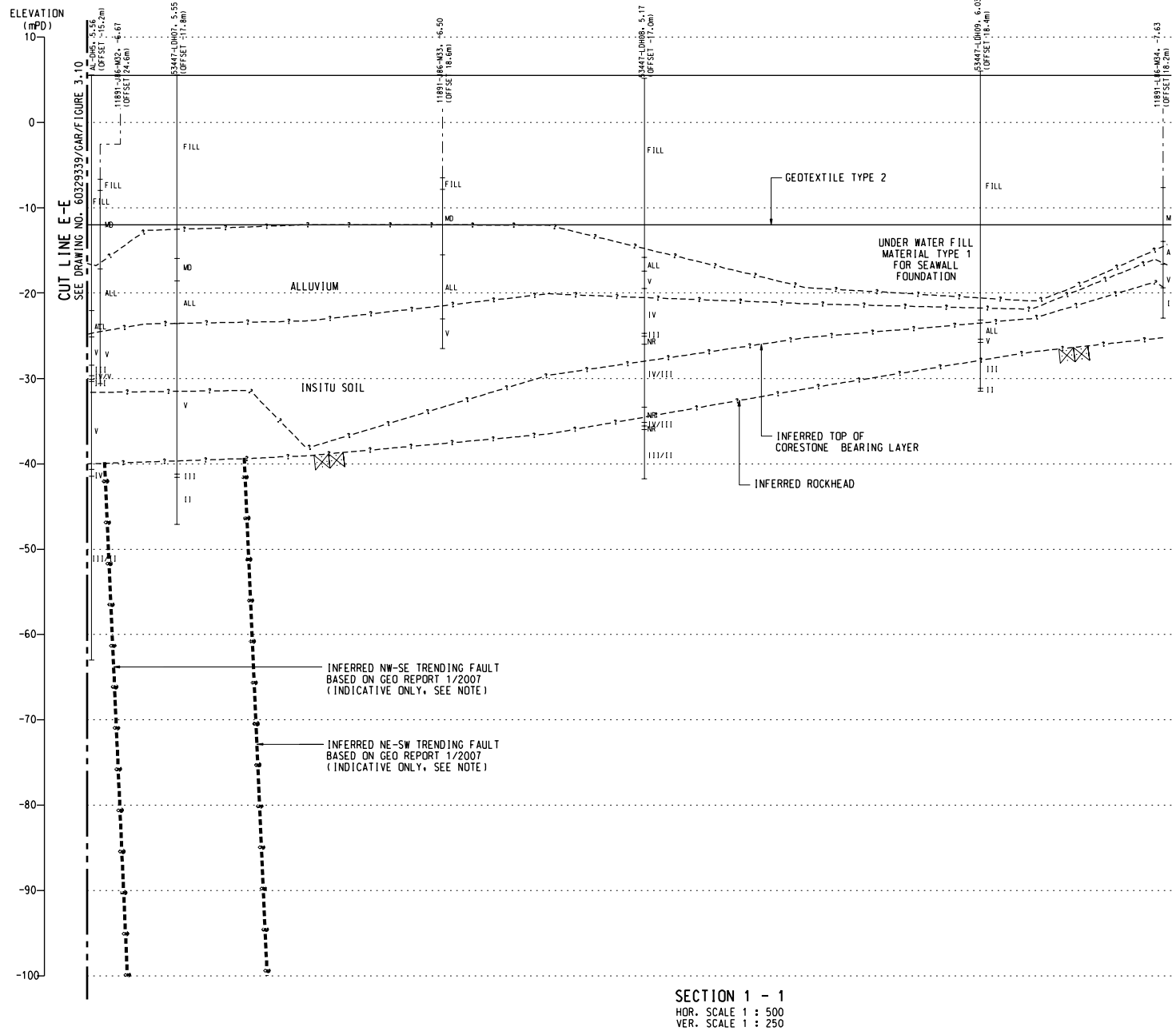
CONTRACT NO.
CE 6/2014 (HY)

SHEET TITLE
GEOLOGICAL SECTION 1 - 1

SHEET 5 OF 6

SHEET NUMBER
60329339/GAR/FIGURE 3.10

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm
Plot File by: XIEYZ 2018/12/7
PATH: P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_310.dgn



SECTION 1 - 1
HOR. SCALE 1 : 500
VER. SCALE 1 : 250

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

BY	DATE	DESCRIPTION	CHK

STATUS

SCALE
A1 AS SHOWN

DIMENSION UNIT
METRES

KEY PLAN

PROJECT NO.
60329339

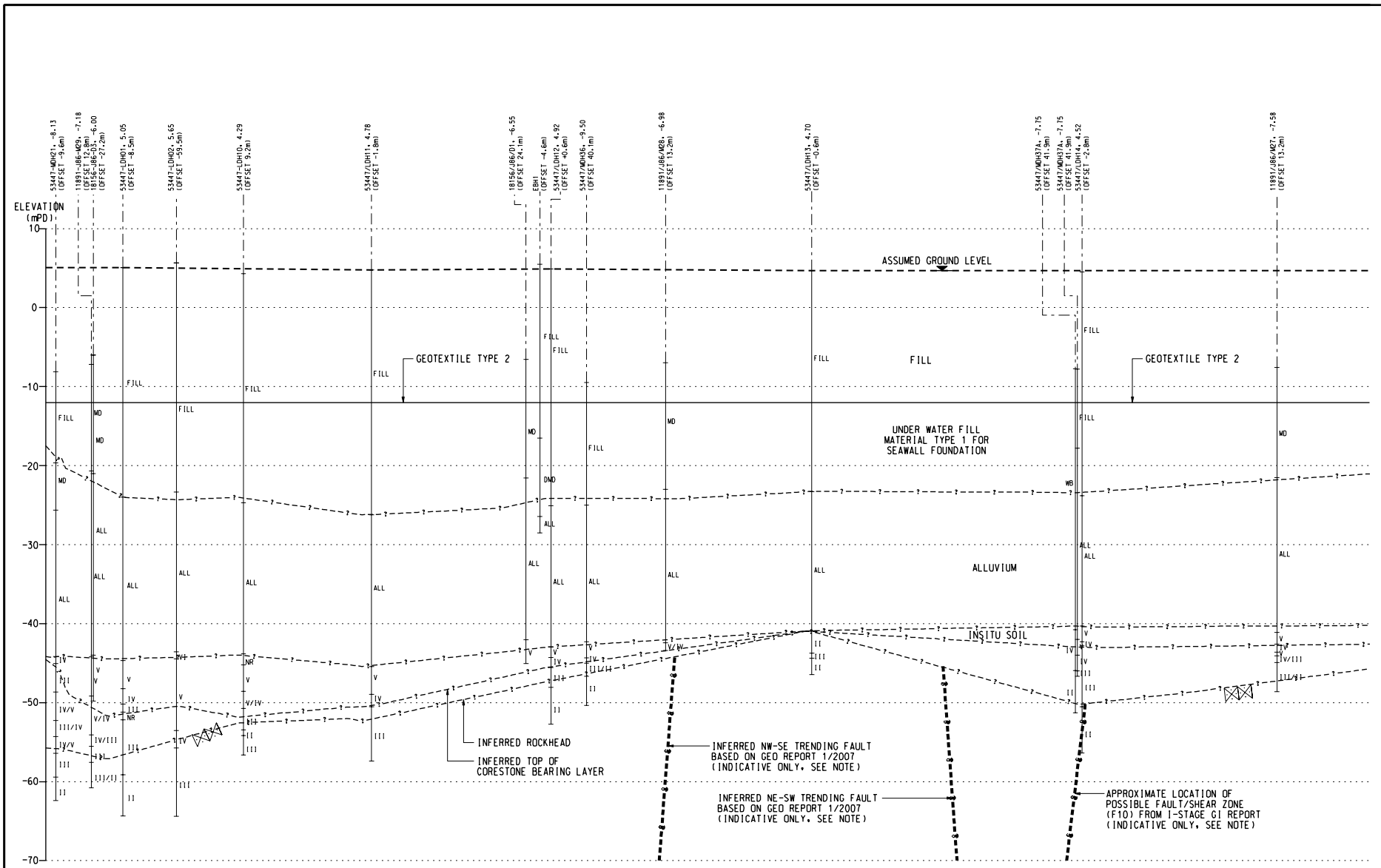
CONTRACT NO.
CE 6/2014 (HY)

SHEET TITLE
GEOLOGICAL SECTION 1 - 1

SHEET 6 OF 6

SHEET NUMBER
60329339/GAR/FIGURE 3.11

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm
Plot File by: SUZB 2015/11/12
PATH: P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_311.dgn



SECTION 2 - 2
HOR. SCALE 1 : 500
VER. SCALE 1 : 250

ISO A1 594mm x 841mm
Approved:
Checked:
Designer:
Project Management Initials:
Plot File by: SUZS 2015/11/9
PATH: P:\PROJECTS\60329339\Drawing\REPORT\GAR\GAR_312.dgn

AECOM

PROJECT
CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT
CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT
AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

REF	DATE	DESCRIPTION	CHK

STATUS

SCALE
A1 AS SHOWN

DIMENSION UNIT
METRES

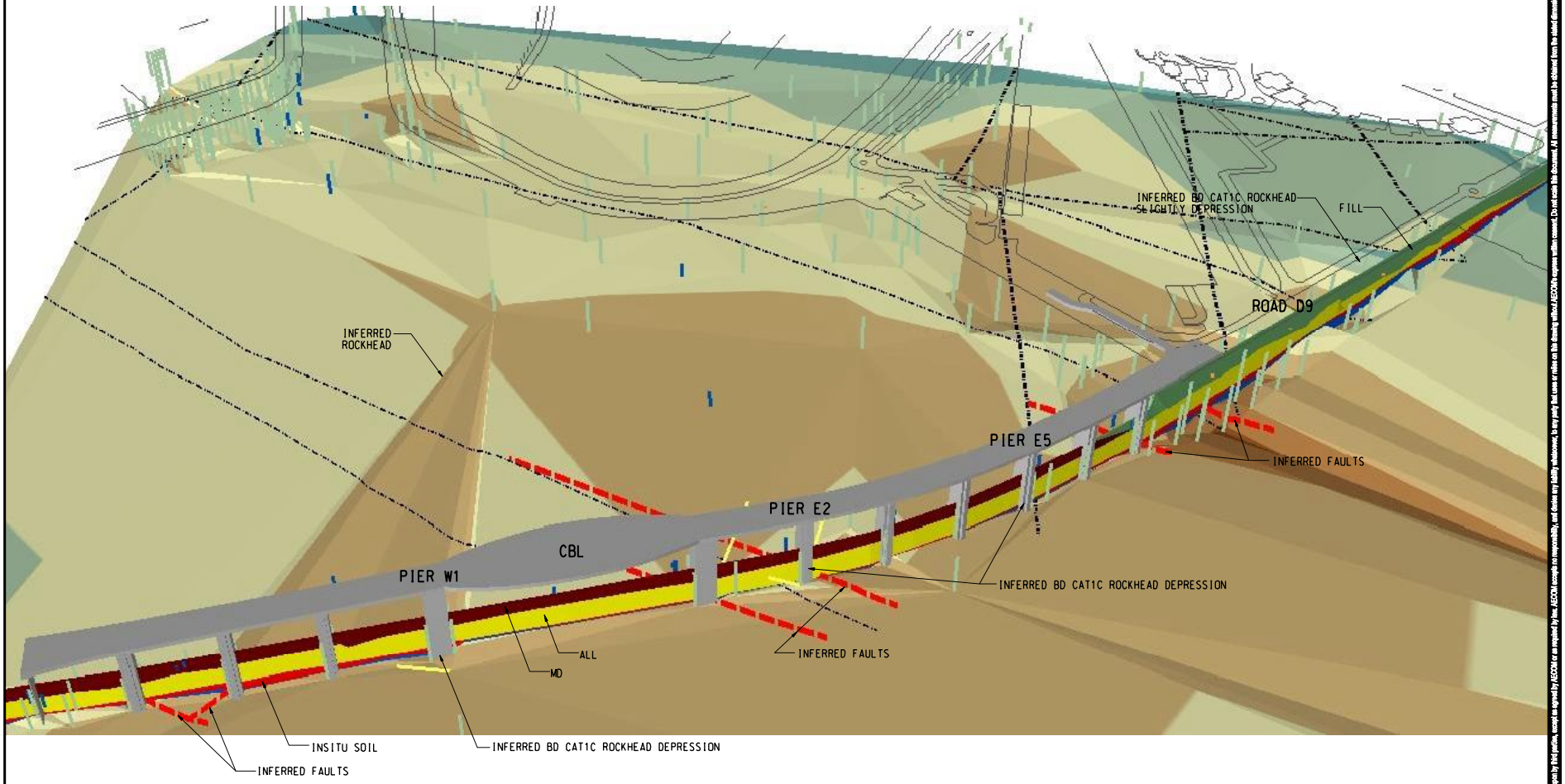
KEY PLAN

PROJECT NO.
60329339

CONTRACT NO.
CE 6/2014 (HY)

SHEET TITLE
GEOLOGICAL SECTION 2 - 2

SHEET NUMBER
60329339/GAR/FIGURE 3.12



AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

CEDD 土木工程拓展署 Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

BY	DATE	DESCRIPTION	CHK

STATUS

SCALE

-

DIMENSION UNIT

-

KEY PLAN

PROJECT NO.

60329339

CONTRACT NO.

CE 6/2014 (HY)

SHEET TITLE

3D MODEL OF SUBSURFACE GEOLOGICAL CONDITIONS

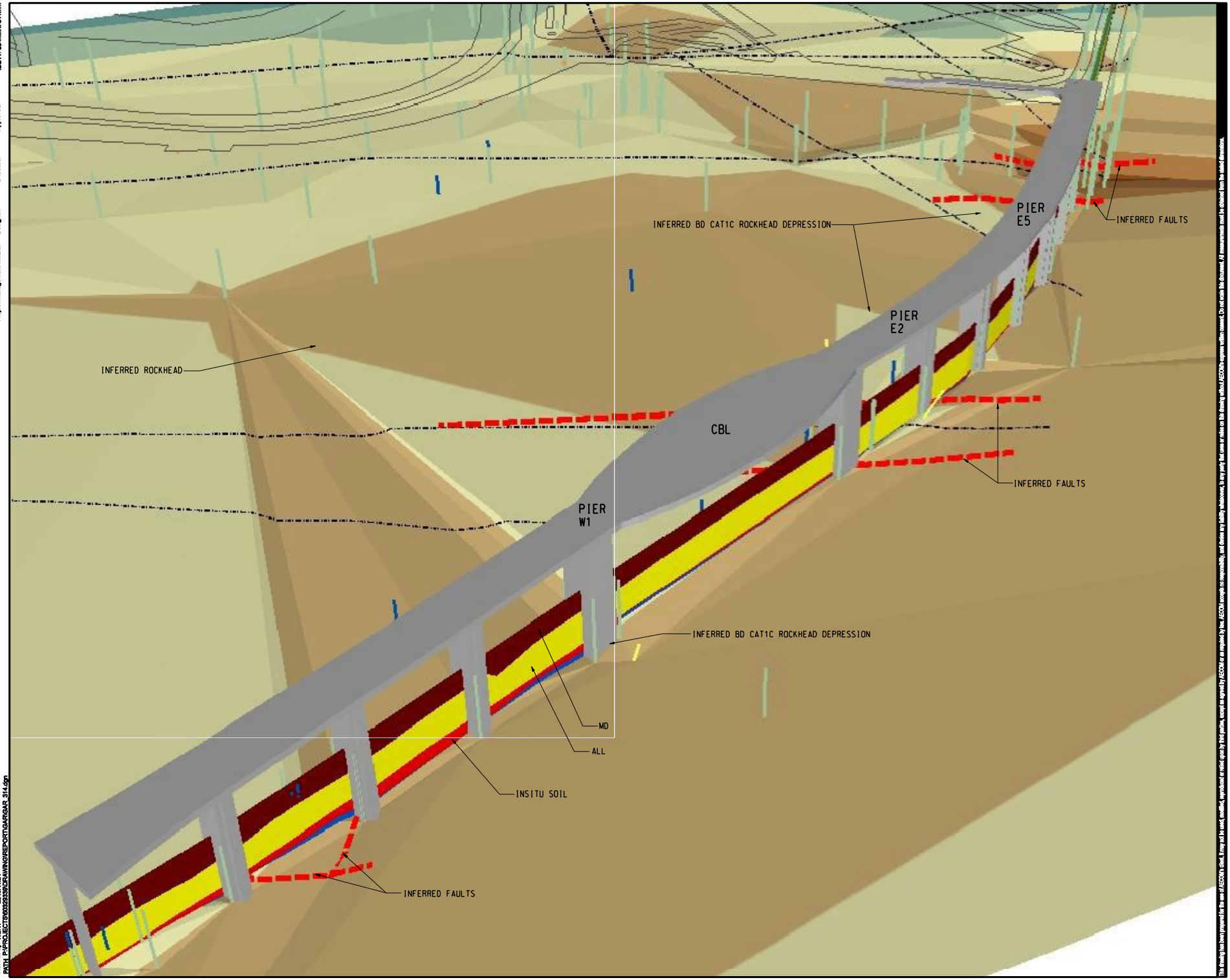
SHEET 1 OF 2

SHEET NUMBER

60329339/GAR/FIGURE 3.13

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Plot File by: WENY 2015/11/24
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_313.dgn



ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

Plot File by: WENY 2015/11/24
PATH: P:\PROJECTS\60329339\DRAWINGS\REPORT\GAR\GAR_314.dgn

AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

IR	DATE	DESCRIPTION	CHK.

STATUS

SCALE

-

DIMENSION UNIT

-

KEY PLAN

PROJECT NO.

60329339

CONTRACT NO.

CE 6/2014 (HY)

SHEET TITLE

3D MODEL OF SUBSURFACE GEOLOGICAL CONDITIONS

SHEET 2 OF 2

SHEET NUMBER

60329339/GAR/FIGURE 3.14

AECOM	Contract CE6/2014(HY)			Job ref. 60329339
	Part of Structure: Previous Groundwater Monitoring Data			Drawing ref.: -
	Calculated by: HW	Checked by: -	Approved by: -	Date: 16/09/2014

FUGRO GEOTECHNICAL SERVICES LTD

Groundwater Level Record Sheet

Contract No:	TK/2009/05	Works Order No :	NIL
Project :	Ground Investigation for Cross Bay Link, Tseung Kwan O		
Drillhole No.	LDH9		
Instrument No.	Standpipe		
Installation Date	14/02/2011		
AGMD Level (mPD)	N/A		
AGMD S/N	N/A		
Logger S/N	N/A		
Gauge Factor (psi/Digit)	N/A		
Thermal Factor (psi/°C)	N/A		
R_0 ($F^2 \times 10^{-3}$)	N/A		
T_0 (°C)	N/A		

Co-ordinates:

Easting	(m)	846197.08
Northing	(m)	816999.63

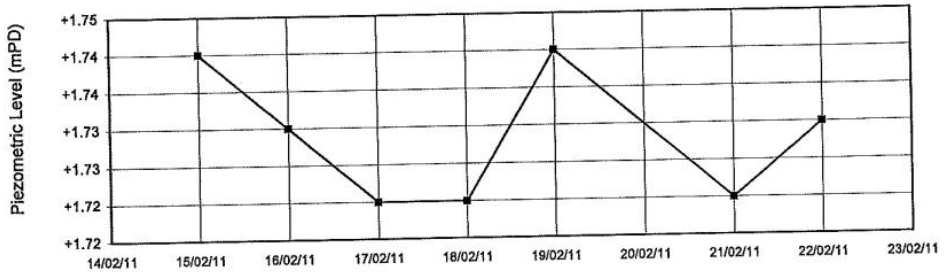
Season:

Wet	1 Apr to 31 Oct
Dry	1 Nov to 31 Mar

Standpipe

Top Level (mPD)	+6.11
Installed Tip Depth from Top Level (m)	10.08
Tip Level (mPD)	-3.97

Contractor: Fugro Geotechnical Services Ltd. Logged By: Kenny Kwong Checked By : A.B-Hollinshead



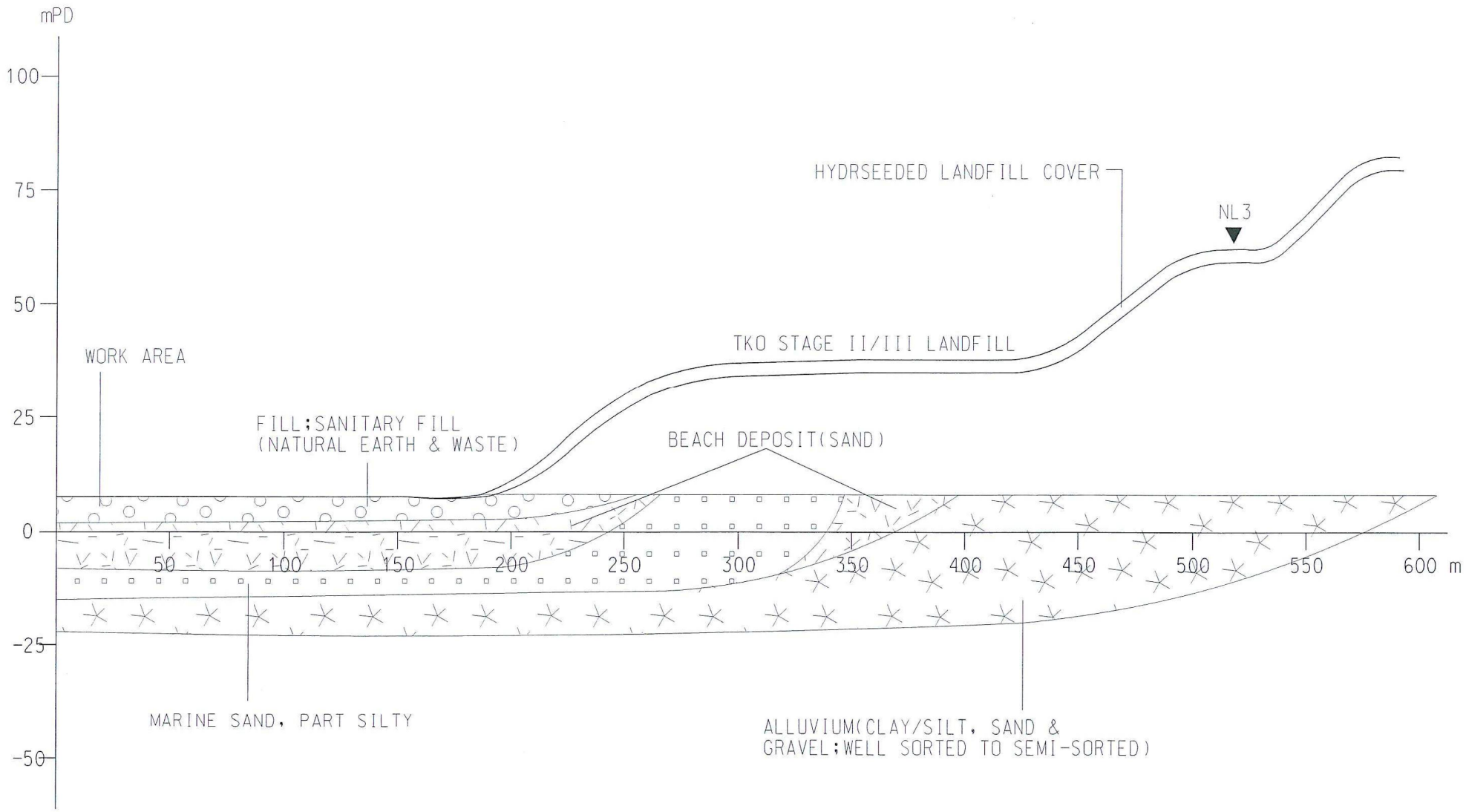
(Automatic Groundwater Monitoring Device)					(Piezometer/Standpipe)			
Date / Time dd/mm/yy hh:mm	R_1 (Hz)	Temp (°C)	Pressure (mH_2O) Above	Piezometric Level (mPD)	Date Time dd/mm/yy hh:mm	Manual Dip (m below top)	Piezometric Level (mPD)	Remark
					15/02/11 10:30	4.37	+1.74	
					16/02/11 11:30	4.38	+1.73	
					17/02/11 10:00	4.39	+1.72	
					18/02/11 10:30	4.39	+1.72	
					19/02/11 10:00	4.37	+1.74	
					21/02/11 10:00	4.39	+1.72	
					22/02/11 15:00	4.38	+1.73	

* AGMD = Automatic groundwater monitoring device

Figure A10.2 Groundwater Monitoring (LDH9)

APPENDIX D

Cross Section of TKO II_III landfill



Maunsell CONSULTANTS ASIA LTD. 茂盛(亞洲)工程顧問有限公司

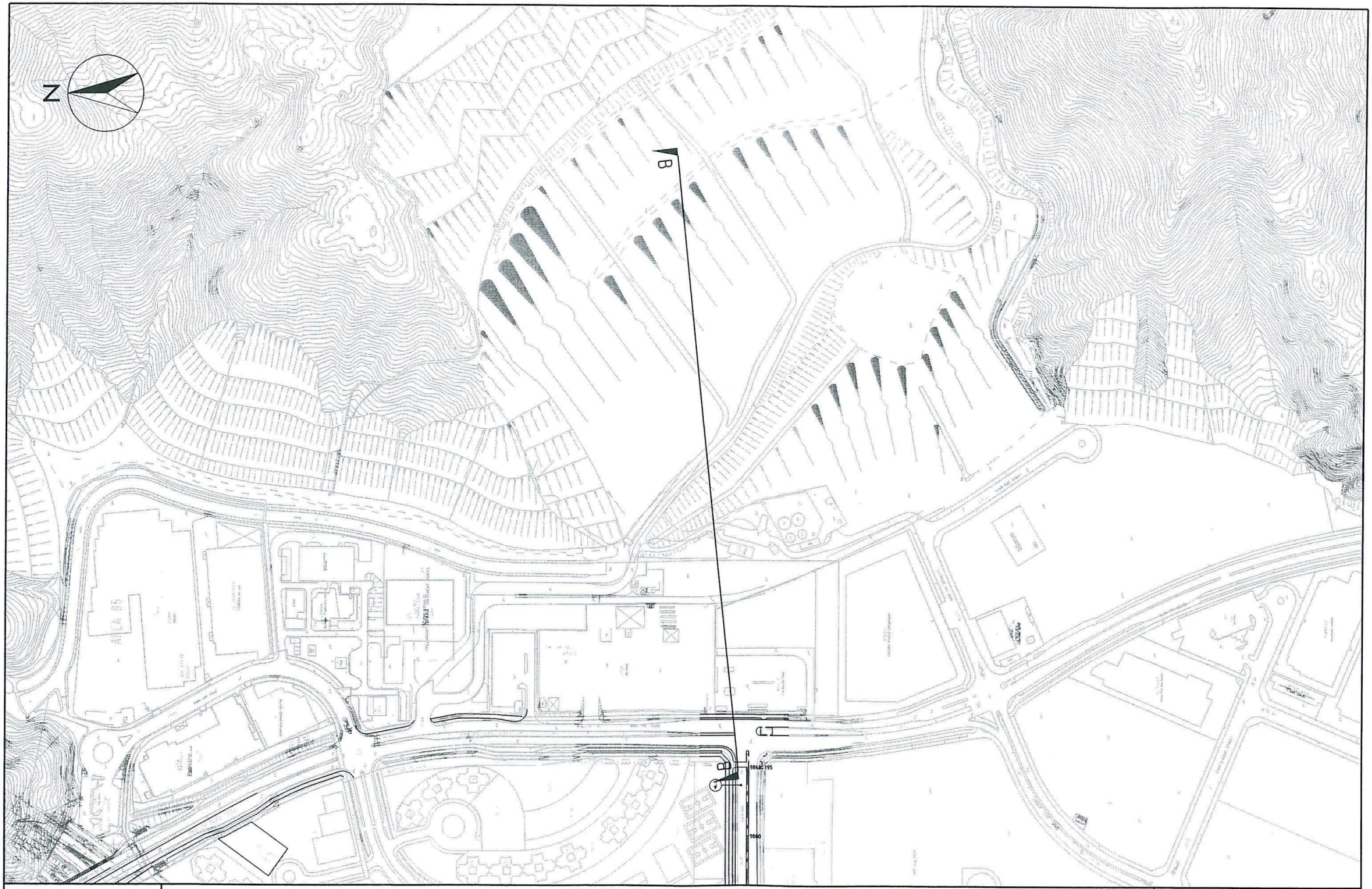
AGREEMENT NO. CE 87/2001(CE)
FURTHER DEVELOPMENT OF TSEUNG KWAN O - FEASIBILITY STUDY

CROSS SECTION B-B BETWEEN THE DEVELOPMENT SITE AND TKO STAGE II/III LANDFILL

CEDD Civil Engineering and Development Department
New Territories East Development Office

FIGURE 14.6b

K:/A05902/DRAWING/DRAWING/LANDFILL/OCT04/SEC-TKO2-3.DGN SCALE N.T.S. NOV 2004



Maunsell
CONSULTANTS ASIA LTD.
茂盛(亞洲)工程顧問有限公司

AGREEMENT NO. CE 87/2001(CE)
FURTHER DEVELOPMENT OF TSEUNG KWAN O - FEASIBILITY STUDY

CROSS-SECTION B-B BETWEEN THE DEVELOPMENT SITE AND TSEUNG KWAN O STAGE II/III LANDFILL

CEDD Civil Engineering and Development Department
New Territories East Development Office

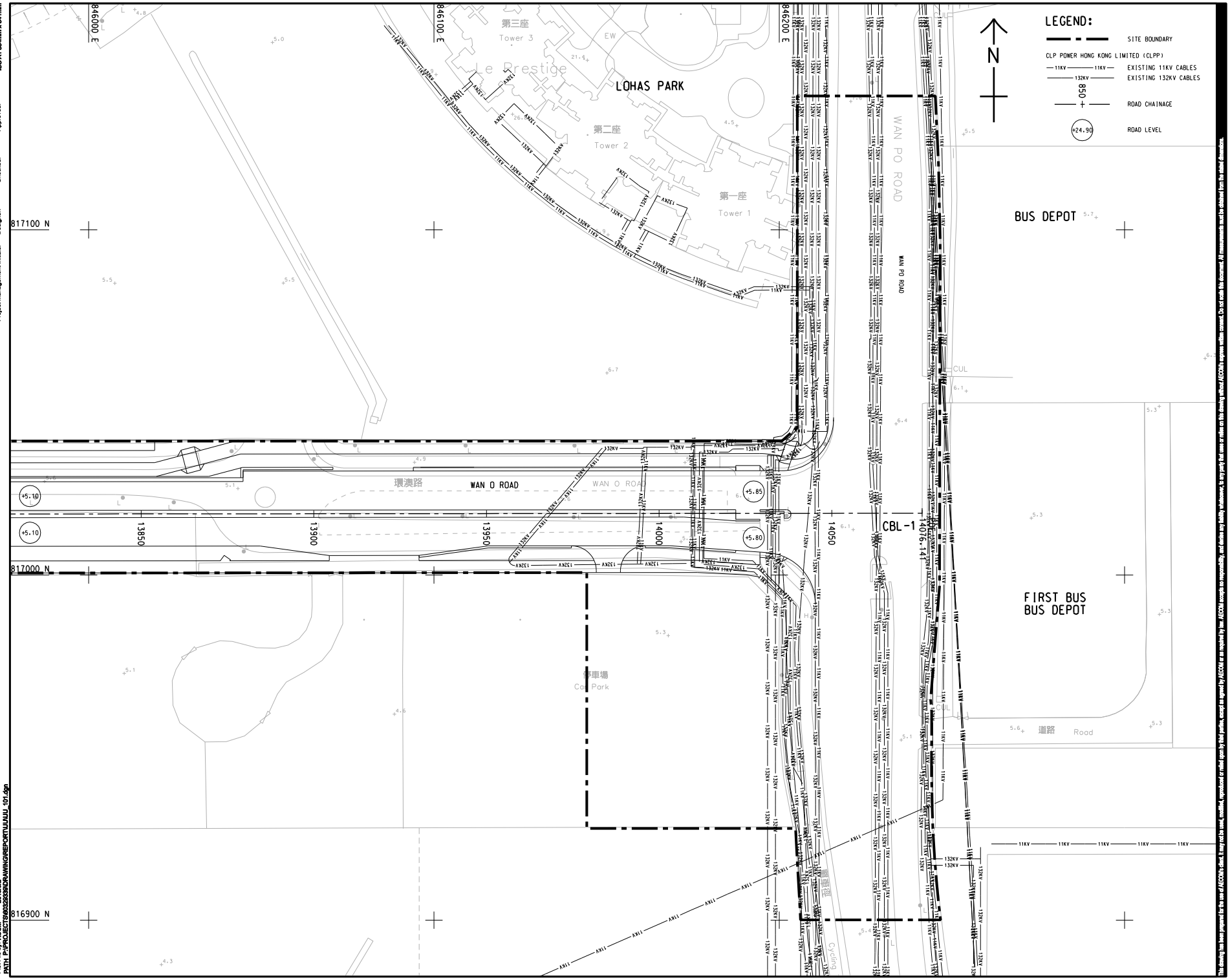
FIGURE 14.6a

K:/A05902/DRAWING/DRAWING/LANDFILL/OCT04/CROSS-TKO2-3.DGN SCALE N.T.S NOV 2004

APPENDIX E

Utility Plan

Proposed Utility Layout Plan



ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

Plot File by: XUCM
2015/9/2
PATH: P:\PROJECTS\60329339\DRAWING\REPORT\UU\UU_101.dgn

AECOM

PROJECT

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS

ISSUE/REVISION

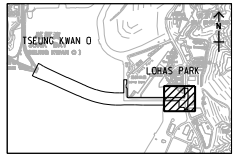
MR	DATE	DESCRIPTION	CHK

STATUS

SCALE: A1 1 : 500

DIMENSION UNIT: METRES

KEY PLAN A1 1 : 30000



PROJECT NO.: 60329339

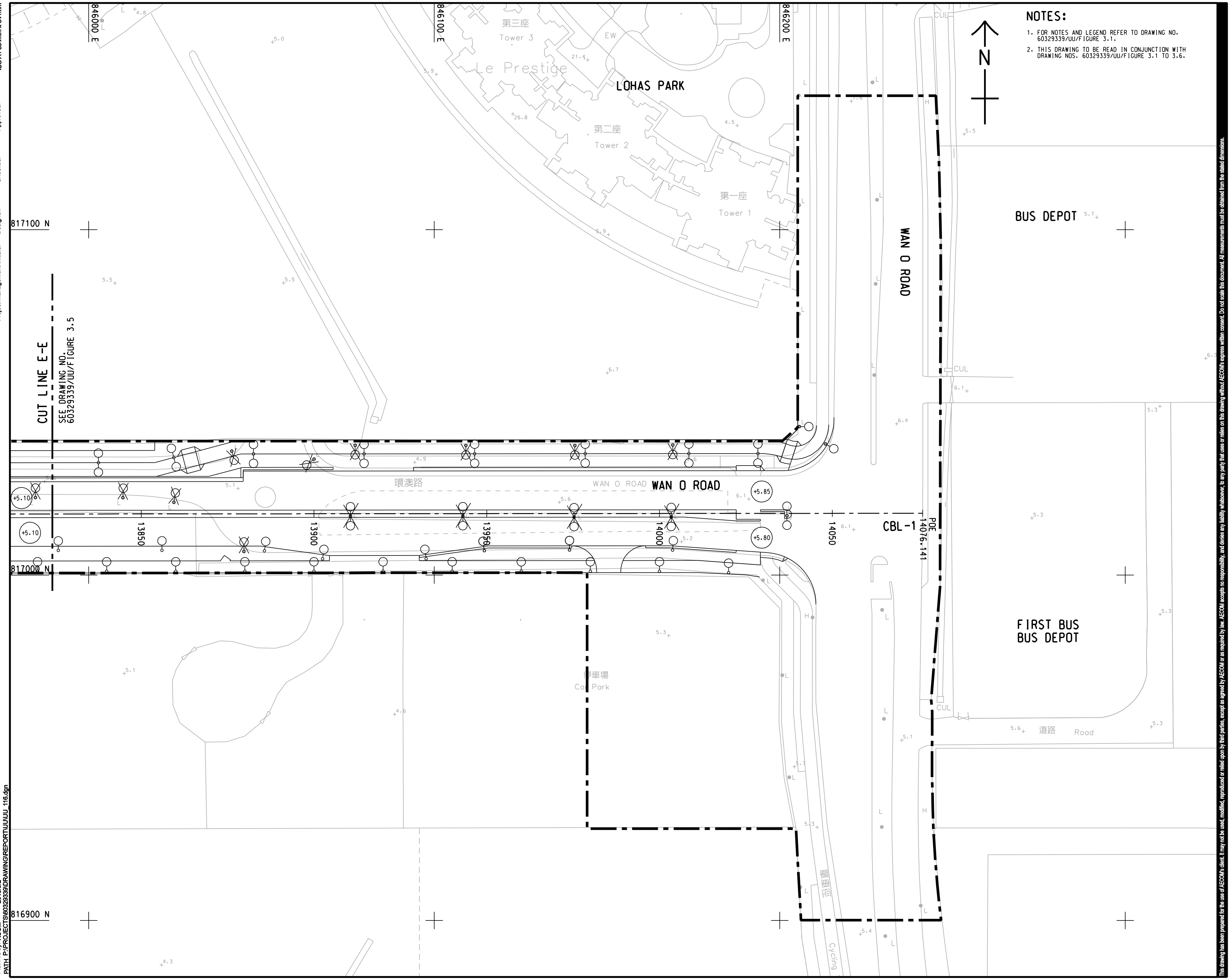
CONTRACT NO.: CE 6/2014 (HY)

SHEET TITLE

CLPP CABLE LAYOUT PLAN

SHEET NUMBER

60329339/UU/FIGURE 2.1



AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

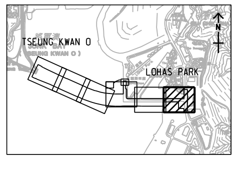
I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 複核

STATUS 階段

SCALE 比例: A1 1 : 500

DIMENSION UNIT 尺寸單位: METRES

KEY PLAN 索引圖: A1 1 : 30000



PROJECT NO. 項目編號: 60329339

CONTRACT NO. 合約編號: CE 6/2014 (HY)

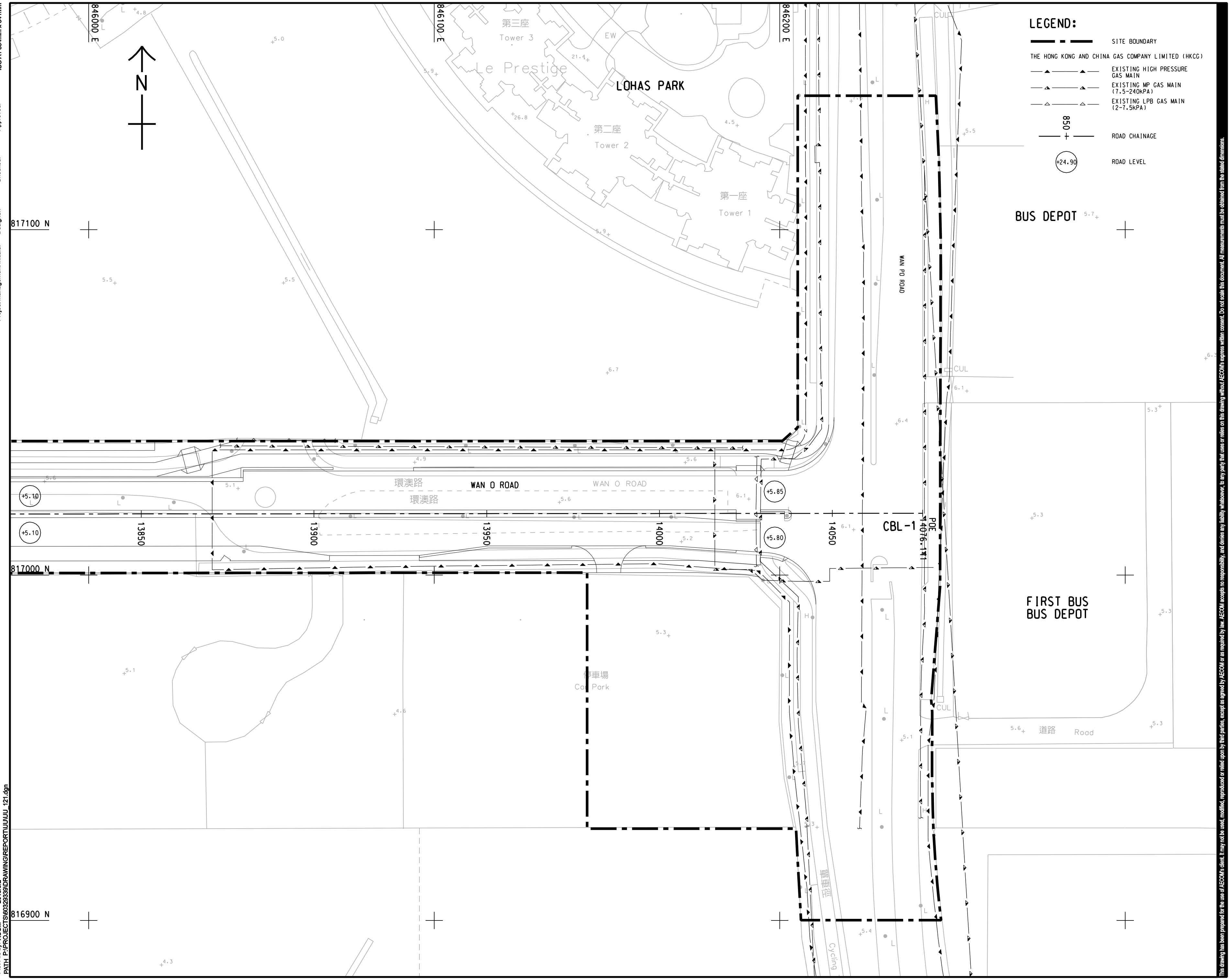
SHEET TITLE 圖紙名稱: LIGHTING LAYOUT PLAN

SHEET 6 OF 6

SHEET NUMBER 圖紙編號: 60329339/UU/FIGURE 3.6

Plot File by: XUCM 2015/9/2
PATH P:\PROJECTS\60329339\DRAWING\REPORT\UU\UU_116.dgn

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm



This drawing has been prepared for the use of AECOM's client. It may not be used, modified, reproduced or relied upon by third parties, except as agreed by AECOM or as required by law. AECOM accepts no responsibility, and denies any liability whatsoever, to any party that uses or relies on this drawing without AECOM's express written consent. Do not scale this document. All measurements must be obtained from the stated dimensions.

AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

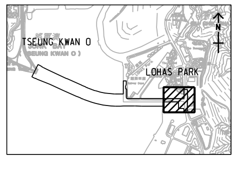
I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 複核

STATUS 階段

SCALE 比例 A1 1 : 500

DIMENSION UNIT 尺寸單位 METRES

KEY PLAN 索引圖 A1 1 : 30000



PROJECT NO. 項目編號 60329339

CONTRACT NO. 合約編號 CE 6/2014 (HY)

SHEET TITLE 圖紙名稱

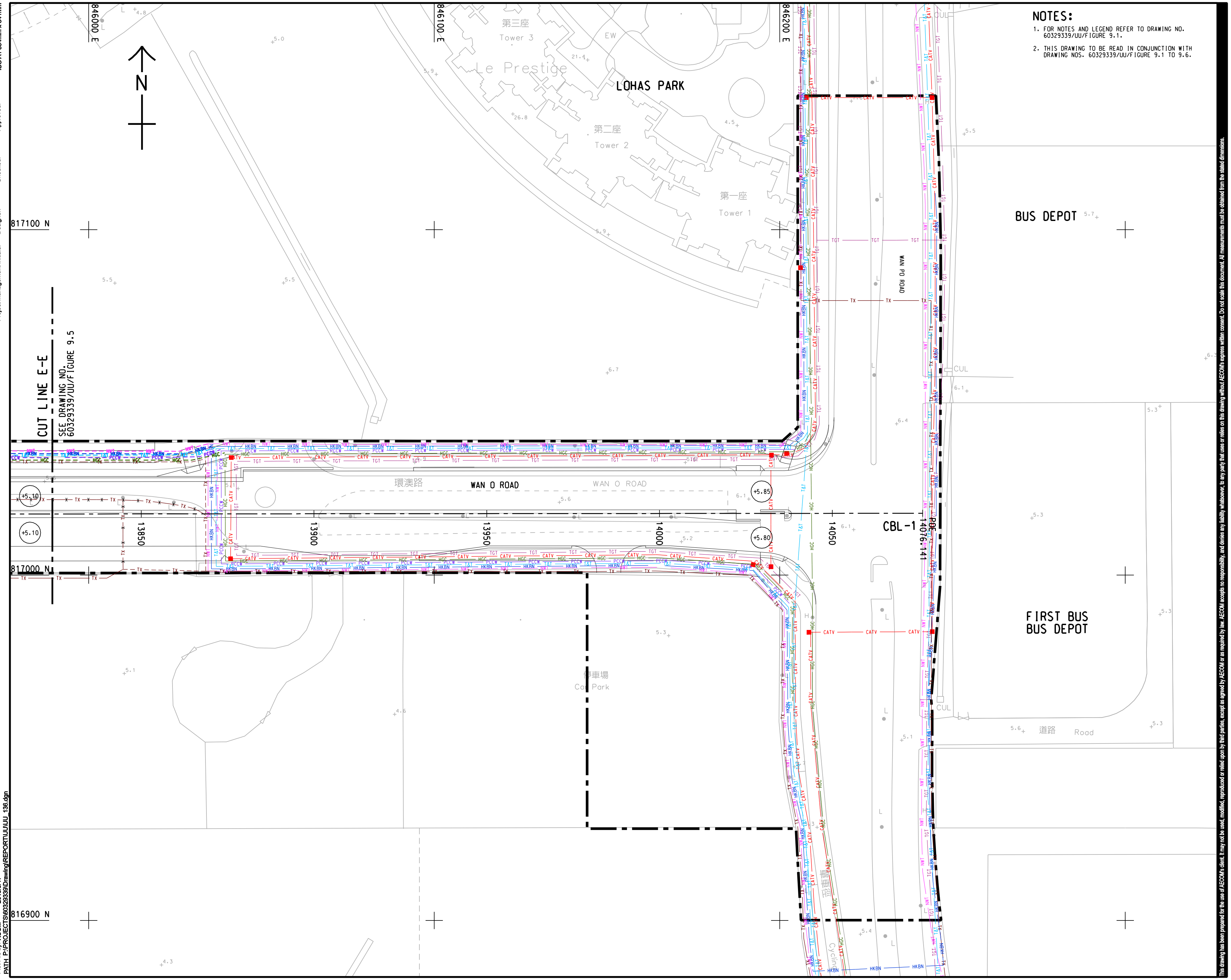
TOWNGAS LAYOUT PLAN

SHEET NUMBER 圖紙編號

60329339/UU/FIGURE 4.1

Plot File by: XUCM 2015/9/2
PATH P:\PROJECTS\60329339\DRAWING\REPORT\UU\UU_121.dgn

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm



NOTES:

1. FOR NOTES AND LEGEND REFER TO DRAWING NO. 60329339/UU/FIGURE 9.1.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH DRAWING NOS. 60329339/UU/FIGURE 9.1 TO 9.6.

AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 複核

STATUS 階段

SCALE 比例: A1 1 : 500

DIMENSION UNIT 尺寸單位: METRES

KEY PLAN 索引圖: A1 1 : 30000

PROJECT NO. 項目編號: 60329339

CONTRACT NO. 合約編號: CE 6/2014 (HY)

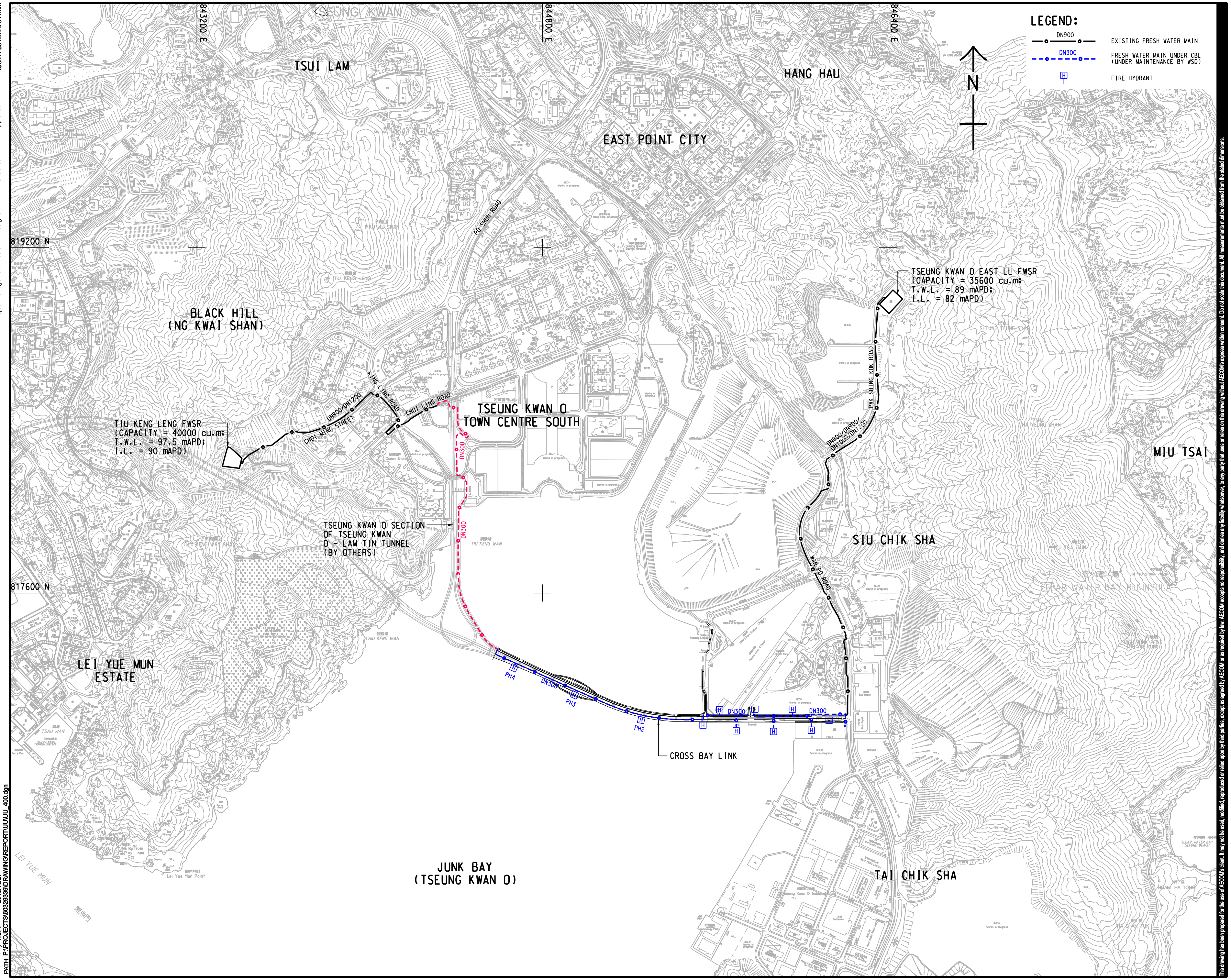
SHEET TITLE 圖紙名稱: TELECOM CABLES LAYOUT PLAN

SHEET 6 OF 6

SHEET NUMBER 圖紙編號: 60329339/UU/FIGURE 9.6

Plot File by: XUCM 2015/9/17
PATH P:\PROJECTS\60329339\Drawing\REPORT\UU\UU_136.dgn

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm



AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 複核

STATUS 階段

SCALE 比例: A1 1 : 8000

DIMENSION UNIT 尺寸單位: METRES

KEY PLAN 索引圖

PROJECT NO. 項目編號: 60329339

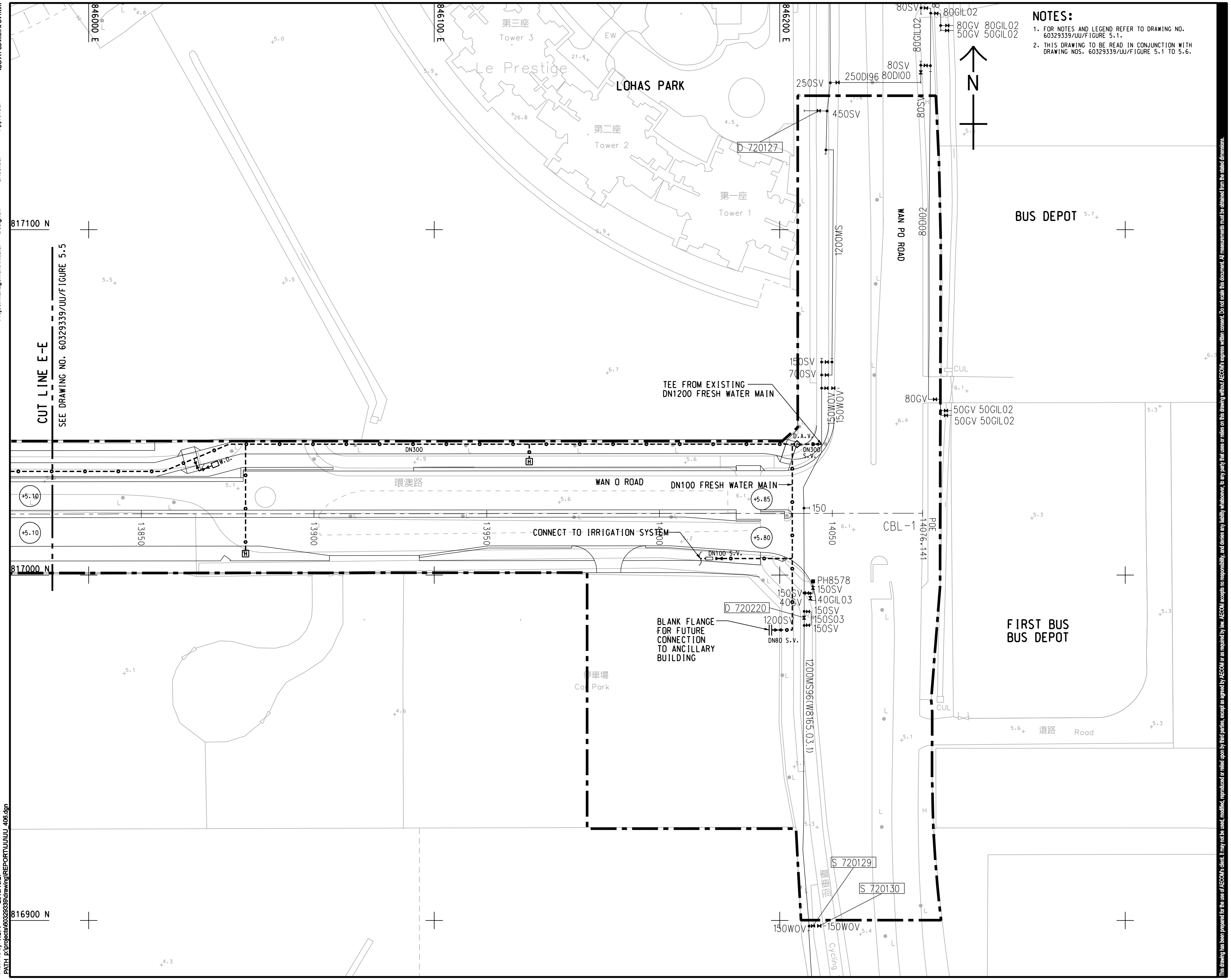
CONTRACT NO. 合約編號: CE 6/2014 (HY)

SHEET TITLE 圖紙名稱: KEY PLAN FOR FRESH WATER MAIN LAYOUT

SHEET NUMBER 圖紙編號: 60329339/UU/FIGURE 5.0

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Plot File by: HUPF 2016/10/27
PATH: P:\PROJECTS\60329339\DRAWING\REPORT\UU\UU_400.dgn



NOTES:

1. FOR NOTES AND LEGEND REFER TO DRAWING NO. 60329339/UU/FIGURE 5.1.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH DRAWING NOS. 60329339/UU/FIGURE 5.1 TO 5.6.

AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

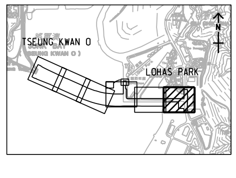
I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 復核

STATUS 階段

SCALE 比例 A1 1 : 500

DIMENSION UNIT 尺寸單位 METRES

KEY PLAN 索引圖 A1 1 : 30000



PROJECT NO. 項目編號 60329339

CONTRACT NO. 合約編號 CE 6/2014 (HY)

SHEET TITLE 圖紙名稱

FRESH WATER MAIN LAYOUT PLAN

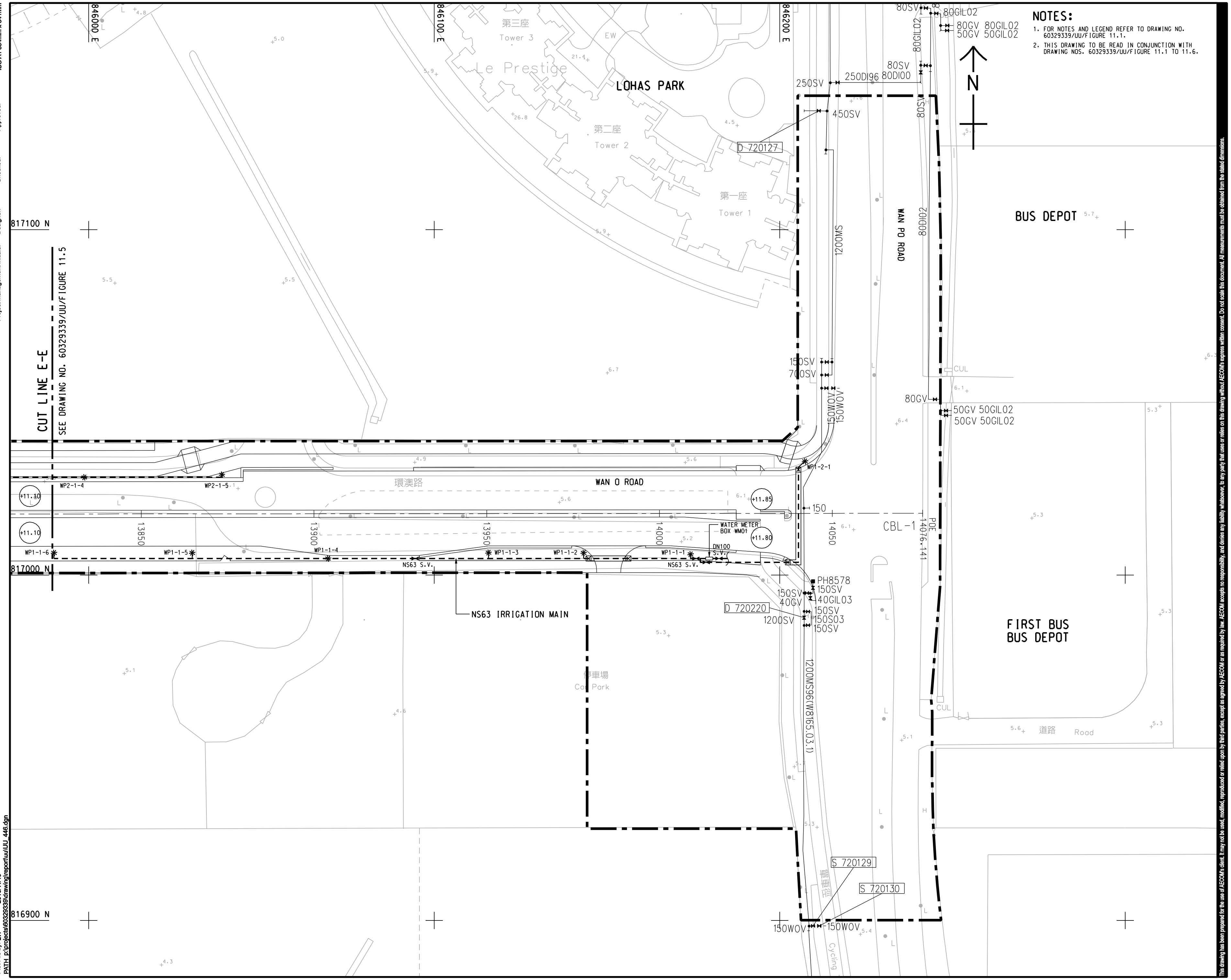
SHEET 6 OF 6

SHEET NUMBER 圖紙編號

60329339/UU/FIGURE 5.6

Plot File by: HUPF 2016/10/27
PATH p:\projects\60329339\drawing\REPORT\UU\UU_406.dgn

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm



NOTES:

1. FOR NOTES AND LEGEND REFER TO DRAWING NO. 60329339/UU/FIGURE 11.1.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH DRAWING NOS. 60329339/UU/FIGURE 11.1 TO 11.6.

AECOM

PROJECT 項目

CROSS BAY LINK, TSEUNG KWAN O - DESIGN AND CONSTRUCTION

CLIENT 業主

土木工程拓展署
Civil Engineering and Development Department

CONSULTANT 工程顧問公司

AECOM Asia Company Ltd.
www.aecom.com

SUB-CONSULTANTS 分判工程顧問公司

ISSUE/REVISION 修訂

I/R 修訂	DATE 日期	DESCRIPTION 內容摘要	CHK. 複核

STATUS 階段

SCALE 比例 A1 1:500

DIMENSION UNIT 尺寸單位 METRES

KEY PLAN 索引圖 A1 1:30000

PROJECT NO. 項目編號 60329339

CONTRACT NO. 合約編號 CE 6/2014 (HY)

SHEET TITLE 圖紙名稱

IRRIGATION LAYOUT PLAN

SHEET 6 OF 6

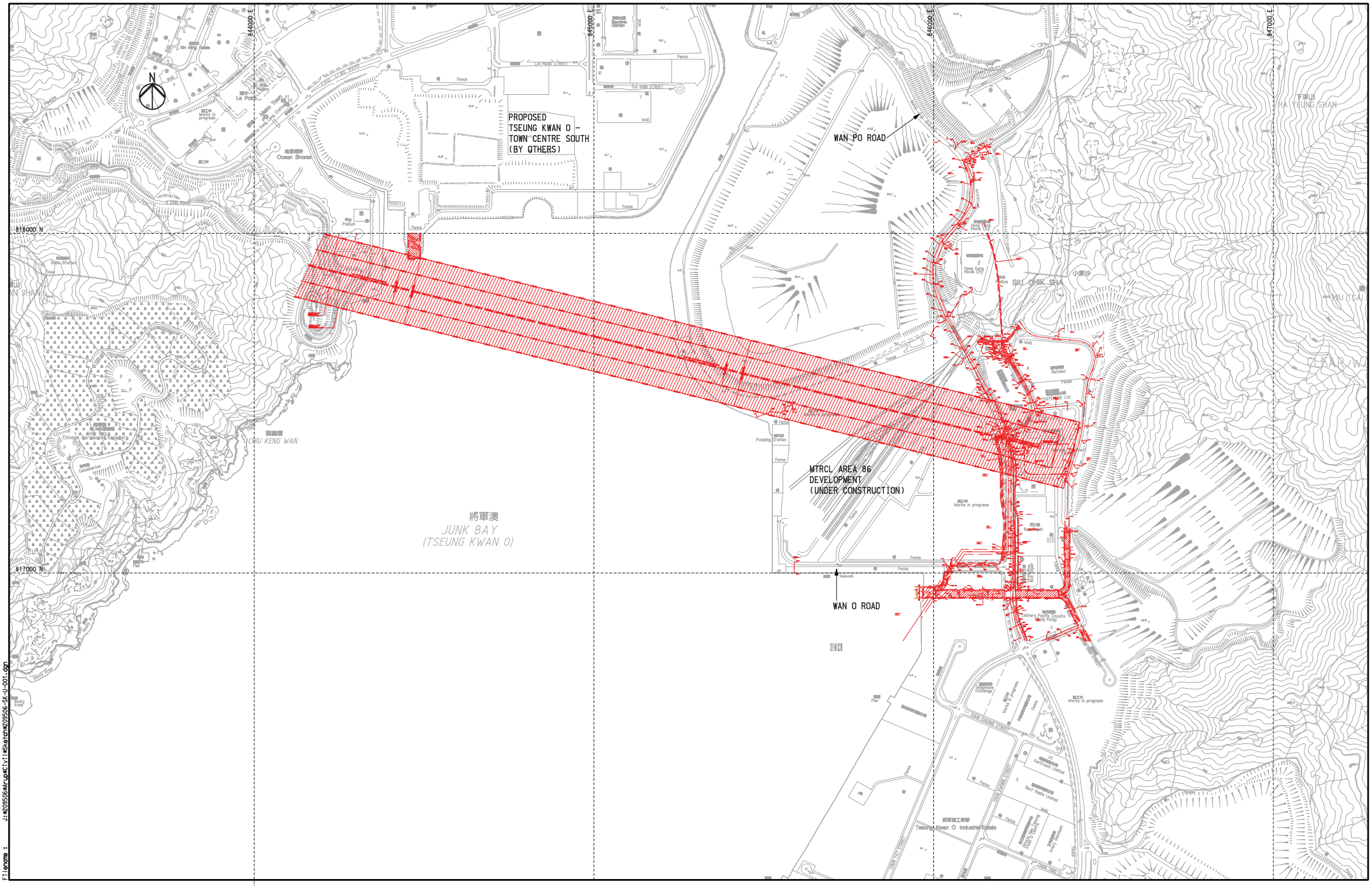
SHEET NUMBER 圖紙編號

60329339/UU/FIGURE 11.6

Plot File by: LVP 2016/11/15
PATH: p:\projects\60329339\drawing\report\uu\UU_446.dgn

Project Management Initials: Designer: Checked: Approved: ISO A1 594mm x 841mm

Extract of Utility Layout Plan from EIA



Printed by : CAD 16/6/2009
File name : J:\209506\Mxd+Lyr\Sketch\209506-SK-U-001.dgn

CEDD 土木工程拓展署 Civil Engineering and Development Department

ARUP Ove Arup & Partners Hong Kong Limited

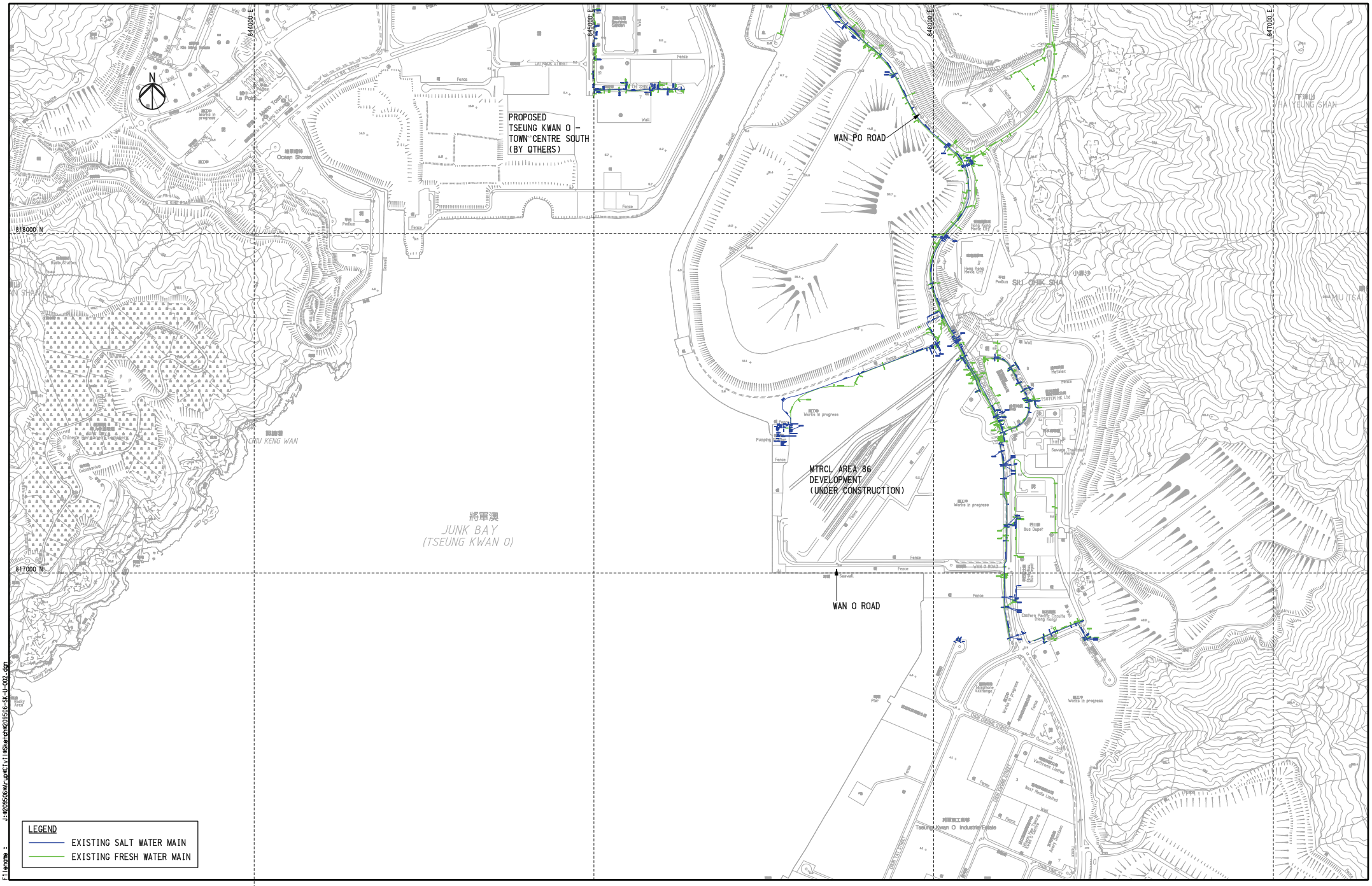
Job Title
Agreement No. CE 43/2008(HY)
Cross Bay Link, Tseung Kwan O – Investigation

Drawing Title
EXISTING UTILITIES IN CBL – STORMWATER DRAINAGE AND SEWERAGE

Rev.	Description	Date
B	SECOND ISSUE	12/12
A	FIRST ISSUE	06/09

Drawn	RY	Date	12/12
Checked	AL	Approved	SYC
Scale	1:10000 on A3		
Status	FINAL	Rev.	B

Drawing No. 209506/SK/U/001



Printed by : CAD 16/6/2009
Filename : J:\209506\Arup\C1vil\MSketch\209506-SK-U-002.dgn

CEDD 土木工程拓展署 Civil Engineering and Development Department

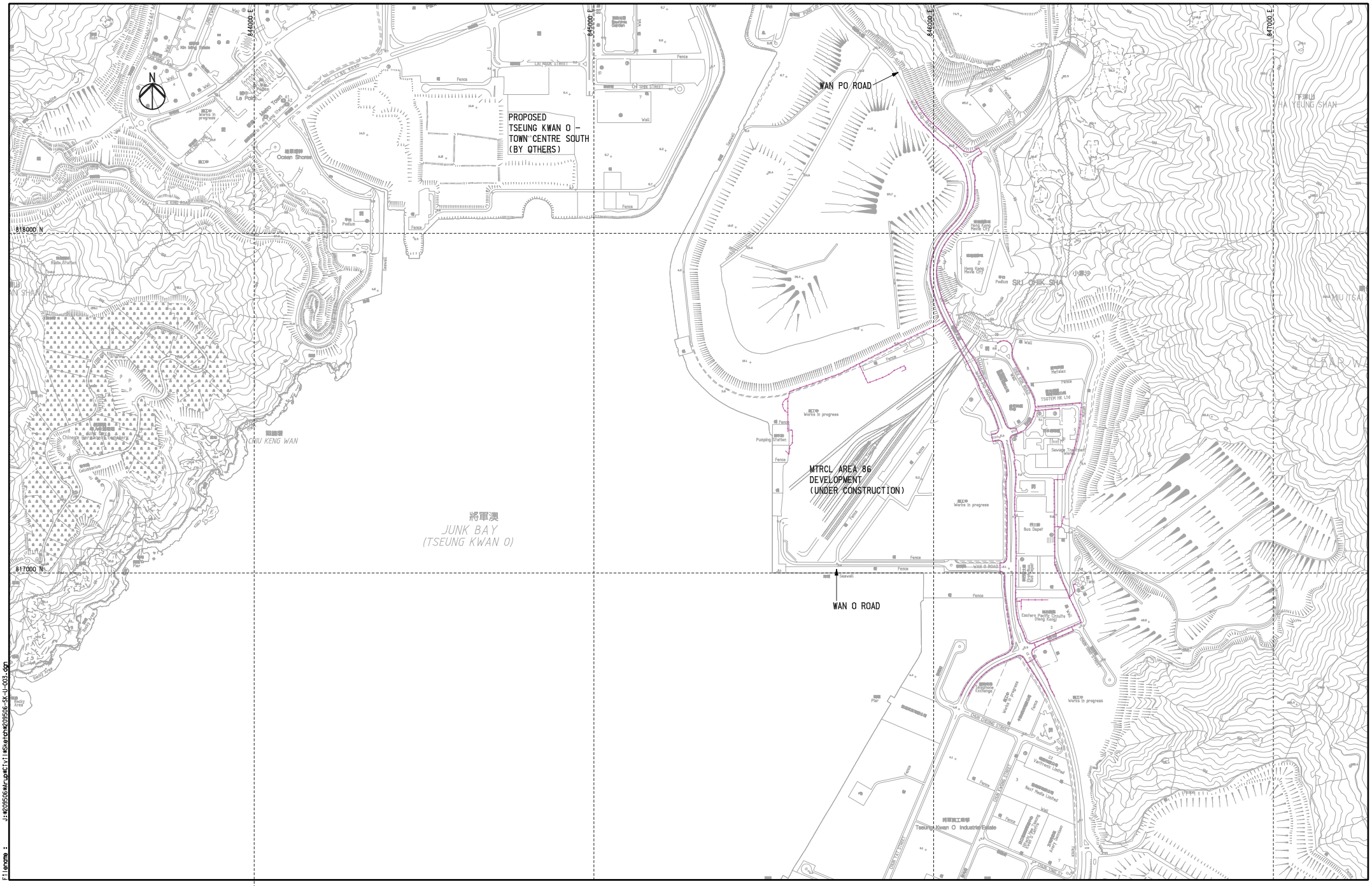
ARUP Ove Arup & Partners Hong Kong Limited

Job Title
Agreement No. CE 43/2008(HY)
Cross Bay Link, Tseung Kwan O – Investigation

Drawing Title
EXISTING UTILITIES IN CBL – FRESH AND SALT WATER MAIN

Rev.	Description	Date
B	SECOND ISSUE	12/12
A	FIRST ISSUE	06/09

Drawn	RY	Date	12/12
Checked	AL	Approved	SYC
Scale	1:10000 on A3		
Drawing No.	209506/SK/U/002		
Status	FINAL	Rev.	B



Printed by : CAD 16/6/2009
Filename : J:\209506\Mxd+Lyr\Civil\MSketch\209506-SK-U-003.dgn

CEDD 土木工程拓展署 Civil Engineering and Development Department	ARUP Ove Arup & Partners Hong Kong Limited	Job Title: **Agreement No. CE 43/2008(HY) Cross Bay Link, Tseung Kwan O – Investigation**
Drawing Title: EXISTING UTILITIES IN CBL – CLP POWER CABLES		

Rev.	Description	Date
B	SECOND ISSUE	12/12
A	FIRST ISSUE	06/09

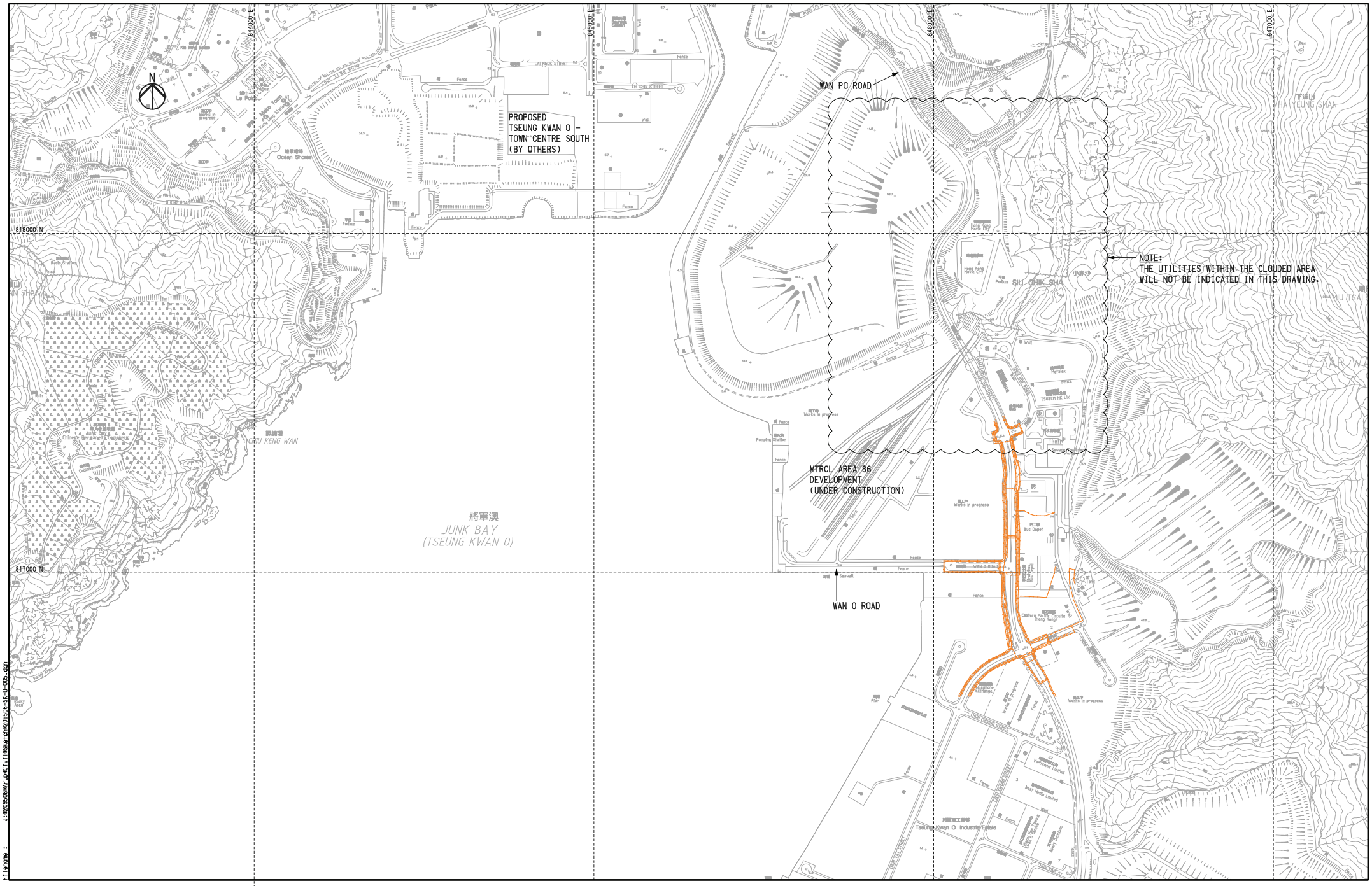
Drawn: RY	Date: 12/12	Drawing No.: 209506/SK/U/003	
Checked: AL	Approved: SYC		
Scale: 1:10000 on A3		Status: FINAL	Rev.: B

Printed by : CAD 16/6/2009
Filename : J:\209506\Admin\Civil\MSketch\209506-SK-U-004.dgn

CEDD 土木工程拓展署 Civil Engineering and Development Department	ARUP Ove Arup & Partners Hong Kong Limited	Job Title: **Agreement No. CE 43/2008(HY) Cross Bay Link, Tseung Kwan O – Investigation**
Drawing Title: EXISTING UTILITIES IN CBL – GAS MAIN		

Rev.	Description	Date
B	SECOND ISSUE	12/12
A	FIRST ISSUE	06/09

Drawn: RY	Date: 12/12	Drawing No.: 209506/SK/U/004	
Checked: AL	Approved: SYC		
Scale: 1:10000 on A3		Status: FINAL	Rev.: B



Printed by : CAD 16/6/2009
Filename : J:\209506\Admin\Civil\MS\sketch\209506-SK-U-005.dgn

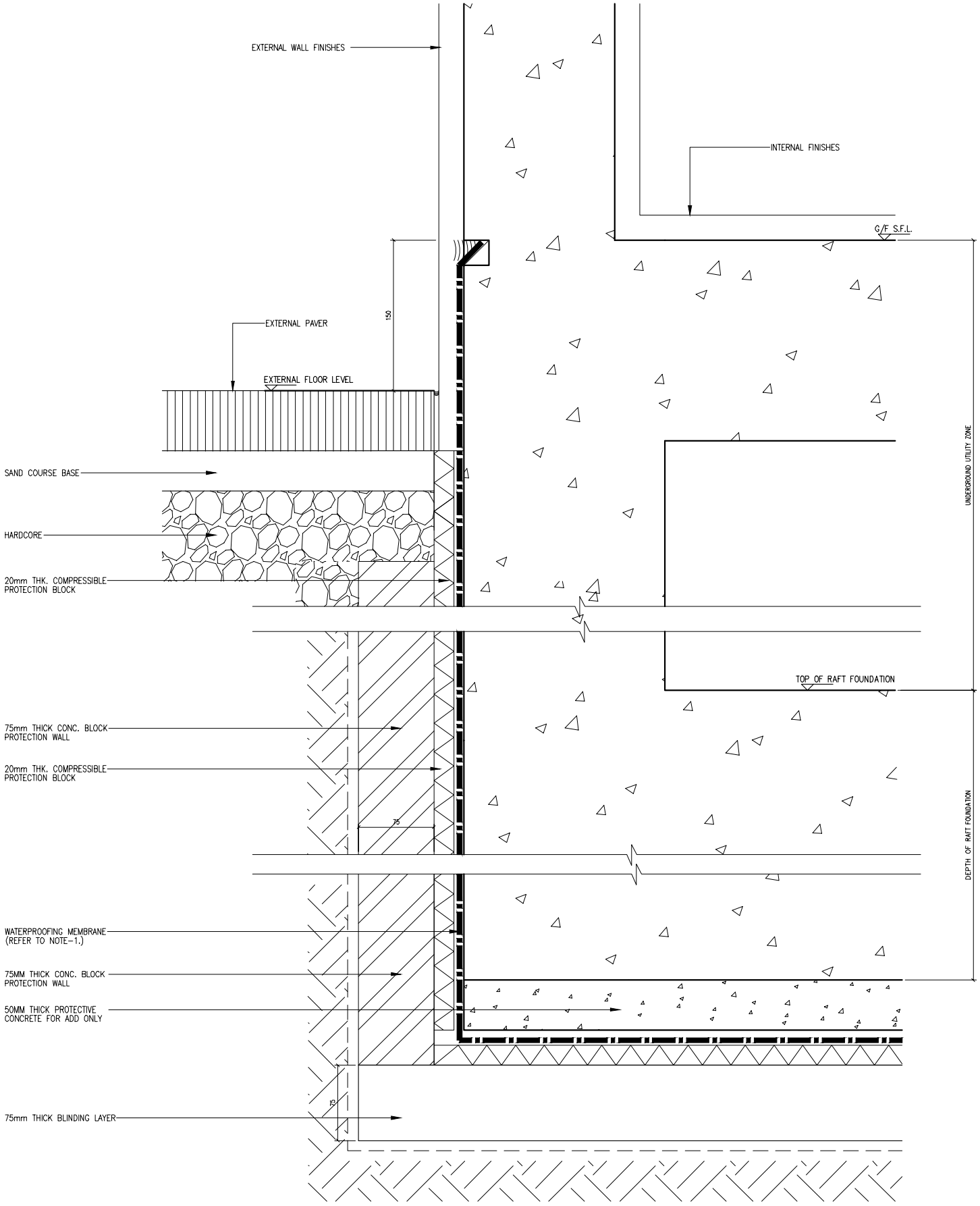
CEDD 土木工程拓展署 Civil Engineering and Development Department	ARUP Ove Arup & Partners Hong Kong Limited	Job Title: **Agreement No. CE 43/2008(HY) Cross Bay Link, Tseung Kwan O – Investigation**
Drawing Title: EXISTING UTILITIES IN CBL – COMMUNICATIONS SERVICES CABLE		

Rev.	Description	Date
B	SECOND ISSUE	12/12
A	FIRST ISSUE	06/09

Drawn: RY	Date: 12/12	Drawing No.: 209506/SK/U/005	
Checked: AL	Approved: SYC		
Scale: 1:10000 on A3		Status: FINAL	Rev.: B

APPENDIX F

Detail of Typical Waterproof



WP-07 TYPICAL DETAIL FOR BASEMENT TANKING

1 : 3

APPENDIX G

Detail of Proposed Ventilation at CBL E&M Plant Room

Notes:

EAL: EXHAUST AIR LOUVRE

FAL: FRESH AIR LOUVRE

DL: DOOR LOUVRE

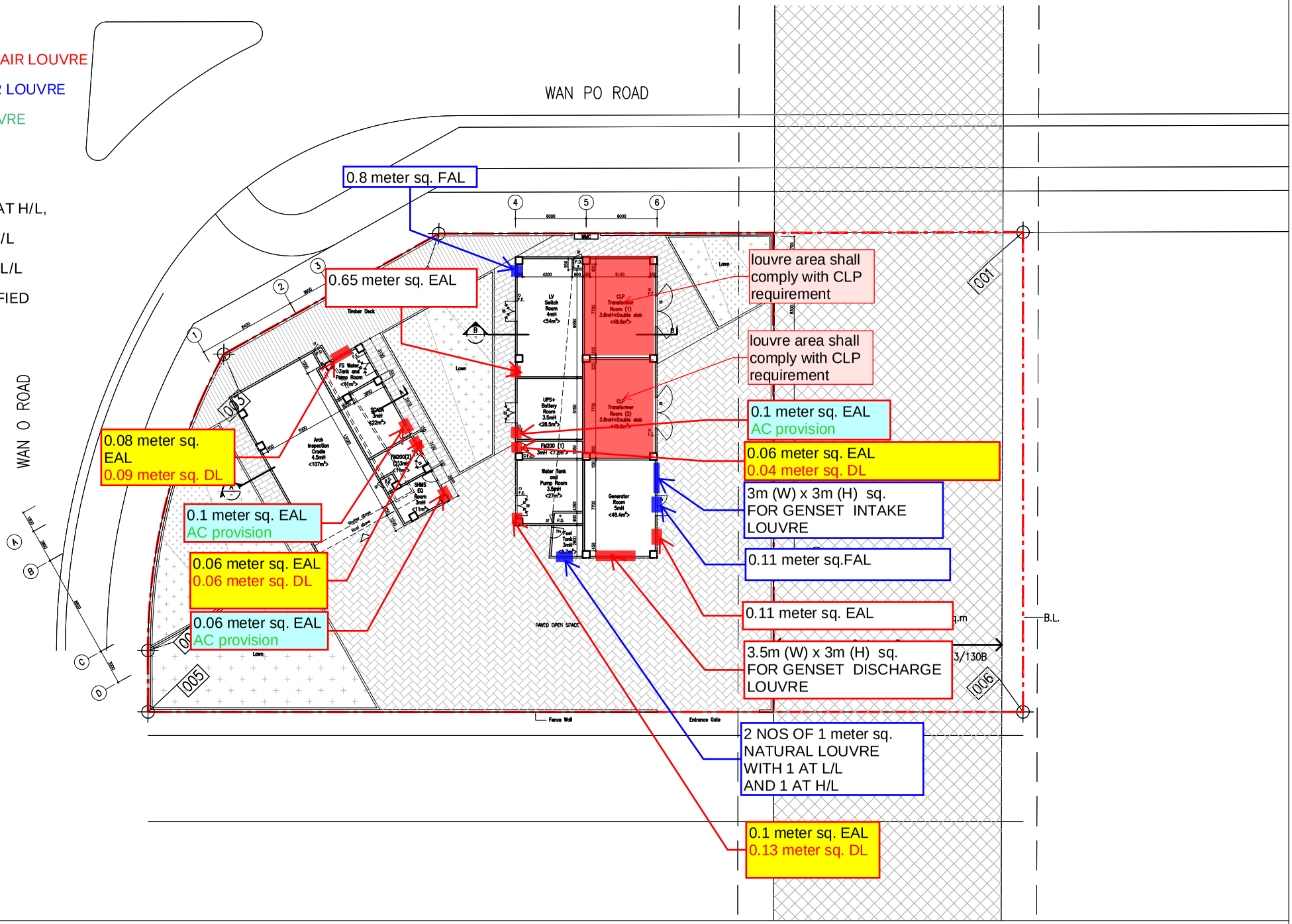
REMARK:

ALL EALs ARE AT H/L,

& DLs ARE AT L/L

& FALs ARE AT L/L

UNLESS SPECIFIED



CBL E&M Plant Room

SK-27 ○ Proposed Master Layout ○ Rev.P ○ 1:300 ○ 21 September 2016

DESIGN 2 (HK) LTD

CONSULTANT ARCHITECTS

APPENDIX H

Specific Landfill Gas Protection Measures for Building Services

Annex B GENERIC DESIGN MEASURES FOR SUB-SURFACE BUILDING SERVICES

The types of gas protection measures which may be applied to building services were discussed in general terms in the main part of the document (Section 7). This Annex provides further, more specific, information on the protection of services and drawings of typical design measures which may be employed.

B1 TYPES OF SERVICES

B1.1 All buildings and related developments invariably have services which are typically located below ground level. As such they can, if not carefully designed and installed, act as preferential conduits through which landfill gas may be lead into the building interior. In broad terms, these services may be divided into two generic categories:

- open-void conduits; and
- in-filled service runs.

B1.2 In terms of potential gas transport, each category behaves in a different manner and therefore requires a different approach to risk minimisation. The main types of service in common use in each of the two generic categories are summarised in *Tables B1.1* and *B1.2*.

Table B1.1 Building Service Types - Open Void Conduits

Service type	**Typical Construction**	**Typical Sizes**	**Comments**
Foul-water/soil pipes	Concrete, glazed earthen ware, ABS/PVC pipework	100mm NB	Water traps may prevent gas entry
Surface water drains/ Culverts	Concrete pipework, Cast *in situ* channel	300mm and greater	Large conduits may require external gas barrier protection.
Cable trunking	ABS/PVC or PE	50-100mm NB	Consider external gas membranes
Ventilation ducting	Concrete, galvanised steel	300mm+	As culvert
Inspection chambers and manholes	Re-inforced concrete	1000mm diameter	As culvert, plus passive vent stacks
Soakaways and drains	ABS/PVC or PE	50-100mm	Depending on location, may not require protection.
Air conditioning cooling water supply	PE, Stainless steel	150-450mm NB	Consider barrier for service trench
Service tunnels	Re-inforced concrete	2000mm+	As Surface water drains/ Culverts
Land drainage pipes	PE/PP ABS/PVC	50mm NB	As soakaways
Box-outs and substructure cavities	Concrete		Consider external barrier plus venting

Note: NB = Nominal bore

Table B1.2 Building Service Types - Infilled

Service Type	Typical Construction	Typical Sizes	Comments
Electricity supply cables	Armoured/wrapped cables	25 - 50mm diameter	Protect service trench or bring entry above the floor slab
Gas supply pipes	Yellow HDPE; black ductile iron; or white or green steel	50mm NB	No protection required (if vented meter-box outside building)
Fresh water supply mains	Blue MDPE; PVC; or ductile iron	25 - 100mm NB	As electricity supply cables
Salt water flushing mains	Black ductile iron Grey UPVC	300 - 600mm NB < 300mm NB	As electricity supply cables
TV cables	Light cable in steel or plastic conduit/duct	5 - 10mm diameter	Consider gas-tight and vented box
Computer/ communications system cables	As TV cable	5 - 10mm diameter	As TV cables
Process pipework	PE or Steel	25-250mm NB	Protect service trench
Hydrants/fire systems	Steel	100mm NB	As process pipework
Landscape irrigation pipework	PE or ABS/PVC	25-50mm NB	Depending on location, may not require protection
Street lighting cables	Armoured/wrapped cables	10-15mm diameter	Protect service trench, consider sealing of standard
Lightning protection/earth rods	Bare copper conducting rods/bars	15-30mm diameter	Seal earthing cable service trench

B2 GAS PROTECTION MEASURES

B2.1 As stated previously, protection measures applied to service conduits should not be considered in isolation. Gas protection measures for a development should integrate protection of the building with the controls to be applied to the service conduits. It should also be noted that, even if a building development itself falls outside the requirements of the *Guidance Note*, any construction work which involves excavation deeper than 300mm and any service runs which are located within the Consultation Zone will require precautionary measures to be taken during construction (see Section 8) and may require some form of protection measures to be incorporated in their design.

B2.2 The advice which follows applies equally to both service installations for developments within the Consultation Zone and also to service conduits and runs which are located within the Consultation Zone but which feed building developments located outside the Consultation Zone.

B2.3 The developers' attention is drawn to the need to consult with Government and

relevant utility companies as indicated in the main part of the report (Section 7).

B2.4 The three generic measures which may be employed to protect services against landfill gas are discussed below.

Gas Barriers

B2.5 Gas barriers are most readily applied to service trenches at a point between the source of the gas and building (or development) itself; preferably as close as is practical to the building although it may form part of a more extensive barrier to prevent general migration towards the development (see Section 7). A barrier to gas movement may be achieved using either clay (or clay rich soil) or soil-bentonite mixtures. A schematic of a natural material cutoff barrier, including sealing of a service trench is shown in *Figure 7.8* (main part of document).

B2.6 As for general cut off barriers, use may also be made of polymeric membranes such as HDPE. For these barriers, the design detail at the point where the service penetrates the membrane is important and use should be made of pre-formed shrouds (or cloaks), skirts and fillets. A schematic for an HDPE flexible membrane cut-off is shown in *Figure 7.9*. In addition, the relative positions and separation of the gas source, the building (or development) and the service trench barrier should also be assessed to identify appropriate dimensions of the cut-off barrier.

B2.7 In some situations, for example where a development is planned very close to an actively gassing landfill, it may be more appropriate to consider routing all services through a sealed culvert or duct which is either completely lined in naturally gas-resistant material (eg clay) or which is lined with an HDPE membrane.

B2.8 Water pipes and sewers which in the normal course of operation are not fully filled with water can provide an additional conduit through which gas could enter a building and, in situations where these are not located in a protected service trench, in-line protection should be provided by incorporating water traps. These may comprise U-bends, drop-legs or chambers with discharge control weirs. An example of a U-bend water seal is shown in Figure B1. The aim of all these features is to provide 'water traps' which will effectively seal off the conduit and prevent gas-phase transport.

B2.9 Even in the absence of permeable backfill to a service pipe, landfill gas tends to migrate along the interface between the pipe and the backfilled soil. Therefore, in order to prevent the ingress of gas into a building via this route, it is important that the annulus around any service entry points is effectively blocked by means of sealant, collars or puddle flanges as appropriate (see Figure B2).

B2.10 In particular circumstances it is possible for methane to become dissolved in water which is at a high pressure and to then be released from solution as the water pressure drops. For water mains which operate at high pressure, therefore, consideration should be given to installing a flash de-pressurisation tank fitted with an appropriately sited atmospheric vent. The aim of a depressurisation tank should be to reduce the water pressure to ambient in an appropriately sized holding tank, in which any dissolved gases will come out of solution and may be safely vented to atmosphere. The original supply pressure may then be re-instated by means of a discharge pumping system.

Gas Vents

B1.11 Vent pipes or gridded manhole covers may be used to avoid build-up of gas in underground utilities manholes.

B1.12 These may be used to serve two purposes:

- to provide additional protection to open conduits such as sewers; or
- to reduce accumulation of gas on the landfill side of a cut-off barrier.

B2.13 In the former case, a simple stack built into an inspection chamber venting to atmosphere at 2-3m above ground level would be adequate. A typical vented manhole arrangement is shown in Figure B3. In the latter case, typical practice would be to lay a high permeability gas drainage layer adjacent to the cut-off barrier and vent any gas to atmosphere through stacks. Care should be taken in the design and construction of such vents to prevent blockages and it is preferable to use washed or single-size aggregate, surrounded by an appropriate geotextile and sealed in to the site surface (see Figure B6).

B2.14 A further type of venting arrangement, which may be appropriate to multiple service entries, comprises a vented gas interceptor cavity through which service pipes pass, as shown in Figure B4. The aim of this protection measure is to locate the barrier component within the building sub-structure in a sealed entry box which is fitted with a vent stack.

B2.15 In some specific cases it will be inconvenient to vent manhole chambers due to their location. Above ground vents to manholes located along highways, for example, would cause obstructions to traffic unless they could be located off the road. Under all circumstances, due to the possible accumulation of gas, care will be needed in accessing any manhole chambers, especially those which are not fitted with vents, and the safety procedures detailed in Section 7 must be rigidly followed.

Location of Service Entries Above Ground

B2.16 In some cases it is possible to route service entries into a building above ground level, thereby effectively providing an 'atmospheric break-leg' and eliminating the risk of gas entry to the building interior. This practice is routinely adopted for Town gas entry pipes and may be extended to cover electricity supply and other types of cable.

B2.17 To overcome architectural constraints, the entry points may be located in ventilated enclosures which may be designed to blend in with the building itself and thereby

minimise the visual impact of the service entries. A typical enclosure with above ground service entries is shown in Figure B5.

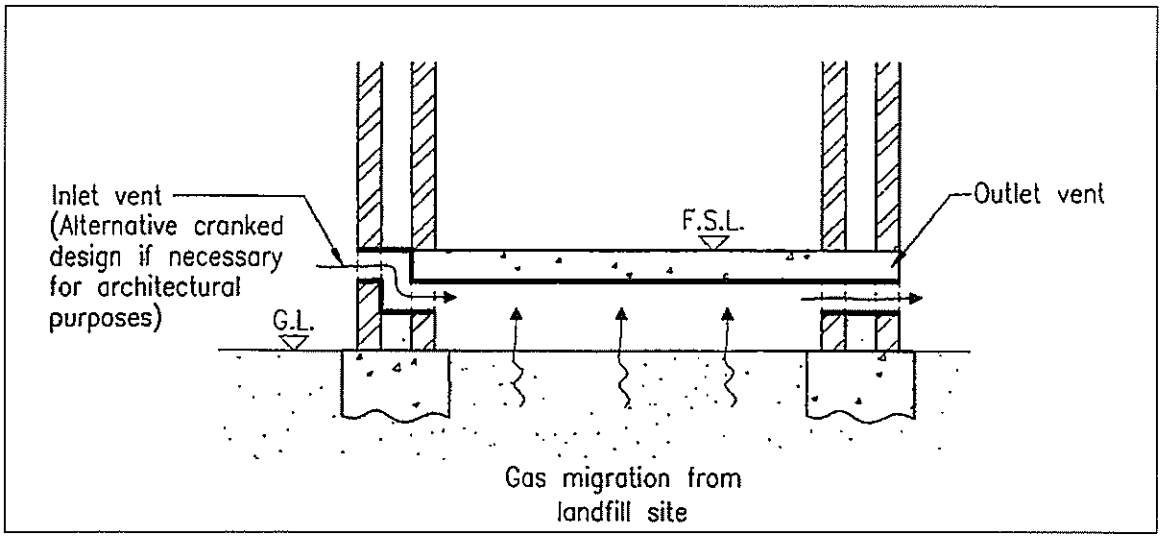
Service Conduits Passing Through The Consultation Zone

B2.18 Recommendations for the measures which should be applied to service conduits which pass through a Consultation Zone with connections to buildings outside the Zone were presented in Section 7. Typical design details of the measures required for services which pass through a Consultation Zone are shown on Figure B6 and Figure B7.

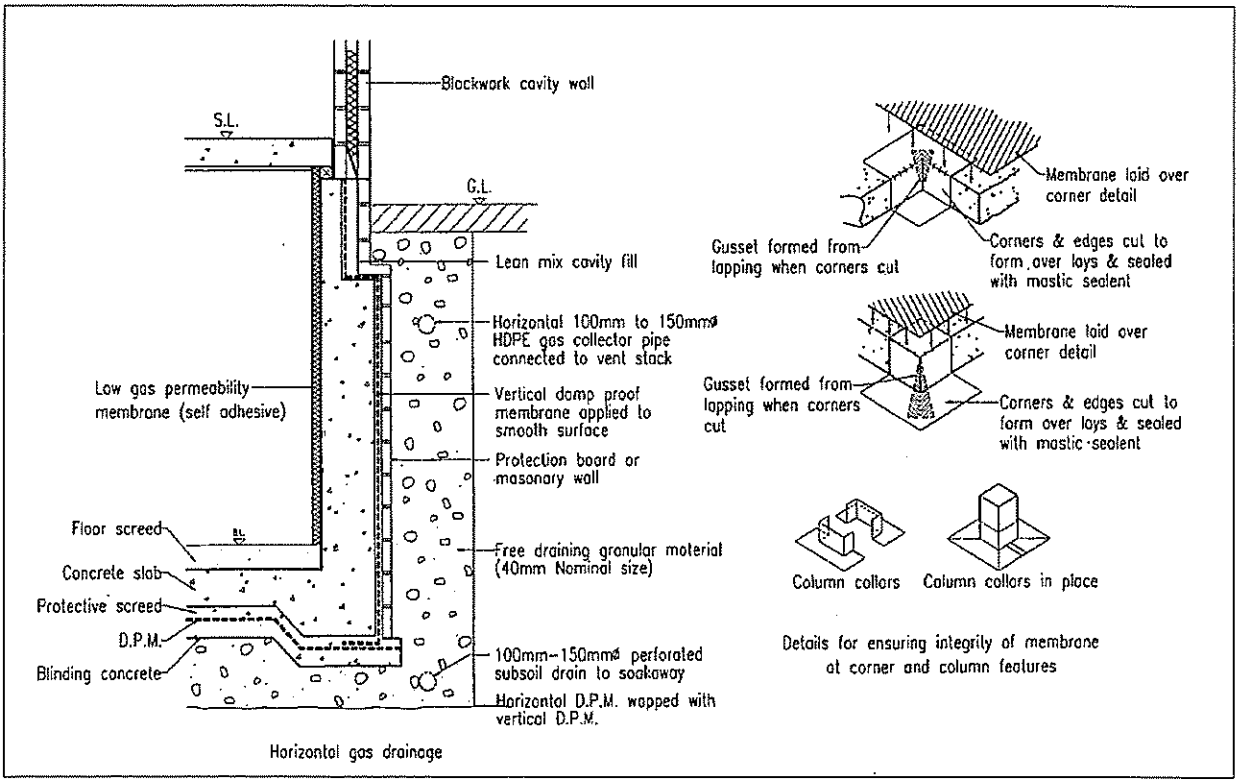
Building Protection Design Measures

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 :

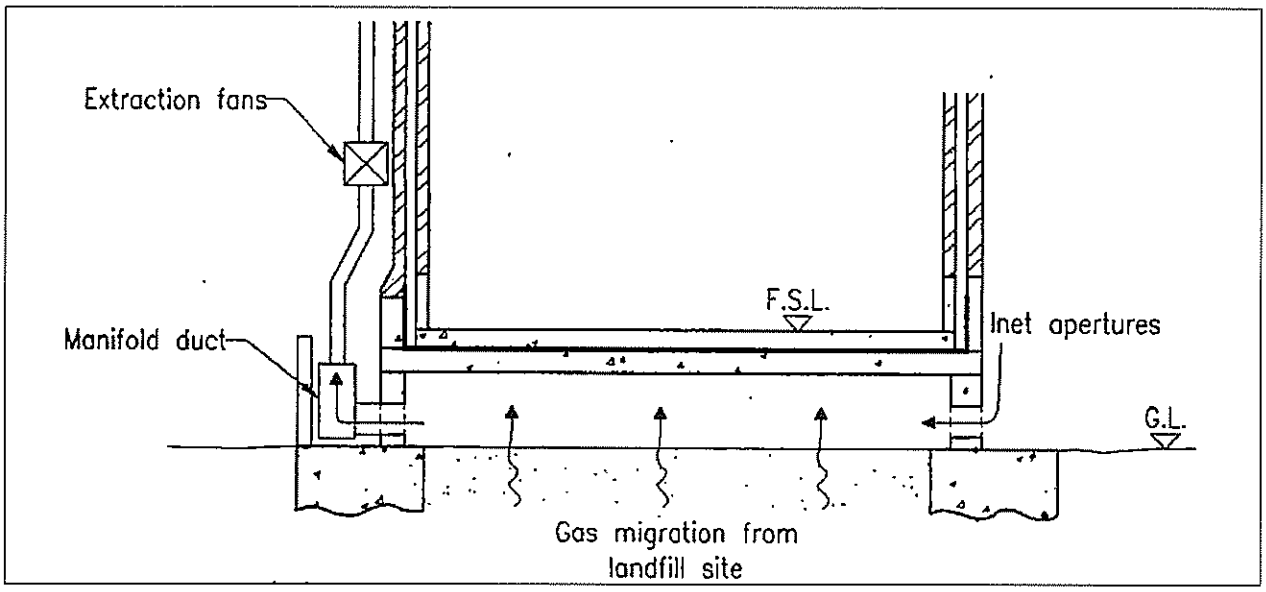


Sub-floor venting system



Typical details for flexible membrane protection measures

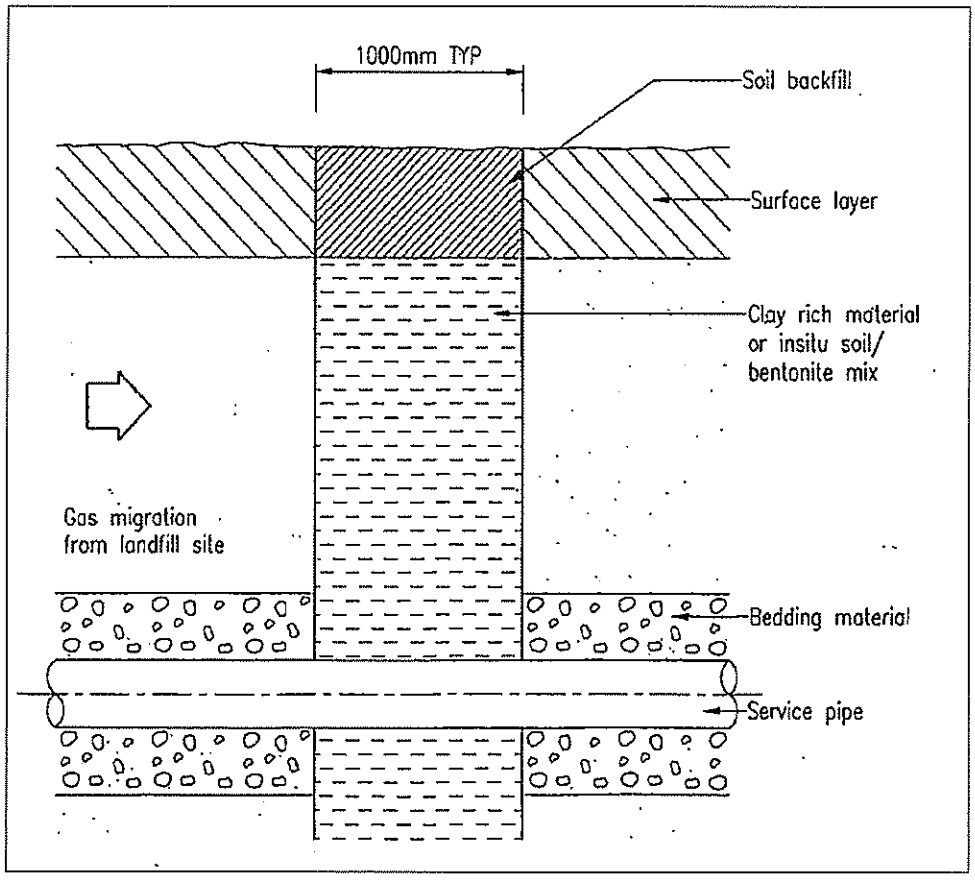
(b) Active Control Systems :



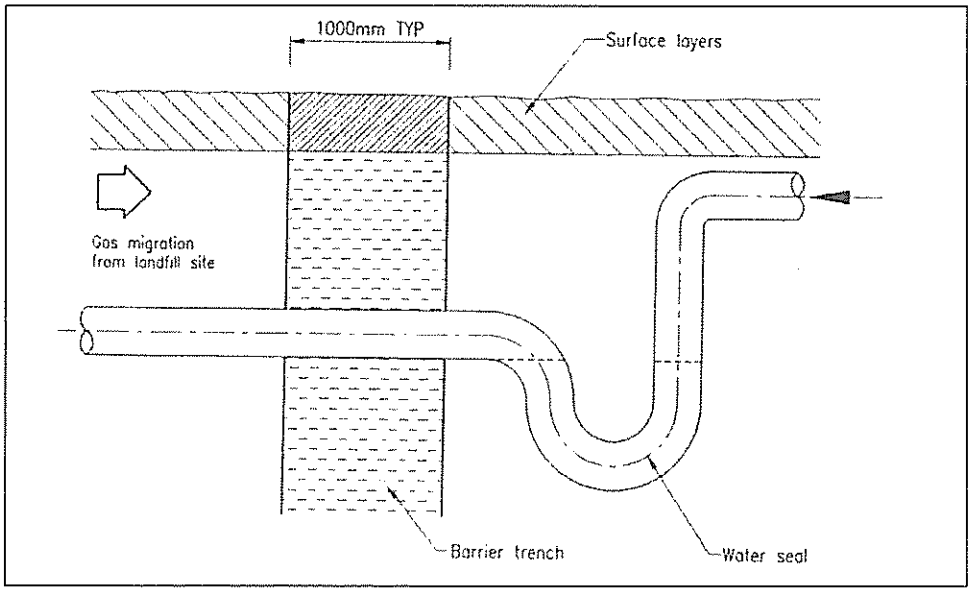
Sub-floor venting system

Design Measures for Sub-surface Building Services

(a) Gas Barriers

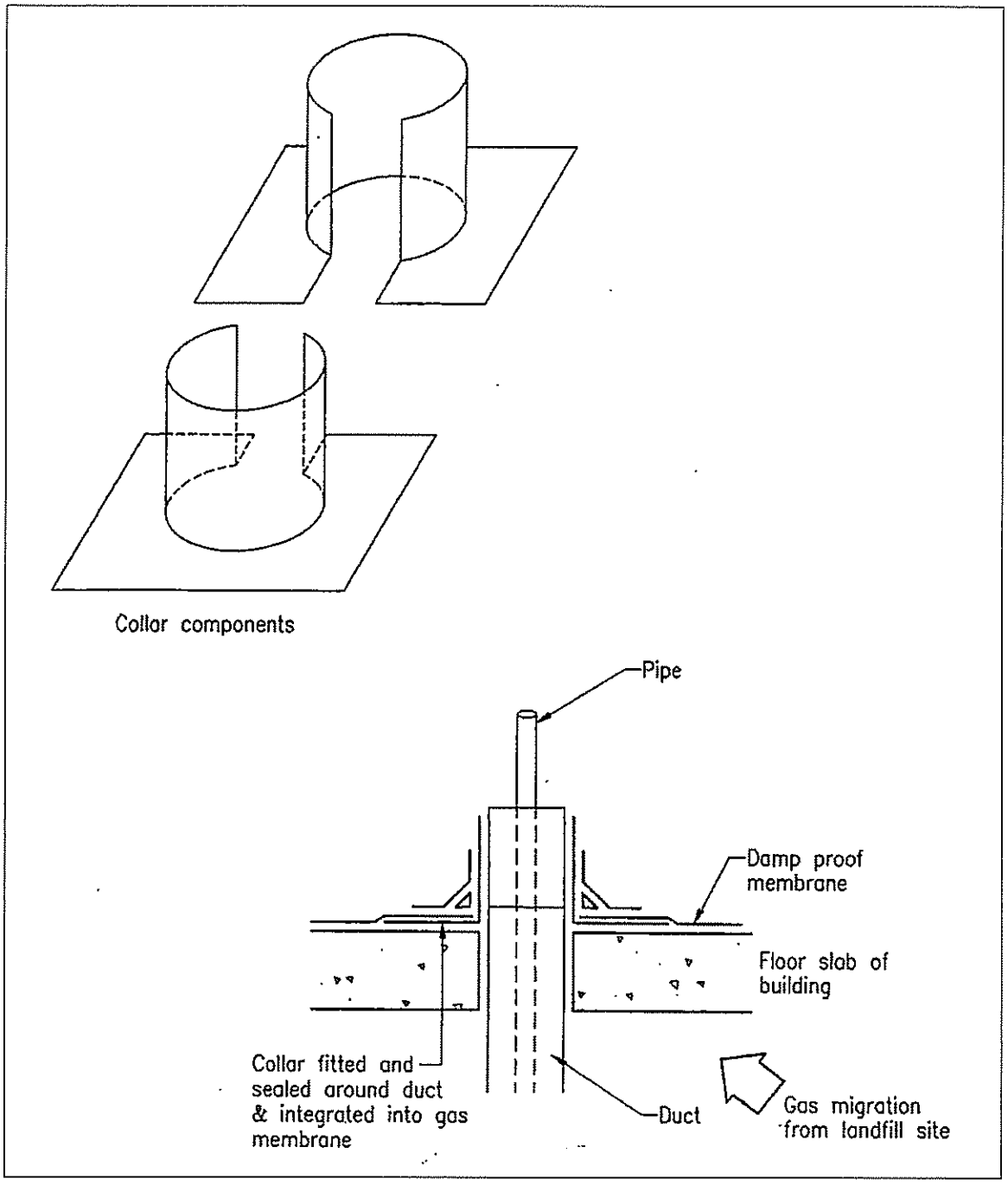


Natural material cut-off barrier

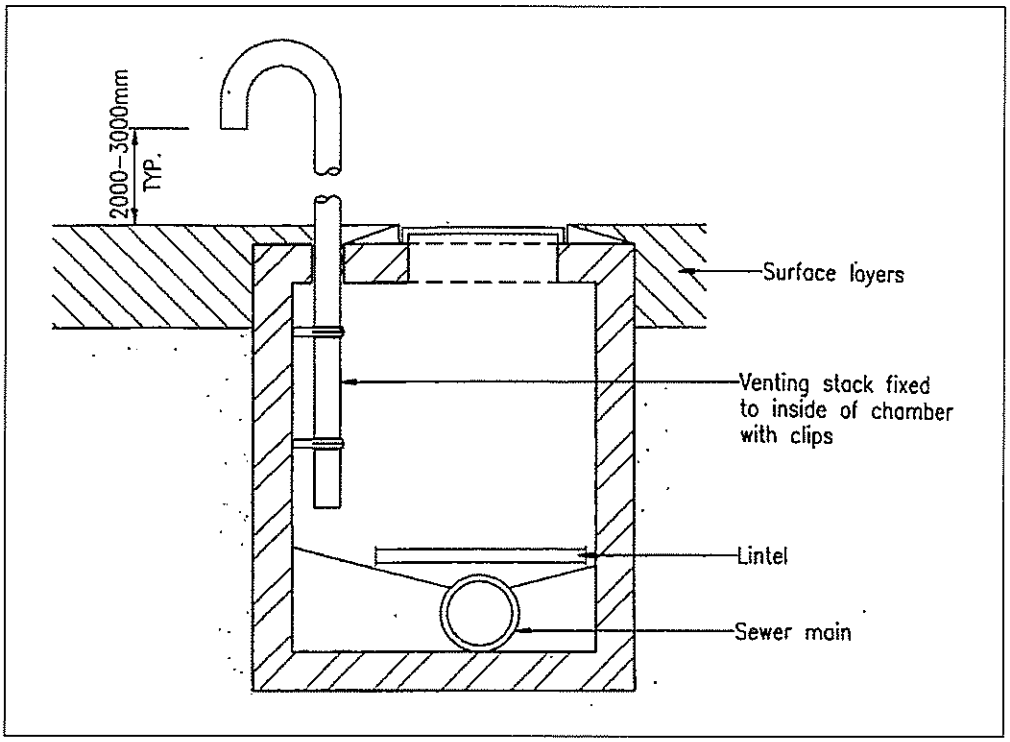


Open conduit protection by water seal

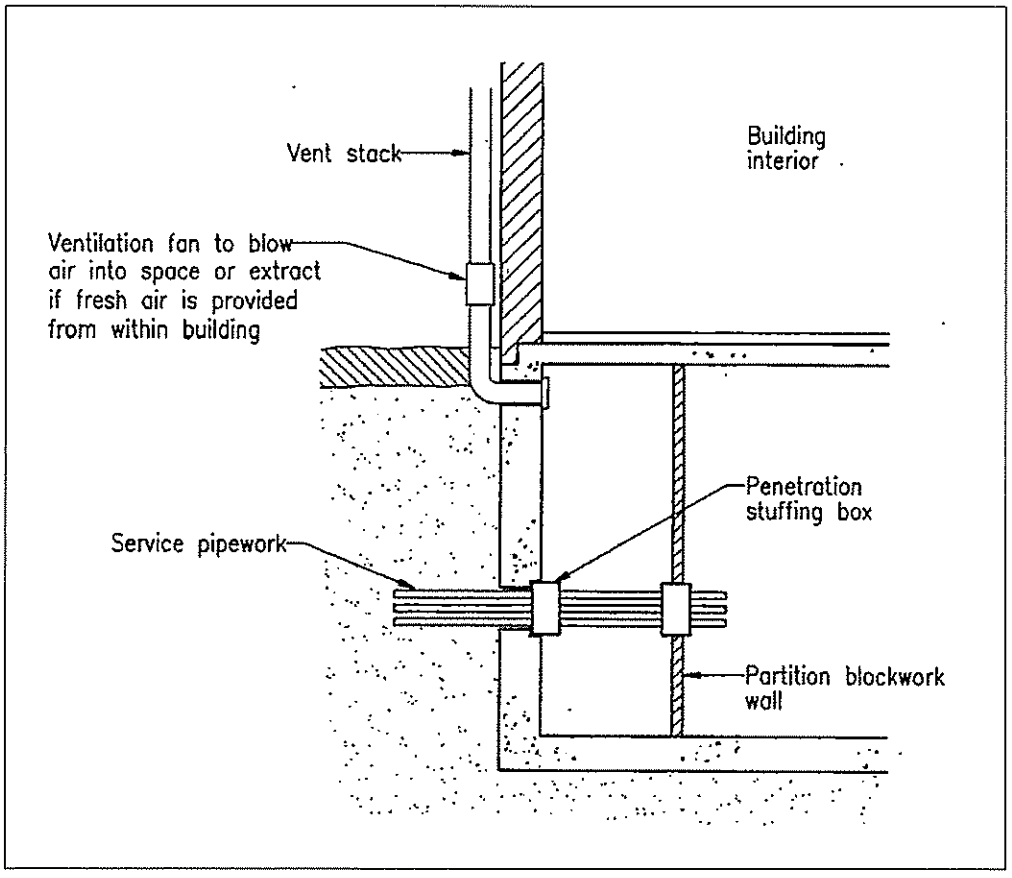
(b) Gas Vents



Typical detail of Collar Seal



Vented manhole



Vented Gas Interceptor Cavity

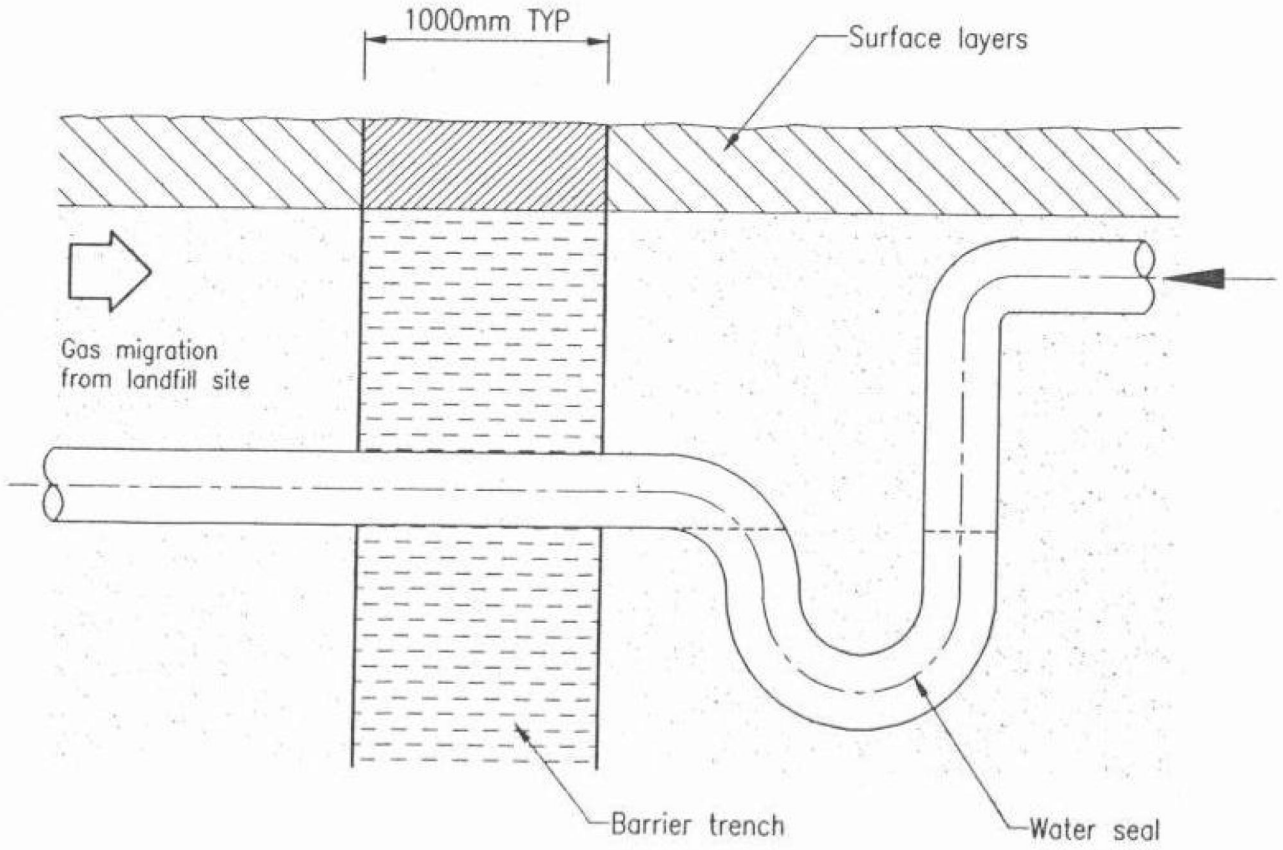
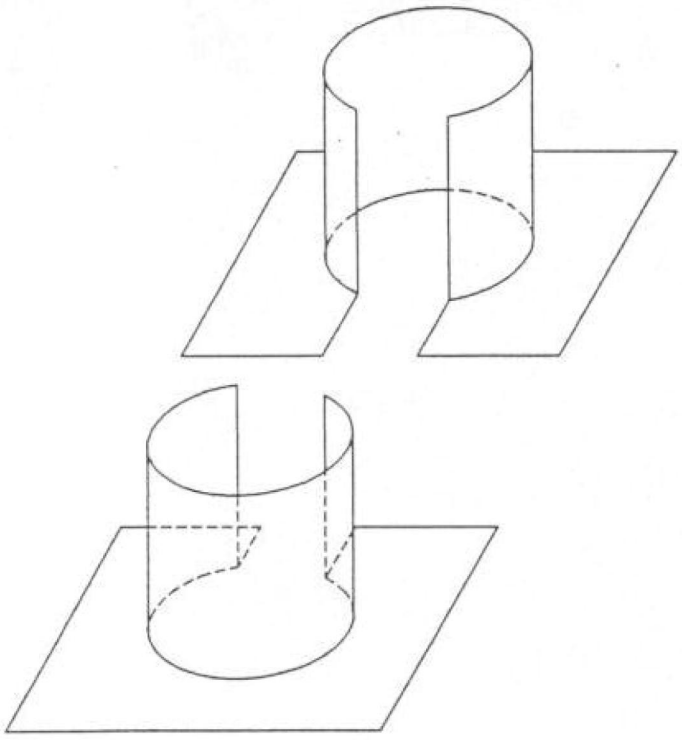


FIGURE B1 : OPEN CONDUIT PROTECTION BY WATER SEAL (LONGITUDINAL SECTION)



Collar components

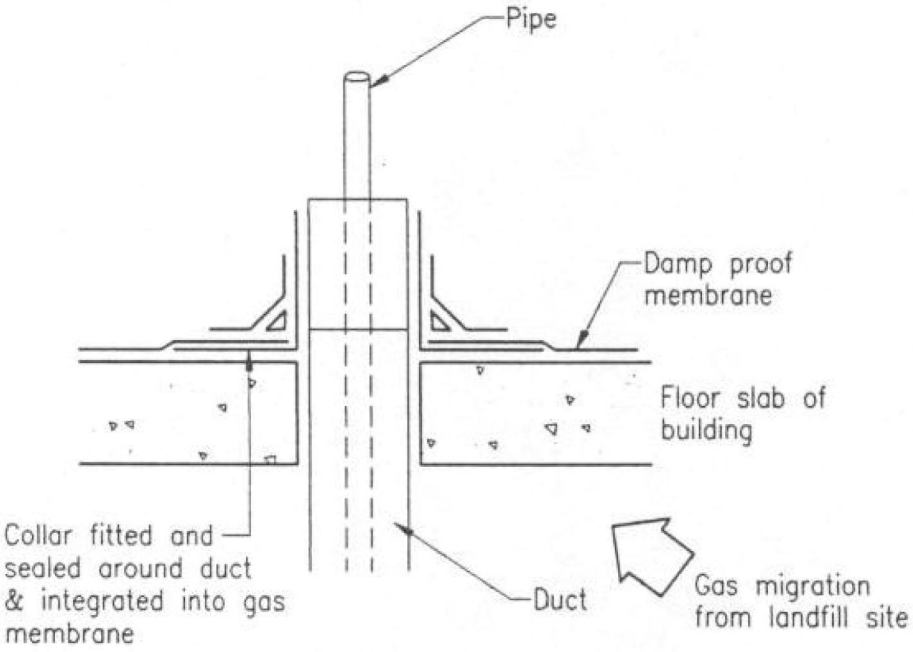


FIGURE B2 : TYPICAL DETAIL OF COLLAR SEAL (CROSS-SECTION)

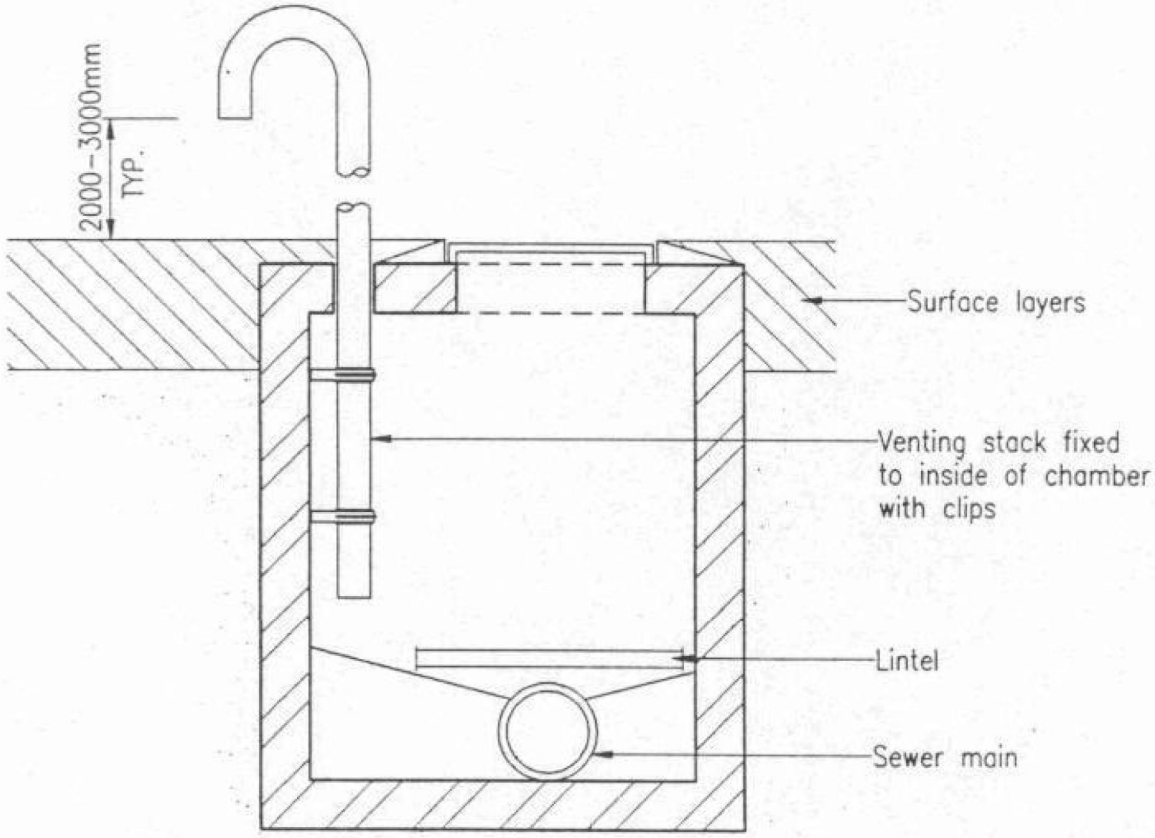


FIGURE B3 : VENTED MANHOLE (CROSS–SECTION)

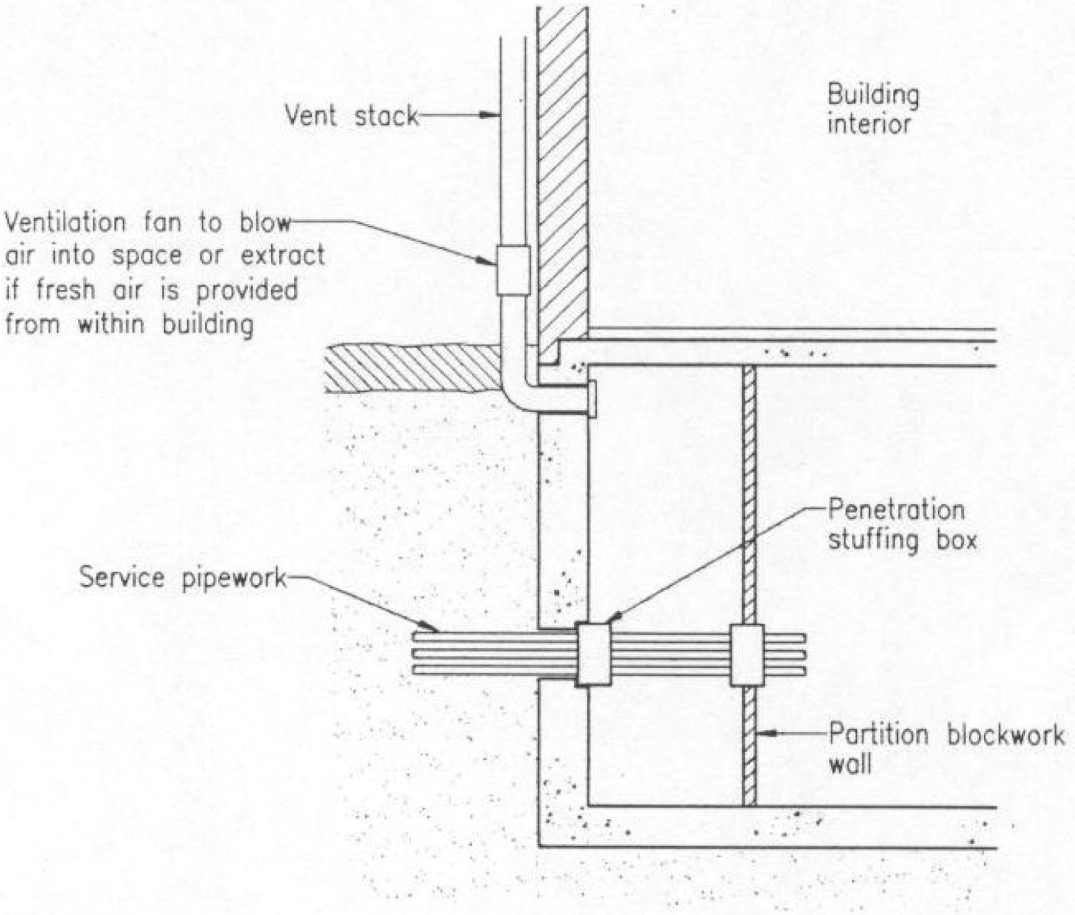


FIGURE B4 : VENTED GAS INTERCEPTOR CAVITY (CROSS-SECTION)

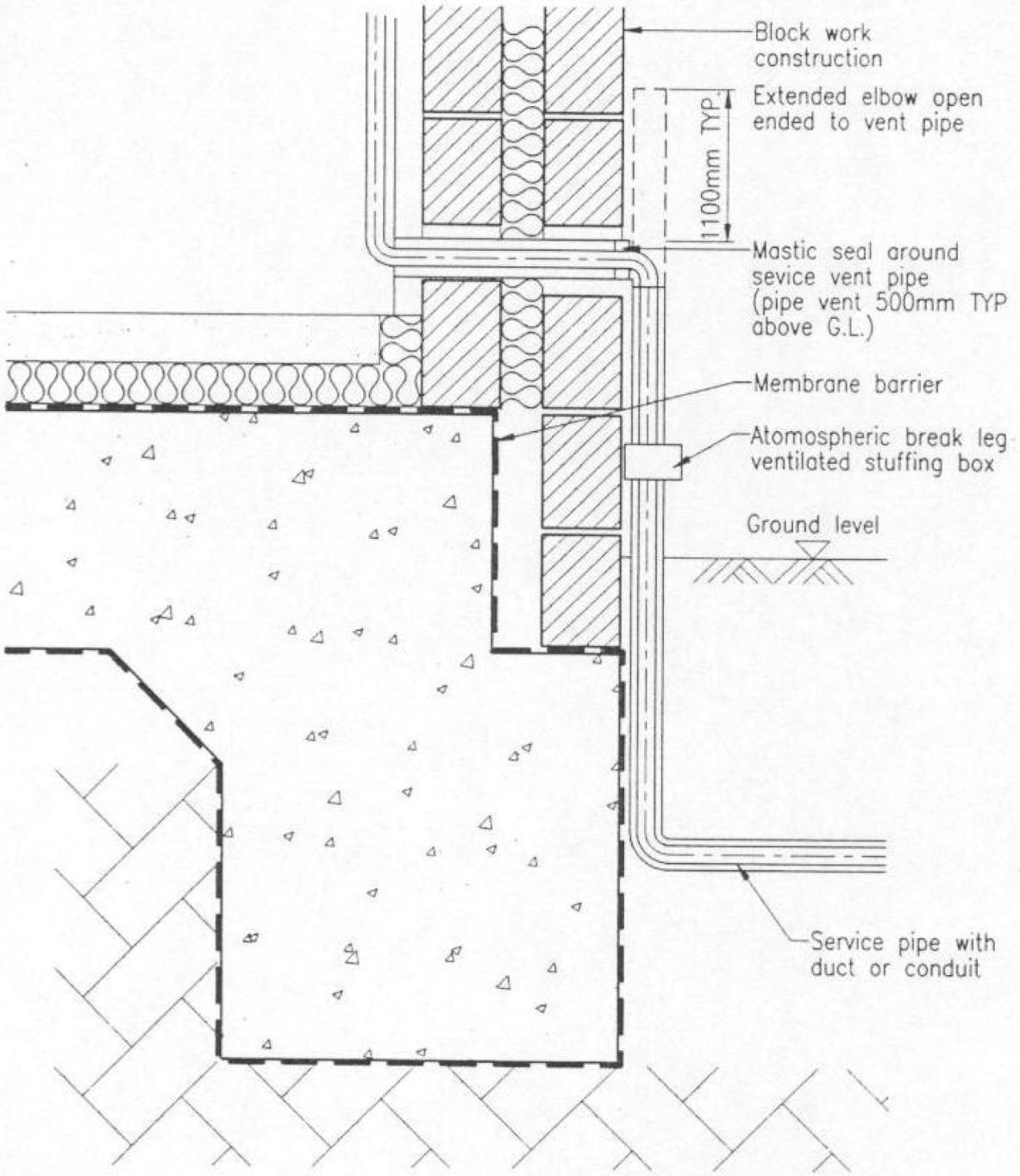


FIGURE B5 : ABOVE GROUND SERVICE ENTRY

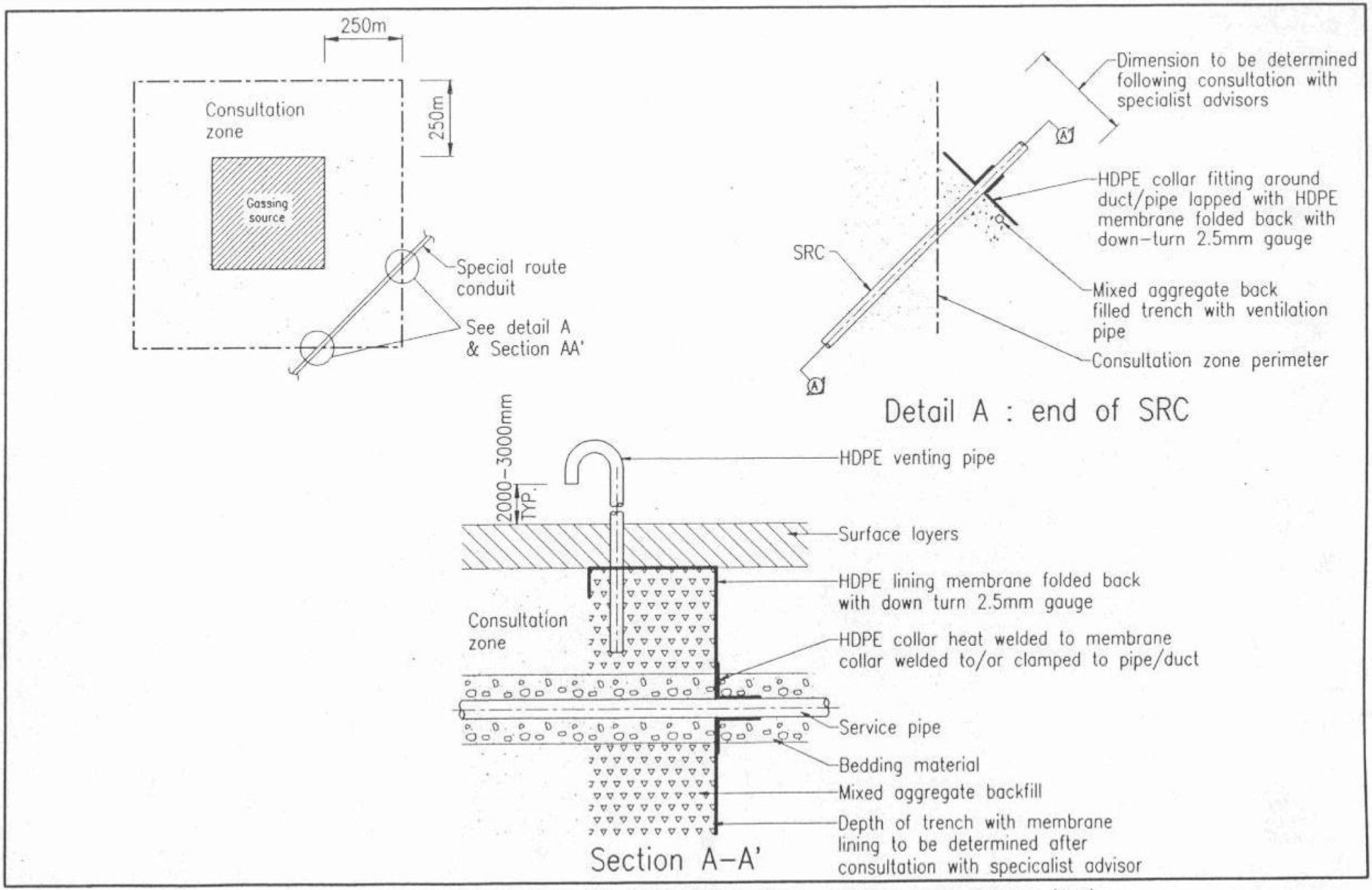


FIGURE B6 : TYPICAL DESIGN FOR SERVICES PASSING THROUGH THE CONSULTATION ZONE - SPECIAL ROUTE CONDUIT (SRC)

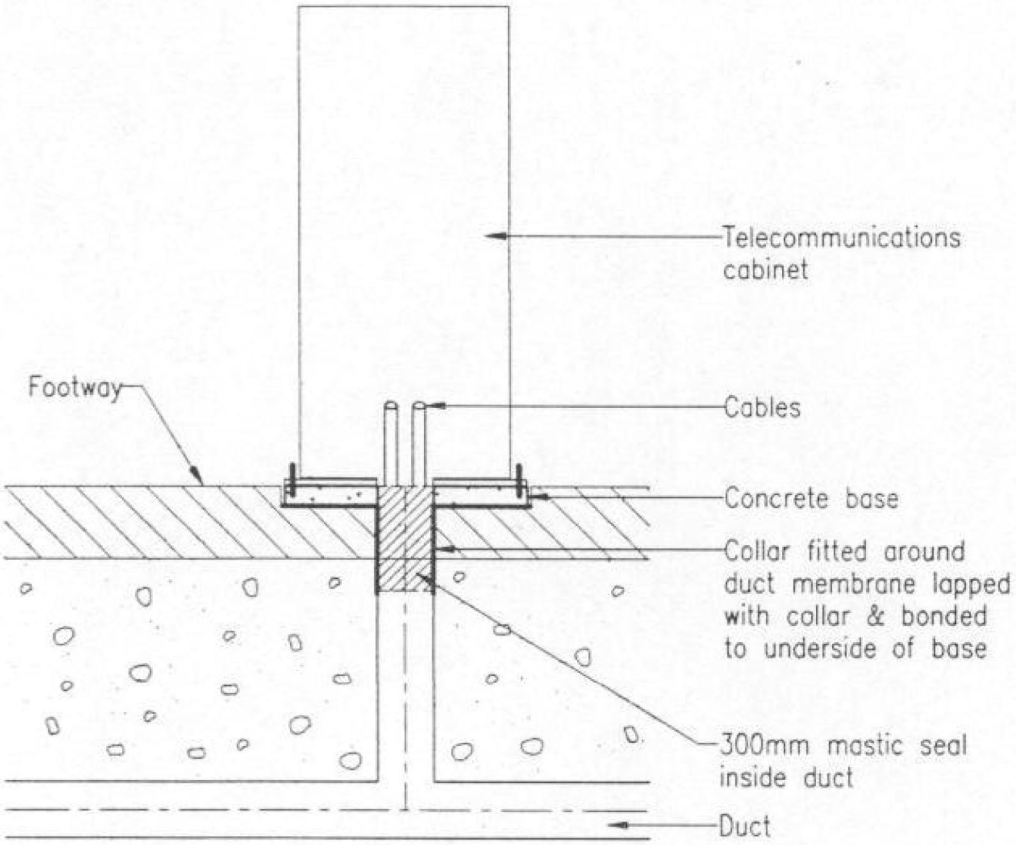


FIGURE B7 : TYPICAL SURFACE DETAIL FOR ABOVE GROUND TERMINATION OF SERVICES WITHIN THE CONSULTATION ZONE (CROSS-SECTION)

APPENDIX I

Responses to Comments

New Territories East Development Office
Civil Engineering and Development Department

Detailed Qualitative Landfill Gas Hazard Assessment Report for Cross Bay Link

Responses to Comments

No.	Comments	Responses
	From : EPD **Date :** 22 February 2017 **Ref :** f(38) in Ax(1) to EP2/N8/A/67 Pt.3	
	I refer to your letter of 11 January 2017 enclosing the Detailed Qualitative Landfill Gas Hazard Assessment Report (Draft) for our review and comments pursuant to Condition 2.7 of the Environmental Permit No. EP-459/2013 (the EP) for the captioned project. Please find below our comments on the captioned report:	
a)	S.1.1.2, line 3: The Study Brief No. ESB-195/2008 is wrong. Please revise.	The Study Brief is revised to ESB-196/2008.
b)	S.1.1.3, line 4: The EP No. ESB-196/2008 is wrong. Please revise.	The EP No. is revised to EP-459/2013.
	Please revise the report accordingly and submit three hard copies and two electronic copies of the revised report for our approval in accordance with Condition 2.7 of the EP.	Noted.

本署檔號 OUR REF: f(2) in EP2/N8/A/67 Pt.8
來函檔號 YOUR REF:
電話 TEL. NO.: 2835 1300
圖文傳真 FAX NO.: 2591 0558

Hong Kong Government
Environmental Protection Department
Headquarters
28th Floor, Southorn Centre,
130 Hennessy Road,
Wan Chai, Hong Kong

環境保護署
香港灣仔
軒尼詩道
130號
修頓中心28樓

By Fax Only – 3922 9797

28 March 2017

AECOM
8/F, Grand Central Plaza, Tower 2,
138 Shatin Rural Committee Road,
Shatin, Hong Kong
(Attn. : Mr. Conrad NG, Executive Director)

Dear Mr. Ng,

Agreement No. CE/6/2014 (HY)
Cross Bay Link, Tseung Kwan O – Design and Construction

Submission of Detailed Qualitative Landfill Gas Hazard Assessment Report (Final)

I refer to your letter of 24 March 2017 enclosing the Detailed Qualitative Landfill Gas Hazard Assessment Report (Final) for our advance comments pursuant to Section 14.8 of the approved EIA Report (Register No. AEIAR-172/2013) for the captioned project.

Please note that we have no comment on the captioned report from landfill gas hazard perspective at this stage. You are reminded to formally submit the captioned report and highlight any subsequent changes (if any), with certification by Environmental Team Leader and verification by Independent Environmental Checker, for our approval no later than one month before the commencement of construction of the project in accordance with Condition 2.7 of the Environmental Permit No. EP-459/2013.

Yours faithfully,

(Wellem CHENG)
for Director of Environmental Protection

Internal
WPE[LD]1