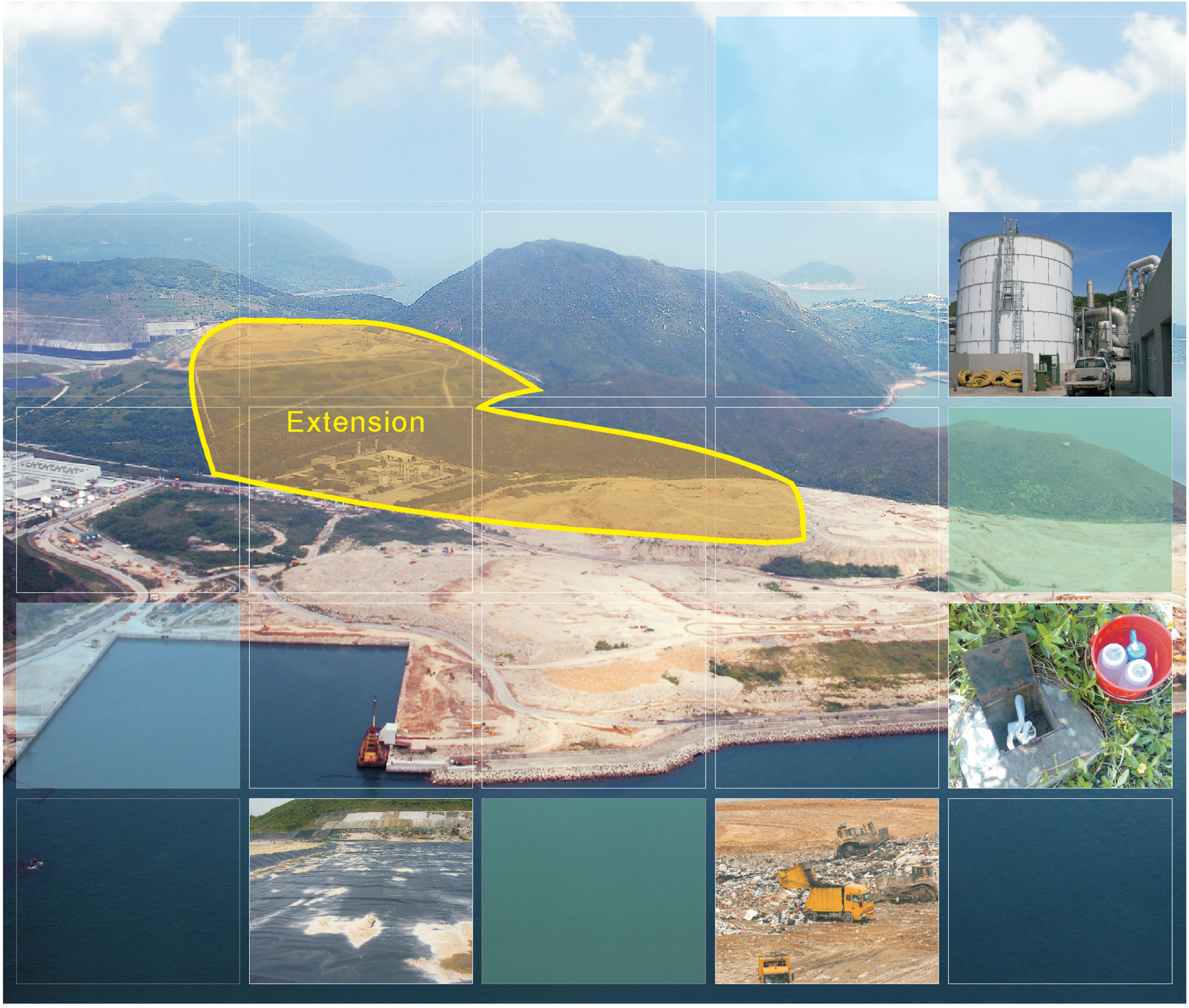
EIA REPORT - VOLUME I



Environmental
Protection
Department

Agreement No. CE 10/2005 (EP)
South East New Territories (SENT) Landfill Extension - Feasibility Study: Environmental Impact Assessment Report - *Volume I*

December 2007

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South East New Territories (SENT) Landfill Extension - Feasibility Study: Environmental Impact Assessment Report

Volume I

December 2007

Reference #0036286

For and on behalf of
Environmental Resources Management

Approved by: Dr Andrew Jackson

Signed:

Position: Managing Director

Date: 14 December 2007

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VOLUME I MAIN TEXT

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1 INTRODUCTION

1.1 BACKGROUND

The existing SENT Landfill is strategically located in the south-east New Territories and currently receives about 6,200 tonnes of a wide variety of waste (1) per day. Based on the current waste input rate, it is predicted that its capacity will be exhausted by around 2012. As the planning, tendering and contract arrangement, detailed design, construction and commissioning of the landfill extension will take several years, it is essential to establish the environmental acceptability and the engineering feasibility of the proposed SENT Landfill Extension (hereafter referred to as "the Extension") now.

ERM-Hong Kong, Ltd (ERM) has been commissioned by the Environmental Protection Department (EPD) to undertake the *South East New Territories (SENT) Landfill Extension – Feasibility Study* (hereafter referred to as the "Assignment") under the *Agreement No. CE 10/2005*. As part of the Assignment, an Environmental Impact Assessment (EIA) Study has been undertaken in accordance with the *EIA Study Brief* (No. ESB-119/2004) issued under the *Environmental Impact Assessment Ordinance (EIAO)*.

This EIA Report addresses the nature and extent of the potential environmental impacts associated with the construction, operation, restoration and aftercare of the Extension (hereafter referred to as "the Project").

1.2 OBJECTIVES OF THE EIA STUDY

The Extension is classified as a Designated Project under Schedule 2, Category G.1 and Q.1 of the EIAO and therefore the construction, operation, restoration and aftercare of the Extension will require an Environmental Permit. The overall objectives of the EIA Study are to provide information on the nature and extent of environmental impacts arising from the Extension; to recommend appropriate mitigation measures to control the potential environmental impacts so that it complies with the requirements of the *Technical Memorandum on Environmental Impact Assessment Process of Environmental Impact Assessment Ordinance* (EIAO-TM), and to confirm the environmental acceptability of the Extension.

The specific objectives of the EIA Study described in the *EIA Study Brief* are listed below.

(i) to describe the Project and associated works together with the requirements for carrying out the Project;

(ii) to identify and describe elements of community and environment likely

(1) Including municipal solid waste, construction waste and special wastes.

to be affected by the Project and/or likely to cause adverse impacts to the Project, including natural and man-made environment and the associated environmental constraints;

(iii) to provide information on the consideration of alternatives to avoid and minimise the potential environmental impacts to the ecological sensitive areas and other sensitive uses; to compare the environmental benefits and dis-benefits of each of the different options; to provide reasons for selecting the preferred option(s) and to describe the part of environmental factors played in the selection;

(iv) to identify and quantify emission sources and determine the significance of impacts on sensitive receivers and potential affected uses;

(v) to identify and quantify any potential landscape and visual impacts and to propose measures to mitigate these impacts;

(vi) to identify and quantify any potential losses or damage and other potential impacts to flora, fauna and natural habitats and to propose measures to mitigate these impacts;

(vii) to propose the provision of mitigation measures so as to minimize pollution, environmental disturbance and nuisance during construction, operation, restoration and aftercare stages of the Project;

(viii) to investigate the feasibility, practicability, effectiveness and implications of the proposed mitigation measures;

(ix) to identify, predict and evaluate the residual environmental impacts (i.e. after practicable mitigation) and the cumulative effects expected to arise during the construction, operation, restoration and aftercare stages of the Project in relation to the sensitive receivers and potential affected uses;

(x) to identify, assess and specify methods, measures and standards, to be included in the detailed design, construction, operation, restoration and aftercare stages of the Project which are necessary to mitigate these environmental impacts and cumulative effects and reduce them to acceptable levels;

(xi) to investigate the extent of the secondary environmental impacts that may arise from the proposed mitigation measures and to identify constraints associated with the mitigation measures recommended in the EIA study, as well as the provision of any necessary modification; and

(xii) to design and specify environmental monitoring and audit requirements to ensure the effective implementation of the recommended environmental protection and pollution control measures.

As specified by the *EIA Study Brief*, the EIA Study will address the following key environmental issues due to the construction, operation, restoration and aftercare of the Project:

- potential noise impacts (including the off-site traffic noise impact along the roads with traffic generated from the Project) to the identified Noise Sensitive Receivers (NSRs) during all stages of Project development;

- potential air quality impacts (including the off-site dust , gaseous emission and odour impacts along the roads due to traffic generated from the Extension) to the identified Air Sensitive Receivers (ASRs) during all stages of Project development;

- potential environmental impacts associated with the handling and disposal of wastes during all stages of Project development, in particular the disposal of surplus excavated materials arising from site formation works;

- potential water quality impacts during all stages of Project development;

- potential landfill gas hazard during all stages of Project development;

- potential landscape and visual impacts due to the Project during all stages of Project development, in particular the potential impact to the landscape value and recreational interests of the Clear Water Bay Country Park (CWBCP);

- potential aquatic and terrestrial ecological impacts during all stages of Project development, including the loss of habitats, removal of vegetation and disturbance to wildlife, in particular the CWBCP and any other sensitive areas that may be identified during the course of the EIA study;

- environmental risk to any nearby waterbodies/watercourses, especially the Fat Tong Chau due to accidental leakage of leachate and/or other wastewater and the necessary contingency measures; and

- potential cumulative environmental impacts of the Extension, through interaction or in combination with other existing (including the existing SENT Landfill), committed and planned developments in the vicinity of the Extension, in particular the planned deep waterfront industries at the southern part of the Project site and that those impacts may have a bearing on the environmental acceptability of the Project.

1.3 ORGANISATION OF THE REPORT

The remainder of this report is organised as follows.

- *Section 2* presents a description of the need of the Extension, the options selection process and the consideration of alternative construction methods;

- *Section 3* presents a description of the Extension;
- *Section 4* presents the air quality assessment;
- *Section 5* presents the noise assessment;
- *Section 6* presents the water quality assessment;
- *Section 7* assesses the waste management implications of the Extension;
- *Section 8* presents the landfill gas hazard assessment;
- *Section 9* presents the ecological assessment;
- *Section 10* presents the landscape and visual assessment;
- *Section 11* describes the requirements for environmental monitoring and audit; and
- *Section 12* summarises the environmental outcomes associated with the Project.

Annex A – Supporting Information for Air Quality Assessment

Annex B – Supporting Information for Noise Assessment

Annex C – Supporting Information for Landfill Gas Hazard Assessment

Annex D – Supporting Information for Ecological Assessment

Annex E – Implementation Schedule

Annex F – Groundwater Quality Monitoring Data

2 CONSIDERATION OF ALTERNATIVES

2.1 INTRODUCTION

In accordance with the requirements of Section 3.3 of the *EIA Study Brief*, this Section describes the need for the Extension and the consideration of design options. The consideration of alternatives also includes alternative construction methods and work sequences.

2.2 JUSTIFICATION FOR THE NEED OF THE EXTENSION

Hong Kong is facing an imminent waste problem as the existing landfills will be filled up in the next decade. In December 2005, the Government published the waste policy document "A Policy Framework for the Management of Municipal Solid Waste (2005-2014)" (hereafter referred to as "the Policy Framework"). This document sets out a comprehensive strategy for the management of municipal solid waste (MSW) in Hong Kong with clear targets and a timetable for ten years, from 2005 to 2014. The strategy embraces the concepts of sustainable waste management and the 3-tiered waste hierarchy with avoidance and minimization as the top priorities, followed by reuse, recovery and recycling, and the bulk waste reduction and landfill disposal.

The Government is therefore actively promoting initiatives to reduce waste generation and promote waste recycling. When comparing the waste statistics for 2006 with those of previous years, the amount of MSW disposed of at the three strategic landfills (WENT, NENT and SENT) dropped by 1% against an economic growth of 6.8% in 2006. Equally encouraging is the increase in the recovery rate of domestic waste from 16% in 2005 to 20% in 2006. At the same time, the overall recovery of MSW has also increased from 43% in 2005 (2.59 million tonnes) to 45% in 2006 (2.84 million tonnes), three years ahead of the target stated in the Policy Framework. There are however areas of concern. Even though the amount of MSW landfilled was reduced by 1% in 2006, there is still a long way to go in achieving the Policy Framework's target of reducing the total MSW landfilled to less than 25%. In addition, despite EPD's efforts in waste reduction and recovery, the amount of MSW generated remains on an increasing trend. This is likely to be the result of growth in commercial, industrial and tourism-related activities in 2006 which has led to an increase of about 4% in commercial and industrial waste generation. Therefore, despite the progress achieved for source separation and waste recycling, it is important to press ahead with the other initiatives in the Policy Framework such as Producer Responsibility Schemes (PRSs), MSW charging, integrated waste management facilities (IWMF) and landfill extensions.

At the same time, the Government is also looking into building modern large scale integrated waste management facilities that would employ thermal treatment as a core technology as it is clearly not sustainable to continue to rely on landfilling alone for the disposal of untreated MSW. The integrated waste management facilities are planned to be commissioned in the mid 2010s, assuming that good progress is made. As mentioned in the Policy Framework, landfills will still be required as the final repositories for non-recyclable waste, inert waste and waste residues after treatment. It has been estimated that the demand for landfill space from 2006 to 2025 is around 200 million tonnes, while the remaining landfill capacity, at the end of 2004 was 90 million tonnes. The provision of sufficient landfill space by extending the capacity of the three existing landfills is an important and integral part of the waste management strategy in Hong Kong and is necessary to meet the shortfall of landfill capacity. Indeed, the Policy Framework recommended that commissioning of these extensions will be required in the early 2010s to mid-2010s.

In addition to the need for landfill capacity on a territory-wide basis, there is a need to meet the regional demand for waste disposal outlets. The three landfills are at strategic locations in Hong Kong and the extension of all three is necessary to maintain the overall waste disposal plan which is based on bulk waste transfer to avoid excessive number of waste collection vehicles travelling in the urban areas (1). Due to its close proximity to the urban areas, the SENT Landfill is the most highly used waste disposal facility amongst the three landfills, particularly by private waste collectors for commercial, industrial as well as construction wastes. It receives about 6,200 tonnes of municipal, construction and special wastes every day. If the SENT Landfill is closed, waste will have to be diverted to the NENT and WENT Landfills. This will require vehicles collecting waste from the catchments of the SENT Landfill to travel an additional hundred thousand kilometres per day in total through the built-up areas to the remotely located NENT and WENT Landfills, thus resulting in additional environmental impacts such as increased traffic movements, vehicular emissions and noise impacts on many more sensitive receivers en-route. To reduce these impacts, we would need a succession plan by developing new waste transfer and/or handling facilities in the south-east region of the territory, such as new handling facility for construction waste (ie the Construction Waste Handling Facility (CWHF)) and refuse transfer station for MSW (ie the South East Kowloon Transfer Station

(1) According to the White Paper "Pollution in Hong Kong – A Time to Act" issued on 5 June 1989 and the subsequent waste disposal strategy under the Waste Disposal Plan approved by the Governor in Council on 12 December 1989, there should be three new landfills in Hong Kong distributed on a regional basis for the following reasons:

- the daily quantity of MSW could not be handled by one or two landfills simply because of the strain that would be placed on the surrounding road network and on the landfill sites themselves;
- the increases in MSW were projected for the western and north-eastern New Territories and provision of disposal facility in each of these areas would help reduce transportation costs; and
- there would continue to be a need for a final disposal facility in reasonable proximity to Hong Kong Island in order to contain the transportation cost for waste arising from urban areas.

The existing 3 strategic landfills were therefore located at the western, north-eastern and south-eastern New Territories regions within the territory in the absence of other alternative site available in Kowloon and Hong Kong Island.

(SEKTS)). As the planning (including the site search), feasibility study, statutory environmental impact assessment process, tendering and contract arrangement, detailed design, construction and commissioning of these facilities would take equally long time as the landfill extension scheme, it further strengthens the importance of maximising the capacity of Extension where feasible in order to minimize those impacts as far as we could manage.

Projecting the time at which these new facilities will be available is very uncertain as the site for the CWHF will unlikely be available in the early 2010s and the site selection for the SEKTS has not yet been started. It will be a long planning and public consultation process to secure suitable waterfront sites at the Tseung Kwan O and South East Kowloon areas which are acceptable to the public for the development of these waste transfer/handlling facilities, but without compromising the overall planning and development of these two areas. In addition, the funding for developing these facilities has not been secured. Under an optimistic set of conditions to form a target programme at the present stage, they could possibly be in place by 2017. With SENT expected to be full by 2012, at least six years of additional void space is necessary. It is important to extend the lifespan of the SENT Landfill so that the Government can have time to plan and develop these new waste handling facilities.

2.2.1 Extension of the SENT Landfill

In 2000, the potential to extend the SENT Landfill was examined in a study entitled the "Extension of Existing Landfills and Identification of Potential New Waste Disposal Sites". The recommendations of this study was presented to the Advisory Council on Environment (ACE) and supported by the ACE members. The possibility of locating extensions to the west, north and east of the existing SENT Landfill was investigated, but sites in these locations were ruled out for the following reasons:

- **Extension to the west**: this area is already occupied by the Tseung Kwan O Industrial Estate (TKOIE);

- **Extension to the north**: extensive excavation into the headland that separates the existing landfill from the TKO Stage II/III Landfill would be required and could significantly interfere with the completed and restored TKO Stage II/III Landfill and works yet to be carried out at the SENT Landfill; and

- **Extension to the east**: this will result in a major encroachment into the CWBCP, destroy the ridge line and sever the High Junk Peak Hiking Trail.

The only feasible option is to extend the landfill southward into TKO Area 137.

EPD identified 15 hectares of land in TKO Area 137 together with an adjoining narrow strip of land within the CWBCP as a potential site for the extension of the SENT Landfill (see *Figure 2.2a*).

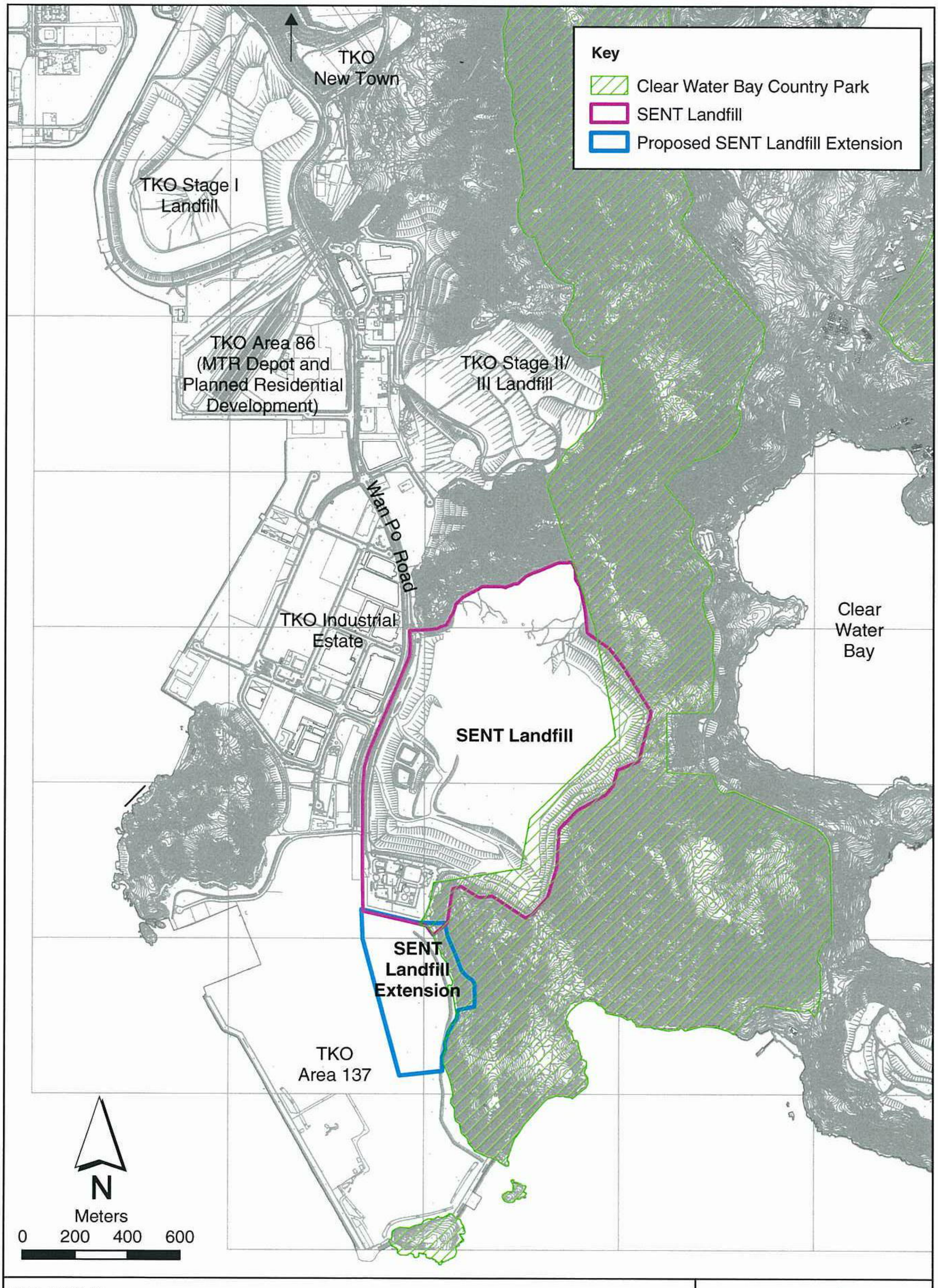

FIGURE 2.2a

Project Location

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2.3 CONSIDERATION OF DIFFERENT EXTENSION OPTIONS

2.3.1 *Extension Options*

The Assignment has identified and examined five options for the extension of the SENT Landfill. They include:

- ***Option 1a*** – a standalone landfill with no incursion into the CWBCP. This option would have completely separate infrastructure, to ensure minimal contractual interfaces with the existing SENT Landfill (see *Figure 2.3a*).

- ***Option 1b*** – a standalone landfill with no incursion into the CWBCP. The area available for landfilling would be maximised and the cost reduced by sharing certain items of infrastructure (eg leachate and landfill gas treatment facilities) with the existing SENT Landfill. A smaller area would therefore be required for the Extension infrastructure (see *Figure 2.3b*).

- ***Option 2*** – the landfill area "piggybacks" over the existing SENT Landfill and its present infrastructure area, but does not require any land within the CWBCP. A new infrastructure area would be provided to the south of the proposed Extension, which would be utilised by both landfills (see *Figure 2.3c*).

- ***Option 3a*** – the landfill area piggybacks over the existing SENT Landfill and its infrastructure area, and makes a small incursion (3 ha) into the CWBCP in order provide more void capacity. A new infrastructure area would be provided to the south of the proposed Extension, which would be utilised by both landfills (see *Figure 2.3d*).

- ***Option 3b*** – the landfill area piggybacks over the existing SENT Landfill and its infrastructure area, and makes a slightly larger incursion (5 ha) into the CWBCP in order to maximise available void capacity. A new infrastructure area would be provided to the south of the proposed Extension, which would be utilised by both landfills (see *Figure 2.3e*).

Table 2.3a summarises the key information for each option.

Table 2.3a Key Information of Extension Options

Options	Characteristics	Net Void Space (million m^3)	Encroachment into CWBCP (hectares)	Estimated Construction Cost (HK$ per tonne of waste)	Additional Lifespan (years)
Option 1a	• Stand-alone landfill • No sharing of Infrastructure	1.3	0	350	<1
Option 1b	• Stand-alone landfill • Sharing of	1.6	0	200	<1

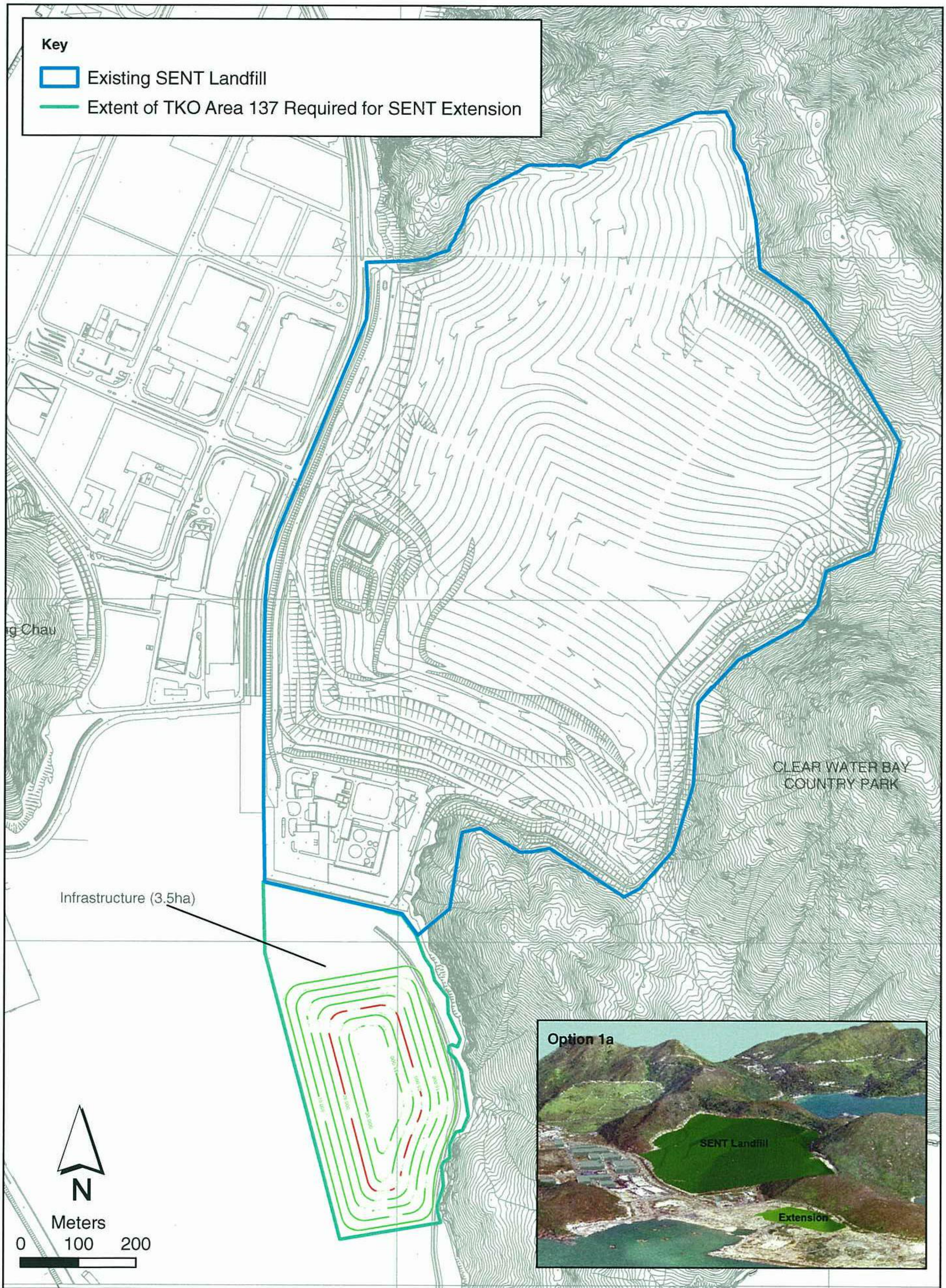

FIGURE 2.3a

Option 1a

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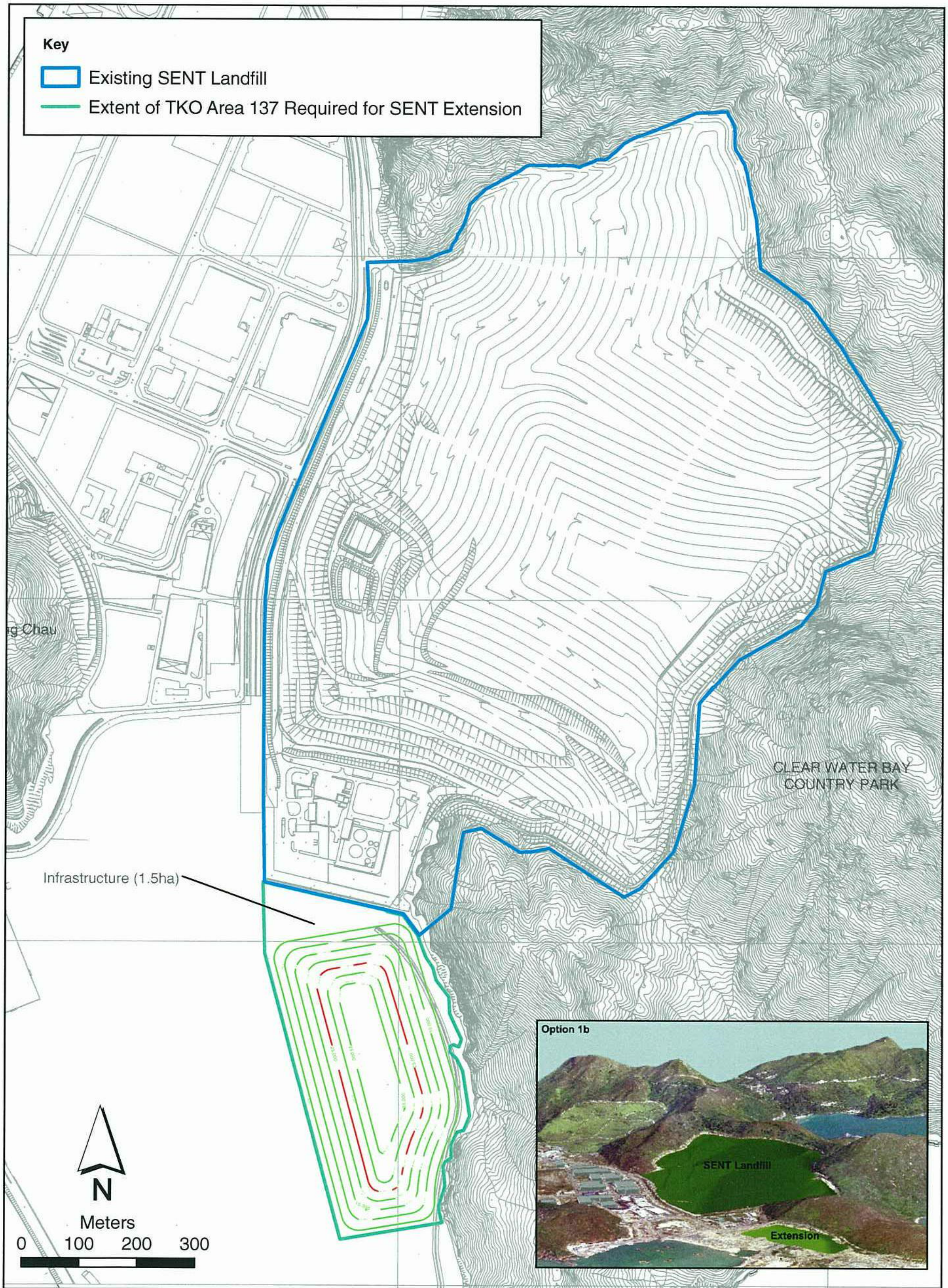

FIGURE 2.3b

Option 1b

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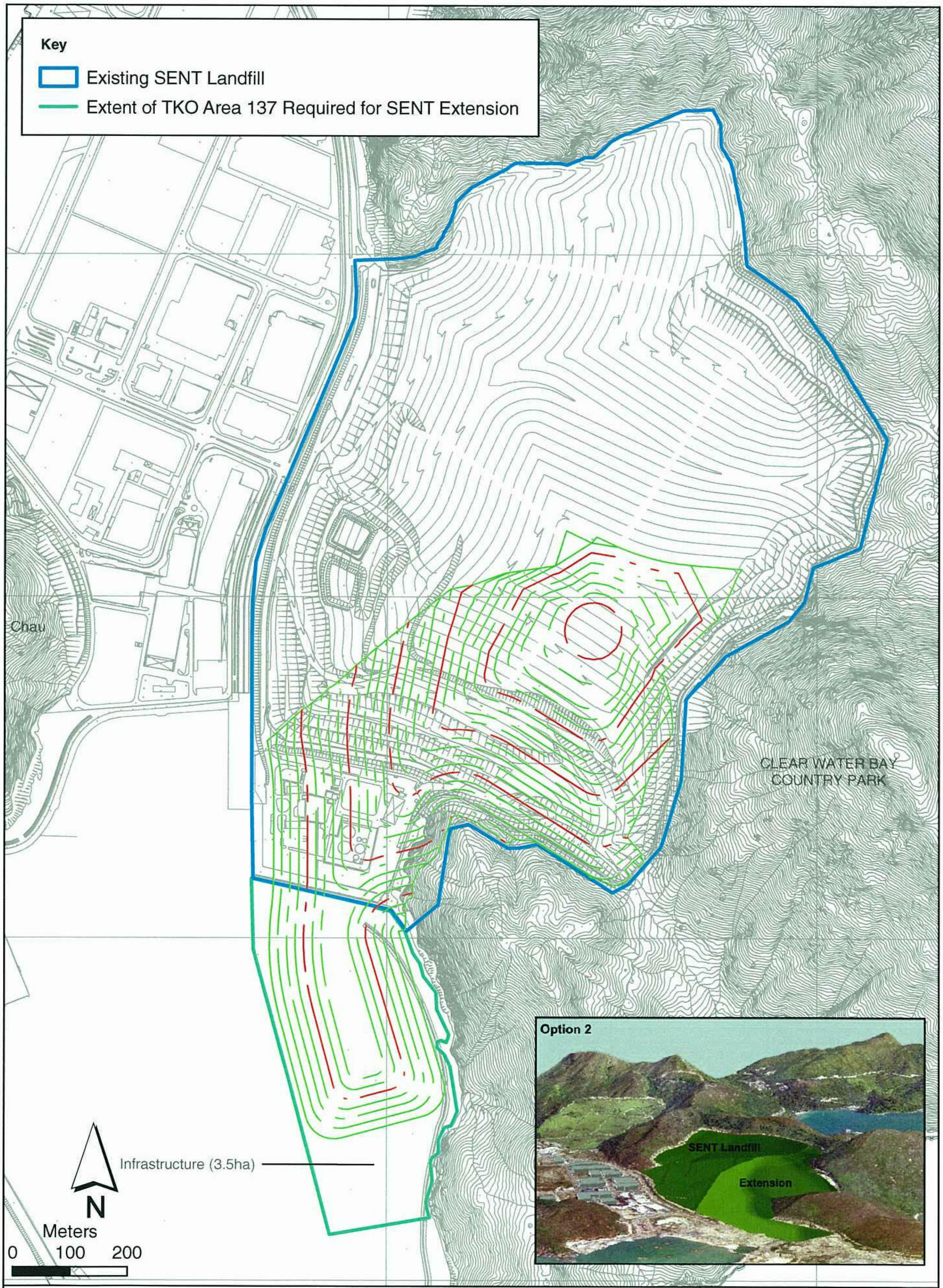

FIGURE 2.3c

Option 2

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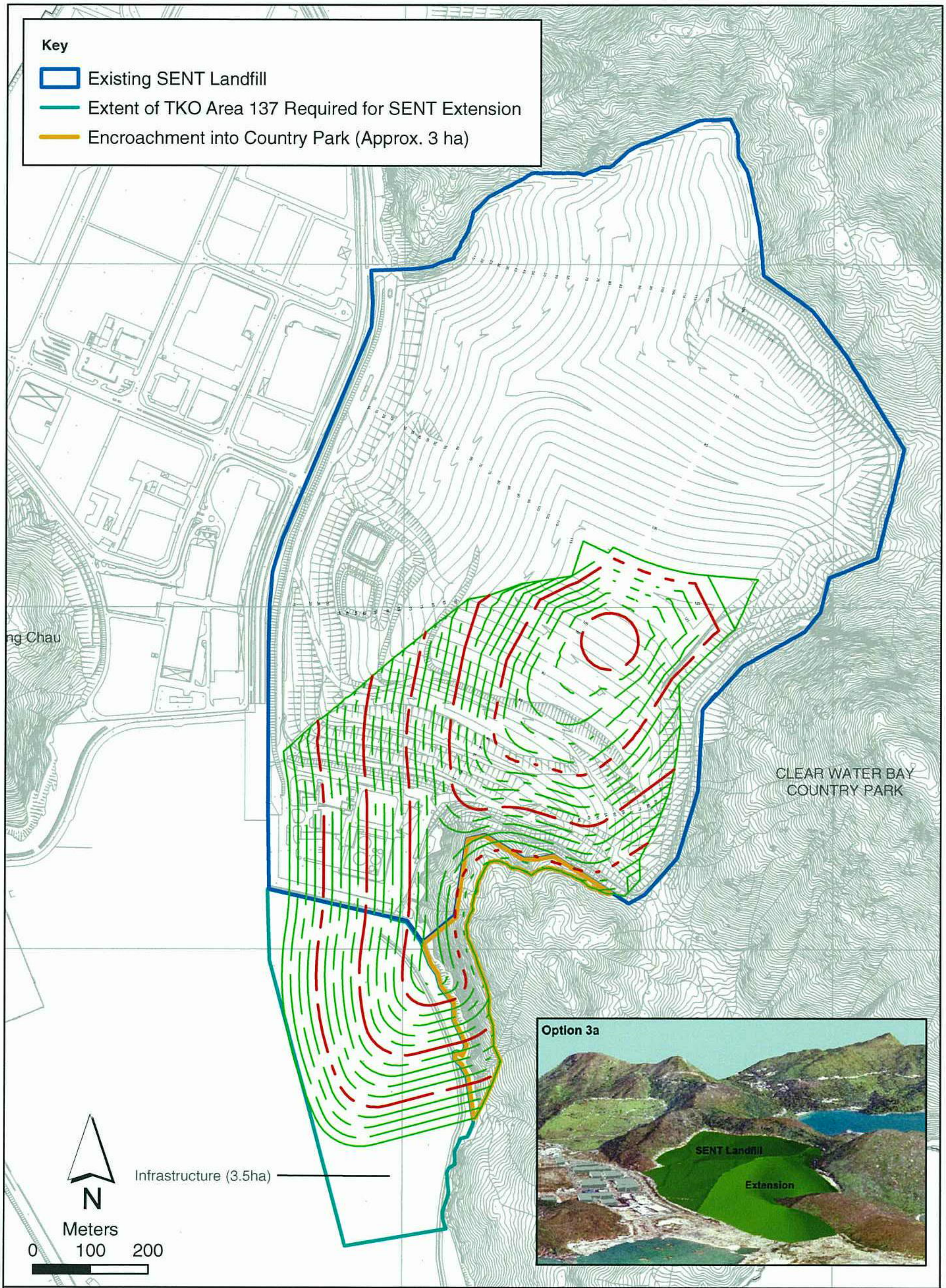

FIGURE 2.3d

Option 3a

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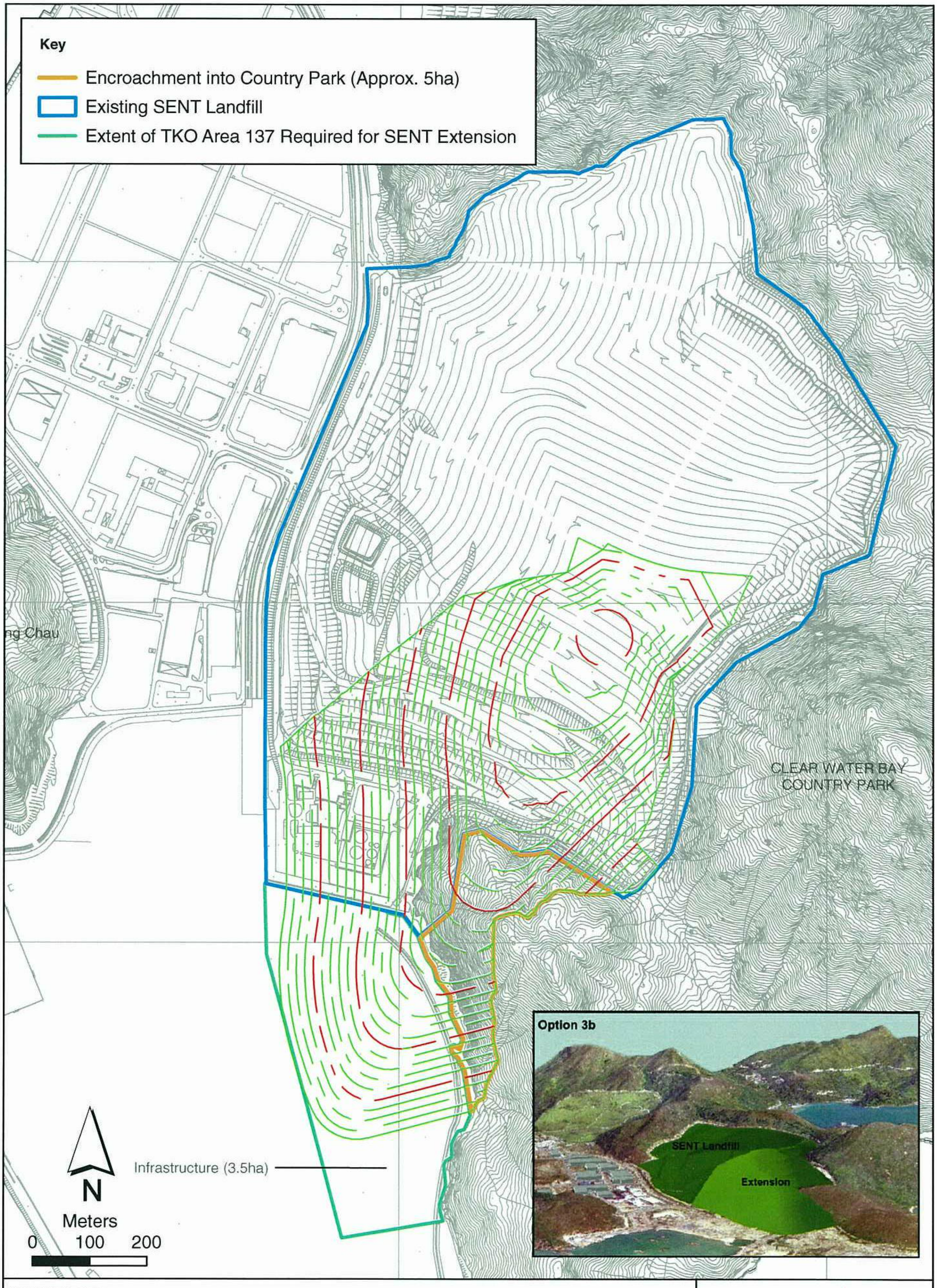

FIGURE 2.3e

Option 3b

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Options	Characteristics	Net Void Space (million m^3)	Encroachment into CWBCP (hectares)	Estimated Construction Cost (HK$ per tonne of waste)	Additional Lifespan (years)
	infrastructure with existing landfill				
Option 2	• Piggy-back landfill • Sharing of infrastructure with existing landfill	10.0	0	80	4
Option 3a	• Piggy-back landfill • Sharing of infrastructure with existing landfill	15.0	3	60	5
Option 3b	• Piggy-back landfill • Sharing of infrastructure with existing landfill	17.0	5	50	6

Note:
(a) Construction cost of existing strategic landfill is about HK$60 per tonne.

2.3.2 *Options Evaluation*

In assessing whether an alternative is practical and reasonable, the circumstances have been taken into account and a balanced judgement reached. Hence, five criteria relevant to the evaluation of the Extension were used to evaluate the five identified options:

- Landfill capacity;
- Efficient use of land;
- Cost effectiveness;
- Encroachment into Country Park; and
- Environmental impacts.

In addition, engineering measures and additional landtake in TKO Area 137 have also been considered.

Landfill Capacity

The stand-alone options provide very low void capacity, 1.3 Mm^3 for Option 1a and 1.6 Mm^3 for Option 1b. This is equivalent to an extended lifetime for the SENT Landfill of less than one year. The piggyback options provide significantly higher void capacity, 10 Mm^3 for Option 2, 15 Mm^3 for Option 3a and 17 Mm^3 for Option 3b. Option 3b provides the highest void capacity of all the options evaluated (see *Table 2.3a*) and provides sufficient time for the new generation of waste management facilities (see *Section 2.2*) to come into operation.

Efficient Use of Land

All options make use of the 15 hectares of land in TKO Area 137 that adjoins the southern end of the existing SENT Landfill. Option 3a requires an additional 3 hectares of land from the CWBCP area, whereas Option 3b requires an additional 5 hectares. As Option 3b will deliver the greatest void capacity per unit site area, it presents the most efficient use of land.

Cost Effectiveness

The estimated capital costs for the stand-alone options at HK$350 per tonne for Option 1a and HK$200 for Option 1b are 6 and 3 times more expensive than the capital cost for the existing landfills (approximately HK$60 per tonne). The capital cost for Option 2 at HK$80 per tonne is 25% higher than that for the existing landfills, whereas Option 3a has the same capital cost per tonne (i.e. around HK$60 per tonne). Option 3b at HK$50 per tonne has the lowest capital cost and thus is the most cost effective option (see *Table 2.3a)*.

Encroachment into Country Park

The Country Parks serve three functions, namely conservation, recreation and education. There is a general presumption against development in Country Parks.

Options 1a, 1b and 2 will not encroach into the CWBCP and hence no direct impact on the CWBCP is envisaged. Option 3a and Option 3b will encroach into approximately 3 ha and 5 ha, respectively, of the CWBCP and will have a direct impact. The potential ecological and landscape impacts are discussed in the next sub-section.

It is noted that the potential encroachment area is a cliff face dominated by shrubland and grassland. At present, there are no hiking trails nor formal footpaths in the area. The area can only be accessed from the existing SENT Landfill or the fill bank in TKO Area 137. The area has not been used for recreational and educational purposes. Hence, it is considered that encroachment into the CWBCP will not adversely affect the conservation, education and recreation uses. On the other hand, the Extension encroached area can be developed for useful education and recreational uses following closure and restoration of the Extension, thus providing a chance to improve the public enjoyment of the area.

Key Environmental Impacts

Local Air Quality Impact: The nearest existing sensitive receiver for air quality is TVB City in the TKOIE. Options 1a and 1b, being standalone landfills in TKO Area 137, are located further away from the TKOIE (> 300m) when compared with Options 2, 3a and 3b, where the piggyback portion is approximately 100m from the TKOIE. The life span of the Extension will also determine the extent of the environmental impacts. Hence, a longer impact period will be associated with Option 3b while Option 1a will pose only a short impact duration. Any air quality impact would decrease significantly following completion of landfill operation.

Local Ecological Impact: Options 1a and 1b will utilise the developed land in TKO Area 137, currently occupied by the fill bank operation. No natural habitat will be directly affected. Option 2 will occupy the developed land in TKO Area 137 plus piggybacking onto the slope of the existing SENT Landfill which will affect some plantations on the restored area of the existing SENT Landfill. The ecological value of the plantations is low and no natural habitat will be directly affected. Options 3a and 3b will encroach into the CWBCP. A 9-months ecological baseline survey identified that the habitats within the encroachment area comprise shrubland and grassland, neither of which is of high ecological value. While some species of conservation interest were recorded within the directly impact area, all of these species were found to be of high mobility and were found to have access to an abundant number of similar habitats close by and within the CWBCP area. Upon completion of the landfill operation, the landfill will be completely restored and landscaped. By planting a mixture of indigenous species, the ecological value of the restored landfill could be enhanced. .

Local Landscape and Visual Impact: The landforms of Options 1a and 1b are small and will be screened or partially screened by the restored SENT Landfill and future development in the TKO Area 137 when viewed from most of the visual sensitive receivers. However, it would be difficult to integrate these landforms into the surrounding landscape. The landforms and footprint of Options 2, 3a and 3b are larger and will be visible by the sensitive receivers. Options 3a and 3b will have direct impact on the landscape within the CWBCP. The landscape and visual impact during the operation phase of the Extension will be temporary and can be reverted by appropriate landscaping during progressive restoration. Once restored, the landform of Option 3b should provide the most harmonic visual and landscape quality to the visual sensitive receivers. It is not anticipated that any of the identified extension options will cause adverse landscape and visual impacts in the long term.

General Environmental Impact at Territorial Level: As there are no waste disposal facilities for MSW, construction waste and special waste in the south-east region of the SAR, the closure of the SENT Landfill would mean that waste currently disposed of at the SENT Landfill will have to be transported to other disposal sites, e.g. the NENT Landfill and the WENT Landfill, located further away. This will lead to the waste collection vehicles travelling an extra of several tens of thousands of kilometres per day resulting in additional environmental impacts such as increased traffic movements, vehicular emissions and noise impacts on many more sensitive receivers en-route. Providing additional landfill void space to serve the SENT catchment area fro as long as practicable would defer such impacts. In view of this consideration, Option 3b will be more preferable since it has the longest lifespan. In the longer term, EPD will develop a new waste transfer/ handling facility in the south-east region of the SAR.

The environmental benefits and dis-benefits of the five options are summarised in *Table 2.3b*.

Table 2.3b Summary of Environmental Benefits and Dis-benefits of the Extension Options

Criteria	Environmental Benefits	Environmental Dis-benefits	Can Environmental Dis-benefit be avoided/ mitigated?	Conclusion
Option 1a	• Small impact at local scale because the development scale is the smallest and the tipping area is located more than 300m from the existing development • No need to encroach into CWBCP • Less visible from most of the existing sensitive receivers	• Very short lifespan meaning earlier diversion of waste collection vehicles to more remote landfills, generating additional environmental impact at territorial scale • Standalone feature which makes it difficult to integrate with the surrounding landforms	• Additional environmental impact at territorial scale cannot be avoided because there are no other similar waste facilities in the south-east region of the SAR • The landscape impact can be minimised by careful restoration landscaping but the shape of the landfill cannot be integrated with the surrounding landform	• Least environmental impact at local scale because of its small scale of development • Relatively larger environmental impact at territorial scale because diversion of waste collection vehicles will be required for a longer period after the relatively short duration of landfilling operation at the Extension • No unacceptable environmental impact anticipated
Option 1b	• Small impact at local scale because the development scale is the second smallest and the tipping area is located more than 300m from the existing development • No need to encroach into CWBCP • Less visible from most of the existing sensitive receivers	• Very short lifespan meaning earlier diversion of waste collection vehicles to more remote landfills, generating additional environmental impact at territorial scale • Standalone feature which makes it difficult to integrate with the surrounding landforms	• Additional environmental impact at territorial scale cannot be avoided because there are no other similar waste facilities in the south-east region of the SAR • The landscape impact can be minimised by careful restoration landscaping but the shape of the landfill cannot be integrated with the surrounding landform	• Minor environmental impact at local scale because of its small scale of development • Relatively larger environmental impact at territorial scale because diversion of waste collection vehicles will be required for a longer period after the relatively short duration of landfilling operation at the Extension • No unacceptable environmental impact anticipated
Option 2	• No need to encroach into CWBCP	• Development scale is larger than Options 1a and 1b with the tipping area is located at around 100m from the existing development • Some diversion of waste collection vehicles to more remote landfills will be required (for less duration than Options	• Environmental impacts at local scale can be mitigated by careful design, good site operation management and restoration arrangement • Additional environmental impact at territorial scale cannot be avoided because there are no other similar waste facilities in the south-east region of the SAR • The landscape impact can be minimised by	• Relatively greater environmental impacts at local scale but lower impacts at territorial scale when compared with Options 1a and 1b • Impacts at local scale can be mitigated • Some environmental impact at territorial scale because diversion of waste collection vehicles will be required after the medium duration of

Criteria	Environmental Benefits	Environmental Dis-benefits	Can Environmental Dis-benefit be avoided/ mitigated?	Conclusion
		1a and 1b), generating additional environmental impact at territorial scale • Visible from most of the existing sensitive receivers and difficult to integrate with the surrounding landforms	careful restoration landscaping but the shape of the landfill will create a narrow valley between the landfill and the surrounding landform	landfilling operation at the Extension • No unacceptable environmental impact anticipated
Option 3a	• Some diversion of waste collection vehicles to more remote landfills may be required (for shorter duration than Options 1a, 1b and 2), generating relatively minor additional environmental impact at territorial scale • Visible by most sensitive receivers but able to integrate with the surrounding landform with appropriate landscape treatment	• Need to encroach approximately 3 ha into CWBCP comprising habitats of low to moderate ecological value • Development scale is the second largest with the tipping area is located at around 100m from the existing development	• Environmental impacts at local scale can be mitigated by careful design, good site management and progressive restoration arrangement • Impact on the natural habitats of low to moderate ecological value within the CWBCP can be compensated by woodland planting as part of the restoration thus enhancing the ecological value in the area • The encroached area within the CWBCP can also be developed for useful afteruse for education and recreational purposes following closure of the Extension and can provide direct linkage to the CWBCP, which is currently not accessible from the TKO area	• Relatively greater environmental impact at local scale but can be mitigated • Will encroach into CWBCP with low to moderate ecological value but can be mitigated by compensatory woodland plantation • Provide chance to develop useful afteruse of the encroached area of CWBCP for education and recreational purposes • No unacceptable environmental impact anticipated
Option 3b	• Least chance for diversion of waste collection vehicles to more remote landfills to be required • Visible by most visual sensitive receivers but able to integrate with the surrounding landform with appropriate landscape treatment	• Need to encroach approximately 5 ha into CWBCP comprising habitats of low to moderate ecological value • Development scale is the largest of all options with the tipping area is located at around 100m from the existing development	• Environmental impacts at local scale can be mitigated by careful design, good site management and progressive restoration arrangement • Impact on the natural habitats of low to moderate ecological value within the CWBCP can be compensated by woodland planting as part of the restoration thus enhancing the ecological value in the area • The encroached area within the CWBCP can also be developed for useful afteruse for education and recreational purposes following	• Relatively greater environmental impact at local scale of all options considered but can be mitigated • Will encroach into CWBCP with low to moderate ecological value but can be mitigated by compensatory woodland plantation • Provide chance to develop useful afteruse of the encroached area of CWBCP for education and recreational purposes • No unacceptable environmental impact

Criteria	Environmental Benefits	Environmental Dis-benefits	Can Environmental Dis-benefit be avoided/ mitigated?	Conclusion
			closure of the Extension and can provide direct linkage to the CWBCP, which is currently not accessible from the TKO area	anticipated

Amongst the five options, Options 1a and 1b will have the least environmental impacts at local level due to their small scale of development. However, their shorter lifespan will imply that diversion of waste collection vehicles to the other landfills will be required for a longer period, thus generating more environmental impacts at a territorial level. Options 2 and 3a will have greater environmental impacts at both a local scale when compared with Options 1a and 1b but have lower environmental impacts at territorial level since their scale of development and lifespan provided are in the medium term. It is understood that with careful design and good site management and progressive restoration, the local environmental impacts can be mitigated. Option 3b being the largest extension option will generate greater environmental impacts at the local scale and will impact upon the natural habitats within the CWBCP. However, it is noted that the impacts on the CWBCP can be mitigated by compensatory planting and the educational and recreational value of the encroached area, which is currently not used for educational or recreational purpose, can be enhanced with appropriate afteruse development.

Engineering Measures Considered

Engineering measures have been considered to maximize the void space of the Extension while not encroaching into CWBCP. One of the measures considered include building a retaining wall around the waste mound at TKO Area 137, ie creating a "bunker" type landfill. However, to make this measure effective, the retaining wall will need to be very tall (more than 40m) and the construction cost will be very high. The standalone feature will also be difficult to integrate with the surrounding landscape and visually difficult to accept. Notwithstanding these particulars, the void space provided would still be far less than Option 3b. To soften the landscape impact, the retaining wall could be replaced by earth bunds. However, to make the earth bund strong enough to support the weight of the waste, the structure of the earth bund will be massive, which in turn will consume a significant portion of the landfill void space. Hence, the use of engineering measures to maximize the capacity of the Extension in order to avoid encroaching the CWBCP was not put forward for further consideration.

Additional Land take in TKO Area 137

An option to increase landtake within TKO Area 137 has been investigated. To develop an extension with a capacity equivalent to that in Option 3b without encroachment into the CWBCP will require more than double the size of the identified site in TKO Area 137 to be used, i.e. an increase from 15 to approximately 34 hectares. However, allocation of approximately 19 hectares of land in this area is not considered feasible.

2.3.3 *Consideration of Alternative Construction Methods and Sequences of Works*

Construction Methods

The construction methods that could be used for the different Extension options are summarised in *Table 2.3c*.

In general, the construction methods to be used for all Extension options at TKO Area 137 and the existing SENT Landfill Infrastructure Area will be the same. The Extension Site will be formed by filling, instead of excavation in the SENT Landfill Infrastructure Area and the TKO Area 137. This method will ensure smaller amount of excavated material to be generated and avoid the base of the landfill intercepting the groundwater level, which is relatively shallow in TKO Area 137. The other construction activities which involve construction and demolition of infrastructure and construction of base liner and leachate and landfill gas collection systems. Typical construction practices in Hong Kong will be adopted. With the implementation of standard pollution control measures, no adverse environmental impacts are anticipated. Hence, alternative construction methods for works in the TKO Area 137 and the existing SENT Landfill Infrastructure Area were not identified.

Table 2.3c Construction Methods for Each Extension Options

Location	Option 1a	Option 1b	Option 2	Option 3a	Option 3b
At TKO Area 137	• Site formation by filling rather than excavation • Construct new infrastructure area by typical method, including the assembly of pre-fabricated plant equipment	• Site formation by filling rather than excavation	• Site formation by filling rather than excavation • Construct new infrastructure area by typical method, including the assembly of pre-fabricated plant equipment	• Site formation by filling rather than excavation • Construct new infrastructure area by typical method, including the assembly of pre-fabricated plant equipment	• Site formation by filling rather than excavation • Construct new infrastructure area by typical method, including the assembly of pre-fabricated plant equipment
At Existing SENT Landfill Infrastructure Area	• No construction work required	• Minor construction work with typical method to connect the Extension to the existing treatment facilities	• Demolish the existing structure using typical method to dissemble the tanks, plant and equipment	• Demolish the existing structure using typical method to dissemble the tanks, plant and equipment	• Demolish the existing structure using typical method to dissemble the tanks, plant and equipment
At CWBCP	• No construction work required	• No construction work required	• No construction work required	• Slope formation	• Slope formation • Tunnel excavation
Alternative construction method identified	Alternatives not identified as the typical construction method is the simplest, most commonly used and will not create adverse environmental impact with standard pollution control measures	Alternatives not identified as the typical construction method is the simplest, most commonly used and will not create adverse environmental impact with standard pollution control measures	Alternatives not identified as the typical construction method is the simplest, most commonly used and will not create adverse environmental impact with standard pollution control measures	Alternatives not identified for works in TKO Area 137 and the existing SENT Landfill Infrastructure area as the typical construction method is the simplest, most commonly used and will not create adverse environmental impact with standard pollution control measures Alternatives are identified	Alternatives not identified for works in TKO Area 137 and the existing SENT Landfill Infrastructure area as the typical construction method is the simplest, most commonly used and will not create adverse environmental impact with standard pollution control measures Alternatives are identified

Location	Option 1a	Option 1b	Option 2	Option 3a	Option 3b
				for the slope formation work: • Blasting using explosives • Excavation using hydraulic rock breakers • Use of non-explosive demolition agent	for the slope formation work: • Blasting using explosives • Excavation using hydraulic rock breakers • Use of non-explosive demolition agent Alternatives are identified for the tunnel construction work: • Tunnel boring • Drill and blast

For Options 3a and 3b, which will encroach into the CWBCP, excavation of the natural slopes during site formation will however be unavoidable. The construction methods identified for the slope formation work, their respective environmental benefits and dis-benefits, as well as other considerations are summarised in *Table 2.3d*.

As described in *Table 2.3d*, the use of non-explosive agents will create the least environment impacts. However, it is very expensive and time consuming to use this method to form the large slope area, thereby significantly lengthening the overall construction period and delaying the opening of the Extension. As this method cannot meet the programme, it is not preferred. It should also be noted that by utilising the blasting method any impacts are confined to a far shorter duration. No adverse environmental impacts are anticipated for the blasting method. The blasting method, which avoids prolonged adverse environmental impacts to the maximum practicable extent, is the preferred option. In fact, this method had been used for slope formation work during the construction of the existing landfills and are commonly used in other construction projects in Hong Kong.

For Option 3b, in order to drain surface water from the low point at the south-eastern corner of the Extension, two small drainage tunnels (2m diameter) will be required. The construction methods identified for the tunnel construction, their respective environmental benefits and dis-benefits, as well as other considerations are summarised in *Table 2.3e*.

As described in *Table 2.3e*, the alternative methods will generate different environmental impacts: tunnel boring will have continuous but lower impacts while blasting will have relatively higher environmental impacts but at instantaneous duration. Since the majority of the environmental impacts will be confined within the tunnel, the overall environmental impacts associated with both options are comparable. However, the merit of tunnel boring is its higher productivity and a better controlled excavation profile. Residual issues requiring careful management related to safety concerns over the use of explosives in confined space in close proximity to potential sources of landfill gas. Tunnel boring is the preferred option.

Table 2.3d Construction Methods for Slope Formation Work

Construction Method	Environmental Benefits	Environmental Dis-benefits	Can Environmental Dis-benefit be avoided/ minimised/mitigated?	Other Considerations	Evaluation
<u>Blasting Using Explosives</u> Shotholes are drilled in the rockface, which are then filled with explosive. The blast will ensure the rock to be adequately fragmented to allow it to be removed by excavation plant.	• Impact restricted to instantaneous noise, dust and vibration (i.e. short impact duration)	• Relatively high noise, dust and vibration during the blast	The environmental dis-benefits can be minimised by appropriate design of the blasting operations and adopting the following well proven control measures: • The quantity of explosive used and the dimensions and spacings of shotholes can carefully designed to minimise air overpressure, flyrock generation and ground-borne vibration • Remove loose material and stones in the site before blasting • Wet the blasting area prior to blasting to minimise dust • Use of fine blast nets, screens and other protective covers to prevent the projection of flying fragments and material resulting from blasting	• Relatively quick and more cost effective • Can fit the tight construction programme to meet the target opening day of the Extension • Well proven method used in the construction of all three existing landfills and common large scale slope formation work	• The magnitude of environmental impacts is the highest but the duration is very short • Impact can be minimised by careful design of blasting method • Shortest construction period and can meet the target opening day of the Extension • Proven and cost effective method used in the construction of previous landfills in Hong Kong

Construction Method	Environmental Benefits	Environmental Dis-benefits	Can Environmental Dis-benefit be avoided/ minimised/mitigated?	Other Considerations	Evaluation
Excavation Using Hydraulic Rock Breakers Using conventional hydraulic rock breaker to break the rock into fragment to allow it to be removed by excavation plant.	• Less noisy, dusty and lower vibration than blasting method	• Need longer construction time with continual use of noisy hydraulic breakers	• Noise can be minimised by reducing the number of hydraulic rock breakers to be used at any one time. As works will be carried out on steep slope, it is not possible to use removable noise barrier to minimise the noise impact.	• Require more time than the blasting method and less cost effective • Construction period will be much longer causing potential delay to the opening of the Extension	• Magnitude of environmental impacts is less than the blasting method but the impact duration is much longer • Impact can be minimised by controlling the number of plant working on-site at any one time mitigation measures • Longer construction period than the blasting method and will cause delay to the opening of the Extension
Use of Non-explosive Demolition Agent Introduce a mixture of inorganic powder with water into pre-drilled holes in the rock mass as a slurry. On hardening, the slurry expands and causes the rock mass to shatter. The fragmented rock will then be removed by excavation plant	• Quiet and will not generate dust and vibration	• None	• None	• Very expensive and time consuming, usually only used where explosive demolition is impractical (e.g. too close to developments) and in small-scale work • Construction period will be much longer causing delay to the opening of the Extension	• Least environmental impacts • Very expensive and time consuming which will results in the longest construction period and cause delay to the opening of the Extension

Table 2.3e Construction Methods for Drainage Tunnel

Construction Method	Environmental Benefits	Environmental Dis-benefits	Can Environmental Dis-benefit be avoided/ minimised/mitigated?	Other Considerations	Conclusion
Tunnel Boring	• Continuous low vibration and noise generation	• Longer impact period	• Environmental impacts are mostly confined to within the tunnel	• Controlled excavation profile • Higher production rates but relatively more expensive	• More efficient
Drill and Blasting	• Impact restricted to instantaneous noise and vibration	• Higher vibration and noise	• Environmental impacts are mostly confined to within the tunnel	• Safety consideration of the use of explosives in confined space of tunnels in close proximity to potential sources of landfill gas • Lower production rates but relatively cheaper	• Less efficient and have potential safety concerns

2.3.4 *Construction Sequences*

The construction sequence for Options 1a and 1b is relatively flexible due to the small scale of the works, i.e. site formation for landfill base and the construction/modification of the infrastructure area can be undertaken concurrently or sequentially. Undertaking the work concurrently can shorten the impact duration associated with the construction work but the magnitude of impact could be slightly higher. On the other hand undertaking the work sequentially will reduce the cumulative impacts but lengthen the impact duration. With the implementation of standard pollution control measures, neither construction sequence will cause adverse environmental impacts.

For Options 2, 3a and 3b, to ensure seamless operation of the infrastructure at the existing SENT Landfill, the new infrastructure at the Extension, which will also be designed to treat leachate and landfill gas from the existing SENT Landfill, will have to be constructed and commissioned before decommissioning and demolishing the existing infrastructure. Also, to make way for the site formation of the landfill base, the existing infrastructure will have to be demolished before the landfill base is formed. Due to the shape and size of the Extension Site, it is necessary to form and line the entire base of the landfill prior to commencement of waste placement, and to commence placement of waste against the newly-formed cut slope within the first year of landfill operation (for Options 3a and 3b). As a result, it will be necessary to form the entire cut slope at an early stage of the landfill development, i.e. completed before commencement of landfill operation. Although this may result in a greater concentration of construction activity, it also ensures that the disturbance due to the slope formation work is limited to a shorter timeframe and will ensure a safe operating condition during landfilling. Given the constraints described above and the fact that the construction work will be required to complete within 24 months to ensure timely opening of the Extension, no other practical and reasonable alternative construction sequences have been identified.

2.3.5 *Work Sequence*

The Extension will be developed in Phases. Applicable to all options, within each Phase, it is proposed that filling should commence on the western side (ie closest to Wan Po Road and the nearby sensitive receivers). The western perimeter of the Phase will be filled to its intended height (each Phase will comprise approximately a 20m increase in elevation of the landfill), and the outward face of the landfill will be progressively restored (ie the final cap will be placed and preliminary landscape planting will occur). This completed portion of the Phase will then act as a screen to minimise noise, visual and air quality impacts from the tipping operations within the remaining part of that Phase.

2.4 *THE PREFERRED OPTION*

With reference to Clause 3.3.2 of the Study Brief, consideration shall be given to avoid or minimize the encroachment onto the CWBCP and the disturbance to the ecosystems in the adjacent areas including the CWBCP. Hence, Options 1a, 1b and 2, which do not encroach the CWBCP are considered first.

Of the five options examined, Options 1a and 1b would have the least impacts on CWBCP and the sensitive receivers in the vicinity in terms of both construction and operation. However, the additional landfill void capacity provided by these options is very small making them very inefficient in terms of cost and land use. The lifespan of these options is very short and thus will result in waste collection vehicles travelling to the more remote landfills in the short-term. This will result in more environmental impacts at territorial level. These options are thus not recommended.

Option 2's void capacity is about 6 times than that of Option 1b and will not require additional land within the CWBCP. However, the void capacity will only be 10 Mm^3 (i.e. still well below the target capacity), and the construction cost will be more expensive than that of the existing strategic landfills. Compared with Options 3a and 3b, the void space provided by Option 2 is 50% less than these options. Some diversion of the waste collection vehicles to the other two more distant strategic landfills will be required and hence there is potential for additional environmental impacts at a territorial level. In terms of environmental impacts at the local level during both construction and operation phases this option will be similar to Options 3a and 3b, except that no natural habitat will be directly impacted. As discussed in the previous section, engineering measures, such as the use of a large retaining wall and earth bund have been investigated but were found to create adverse visual impacts, to be very expensive and will only gain a small increase in void space.

Options 1a, 1b and 2 cannot satisfactorily fulfil the requirement of maximising landfill space to meet the landfill space demand in Hong Kong for the next 20 years and so Options 3a and 3b are considered further.

It is recognised that Options 3a and 3b will both have a direct impact on the CWBCP. In terms of maximising void capacity, making the most effective use of available land and achieving the highest cost effectiveness, Option 3b performs the best. The local environment impacts are similar to those associated with Option 2 and can be mitigated by careful design and good site practices. As discussed in *Section 2.3.2*, the encroachment area is primarily a cliff face without any hiking trail and proper access. It is unlikely that public enjoyment of the CWBCP would be affected. In terms of impacts on natural habitats, the encroachment area is of low to moderate ecological value with flora and fauna commonly found within the CWBCP. Adverse ecological impacts are not expected (refer to *Section 9* of this EIA Report for details of the ecological impact assessment). When the encroached area is restored together with the fully restored landfill in the vicinity after the completion of landfill operation, it is anticipated that the restored Extension could be enriched to provide a higher amenity value.

It is understood that there is a public need for both landfill space and country parks. The loss of void space as a result of not maximising the use of this Extension Site would require void space to be provided at other landfills, resulting in a shortfall of space at the other landfills and an overall shortfall of landfill space in Hong Kong within the next 20 years. When balancing all of the above considerations and taking account of the recommended benefits and dis-benefits of all the options, Option 3b, gives the largest void space and lifespan while avoiding prolonged adverse environmental impacts to the maximum practicable extent. With proper design and mitigation, Option 3b is recommended as the preferred option for detailed environmental impact assessment.

The recommendation for adopting Option 3b as the preferred option for the SENT Landfill Extension was taken to the Country and Marine Parks Board (CMBP) on 22 May 2007 and was agreed by the CMPB subject to the following conditions:

- Government to press ahead a series of waste management strategy including the commissioning of the Integrated Waste Management Facilities by 2014;
- EIA of SENT Landfill Extension to be approved by the ACE and the EIA report to be presented to CMPB members for consideration;
- EPD to report to CMPB to update members progress of the waste management strategies; and
- Progressive restoration to be adopted for the SENT Landfill Extension. The encroachment area to be properly restored before it was returned to AFCD for country park use.

2.5 *CONSIDERATION OF CONTRACTUAL ARRANGEMENTS*

The contractual options for procuring the Extension have been thoroughly assessed taking into consideration the interface with the existing SENT Landfill contract. In general, the two broad categories are:

- Design, construct and operate by one contractor (i.e. the same contractor will manage both the existing SENT Landfill and the Extension)
- Design, construct and operate by two contractors (i.e. the existing SENT Landfill and the Extension will be managed by two separate contractors)

The key difference to the design is the requirement for modifying the existing landfill gas extraction wells and the placement of liner on the piggybacked portion of the Extension. Under the "one contractor" scenario, the two landfills (ie the existing SENT Landfill and the Extension) will become one landfill. It will not be required to install a leachate containment system on top of the final cap of the existing SENT Landfill to separate the two landfills.

For the "two separate contractors" option, the piggybacked area will have to be separated by a new leachate containment system so that management of the two landfills (eg collection and treatment of leachate and landfill gas) will be completely separated. Modification of the existing landfill gas extraction wells in the piggybacked area will be required so that the liner of the leachate containment system of the Extension will not be damaged by existing gas wells as a result of differential settlement of waste mass of the existing SENT Landfill.

The environmental implications of the different contractual options are evaluated in *Table 2.5a*.

Table 2.5a ***Difference of Environmental Implications Associated With Different Contractual Options***

Environmental Aspects	**Differences**
Air Quality	No difference as the modification and lining works for the "two contractors" option is not dusty.
Noise	"Two contractors" option is considered the worst case scenario due to the use of powered mechanical equipment for the modification and lining works.
Water Quality	No difference as the total leachate quantity will not be affected.
Waste	No difference as the modification and lining works will not generate significant amount of waste.
Landfill Gas Hazards	"Two contractors" option is considered as the worst case scenario due to the possibility of contact with landfill gas during the well modification and lining works.
Ecology	No difference to the ecological resources to be affected.
Landscape and Visual	No difference to the landscape resources to be affected.

For the purpose of assessing the worst case scenario for this EIA, the "two contractors" option, which is technical and contractual more complex, has been assumed.

3 *DESCRIPTION OF THE EXTENSION*

3.1 *SITE DESCRIPTION*

The Extension Site is located at TKO Area 137 with a piggyback area occupying the southern slope of the existing SENT Landfill and its infrastructure area and extends over the boundary of the Clear Water Bay Country Park (CWBCP). *Figure 3.1a* shows the location of the Extension Site.

The Extension Site is surrounded by existing and future developments on the northern, southern and western sides. To the north of the Site is the existing SENT Landfill. To the south and west of the Site is a reclaimed area currently used by the Civil Engineering and Development Department (CEDD) for a fill bank operation. The eastern side of the Site is bounded by the natural headland of the CWBCP. The sides of the natural headland adjoining the Site are steep, undeveloped and support grassland or shrub vegetation. This headland forms a natural screen between the Extension and the largely undeveloped environments of Clearwater Bay and Port Shelter further to the east. The TKO New Town lies approximately 3.5km to the north of the Extension Site.

The nearest existing development to the Extension Site is the industrial development within TKOIE located to the northwest and separated by Wan Po Road. The main access route to the SENT Landfill and the Extension Site is via Wan Po Road.

3.2 *SITE HISTORY*

In the 1990s, the SENT Landfill and the surrounding area were relatively remote and lightly populated. In the intervening years, there has been considerable development nearby. Further reclamation has occurred on the seaward side of the SENT Landfill. This reclamation is now occupied by the TKOIE and the TKO Area 137, where the Extension Site will be located. The majority of TKO Area 137 is currently occupied by the temporary public fill bank. The fill bank is used for storage of inert construction and demolition material, pending its beneficial reuse in construction projects elsewhere.

The Extension Site area within the CWBCP, designated in 1979, is undeveloped. Part of the natural coastline of the CWBCP was lost due to the development of the SENT Landfill and the reclamation of TKO Area 137.

3.3 *DESIGN OF THE EXTENSION*

The Extension is a piggyback landfill, occupying the existing SENT Landfill infrastructure area, 15 ha of TKO Area 137 and approximately 5 ha of the CWBCP. A layout plan of the Extension is shown in *Figure 3.3a*. The new infrastructure area will be located to the south of the waste filling area.

Figure 3.3b shows the layout of the infrastructure area, which houses the landfill gas treatment facility and leachate treatment plant, offices, maintenance workshops, etc.

The Extension covers an area of around 50 ha (including all site infrastructure). Discounting the void space required for miscellaneous engineering works and daily and intermediate covers, the total net void capacity for waste is estimated to be around 17 Mm^3. The lifespan of the Extension is estimated to be around 6 years, commencing operation in 2013 (1).

The design of the Extension comprises the following key components:

- Landfill liner and capping;
- Landfill gas management system;
- Leachate management system;
- Surface water management system;
- Groundwater management system; and
- Site infrastructure.

The design of these components is described in the following sections.

3.3.1 *Landfill Liner and Cap*

The Extension will be designed and constructed as a fully contained facility incorporating multilayer composite liner systems covering the entire surface area of the Extension Site where waste will be deposited. Four different liner systems will be used for the different areas of the Extension Site, as follows:

- Basal;
- Rock slope;
- Soil slope; and
- Piggyback

Sections of the liner systems are shown in *Figure 3.3c*. In general, the design of all liner systems contains at least one impermeable layer, ie HDPE liner, a geocomposite clay liner (GCL), a geotextile cushion, and leachate and groundwater drainage layers.

After final levels of waste are reached, a protective soil layer will be placed over the waste before placing the final cap. The final cap comprises non-

(1) It is based on the assumption that the existing SENT Landfill will be closed by about 2012 and the Extension will commencement operation in 2013. However, this commencement year is subject to changes and will follow immediately after the closure of the existing SENT Landfill.

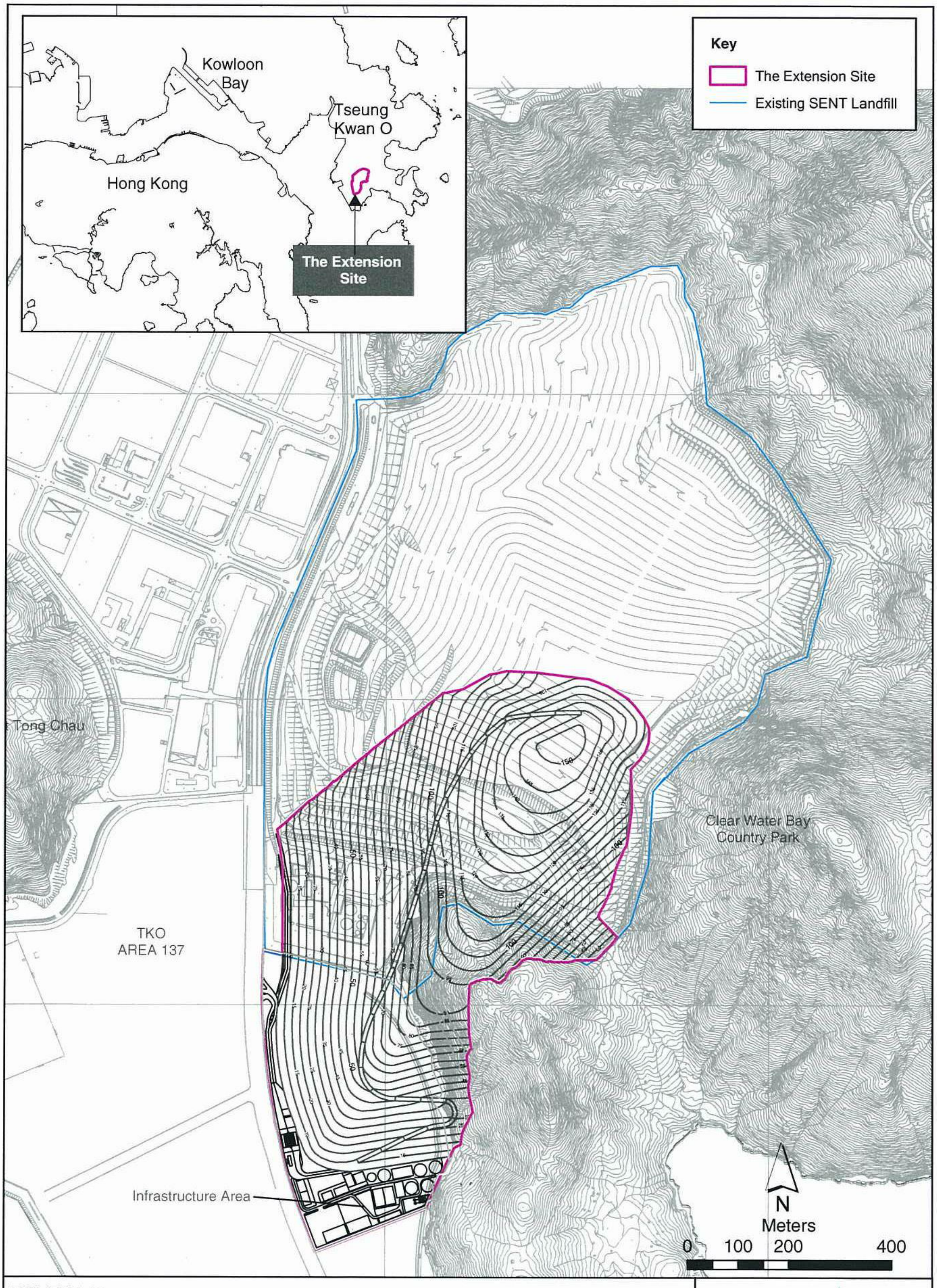

FIGURE 3.1a

Location of Extension Site

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Date: 25/09/2007

Environmental Resources Management
ERM

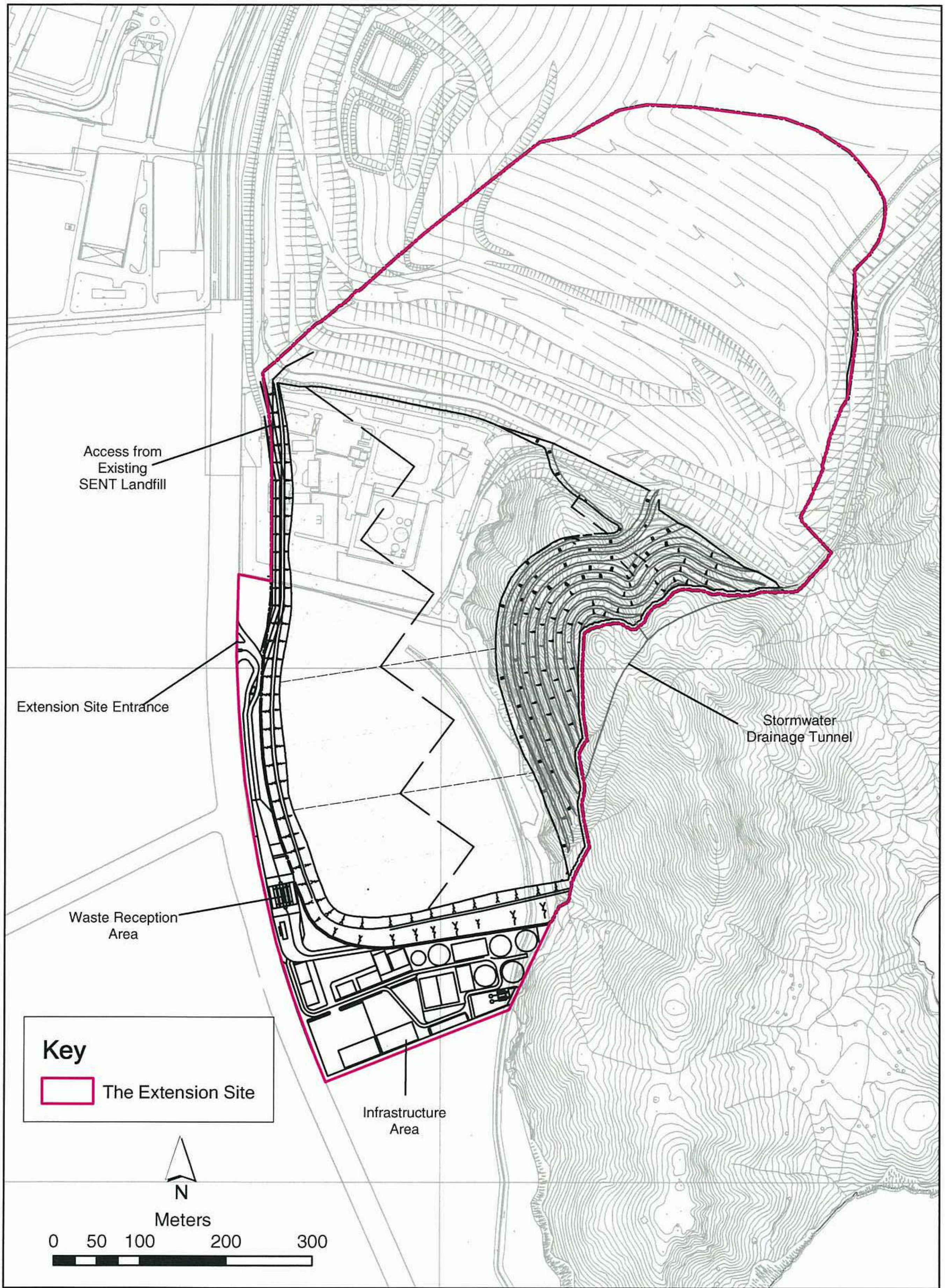

FIGURE 3.3a

Layout Plan of the Extension

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Date: 25/09/2007

Environmental Resources Management ERM

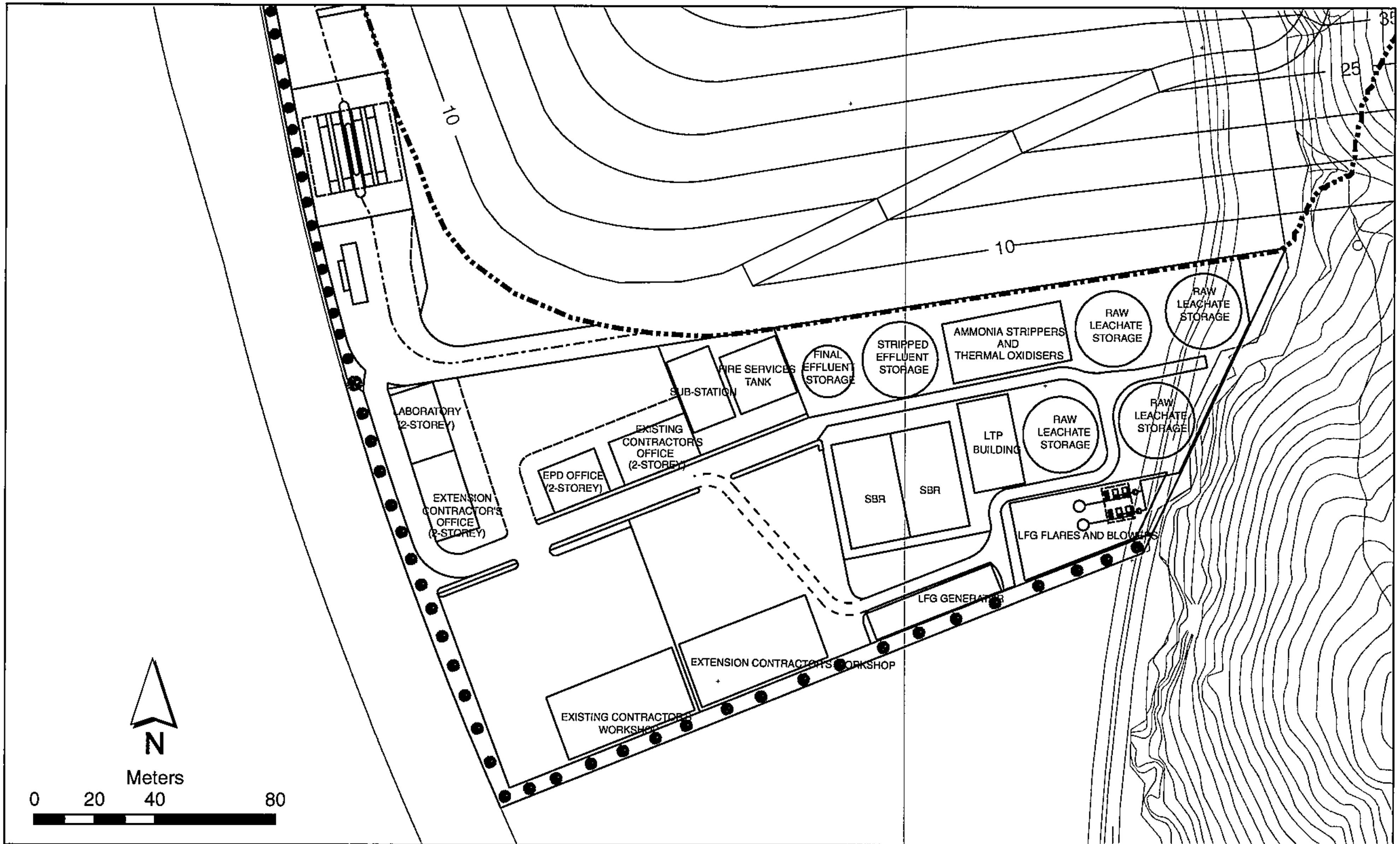

Figure 3.3b

Layout Plan of the Infrastructure Area

File: 0036286_Infrastructure_Layout2.mxd
Date: 22/06/2007

Environmental Resources Management
ERM

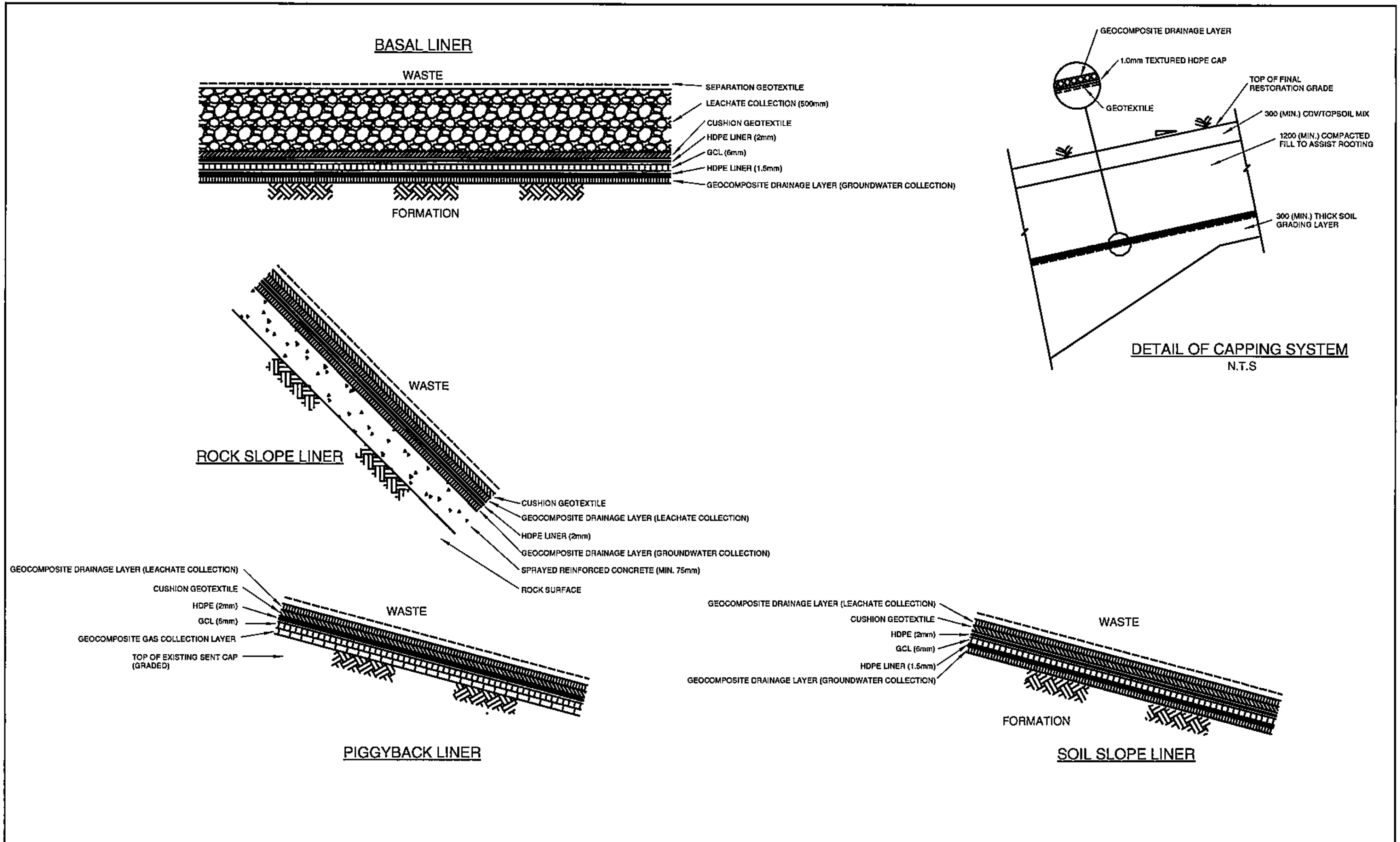

Figure 3.3c

Liner and Cap

File: 0036286_Liner_Capt.mxd
Date: 07/02/2007

Environmental
Resources
Management

ERM

woven geotextile, HDPE liner (impermeable layer), a drainage layer and a soil layer. The impermeable liner and cap will form a containment of void for waste so as to ensure that the waste is completely separated from the surrounding environment. Hence, this containment system will ensure minimal runoff and groundwater entering the waste and prevent off-site migration of leachate and landfill gas.

3.3.2 Landfill Gas Management

Landfill Gas Collectors at the Extension

Three types of collectors are proposed to be included to provide effective collection of landfill gas at the Extension as soon as possible:

- Horizontal collectors above the leachate drainage layer – these have been allowed for at approximately 100m intervals above the basal liner system;

- Horizontal collectors in the waste mass – these have been allowed for at approximately 75m centres; and

- Vertical drilled wells – at 40m centres on the perimeter of the waste boundary and 80m centres within the body of the waste nass.

The locations of these collectors are shown in *Figure 3.3d*. Together with the impermeable liner as part of the intermediate cover system, and the final capping system, these types of collector effectively minimise landfill gas emissions from the Extension at any time during the operation.

Landfill Gas Collectors at the Existing SENT Landfill

To avoid damaging the liner system of the Extension, modifications to the landfill gas collection wells at the southern waste slope of the existing SENT Landfill will be required. The modification work will include removal of well pipes, placement of a concrete cap over the top of the affected wells and installing a short length of pipe to connect the affected wells to the existing gas collection system of the SENT Landfill (see *Figure 3.3e*). If the existing landfill gas collection wells are damaged beyond economical repair and rendered useless or it is considered that there is a need to have greater collection ability during the construction of the Extension, new wells can be drilled to enhance gas collection.

As part of the liner design, a landfill gas drainage layer will be sandwiched between the SENT Landfill cap and the Extension liner (see *Figure 3.3f*). This gas drainage layer comprises a layer of granular fill over the landfill surface and to collect gas emanating from the surface should leakage in the capping system and around the damaged gas wells occur. It also serves a secondary function to provide a mean of collection which may be beneficial after a period, when settlement is or has occurred, and the existing and interim gas collection system and/or cap has suffered damage.

Landfill Gas Collection Pipework

Interim pipework will be required to connect the various collector types in both the Extension and the existing SENT Landfill. The pipework will be laid using either welded HDPE pipes laid over the surface, or a system of reasonable flexible convoluted polypropylene pipe with suitable robust connection methods. The interim pipework can be laid to connect the landfill gas treatment facility at the infrastructure area or to localised temporary gas flares.

Permanent pipework will be installed to eventually connect all gas collectors and allow the gas extracted to be delivered to the landfill gas treatment facility. It will be laid over the surface, provided that the polymer used contains sufficient UV inhibitors to prevent degradation occurring. Alternatively, the pipework will be buried within the landfill cap.

The landfill gas collected from the existing SENT Landfill will be delivered to the landfill gas utilisation plant proposed by GVL and the remaining gas will be delivered to the landfill gas treatment facility located at the new infrastructure area. The landfill gas collected from the Extension will be transferred to the landfill gas treatment facility located in the infrastructure area.

Landfill Gas Treatment Facility

The landfill gas treatment facility will be located in the infrastructure area and will comprise the following key components:

- Condensate knockout pot to remove moisture droplets;
- Gas boosters to provide suction to the well field and pressure to downstream facilities;
- Enclosed flares to efficiently destroy the methane and trace components;
- A control system to ensure safe initiation of the flare burn and subsequent operation; and
- Connections to permit an off-take for utilization of the landfill gas.

The predicted gas yield indicates that a peak combined gas flow from both the Extension and the existing SENT Landfill of approximately 16,600 $m^3 hr^{-1}$ is expected in year 2020, whilst the flow is anticipated to be over 10,000 m^3hr^{-1} over a twenty year period, between 2008 and 2028. The design will include two identical enclosed flares with a capacity of 10,000 $m^3 hr^{-1}$ each, to provide a maximum handling capacity of 20,000 $m^3 hr^{-1}$.

Landfill Gas Utilisation

Landfill gas is flammable, which has value as a renewable fuel and has utilised as such around the world in many applications. The potential

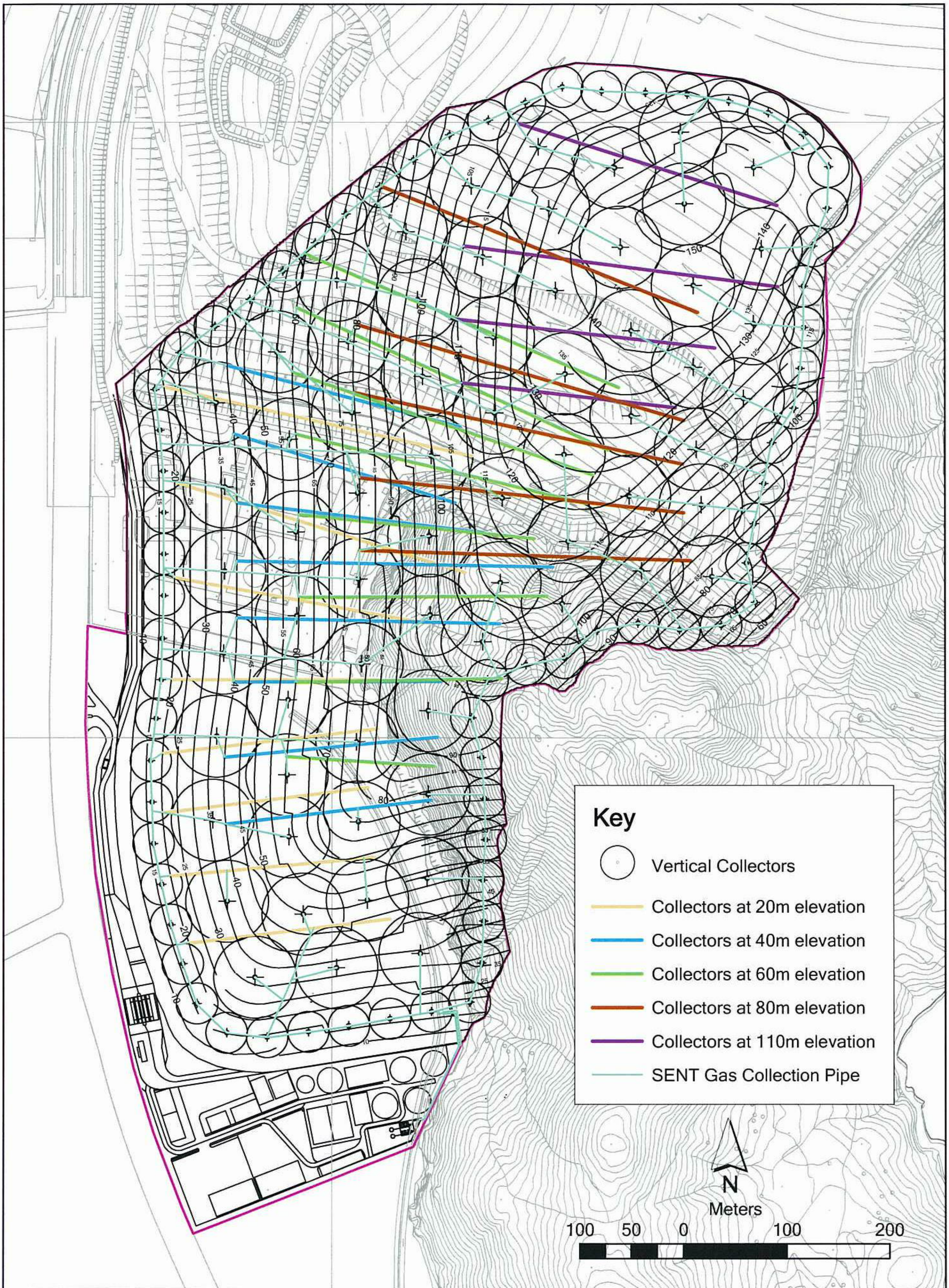

Figure 3.3d

Landfill Gas Collectors for the Extension

File: 0036286_Extension_Gas_Collector.mxd
Date: 28/09/2007

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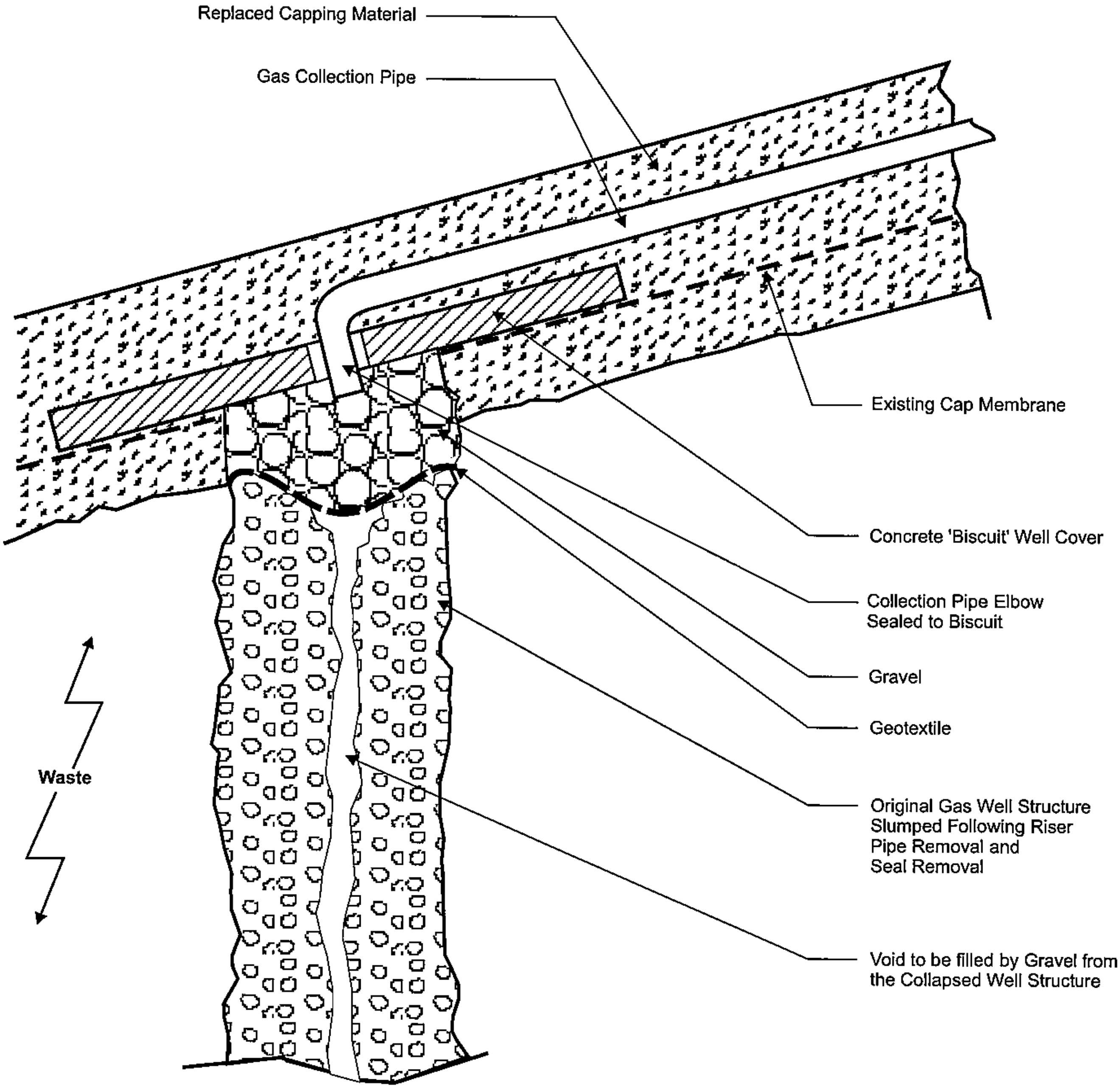

Notes:
1. Bentonite and all permeability materials to be removed from well.
2. No rigid materials likely impose stress on overlying liner system to be used.
3. Collector pipe to be laid to falls sufficient for settlement and to maintain gravity contra-flow of condensate.

Figure 3.3e

Existing Well Re-connection

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DATE: 18/01/2008

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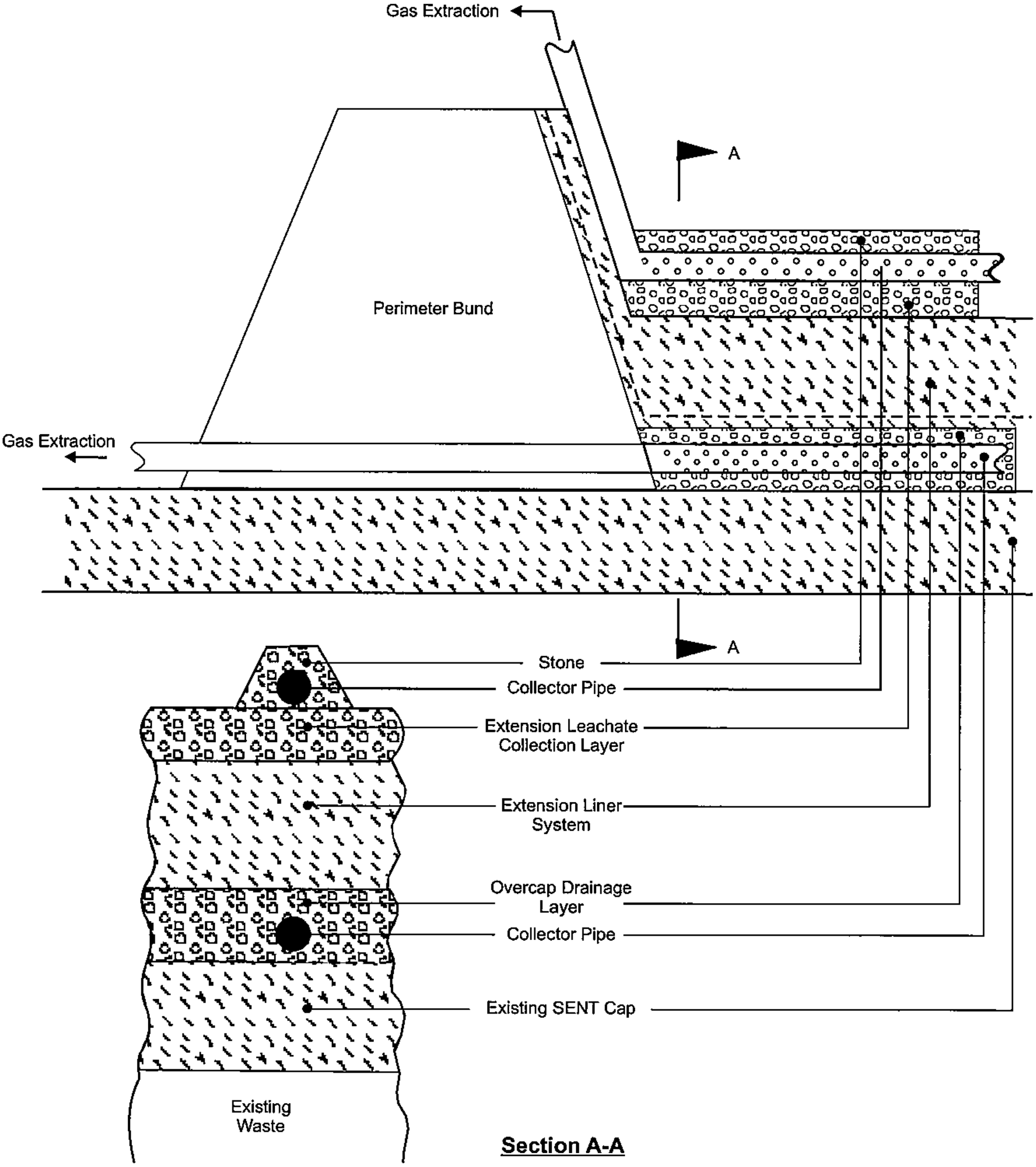

Figure 3.3f

Overcap and Over Leachate Layer Gas Collection

FILE: 0036286Z25a
DATE: 25/09/2007

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utilisation options which may be considered for the landfill gas collected from the Extension include:

- On site utilisation in the leachate treatment plant;
- On-site utilisation for site power requirements;
- Delivery to the proposed landfill gas utilisation plant at the existing SENT Landfill;
- On-site Combined Heat and Power (CHP);
- Dedicated use in the adjacent industrial area. Uses include direct firing in boilers for process heat, or in an absorption chiller to provide for air conditioning or CHP schemes; and
- Power generation for export to the CLP grid.

The precise type of utilisation will be determined during the detailed design stage by the Extension Contractor. For the purpose of the assessment, it is assumed that landfill gas will be used to fuel the LTP while the remaining gas will be flared.

3.3.3 Leachate Management

With the proposed design of the liner and capping systems, water ingress into the Extension will be minimized and off-site migration of leachate will be negligible. Leachate will be contained and collected via the collection system to the LTP in the new infrastructure area. The main features of the leachate management system are:

- Leachate collection system comprising aggregate and geosynthetic drainage layers;
- Leachate extraction system comprising HDPE sideslope risers and collection sumps; and
- The LTP.

Location of the main features of the leachate management system is shown in *Figure 3.3g*.

Leachate Collection System

The leachate collection layer is designed to collect and drain leachate which percolates downwards from the waste. The layer, comprising aggregate (a minimum depth of 300mm) in the basal liner or geosynthetic drainage layer (in the slope and piggyback liners) will be placed on top of the impermeable liner with a layer of cushion (eg geotextile) between the two. Drainage pipework will be installed within the leachate collection layer in the basal liner. At the piggyback and side slope area, leachate will be collected at the geosynthetic drainage layer and flow by gravity to the basal liner where leachate will be collected by the pipwork. The pipework will be manufactured from either HDPE, u-PVC or polypropylene, and will be perforated (with slots or holes) except for the lower 120^{o} of the pipe cross-section, which will be solid to allow for flow of leachate. The leachate drainage pipework will be designed such that the maximum head of leachate above the basal lining system does not exceed 1m. The maximum pipe spacing will be 50m, and the gradient should be at least 1(v) : 50(h). The pipework will collect leachate from the waste and drain it to the collection sumps.

Leachate Extraction System

Leachate will be extracted from the landfill via four collection sumps around the western and southern perimeter of the Extension Site (see *Figure 3.3g*).

The leachate collection sumps will be constructed of pre-cast concrete and will be equipped with submersible pumps to enable leachate to be pumped from the base of the landfill to the leachate collection main, which will transfer leachate to the LTP in the new infrastructure area.

The leachate collection sumps will be accessed by HDPE upslope risers along the toe bund of the Extension, and therefore will not be prone to damage due to movements of the waste mass.

Leachate Treatment Plant

The process flow diagram of the proposed leachate treatment process is shown in *Figure 3.3h*. All processing tanks, except the SBR tanks, will be covered.

The predicted average daily leachate flow from the Extension during its period of operation is 332 $m^3 d^{-1}$. However, the daily flow rate will vary according to seasonal rainfall. The predicted average daily flow from the existing SENT Landfill following restoration is 23 $m^3 d^{-1}$.

The proposed leachate treatment option is to provide an LTP with maximum design flow rate of 1,500 $m^3 d^{-1}$, coupled with a buffer storage capacity of 22,000 m^3. This capacity will be able to cope with the anticipated peak leachate treatment requirement during the last year operation of the existing SENT Landfill when the existing Bioplant will be demolished, and subsequently during the Extension operation. Following full restoration of the existing SENT Landfill, the buffer storage capacity could be reduced, subject to further review, as the leachate generation from the Extension is smaller. *Table 3.3a* summarises the design leachate flow and quality of the LTP.

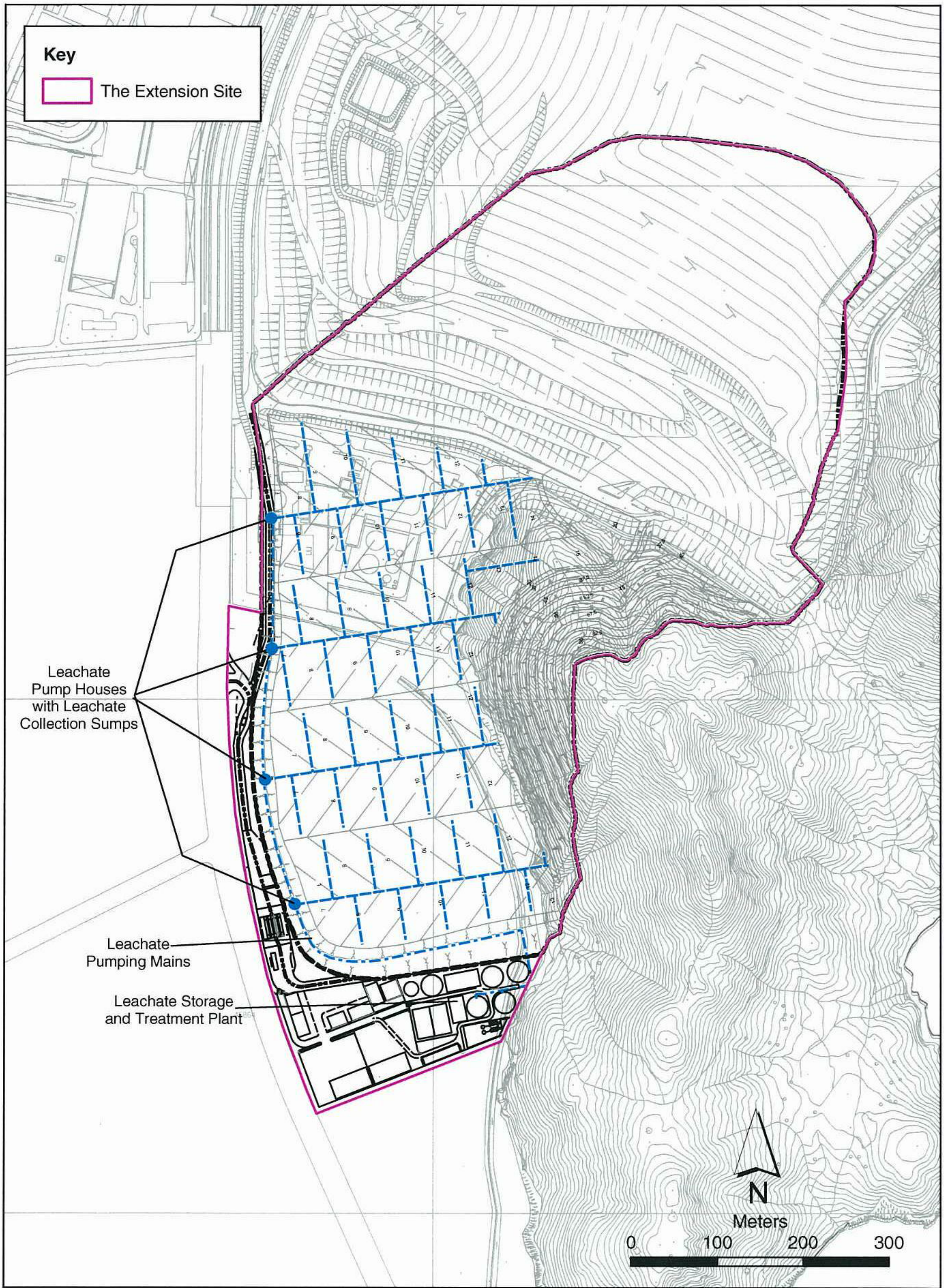

FIGURE 3.3g

Leachate Management System

File: 0036286_Leachate_Magmnt.mxd
Date: 22/06/2007

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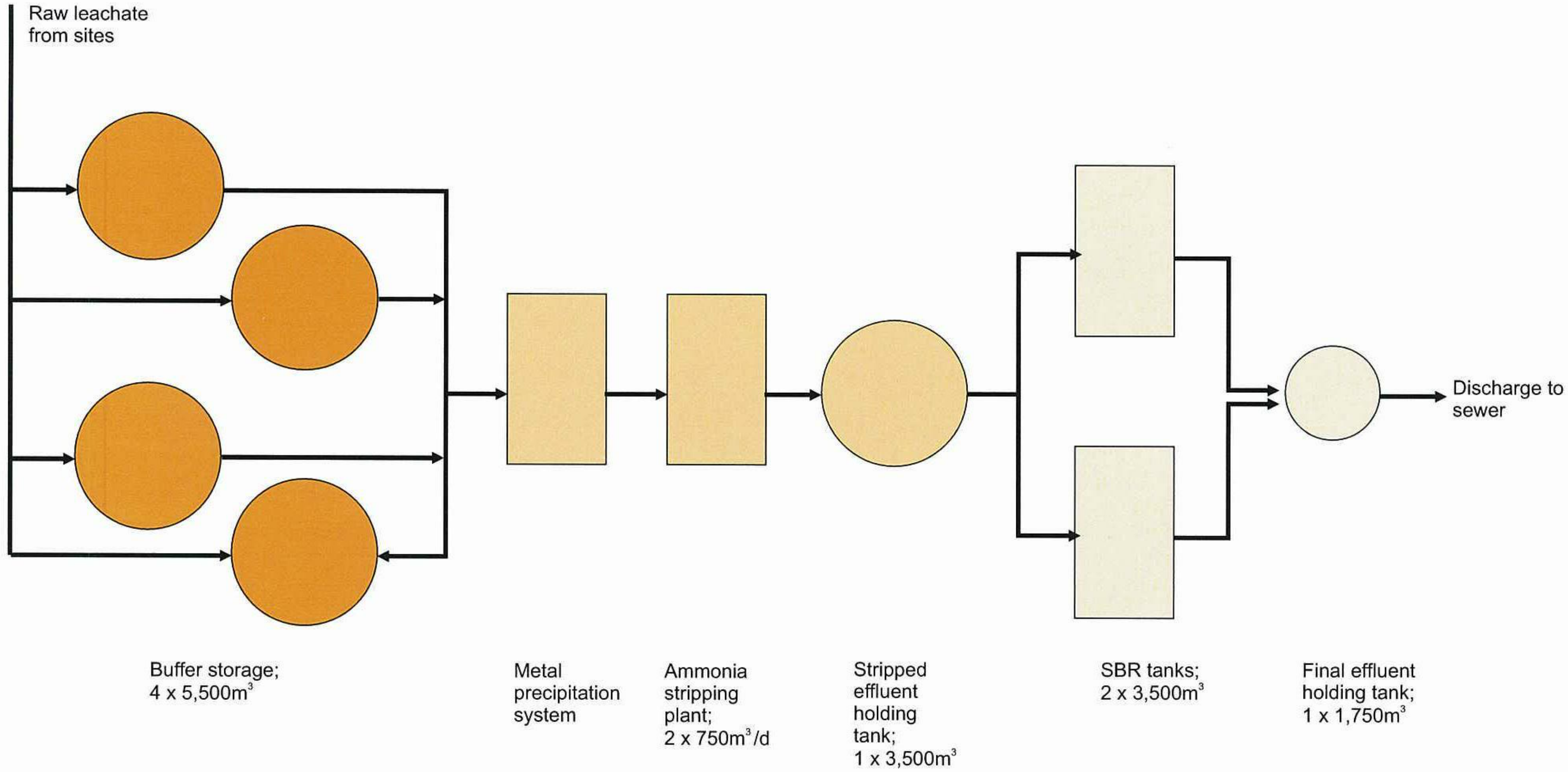

Figure 3.3h

Process Flow Diagram of Proposed Leachate Treatment

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Table 3.3a ***Summary of Design Leachate Flow and Quality Used in Plant Sizing***

Design Flow Rate		1,500		m^3d^{-1}
Design effluent limits				
Total inorganic nitrogen (TIN)		100		mgL^{-1}
Total nitrogen (TN)		200		mgL^{-1}
COD		2,000		mgL^{-1}
Design Raw Leachate Quality	**Mean**	**Max**	**Min**	
Influent NH_4-N	2,500	4,500	1,500	mgL^{-1}
Influent COD	3,000	4,500	2,000	mgL^{-1}
Hard COD	1,000	1,500	650	mgL^{-1}
Hard TKN	75	125	40	mgL^{-1}

From the buffer storage tanks, leachate will be pumped to the metal precipitation system and then to ammonia stripping plant which consisting of two stripping towers, two thermal oxidizer towers (one operating and one on standby), heat exchangers and ancillary equipment. The two ammonia stripping towers, each with a capacity of 750 m^3 d^{-1} can operate alternately to allow for regular maintenance. The stripping process would be operated to remove approximately 92 to 98% of the ammonia, leaving approximately 100 to 200 mg L^{-1} of ammonical nitrogen (NH_4-N) to be removed biologically together with the degradable chemical oxygen demand (COD). The ammonia-laden air then passes to the thermal oxidizer where the ammonia will be oxidized to nitrogen gas prior to discharge to atmosphere.

Stripped effluent will be stored in a holding tank from where it will be fed to the Sequential Batch Reactor (SBR) tanks. The SBRs will operate on a 24-hour cycle with denitrification. From the SBRs, treated leachate is decanted, after a settling period, into the final effluent holding tank. This allows continuous discharge of the treated effluent to the receiving foul sewer. The Sewerage Impact Assessment has confirmed that the existing sewage infrastructure is adequate for the predicted flows.

The LTP will be commissioned during the last year of operation at the SENT Landfill and will replace the existing Bioplant of the SENT Landfill. The LTP is capable of treating leachate to comply with the discharge standard stipulated in the existing discharge license of the SENT Landfill. Following closure and restoration of the existing SENT Landfill, leachate generation at the existing SENT Landfill will be reduced significantly. It is estimated that the averaged combined leachate flow from the restored SENT Landfill and the operating Extension will be around 355 m^3 d^{-1} while the peak treated effluent flow will be limited to 1,000 m^3 d^{-1}. The LTP is capable of treating leachate to comply with discharge standards stipulated in EPD's *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewage Systems, Inland and Coastal Waters*.

3.3.4 Surface Water Management

The surface water management system for the Extension is designed to minimise surface water entering the Extension Site from the upgradient area of CWBCP and the restored slope of the existing SENT Landfill. It also controls contaminated runoff from the Extension Site entering the surrounding area. Key features of the surface water management system include:

- Permanent perimeter cut-off channel and drainage tunnels;
- Temporary cut-off channels; and
- Sediment traps and oil separator.

The location of these features is shown in *Figure 3.3i*.

Permanent Perimeter Cut-off Channel

A permanent cut-off channel will be constructed along the waste boundary of the Extension and will connect with the drainage features that are incorporated into the SENT Landfill restoration design. The southern part of this cut-off channel will drain by gravity to the south-eastern corner of the Extension. The northern part of this cut-off channel falls to the north, to a low point near the south-eastern corner of the existing SENT Landfill, where it will meet up with the existing cut-off channel for the existing SENT Landfill.

At present, the existing SENT Landfill cut-off channel traverses the eastern edge of the landfill, and then turns to the west, towards the existing SENT Landfill infrastructure area. As part of the Extension development, this portion of the channel will be covered by waste. The design of the surface water management system has therefore included the construction of a twin drainage tunnel (2,000mm diameter) to drain surface water collected at the low point near the south-eastern corner of the existing SENT Landfill to TKO Area 137. The outfall of the twin drainage tunnels will join the perimeter cut-off channel at the eastern boundary of the Extension in TKO Area 137.

Following completion of the Extension, an additional channel will be constructed around the eastern flank of the Extension and then to the west, to convey flows directly to the western boundary of the Extension Site avoiding the low point to the east.

Temporary Cut-off Channel

Prior to completion of the Extension, temporary collection and pumping of surface water (at low points) will be required as part of the surface water management plan, to avoid any discharge of stormwater eastwards into Clear Water Bay.

Run-off that has been in contact with waste will be treated as leachate and collected for treatment at the LTP.

Rain falling onto the restored slopes of the Extension will be collected by surface water channels on the slopes, and drained to the perimeter of the Extension Site.

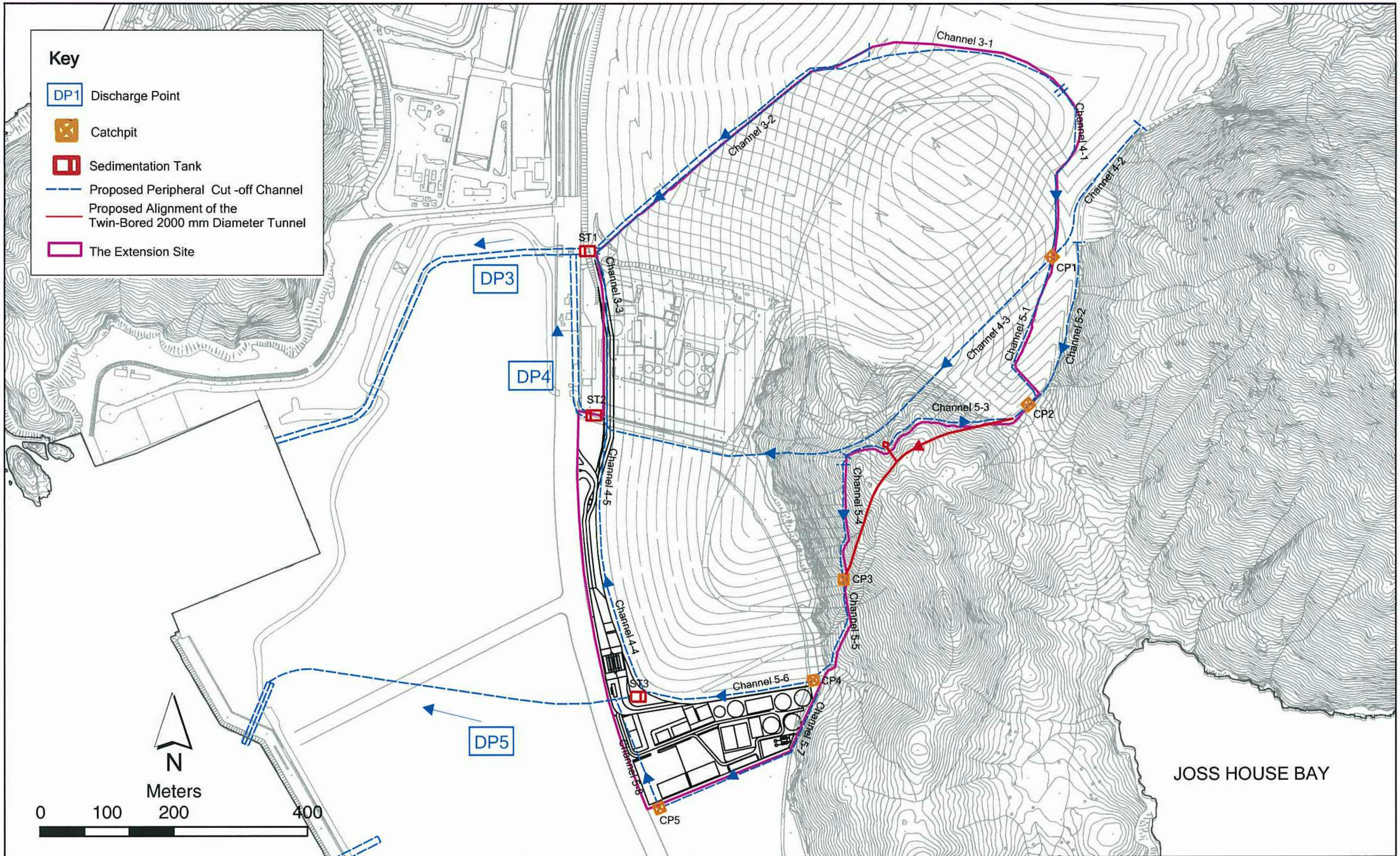

Figure 3.3i

Surface Water Drainage

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Date: 25/09/2007

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Rain falling onto areas of active tipping and daily cover areas will infiltrate into the waste and be collected by the leachate collection system, for treatment prior to discharge into the foul sewer.

A series of temporary cut-off channels will be constructed on the side slopes and on the southern waste slopes of the existing SENT Landfill that lie within the Extension. These channels will intercept rain falling on areas above the active tipping face, and divert it to the perimeter cut-off channels.

Within each development phase, areas outside the active tipping face will be covered with intermediate cover. In order to minimise odour emission, leachate generation and to control contamination of surface water runoff, the intermediate cover will include an impermeable liner. Temporary surface water management will be provided in order to collect rain falling onto areas of intermediate cover, and divert the clean runoff to the perimeter cut-off channels.

Sediment Traps and Oil Separator

All surface water drainage channels that discharge either directly or indirectly to surface watercourses or to the sea will be provided with sediment traps, stilling basins and oil separators to control suspended solid concentrations and oil in the surface water discharged from the Extension Site.

3.3.5 Groundwater Management

Groundwater will be managed to prevent a hydrostatic build-up of water below the base liner and to prevent contamination by leachate. The basal liner has been designed to contain two impermeable layers to avoid leachate migrating out of the lining system. The design of the leachate collection system will also minimise the leachate head and thus minimise the driving force of leachate migration through any holes in the base and sideslope liner system. A geocomposite drainage layer below the base liner (see *Figure 3.3c*) will collect and transport groundwater away from the liner. The base of the Extension has been kept above the groundwater level, in order to minimise difficulties during construction, and minimise the consequences of any leakage from the lining system.

The groundwater collection layer on the side slopes of the Extension will be connected to groundwater diversion pipe trenches, and groundwater flows will be diverted to a series of groundwater collection sumps along the western boundary of the Extension adjacent to the leachate sumps before discharge off-site (see *Figure 3.3j*). The design has allowed for the provision of a submersible pump in the sump for pumping to the leachate collections sumps (adjacent) in the event of contamination being detected.

3.3.6 Site Infrastructure

The new infrastructure area is located south of the waste filling area. This area is occupied by offices, maintenance workshops, landfill gas treatment facility and the LTP, as shown in *Figure 3.3b*. A loop road system is designed to provide access to all tanks and equipment within the infrastructure area. A 5m wide landscape planting strip has been allowed along the boundary to screen the access road and the infrastructure area.

Other site infrastructure includes the weighbridge and vehicle washing facility, located to the north of the new infrastructure area. The weighbridges will be enclosed and will be maintained at a slight negative pressure. Air extracted from the enclosed area will pass through the air scrubbing system prior to discharge to the atmosphere.

The vehicle washing facility will be located just before the out-weighbridge. The water spray at the facility will ensure that the outside of the whole vehicle to be washed so as to minimize potential odour impacts from the RCVs leaving the Extension Site. The wash water will be drained to the LTP for treatment.

3.4 *EXTENSION DEVELOPMENT PROGRAMME*

The key tasks of the Extension development are shown in *Figure 3.4a*. Construction works will commence two years prior to commencement of waste filling. The Extension will be developed and operated under six phases, each will last for about one year. Upon the completion of each phase, the areas that reached the final profile will be restored immediately.

3.5 *CONSTRUCTION OF THE EXTENSION*

Construction works will commence in early 2011, two years before the Extension starts operation. During the first year of construction, works including site formation and construction of superstructure will be carried out in the new infrastructure area. Pipes will be constructed to transfer the leachate and landfill gas collected from the existing SENT Landfill to the treatment facilities at the new infrastructure area. Waste reception facilities, including the site access road and weighbridges and monitoring wells will also be constructed.

Formation of side slopes on the eastern side of the Extension will begin in the third quarter of 2011. The formation of side slopes will require blasting of the rock slopes. The total volume of rock to be excavated for the Extension is around 320,000 m^3. With the assumption that there will be one blast per day and a volume of 3,000 m^3 per blast, the total blasting period would be around 107 days. The quantity of explosive used and the dimensions and spacings of shotholes will be carefully designed to minimize air overpressure, flyrock generation and ground-borne vibration. To minimize environmental impacts and ensure safe operation, loose material and stones in the Site will be removed prior to the blast operation. The area within 30m from the blasting area will be wetted prior to blasting to minimize dust generation. During blasting, blast nets, screens and other protective covers will be used to prevent the projection of flying fragments and other material resulting from blasting.

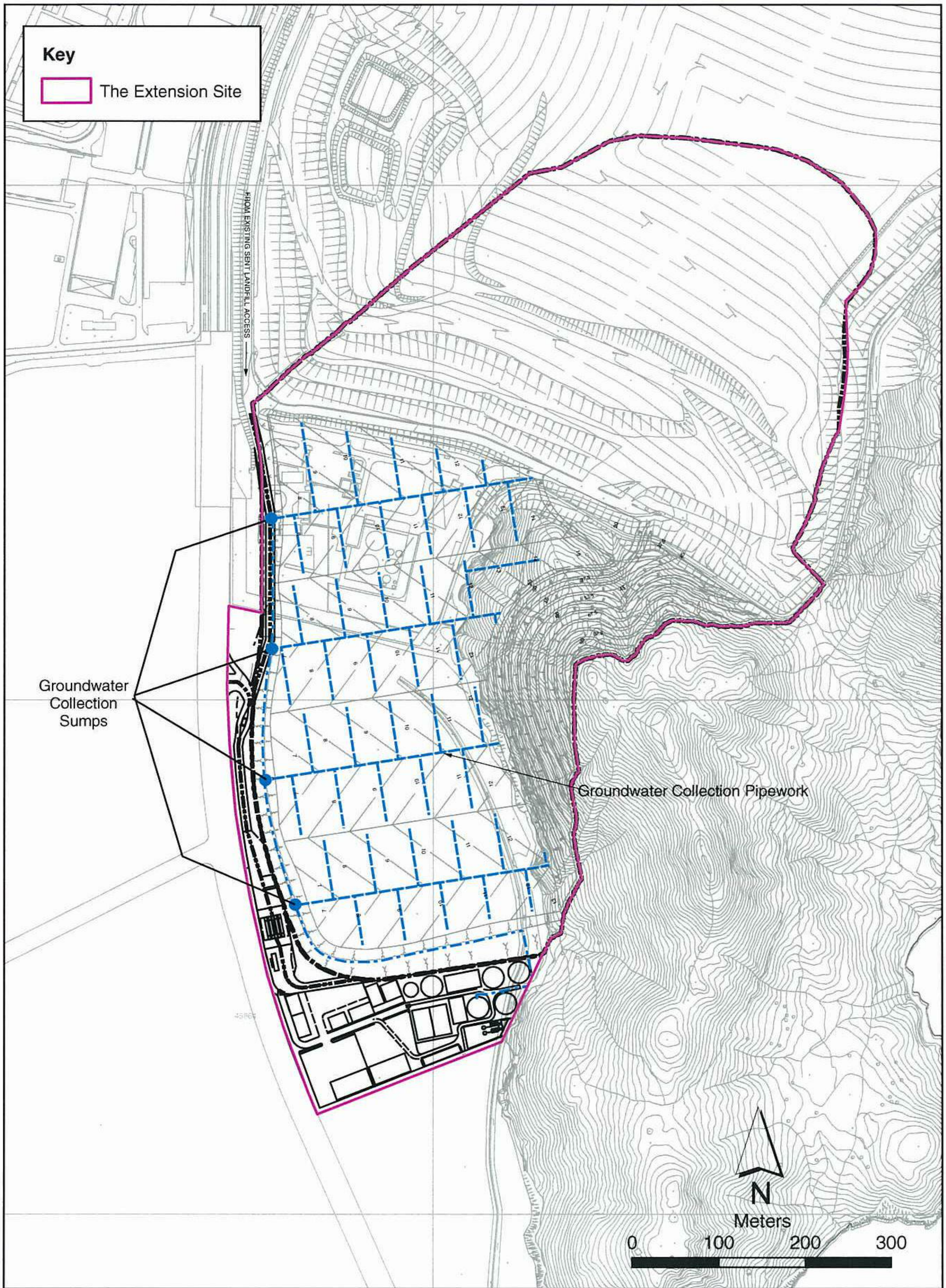

FIGURE 3.3j

Groundwater Management System

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Date: 22/06/2007

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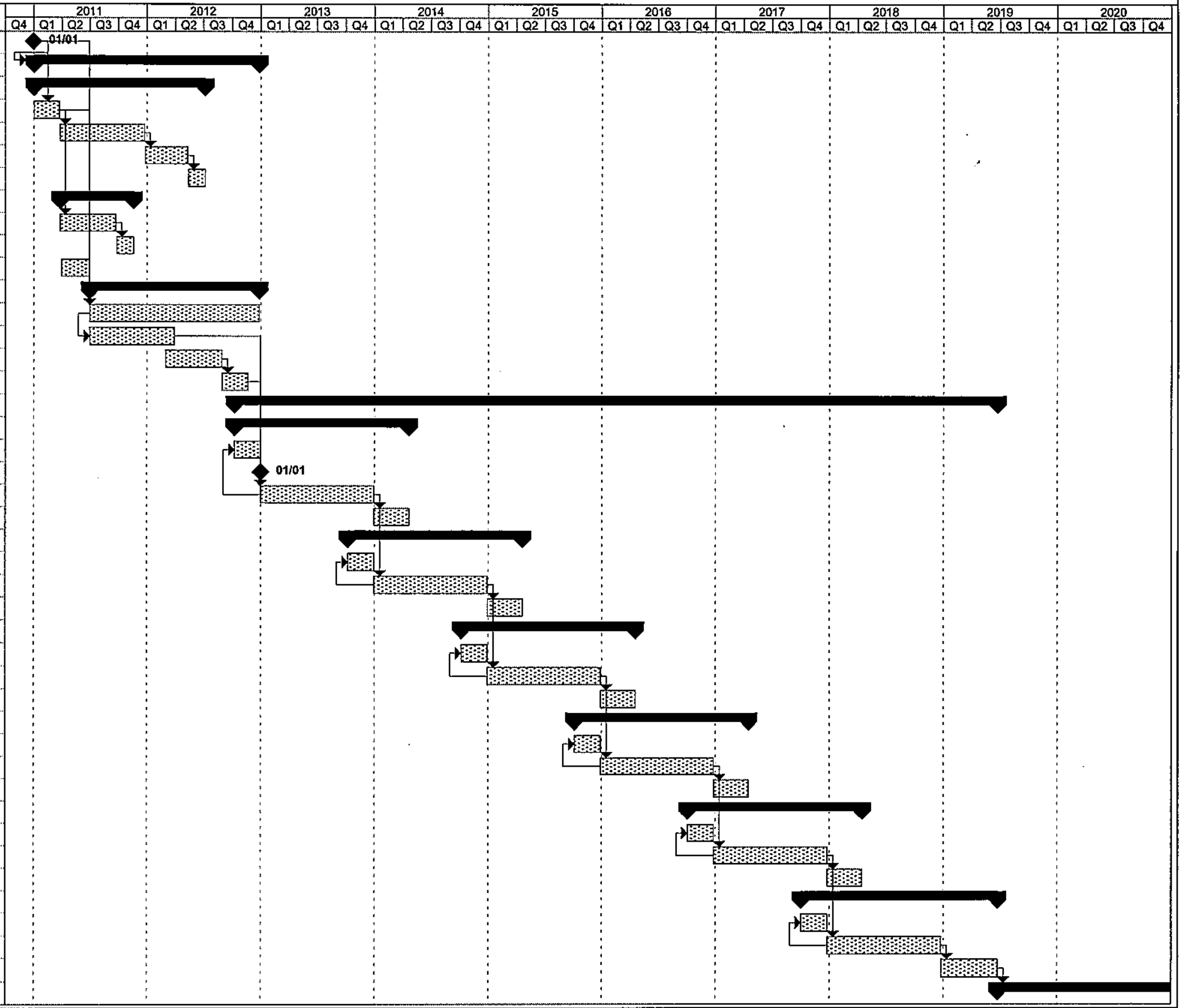
Figure 3.4a Project Programme

ID	Task Name
1	Handover of TKO 137 Site
2	**Construction Phase**
3	**Infrastructure Area**
4	Site Formation
5	Construction
6	Commissioning
7	Demolition of existing infrastructure
8	**Waste Reception Facilities**
9	Access Road
10	Weighbridges
11	**Construction of Monitoring Wells**
12	**Site Formation**
13	Formation of side slopes
14	Construction of cut-off drains (including drainage tunnel)
15	Formation of base grades
16	Base liner and leachate collection system
17	**Operation/Restoration Phase**
18	**Phase 1**
19	Lining of side slopes
20	Commencement of Operation
21	Waste Placement
22	Restoration
23	**Phase 2**
24	Lining of side slopes
25	Waste Placement
26	Restoration
27	**Phase 3**
28	Lining of side slopes
29	Waste Placement
30	Restoration
31	**Phase 4**
32	Lining of side slopes
33	Waste Placement
34	Restoration
35	**Phase 5**
36	Lining of side slopes
37	Waste Placement
38	Restoration
39	**Phase 6**
40	Lining of side slopes
41	Waste Placement
42	Restoration
43	**Aftercare Phase**



The rock obtained from blasting will be crushed on-site for reuse as leachate stone and subsequent site formation and engineering works.

The construction of the surface cut off drain and the 2,000mm twin drainage tunnels will commence in the third quarter of 2011 and will last for about 6 months. The tunnels will be constructed using micro-tunnelling techniques (using a tunnel boring machine (TBM)). The tunnel will be constructed from the lower end, ie at TKO Area 137.

In the second year, plant and equipment in the new infrastructure area will be commissioned, followed by demolition of the existing infrastructure at the SENT Landfill. This arrangement will ensure that treatment of leachate and landfill gas from the existing SENT Landfill is not interrupted.

The base grades of the waste filling area will be formed, followed by laying of base liner and the groundwater and leachate collection system. The formation of side slopes with blasting will continue throughout the second year and be completed by 2012.

The waste filling area will be ready for tipping operations in 2013.

3.6 OPERATION OF THE EXTENSION

The Extension will be developed in six phases (see *Figures 3.6a* to *3.6k*). Towards the end of each phase, liner will be installed on the side slope for the next phase.

Based on the waste arisings forecast, the Extension will receive on average around 8,600 tonnes per day throughout its operational life time, generating around 1,500 vehicle per day (1). It is anticipated that the Sludge Treatment Facilities (STF) will commence operation in 2012, before the commissioning of the Extension. The incineration ash generated by the Integrated Waste Management Facilities (IWMF) planned to be in operation by 2014 will also be disposed of at the Extension. Hence, the type of waste to be received by the Extension will include MSW, construction waste and special waste (without sludge from the sewage treatment facilities (2) but including the residues from the STF and IWMF).

Similar to the existing practice, the Extension will be receiving waste from 8:00am till 11:00pm. Preparation of the daily tipping face will start before 8:00am. The preparation work includes mobilizing equipment to the tipping face and removal of cover soil. The special waste trench will be constructed after 8:00 am.

(1) The additional waste tonnage is mainly coming from inert incineration residues which will be stablised before before delivering to the landfill. At present, only the SENT Landfill is designed to accept residues from thermal treatment facilities. For conservative assumption, it is assumed that all residues of the STF and IWMF will be disposed of at the Extension. However, it is understood that the disposal location of the residues will also depend on the location of the STF and the IWMF.

(2) The Extension will however receive insignificant amount of sludge generated from the on-site leachate treatment plant.

When a waste collection vehicle arrives at the site, it will go through the in-weighbridge and then heading to the designated tipping face. The size of the active tipping face will be around 1,200 m^2. The waste collection vehicle will unload the waste in the designated areas, depending on the type of waste it is carrying. In general, MSW and the non-inert waste are unloaded in the "wet waste" tipping area, the inert waste and construction waste are unloaded in the "dry waste" tipping area and selected special waste (1) is unloaded in the special waste trench, approximately 15 m^2 in size. Waste unloaded in the "wet waste" tipping area will be immediately covered by the construction waste from the "dry waste" tipping area. Waste will then be compacted by landfill compactors and dozers. When the waste collection vehicle leaves the tipping area, it will go through the vehicle wash facility and the out-weighbridge before leaving the Extension Site.

Towards the end of each working day the whole tipping face will be covered with 300mm of soil and compacted. The special waste trench will be opened from 9:00am to 6:00pm and will be covered with soil immediately after closure.

To control odour emission and reduce leachate generation in areas not actively used for tipping (ie the intermediate covered area), an impermeable liner will be placed on top of the 600mm thick cover soil (2). When the area is to be used for tipping, the impermeable liner and the cover soil will be removed.

It is expected that the landfill operation will last for about six years. The Extension will be operated to comply with international best practice for landfill operation.

3.7 RESTORATION OF THE EXTENSION

Areas filled to final grades will be restored as soon as possible. Restoration will be carried out in stages as phases are progressively filled with waste. After final levels are reached within a given phase, a 300mm protective soil layer will be placed over the waste. The final cap, comprising a non-woven geotextile, a HDPE geomembrane, a high permeability geocomposite drainage layer and a 1,500mm fill layer, will then be placed (see *Figure 3.3c*).

The first 1,200mm of fill directly above the drainage layer will be compacted to reduce surface water infiltration. The thickness of the fill layer will be increased in some planting areas to provide depth sufficient to prevent damage to the liner from vegetation rooting. After placement of the final cover system, the areas will be landscaped.

Vertical landfill gas extraction wells will be drilled during restoration. The restoration work will also include the construction of permanent surface water drains.

(1) Including animal carcasses, asbestos waste, chemical waste and clinical waste.

(2) The use of impermeable liner has been adopted at the existing NENT and WENT Landfill operations.

FIGURE 3.6a

Phase 1A

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FIGURE 3.6b

Phase 1B

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FILE: 0036266_Phase1B_01.dgn
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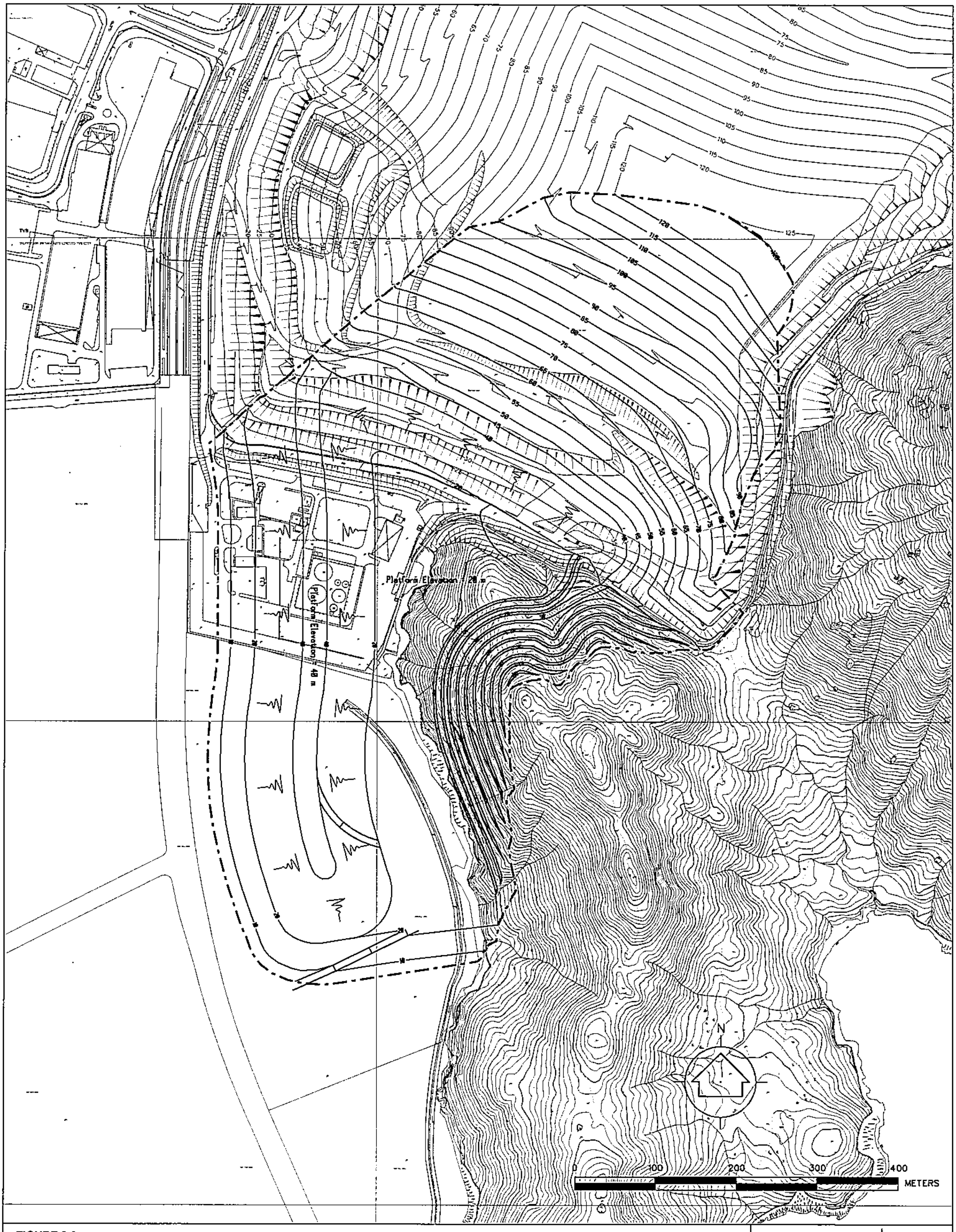

FIGURE 3.6c

Phase 2A

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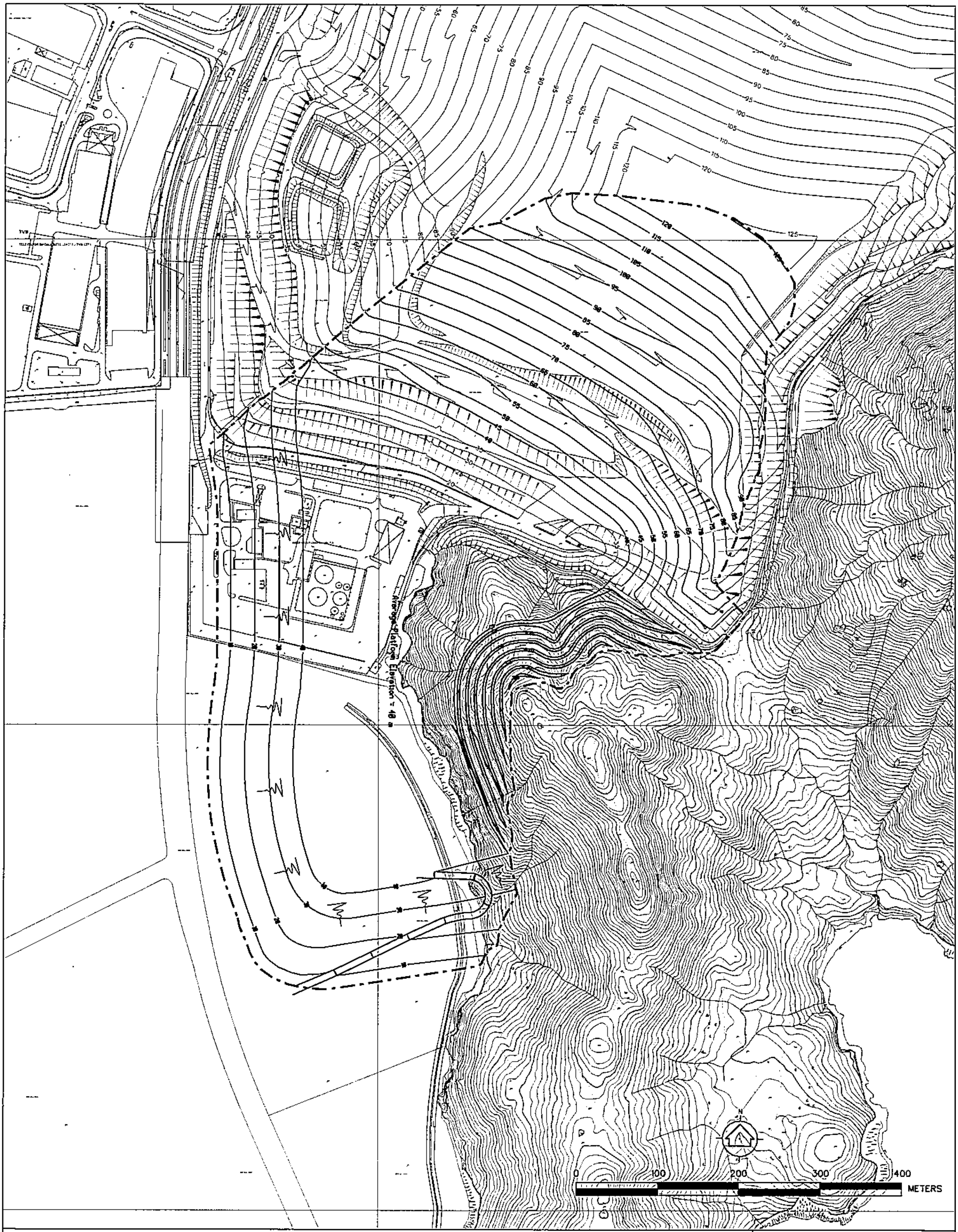

FIGURE 3.6d

Phase 2B

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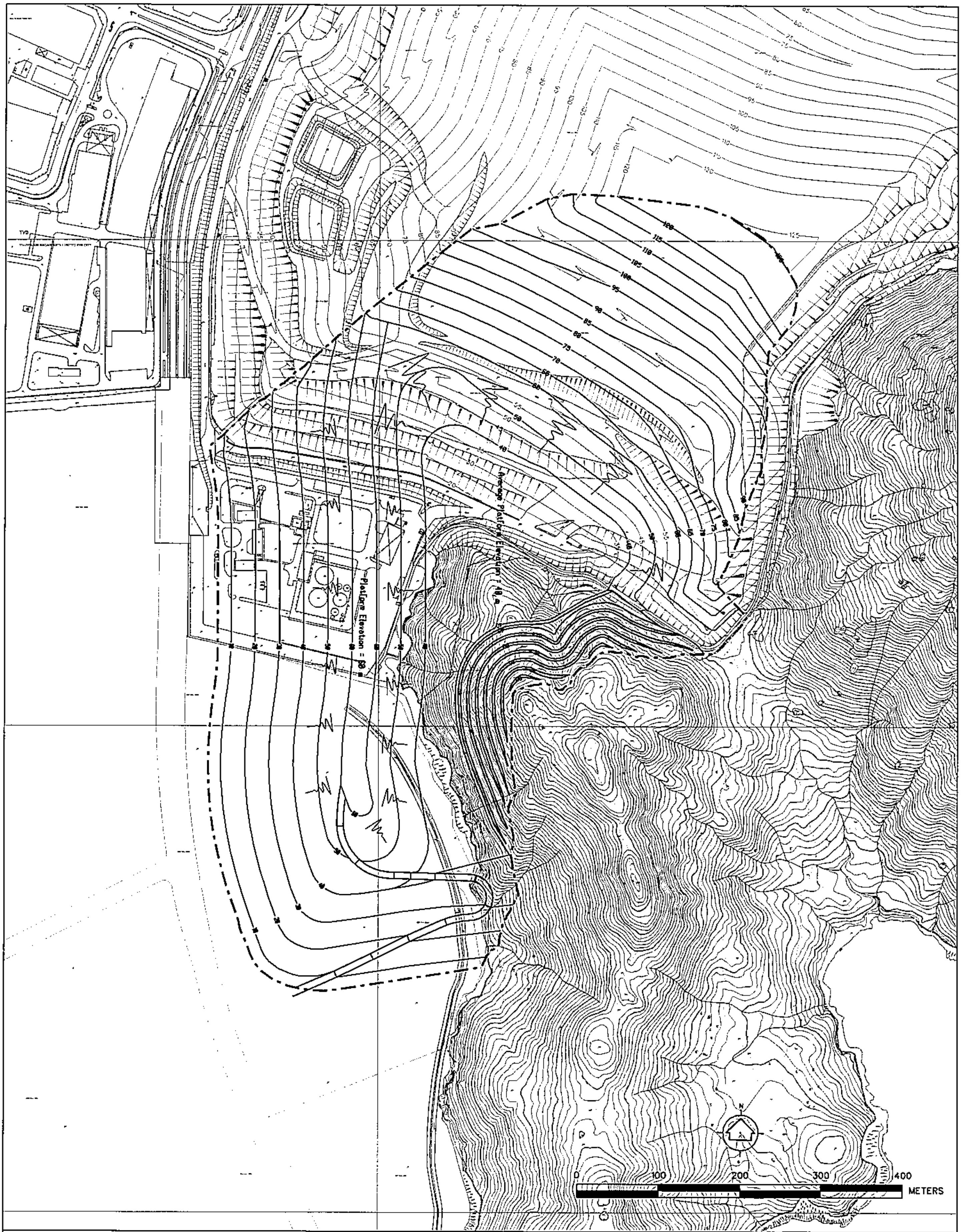

FIGURE 3.6e

Phase 3A

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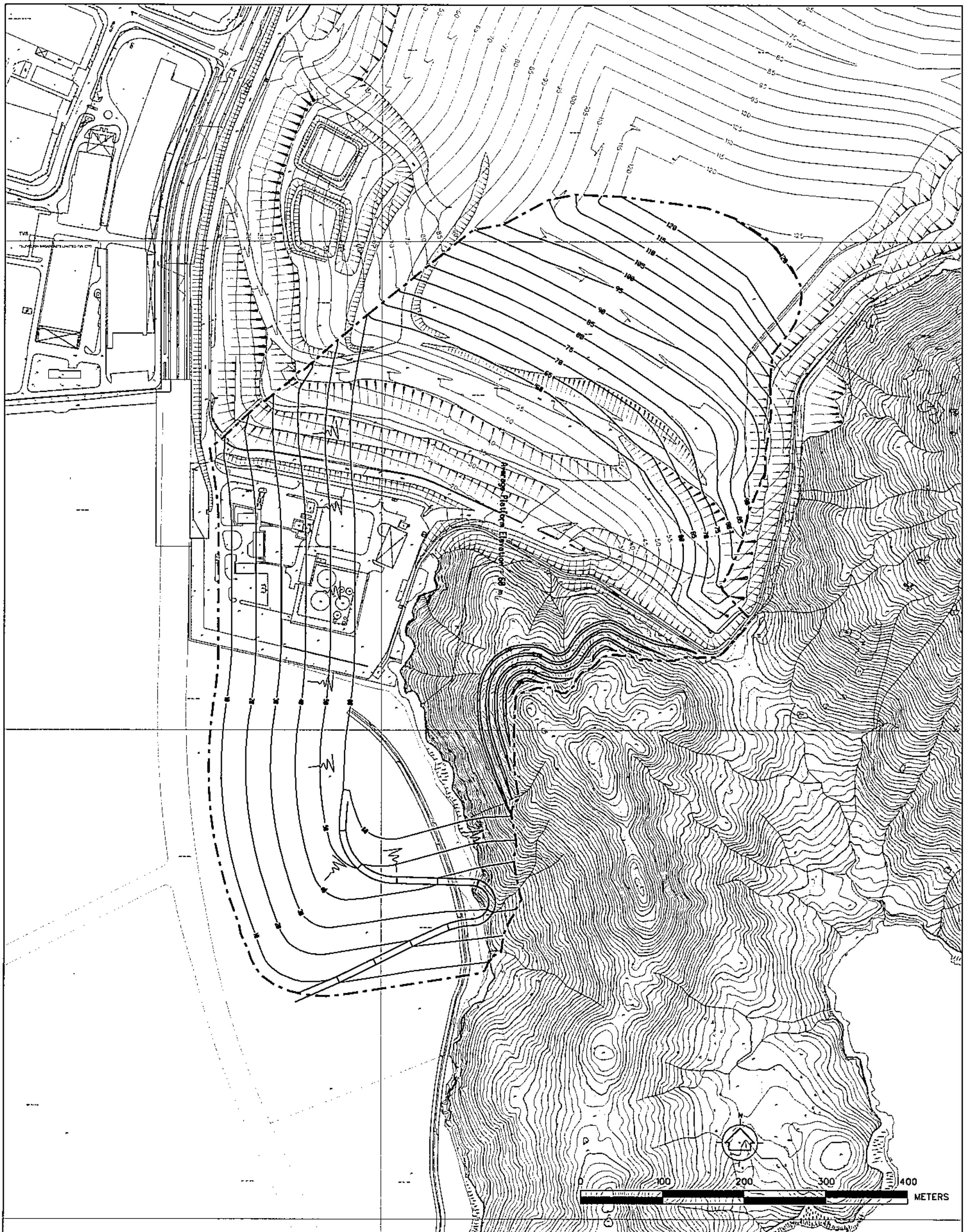

FIGURE 3.6f

Phase 3B

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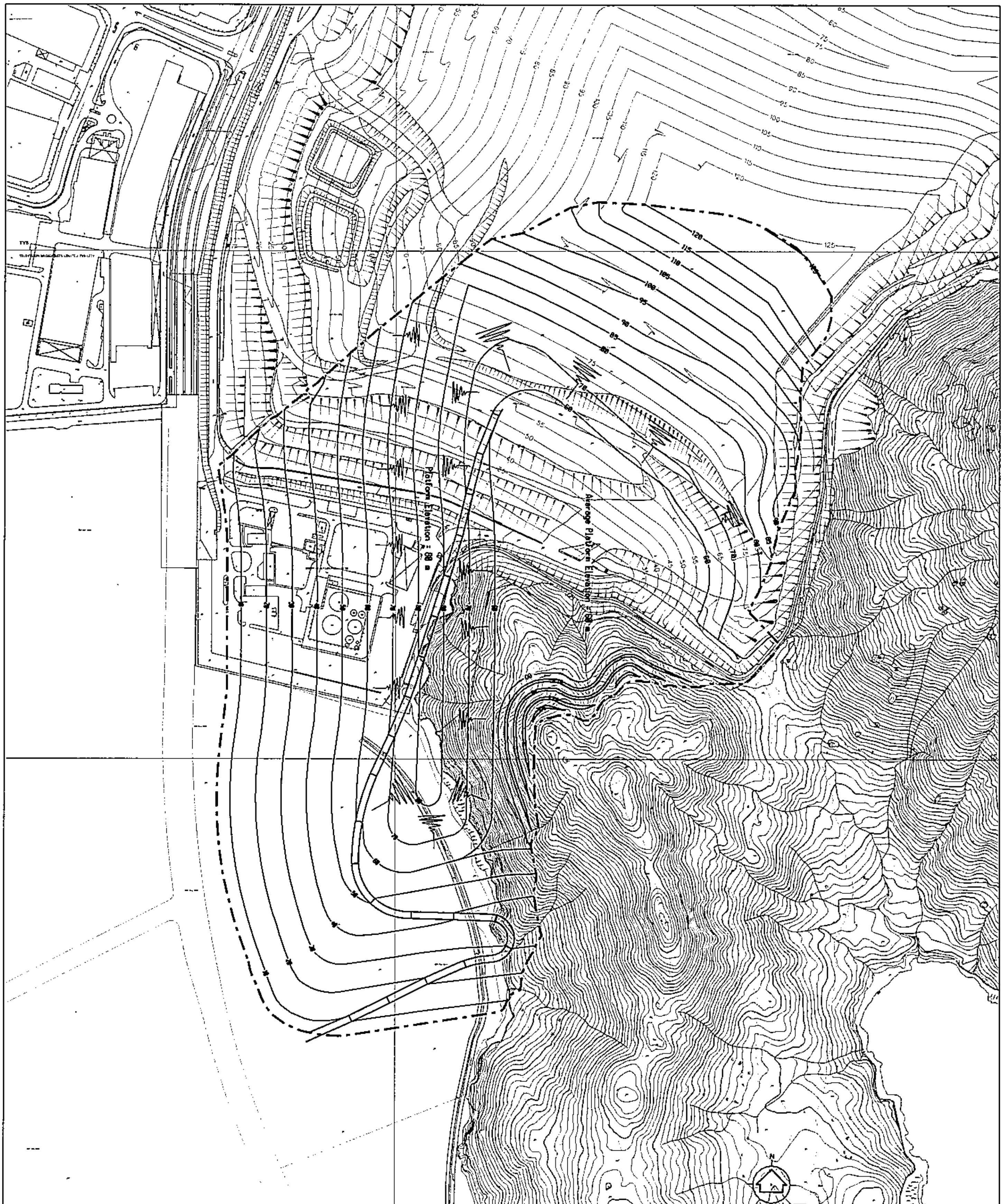

FIGURE 3.6g

Phase 4A

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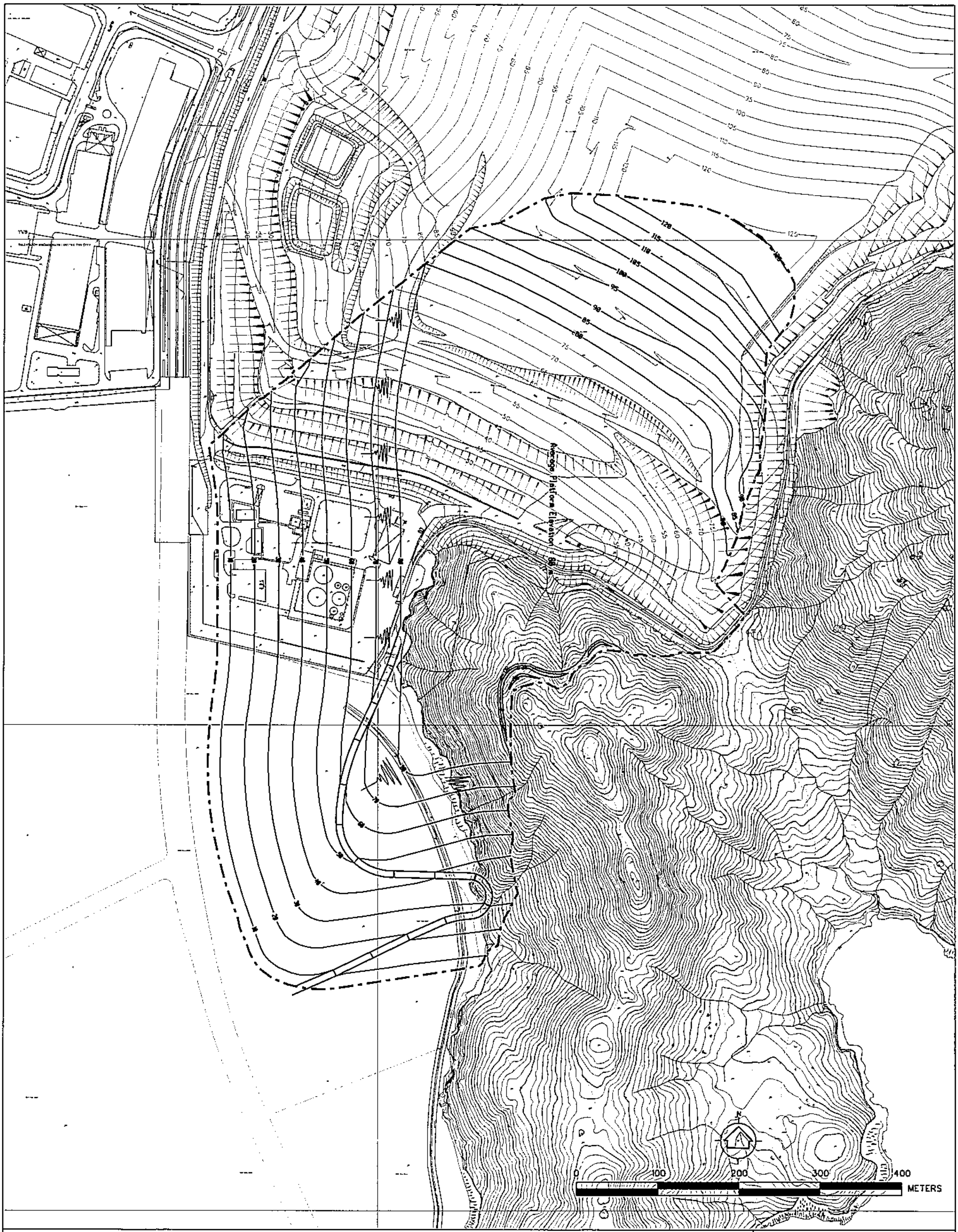

FIGURE 3.6h

Phase 4B

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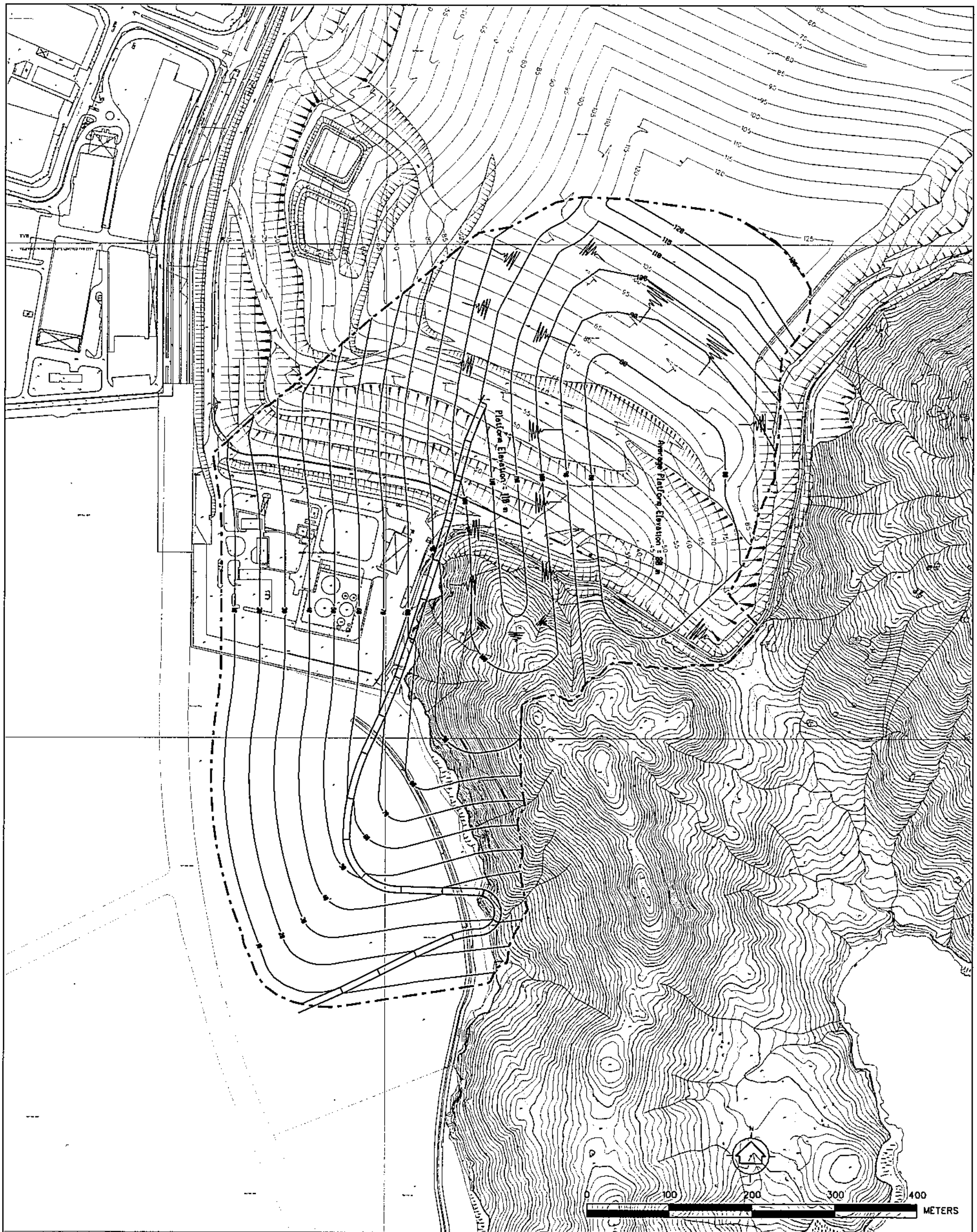

FIGURE 3.6i

Phase 5A

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DATE: 23/10/2007

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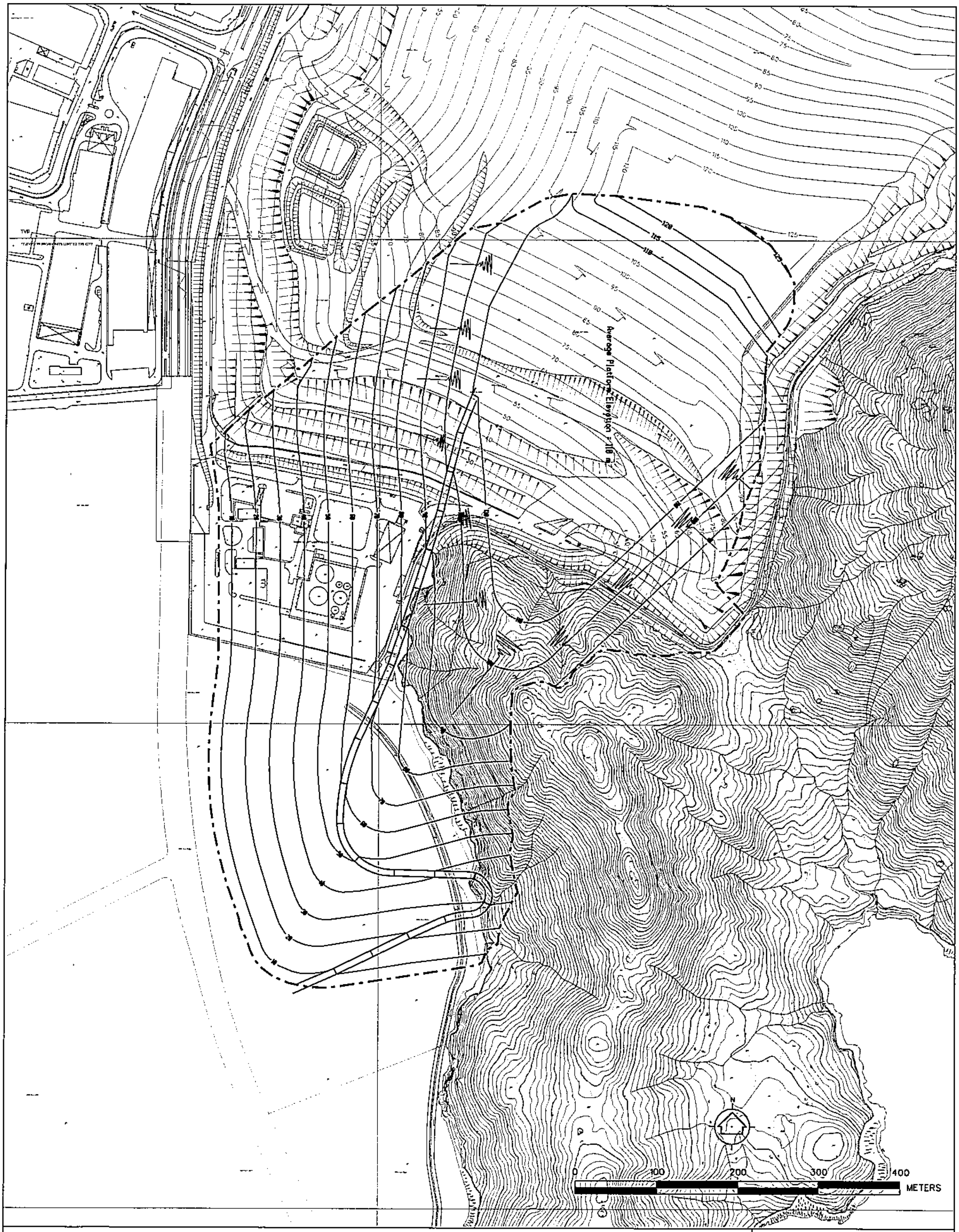

FIGURE 3.6j

Phase 5B

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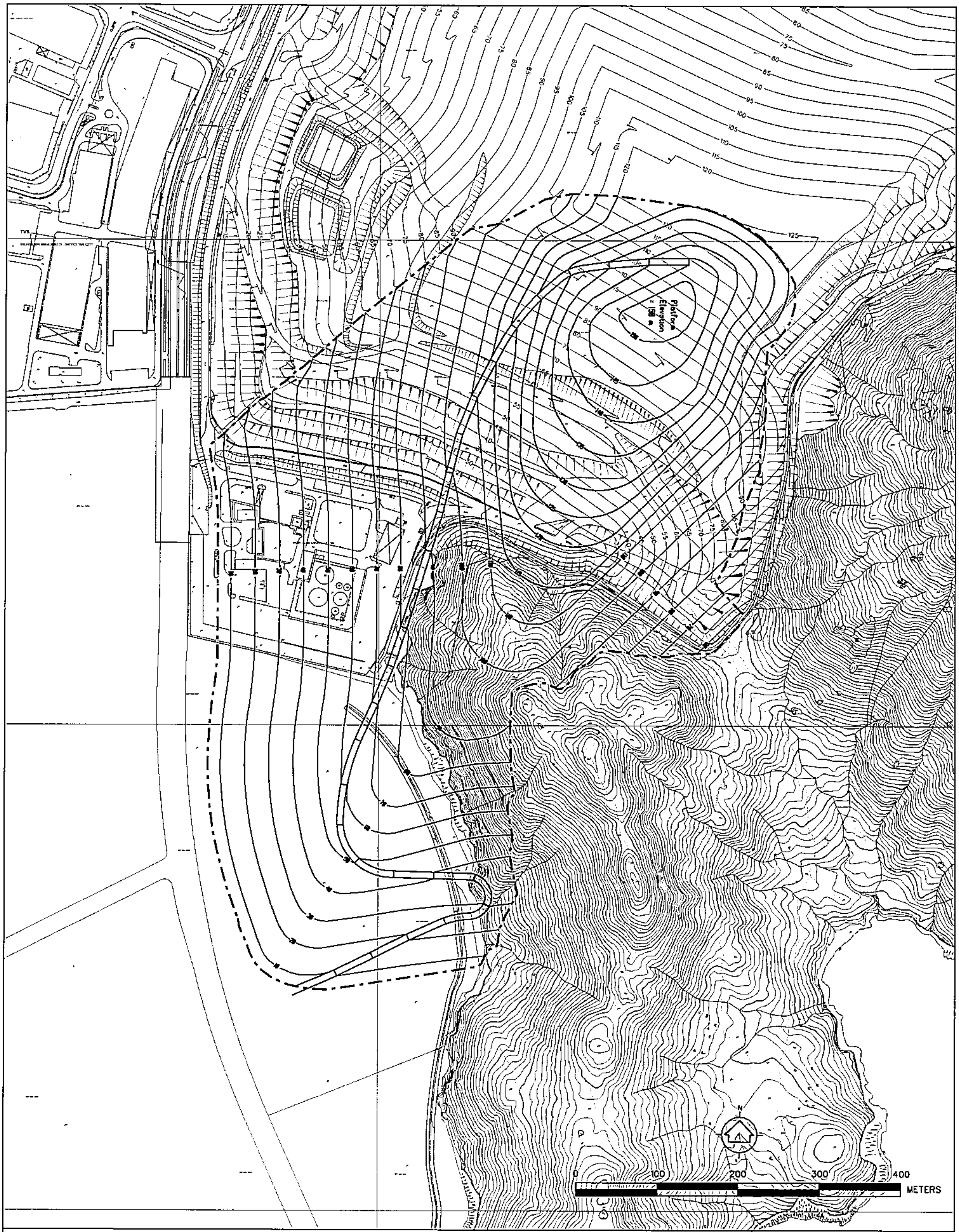

FIGURE 3.6k

Phase 6

Environmental Resources Management

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3.8 *AFTERCARE OF THE EXTENSION*

Upon completion of final filling and site restoration, the period of aftercare will begin and last for 30 years. During this period, by-products from waste disposal will continue to be generated including leachate and landfill gas. The established leachate and landfill gas management control and treatment facilities will continue to operate throughout the aftercare period.

Regular site maintenance will be required during the aftercare period to keep the incorporated systems functioning as designed. Site monitoring during the aftercare period will continue in accordance with the monitoring plan, but may be decreased if warranted and approved by the EPD.

During the aftercare period, afteruse(s) could be developed on the restored landfill for beneficial uses. However, the definition of the afteruse development is outside the scope of the current assessment and the Extension contract. A separate feasibility study and environmental impact assessment (if required) will be carried out for the development of the afteruse(s).

3.9 *CONCURRENT PROJECTS*

3.9.1 *Interfacing with the Existing SENT Landfill Operation*

There will be an overnight switch of tipping areas from the existing SENT Landfill to the new tipping area at the Extension. During the first quarter of the operation at the Extension, restoration at the last filling area at the existing SENT Landfill will be undertaken. Based on the phasing plan from the existing SENT Landfill operator, the last filling area will be located at the northern end of the existing SENT Landfill, as shown in *Figure 3.9a*. Since the distance between the last filling area at the SENT Landfill and the new active tipping face at the Extension is over 1km, cumulative impacts are not anticipated.

3.9.2 *Development in TKO Area 137*

The rest of the area in TKO Area 137 is currently planned for Deep Water Front Industrial uses. With reference to the Engineering Feasibility Study of Development of TKO Area 137 (March 1993), potential hazardous installation (PHI) may be developed in the area and hence there is a worker density restriction imposed in TKO Area 137, although there is no committed PHI development at presence. The risk assessment as part of that Engineering Feasibility Study recommended a worker density of 30 persons/ha within the Consultation Zone in Area 137. As the worker density at the Extension during both construction and operation phases will not exceed this recommendation, it is expected that risk to the workers within the Extension Site due to the potential PHI development is acceptable.

While the planning of landuses within TKO Area 137 is still ongoing, a Construction and Demolition Material Handling Facility is committed to be located at the TKO Area 137 (see *Figure 3.9b*). The Facility is planned to start

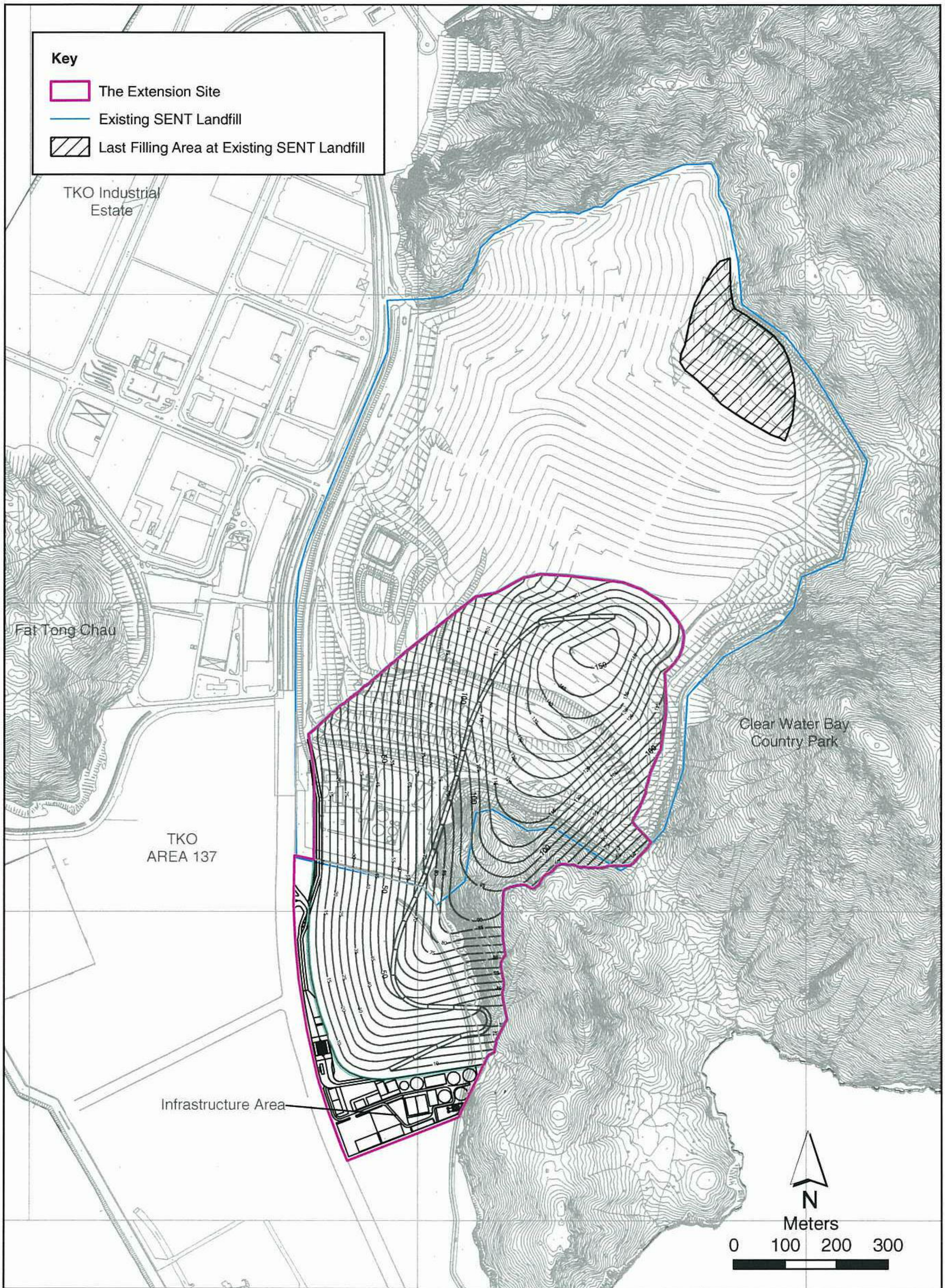

FIGURE 3.9a

Lasting Filling Area of the Existing SENT Landfill

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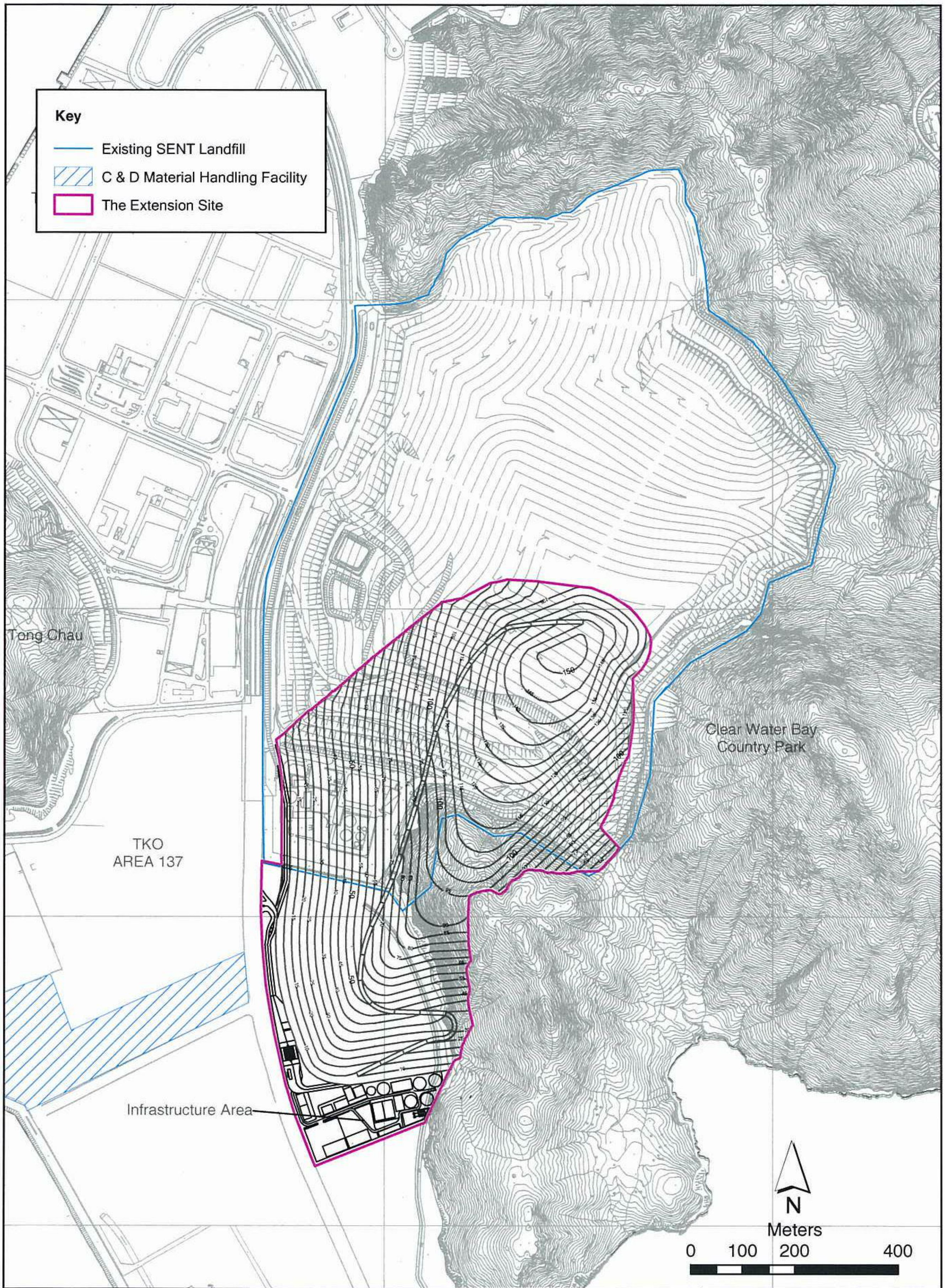

FIGURE 3.9b

C & D Material Handling Facility

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operation in phases in 2009. The capacity of the Facility is 20,000 tpd. The potential cumulative dust impact is addressed in *Section 4*.

The programme of developing other uses in TKO Area 137 is uncertain at the moment. Hence, cumulative impacts cannot be assessed in this EIA. Nevertheless, these uses have been considered as sensitive receivers, where appropriate, in this EIA.

4 AIR QUALITY IMPACT ASSESSMENT

4.1 INTRODUCTION

This section presents an assessment of the potential air quality impacts arising from the construction, operation, restoration and aftercare of the proposed Extension.

During the construction phase, dust nuisance arising from blasting, excavation and filling, slope stabilisation, site formation, stone crushing and vehicle movements on the site is a potential concern. Potential sources of air quality and odour impacts during the operation, restoration and aftercare phases of the Extension will include waste filling activities, the landfill gas (LFG) treatment facility, the new leachate treatment plant (LTP) and the LFG generator.

Representative Air Sensitive Receivers (ASRs) have been identified and an assessment of the potential air quality impacts has been conducted. Adjacent emission sources such as industrial emissions from Tseung Kwan O Industrial Estate (TKOIE), restoration of existing SENT Landfill and the future operations in TKO Area 137 during construction operation/restoration and aftercare phases of the Extension have also been taken into consideration. Mitigation measures have been recommended, where appropriate, to reduce the impacts.

4.2 LEGISLATION REQUIREMENT AND EVALUATION CRITERIA

4.2.1 *Air Pollutants Covered by Hong Kong Air Quality Objectives (HKAQOs)*

The principal legislation for the management of air quality in Hong Kong is the *Air Pollution Control Ordinance* (APCO) (Cap. 311). Under the *APCO*, the *Hong Kong Air Quality Objectives* (HKAQOs), which are presented in *Table 4.2a,* stipulate the statutory limits for air pollutants and the maximum allowable numbers of exceedences over specific periods.

Table 4.2a ***Hong Kong Air Quality Objectives ($\mu g\ m^{-3}$)*** *[(a)]*

Air Pollutant	Averaging Time			
	1 Hour [(b)]	**8 Hour [(c)]**	**24 Hour [(c)]**	**1 Year [(d)]**
Total Suspended Particulates (TSP)	-	-	260	80
Respirable Suspended Particulates (RSP) [(e)]	-	-	180	55
Sulphur Dioxide (SO_2)	800	-	350	80
Nitrogen Dioxide (NO_2)	300	-	150	80
Carbon Monoxide (CO)	30,000	10,000	-	-

Notes:

(a) Measured at 298K (25°C) and 101.325 kPa (one atmosphere)
(b) Not to be exceeded more than three times per year
(c) Not to be exceeded more than once per year
(d) Arithmetic means
(e) Suspended airborne particulates with a nominal aerodynamic diameter of 10 micrometres or smaller

The *Technical Memorandum on Environmental Impact Assessment Process* (*EIAO-TM*) also includes an hourly TSP criterion of 500 $\mu g\ m^{-3}$ for construction dust impacts and an odour criterion of 5 Odour Units (OUs) for a 5-second averaging period for odour impact assessment.

The criteria outlined in *Table 4.2a* and in the *EIAO-TM* were used to assess the potential air quality impacts associated with the Extension.

The measures set out in the *Air Pollution Control (Construction Dust) Regulations* should be followed to reduce dust impacts from this Project.

If a stone crushing plant of a capacity greater than 5,000 tonnes per year is needed, a licence must be obtained under the *Air Pollution Control (Specified Process) Regulation* and the control measures set out in the *Guidance Note on the Best Practicable Means for Mineral Works (Stone Crushing Plants) (BPM 11/1)* should be followed.

Should the fuel consumption rate of a premises/process with chimney emission exceed the specified fuel consumption rates stated in the *Air Pollution Control (Furnaces, Ovens and chimneys) (Installation and Alternation) Regulations*, an approval of chimney installation/alternation should be obtained from the EPD prior to the operation.

4.2.2 *Air Pollutants Not Covered by HKAQOs*

For those pollutants not covered by the HKAQOs, health risk criteria recommended in the international guidelines, such as those promulgated by the *World Health Organisation* (WHO), the *United States Environmental Protection Agency* (US EPA) and the *California Air Resources Board* (CARB) have been considered. The criteria/guideline values were selected in the following order of preference:

- WHO;
- US EPA; and

- CARB.

Cancer Health Risk Assessment

Of the non-criteria substances emitted during the operation/restoration and aftercare phases, benzene and vinyl chloride are considered carcinogenic. *Table 4.2b* shows the Unit Risk Factors (URFs) for the carcinogenic substances considered in this assessment.

Table 4.2b Guideline Unit Risk Factors for Carcinogenic Substances

Substance	**Unit Risk Factor ($\mu g\ m^{-3})^{-1}$**
Benzene	7.8×10^{-6} (a)
Vinyl Chloride	8.8×10^{-6} (b)

Notes:

(a) Reference to US EPA – Integrated Risk Information System – On-line data as in October 2007. The URF of benzene is in a range of 2.2×10^{-6} – 7.8×10^{-6} per $\mu g\ m^{-3}$. Upper range of URF is adopted for the worst case assessment (http://cfpub.epa.gov/iris/quickview.cfm?substance_nmbr=0276).

(b) Reference to US EPA – Integrated Risk Information System – On-line data as in October 2007. The URFs of vinyl chloride are 4.4×10^{-6} per $\mu g\ m^{-3}$ for the exposure during adulthood and 8.8×10^{-6} per $\mu g\ m^{-3}$ for the exposure from birth. Higher URF is adopted for the worst case assessment (http://cfpub.epa.gov/iris/quickview.cfm?substance_nmbr=1001).

The risk assessment guidelines for assessing the carcinogenic health risks from exposure to air toxics are summarised in *Table 4.2c*.

Table 4.2c Risk Assessment Guidelines for the Assessment of Carcinogenic Health Risks

Acceptability of Cancer Risk	**Estimated Individual Lifetime Cancer Risk Level**
Significant	$> 10^{-4}$
Risk should be reduced to As Low As Reasonably Practicable (ALARP)	$> 10^{-6}$ – 10^{-4}
Insignificant	$\leq 10^{-6}$

Non-Cancer Health Risk Assessment

Benzene and vinyl chloride have the potential to cause chronic and/or acute impacts for long and/or short-term exposures, respectively. The reference chronic and acute concentrations of these pollutants are summarised in *Table 4.2d*.

Table 4.2d *Guideline Values for Chronic and Acute Reference Concentrations*

Substance	Chronic Reference Concentration (Annual Average in μg m^{-3})	Acute Reference Concentration (Hourly Average in μg m^{-3})
Benzene	30 (a)	1,300 (b)
Vinyl Chloride	100 (a)	$1.8x10^5$ (b)

Notes:
(a) US EPA – Integrated Risk Information System – On-line data as in October 2007
(b) California Environmental Protection Agency, Air Resources Board (ARB)/Office of Environmental Health Hazard Assessment (OEHHA) (http://www.oehha.ca.gov/air/acute_rels/allAcRELs.html).

The risk assessment guidelines also recommend criteria to assess the acceptability of chronic and acute non-cancer health risks and these are summarised in *Tables 4.2e* and *4.2f*, respectively.

Table 4.2e *Acceptability of Chronic Non-Cancer Health Risks*

Acceptability	Assessment Results (a)
Chronic non-cancer risks are considered "**Insignificant**"	$AC_A \leq RC_c$
Chronic non-cancer health risks are considered "**Significant**". A more detailed assessment of the control requirements and further mitigation measures are needed.	$AC_A > RC_c$

Note:
(a) AC_A and RC_c represent annual average concentration and chronic reference concentration, respectively.

Table 4.2f *Acceptability of Acute Non-cancer Health Risks*

Acceptability	Assessment Results (a)
Acute non-cancer risks are considered "**Insignificant**"	$AC_{HM} \leq RC_A$
Acute non-cancer health risks are considered "**Significant**". A more detailed assessment of the control requirements and further mitigation measures are needed.	$AC_{HM} > RC_A$

Note:
(a) AC_{HM} and RC_A represent hourly average and acute reference concentrations, respectively.

4.3 BASELINE CONDITIONS AND BACKGROUND AIR QUALITY

4.3.1 Baseline Conditions

The proposed Extension is located to the south of the existing SENT Landfill. The TKOIE is located to the north west of the Extension (see *Figure 4.4a*). The TKO Area 137 Fill Bank currently occupies part of the Extension site and the area south of the Extension. TKO Area 137 has been zoned for industrial activity (Deep Waterfront Industry) according to the Outline Zoning Plan (OZP) No. S/TKO/15 gazetted in November 2004.

No residential dwellings have been identified within 500m of the Extension site boundary. The nearest residential use (LOHAS Park), which is under construction, is located at about 1.8 km from the Extension site boundary.

The existing air quality in the vicinity of the Extension is affected by:

- Emissions from facilities in the TKOIE;
- Dust, odour and stack emissions from the SENT Landfill;
- Dust nuisance from TKO Area 137 Fill Bank;
- Vehicular emissions on Wan Po Road (both to and from the SENT Landfill and TKO Area 137 Fill Bank); and
- Background air quality in the Pearl River Delta.

During the operation of the Extension, the existing SENT Landfill will be closed. A capping system which will comprise (from bottom to top), as soil layer, a non-woven geotextile, an HDPE liner (impermeable liner), a sub-soil drainage layer and a final cover soil layer, will be installed. The LFG and leachate generated from the existing SENT Landfill will be collected by the leachate and LFG collection system and conveyed to the new LTP and LFG treatment facility for treatment. Therefore, no odour will be anticipated to be emitted from the restored area of the existing SENT Landfill.

4.3.2 Background Air Quality

EPD does not operate any Air Quality Monitoring Stations (AQMSs) in the Tseung Kwan O area.

For TSP, RSP, NO_2 and SO_2, the past six years (2001 - 2006) of air pollutant data [(1)] recorded at the Kwun Tong AQMS (see *Table 4.3a*), which is the nearest EPD AQMS to the Extension, have been used to characterise the background air quality for the impact assessment. For CO, the past six years (2001 – 2006) of air pollutant data recorded at the Mongkok AQMS have been used as no CO monitored at Kwun Tong AQMS.

(1) Since the annual average concentration of TSP, RSP, NO_2 and SO_2 in year 2002 are not available, the data recorded in 2001 was used instead.

Table 4.3a *Background Air Quality*

Air Pollutant	Background Concentration ($\mu g\ m^{-3}$)
Total Suspended Particulates (TSP)	78 [(a)]
Respirable Suspended Particulates (RSP)	57 [(a)]
Nitrogen Dioxide (NO_2)	66 [(a)]
Sulphur Dioxide (SO_2)	18 [(a)]
Carbon Monoxide (CO)	1,294 [(b)]
Benzene	2.1 [(c)]
Vinyl Chloride	5.1 [(c)]

Notes:

(a) From six years (2001-2006) annual average data on air pollutant concentrations measured at the EPD Kwun Tong AQMS (http://www.epd-asg.gov.hk/english/report/aqr.php).

(b) Since no CO data is recorded at EPD Kwun Tong AQMS, therefore, the CO data recorded at Mongkok AQMS is used.

(c) Reference to *Table 4.5f*. The maximum average benzene and vinyl chloride concentrations measured at the ambient VOC monitoring stations at the existing SENT Landfill for the past 5 years (2002 – 2006) were used.

Ambient benzene and vinyl chloride concentrations are measured at the ambient monitoring stations at the existing SENT Landfill. The locations of the ambient monitoring stations are shown in *Figure 4.3a*. In accordance with the Environmental Management Plan (EMP) of the existing SENT Landfill, benzene and vinyl chloride levels are measured at quarterly intervals. The measured data of benzene and vinyl chloride at the existing SENT Landfill monitoring stations were used to establish the background concentrations of these pollutants in the Study Area (see *Table 4.3a*).

As the existing SENT Landfill will be closed during the operation of the Extension, there will be no other similar odour sources identified within 500m of the Extension site boundary. Hence, no background odour is anticipated.

4.4 AIR SENSITIVE RECEIVERS

Table 4.4a and *Figure 4.4a* show the ASRs or those buildings that may be affected. Representative ASRs were identified in line with the requirements set out in the *EIA Study Brief* (*ESB-199/2004)* and Annex 12 of the *EIAO-TM.* The list includes existing and planned buildings within 500m of the Extension and ASRs along the Wan Po Road and Chiu Shun Road, in accordance with the requirements of *Section 3.4.1.2* of the *EIA Study Brief*. Planned developments were identified with reference to the latest Outline Zoning Plans (No. S/TKO/15 gazetted in November 2004).

For the assessment of construction dust and gaseous emission, the Study Area is defined as 500m from the Extension site boundary.

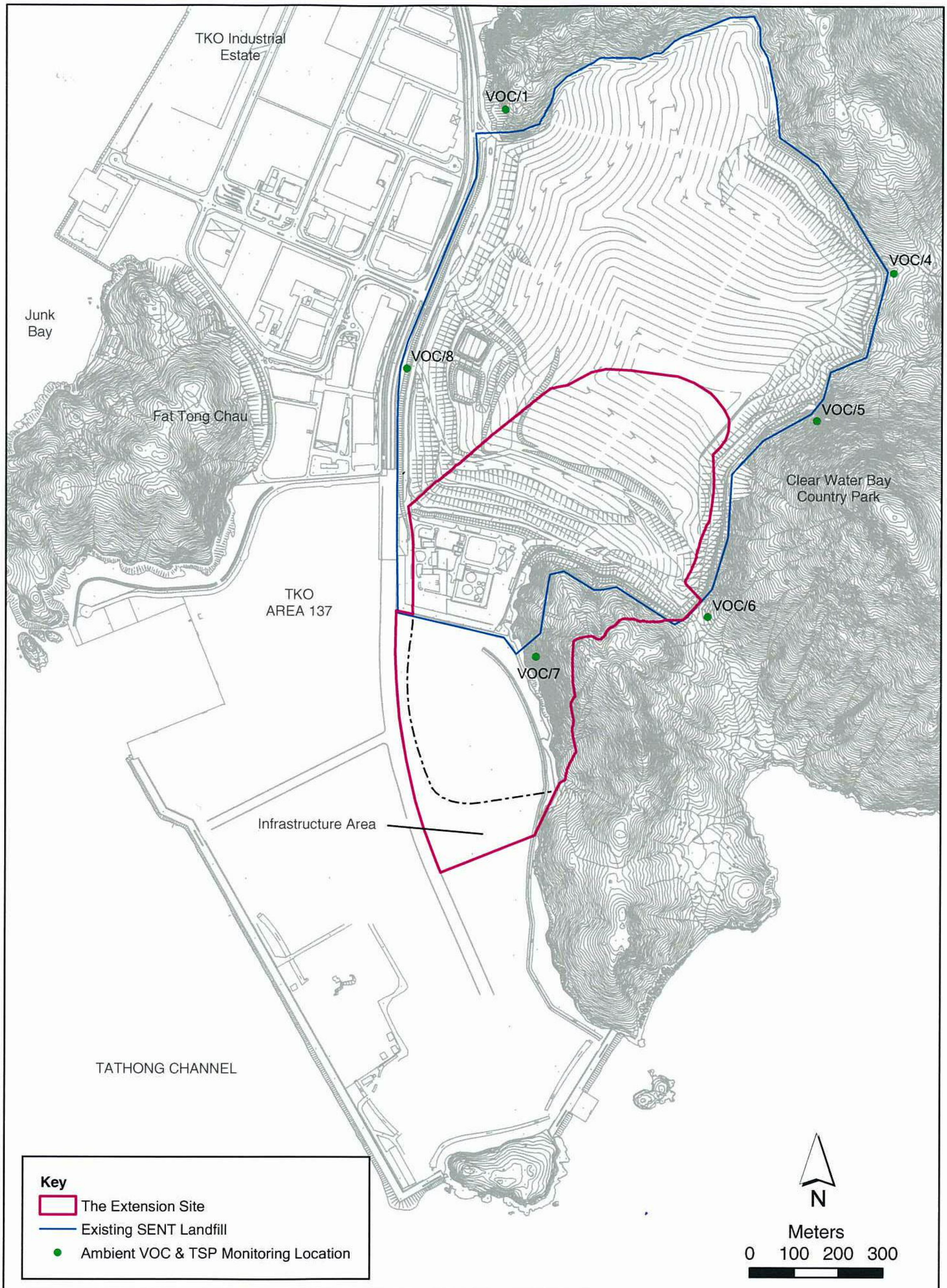

FIGURE 4.3a

Ambient VOC & TSP Monitoring Locations at Existing SENT Landfill

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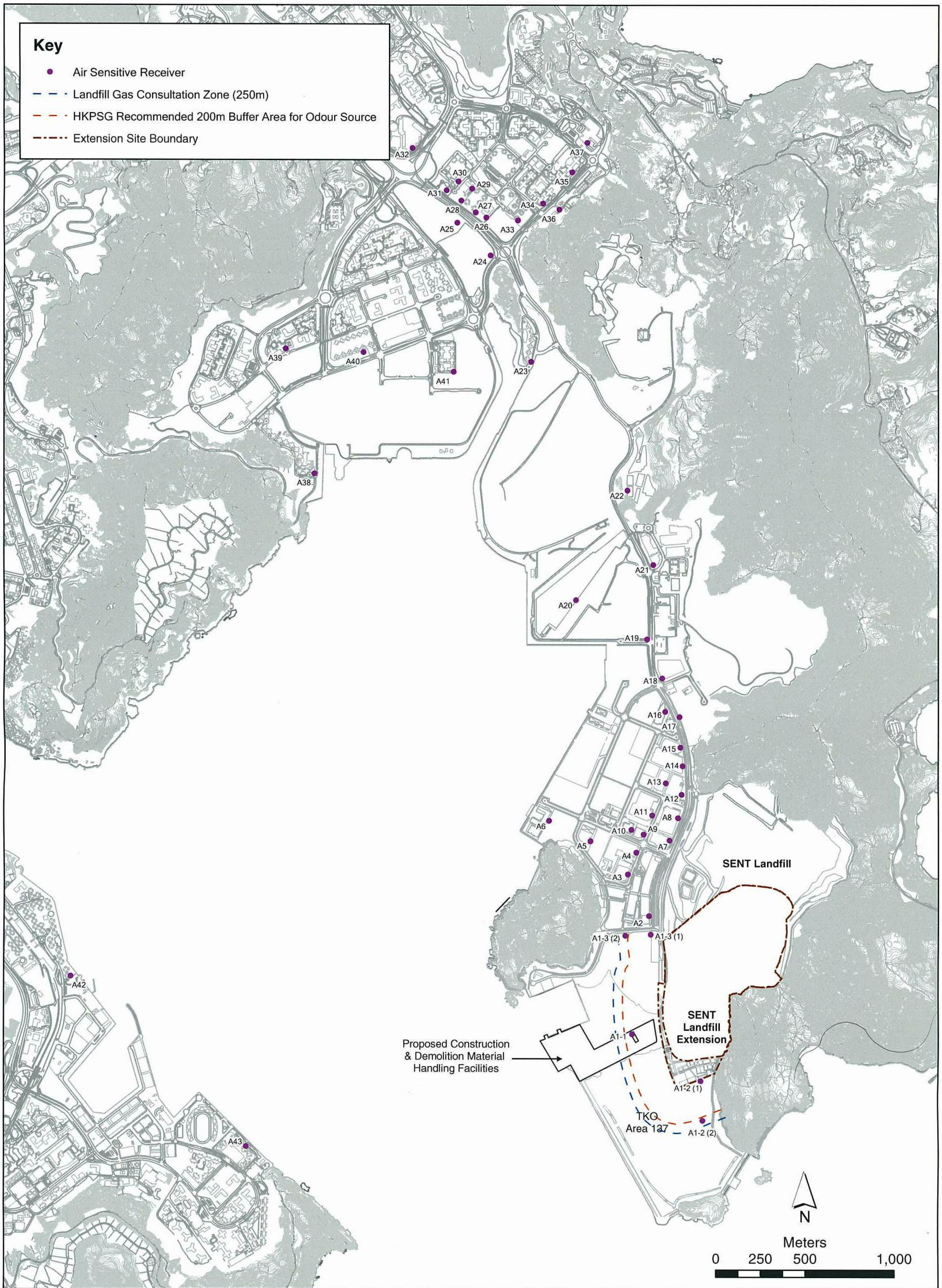

FIGURE 4.4a

Location of Air Sensitive Receivers

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Table 4.4a Identified Representative Air Sensitive Receivers

ASR	Location	Approx. Distance from Extension Site Boundary (m)	Type of Uses (a)	Approx. Max. Height above Ground (m)	Construction Dust (d)	Gaseous Emission (d)	Odour
A1-1	Proposed C&DM Handling Facility	150	I	30 (c)	√	√	√
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) – 1	10	I	30 (c)	√	√	√
A1-2 (2) (b)	Planned Industrial Uses in TKO 137 (south of Extension) – 2	200	I	30 (c)	√	√	√
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) – 1	90	I	30 (c)	√	√	√
A1-3 (2) (b)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	200	I	30 (c)	√	√	√
A2	TVB City	110	C	30	√	√	√
A3	HAESL	410	I	30	√	√	√
A4	HAECO Component Overhaul Building	470	I	30	√	√	√
A5	Exhibition Services & Logistics Centre	690	I	30	-	-	√
A6	Gammon Skanska	950	I	30	-	-	√
A7	Yan Hing Machinery Industrial Building	400	I	30	√	√	√
A8	Apple Daily	505	C	30	√	√	√
A9	Mei Ah Industrial Building	530	I	30	-	-	√
A10	Asia Netcom	590	C	30	-	-	√
A11	Wellcome Storage	580	I	30	-	-	√
A12	Avery Dennison Machinery	600	I	30	-	-	√
A13	Hitachi	700	I	30	-	-	√
A14	Next Media Co. Ltd	740	C	30	-	-	√
A15	Varitronix	850	I	30	-	-	√
A16	Four Seas Food Processing Co. Ltd	1,060	I	30	-	-	√
A17	Committed HSBC Office	1,000	C	30	-	-	√
A18	Eastern Pacific Electronics	1,250	I	30	-	-	√
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School	1,470	E	20	-	-	√
A20	LOHAS Park	1,830	R	200	-	-	√
A21	Chiaphua-Shinko Centre	1,860	I	30	-	-	√
A22	Shaw Film Studios	2,290	C	30	-	-	√
A23	Oscar by the Sea	3,160	R	170	-	-	√

ASR	Location	Approx. Distance from Extension Site Boundary (m)	Type of Uses (a)	Approx. Max. Height above Ground (m)	Construction Dust (d)	Gaseous Emission (d)	Odour
A24	Tseung Kwan O Sport Ground	3,810	Rec	1.5	-	-	√
A25	Tseung Kwan O Town Park	4,050	Rec	1.5	-	-	√
A26	Leung Sing Tak Primary School	4,010	E	20	-	-	√
A27	Nan Fung Plaza	4,070	R	130	-	-	√
A28	St Andrew's Church	4,160	Church	20	-	-	√
A29	Fung Ching Memorial Primary School	4,190	E	20	-	-	√
A30	On Ning Garden	4,260	R	120	-	-	√
A31	Sheung Ning Playground	4,240	Rec	1.5	-	-	√
A32	Tseung Kwan O Swimming Pool	4,530	Rec	1.5	-	-	√
A33	La Cite Noble	3,930	R	140	-	-	√
A34	Yuk Ming Court	3,980	R	110	-	-	√
A35	Ming Tak Estate	4,130	R	110	-	-	√
A36	Tin Ha Wan Village	3,950	R	10	-	-	√
A37	Tseung Kwan O Hospital	4,260	Hospital	25	-	-	√
A38	Ocean Shore Phase I	3,900	R	160	-	-	√
A39	Choi Ming Estate, Choi Yiu Court	3,820	R	155	-	-	√
A40	Park Central Block 1	3,530	R	185	-	-	√
A41	Bauhinia Garden Block 5	3,200	R	165	-	-	√
A42	Heng Fa Chuen	3,300	R	70	-	-	√
A43	Island Resort	2,400	R	160	-	-	√

Notes:

(a) I = Industrial premises, R = Residential developments, C = Commercial premises, and Rec = Recreational facilities

(b) As the type of industrial uses in the TKO Area 137 is not available (except the C&DM Handling Facility) at the time of the EIA Study, the HKPSG recommended setback distance of 200m from the major odour source (ie the SENT Landfill Extension) is included. The potential air quality impact within and outside the 200m buffer area has been assessed.

(c) Planning Department has been consulted with respect to the building height restriction of TKO Area 137. It was agreed that the consultant should assume that the maximum height of the buildings at TKO Area 137 will be 30m.

(d) Representative ASRs within 500m from the Extension site boundary will be included in the assessment of the construction dust impact and impact due to gaseous emission.

4.5 POTENTIAL SOURCES OF IMPACTS

4.5.1 Construction Phase

Nuisance from dust generating activities has the potential to arise during construction. The major construction works include blasting, slope stabilization, excavation and filling, site formation, stone crushing and vehicle movements on the site. Blasting, materials handling during slope cutting and site formation, rock crushing and wind erosion of the filled area will be the major dust generating activities during the construction of the Extension. The construction works area is shown in *Figure 4.5a.*

Blasting will take place for the slope cutting at the area currently occupied by the TKO Area 137 for about 107 days between the third quarter of 2011 and end of 2012. One blast will be made each day. A total of about 320,000 m^3 of rock will be generated and approximately 3,000 m^3 of rock will be generated per day. It should be noted that all construction works will be ceased during the blasting due to site constraint and safety reason.

Due to limited space at the Extension site, most of the rocks will be exported off-site. A small rock crushing plant will be employed on-site to crush the blasted rocks (about 155,800 m^3) into 25mm – 100mm in size and used as leachate drainage stones for the Project and the rest of the blasted rock will be broken down to about 250 mm in size for disposal off-site. During this process, watering will be carried out and no fugitive emission will be generated. Dust will be generated from the rock crushing activities screening and at the conveyor transfer point. With the provision of enclosure for the conveyor belt and watering at the conveyor transfer point, no fugitive dust emission is anticipated. Other dust control measures recommended in the *Guidance Note on the Best Practicable Means for Mineral Works (Stone Crushing Plants) (BPM 11/1)* will also be implemented at the rock crusher, and hence dust will only be emitted from the crushing and screening processes.

Should the processing capacity of the rock crusher exceeded 5,000 tonnes per day, it will be classified as a Specified Process (SP) and a licence will be required for the operation under the *Air Pollution Control (Specified Process) Regulations*.

About 770,000 m^3 of excavated soil will also be generated during the slope cutting period between the third quarter of 2011 and end of 2012 (around one and a half years). Some of which will be reused for site formation works (about 475,000 m^3). Due to limited space at the Extension, a small portion of the surplus soils (10,000 m^3) will be stockpiled on-site for subsequent use as daily or intermediate cover materials for the Phase 1 operation of the Extension.

Throughout the construction period, good site practices and dust control measures stipulated in the *Air Pollution Control (Construction Dust) Regulations* will be implemented to reduce the dust emission as much as possible. The site-specific good site practices and dust control measures are recommended in *Section 4.8.1*.

4.5.2 *Operational/Restoration Phase*

Section 3 details the activities that will take place during operation and restoration of the Extension. As the restoration will take place progressively,

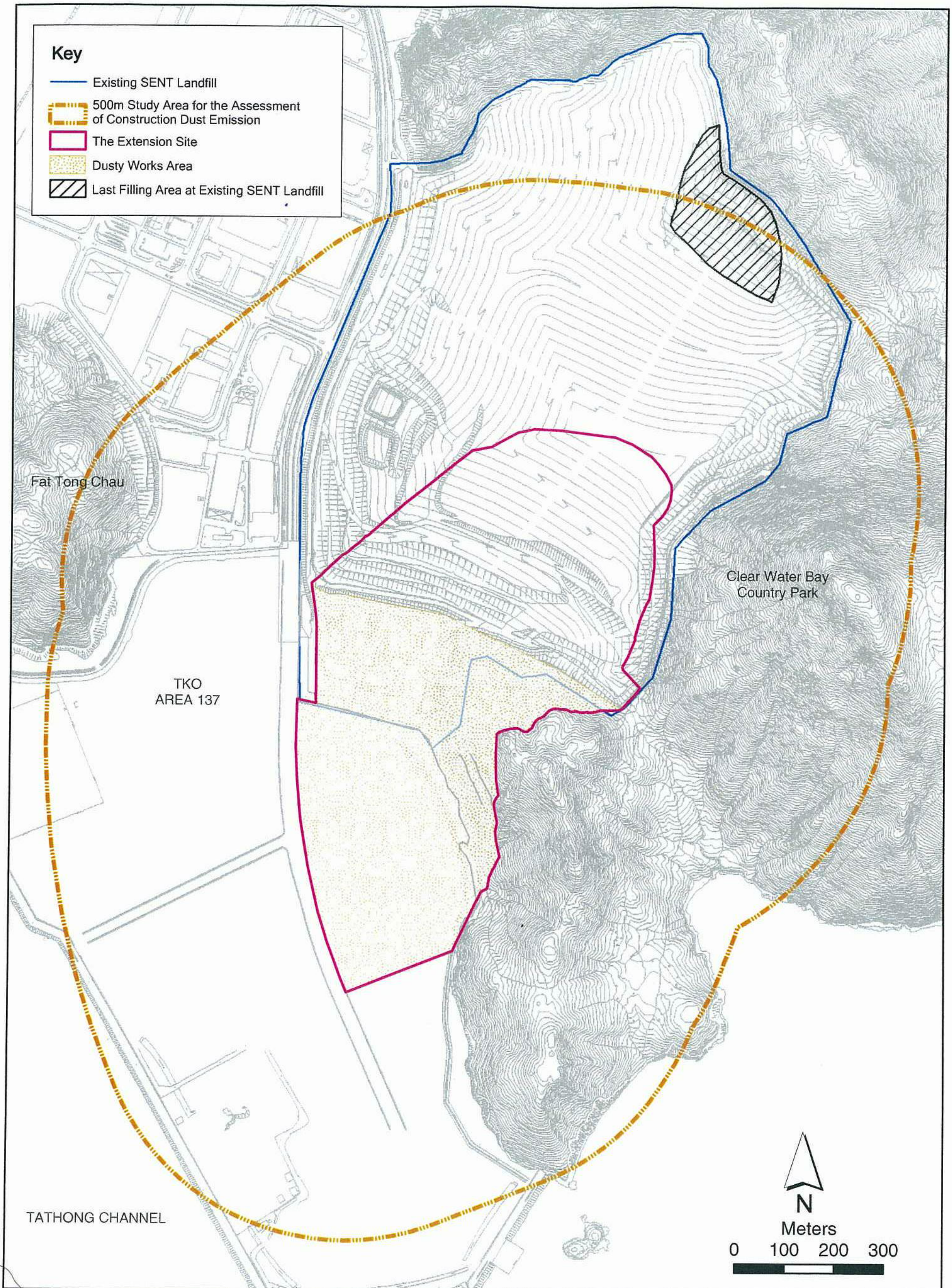

FIGURE 4.5a

Location of Last Filling Area of the Existing SENT Landfill and Dusty Construction Works Area of the Extension

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whilst operations are ongoing on other parts of the site, these two phases have been considered together in the assessment.

The potential sources of air quality and odour impacts arising from the Extension during the operational/restoration phase include:

- Gaseous emissions from the new LFG treatment facility, the thermal oxidizer of the LTP and generator at the new infrastructure area;
- Vehicular emissions from traffic associated with the Extension;
- Fugitive emissions from the active tipping face; and
- Odour emissions arising from Waste Filling Activities and Operation of LTP.

Gaseous Emissions from the LFG Treatment Facility

LFG is a by-product of the waste decomposition process when this takes place under anaerobic conditions. Typically, this comprises methane (CH_4), carbon dioxide (CO_2) and trace amounts of other gases (eg volatile organic compounds (VOCs), hydrogen sulphide (H_2S), etc). The proportions of these compounds vary over the life of the landfill and from landfill to landfill. The quantity also varies from little or none in the early years of operation, rising to a peak during the operational period, before gradually declining over time following restoration of the landfill.

During the operation/restoration phase, the majority of the LFG generated will be collected by the extensive LFG collection system and used on-site (as the first priority) or flared off. The LFG will be pre-treated (removal of moisture) prior to utilization or flaring in order to minimize corrosion to the equipment.

The LFG treatment facility will comprise two flares (each with a maximum capacity of 10,000 $m^3 hr^{-1}$) located at the south-eastern boundary of the site (see *Figure 4.5a*). During the operation/restoration phase, the LFG collected will mainly be used in the LTP and LFG generator (IMW) to supply power for the facilities in the Infrastructure Area and the remainder will be diverted to the on-site utilization plant or flares at the LFG treatment facility. Based on the outline design of the LTP, the plant will consume a maximum of 3,125 m^3 of LFG per hour and the LFG generator will consume about 1,500 m^3 of LFG per hour. If not utilized for other beneficial uses, the remaining LFG (a maximum of 15,375 $m^3 hr^{-1}$) will be flared. For the worst case assessment, it is assumed that the LFG flares will be operated at their maximum design capacity (ie 10,000 $m^3 hr^{-1}$ each). The combustion temperature of the flares will be about 850°C. At this temperature, methane, VOCs and the trace pollutants (such as H_2S) will be oxidised and destroyed. After flaring, trace amount of nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2) from the oxidation of H_2S, benzene, vinyl chloride and non-methane organic compound (NMOCs) will be emitted and the potential impacts of these air pollutants have been assessed in the following section.

The diameter and height of each flare stack will be 3.8m and 25m above the ground, respectively. The exit flowrate and velocity of the exhaust gas for each flare will be about 499,582 $m^3 hr^{-1}$ and 12.24 m s^{-1} at 850°C. *Table 4.5a* shows the performance standards to which the flares will be operated to maintain a destruction efficiency of at least 99%.

Table 4.5a *Designed Performance Standards of the LFG Flare*

Parameter	Performance Standards
Emission limit for nitrogen oxides (NO_x)	11.28 mg m^{-3} [(a) (b)]
Emission limit for carbon monoxide (CO)	28.19 mg m^{-3} [(a) (b)]
Emission limit for sulphur dioxide (SO_2)	1.55 mg m^{-3} [(a)]
Emission limit for benzene	2.98×10^{-3} mg m^{-3} [(a) (c)]
Emission limit for vinyl chloride	1.88×10^{-3} mg m^{-3} [(a) (c)]
No. of flares	2
Stack height	25 m
Stack diameter	3.8 m
Exit temperature [(d)]	850°C
Exhaust gas flowrate	499,582 $m^3 hr^{-1}$ [(a)]
Exhaust gas velocity	12.24 m s^{-1}

Notes:

(a) Emission limit of air pollutant in exhaust gas. For SO_2, please refer to *Annex A1* for detailed calculations.

(b) Emission limits were estimated based on the specification of flares operating in the existing SENT Landfill.

(c) Emission limits for benzene and vinyl chloride were estimated from the maximum concentrations of benzene and vinyl chloride in raw LFG measured at the inlet of the flare at the existing SENT Landfill. The maximum emissions of vinyl chloride and benzene were 4.4 ppm and 5.6 ppm, respectively. In accordance with the existing SENT Landfill Contract Specification, at least 99% of VOC destruction efficiency should be maintained. The emission limits are estimated based on the emission concentrations in the inlet, LFG flowrate, exhaust flowrate and the VOC removal efficiency. Please refer to *Annex A1* for the detailed calculations.

Gaseous Emissions from Thermal Oxidizer of LTP

Leachate will be collected from the Extension and the restored existing SENT Landfill and pumped to the LTP in the new infrastructure area. The LTP will consist of four buffer storage tanks, two ammonia stripping towers and two thermal oxidisers (ie, one duty and one standby), a stripped leachate storage tank, two SBR tanks and a sludge holding tank. Except for the SBRs, all tanks will be enclosed and the air exhaust from the tanks will be diverted to the thermal oxidiser as part of the air intake.

The raw leachate will be stripped in the ammonia stripping towers. The ammonia laden air and the exhaust air of the enclosed tanks will be oxidised and destroyed in the thermal oxidiser (which will operate at 850°C) prior to discharge to the atmosphere. Under this combustion temperature, the ammonia gas will be completely destroyed [(1)].

(1) Reference to http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ammonia/working_ammonia.html

LFG will be used as a fuel for the thermal oxidiser. The estimated maximum LFG consumption will be 3,125 $m^3 hr^{-1}$ assuming that the LTP is operating at its maximum capacity of 1,500 $m^3 d^{-1}$ (1), and 50 m^3 of LFG is required for each cubic metre of leachate treated. A worst case assumption has been adopted whereby the emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2) (product of decomposition of any residual H_2S at high temperature), carbon monoxide (CO), benzene, vinyl chloride and NMOCs are assumed to be same as those for the flares (see *Table 4.5a*).

The physical parameters and emission data of thermal oxidiser are summarized in *Table 4.5b*.

Table 4.5b Stack Emissions and Physical Parameters of the Thermal Oxidiser

Parameter	**Thermal Oxidiser of the LTP**
Emission limit for NO_x	28.4 mg m^{-3} (a)
Emission limit for CO	70.91 mg m^{-3} (a)
Emission limit for SO_2	3.9 mg m^{-3} (a)
Emission limit for benzene	7.51×10^{-3} mg m^{-3} (a)
Emission limit for vinyl chloride	4.73×10^{-3} mg m^{-3} (a)
No. of Stack	2 (one duty and one standby)
Stack height	9.76 m (c)
Stack diameter	1.12 m (c)
Exit temperature	171.6 °C (c)
Exhaust gas velocity	17.5 m s^{-1} (c)
Exhaust gas flowrate	62,068 $m^3 hr^{-1}$

Notes:
(a) All emission limits are under its exhaust gas condition.
(b) Refer to the detailed calculations presented in *Annex A1*.
(c) With reference to the design of the Thermal Catalytic Units of the existing Bioplant at SENT Landfill.

Gaseous Emissions from LFG Generator

A generator fuelled by LFG will be installed to provide power for on-site plant and equipment. Taking account of the anticipated power requirements of the infrastructure area of the Extension, the capacity of the generator will be about 1MW which is similar to the generator used in the existing SENT Landfill. The physical parameters and emission data of generator, reference to the LFG generator operating in the existing SENT Landfill, are summarized in *Table 4.5c*.

(1) Maximum design capacity of the LTP in order to handle the leachate generated from the last year of operation of the existing SENT landfill. Once the existing SENT Landfill is closed and capped, the leachate volume will be reduced to about 23 m^3d^{-1}. The average volume of leachate to be treated at the LTP during the operation/restoration phase (including the leachate generated from the closed SENT Landfill) will be about 335 m^3d^{-1}. In the assessment, the LFG consumption rate of 3,125 m^3hr^{-1}has been used as a conservative assessment.

Table 4.5c *Stack Emissions and Physical Parameters of the LFG Generator*

Parameter	LFG Generator
Engine power	1MW [(a)]
LFG input to generator	1,500 m^3 hr^{-1} [(a)]
Emission limit for NO_x	0.14 lb $mmBTU^{-1}$ [(b)]
Emission limit for CO	0.44 lb $mmBTU^{-1}$ [(b)]
Emission limit for SO_2	0.045 lb $mmBTU^{-1}$ [(b)]
Emission limit for benzene	$2.1x10^{-5}$ lb $mmBTU^{-1}$ [(b)]
Emission limit for vinyl chloride	$1.6x10^{-6}$ lb $mmBTU^{-1}$ [(b)]
No. of Stack	2 (one duty and one standby)
Stack height	28 m
Stack diameter	0.305 m [(a)]
Exit temperature	454°C [(a)]
Exhaust gas velocity	48.6 m s^{-1} [(a)]

Notes:

(a) Reference to the generator being operated at the existing SENT Landfill.

(b) Reference to the *Compilation of Air Pollutant Emission Factors, AP-42, 5th Edition, Table 3.1-1 and 3.1-2b.*

Summary: Under normal operations, LFG collected from the Extension will be primarily used as fuel for the LTP and generator. The remainder will be utilised or flared. *Table 4.5d* summarises the emission data of each facility and the location of these facilities is shown in *Figure 4.5b.* The detailed calculation is summarized in *Annex A1*.

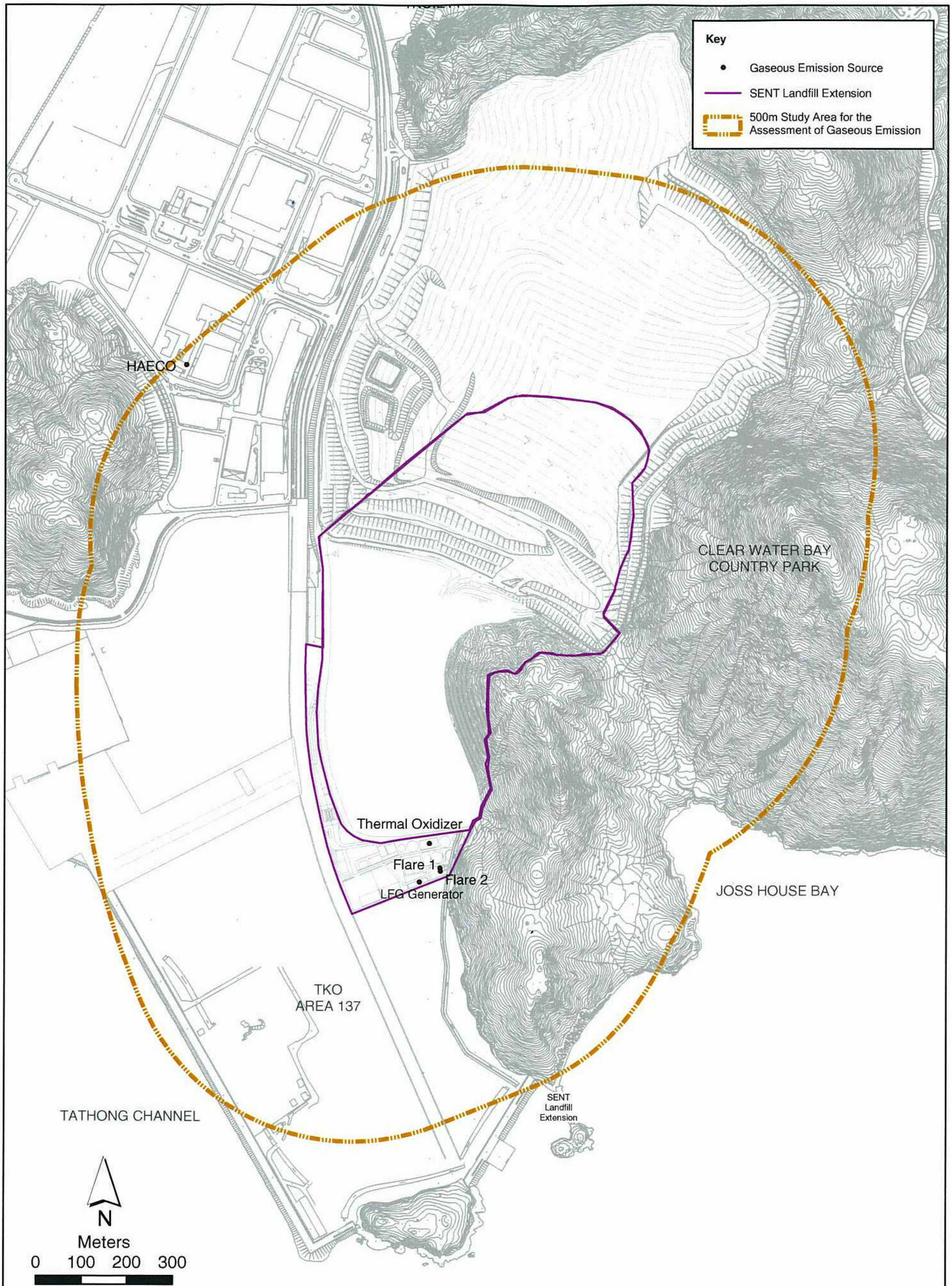

FIGURE 4.5b

Locations of LFG Flares,Thermal Oxidizer, LFG Generator and HAECO Stack at TKOIE

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Table 4.5d ***Summary of Gaseous Emission Inventory for the Flares and Thermal Oxidiser During Operation/Restoration Phase*** *(a)*

Parameter	**Flare**	**Thermal Oxidiser**	**LFG Generator**
No. of emission points	2	1 (one duty and one standby)	1 (one duty and one standby)
Stack height (m)	25	9.76	28
Stack diameter (m)	3.8	1.12	0.305
Exhaust gas velocity ($m\ s^{-1}$)	12.24	17.5	48.6
Exhaust gas flowrate ($m^3\ s^{-1}$)	499,582	62,068	12,780
Exit temperature (°C)	850	171.6	454
Emission limit for NO_x (b)	11.28 mg m^{-3}	28.4 mg m^{-3}	0.14 lb $mmBTU^{-1}$
Emission limit for CO (b)	28.19 mg m^{-3}	70.91 mg m^{-3}	0.44 lb $mmBTU^{-1}$
Emission limit for SO_2 (b)	1.55 mg m^{-3}	3.90 mg m^{-3}	0.045 lb $mmBTU^{-1}$
Emission limit for benzene (b)	2.98×10^{-3} mg m^{-3}	7.51×10^{-3} mg m^{-3}	2.1×10^{-5} lb $mmBTU^{-1}$
Emission limit for vinyl chloride (b)	1.88×10^{-3} mg m^{-3}	4.73×10^{-3} mg m^{-3}	1.6×10^{-6} lb $mmBTU^{-1}$
Emission rate for NO_2 ($g\ s^{-1}$)	0.31 (c)	0.10 (c)	0.11 (c)
Emission rate for CO ($g\ s^{-1}$)	3.91	1.22	1.721
Emission rate for SO_2 ($g\ s^{-1}$)	0.22	0.07	0.176
Emission rate for benzene ($g\ s^{-1}$)	4.14×10^{-4}	1.29×10^{-4}	8.22×10^{-5}
Emission rate for vinyl chloride ($g\ s^{-1}$)	2.61×10^{-4}	8.15×10^{-5}	6.26×10^{-6}

Notes:
(a) Detailed calculations are summarized in *Annex A1*.
(b) All emission limits are under its exhaust gas condition.
(c) Assuming 20% of NO_x is NO_2.

Vehicular Emissions from Traffic Associated with the Extension

The waste arising forecast indicates that a maximum of 134 vehicles per hour(1) will be generated from the operation of the Extension which will be about 19% on the Wan Po Road south of Chung Wang Street and about 2.4% on the Wan Po Road south of Pak Shing Kok Road as compared to forecasted background traffic in 2018 (refer to *Annex B2-3*). It is anticipated that this limited increase in traffic flow will not result in adverse air quality impacts at the identified ASRs.

Fugitive Emissions at Landfilling Area in the Extension

The landfill activities during the operation/restoration phase of the Extension will generate fugitive dust and gaseous emissions from (1) the construction of drainage channels and sumps, LFG and leachate extraction wells and collection systems; (2) haul roads; and (3) operation of the construction equipment. Landfill surface emission from the active tipping face is also a potential fugitive emission source.

(1) The maximum traffic flow is predicted in 2018.

Fugitive Dust Emissions: Fugitive dust will be emitted from the placement of cover materials, construction of LFG and leachate collection pipes and wells, traffic movements on the unpaved haul roads and traffic movements at the waste reception area. The quantities of soil and rock to be handled for different phases of the Extension are summarized in *Table 4.5e*.

Table 4.5e *Total Soil and Rock Fill Requirements*

Phase	Total Fill Requirement (m^3)		Fill Requirement Per Day (m^3d^{-1}) [(a)]	
	Soil	Rock	Soil	Rock
1	365,600	60,500	1,000	165.8
2	453,100	60,500	1,240	165.8
3	478,700	60,500	1,310	165.8
4	557,900	60,500	1,530	165.8
5	590,800	60,500	1,620	165.8
6	658,800	60,500	1,800	165.8
Total	**3,104,900**	**363,000**	**-**	**-**

Note:
(a) For each phase, no. of day is 365.

The management of fugitive dust at the Extension will be similar to that being implemented at the existing SENT Landfill and will include immediate compaction of the fill area; regular damping down of the surface of the haul road; provision of vehicle washing facility for RCVs at the exit of the Extension (to ensure no significant dust will be brought onto the public road); and regular cleaning of the main access road and waste reception area by road sweeper.

Although the lining of side slopes will be carried out concurrently with the waste tipping operation, no earthworks will be required for the slope lining works. Hence, there will be no cumulative dust impacts for these activities.

At the existing SENT Landfill, the average ambient daily TSP concentration record at the ambient TSP monitoring stations located at the site boundary [(1)] over the past five years (2002-2006) was 89 $\mu g\ m^{-3}$. There were no exceedances of the daily dust criterion of 260 $\mu g\ m^{-3}$ due to the operation of the landfill.

As the majority of the Extension site will be covered with impermeable liner, the potential areas from which dust can be generated will be much lower when compared with the existing SENT Landfill operation. Hence, it is anticipated that the potential dust to be generated due to the operation of the Extension will be much lower than that from the operation of the existing SENT Landfill. With the implementation of the dust control measures recommended in *Section 4.8.2*, it is expected that the TSP concentrations at the Extension site boundary during the operation/restoration phase will be well below the daily dust criterion and there will be no adverse dust impacts to the identified ASRs.

(1) The ambient daily TSP concentration measurements were taken at four ambient monitoring stations located at four sides of the site boundary (ie VOC/1, VOC/5, VOC/6 and VOC/8 shown in *Figure 4.3a*) once every six days.

Gaseous Emissions from Construction Plant: Gaseous emissions such as nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) will be generated from the operation of diesel-fuelled construction for the following activities.

- *Construction of drainage channels and sumps* – transportation of materials, bar bending and cutting as well as concreting;
- *Road construction* – transportation of materials, grading, road rolling;
- *Deposition and compaction of waste* – transportation, deposition and compaction of waste;
- *Placement and removal of daily covered materials* – by excavator, bulldozer, dump truck, vibratory roller and loader; and
- *Capping and landscaping (progressive restoration)* – by bulldozer, dump truck, vibratory roller, loader and mobile crane.

These plants will be located across the site, depending on need. The nearest representative ASR, TVB City, is located at about 110 m away from the nearest construction site boundary. The total gaseous emissions generated by the plant over the construction site area (ie, 20ha) are small and it will disperse and diluted with the ambient air very rapidly. Therefore, the potential air quality impact associated with operation of the construction plant on the identified ASRs is envisaged to be limited and minor.

Emissions of LFG including VOCs from Landfill Surfaces: The predicted LFG generation rates have been discussed in *Section 8.5.1*. The LFG management system is designed to collect LFG generated from the Extension as early as possible. Except the active tipping face and the special waste trench, all the areas will be covered by 600mm of soil and an impermeable liner. In addition to the vertical LFG collection wells, a number of horizontal LFG collection wells will be installed above the leachate drainage layer and within the waste mass. The majority of LFG will be captured by the collection system.

The composition of LFG is anticipated to be similar to that from the existing SENT landfill, given that the waste types accepted will be similar.

Samples obtained from the LFG abstraction wells of the existing SENT Landfill contain about 40 to 60% methane, 30 to 45% carbon dioxide and a trace amount of VOCs (1). In 2005 and 2006, out of the 39 VOCs (2) analysed,

(1) Development & Management of SENT Landfill – Operation and Environmental Monitoring Annual Report, 2002 – 2005

(2) The 39 individual VOCs include dichlorodifluoromethane, vinyl chloride, methanol, ethanol, dimethyl sulphide, carbon disulphide, methylene chloride, chloroform, methyl propionate, butan-2-ol, 1,1,1-trchloroethane, 1,2-dichlroethane, benzene, carbon tetrachloride, di-n-propyl ethene, heptane, trichloroethylene, ethyl propionate, methyl butyrate, methanethiol, toluene, ethyl butyrate, octane, propyl propionate, 1,2-dibromoethane, n-butyl acetate, tetrachloroethylene, ethylbenzene, xylene, nonane, ethanethiol, terpenes, propyl benzene, decane, dichlorobenzene, limonene, butyl benzene, undecane and butanethiol. These compounds may be found in LFG generated from municipal solid waste landfill.

only dichlorodifluoromethane, vinyl chloride, dimethyle sulphide, methylene chloride, benzene, heptanes, trichloroethylene, toluene, octanes, tetrachloroethylene, ethylbenzene, xylenes, propyl benzene and dichlorobenzene were detected. For most of these, the measured concentrations were in the range 0.01 and 39.7 µg m^{-3}.

The ambient concentrations of the 39 VOCs were also monitored on a quarterly basis at the ambient air quality monitoring stations at the site boundary. A summary of the measured concentrations of these 39 VOCs from 2002 to 2006 is presented in *Table 4.5f*. Benzene, chloroform, dichlorodifluoromethane, ethylbenzene, methylene chloride, propyl benzene, toluene and xylene were measured in most of the samples. However, the concentrations were well below the respective trigger levels. Other VOCs were not detected or measured. Exceedances of the trigger levels for chloroform and propyl benzene were detected in one occasion at the ambient VOC monitoring stations. Investigations were conducted and it was considered that the abnormal readings were caused by off-site sources such as vehicle exhaust.

Table 4.5f VOC Concentrations at Site Boundary and On-site of the Existing SENT Landfill (2002 - 2006)

Pollutant	Trigger Level	Monitored VOC Concentration (μgm-3)														
		VOC/1			VOC/4			VOC/6			VOC/8			On-site		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
1,1,1-Trichloroethane	19,000	ND	2.3	1.2	ND	2.9	1.5	ND	5.8	1.7	ND	4.1	1.2	ND	4.1	1.4
1,2-Dibromoethane	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.4	4.4	ND	ND	ND
1,2-Dichloroethane	400	ND	0.6	0.4	ND	2.1	0.9	ND	1.3	0.7	ND	2.5	1.2	ND	4.4	1.7
Benzene	160	ND	4.4	1.0	<0.5	10.1	1.5	<0.5	25.1	2.1	<0.5	13.1	1.5	<0.5	4	1.2
Butan-2-ol	3,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Buthanethiol	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butyl Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulphide	255	ND	0.9	0.9	ND	41.2	26.0	ND	5.5	5.1	ND	6.7	6.7	ND	6.8	6.3
Carbon Tetrachloride	126	ND	3.5	1.1	ND	0.9	0.7	ND	1.3	0.8	ND	5	1.2	ND	3.8	1.6
Chloroform	98	ND	67	9.5	ND	**409.2**	36.1	ND	19.1	3.4	ND	30.2	11.0	ND	67	17.2
Decane	1,000	ND	ND	ND	ND	<1	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorobenzene	1500	ND	29	4.1	ND	95	19.3	ND	65	5.6	ND	137	13.8	ND	4	1.5
Dichlorodifluoromethane	49,500	1	37.1	3.7	ND	450	27.1	ND	159.4	11.0	ND	490	25.9	ND	8.1	1.9
Dimethyl Sulphide	11	ND	ND	ND	ND	9.4	5.0	ND	0.7	0.7	ND	ND	0.4	ND	0.2	0.2
Di-n-Propyl Ether	2700	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanethiol	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol	1,900	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Butyrate	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Propionate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	1,000	ND	160	14.1	ND	268	28.3	ND	562	32.3	ND	182	17.8	ND	160	16.7
Heptane	16,000	ND	21.9	7.2	ND	<1	0.8	ND	34	17.8	ND	49	17.0	ND	47.9	21.6
Limonene	57	ND	5.2	5.2	ND	ND	ND	ND	3.5	3.5	ND	2	2.0	ND	ND	ND
Methane	-	<1	480	31.2	<1	250	48.7	<1	97.9	21.1	<1	436.7	34.4	<1	130	10.2
Methanethiol	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methanol	2,600	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Butyrate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Propionate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	3,500	<0.4	557.3	49.5	<0.4	174	28.9	<0.4	104.2	17.1	ND	680.6	97.9	<0.4	2885	197.5
n-Butyl Acetate	1,500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nonane	24,000	ND	5	1.8	ND	29	7.9	ND	<0.9	<0.9	ND	<0.9	<0.9	ND	26	16.0

Pollutant	Trigger Level	Monitored VOC Concentration (µgm^{-3})														
		VOC/1			VOC/4			VOC/6			VOC/8			On-site		
		Min	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Octane	14500	ND	13	4.5	ND	3	1.8	ND	37	25.9	ND	30	12.2	ND	14.5	6.2
Propyl Benzene	196	ND	74.9	11.1	<0.8	**<u>605.1</u>**	42.3	ND	**<u>340</u>**	31.0	ND	280	24.0	ND	**<u>282</u>**	21.9
Propyl Propionate	56,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Terpenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	3,350	ND	94.5	10.1	ND	19.5	6.3	ND	24.5	3.8	ND	11.5	6.1	ND	7.5	2.7
Toluene	1,880	4	124	24.2	<0.5	463	89.6	<0.5	1003	74.2	<0.5	423	55.0	<0.5	264	50.4
Trichloroethylene	5,350	ND	2.2	1.4	ND	6	3.1	ND	4.8	2.8	ND	4.4	2.0	ND	<1.2	<1.2
Undecane	1,300	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	78	0.4	0.4	0.4	ND	9.5	4.2	ND	36.5	5.1	ND	4.9	3.5	ND	<0.3	0.3
Xylene	4,350	ND	200	16.7	<0.5	479	50.1	<0.5	941	54.4	<0.5	271	29.8	<0.5	200	22.8

Notes:

(a) "ND" means Not Detectable.

(b) **Bold** and underlined figure indicates the exceedance of the trigger level.

As the majority of the Extension site will be covered with an impermeable liner and LFG will be extracted via a comprehensive LFG collection system during the operation phase, it is anticipated that the fugitive LFG emission from the Extension due to waste tipping activities will be significantly reduced relative to the existing SENT Landfill. Taking account of the ambient VOC monitoring results at the existing SENT Landfill, it is expected that the ambient VOC concentrations at the Extension Site boundary will be well below the trigger levels for individual compounds. Further dilution of the VOC concentration is expected due to dispersion off-site. The anticipated VOC concentrations at the identified ASRs will be minimal and will not cause adverse impacts.

Odour Emissions from Waste Filling Activities and Operation of LTP

The restoration of the landfill will take place progressively, whilst operations are ongoing on other parts of the site, therefore, these two phases have been considered together in the assessment.

Potential sources of odour impact during operation/restoration phase included:

- Waste filling area; and
- Operation of the LTP and the LFG treatment facility.

In order to minimize the potential odour emissions during the operational phase of the Extension, a number of odour management and control measures have been incorporated into the outline design. These measures are summarized in *Table 4.8a*.

<u>Odour Emissions from Waste Filling Area</u>

The Extension is scheduled to commence operation in 2013 and will be designed to receive MSW, special waste (1) and construction waste. By that time, the Sludge Treatment Facilities (STF) are scheduled to be in operation (2) and sludge from sewage treatment works (STWs) will be diverted to the STF for treatment and disposal.

The operational life of the Extension is expected to be about 6 years. The Extension will be developed in 6 phases (Phases 1 to 6) and each phase will be in operation for approximately 1 year. The ground level of the first phase will be at about +6mPD and the highest level will be at +150 mPD. The Extension will open to receive wastes from 8 am to 11 pm every day.

Waste Reception Area: All incoming and outgoing refuse collection vehicles (RCVs) will be weighed at the enclosed weighbridge office at the waste

(1) Special waste means animal carcasses, asbestos waste, chemical waste, incineration residues and clinical waste.

(2) Reference to the Sludge Treatment Facilities - Project Profile (ESB 169/2007) submitted for the application of EIA Study Brief (http://www.epd.gov.hk/eia/register/profile/latest/esb169/esb169.pdf) dated 20 August 2007.

reception area. All RCVs visiting the Extension are of enclosed-type and expected to comply with relevant regulations and to be properly maintained, therefore, the potential odour emission from RCVs and at the waste reception area are assumed to be minimal.

Active Tipping Face: After weighing, the RCVs will be directed to the active tipping face for unloading. The operation at the active tipping face will be similar to that of the existing SENT Landfill. Two platforms (ie lower and upper platforms) will be used for separate unloading of MSW (at the lower platform) and construction waste (at the upper platform). The construction waste will overlay the MSW. The wastes will be promptly spread by bulldozer and compacted by a landfill compactor to minimize the exposure time of MSW thus minimise the opportunity of odour emission to the atmosphere. The tipping face area will be 30m x 40m (1). After 11 pm, the Extension will be closed and the compacted waste will be covered with 300mm of cover soil immediately. Therefore, odour emissions from the active tipping face are expected during the operating hours; however, the emissions will be much reduced thereafter.

Special Waste Trench: A trench will be excavated into the landfill mass for the disposal of waste that needs special handling. The trench will be located at least 50 m from the active tipping face and the waste boundary. The trench will only operate when the waste depth is at least 10m above the base to avoid damage to the leachate collection system. The size of the trench will vary in accordance with the volume of special waste that has been pre-registered for disposal by the special waste producers. With reference to the operational experience at the existing SENT Landfill and the quantity of special waste received, it is expected that the maximum size of the trench will be about 6m x 2.5m. The trench will be open to receive special waste from 9 am to 5 pm everyday. After 5 pm, the trench will be backfilled with inert waste and covered by 600 mm of soil and an impermeable liner to minimise odour emissions. Special waste for trench disposal is normally required to be delivered in sealed bags and no odour will be generated from the bagged waste. However, odour will potentially be emitted from the side walls and the base of the trench itself during operating hours. In order to reduce the odour emission from the trench, the trench will be covered by a movable cover with retractable or suitable opening so that the trench is covered at all times except during waste deposition. The air trapped inside the trench will be extracted and scrubbed by a mobile odour removal unit prior to discharge to the atmosphere. Therefore, the odour emitted from the trench will be minimal. However, for the worst-case assessment in this Study, it is assumed that the trench is open to atmosphere without any odour removal.

Main Haul Road to Active Tipping Face: The MSW will be delivered in RCVs with enclosed compactor body. It is therefore anticipated that the potential odour emission from the RCVs along the haul road of the Extension will be minimal.

(1) Half of the area for MSW mixed with construction waste and half of the area for construction waste tipping only.

Daily Covered Area: At the end of each working day (ie after 11 pm), the active tipping face will be covered with 300 mm of soil and compacted.

Intermediate Cover Area: Except for the active tipping face and the final cover area (see below for details), all other areas of the Extension will be covered with 600mm of soil (1) and an impermeable liner in order to minimize rainwater infiltration into the waste and odour emission as well as to enhance LFG extraction. It is therefore anticipated that no odour will be emitted from this area (2).

Final Cover Areas: After waste tipping reaches the final levels, a capping system will be installed. The capping system will comprise (from bottom to top) a soil layer, a non-woven geotextile, an HDPE liner (impermeable layer), a sub-soil drainage layer and a final cover soil layer. Permanent gas extraction system will be installed to extract LFG from the waste mass. Planting will also be provided for the final covered area. It is therefore anticipated that no odour will be emitted from this area (3).

<u>Operation of Leachate Treatment Plant (LTP)</u>

Leachate collected from the Extension and the existing SENT Landfill will be pumped to the LTP in the new infrastructure area. The LTP will consist of four buffer storage tanks, two ammonia stripping towers, two thermal oxidisers (i.e., one in operation and one standby), a stripped leachate storage tank, two SBR tanks and a sludge holding tank. Except for the SBR tanks, all tanks will be enclosed and the air exhaust from the tanks will be diverted to the thermal oxidiser. The operation temperature of the thermal oxidizer is about 850°C. Odorous gas in the exhaust air (such as ammonia) will be oxidised and destroyed at such high temperature (4) in the thermal oxidiser prior to discharge to the atmosphere. The SBR tanks will therefore be the only odour emission source in the LTP.

The dimension of each of the SBR tanks is 20m (width) x 35m (length). The tank height is about 5m. The leachate temperature in the SBR will be maintained at about 40°C throughout the year. The LTP will operate on a 24-hours per day basis.

(1) For preparation of the active tipping face, the top layer of intermediate cover soil (600mm) will be removed and stockpiled for daily cover at the end of the working day.

(2) Reference to EIA Report for *Agreement No. CE 20/2004 (EP) North East New Territories Landfill Extension (EIA 133/2007), Table 3.30.* Effective temporary covers with impermeable plastic sheets will be applied at the inactive tipping areas.

(3) Reference to EIA Report for *Agreement No. CE 20/2004 (EP) North East New Territories Landfill Extension (EIA 133/2007).* The final cover of both SENT and NENT Extensions adopt similar design concept which includes (from bottom to top) a soil layer, non-woven geotextile, HDPE liner, sub-soil drainage layer, and a final cover soil layer. LFG will be extracted for flaring or utilization. The contractor will be responsible for regular maintaining the restoration facilities (including the capping, LFG and leachate management systems) for up to 30 years. Both Extensions will require the Extension Contractors to undertake routine monitoring integrity of the capping system, operation of the flares, surface emission of LFG, ambient VOC emissions and sub-surface migration of LFG.

(4) Reference to http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ammonia/working_ammonia.html

Operation of LFG Treatment Facility

The LFG treatment facility will be operated on a 24-hours per day basis. The LFG collected from the LFG extraction system will be either diverted to other utilization scheme for beneficial use or flared at the treatment facility. The flaring temperature is about 850°C and odorous compounds such as VOCs or H_2S in the LFG will be oxidised and destroyed at such temperatures. Therefore, no odour emission is expected from the LFG treatment facility.

Summary of Potential Odour Emission Sources

As discussed above, the major potential odour sources will include waste tipping activities at the active tipping face and at the special waste trench as well as the operation of the LTP.

The odour emission sources during the operation/ restoration phase are summarized in *Table 4.5g*.

Table 4.5g Summary of Odour Emission Sources

Odour Emission Source	**Area**	**Remarks**
During Operation Hour (8am – 12 midnight)		
Active tipping face for MSW + construction waste	30m x 20m	• From 8am to 11pm. Covering the active tipping face after operation at 11pm to 12 midnight
Active tipping face for construction waste	30m x 20m	• From 8am to 11pm. Covering the active tipping face after operation at 11pm to 12 midnight
Special waste trench	6m x 2.5m (plan area exposed to air) (a)	• From 9am to 5pm. Covering the trench at 5pm – 6pm
After Operation Hour (12 midnight – 8am on the next day)		
Daily cover area	30m x 40m	12 midnight – 8am (on the next day)
24-hour Operation		
SBR tanks of the LTP	20m x 35m (2 nos.)	24 hours

Note:
(a) Longer side : 6m (l) x 2m (H); shorter side: 2.5m (l) x 2m (H); bottom: 6m x 2.5m

4.5.3 *Aftercare Phase*

Upon completion of final filling and capping, the aftercare phase will commence and is estimated to last for up to 30 years. The LFG and leachate management systems as well as the LFG generator will continue to operate during the aftercare phase.

Operation of LTP

It should be noted that once the landfill is restored, the leachate generation rate from the Extension will be significantly reduced and hence the average daily volume of leachate to be treated will be reduced from about 350 $m^3 d^{-1}$ to 23 $m^3 d^{-1}$, ie approximately an 93% reduction). With respect to the small volume of leachate generated, it will be able to reduce the nitrogen levels in the leachate using biological treatment (ie, nitrification and denitrification) so that the effluent will comply with the discharge standards. The operation of the ammonia strippers and thermal oxidisers will not be necessary.

The vent gas from the enclosed leachate storage and treatment tanks will be diverted to an air scrubber or the flares prior to discharge to the atmosphere. The designed odour (including ammonia gas) removal efficiency of the air scrubber will be at least 95%. Therefore, majority of the odorous gas in the vent gas from enclosed tanks will be removed. The scrubbed vent gas will be used as part of the air intake for the aeration system of the SBR tank. If the vent is diverted to the flare(s) as part of the air intake, the odorous gas will be destroyed at high combustion temperature (at 850^{o}C).

The potential source of odour emission during the aftercare phase will only be the open SBR tanks (please refer to *Table 4.6e* for the odour emission rate of the SBR tanks).

Operation of LFG Treatment Facility

Together with the final capping system, the permanent LFG extraction system will prevent fugitive emission of LFG from the restored landfill. The LFG abstracted will be utilised or flared. Under a high combustion temperature (850^{o}C) at the flare, the odorous VOCs in the LFG will be completely oxidised and destroyed.

Conversely, the total LFG generated from the restored SENT Landfill and the Extension will increase (maximum yield of about 17,000 $m^3 hr^{-1}$). A worst case scenario has been assumed where the two flares will be operated at full load (20,000 $m^3 hr^{-1}$). The emission inventory of flares is summarized in *Table 4.5h*. The detailed calculation is summarized in *Annex A1*.

LFG Generator

LFG generator will continue to provide power supply for the operation of LFG Treatment Facility, LTP and other facilities at the infrastructure area. The emission inventory of the LFG generator is summarized in *Table 4.5h* and detailed calculations are presented in *Annex A1*.

Table 4.5h *Summary of Gaseous Emission Inventory for the Flares and Generator During Aftercare Phase (a) (b)*

Parameter	**Flare**	**LFG Generator**
No. of emission points	2	1 (one duty and one standby)
Stack height (m)	25	28
Stack diameter (m)	3.8	0.305
Exhaust gas velocity ($m\ s^{-1}$)	12.24	48.6
Exhaust gas flowrate ($m^3\ s^{-1}$)	499,582	12,780
Exit temperature (°C)	850	454
Emission limit for NO_x (c)	11.28 $mg\ m^{-3}$	0.14 lb $mmBTU^{-1}$
Emission limit for CO (c)	28.19 $mg\ m^{-3}$	0.44 lb $mmBTU^{-1}$
Emission limit for SO_2 (c)	1.55 $mg\ m^{-3}$	0.045 lb $mmBTU^{-1}$
Emission limit for benzene (c)	$2.98x10^{-3}$ $mg\ m^{-3}$	$2.1x10^{-5}$ lb $mmBTU^{-1}$
Emission limit for vinyl chloride (c)	$1.88x10^{-3}$ $mg\ m^{-3}$	$1.6x10^{-6}$ lb $mmBTU^{-1}$
Emission rate for NO_2 ($g\ s^{-1}$) (d)	0.31	0.11
Emission rate for CO ($g\ s^{-1}$)	3.91	1.721
Emission rate for SO_2 ($g\ s^{-1}$)	0.22	0.176
Emission rate for vinyl chloride ($g\ s^{-1}$)	$4.14x10^{-4}$	$8.22x10^{-5}$
Emission rate for benzene ($g\ s^{-1}$)	$2.61x10^{-4}$	$6.26x10^{-6}$

Notes:
(a) Detailed calculations are summarized in *Annex A1*.
(b) Reference to *Table 4.5d*
(c) All emission limits are under exhaust gas condition.
(d) Assuming 20% of NO_x is NO_2

4.5.4 *Cumulative Impacts*

According to the EIA Study Brief requirement, major emission sources in the vicinity should be included to assess the cumulative air quality impact.

Construction Phase

The operation of the existing SENT Landfill (last year of operation) and the C&DM Handling Facility in TKO Area 137 are identified as potential concurrent projects during the construction phase of the Extension.

During the last year of the operation of the existing SENT Landfill, most of the landfill area will be capped and restored. Dust will be emitted from the placement of cover materials, traffic movements on the unpaved haul roads and traffic movements at the waste reception area (please refer to *Figure 4.5a*). As discussed in *Section 4.5.3*, due generation will be minimised by implementation of dust control measures, including immediate compaction of the fill area; regular damping down of the surface of the haul road; provision of vehicle washing facility for RCVs at the exit of the existing SENT Landfill (to ensure no significant dust will be brought onto the public road); and regular cleaning of the main access road and waste reception area by road sweeper.

The separation distance between the active tipping area of the existing SENT Landfill and the dusty construction work area of the Extension site is about 850m (refer to *Figure 4.5a*). As the worse wind angles which carry the dust from dusty activity area of Extension and that for dust generated from the active tipping area of the existing SENT Landfill are different, no cumulative dust impacts are anticipated due to the operation of the existing SENT Landfill and the construction of the Extension.

TKO Area 137 is currently planned for Deep Water Front Industrial uses. A Construction and Demolition Material (C&DM) Handling Facility is scheduled to be commissioned in phases in TKO Area 137 (see *Figure 3.9b*) in 2009. The capacity of the C&DM Handling Facility is about 20,000 tonnes per day. However, the detailed design information is not available at this stage but it is understood that the potential dust impacts associated with the operation of the C&DM Handling Facility will be assessed as part of the feasibility and engineering design of the facility. It is recommended that the cumulative dust impact in the vicinity should be addressed in the environmental study under that study. It is anticipated that the facility will incorporate necessary dust control measures (as stipulated in the *Air Pollution Control (Construction Dust) Regulations)* in the design of the facility (which may include enclosure of the dusty operations) and good site practices to control dust emissions from the facility. It is expected that no adverse dust impact will result from the operation of the facility.

As of the existing fill bank at TKO Area 137 will be decommissioned by the end of 2008, no cumulative dust impact will be anticipated.

In summary, no cumulative dust impact is anticipated during the construction of the Extension.

Operation/Restoration and Aftercare Phases

<u>Odour Impact</u>

When the Extension commences operation, the existing SENT Landfill will be closed and will not generate odour. No other similar concurrent type of odour source is identified within 500m of the Extension site boundary during the operation/restoration and aftercare phases. Hence, no cumulative landfill odour impact is expected.

<u>Gaseous Emissions from the existing TKO Industrial Estate</u>

Within 500m from the Extension site boundary, emissions from TVB City and HAESL may cause cumulative air quality impact. On-site chimney survey within the 500m area from the Extension site boundary was conducted in January 2008. Interviews were also conducted to validate the stack operation and its emission inventory.

According to the information provided by TVB City and the public information obtained from the EPD Regional Office (East), the major gaseous emission sources identified at TVB City are the emergency generators. As the emergency generators will only operate when CLP's grid is suspended, the operating time of these generators is very limited and it will not expected to cause cumulative air quality impact within the Study Area.

With reference to the EIA Report of *HAECO Aircraft Engine Test Cell Facility at TKO*, NO_2, CO and SO_2 are the key air pollutants to be emitted during engine testing. These emission rates and stack characteristics are summarized in *Table 4.5i*.

Table 4.5i ***Stack and Emission Characteristics in Study Area*** *[(a)]*

Stack ID	No. of Stacks	Efflux Velocity ($m\ s^{-1}$)	Stack Diameter (m)	Stack Height Above Ground (m)	Exit Temp. (°C)	Emission Rate ($g\ s^{-1}$)		
						NO_2	CO	SO_2
HAECO / HAESL [(c)]	1	16.4 for NO_2 and SO_2; 12 for CO	14.7	40	52	21.2	23.9	1.92

Notes:

(a) Reference to the EIA Report of *HAECO Aircraft Engine Test Cell Facility at TKO*.

(b) It is the equivalent diameter. The stack is in square shape with an area of 13m x 13m.

The above stack characteristic, emission inventory and engine type being tested at HAESL have been confirmed by HAESL.

The emissions of NO_2, CO and SO_2 from HAESL are included to assess the cumulative air quality impact during both the operation/restoration and aftercare phases.

4.6 *ASSESSMENT METHODOLOGY*

4.6.1 *Construction Phase*

Dust will be generated from blasting, materials handling, wind erosion, rock crushing and truck movements on paved haul roads within the site. It should be noted that no construction works will be carried out during blasting due to the site constraint and safety reason. The dust impact from blasting will be assessed individually.

TSP levels at the identified ASRs were predicted using the Fugitive Dust Model (FDM). The 2006 meteorological data obtained from the existing SENT Landfill weather station and TKO weather station operated by the Hong Kong Observatory (HKO) were used for the model runs. Dust emission rates and associated particle size distributions for the assessment were determined in accordance with the *Compilation of Air Pollutant Emission Factors, AP-42, 5th Edition*. One blast will be made each day and the construction works would be carried out for 12 hours (from 7am to 7pm) per day and 24 days per month. During night-time (7pm to 7am on next day), only wind erosion of open fill area was considered. Mitigation measures recommended in *Section 4.8.1* have been considered in the dust emission rate estimation.

The mitigated TSP emission rates during blasting, rock crushing, materials handling, wind erosion and truck movement on unpaved haul road within the construction site are estimated and summarized in *Table 4.6a* and detailed calculations are presented in *Annex A2*.

Table 4.6a ***Mitigated Dust Emission Rates*** *[(a) (b) (c)]*

Construction Works	Dust Generating Activities	Dust Emission Rate	Remarks
Slope Cutting	Blasting	1.93 gs^{-1}	• Blasting area = 1,000 m^2 (estimated by the engineer) • 1 blast per day during daytime • Total no. of day = 107 days • Emission height = 0,5m
Excavation	Materials Handling	0.0103 gs^{-1}	• Excavation period = 1.5 year • Total volume of soil excavated = 770,000 m^3 • Hourly soil generation rate = 148.5 m^3/hr • 50% dust removal efficiency by watering • Working time: between 7am and 7pm • Emission height: 0.5m
	Rock crushing	• Crushing = 0.0098 gs^{-1} • Screening = 0.018 gs^{-1}	• Rock to be crushed per day = 400m^3 per day (max.) • Working time: between 7am and 7pm • Emission height = 5m
	Truck movement on unpaved haul road	0.00435 $gm^{-2}s^{-1}$	• Total no. of vehicle trip per hour = 70 (including return trip) • Average truck weight = 21.5 tonnes • 90% dust removal efficiency by watering of main haul road, limiting vehicle speed and paving with aggregate/gravel • Working time: between 7am and 7pm • Emission height: 0.5m
Filling	Materials Handling	0.0054 gs^{-1}	• Filling period = 1.5 year • Total volume of fill materials = 407,200 m^3 • Hourly filling rate = 78.5 m^3/hr • 50% dust removal efficiency by watering • Working time: between 7am and 7pm • Emission height: 0.5m

Construction Works	Dust Generating Activities	Dust Emission Rate	Remarks
	Truck movement unpaved haul road	0.00156 $gm^{-1}s^{-1}$	• Total no. of vehicle trip per hour = 26 (including return trip) • Average truck weight = 20 tonnes • 90% dust removal efficiency by watering of main haul road, limiting vehicle speed and paving with aggregate/gravel • Only carried out during daytime between 7am and 7pm
	Wind erosion	▪ Daytime : $1.35x10^{-6}$ $gm^{-2}s^{-1}$ ▪ Night-time : $2.7x10^{-6}$ $gm^{-2}s^{-1}$	• Total area = about 15 hectare • 50% dust removal efficiency by watering during daytime and no dust reduction at night-time • 24-hour

Notes:

(a) Detailed calculations and location of the dust emission sources are presented in *Annex A2*.

(b) Dust emission factors in Compilation *of Air Pollutant Emission factors, (AP-42), 5th Edition* by USEPA is used.

(c) Dust control measures recommended in *Section 4.8.2* have been adopted.

Hourly and daily TSP concentrations were predicted at 1.5m and 10m above ground of the representative ASRs A1 to A4, A7 and A8 which are located within 500m of the Extension site boundary as the dust impact is localized. Daily TSP concentrations predicted from blasting, construction works and night-time wind erosion activities will be directly added to obtain an overall daily TSP concentration at the ASRs. The background TSP concentration, as presented in *Table 4.3a*, was also used to assess the cumulative TSP concentrations.

4.6.2 *Cumulative Gaseous Emissions During Operation/Restoration and Aftercare Phases*

An EPD approved air dispersion model, ISCST3, was employed for the assessment. The 2006 meteorological data obtained from the existing SENT Landfill weather station and TKO weather station operated by the Hong Kong Observatory (HKO) were used for the model runs. The "rural" mode was used. Terrain effects within 500m of the Extension site boundary have been included.

The emission rates of NO_2, CO, SO_2, benzene and vinyl chloride from the operation of the LFG treatment facility, LTP and LFG generator during operation/restoration and aftercare phases, presented in *Tables 4.5d* and *4.5h*, respectively, were used for the prediction. The thermal oxidiser, LFG flares and LFG generator will be operated 24 hours per day. It is conservatively assumed that the engine testing at HASEL will be carried on a 24-hour basis. The locations of the LFG treatment facility, LTP, LFG generator and the emission points at HASEL are shown in *Figure 4.5b*.

The hourly, daily and annual average concentrations of the key air pollutants were predicted at 1.5m to 30m above ground at the representative ASRs A1 to

A4, A7 and A8 as the maximum height of these ASRs is 30 m above ground. The worst affected height was identified and isopleths showing the levels of these key air pollutants at 1.5m above ground and the worst affected height were plotted.

Background concentrations presented in *Table 4.3a* were included in the assessment of the cumulative air quality impact.

4.6.3 Odour Emissions from Waste Filling Activities and Operation of LTP During Operation/Restoration Phase

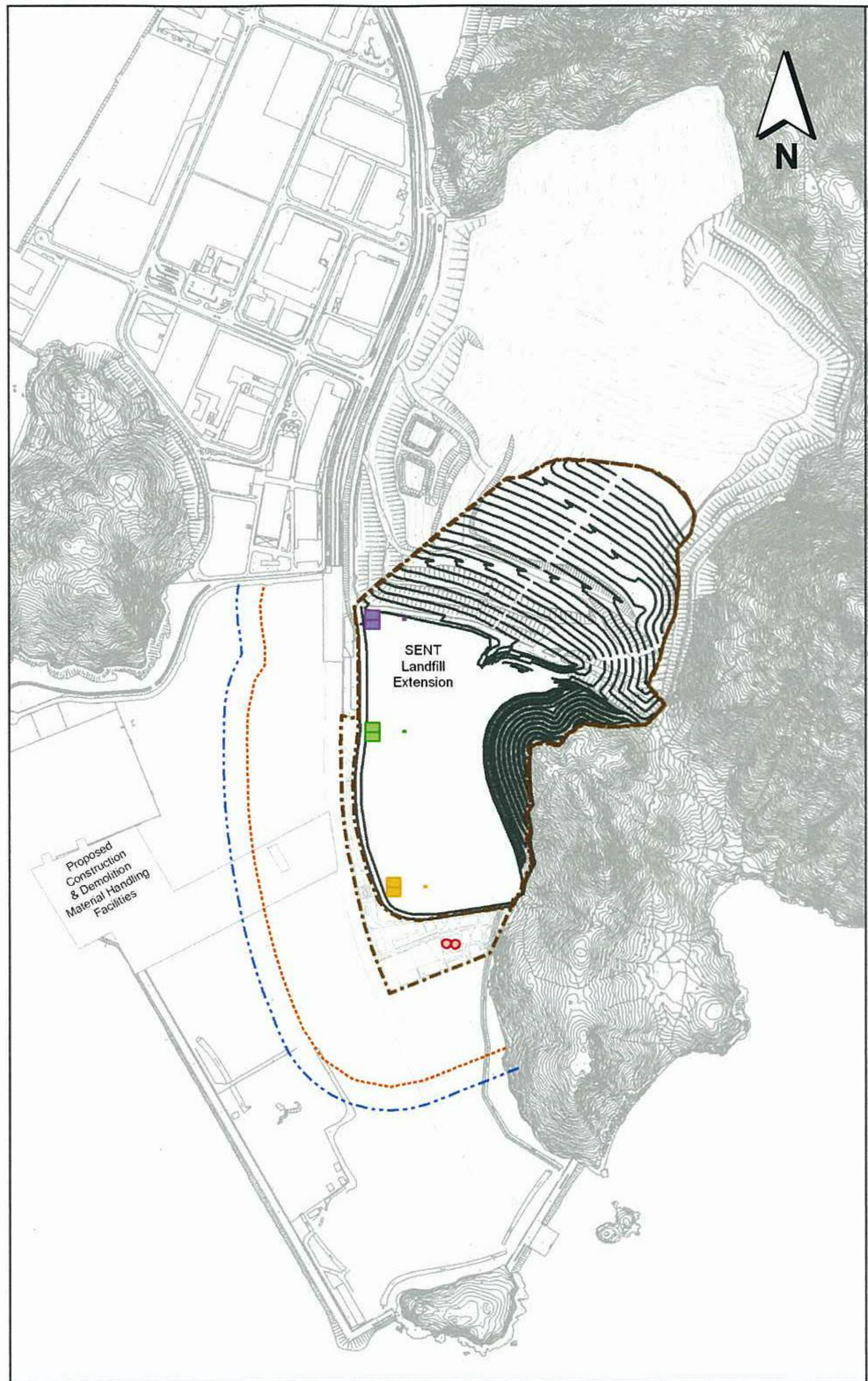
Selection of Emission Source Locations for Worst Cases

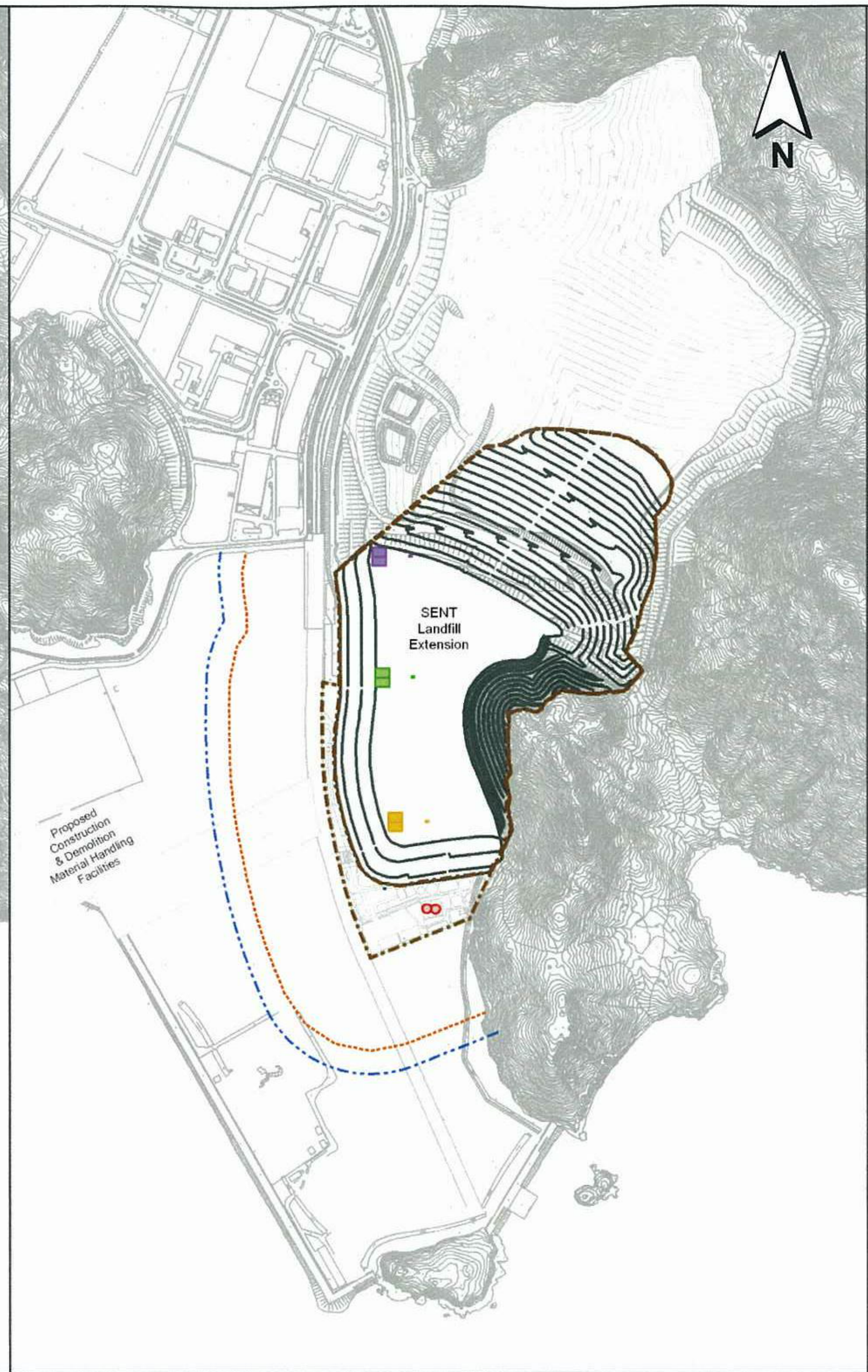
The operation/restoration of the Extension will be divided into six phases starting from the south and filling progressively to the north (see *Figures 4.6a-1* and *4.6a-2*) in general. Three worst-cases (Cases 1 – 3) in each phase (except Phase 6) have been identified for the odour impact assessment, which have taken into account the worst case odour impacts to existing ASRs in TKOIE (eg TVB City), planned ASRs in the TKO Area 137, and ASRs at higher elevations (eg LOHAS Park (ASR A20)). Odour emission inventory including type of source, source area, source height, duration and the temperature of each worst-case are summarized in *Table 4.6b*.

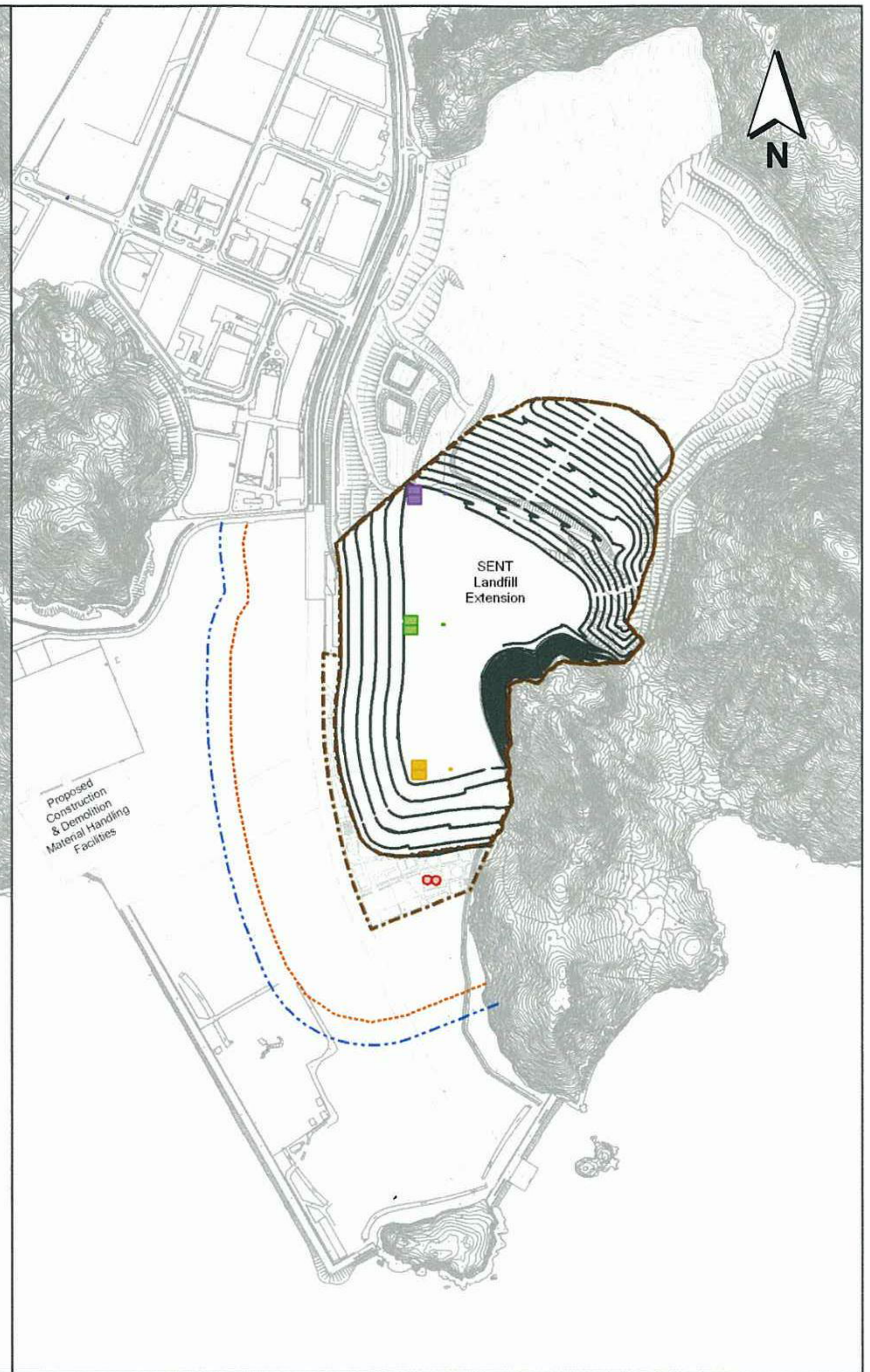
Table 4.6b Odour Emission Inventory in Each Worst Case

Source Height	**Worst-case Scenario (b)**	**Odour Source**	**Area**	**Air Temperature of Odour Emission (a)**
Phase 1 • 10m above ground Phase 2 • 30m above ground Phase 3 • 50m above ground Phase 4 • 70m above ground Phase 5 • 100m above ground Phase 6 • 130m above ground	In each phase, there will be 3 worst cases (b): • Case 1 (southern end of Extension) • Case 2 (western side of Extension close to A1-1) • Case 3 (northern side of the Extension)	<u>*During Extension Opening Hours (8am – 12 midnight)*</u>		
		Active tipping face for MSW + construction waste	• 30m x 20m •	30°C
		Active tipping face for construction waste	• 30m x 20m	30°C
		Special waste trench	• 6m x 2.5m (plan area exposed to air)	30°C
		<u>*After Extension Opening Hours (12 midnight – 8am on the next day)*</u>		
		Daily cover area	• 30m x 40m	30°C
		<u>*24-hour Operation*</u>		
		SBR tanks	• 35m x 20m (2 nos.)	30°C

Notes:
(a) Reference to the sensitivity analysis summarized in *Annex A3*.
(b) For Phase 6, since the waste tipping area is small, therefore, 2 worst cases are assumed.







Phase 1
(Emission Source Height at 10m above Ground)

Phase 2
(Emission Source Height at 30m above Ground)

Phase 3
(Emission Source Height at 50m above Ground)

Key

- SBR Tanks
- Case 1 Emission Sources
- Case 2 Emission Sources
- Case 3 Emission Sources
- Extension Site Boundary
- HKPSG Recommended 200m Buffer Area for Odour
- Landfill Gas Consultation Zone (250m)

Not To Scale

Figure 4.6a - 1

Location of Odour Emission Sources for each Waste Filling Phase (1 of 2)

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Environmental Resources Management

ERM

Key

- SBR Tanks
- Case 1 Emission Sources
- Case 2 Emission Sources
- Case 3 Emission Sources
- Extension Site Boundary
- HKPSG Recommended 200m Buffer Area for Odour
- Landfill Gas Consultation Zone (250m)

Not To Scale

Figure 4.6a - 2

Location of Odour Emission Sources for each Waste Filling Phase (2 of 2)

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DATE: 16/11/2007

Environmental Resources Management
ERM

Reasonable Worst-case Odour Modelling Parameter

Odour Sampling at SENT Landfill

Odour generated from landfill operation varies from landfill site to landfill site; no general odour emission rates for landfilling activities are available. Odour samples were taken from the existing SENT Landfill for olfactometry analysis by the Odour Research Laboratory of the Hong Kong Polytechnic University to establish a set of odour emission rates for this study.

Sampling Time and Locations: Measurements were taken between 9:00 am and 9:30 pm at four locations (see *Table 4.6c*). The sampling locations and the ambient temperature during sampling are presented in *Table 4.6c*.

Table 4.6c Odour Sampling Regime

Location	Sampling ID	Ambient Temperature (°C)
MSW + Construction Waste (S1)	S1-1	30.83
	S1-2	31.45
	S1-3	26.01
	S1-4	23.03
	S1-5	20.85
	S1-6	30.05
MSW + Construction Waste + 300mm Soil Cover (S2)	S2-1	30.97
	S2-2	31.58
	S2-3	26.16
	S2-4	29.55
Special Waste Trench (S3)	S3-1	27.00
	S3-2	26.47
SBR of LTP (S4)	S4-1	26.90

As the existing SENT Landfill receives MSW, construction waste, special wastes as well as dewatered sludge from sewage treatment works (STWs), the sampling locations for S1 and S2 were therefore selected away the existing active tipping face and at the upwind location to avoid potential odour contamination. A new tipping platform was formed at the sampling location and MSW and construction waste were disposed of using the normal practices. The ratio of MSW to construction waste disposed was the same as that predicted for the Extension (ie the ratio of MSW to construction waste is about 1 : 2). For S2, the compacted MSW and construction waste was covered with 300mm of cover soil. The odour samples for S3 and S4 were taken at the base of the special waste trench and at the water surface of the SBR tank of the SENT Bioplant, respectively.

The odour emission from construction waste is very low and on a conservative basis, it is assumed that the odour emission rate from construction waste tipping is the same as that for S2.

It should be noted that the existing SENT Landfill also receives sewage sludge; therefore, the odour emission rate measured at the trench will be much higher than that expected for the Extension. Adopting the measured odour emission rates measured at the existing special waste trench in the assessment is a conservative approach.

Odour Sampling and Analysis Methods: Odour samples were taken using the flux chamber method which is the method recommended by the USEPA [(1)] and is also the most commonly used odour sampling method for large surface emission source such as landfill sites. The flux chamber used is a circular chamber with a diameter of 0.41m and an area of 0.13 m^2. It was tightly placed on the surface of the odour source and the air inside the chamber was purged with nitrogen gas at a sweeping rate of 5 litres per minute. The odour sample was collected in a Tedlar bag at a rate of 3 litres per minute. Before taking the next sample, the flux chamber was cleaned with distilled water and then flushed with nitrogen for about 10 minutes to remove residual odour in the chamber. The sampling system and the flux chamber are shown in *Figure 4.6b*.

The odour samples were analysed within 24 hours of the sampling using the olfactometry method by the Odour Research Laboratory of the Hong Kong Polytechnic University. The odour concentration of the samples, measured in Odour Units (OU) per m^3, was determined by a Forced-choice Dynamic Olfactometer in accordance with the European Standard Method EN 13725.

Odour emission rate was then calculated using the following equation:

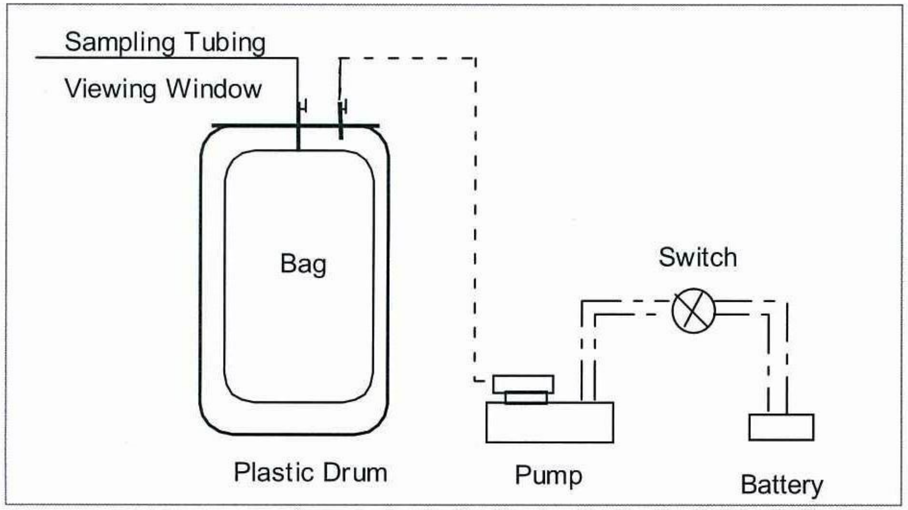
$$\text{Odour Emission Rate (ou/m}^2\text{/s)} = \frac{\text{Measured odour concentration (ou/m}^3\text{) x Sweeping flowrate (0.005/60 m}^3\text{/s)}}{\text{Covered surface area (0.13 m}^2\text{)}}$$

Odour Sampling Results: The measured odour concentrations and calculated odour emission rates of each odour source are summarized in *Table 4.6d*.

Table 4.6d *Odour Sampling Results*

Location	Sampling ID	Onsite Ambient Temperature During Sampling (°C)	Measured Odour Concentration (OU/m^3)	Odour Emission Rate ($OU/m^2/s$)
MSW + Construction Waste (S1)	S1-1	30.83	1,092	0.70
	S1-2	31.45	1,738	1.11
	S1-3	26.01	1,521	0.98
	S1-4	23.03	1,296	0.83
	S1-5	20.85	264	0.17
	S1-6	30.05	1,579	1.01
MSW + Construction Waste + 300mm Soil	S2-1	30.97	80	0.051
	S2-2	31.58	160	0.10

(1) Reference to http://www.odour.unsw.edu.au/flux-hood-sampling.html



Scheme of an Odour Sampling System

Flux Chamber

Onsite Odour Sampling

Figure 4.6b

Onsite Odour Sampling by Flux Chamber

Environmental Resources Management
ERM

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Location	Sampling ID	Onsite Ambient Temperature During Sampling (°C)	Measured Odour Concentration (OU/m^3)	Odour Emission Rate ($OU/m^2/s$)
Cover (S2)	S2-3	26.16	169	0.11
	S2-4	29.55	193	0.12
Special Waste Trench (S3)	S3-1	27.00	10,768	6.90
	S3-2	26.47	16,830	10.79
SBR of LTP (S4)	S4-1	26.90	76	0.049

Definition of a Reasonable Worst-case Odour Modelling Parameters

A sensitivity analysis was undertaken to determine a reasonable worst-case scenario for the odour assessment. Details of the sensitivity analysis can be found in *Annex A3*. The analysis shows that the reasonable worst-case ambient temperature for estimating the odour emission rate is 30°C. Therefore, the reasonable worst-case odour emission rates at this temperature are summarized in *Table 4.6e*.

Table 4.6e ***Reasonable Worst-case Odour Emission Rates Adopted in Odour Impact Assessment***

Odour Source	Source Area	Odour Emission Rates at 30°C ($OU/m^2/s$) [(a)]	Total Odour Emission (OU/s)
During Extension Opening Hours (8am – 12 midnight)			
Active tipping face for MSW + Construction Waste	30m x 20m	0.94	564
Active tipping face for construction waste	30m x 20m	0.12	72
Special waste trench	6m x 2.5m (plan area exposed to air)	31.74 [(c)]	476
After Extension Opening Hours (12 midnight – 8am on the next day)			
Daily cover area [(b)]	30m x 40m	0.12	144
24-hour Operation			
SBR tanks	2 number of 35m x 20m	0.049	69

Notes:
(a) Reference to *Annex A3*.
(b) Total area of active tipping face.
(c) Reference to *Annex A3* for the adjustment of the odour emission rate at 30°C.

Air Dispersion Model and Worst-case Odour Modelling Parameters

The AUSPLUME model, developed by the Australian Government (Environmental Protection Agency, Victoria), was employed for the odour impact assessment. The use of the AUSPLUME model has been approved by the EPD.

As discussed in *Annex A3*, the modelling parameters are summarized in *Table 4.6f*.

Table 4.6f Worst-case Odour Modelling Parameters

Modelling Parameter	Setting
Surface roughness	• 120 cm
Meteorological data	• 2006 hourly SENT landfill weather data : wind speed, wind direction and air temperature • 2006 HKO TKO weather data : stability class • 2006 HKO King's Park weather data : mixing height • 90% of data are valid
Terrain effect	• Terrain data within 500m from the Extension site boundary have been included in model • "Egan half height" option is selected
Type of odour source in model	• Area source : active tipping faces for MSW and construction waste, daily cover area at night-time and special waste trench • Point source : SBR tanks (with very low exit velocity of 0.001 m s^{-1}) as the leachate temperature is slightly higher than ambient

Also, odour management and control measures summarized in *Table 4.8a* have been considered in the worst-case assessment.

Assessment Height and Presentation of Predicted Results

5-second odour concentrations were modelled at 1.5m, 10m, 20m, 30m, 50m, 70m and 90m (1) above ground level at the identified ASRs and the worst affected heights under different worst-case scenarios are also identified in the assessment. Contours of the predicted odour concentrations at the worst affected height within the Study Area (500m from the Extension site boundary) under different scenarios were plotted.

Conversion of Modelled Results From 3-minute Averaging Time to 5-second Averaging Time

Under the *EIAO-TM*, the odour assessment criterion is defined as 5 OU under a 5-second averaging time. To convert the AUSPLUME output (presented as the maximum 3-minute mean concentration) to a maximum 5-second mean concentration, the approach suggested by the Warren Spring Laboratory (WSL) (2) was adopted:

"*Typical maximum or peak 5-second average concentrations within any 3-minute period appear to be of the order of 5 times the 3-minute average. During very unstable conditions larger ratios, perhaps 10:1, are more appropriate…..*"

It should be noted that the ratios provided in the WSL report refer to peak to mean concentrations for emissions from stacks. Emissions from low-level area sources will fluctuate less and therefore the peak to mean ratios will be

(1) The odour concentration drops significant against the increase of height at ASRs, therefore, the prediction level is set at 90m above ground. The odour concentration predicted at the height higher than 90m is much lower.

(2) Warren Spring Laboratory, "Odour Control - A Concise Guide", 1980.

lower. The use of the peak to mean ratios provided in the WSL report therefore provides a conservative estimate for the 5-second mean concentrations for area sources.

For stable conditions (stability classes C to F), a factor of 5 was applied whilst for unstable conditions (stability classes A and B) a factor of 10 was applied to the emission rates input in the model run. The modelled results will be the 5-second odour concentrations.

The factored odour emission rates are presented in *Table 4.6g*. These odour emission rates applied to the three worst-cases described in *Table 4.6b*. An example showing hourly emission rate file adopted in AUSPLUME model is presented in *Annex A4*.

Table 4.6g *Odour Emission Rates for AUSPLUME Model Run*

Modelling Period	Odour Emission Source	Area Size in Model	Air Temperature of Odour Emission	Factored Odour Emission Rate to be used in Model Run to obtain 5-second Results ($OU\ m^{-2}\ s^{-1}$) (b)	
				Stability Class A & B (c)	Stability Class C to F (d)
During Operation (8am – 12 midnight)	Active tipping face for MSW + Construction Waste	30m x 20m	30°C	9.4	4.7
	Active tipping face for construction Waste (a)	30m x 20m	30°C	1.2	0.6
	Special Waste Trench	6m x 2.5m (plan area exposed to air)	30°C	317.41	158.7
Night-time (Midnight to 8am on the next day)	Daily Cover Area (a)	30m x 40m	30°C	1.2	0.6
24-hour Operation	2 numbers of SBR tanks	20m x 35m (each)	30°C	343 ($OU\ s^{-1}$)	171.5 ($OU\ s^{-1}$)

Notes:

(a) The odour emission rates of daily cover area at night and the active tipping face for construction waste during operation are similar due to the odour nature of the ground is the same.

(b) Reference to *Tables 4.6b* and *4.6e* for original odour emission at 30°C.

(c) A factor of 10 is applied to convert the results from 3 minutes to 5 seconds.

(d) A factor of 5 is applied to convert the results from 3 minutes to 5 seconds.

4.7 EVALUATION OF IMPACTS

4.7.1 *Construction Phase*

The cumulative hourly and daily TSP concentrations at 1.5m and 10m above ground of ASRs within 500m of the Extension site boundary were predicted taking account of the implementation of the suitable dust control measures and the predicted results are summarized in *Tables 4.7a* and *4.7b*, respectively.

Table 4.7a Predicted Mitigated Cumulative Hourly TSP Concentrations at ASRs within 500m of the Extension Site Boundary

ASR	Description	Predicted Mitigated Cumulative Maximum Hourly TSP Concentrations (μgm^{-3}) [(a)]			
		Blasting		Construction Activities	
		1.5m Above Ground	10m Above Ground	1.5m Above Ground	10m Above Ground
A1-1	Proposed C&DM Handling Facility	310	204	272	174
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) - 1	312	376	260	264
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2	195	243	183	218
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) - 1	462	424	371	309
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	336	254	297	217
A2	TVB City	363	345	312	282
A3	HAESL	214	213	202	201
A4	HAECO Component Overhaul Building	196	195	188	186
A7	Yan Hing Machinery Industrial Building	179	200	172	193
A8	Apple Daily	170	190	165	186
Hourly TSP Criterion		**500**	**500**	**500**	**500**

Note:

(a) Background TSP concentration (ie 78 μgm^{-3}) has been included in the results.

Table 4.7b Predicted Mitigated Cumulative Daily TSP Concentrations at ASRs within 500m of the Extension Site Boundary

ASR	Description	Predicted Mitigated Cumulative Daily TSP Concentrations (μgm^{-3})							
		1.5m Above Ground				**10m Above Ground**			
		Blasting (i)	**Daytime Construction Works (ii)**	**Night-time Wind Erosion (iii)**	**Total = (i) + (ii) + (iii) + background [(a)]**	**Blasting (i)**	**Daytime Construction Works (ii)**	**Night-time Wind Erosion (iii)**	**Total = (i) + (ii) + (iii) + background [(a)]**
A1-1	Proposed C&DM Handling Facility	28	24	9	139	25	19	6	128
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) - 1	34	55	19	185	27	39	6	149
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2	16	24	5	123	15	20	4	117
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) - 1	36	48	11	173	31	35	6	150
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	29	23	7	138	26	20	6	130
A2	TVB City	39	27	7	151	31	22	6	136
A3	HAESL	15	10	4	107	14	10	4	105
A4	HAECO Component Overhaul Building	9	7	4	98	8	7	4	96
A7	Yan Hing Machinery Industrial Building	8	13	7	106	7	13	6	104
A8	Apple Daily	10	15	5	107	9	14	5	106
				Daily TSP Criterion	**260**			**Daily TSP Criterion**	**260**

Note:

(a) Background TSP concentration (ie 78 μgm^{-3}) has been included in the total results.

With the implementation of good construction site practices and dust control measures recommended in *Section 4.8.1*, the predicted cumulative hourly and daily TSP levels at identified ASRs within 500 m from the Extension site boundary are all well below the respective dust criteria. Isopleths showing the predicted cumulative hourly and daily TSP levels at the worst affected level (ie, 1.5m above ground) in the vicinity are illustrated in *Figures 4.7a-1* to *4.7a-2* and *4.7b*.

In particular for the blasting, exceedance of hourly TSP levels was predicted at the area close to site boundary of TKO Area 137 (as shown in *Figure 4.7a-1*). It should be noted that the blasting will last for very short instances (ie few second) and one blast will be carried out each day for a total of 107 days, therefore, the dust impact will be transient. With the implementation of the mitigation measures during blasting, the dust impact will be controlled to within the dust criteria.

Exceedance of hourly TSP levels was predicted on a small section of the future road during daytime construction works. No ASRs are located within the affected area and the dust impact during daytime construction works is within the dust criteria.

4.7.2 *Gaseous Emissions from LFG Flares, Thermal Oxidizer of LTP and LFG Generator During Operation/Restoration Phase*

The highest predicted maximum hourly average, daily average and annual average concentrations of NO_2, SO_2, benzene and vinyl chloride are presented in *Table 4.7c*. The highest predicted hourly and 8-hour average concentrations of CO are also presented in *Table 4.7c*. The predicted concentrations of these air pollutants at different ASR elevations of are summarized in *Annex A5-1*.

A sample input file of ISCST3 is attached in *Annex A6*.

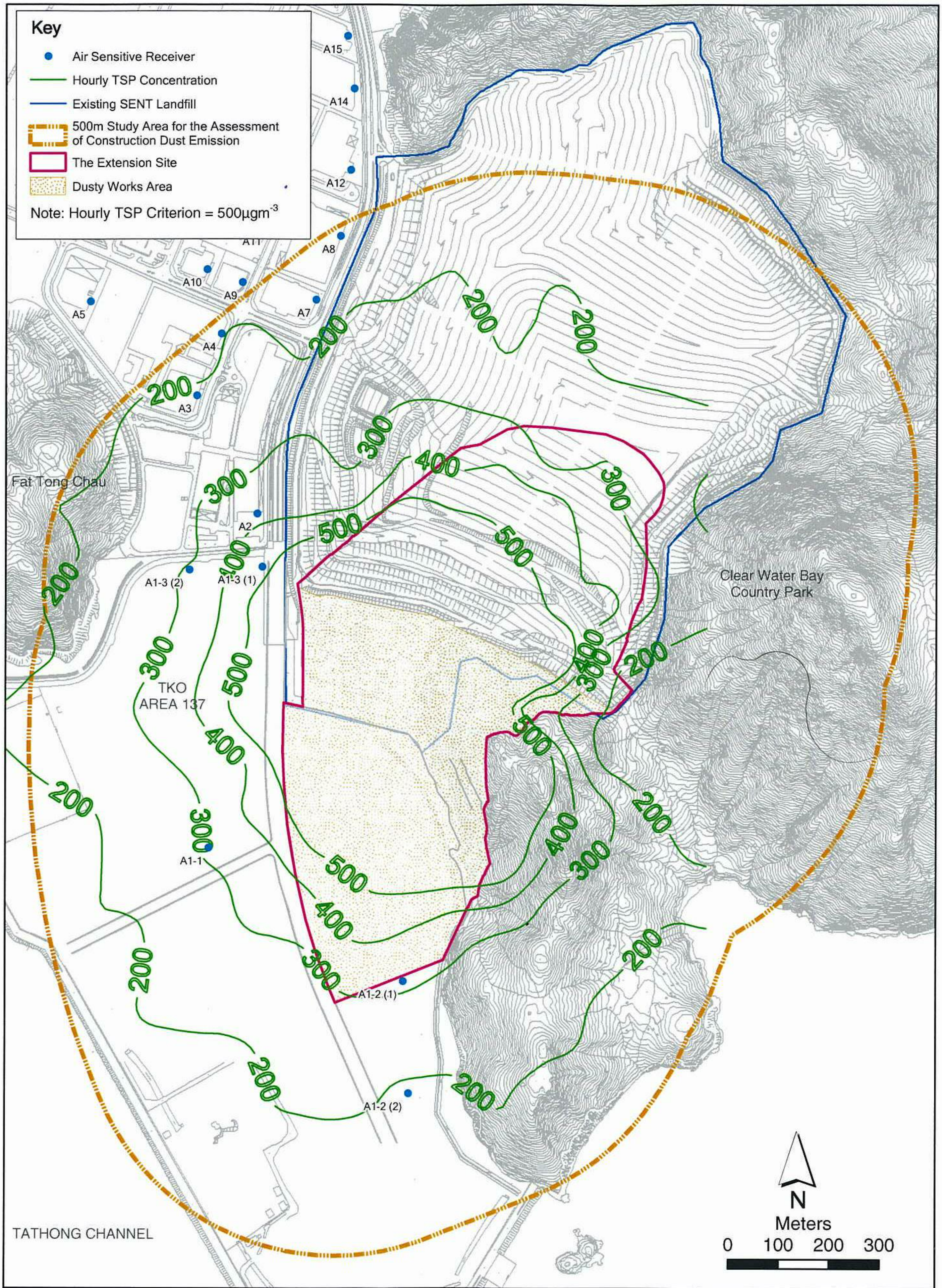

FIGURE 4.7a-1

Isopleths of Maximum Hourly TSP Concentrations at 1.5m Above Ground During Construction Phase (Blasting)

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File: 0036286_TSP_1.mxd
Date: 18/01/2008

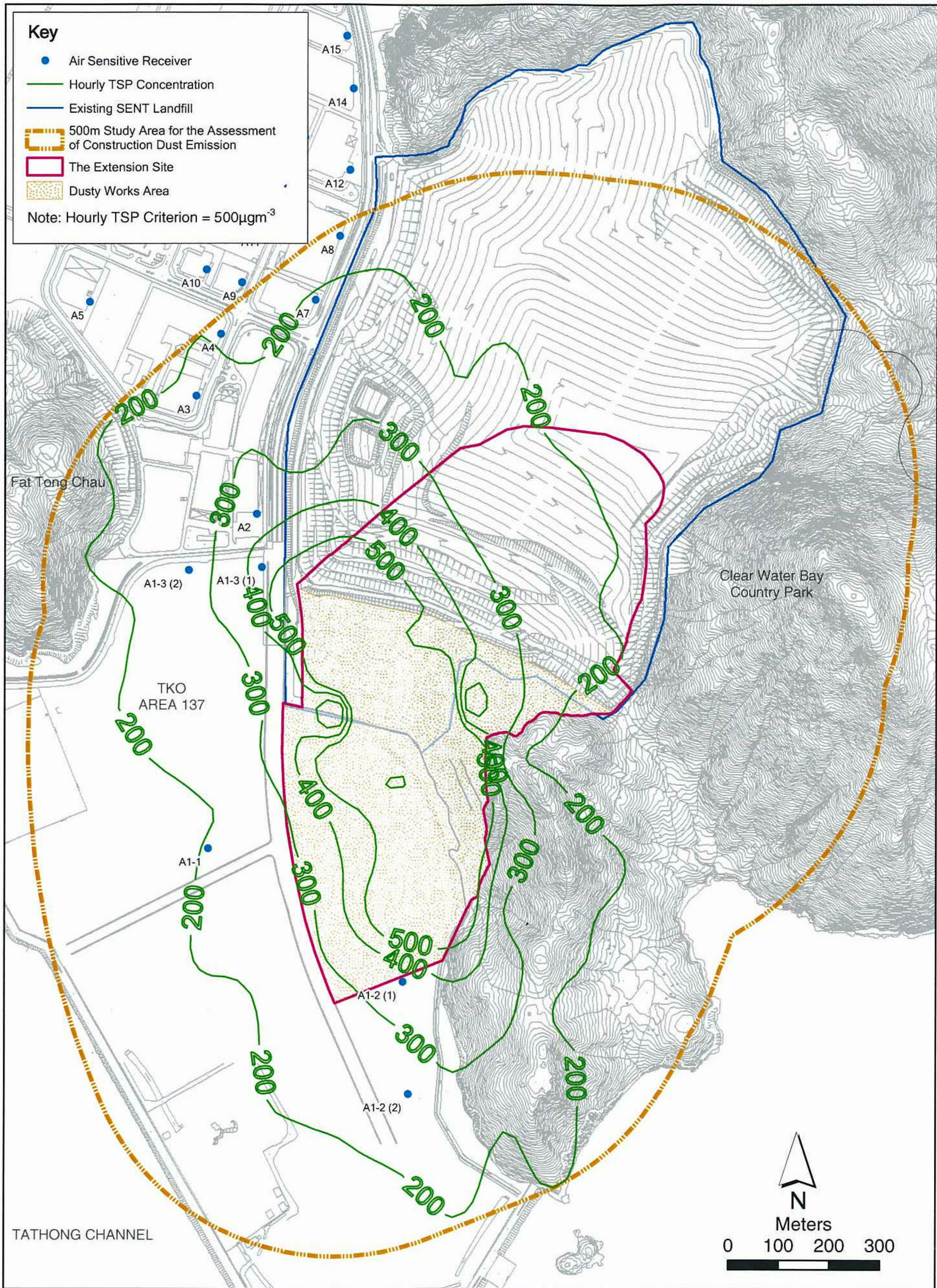

FIGURE 4.7a-2

Isopleths of Maximum Hourly TSP Concentrations at 1.5m Above Ground During Construction Phase (Construction Works)

File: 0036286_TSP_2.mxd
Date: 18/01/2008

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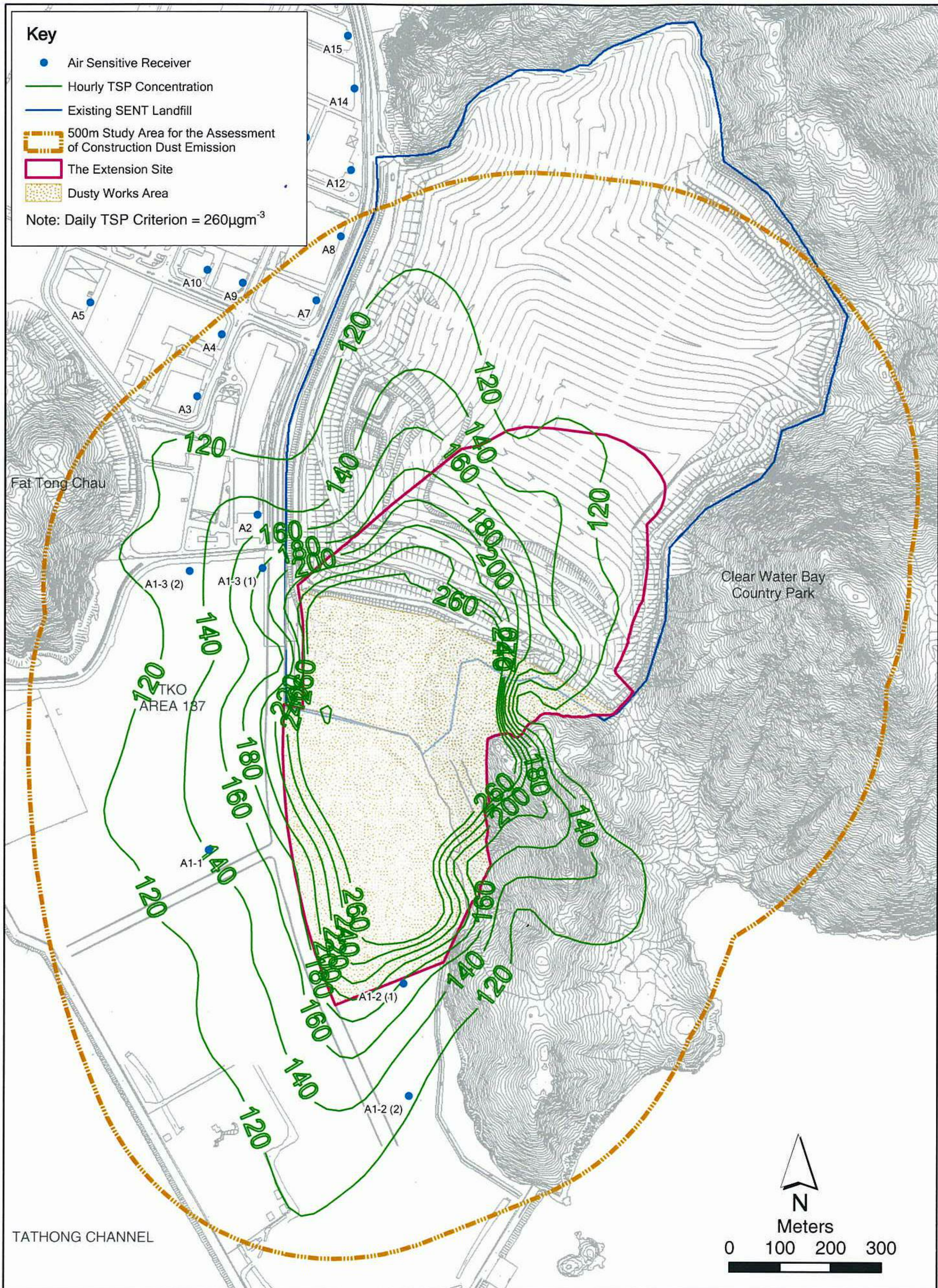

FIGURE 4.7b

Isopleths of Daily TSP Concentrations at 1.5m Above Ground During Construction Phase

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Date: 18/01/2008

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Table 4.7c Highest Concentrations of NO_2, CO, SO_2, Benzene and Vinyl Chloride in Different Averaging Times During the Operation/Restoration Phase

ASR	Location	Highest Hourly Average Concentration ($\mu g\ m^{-3}$) [(a) (b)]					Highest Daily Average Concentration ($\mu g\ m^{-3}$) [(a) (b)]		Highest 8-hr Average Concentration ($\mu g\ m^{-3}$) [(a) (b)]	Highest Annual Average Concentration ($\mu g\ m^{-3}$) [(a) (b)]			
		NO_2	**CO**	**SO_2**	**Benzene**	**Vinyl Chloride**	**NO_2**	**SO_2**	**CO**	**NO_2**	**SO_2**	**Benzene**	**Vinyl Chloride**
A1-1	Proposed C&DM Handling Facility	75	1357	24.1	2.11	5.10	67.0	19.0	1326	66.10	18.11	2.100	5.100
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) – 1	134	2273	118.1	2.19	5.16	90.3	51.2	1764	67.93	20.16	2.102	5.101
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2 *(outside HKPSG 200m buffer distance)*	77	1448	31.1	2.11	5.10	67.8	20.0	1361	66.12	18.14	2.100	5.100
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) – 1	71	1359	22.8	2.11	5.10	66.6	18.7	1312	66.09	18.09	2.100	5.100
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2 *(outside HKPSG 200m buffer distance)*	71	1358	22.7	2.11	5.10	67.3	19.5	1325	66.11	18.11	2.100	5.100
A2	TVB City	71	1362	23.0	2.11	5.10	66.5	18.7	1312	66.08	18.09	2.100	5.100
A3	HAESL	71	1359	23.0	2.11	5.10	66.8	18.5	1310	66.24	18.08	2.100	5.100
A4	HAECO Component Overhaul Building	75	1358	23.0	2.11	5.10	67.0	18.7	1308	66.15	18.08	2.100	5.100
A7	Yan Hing Machinery Industrial Building	74	1360	23.1	2.11	5.10	67.5	19.6	1323	66.15	18.13	2.100	5.100
A8	Apple Daily	84	1358	23.1	2.11	5.10	67.3	19.2	1322	66.16	18.12	2.100	5.100
	Background Concentration	**66**	**1294**	**18**	**2.1**	**5.1**	**66**	**18**	**1294**	**66**	**18**	**2.1**	**5.1**
	AQO / Chronic or Acute Reference Concentration	**300**	**30,000**	**800**	**1,300** [(c)]	**180,000** [(c)]	**150**	**350**	**10,000**	**80**	**80**	**30** [(c)]	**100** [(c)]

Notes:

(a) Detailed Assessment Results are summarized in *Annex A5-1*.

(b) Background NO_2, CO, SO_2, benzene and vinyl chloride (presented in *Table 4.3a*) concentrations were included in the results.

(c) Acute/Chronic Reference Concentrations are referred to *Table 4.2d*.

NO_2, CO and SO_2

The highest predicted NO_2, CO and SO_2 concentrations at different elevations of ASRs are low and well within the respective AQO criteria. Isopleths showing cumulative maximum hourly concentrations of NO_2, CO and SO_2 at 1.5m above ground and the worst affected height (30m above ground) within 500m of the Extension site boundary are plotted and presented in *Figures 4.7c* to *4.7e*, respectively [(1)]. The isopleths show that the concentrations of NO_2, CO and SO_2 at the identified ASRs under different averaging time are within the respective AQO criteria. It is therefore concluded that the operation of LFG flares, thermal oxidiser(s) and the LFG generator during the operation/restoration phase will not cause adverse air quality impact to the identified ASRs.

Benzene and Vinyl Chloride

Non-cancer Health Risk Assessment: The predicted maximum hourly and annual average benzene and vinyl chloride concentrations (see *Tables 4.7c* and *Annex A5-1*), taking account of the background, are well below the respective reference acute and chronic concentrations (see *Table 4.2d*), hence, the acute and chronic health effect of benzene and vinyl chloride is considered to be insignificant (refer to *Tables 4.2e* and *4.2f*).

Cancer Health Risk Assessment: Benzene and vinyl chloride are considered to be carcinogenic. A cancer health risk assessment was undertaken using the predicted annual average benzene and vinyl chloride concentrations and the guideline unit risk factors, as shown in *Table 4.2b*. The highest calculated individual cancer health risk levels of benzene and vinyl chloride and total cancer health risk levels are presented in *Table 4.7d* and the calculated individual cancer risk level of benzene and vinyl chloride and total cancer health risk levels at different ASR elevations are summarized in *Annex A5-2*. The calculated total cancer health risk levels are low than 10^{-6} at different elevations of all identified ASRs and the total health risks are considered to be insignificant at all identified ASRs.

(1) *Figure 4.7c-2* presents an isopleths showing the 2nd highest concentration of NO_2 within 500m area from the Extension site boundary.

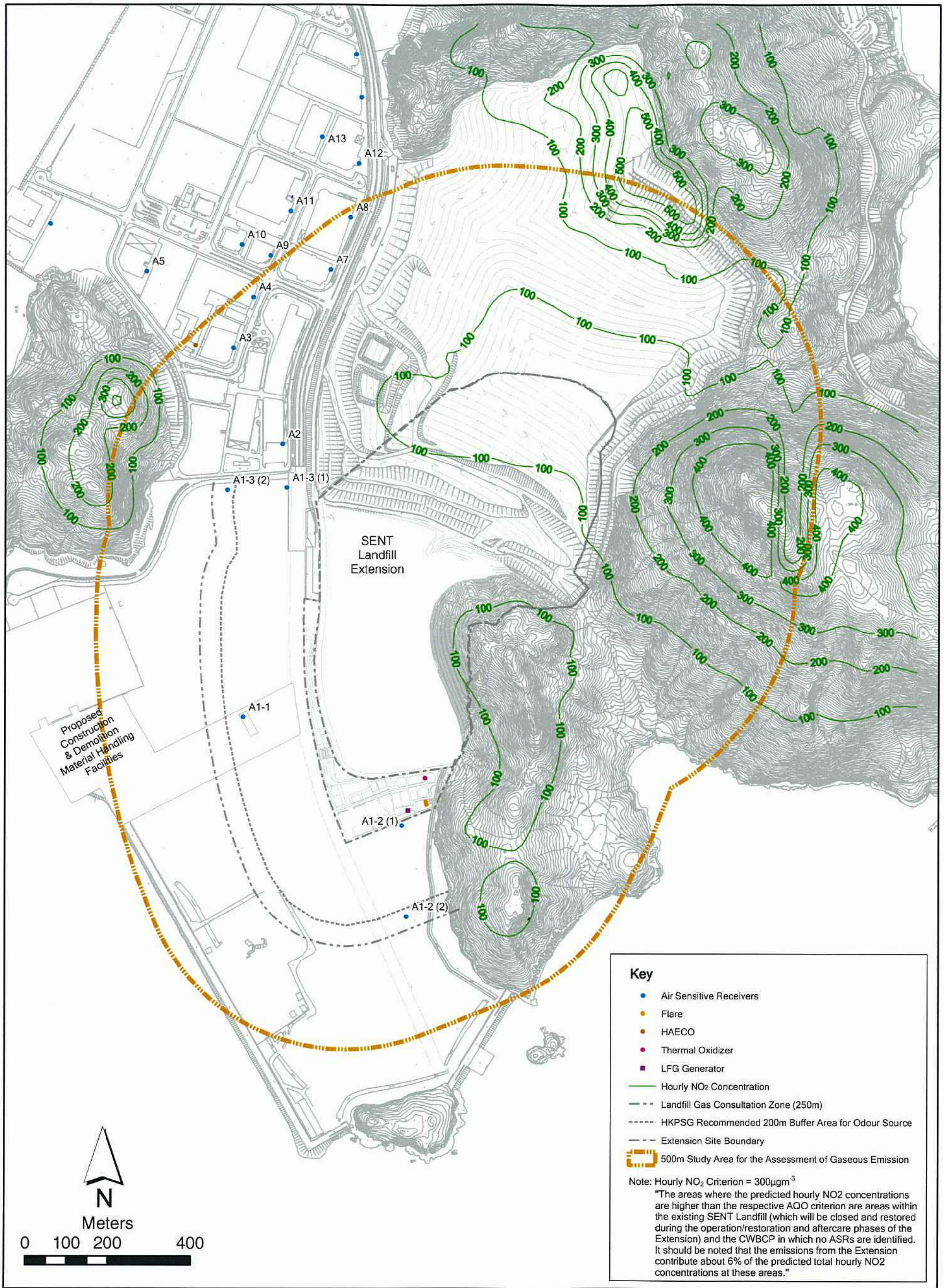

FIGURE 4.7c-1

Isopleths of Cumulative Maximum Hourly NO_2 Concentration at 1.5m above ground during Operation/ Restoration Phase

File: 0036286_NO2_1.5.mxd
Date: 18/01/2008

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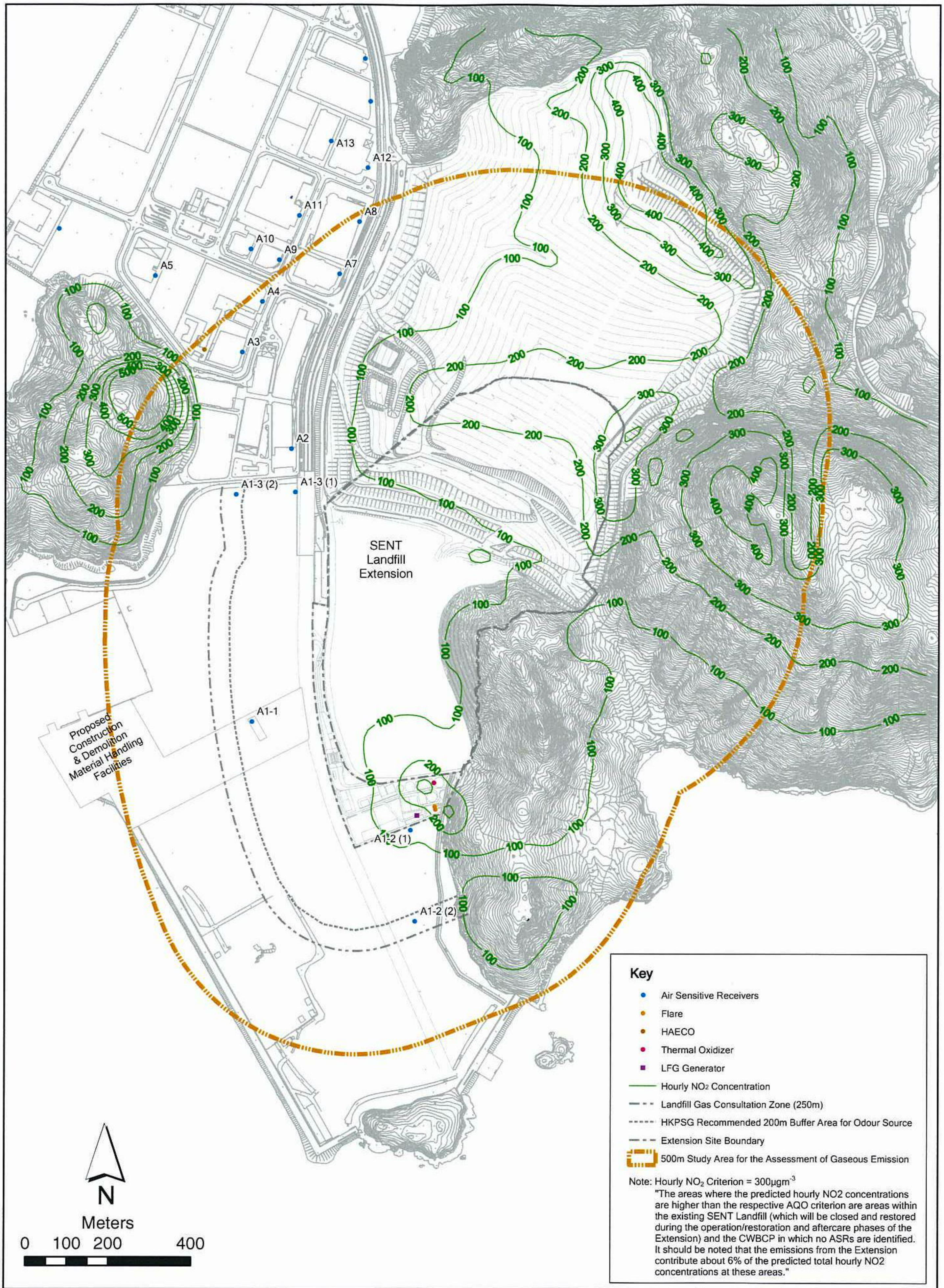

FIGURE 4.7c-2

Isopleths of Cumulative Maximum Hourly NO_2 Concentration at 30m above ground during Operation/ Restoration Phase

File: 0036286_NO2_30.mxd
Date: 18/01/2008

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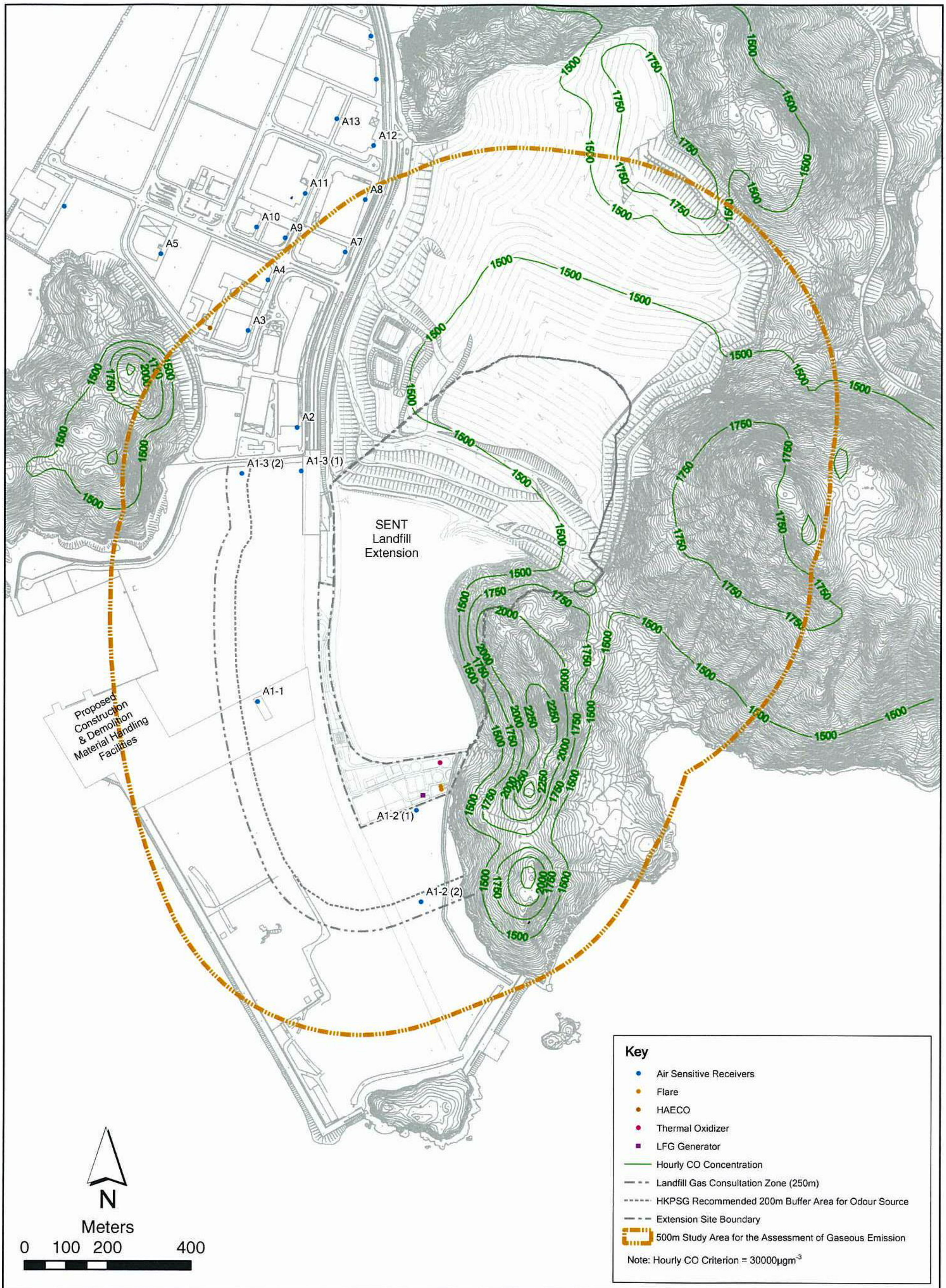

FIGURE 4.7d-1

Isopleths of Cumulative Maximum Hourly CO Concentration at 1.5m above ground during Operation/ Restoration Phase

File: 0036286_CO_1.5.mxd
Date: 18/01/2008

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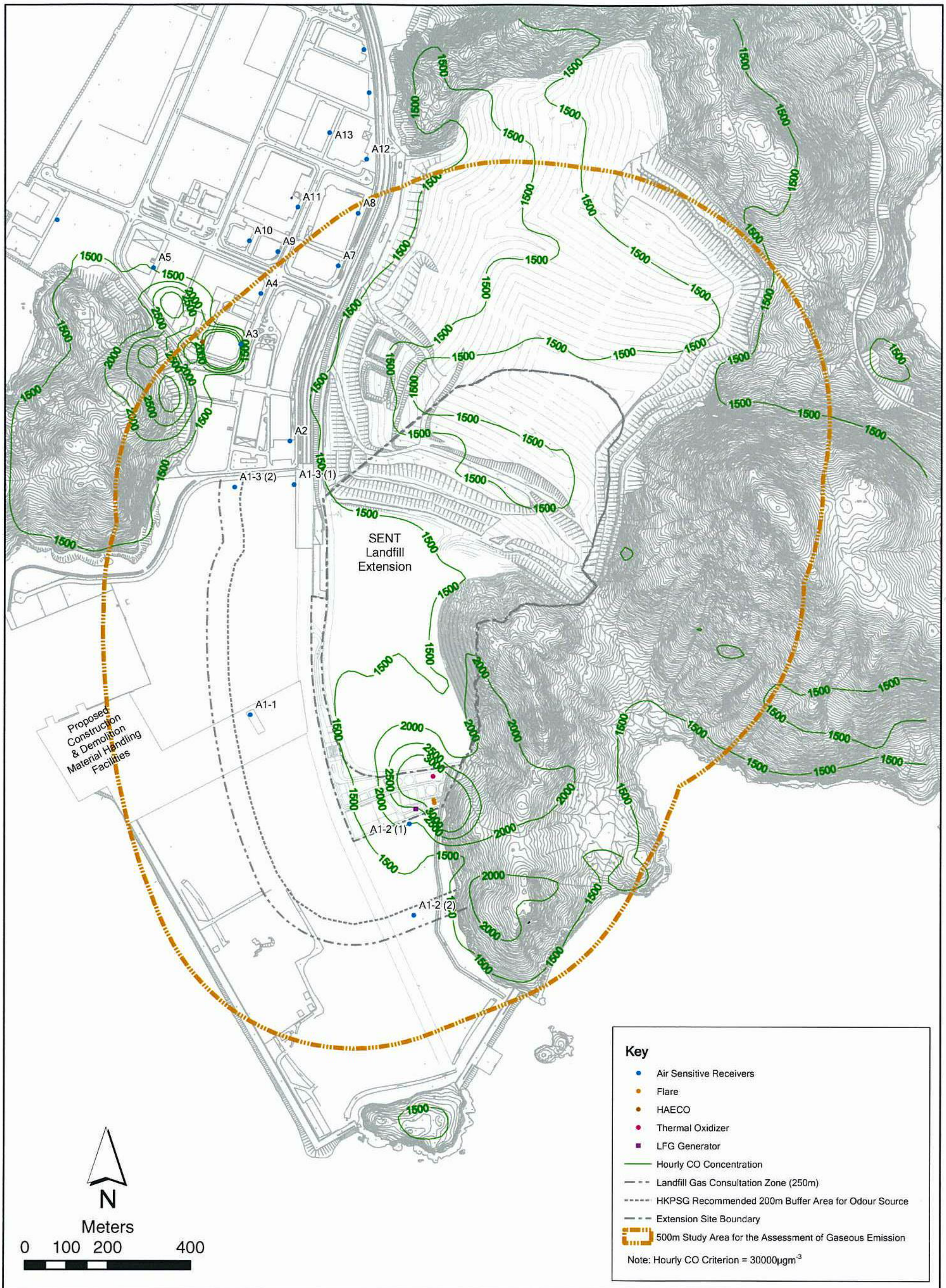

FIGURE 4.7d-2

Isopleths of Cumulative Maximum Hourly CO Concentration at 30m above ground during Operation/ Restoration Phase

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Date: 18/01/2008

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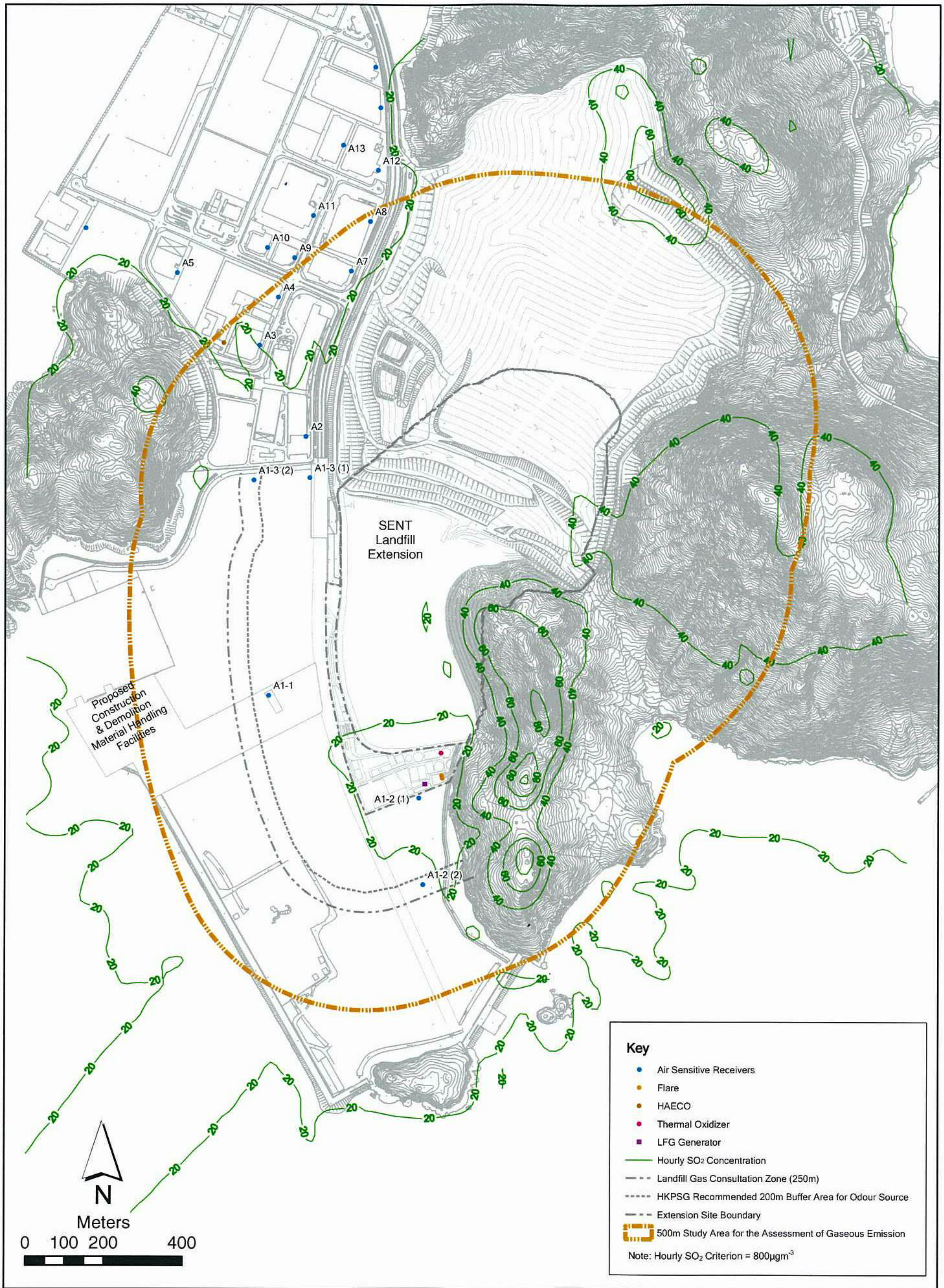

FIGURE 4.7e-1

Isopleths of Cumulative Maximum Hourly SO_2 Concentration at 1.5m above ground during Operation/ Restoration Phase

File: 0036286_SO2_1.5.mxd
Date: 18/01/2008

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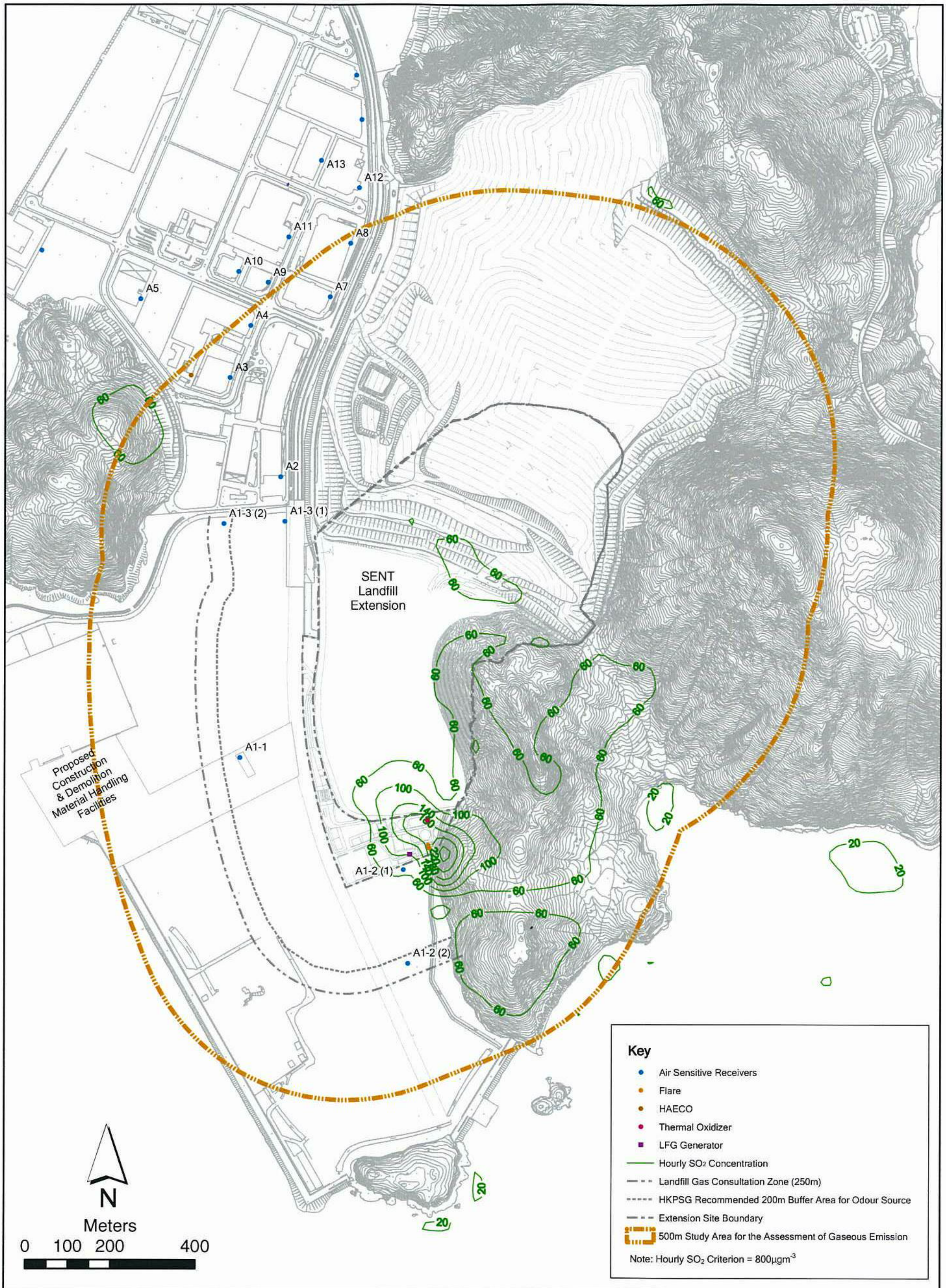

FIGURE 4.7e-2

Isopleths of Cumulative Maximum Hourly SO_2 Concentration at 30m above ground during Operation/ Restoration Phase

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Date: 18/01/2008

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Table 4.7d *Highest Calculated Cancer Health Risk Levels of Benzene and Vinyl Chloride During Operation/Restoration Phase*

ASR	**Location**	**Individual Highest Calculated Cancer Health Risk Level** [a] [b]		**Total Cancer Health Risk Level**
		Benzene	**Vinyl Chloride**	
A1-1	Proposed C&DM Handling Facility	7.0E-10	3.5E-10	1.1E-09
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) – 1	1.6E-08	7.8E-09	2.3E-08
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2	9.4E-10	4.4E-10	1.4E-09
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) – 1	6.2E-10	3.5E-10	9.8E-10
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	8.6E-10	4.4E-10	1.3E-09
A2	TVB City	6.2E-10	2.6E-10	8.9E-10
A3	HAESL	4.7E-10	2.6E-10	7.3E-10
A4	HAECO Component Overhaul Building	4.7E-10	2.6E-10	7.3E-10
A7	Yan Hing Machinery Industrial Building	1.0E-09	5.3E-10	1.5E-09
A8	Apple Daily	8.6E-10	4.4E-10	1.3E-09

Notes:

(a) Detailed calculated cancer health risk levels are summarized in *Annex A5-2*.

(b) Unit risk factors of benzene and vinyl chloride (as presented in *Table 4.2b*) have been used for the calculation.

4.7.3 Odour Emissions from Waste Filling Activities and Operation of LTP During Operation/Restoration Phase

The predicted 5-second odour concentrations at different elevations of identified ASRs (where appropriate) are summarized in *Annex A7-1* and the highest predicted 5-second odour concentration at the identified ASRs are presented in *Table 4.7e*. The numbers of events of exceedance predicted at different elevations at A1-1 to A3 for the different emission source heights are summarized in *Annex A7-2*. The AUSPLUME input file is presented in *Annex A8*.

The results indicate that exceedances of the 5-second odour criterion were predicted at the ASRs located in the immediate vicinity of the Extension, ie A1-1 to A3. For those ASRs in TKO Town (ASRs A24 to A41) and in Siu Sai Wan and Hang Fa Chuen (ASRs A42 to A43), the predicted odour concentrations are very low relative to the odour criterion.

As shown in *Annex A7-1*, the worst affected height at the ASRs will be at 1.5m above ground and the predicted 5-second odour concentrations decrease with the increase in the height of ASRs. Isopleths of the maximum 5-second odour concentrations at the worst affected height, ie, 1.5m above ground within 500m from the Extension Site boundary for the six phases of waste tipping activities are plotted (see *Figures 4.7f* to *4.7k*) [(1)]. It can be seen that the area outside the site boundary in which peak 5-second odour concentrations exceed the criterion diminishes over time.

The zone of possible impact (the area with a potential for exceedance of the odour criterion) due to odour emissions during each waste tipping phase are illustrated in *Figures 4.7l-1* and *4.7l-2*. The predicted highest 5-second odour levels and numbers of exceedances predicted at the representative ASRs A1-1 to A2 are also summarized in *Figures 4.7l-1* and *4.7l-2*. The figures show that the potential odour impact is localized to within about 500 of the Extension boundary. It should be noted that zones shown on the figures are an indication of the overall extent of the potential odour impact for that particular phase of waste tipping and on any waste tipping day. Only the ASRs that are located downwind of the tipping face may experience an odour level exceeding the odour criterion. The actual affected area would be a much smaller than that bounded by the 5OU contour line (see *Figure 4.7l-1* and *4.7l-2*). The summary tables in the figures also show that highest number of exceedance predicted at the ASRs is 71 (1.5m above ground of A1-3 (1)). When the waste tipping face moves to higher levels as the Extension is developed, the number of exceedances decreases to zero over a six-year period.

For this assessment, the special waste trench is assumed to be open to the atmosphere. In the outline design, the trench will be covered and the air extracted from the trench will be scrubbed prior to discharge to atmosphere. As mentioned in *Section 4.6.2*, the odour emission rate of the trench adopted in the assessment is very conservative. In reality, the predicted odour levels should be lower and the number of exceedances will be less than predicted.

(1) The contour plots are approximations only and the assessment results at the individual ASRs should be referred to *Annex A6-1*.

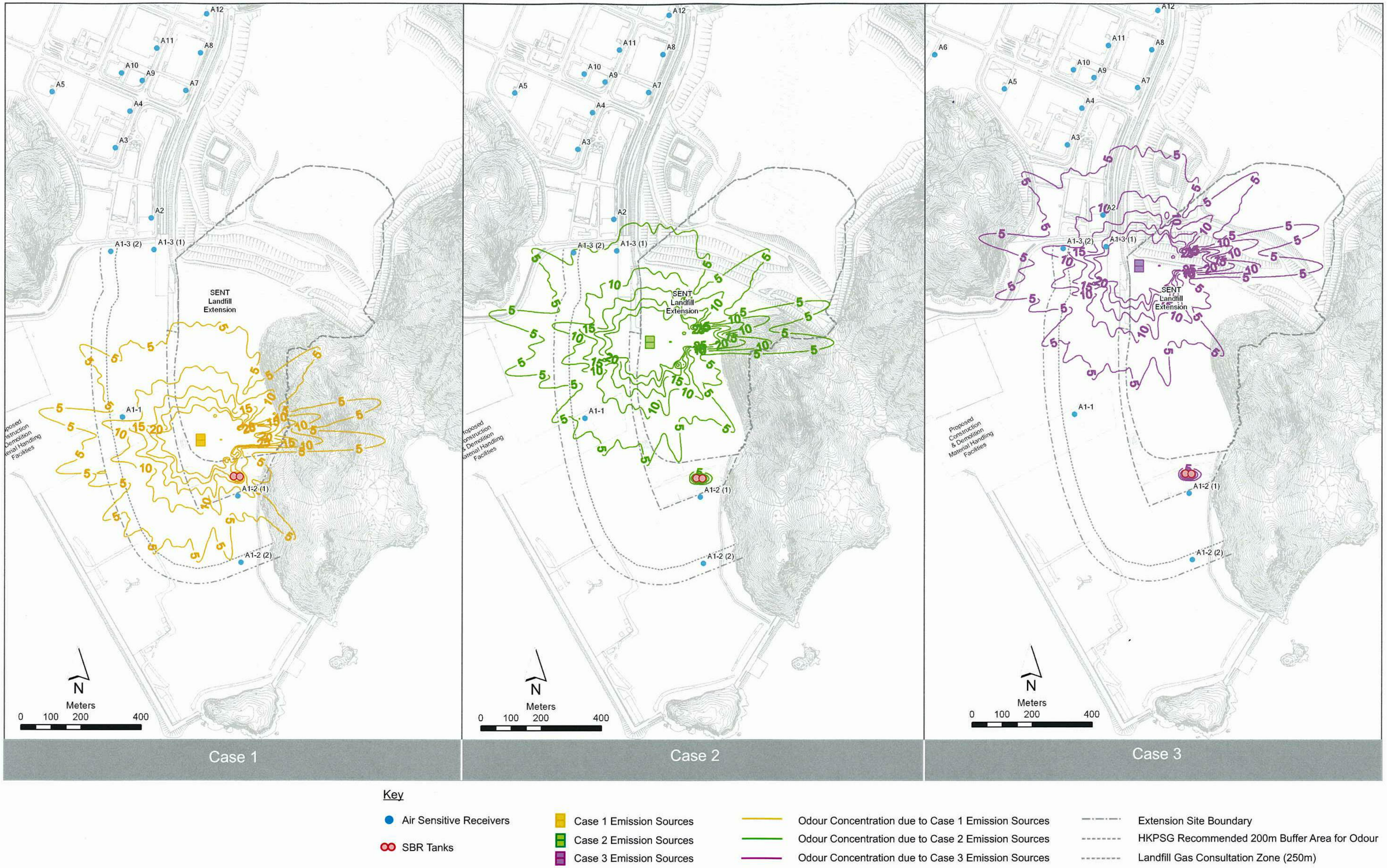

Figure 4.7f

Predicted Worst-case 5 sec Odour Concentration at 1.5m above Ground
(Source Height at 10m above ground)

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DATE: 07/01/2008

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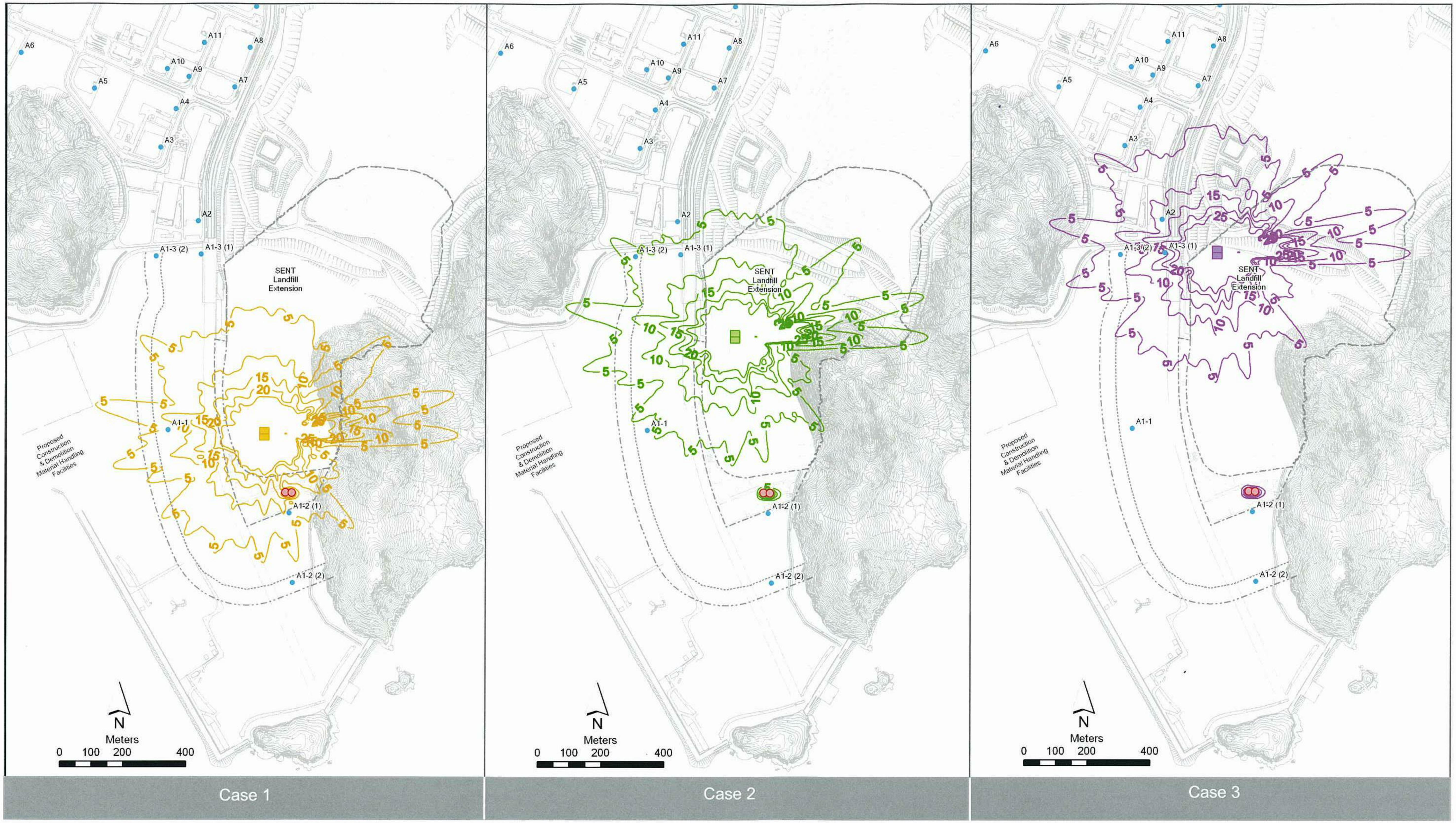

Key

- Air Sensitive Receivers
- SBR Tanks
- Case 1 Emission Sources
- Case 2 Emission Sources
- Case 3 Emission Sources
- Odour Concentration due to Case 1 Emission Sources
- Odour Concentration due to Case 2 Emission Sources
- Odour Concentration due to Case 3 Emission Sources
- Extension Site Boundary
- HKPSG Recommended 200m Buffer Area for Odour
- Landfill Gas Consultation Zone (250m)

Figure 4.7g

Predicted Worst-case 5 sec Odour Concentration at 1.5m above Ground
(Source Height at 30m above ground)

FILE: 0036286z39a
DATE: 07/01/2008

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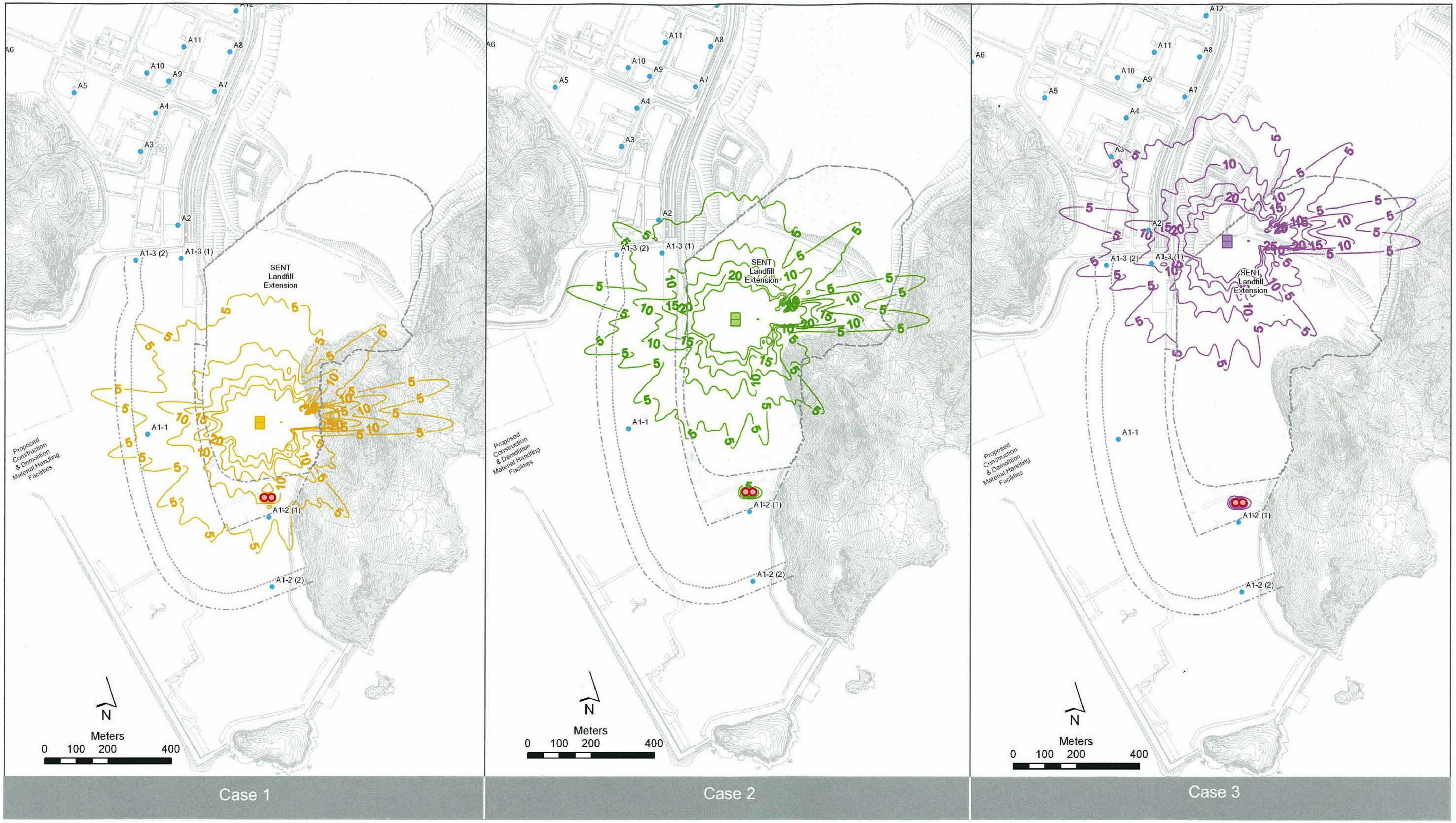

Figure 4.7h

Predicted Worst-case 5 sec Odour Concentration at 1.5m above Ground
(Source Height at 50m above ground)

FILE: 0036286z39b
DATE: 07/01/2008

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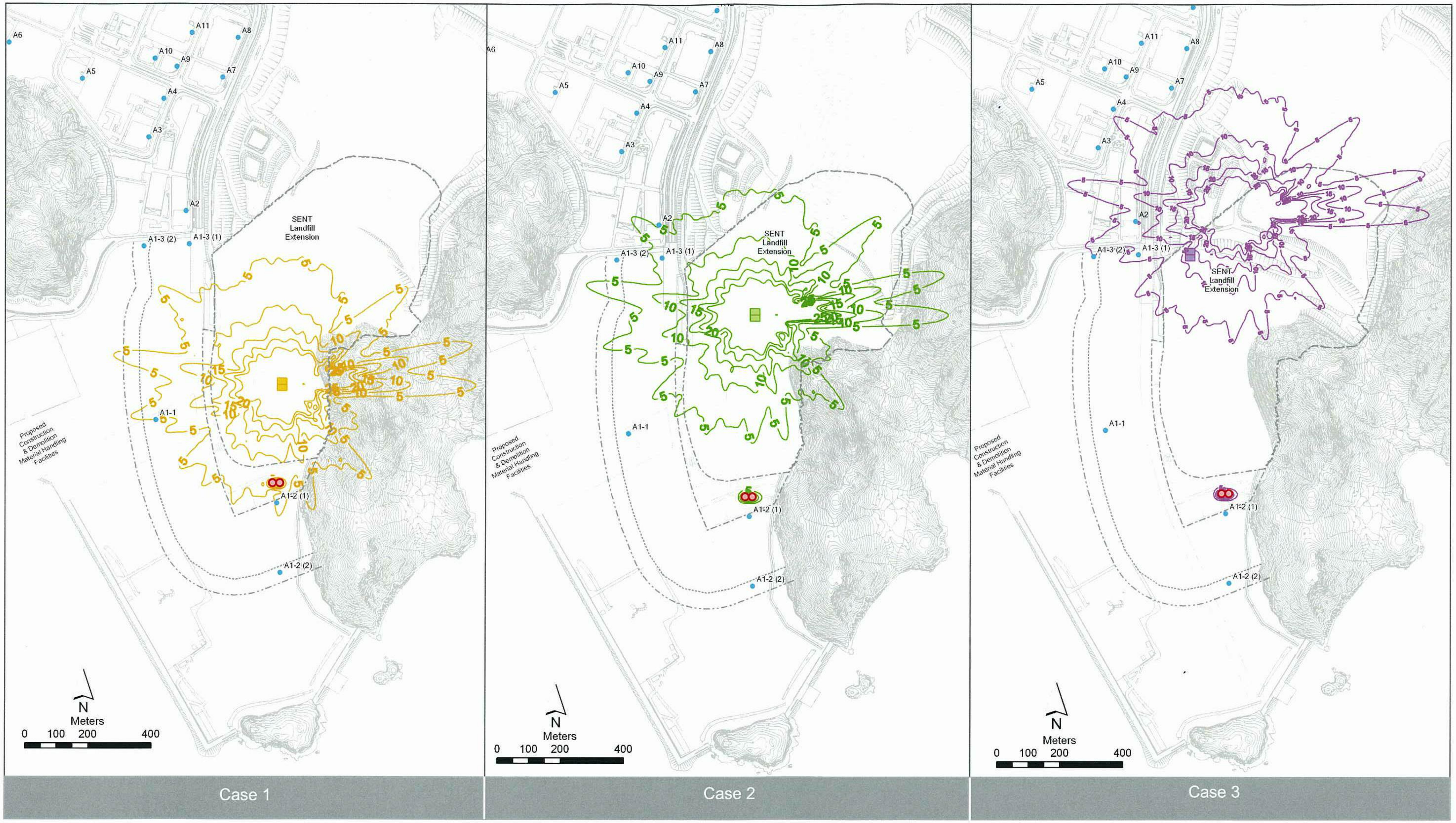

Key

Air Sensitive Receivers	Case 1 Emission Sources	Odour Concentration due to Case 1 Emission Sources
SBR Tanks	Case 2 Emission Sources	Odour Concentration due to Case 2 Emission Sources
	Case 3 Emission Sources	Odour Concentration due to Case 3 Emission Sources

Extension Site Boundary

HKPSG Recommended 200m Buffer Area for Odour

Landfill Gas Consultation Zone (250m)

Figure 4.7i

Predicted Worst-case 5 sec Odour Concentration at 1.5m above Ground
(Source Height at 70m above ground)

FILE: 0036286z39c
DATE: 28/01/2008

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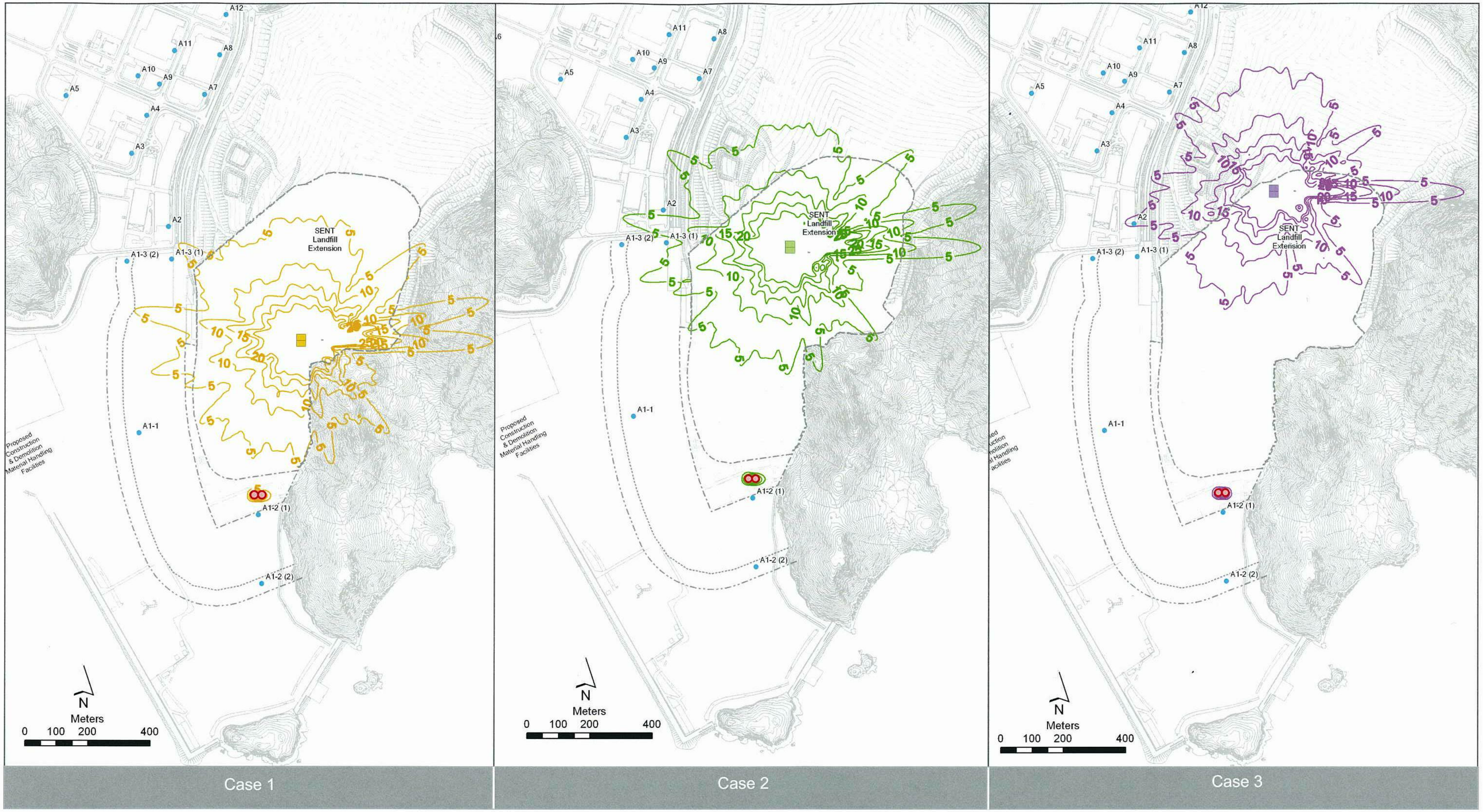

Key

Air Sensitive Receivers	SBR Tanks
Case 1 Emission Sources	Odour Concentration due to Case 1 Emission Sources
Case 2 Emission Sources	Odour Concentration due to Case 2 Emission Sources
Case 3 Emission Sources	Odour Concentration due to Case 3 Emission Sources
Extension Site Boundary	HKPSG Recommended 200m Buffer Area for Odour
Landfill Gas Consultation Zone (250m)	

Figure 4.7j

Predicted Worst-case 5 sec Odour Concentration at 1.5m above Ground
(Source Height at 100m above ground)

FILE: 0036286z39d
DATE: 07/01/2008

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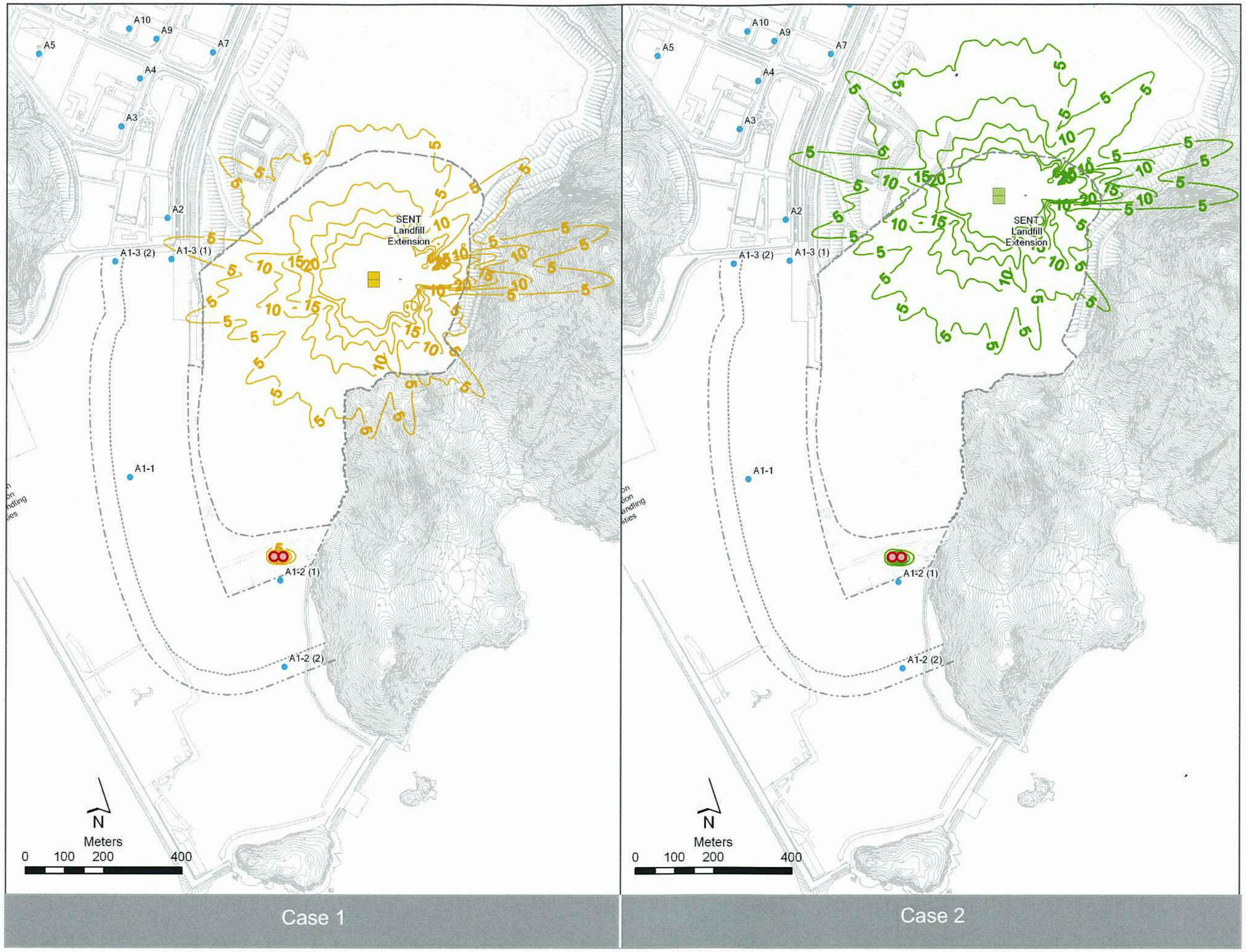

Key

- Air Sensitive Receivers
- SBR Tanks
- Case 1 Emission Sources
- Case 2 Emission Sources
- Case 3 Emission Sources
- Odour Concentration due to Case 1 Emission Sources
- Odour Concentration due to Case 2 Emission Sources
- Odour Concentration due to Case 3 Emission Sources
- Extension Site Boundary
- HKPSG Recommended 200m Buffer Area for Odour
- Landfill Gas Consultation Zone (250m)

Figure 4.7k

Predicted Worst-case 5 sec Odour Concentration at 1.5m above Ground
(Source Height at 130m above ground)

FILE: 0036286z39e
DATE: 07/01/2008

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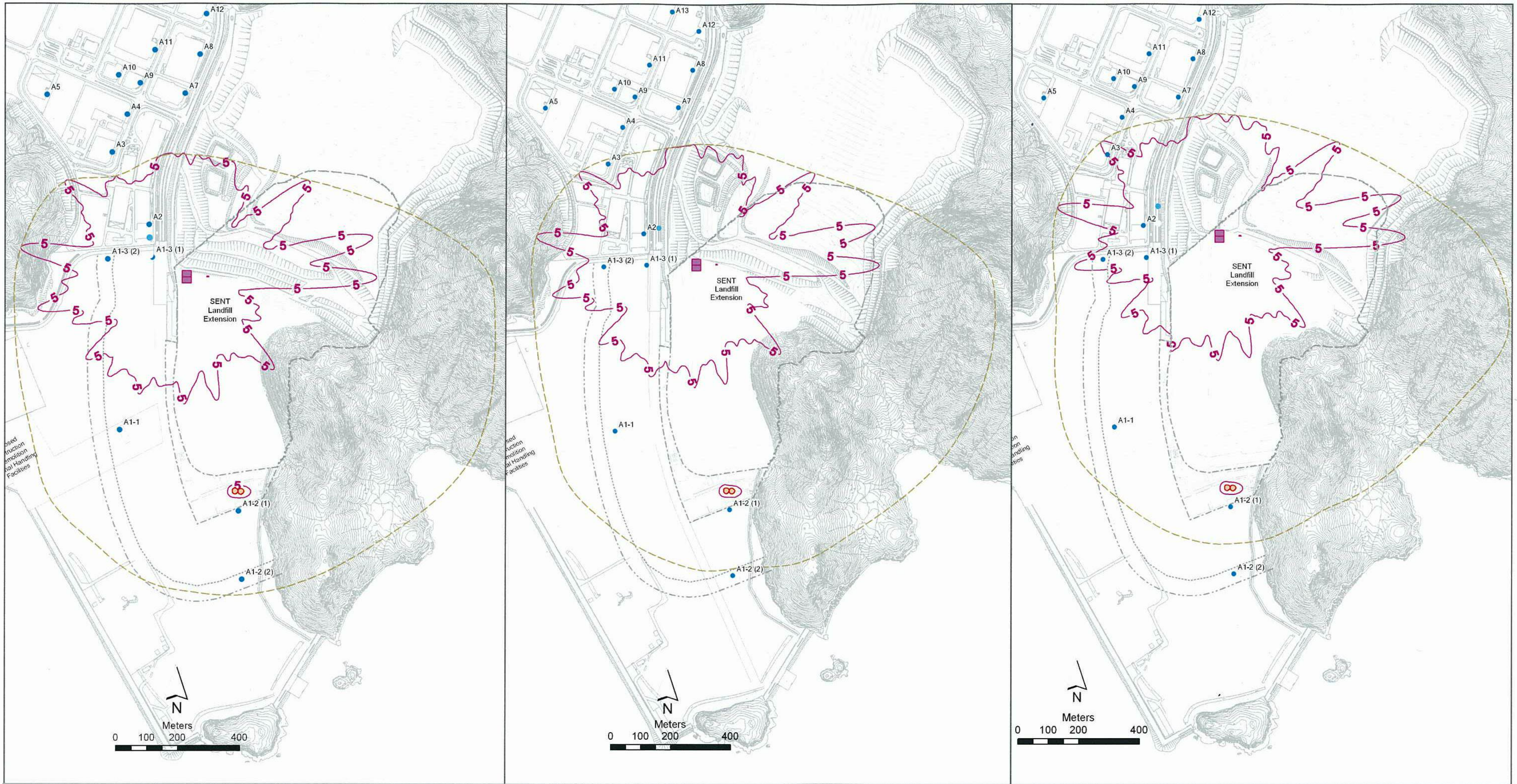

Phase 1

ASR	Predicted Highest 5-sec Odour Level at 1.5m above ground			No. of Exceedances over Yr 2006		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
A1-1	6.1	6.3	3.2	4	4	-
A1-2 (1)	8.9	2.3	2.3	2	-	-
A1-2 (2)	2.7	1.9	1.3	-	-	-
A1-3 (1)	2.4	5.5	23.2	-	1	71
A1-3 (2)	1.7	5.1	11.4	-	1	4
A2	1.9	4.1	12.5	-	-	26
A3	1.1	1.9	3.3	-	-	-

Phase 2

ASR	Predicted Highest 5-sec Odour Level at 1.5m above ground			No. of Exceedances over Yr 2006		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
A1-1	6.3	4.1	2.2	2	-	-
A1-2 (1)	7.0	2.9	2.4	2	-	-
A1-2 (2)	3.3	2.1	1.6	-	-	-
A1-3 (1)	2.2	6.4	14.4	-	3	26
A1-3 (2)	2.0	6.4	7.3	-	1	2
A2	1.8	3.9	13.1	-	-	21
A3	1.2	1.9	4.2	-	-	-

Phase 3

ASR	Predicted Highest 5-sec Odour Level at 1.5m above ground			No. of Exceedances over Yr 2006		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
A1-1	5.9	3.2	1.7	2	-	-
A1-2 (1)	6.0	2.8	1.9	1	-	-
A1-2 (2)	3.1	1.8	1.1	-	-	-
A1-3 (1)	2.2	7.0	11.2	-	6	5
A1-3 (2)	2.2	3.9	6.9	-	-	1
A2	1.9	4.6	14.0	-	-	10
A3	1.2	2.1	5.2	-	-	1

Key: Air Sensitive Receivers; SBR Tanks; Zone of Possible Impact; Odour Emission Source; Odour Concentration; Extension Site Boundary; HKPSG Recommended 200m Buffer Area for Odour; Landfill Gas Consultation Zone (250m)

Note : It should be noted that only the ASRs located downwind of the active tipping face may experience an odour level exceeding the odour criterion and the actually affected area at any given time would be a much smaller than the area within the 5OU contour line.

Figure 4.7l - 1

Zone of Possible Impact Due to Landfill Odour Emission from the Extension (Area with a Potential for Exceedance of Odour Criterion) (Phases 1 to 3)

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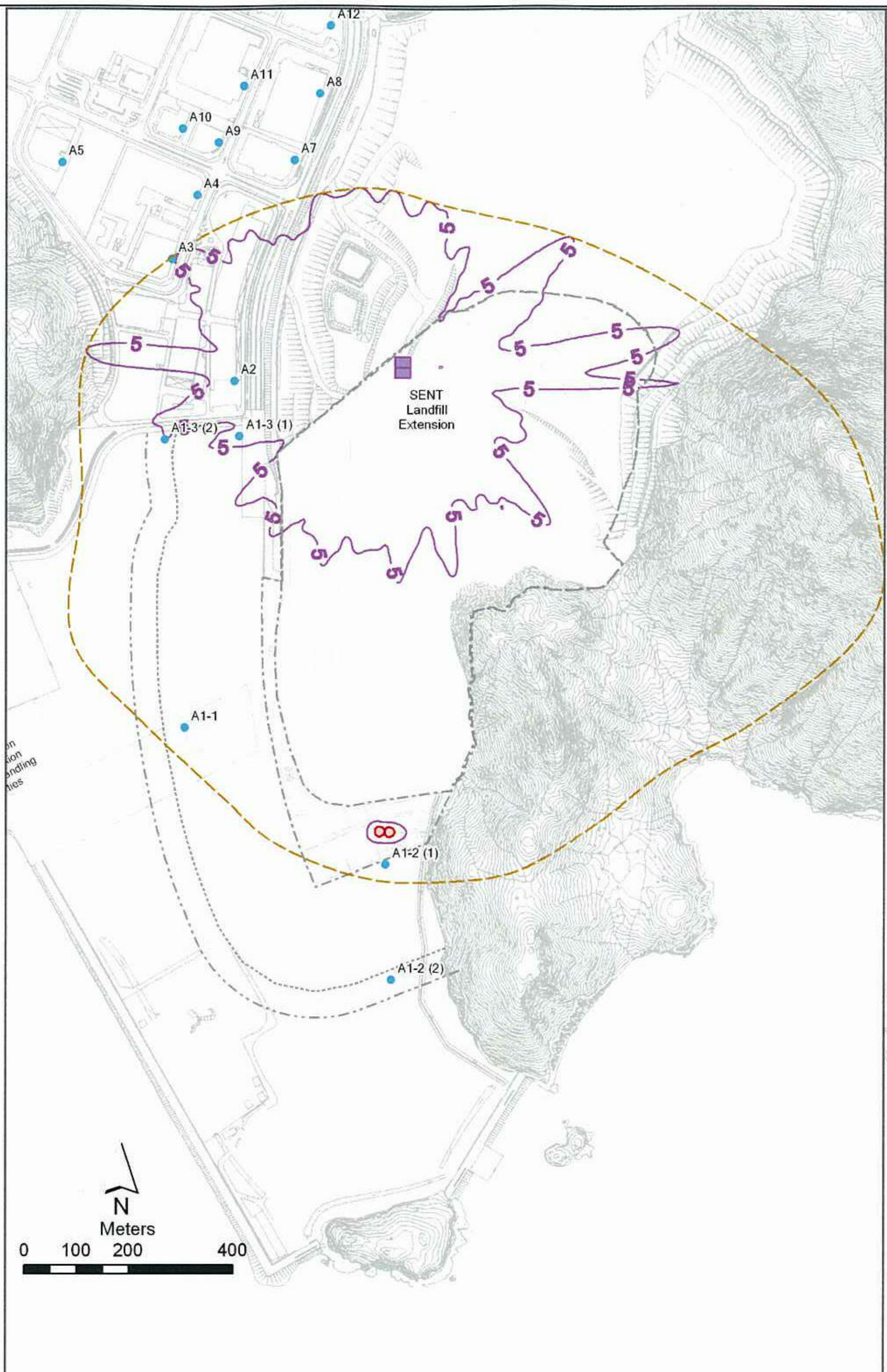
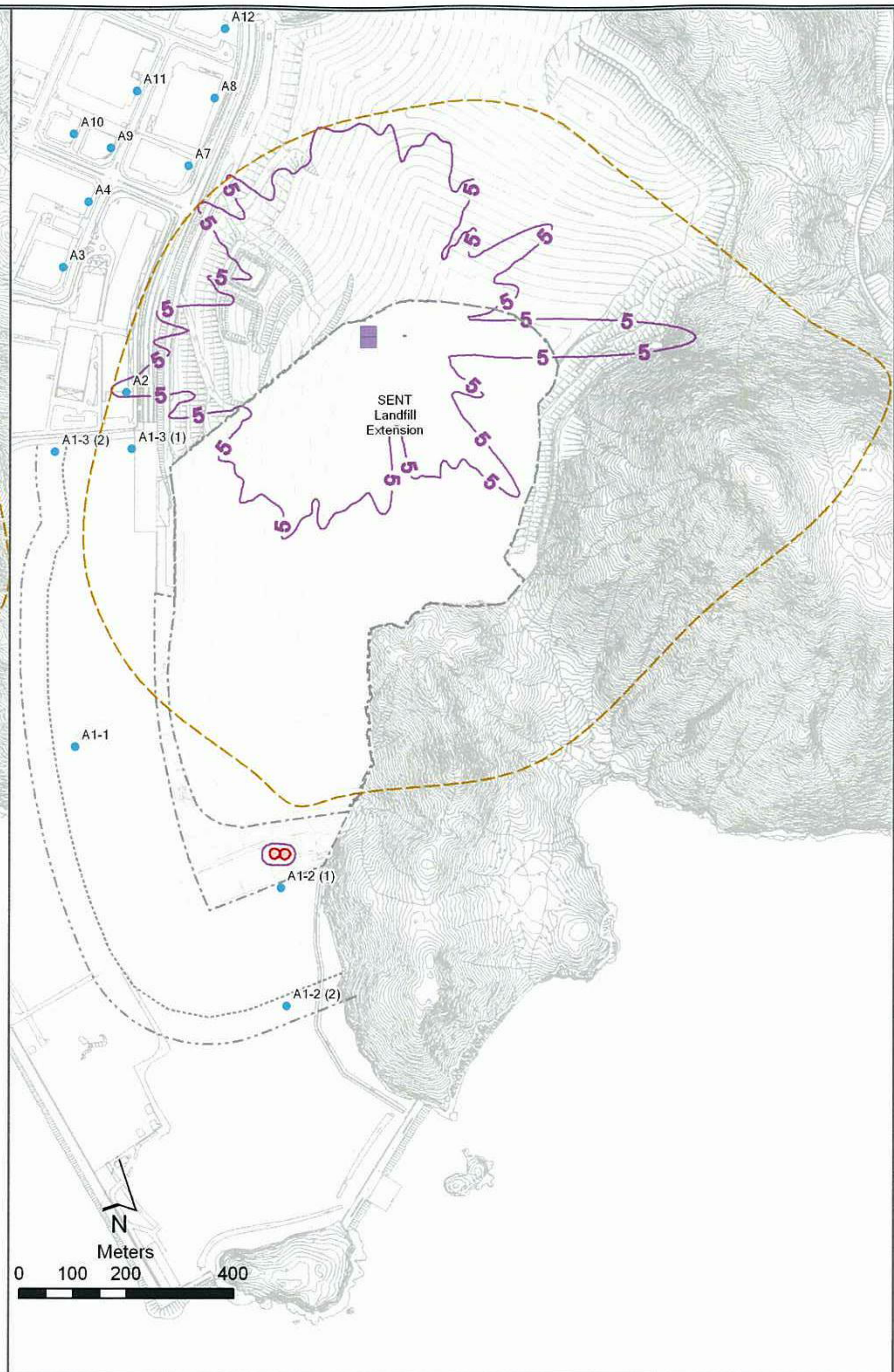


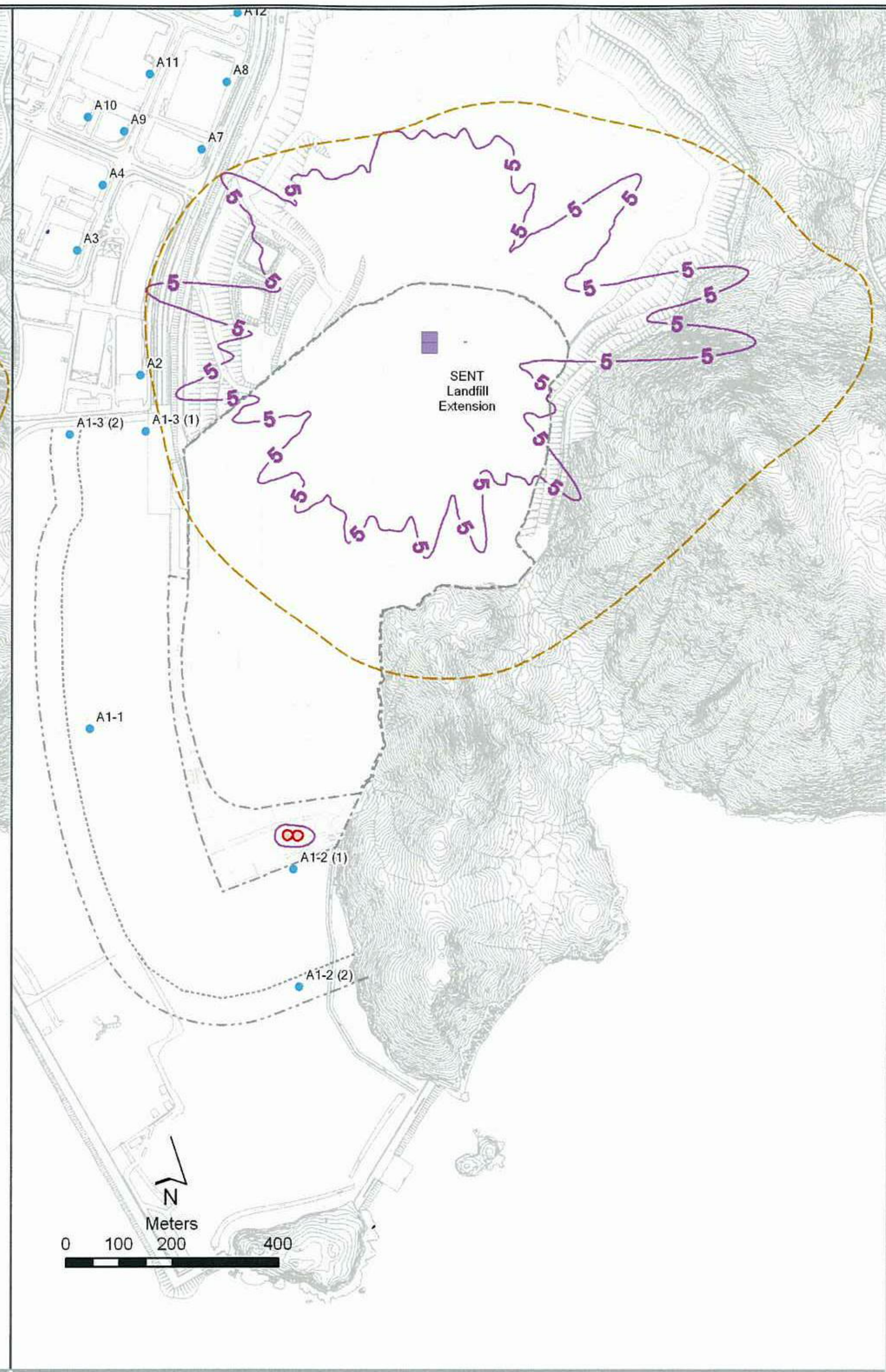
Phase 4

ASR	Predicted Highest 5-sec Odour Level at 1.5m above ground			No. of Exceedances over Yr 2006		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
A1-1	5.0	2.3	1.4	-	-	-
A1-2 (1)	5.7	3.0	2.1	1	-	-
A1-2 (2)	3.0	1.8	1.2	-	-	-
A1-3 (1)	2.9	6.2	6.4	-	1	2
A1-3 (2)	2.1	2.8	3.3	-	-	-
A2	2.0	4.6	6.5	-	-	4
A3	1.2	2.2	3.1	-	-	-



Phase 5

ASR	Predicted Highest 5-sec Odour Level at 1.5m above ground			No. of Exceedances over Yr 2006		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
A1-1	1.5	1.5	1.2	-	-	-
A1-2 (1)	2.7	1.9	1.7	-	-	-
A1-2 (2)	1.5	0.9	0.7	-	-	-
A1-3 (1)	3.6	3.8	2.9	-	-	-
A1-3 (2)	2.2	2.6	2.6	-	-	-
A2	3.8	3.3	5.4	-	-	1
A3	1.7	2.6	3.8	-	-	-



Phase 6

ASR	Predicted Highest 5-sec Odour Level at 1.5m above ground		No. of Exceedances over Yr 2006	
	Case 1	Case 2	Case 1	Case 2
A1-1	2.0	1.3	-	-
A1-2 (1)	1.9	1.4	-	-
A1-2 (2)	1.0	0.7	-	-
A1-3 (1)	3.4	2.2	-	-
A1-3 (2)	2.0	2.4	-	-
A2	2.3	3.2	-	-
A3	1.9	2.3	-	-

Key: Air Sensitive Receivers; SBR Tanks; Zone of Possible Impact; Odour Emission Source; Odour Concentration; Extension Site Boundary; HKPSG Recommended 200m Buffer Area for Odour; Landfill Gas Consultation Zone (250m)

Note : It should be noted that only the ASRs located downwind of the active tipping face may experience an odour level exceeding the odour criterion and the actually affected area at any given time would be a much smaller than the area within the 5OU contour line.

Figure 4.7l - 2

Zone of Possible Impact Due to Landfill Odour Emission from the Extension (Area with a Potential for Exceedance of Odour Criterion) (Phases 4 to 6)

FILE: 0036286z39g
DATE: 18/01/2008

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Table 4.7e Predicted Highest 5-second Odour Concentrations at the Identified Representatie ASRs During Operation/Restoration Phase

ASR	Location	Highest 5-second Odour Level [(a)] [(b)]																
		Worst-case 1						Worst-case 2						Worst-case 3 [(c)]				
		Source Height = 10m	Source Height = 30m	Source Height = 50m	Source Height = 70m	Source Height = 100m	Source Height = 130m	Source Height = 10m	Source Height = 30m	Source Height = 50m	Source Height = 70m	Source Height = 100m	Source Height = 130m	Source Height = 10m	Source Height = 30m	Source Height = 50m	Source Height = 70m	Source Height = 100m
A1-1	Proposed C&DM Handling Facility	**6.1**	**6.3**	**5.9**	5.0	1.5	2.0	**6.3**	4.1	3.2	2.3	1.5	1.3	3.2	2.2	1.8	1.4	1.2
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) - 1	**8.9**	**7.0**	**6.0**	**5.7**	2.7	1.9	2.3	2.9	2.8	3.0	1.9	1.4	2.3	2.4	2.4	2.1	1.7
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2	2.7	3.3	3.1	3.0	1.5	1.0	1.9	2.1	1.8	1.8	0.9	0.7	1.3	1.6	1.5	1.2	0.7
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) - 1	2.4	2.2	2.2	2.9	3.6	3.4	**5.5**	**6.4**	**7.0**	**6.2**	3.8	2.2	**23.2**	**14.4**	**11.2**	**6.4**	2.9
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	1.7	2.0	2.2	2.1	2.2	2.0	**5.1**	**6.4**	3.9	2.8	2.6	2.4	**11.4**	**7.3**	**6.9**	3.3	2.6
A2	TVB City	1.9	1.8	1.9	2.0	3.8	2.3	4.1	3.9	4.6	4.6	3.3	3.2	**12.5**	**13.1**	**14.0**	**6.5**	**5.4**
A3	HAESL	1.1	1.2	1.2	1.2	1.7	1.9	1.9	1.9	2.1	2.2	2.6	2.3	3.3	4.2	**5.2**	3.1	3.8
A4	HAECO Component Overhaul Building	1.1	1.1	1.1	1.2	1.5	2.4	1.8	1.6	1.4	1.6	1.9	1.8	2.4	2.8	3.5	4.4	2.3
A5	Exhibition Services & Logistics Centre	0.9	0.8	0.8	0.9	1.1	1.3	1.2	1.2	1.3	1.3	2.2	0.9	1.7	1.8	3.0	1.9	1.1
A6	Gammon Skanska	0.6	0.6	0.8	0.8	0.7	0.9	1.0	1.0	1.0	0.8	1.1	0.7	1.2	1.6	1.7	1.1	0.8
A7	Yan Hing Machinery Industrial Building	1.0	1.2	1.3	1.3	1.5	2.1	1.6	1.9	2.0	1.9	2.1	4.1	2.7	3.3	3.4	3.5	3.7
A8	Apple Daily	0.9	1.0	1.1	1.2	1.2	1.5	1.2	1.5	1.6	1.6	1.6	2.5	1.9	2.4	2.7	2.6	2.8
A9	Mei Ah Industrial Building	1.0	1.1	1.1	1.0	1.1	1.6	1.5	1.6	1.4	1.3	1.9	2.4	2.4	2.2	2.4	3.0	3.8
A10	Asia Netcom	0.9	1.0	0.9	1.1	1.0	1.4	1.5	1.3	1.4	1.3	1.8	1.7	1.8	1.7	2.4	2.5	2.7
A11	Wellcome Storage	1.0	1.0	1.0	1.1	1.1	1.5	1.5	1.4	1.5	1.2	1.5	1.7	1.9	2.2	2.1	2.1	2.3
A12	Avery Dennison Machinery	0.8	0.8	0.9	1.1	1.1	1.4	1.0	1.2	1.3	1.4	1.5	1.7	1.5	1.7	2.1	2.3	1.8
A13	Hitachi	0.7	0.8	1.0	0.9	0.8	1.0	1.0	1.1	1.2	1.2	1.1	1.6	1.4	1.7	1.8	1.5	1.6
A14	Next Media Co. Ltd	0.7	0.7	0.8	0.8	0.9	1.0	0.8	1.0	1.1	1.2	1.3	1.2	1.2	1.3	1.5	1.6	1.6
A15	Varitronix	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.1	1.1	1.2	0.9	1.2	1.3	1.3	1.2
A16	Four Seas Food Processing Co. Ltd	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	1.0	0.9	0.9	1.1	1.0	0.9
A17	Committed HSBC Office	0.6	0.6	0.6	0.6	0.7	0.8	0.7	0.7	0.8	0.9	0.9	0.9	0.8	1.0	1.0	1.2	1.1
A18	Eastern Pacific Electronics	0.5	0.5	0.5	0.6	0.6	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.7	0.7	0.9	0.8	0.7
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.6
A20	LOHAS Park	0.3	0.4	0.3	0.3	0.4	0.3	0.4	0.4	0.3	0.3	0.4	0.4	0.5	0.4	0.4	0.5	0.4
A21	Chiaphua-Shinko Centre	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.6	0.5	0.5
A22	Shaw Film Studios	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4

ASR	Location	Highest 5-second Odour Level (a) (b)																
		Worst-case 1						Worst-case 2						Worst-case 3 (c)				
		Source Height = 10m	Source Height = 30m	Source Height = 50m	Source Height = 70m	Source Height = 100m	Source Height = 130m	Source Height = 10m	Source Height = 30m	Source Height = 50m	Source Height = 70m	Source Height = 100m	Source Height = 130m	Source Height = 10m	Source Height = 30m	Source Height = 50m	Source Height = 70m	Source Height = 100m
A23	Oscar by the Sea	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A24	Tseung Kwan O Sport Ground	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A25	Tseung Kwan O Town Park	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.2
A26	Leung Sing Tak Primary School	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1
A27	Nan Fung Plaza	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
A28	St Andrew's Church	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2
A29	Fung Ching Memorial Primary School	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1
A30	On Ning Garden	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.2
A31	Sheung Ning Playground	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2
A32	Tseung Kwan O Swimming Pool	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.2
A33	La Cite Noble	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A34	Yuk Ming Court	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A35	Ming Tak Estate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A36	Tin Ha Wan Village	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A37	Tseung Kwan O Hospital	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A38	Ocean Shore Phase I	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A39	Choi Ming Estate, Choi Yiu Court	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A40	Park Central Block 1	0.2	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A41	Bauhinia Garden Block 5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A42	Heng Fa Chuen	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
A43	Island Resort	0.5	0.4	0.4	0.2	0.3	0.2	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1
5-second Odour Criterion		**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**

Notes:

(a) 5-second odour concentrations predicted at different elevations of ASRs in different worst case for different source heights are presented in *Annex A6-1*.

(b) **Bold** and underlined figures show exceedance of 5-second odour criterion.

(c) Since the waste filling area will be small when the waste filling height is at 130m, therefore, only 2 worst cases were identified in the assessment.

4.7.4 *Gaseous Emissions from LFG Flares and LFG Generator During Aftercare Phase*

During aftercare phase, landfilling will no longer take place but the LFG flares, the LTP and the LFG generator will continue to operate. However, as described in *Section 4.5.3*, the operation of the thermal oxidiser will not be required during the aftercare phase and hence there will be no gaseous emissions from the thermal oxidizer.

The highest predicted maximum hourly average, daily average and annual average concentrations of NO_2, SO_2, benzene and vinyl chloride are presented in *Table 4.7f*. The highest hourly and daily average concentrations of CO are also presented in *Table 4.7f*. The predicted concentrations of these air pollutants at different elevations of ASRs are summarized in *Annex A9-1*. The emissions from HAESL and the general background were included in the predictions.

NO_2, CO and SO_2

The highest predicted NO_2, CO and SO_2 concentrations at different elevations of the identified ASRs are low and well within the respective AQO criteria. The worst affected height within TKOIE is at 30m above ground. Isopleths showing cumulative maximum hourly concentrations of NO_2, CO and SO_2 at the 1.5 m above ground and the worst affected height (30m above ground) within 500m of the Extension site boundary are plotted and presented in *Figures 4.7m* to *4.7o*, respectively. It is therefore concluded that the operation of LFG flares, thermal oxidiser(s) and the LFG generator during the aftercare phase will not cause adverse air quality impact to the identified ASRs.

Benzene, Vinyl Chloride and VOCs

Non-cancer Health Risk Assessment: The predicted maximum hourly and annual average benzene and vinyl chloride concentrations (see *Tables 4.7g* and *Annex A9-1*) are well below the respective reference acute and chronic concentrations (see *Table 4.2d*). Hence, the acute and chronic health effects of benzene and vinyl chloride are considered to be insignificant (see *Tables 4.2e* and *4.2f*).

Cancer Health Risk Assessment: The highest calculated individual cancer health risk levels of benzene and vinyl chloride and the total health risk levels are presented in *Table 4.7g*. The calculated individual cancer risk level of benzene and vinyl chloride and total health risk levels at different elevations of ASRs during each phase are summarized in *Annex A9-2*. The calculated total cancer health risk levels are lower than 10^{-6} and they are considered to be low and insignificant.

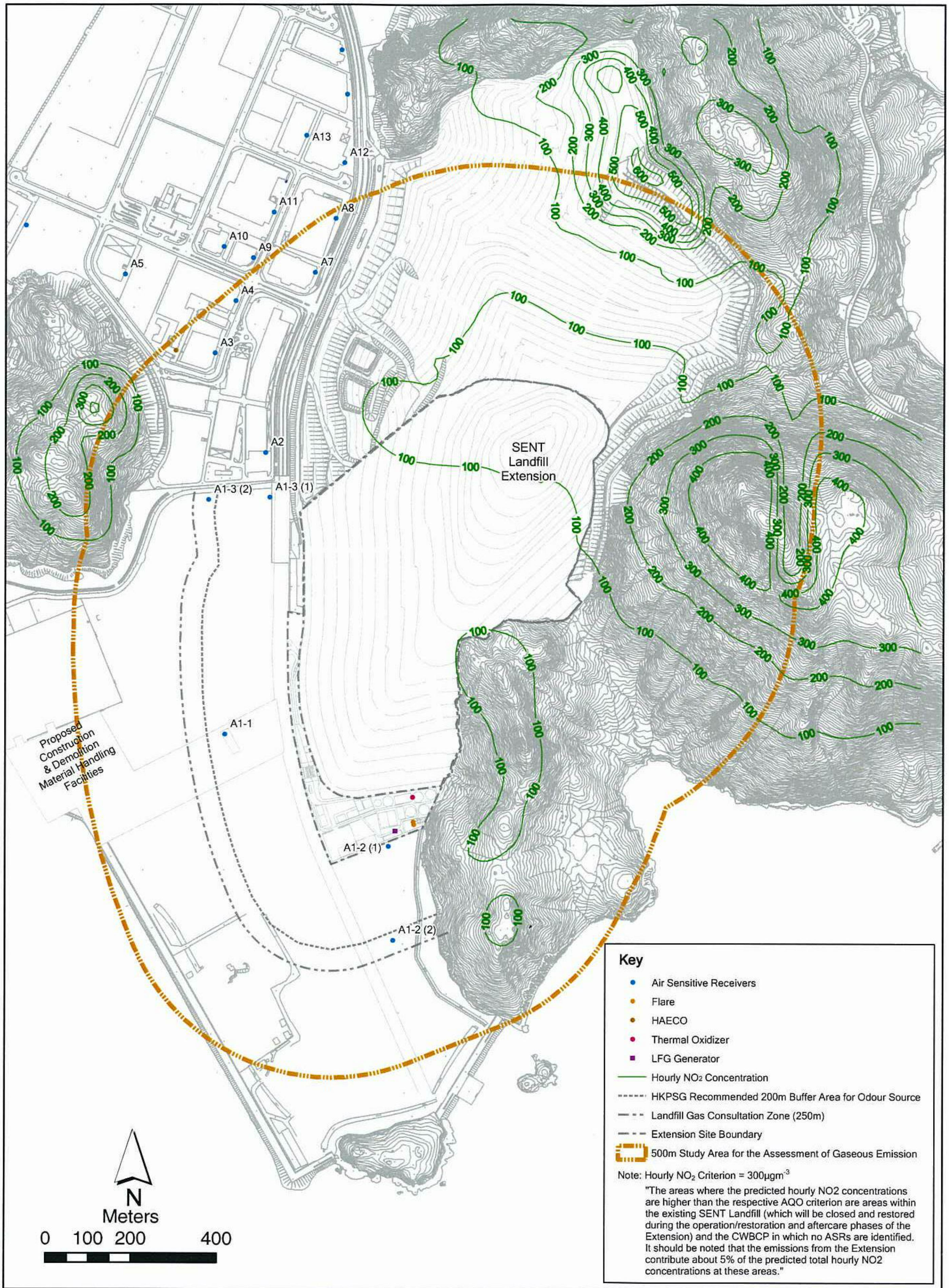

FIGURE 4.7m-1

Isopleths of Cumulative Maximum Hourly NO_2 Concentration at 1.5m above ground during Aftercare Phase

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Date: 18/01/2008

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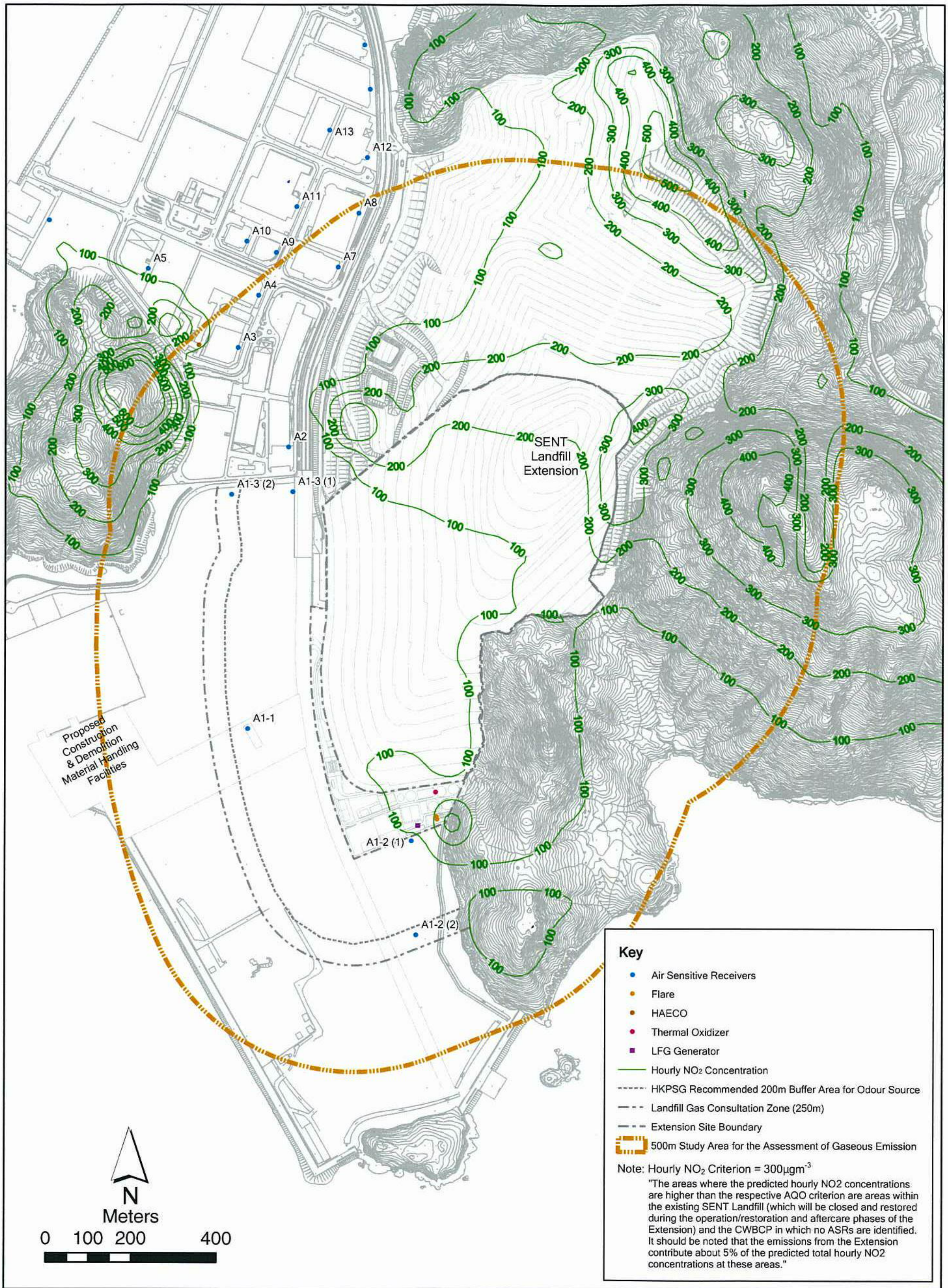

FIGURE 4.7m-2

Isopleths of Cumulative Maximum Hourly NO_2 Concentration at 30m above ground during Aftercare Phase

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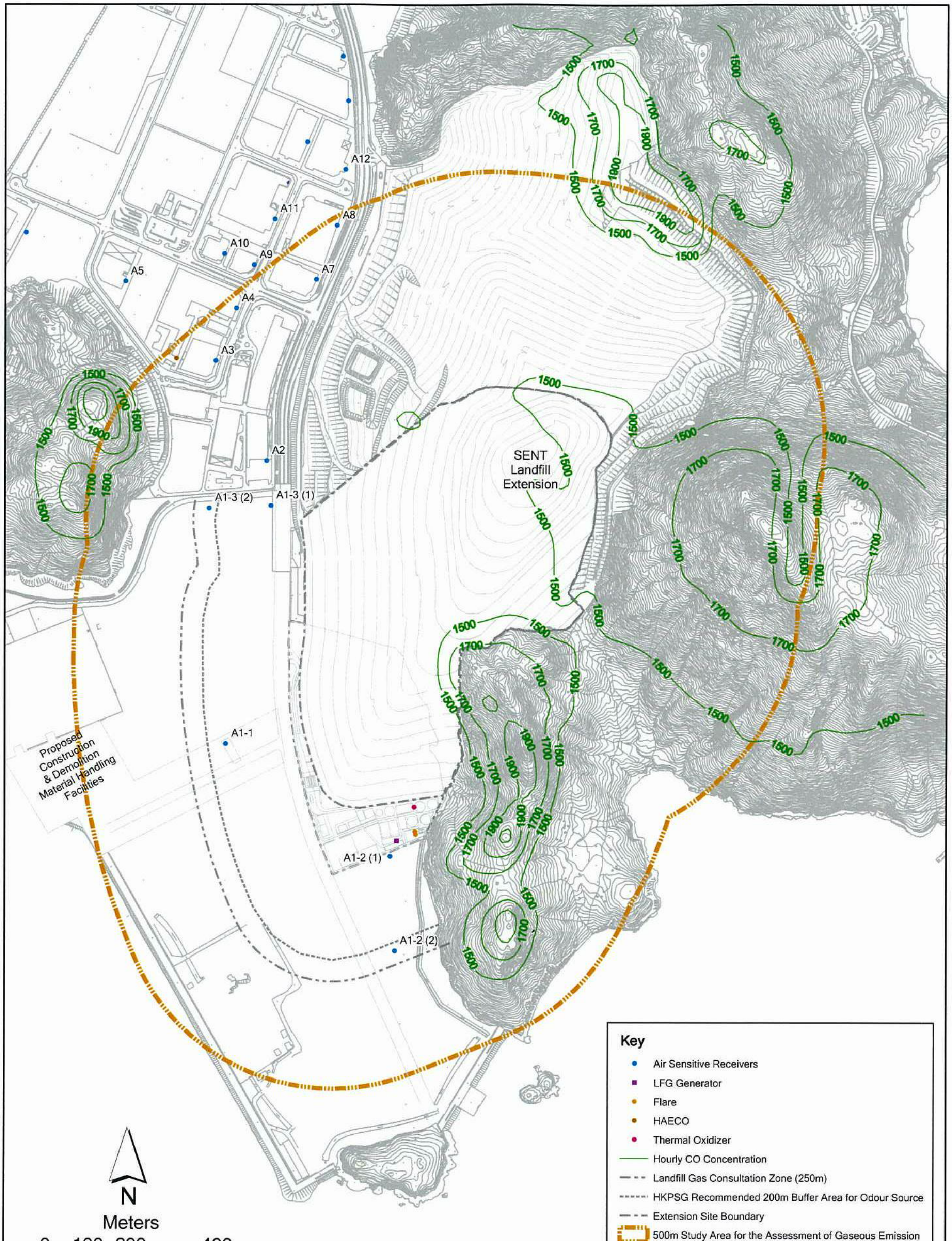

FIGURE 4.7n-1

Isopleths of Cumulative Maximum Hourly CO Concentration at 1.5m above ground during Aftercare Phase

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Date: 18/01/2008

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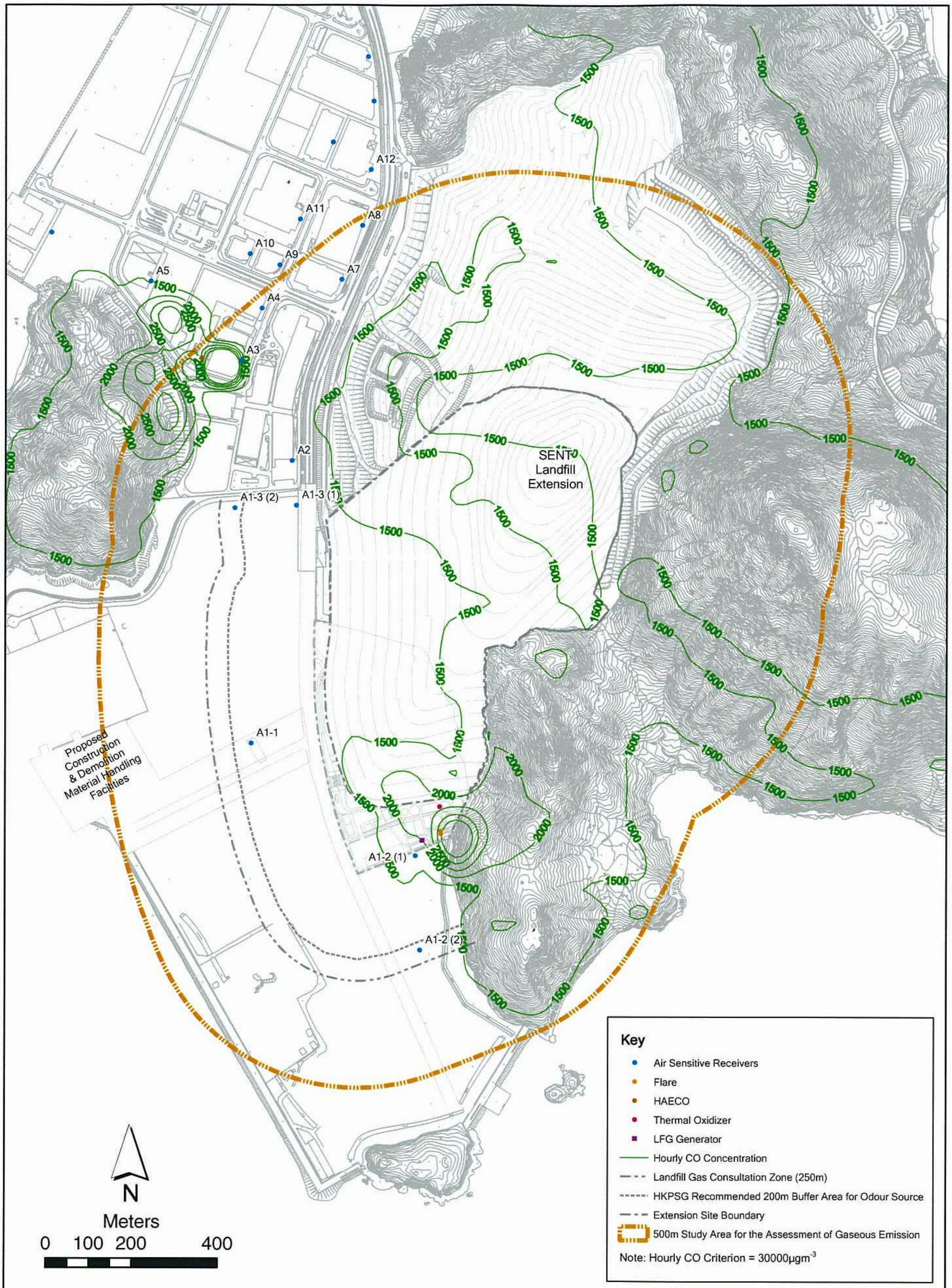

FIGURE 4.7n-2

Isopleths of Cumulative Maximum Hourly CO Concentration at 30m above ground during Aftercare Phase

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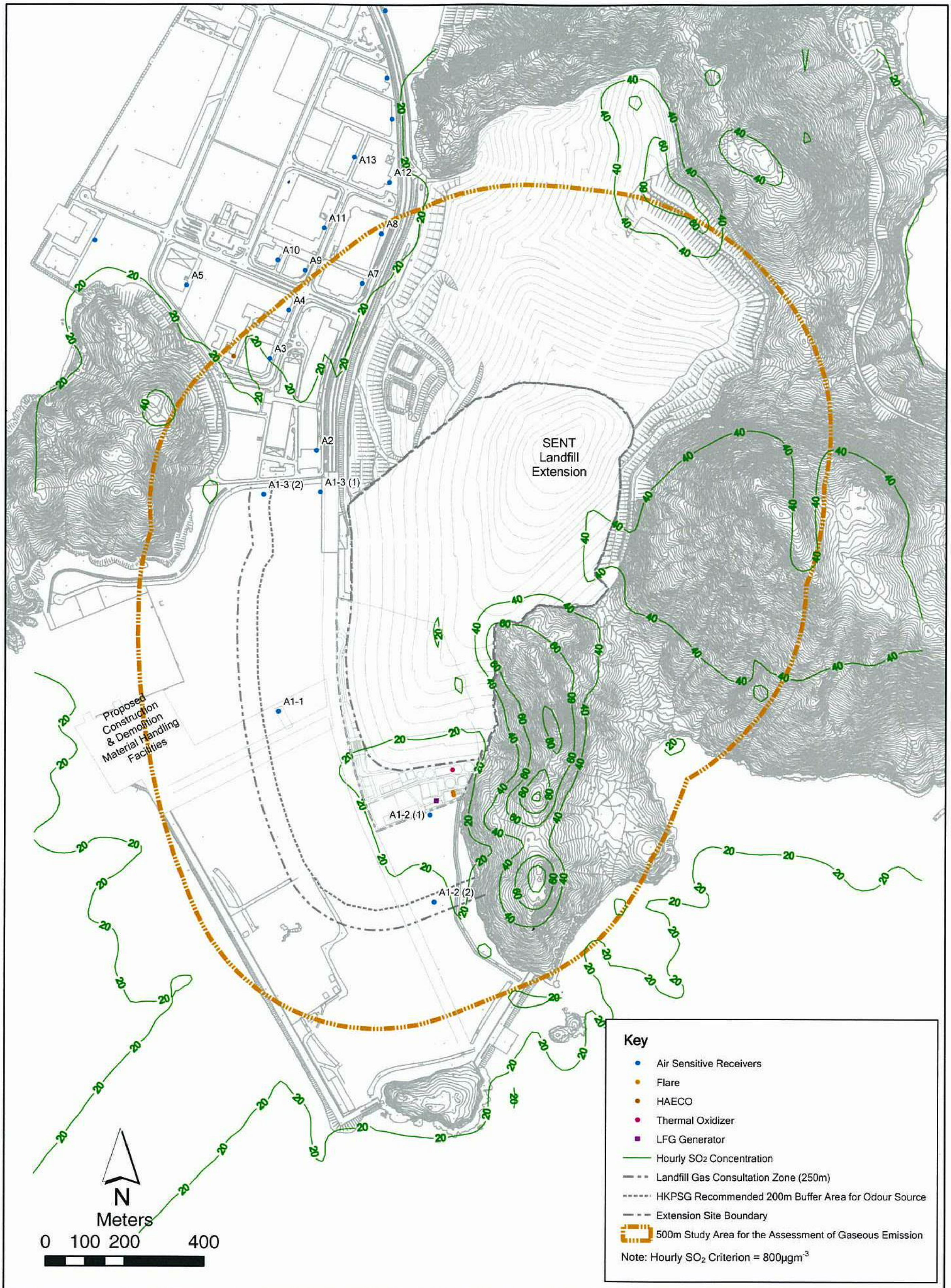

FIGURE 4.7o-1

Isopleths of Cumulative Maximum Hourly SO_2 Concentration at 1.5m above ground during Aftercare Phase

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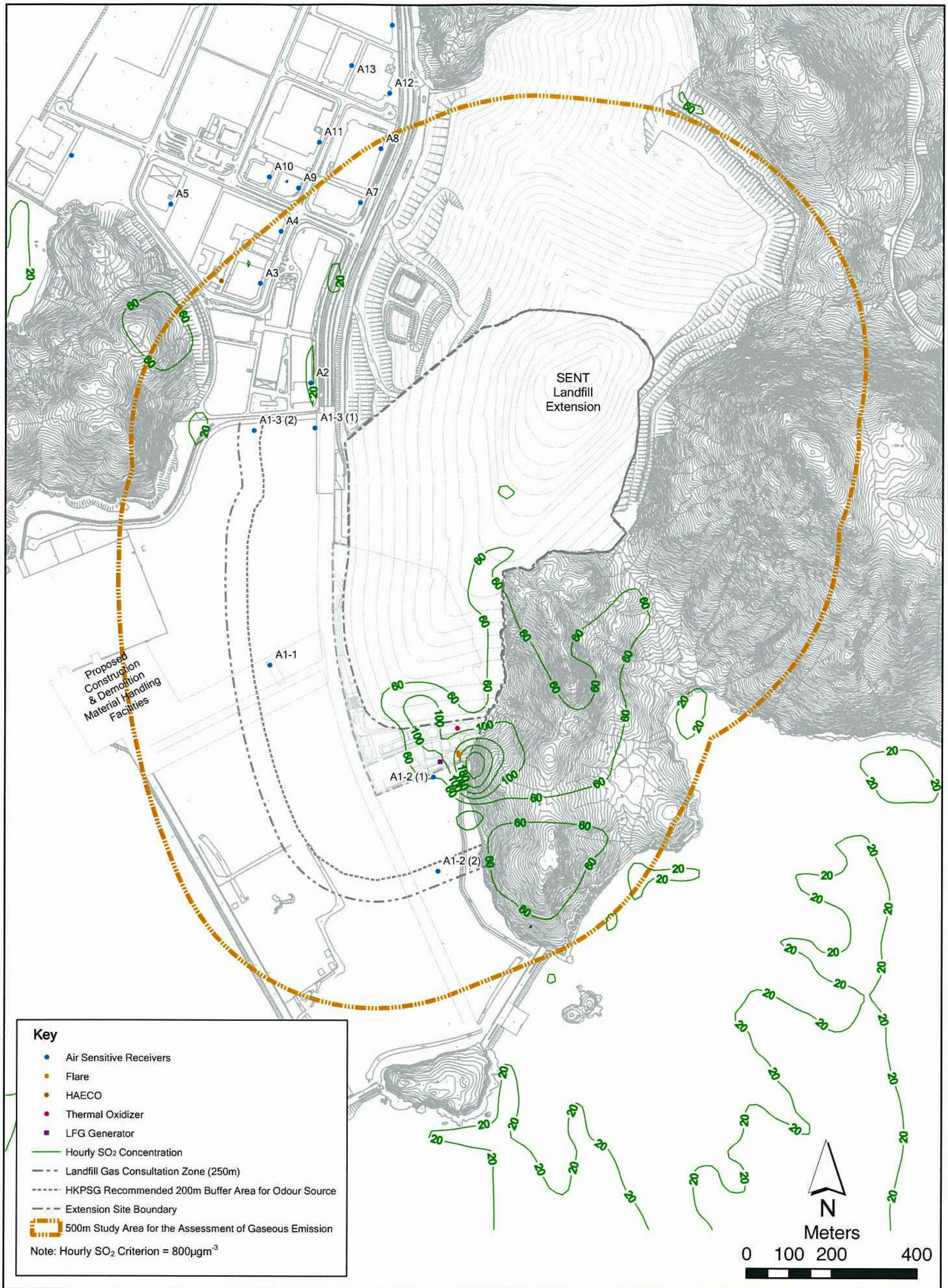

FIGURE 4.7o-2

Isopleths of Cumulative Maximum Hourly SO_2 Concentration at 30m above ground during Aftercare Phase

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Table 4.7f ***Highest Concentrations of NO_2, CO, SO_2, Benzene and Vinyl Chloride in Different Time Averaging During the Aftercare Phase***

ASR	Location	Highest Hourly Average Concentration (μg m^{-3}) (a) (b)					Highest Daily Average Concentration (μg m^{-3}) (a) (b)		Highest 8-hr Average Concentration (μg m^{-3}) (a) (b)	Highest Annual Average Concentration (μg m^{-3}) (a) (b)			
		NO_2	**CO**	**SO_2**	**Benzene**	**Vinyl Chloride**	**NO_2**	**SO_2**	**CO**	**NO_2**	**SO_2**	**Benzene**	**Vinyl Chloride**
A1-1	Proposed C&DM Handling Facility	75	1350	24	2.103	5.100	66.5	18.8	1315	66.1	18.08	2.100	5.100
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) - 1	129	2273	118	2.147	5.104	85.7	49.5	1764	67.0	19.48	2.101	5.100
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2	73	1395	28	2.105	5.102	67.2	19.6	1342	66.1	18.10	2.100	5.100
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) – 1	68	1328	21	2.102	5.100	66.4	18.6	1306	66.1	18.07	2.100	5.100
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	68	1326	21	2.102	5.100	66.7	19.1	1311	66.1	18.07	2.100	5.100
A2	TVB City	68	1326	21	2.102	5.100	66.4	18.5	1306	66.0	18.06	2.100	5.100
A3	HAESL	68	1325	21	2.102	5.100	66.7	18.4	1302	66.2	18.06	2.100	5.100
A4	HAECO Component Overhaul Building	75	1326	21	2.102	5.100	67.0	18.4	1302	66.1	18.06	2.100	5.100
A7	Yan Hing Machinery Industrial Building	74	1326	21	2.102	5.100	66.7	19.0	1308	66.1	18.09	2.100	5.100
A8	Apple Daily	84	1326	21	2.102	5.100	67.3	18.8	1309	66.1	18.09	2.100	5.100
	Background Concentration	**66**	**1294**	**18**	**2.1**	**5.1**	**66**	**18**	**1294**	**66**	66.1	**2.1**	**5.1**
	AQO / Chronic or Acute Reference Concentration	**300**	**30,000**	**800**	**1,300** (c)	**180,000** (c)	**150**	**350**	**10,000**	**80**	**80**	**30** (c)	**100** (c)

Notes:

(a) Detailed Assessment Results are summarized in *Annex A9-1*.

(b) Background NO_2, CO and SO_2 (presented in *Table 4.3a*) concentrations were included in the results.

(c) Acute/Chronic Reference Concentrations are referred to *Table 4.2d*.

Table 4.7g Highest Calculated Cancer Health Risk Levels of Benzene and Vinyl Chloride During the Aftercare Phase

ASR	Location	Individual Highest Calculated Cancer Health Risk Level (a) (b)		Total Cancer Health Risk Level
		Benzene	**Vinyl Chloride**	
A1-1	Proposed C&DM Handling Facility	3.1E-10	8.8E-11	4.0E-10
A1-2 (1)	Planned Industrial Uses in TKO 137 (south of Extension) - 1	5.9E-09	8.8E-10	6.7E-09
A1-2 (2)	Planned Industrial Uses in TKO 137 (south of Extension) - 2	4.7E-10	8.8E-11	5.6E-10
A1-3 (1)	Planned Industrial Uses in TKO 137 (south of TVB City) - 1	3.1E-10	8.8E-11	4.0E-10
A1-3 (2)	Planned Industrial Uses in TKO 137 (south of TVB City) - 2	3.1E-10	8.8E-11	4.0E-10
A2	TVB City	2.3E-10	8.8E-11	3.2E-10
A3	HAESL	2.3E-10	8.8E-11	3.2E-10
A4	HAECO Component Overhaul Building	2.3E-10	8.8E-11	3.2E-10
A7	Yan Hing Machinery Industrial Building	3.9E-10	8.8E-11	4.8E-10
A8	Apple Daily	3.9E-10	8.8E-11	4.8E-10

Notes:

(a) Detailed calculated health risk levels are summarized in *Annex 9-2*.

(b) Unit risk factors of benzene and vinyl chloride (as presented in *Table 4.2b*) have been used for the calculation.

4.7.5 Odour Emissions from the Operation of LTP during Aftercare Phase

As discussed in *Section 4.5.3*, during this phase, the sources of odour emissions will be the two SBR tanks. With reference to the total odour emission rates summarized in *Table 4.6e*, the total odour emission rate of SBRs is only 6% of the total during landfill operation.

According to the odour impacts predicted for the last waste tipping phase (ie Phase 6, the source height at 130m), no exceedance of odour criterion was predicted at any of the ASRs and the odour impact is confined within the Extension. During the aftercare phase (without waste tipping activities), as the odour emission rate is lower than that estimated during the last tipping phase (see *Table 4.7e*), the predicted odour levels at the ASRs will be lower than those predicted for the last tipping phase. Hence, no adverse odour impact is anticipated during the aftercare phase.

4.8 MITIGATION MEASURES

4.8.1 Construction Phase

The following control measures are set out in the *Air Pollution Control (Construction Dust) Regulations* and will be implemented to limit the dust emissions from the construction works.

Blasting

- The area within 30m of the blasting area will be wetted prior to blasting.
- Blasting will not be carried out when the strong wind signal or tropical cyclone warning signal No. 3 or higher is hoisted, unless this is with the express prior permission of the Commissioner of Mines.
- Loose material and stones in the Site will be removed prior to the blast operation.
- Blast nets, screens and other protective covers will be used to prevent the projection of flying fragments and material resulting from blasting.

Rock Drilling

- Watering will be carried out at the rock drilling activities to avoid fugitive dust emissions.

Site Access Road

- The main haul road will be kept clear of dusty materials or sprayed with water.
- The main haul road will be laid with aggregate or gravel.
- Vehicle speed will be limited to 10 kph.

Stockpiling of Dusty Materials

- Any stockpile of dusty materials will be covered entirely by impervious sheeting or placed in an area sheltered on the top and three sides or sprayed with water so as to ensure that the entire surface is wet.

Loading, unloading or transfer of dusty materials

- All dusty materials will be sprayed with water immediately prior to any loading, unloading or transfer operation so as to maintain the dusty material wet.

Site Boundary and Entrance

- Where a site boundary adjoins a road, street, service lane or other area accessible to the public, hoarding of not less than 2.4m from ground level will be provided along the entire length of that portion of the site boundary except for the site entrance or exit.

Excavation Works

- Working area of any excavation or earth moving operation will be sprayed with water immediately before, during and immediately after the operation so as to ensure that the entire surface is wet.

Building Demolition

- The area where the demolition works are planned to take place will be sprayed with water immediately prior to, during and immediately after the demolition activities.

- Any dusty materials remaining after a stockpile is removed will be wetted with water and cleared from the surface of roads or street.

Construction of the Superstructure of Building

- Effective dust screens, sheeting or netting will be provided to enclose the scaffolding from the ground level up to the highest level of the scaffolding.

The control measures recommended in the *Best Practicable Means Requirement for Mineral Works (Stone Crushing Plants) BPM 11/1* will be implemented during the operation of the stone crushing plant.

Good site practices such as regular maintenance and checking of the diesel powered mechanical equipment will be adopted to avoid any black smoke emissions and to minimize gaseous emissions.

4.8.2 *Operation/Restoration Phase*

Fugitive Emissions at Landfilling Area at the Extension

The following measures will be implemented to minimize any fugitive emissions during landfilling at the Extension:

- The main haul road to the waste filling area will be watered regularly to keep wet at any time.

- The exposed daily and intermediate covered areas will be compacted well to avoid fugitive dust emission.

- The vehicle speed will be limited within the Extension.

- Vehicle washing bay will be provided to avoid vehicles carrying dust to public roads.

- The engine will be switched off when the diesel-driven equipment is idling.

- The construction equipment will be properly maintained to avoid any black smoke emission.

- Sufficient underground landfill gas collection system will be provided to capture the landfill gas generated as much as possible.

- Periodic inspections of the final cover will be undertaken to ensure that the capping layer is in good conditions at all times.

Gaseous Emissions from the Operation of LFG Treatment Facility, LTP and LFG Generator

No mitigation measures are required associated with the gaseous emissions from the operation of LFG treatment facility LTP and LFG generator as no exceedance of criteria are predicted.

Odour Emissions from Waste Filling Activities and Operation of LTP

Exceedance of the 5-second odour criterion was predicted at some ASRs, mitigation measures are recommended to minimize the odour impacts.

Odour management and control measures, as summarized in *Table 4.8a*, will be incorporated into the outline design. These measures will be implemented during the operation/restoration phase of the Extension to minimize the potential odour impacts to identified ASRs.

Table 4.8a ***Summary of Odour Management and Control Measures During Operation/Restoration Phase***

Proposed Odour Management and Control Measures [(a)]	
(i)	Installing deodorizers along the site boundary adjacent to the ASRs
(ii)	Erecting a vertical barrier, wall or structure soften by planting rows of trees/shrubs or landscape feature along the site boundary, particularly in the areas near the ASRs
(iii)	Enclosing the weighbridge area
(iv)	Providing a vehicle washing facility before the exit of the landfill and providing sufficient signage to remind RCV drivers to pass through the facility before leaving the landfill
(v)	Reminding the RCV drivers to empty the liquor collection sump and close the valve before leaving the tipping face.
(vi)	Washing down the area where spillage of RCV liquor is discovered promptly
(vii)	Reminding operators to properly maintain their RCVs properly and that liquor does not leak from the vehicles
(viii)	Installation of vertical and/or horizontal LFG extraction system to enhance extraction of LFG from the waste mass and hence minimise odour associated with fugitive LFG emissions
(ix)	Progressive restoration of the areas which reach the finished profile (a final capping system including an impermeable liner will be put in place) and installation of a permanent LFG extraction system
(x)	Maintaining the size of the active tipping face only not greater than 40 m x 30 m, of which the size of the active tipping face for MSW + construction waste will be limited to 20 m x 30 m and the size of the active tipping face for construction waste only will be limited to 20 m x 30 m
(xi)	Promptly covering the MSW with soil or selected inert materials to reduce odour emissions
(xii)	Maintaining the size of the special waste trench not greater than 6m x 2.5m
(xiii)	Covering daily covered area with 300mm of soil at 11pm
(xiv)	Covering special waste trench with 600 mm of soil and an impervious liner after 5 pm
(xv)	Covering the non-active tipping face with 600mm of soil and an impermeable liner (on top of the intermediate cover), which will not only prevent odour emissions from landfilled waste but also enhance LFG extraction by the LFG extraction system

Proposed Odour Management and Control Measures [(a)]	
(xvi)	Applying deodorizers or odour suppression agents to control odour emissions from the active tipping face and special waste trench, if any, through spraying or fogging equipment
(xvii)	Providing a mobile cover with retractable or suitable opening to cover the special waste trench except during waste deposition. The air trapped inside the trench will be extracted and scrubbed by a mobile odour removal unit prior to discharge to the atmosphere
(xviii)	Providing thermal oxidizer (one duty and one standby) for the LTP
(xix)	Enclosing all the leachate storage and treatment tanks (except for the SBR tanks) and diverting the exhaust air from these tanks to a thermal oxidizer to avoid potential odour emissions from the LTP

Note:

(a) Items (iii) to (xv), (xviii) and (xix) have been considered in the assessment. As the removal efficiency of deodorizer cannot be quantified, it was not included in the odour modelling. As a conservative assessment, the odour modelling assumed that there were no cover and air scrubbing for the special waste trench.

In particular, rephasing of the waste tipping activities on-site has been considered to minimize the potential odour impact at A1-3 and A2 as far as practicable. By avoiding waste tipping activities at the northern area of the site in the months between July to November (see *Figures 4.9a-1* and *4.9a-2*), the number of exceedances can be reduced by 70% (maximum) at A2.

4.8.3 Aftercare Phase

No mitigation measures regarding gaseous emission are required.

Odour management and control measures to be carried out during aftercare phase are summarized in *Table 4.8b*.

Table 4.8b Summary of Odour Management and Control Measures During Aftercare Phase

Proposed Odour Management and Control Measures	
(i)	Continue to maintain the integrity of the capping system
(ii)	Provision of vertical and/or horizontal LFG extraction system to enhance extraction of LFG from the waste mass and hence minimise odour associated with fugitive LFG emissions
(iii)	Enclosing all the leachate storage and treatment tanks (except for the SBR tanks) and diverting the exhaust air from these tanks to an air scrubber or the flares to avoid potential odour emissions from the LTP

4.9 RESIDUAL IMPACTS

4.9.1 Construction Phase

No residual impact is anticipated after the implementation of the recommended mitigation measures described in *Section 4.8.1*.

4.9.2 *Operational/Restoration Phase*

Gaseous Emissions from LFG Treatment Facility and Thermal Oxidizers, Vehicle Emissions from Traffic associated with the Extension and Fugitive Emissions from Active Tipping Face

No residual impact is anticipated associated with the gaseous emissions from LFG treatment facility and LTP, vehicle emissions and fugitive emissions from active tipping face.

Odour Emissions Arising from Waste Filling Activities and Operation of LTP

As noted above the predicted odour levels exceed the odour assessment criterion at those ASRs in close proximity to the Extension and hence residual impacts are predicted.

TKO Area 137 (ie A1-1 to A1-3) has been zoned "Other Specified Uses" annotated "Deep Waterfront Industry". The intent is for the land adjacent to the Extension to be used for industrial uses. Under Column 1 in the OZP Explanatory Note, 23 types of uses [(1)] are always permitted to be located at TKO Area 137. Among them, some of the permitted uses including government refuse collection point, public vehicle park and warehouse are considered less sensitive to odour impacts than land zoned for residential, commercial or institutional development. Furthermore, under the HKPSG "acceptable uses" of land within 200m of odour sources include industrial development. The waste tipping activities will be scheduled to avoid waste tipping at the northern sectors of the Extension between July and November in order to reduce the number of exceedances of the odour criterion at A2 to the greatest extend feasible (please refer to *Figures 4.9a-1* and *4.9a-2*). *Annex A11-1* presents the reduction of odour levels and *Annex A11-2* shows the reduction of the number of exceedances after rephasing. It also shows that the number of exceedances gradually reduces to zero over six years.

A2 is the nearest location of TVB City to the Extension. It is predicted to have residual impacts at this location when waste is being disposed in the northern sector of the landfill (ie, Worst Case 3). No exceedances are predicted at A2 when landfilling is in the middle and southern sectors of the site. With the proposed rephasing of landfilling activities (ie by avoiding waste tipping at northern sector of the site between July and November), the predicted highest odour concentrations at A2 will reduce from 14 OU to 9.5OU and the number of exceedances at A2 will decline by 58% from 26 to 11 events in the first year and 71% from 21 to 6 events in the second year of operation (please see *Annexes A10*, *A11-1* and *A11-2*). This is an upper bound estimate due to the

(1) 23 types of uses include ambulance depot, cargo handling and forwarding facility, eating place, government refuse collection point, government use, industrial uses (motor-vehicle assembly plant, paint manufacturing, service trades, steel works only), IT and Telecommunications industries, marine fuelling station, open storage of construction materials, open storage of cement/sand, petrol filling station, pier, public convenience, public transport terminus or station, public utility installation, public vehicle park, recyclable collection centre, research, design and development centre, refuse disposal installation, ship-building, ship-breaking and ship-repairing yard, utility installation for private project and warehouse.

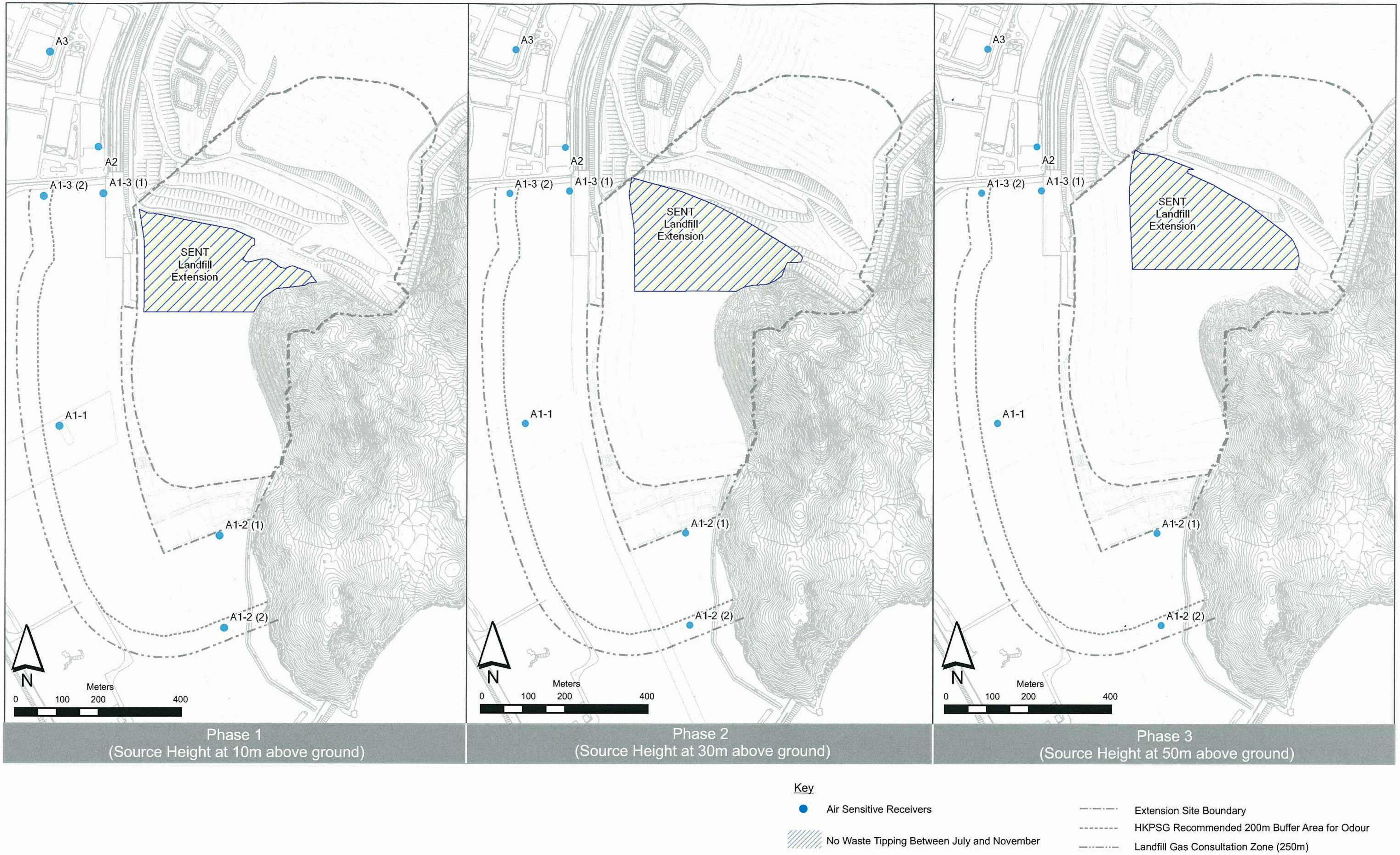

Figure 4.9a - 1

Indicative Recommended Rephasing Plan

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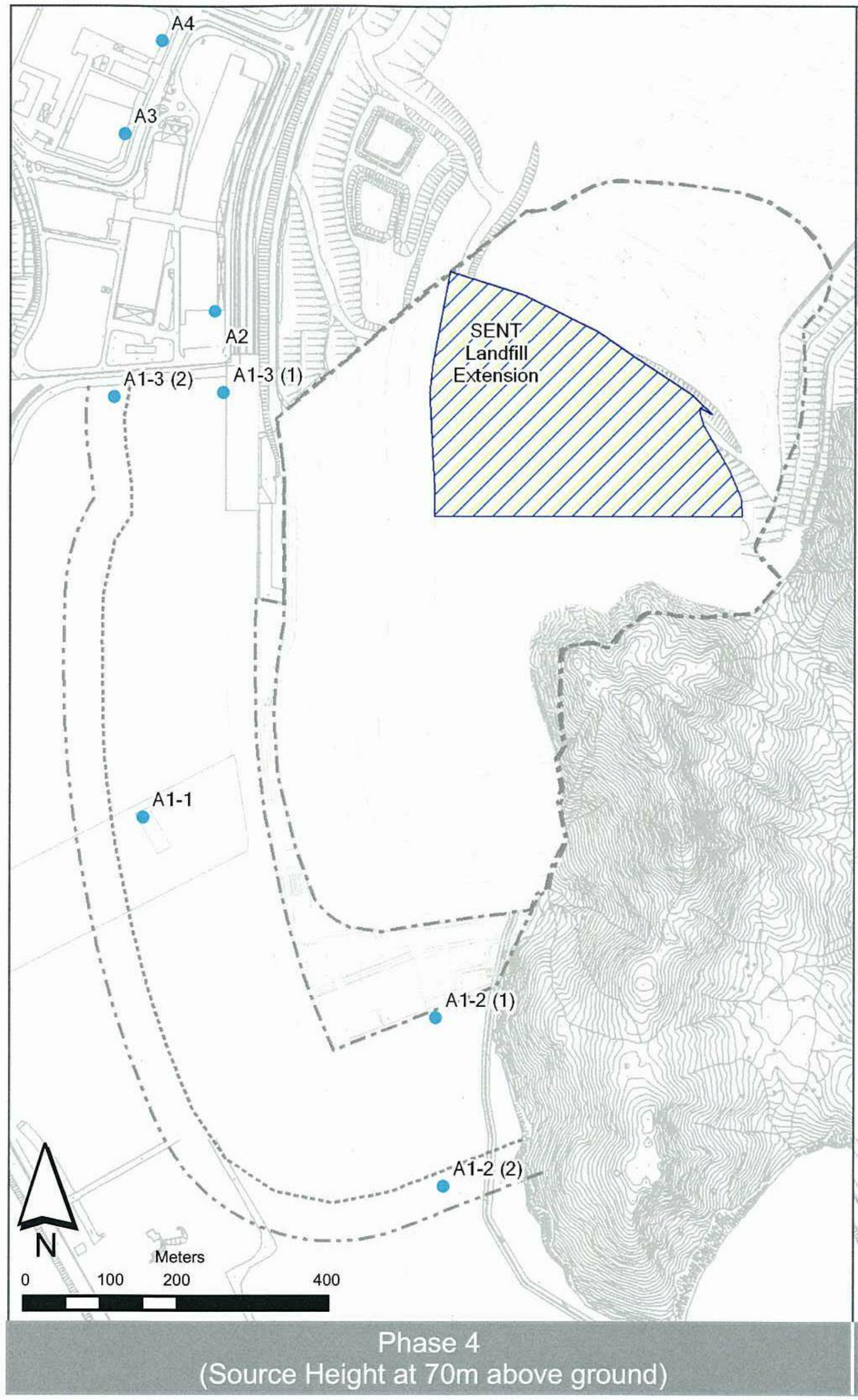

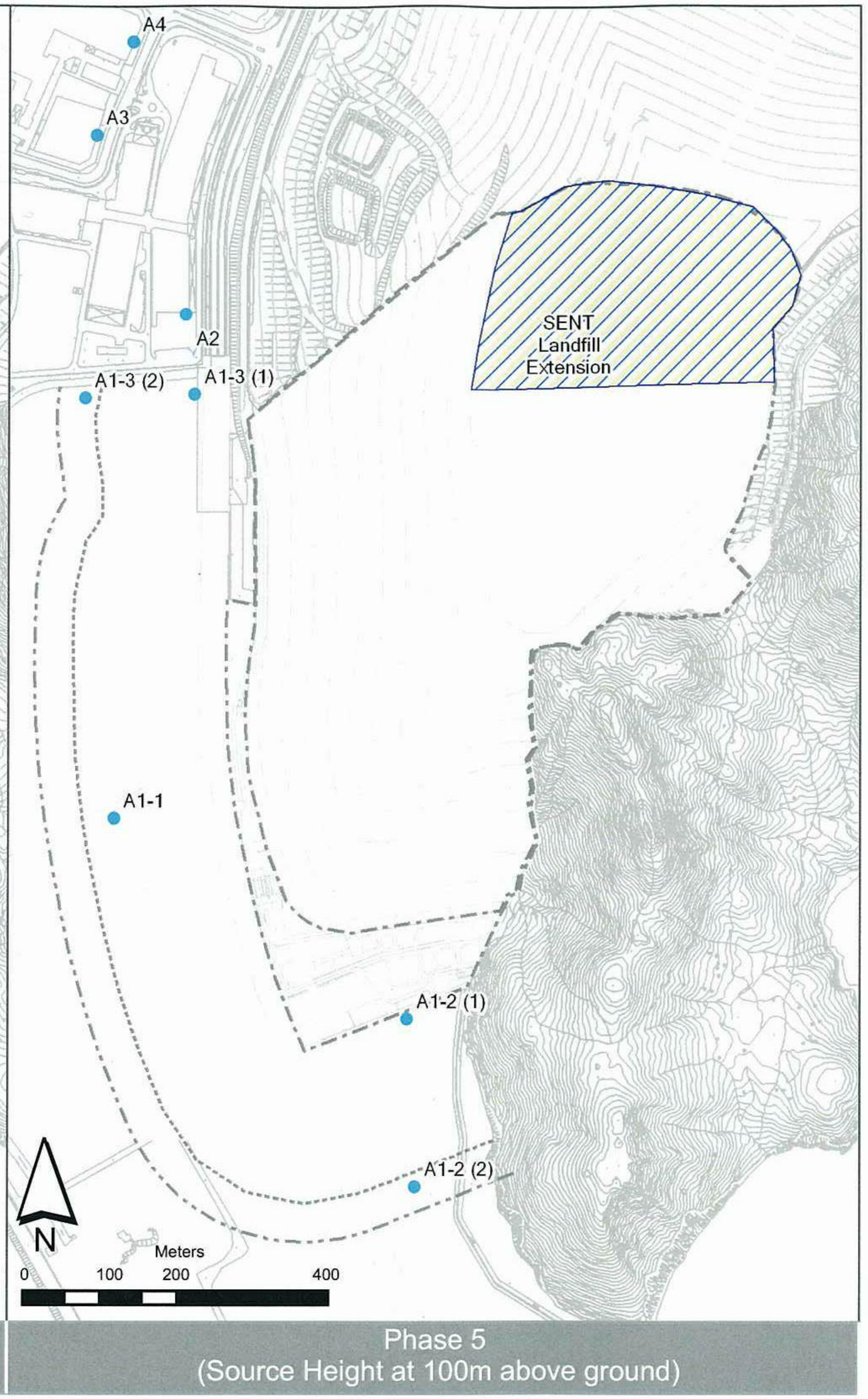

Key

- Air Sensitive Receivers
- No Waste Tipping Between July and November
- Extension Site Boundary
- HKPSG Recommended 200m Buffer Area for Odour
- Landfill Gas Consultation Zone (250m)

Figure 4.9a - 2

Indicative Recommended Rephasing Plan

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adoption of a series of conservative assumptions in the impact assessment. As the landfill works progress, the frequency of exceedances of the odour criterion at A2 will diminish to zero over the six year period (ie, from 11 events in the first year of operation to 0 events in the last year).

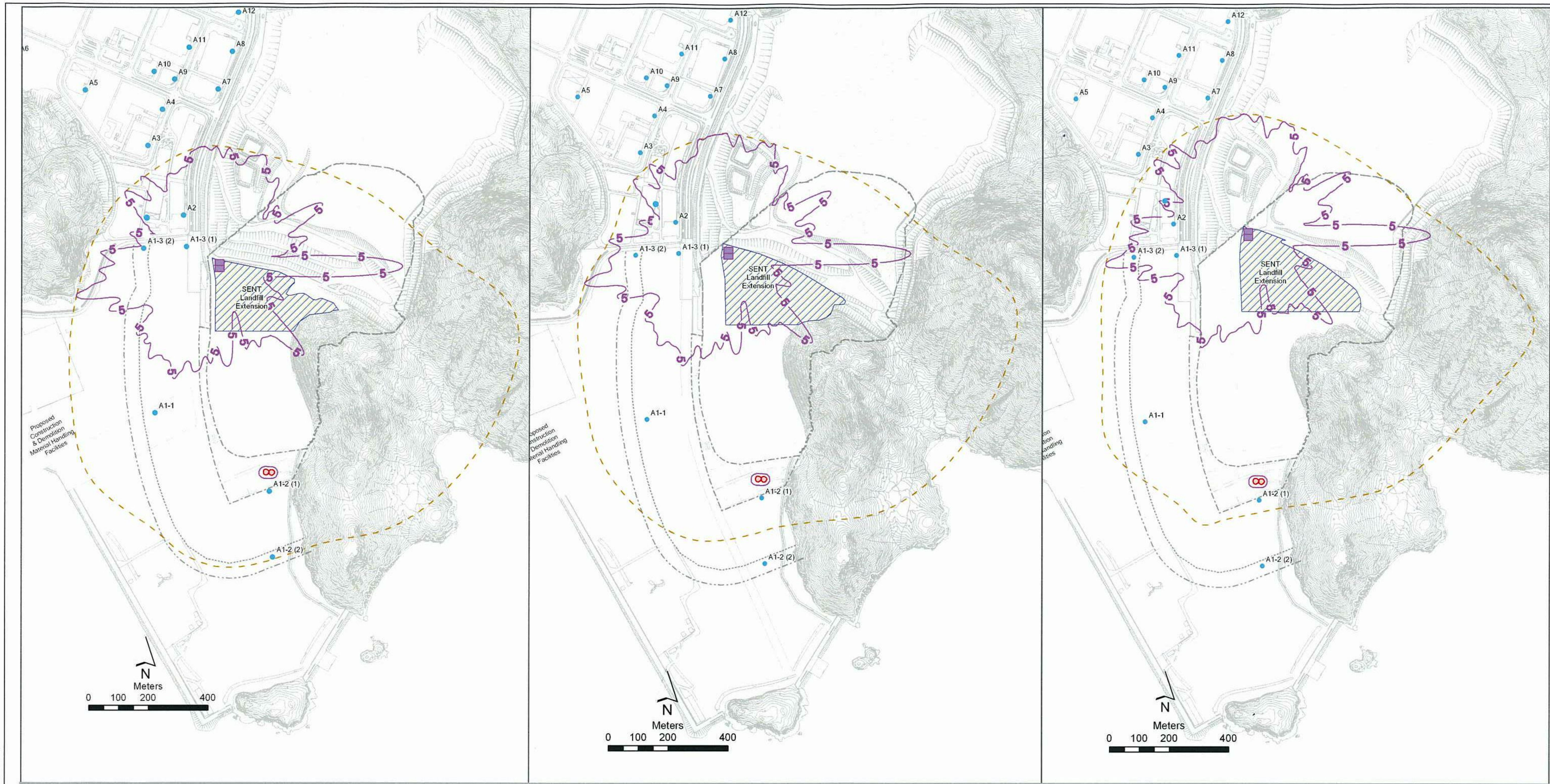
Table 4.9a presents an assessment of the residual impacts at the representative assessment points of the TKO Area 137 and TVB City (ie A1-1, A1-2 (1), A1-2 (2), A1-3 (1), A1-3 (2) and A2) with respect to the guidelines described in *Section 4.4.3* and *Annex 20* of the *EIAO-TM.*

Figures 4.9b-1 and *4.9b-2* show the zones of possible impact (the area with a potential for exceedance of odour criterion) and summarize the predicted highest odour levels at A1-1 (the only committed facility at TKO Area 137 as identified during the EIA Study) to A3 and the number of exceedances during different waste tipping phases after rephasing. The figures indicate that the size of the zones of possible impact (the area with a potential for exceedance of odour criterion) close to A1-3 and A2 are slightly reduced. It should be noted that only the ASRs located downwind of the active tipping face may experience an odour level exceeding the odour criterion and the actually affected area at any given time would be a much smaller than the area within the 5OU contour line (see *Figures 4.9b-1* and *4.9b-2*). In addition, the number of exceedances will be reduced (ie, 71 instances will be reduced to 21 instances at A1-3 (1) in the first year) after rephasing of the waste tipping activities for Phase 1. As the waste tipping face moves further away from the ASRs as the Extension is developed, the number of exceedances decreases to zero over a six-year period. The southern and eastern areas of TVB City may also be affected by emissions from the operation/restoration of the Extension.

The residual impacts will be infrequent, transient and limited to the areas within 350m from the Extension and will not affect any residential developments. As discussed in *Section 4.7.2*, the odour emission rate of the special waste trench adopted in the assessment is conservative and the actual rate is expected to be much lower as the trench will be covered and the air inside the trench will be scrubbed prior to discharge to the atmosphere. Furthermore, no sludge will be received in the Extension. Hence, the residual impacts will be lower and the number of exceedances will be less than those predicted.

Taking account of the nature of the developments affected (industrial and commercial premises), the number of people impacted, the transient nature, low frequency and magnitude of the exceedances, the residual impacts are considered acceptable.

Odour assessment criteria adopted by other countries was also referenced and the comparison with the assessment results and different odour assessment criteria adopted by other countries are summarized in *Annex A12*.



Phase 1

ASR	Maximum 5-second Odour Levels		No. of Instances having Exceedance		
	Worst Case 3		Worst Case 3		
	1.5m above ground		1.5m above ground		
	w/o rephasing	w/ rephasing	w/o rephasing	w/ rephasing	% reduction
A1-1	3.2	3.2	-	-	-
A1-2 (1)	1.9	1.2	-	-	-
A1-2 (2)	1.3	1.3	-	-	-
A1-3 (1)	23.2	19.3	71	21	70
A1-3 (2)	11.4	5.6	4	1	75
A2	12.5	8.9	26	11	58
A3	3.3	3.3	-	-	-

Phase 2

ASR	Maximum 5-second Odour Levels		No. of Instances having Exceedance		
	Worst Case 3		Worst Case 3		
	1.5m above ground		1.5m above ground		
	w/o rephasing	w/ rephasing	w/o rephasing	w/ rephasing	% reduction
A1-1	2.2	2.2	-	-	-
A1-2 (1)	1.9	1.9	-	-	-
A1-2 (2)	1.6	1.6	-	-	-
A1-3 (1)	14.4	14.4	26	19	27
A1-3 (2)	7.3	7.3	2	2	0
A2	13.1	9.5	21	6	71
A3	4.2	4.2	-	-	-

Phase 3

ASR	Maximum 5-second Odour Levels		No. of Instances having Exceedance		
	Worst Case 3		Worst Case 3		
	1.5m above ground		1.5m above ground		
	w/o rephasing	w/ rephasing	w/o rephasing	w/ rephasing	% reduction
A1-1	1.7	1.7	-	-	-
A1-2 (1)	1.3	1.3	-	-	-
A1-2 (2)	1.1	1.1	-	-	-
A1-3 (1)	11.2	11.2	5	5	-
A1-3 (2)	6.9	6.9	1	1	-
A2	14.0	8.6	10	5	50
A3	5.2	4.0	1	-	100

Key: Air Sensitive Receivers; SBR Tanks; Zone of Possible Impact; Odour Emission Source; Odour Concentration; Extension Site Boundary; HKPSG Recommended 200m Buffer Area for Odour; Landfill Gas Consultation Zone (250m); No Waste Tipping between July and November

Note : It should be noted that only the ASRs located downwind of the active tipping face may experience an odour level exceeding the odour criterion and the actually affected area at any given time would be a much smaller than the area within the 5OU contour line.

Figure 4.9b - 1

Zone of Possible Impact Due to Landfill Odour Emission (Area with a Potential for Exceedance of Odour Criterion)
(After Rephasing - no waste tipping between July and November at Northern Sector)
(Phases 1 to 3)

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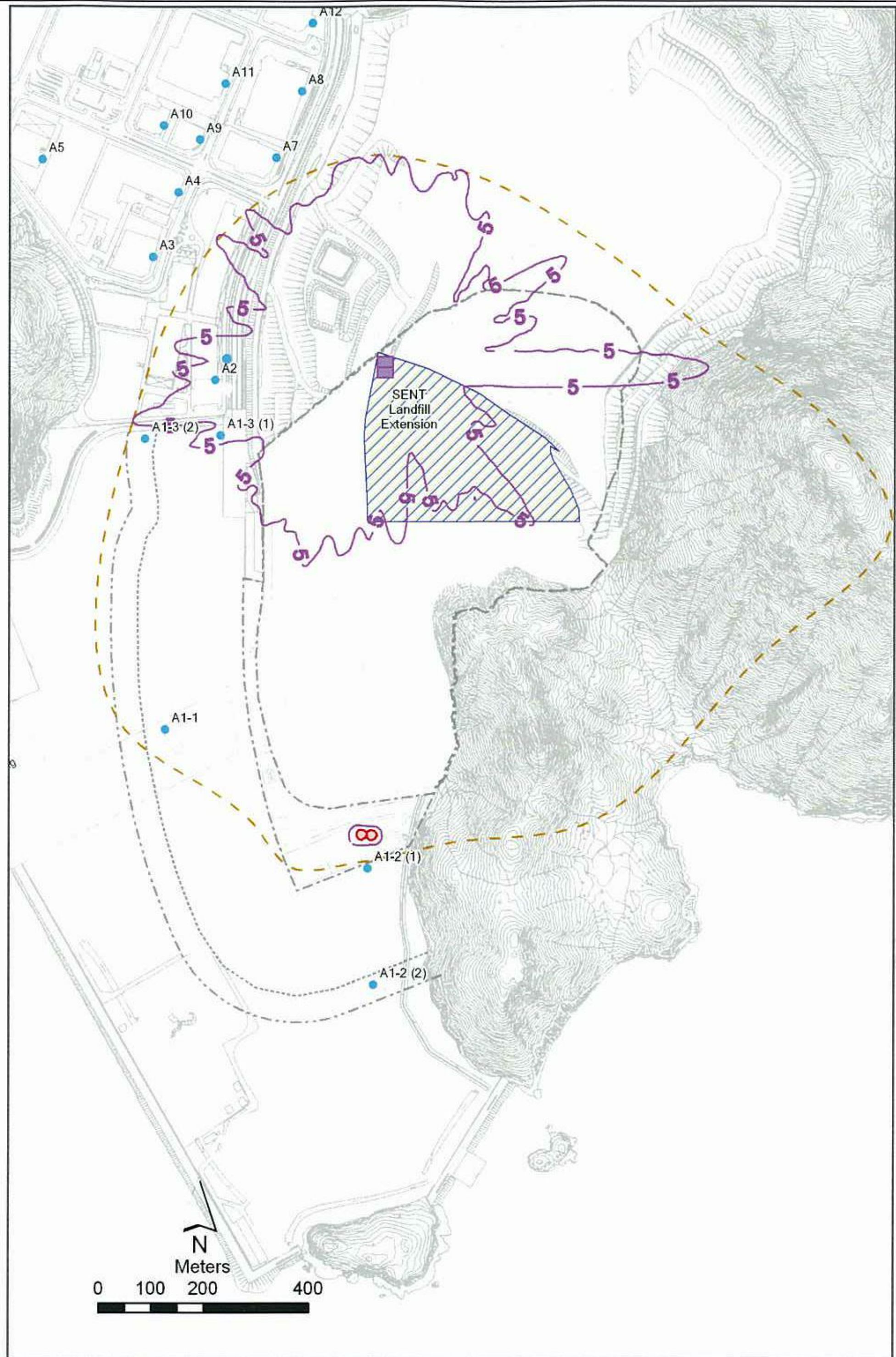
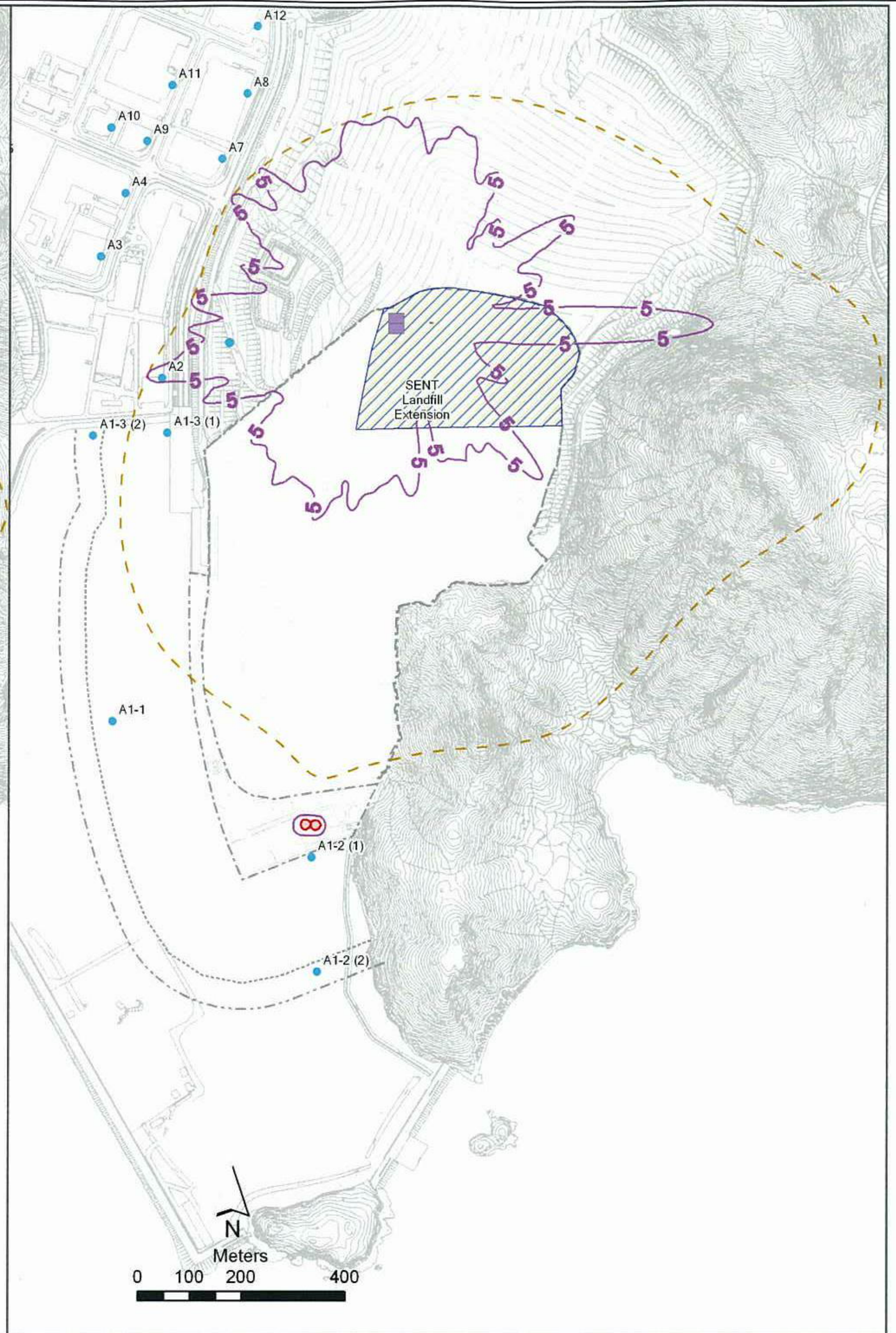


Phase 4

ASR	Maximum 5-second Odour Levels		No. of Instances having Exceedance		
	Worst Case 3		Worst Case 3		
	1.5m above ground		1.5m above ground		
	w/o rephasing	w/ rephasing	w/o rephasing	w/ rephasing	% reduction
A1-1	1.4	1.5	-	-	-
A1-2 (1)	1.5	1.2	-	-	-
A1-2 (2)	1.2	0.8	-	-	-
A1-3 (1)	6.4	6.4	2	1	50
A1-3 (2)	3.3	3.3	-	-	-
A2	6.5	6.5	4	2	50
A3	3.1	1.8	-	-	-



Phase 5

ASR	Maximum 5-second Odour Levels		No. of Instances having Exceedance		
	Worst Case 3		Worst Case 3		
	1.5m above ground		1.5m above ground		
	w/o rephasing	w/ rephasing	w/o rephasing	w/ rephasing	% reduction
A1-1	1.2	1.2	-	-	-
A1-2 (1)	1.2	1.2	-	-	-
A1-2 (2)	0.7	0.7	-	-	-
A1-3 (1)	2.9	2.6	-	-	-
A1-3 (2)	2.6	2.6	-	-	-
A2	5.4	5.4	1	1	0
A3	3.8	1.8	-	-	-

No Waste Tipping between July and November

Key: Air Sensitive Receivers; SBR Tanks; Zone of Possible Impact; Odour Emission Source; Odour Concentration; Extension Site Boundary; HKPSG Recommended 200m Buffer Area for Odour; Landfill Gas Consultation Zone (250m)

Note : It should be noted that only the ASRs located downwind of the active tipping face may experience an odour level exceeding the odour criterion and the actually affected area at any given time would be a much smaller than the area within the 5OU contour line.

Figure 4.9b - 2

Zone of Possible Impact Due to Landfill Odour Emission (Area with a Potential for Exceedance of Odour Criterion)
(After Rephasing - no waste tipping between July and November at Northern Sector)
(Phases 4 to 5)

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Table 4.9a Evaluation of Residual Odour Impacts

Factors to Evaluate Residual Impacts	TKO Area 137 (A1-1, A1-2 (1), A1-2 (2), A1-3 (1) and A1-3 (2))	TVB City (A2)
Effects on public health and health of biota or risk to life	TKO Area 137 has been zoned "Other Specified Uses" annotated "Deep Waterfront Industry" for industrial uses and some of the permitted uses in this area under Column 1 in the OZP Explanatory Note (such as government refuse collection point, public vehicle park and warehouse) are not considered to be particularly sensitive to odour impacts. Impacts to public health are not predicted and there is no reliable evidence linking odour to adverse health outcomes. Any health issues would be related to emissions of substances such as VOCs. Regular monitoring at the boundary of the existing SENT Landfill shows that concentrations of such substances remain well within the trigger level. Odour is widely considered to be related to amenity value rather than public health. No impact to the health of biota, are predicted (including rare and/or endangered species).	Impacts to public health are not predicted and there is no reliable evidence linking odour to adverse health outcomes. Regular monitoring at the boundary of the existing SENT Landfill shows that concentrations of such substances remain well within the trigger level. Odour is widely considered to be related to amenity value rather than public health. No impact to the health of biota, are predicted (including rare and/or endangered species).
Magnitude of the adverse environmental impacts	The affected areas at the worst affected height of the representative assessment points (ie A1-1, A1-2(1), A1-2(2), A1-3(1), and A1-3(2)) at TKO Area 137 during different waste tipping phases are indicated in *Figures 4.7f* to *4.7k* and the zones of possible impacts (the area with a potential for exceedance of odour criterion) during different waste tipping phases are also illustrated in *Figures 4.7l-1* and *4.7l-2*. As discussed above, industrial premises are planned for development in TKO Area 137 and 23 types of uses are always permitted to be located at TKO Area 137 under Column 1 in the OZP Explanatory Note. Some of the permitted uses such as government refuse collection point, public vehicle park and warehouse are not considered to be particularly sensitive to odour impacts. There will be no concurrent projects that generated similar type of	Without rephasing, the affected areas at the worst affected height of the representative assessment point (ie A2 which is the nearest point to the Extension) at TVB City during different waste tipping phases are indicated in *Figures 4.7f* to *4.7k* and the affected zone during different waste tipping phases are also illustrated in *Figures 4.7l-1*to *4.7l-2*. After rephasing of the waste tipping activities (by avoiding waste tipping at northern sector between July and November), the numbers and levels of exceedance at the representative assessment point of TVB City will be significantly reduced (please also refer to *Annexes A10-1* and *A10-2* for detail).

<table>
<tr><th>Factors to Evaluate Residual Impacts</th><th>TKO Area 137 (A1-1, A1-2 (1), A1-2 (2), A1-3 (1) and A1-3 (2))</th><th>TVB City (A2)</th></tr>
<tr><td></td><td>odour in the vicinity; therefore, no cumulative odour impacts are predicted.</td><td>
<table>
<tr><th rowspan="2">Waste Tipping</th><th colspan="3">No. of Exceedance of 5-sec Odour Criterion</th><th colspan="2">Highest 5-sec Odour Concentration</th></tr>
<tr><th>Without Rephasing</th><th>With Rephasing</th><th>% Reduction</th><th>Without Rephasing</th><th>With Rephasing</th></tr>
<tr><td>Phase 1</td><td>26</td><td>11</td><td>58</td><td>12.5</td><td>8.9</td></tr>
<tr><td>Phase 2</td><td>21</td><td>6</td><td>71</td><td>13.1</td><td>9.5</td></tr>
<tr><td>Phase 3</td><td>10</td><td>5</td><td>50</td><td>14.0</td><td>8.6</td></tr>
<tr><td>Phase 4</td><td>4</td><td>2</td><td>50</td><td>6.5</td><td>6.5</td></tr>
<tr><td>Phase 5</td><td>1</td><td>1</td><td>0</td><td>5.4</td><td>5.4</td></tr>
<tr><td colspan="6">Notes:
(a) Each phase will last for about 1 year.
(b) Please refer to Annex A5 for detailed calculation.</td></tr>
</table>
After rephasing of the tipping operation, the highest 5-second odour concentration predicted at A2 will be reduced to 9.5 OU and the number of exceedance per year will be reduced by about 70% (maximum) at A2 and will diminish over time.
There will be no concurrent projects that generated similar type of odour in the vicinity; therefore, no cumulative odour impacts are predicted.
</td></tr>
<tr><td>Geographic extent of the adverse environmental impacts</td><td> The residual impacts will be localized and limited to the area in close proximity to the Extension (refer to Figures 4.7f to 1.7k). Out of 43 ASRs assessed, only 4 ASRs (in TKO Area 137 (consisting of group of 3 planned ASRs which are industrial developments) and TVB City) will experience residual impacts. The Extension will not cause widespread adverse odour impact to residential developments. For all other ASRs, the predicted odour impacts are well within the odour criterion.
The areas in TKO Area 137 which exceed the odour criterion are limited to a distance of about 350 m from the Extension site boundary.
Long range transportation of odour is not predicted. </td><td>The area which exceeds the odour criterion is limited to the southern and eastern areas of the TVB City.</td></tr>
</table>

Factors to Evaluate Residual Impacts	TKO Area 137 (A1-1, A1-2 (1), A1-2 (2), A1-3 (1) and A1-3 (2))	TVB City (A2)
Duration and frequency of the adverse environmental impacts	The predicted residual impacts are intermittent and will last for about five years (from 2013 to 2017). The number and level of exceedance will reduce over time as the tipping area moves to higher levels and further away from the ASRs. The residual impacts will be reduced to zero.	After rephasing, the number of exceedance of the 5-second odour criterion at the representative assessment point of TVB City (ie A2 which is the nearest point to the Extension) will be reduced to a maximum of 11 events per year and gradually decline to zero over six years. The predicted residual impacts are intermittent and will last for about five years (from 2013 to 2017).
Likely size of the community or the environment that may be affected by the adverse impacts	The number of workers in the industrial developments at TKO Area 137 to be impacted by the residual impacts will depend on future developments. The only committed development in the TKO Area 137 is the CEDD's C&DM Handling Facility. With respect to the nature of this development, it is anticipated that the number of workers impacted will be less than 50. According to the Adopted Departmental Plan, L/TKO-137/1, TKO Area 137 is planned for PHI development. With reference to its explanatory note, it is stated that the maximum worker density should not exceed 20 workers per hectare. Based on the contour plots in *Figures 4.7f* to *4.7k*, the maximum affected area (area within contour line of 5OU) for all assessment cases is approximately 13.5 ha. Therefore, it is estimated that up to 270 workers will be impacted.	It is estimated that the total number of people working within the affected zone of A2 will be about 1,000. According to the predicted odour levels at different elevations of A2 (refer to *Annex A10-1*), the worst affected heights are 1.5m and 10m above ground during different waste tipping phases. The buildings within the affected area are equipped with centralised air conditioning system and the fresh air intakes are located at the rooftop of the TVB main building (ie 30m above ground) and at the level of about 13m above ground for the buildings (which is the lowest) along Wan Po Road. As the odour levels predicted at levels higher than 10m above ground at A2 are well below the odour criterion, there will be no adverse odour impact to the people (about 900) working indoor. In conclusion, 100 people who are working outdoor will be potentially affected. It should be noted that the number of people affected will reduce when the waste tipping activities will move higher and further away from the TVB City.
Degree to which the adverse environmental impacts are reversible or irreversible	Odour impact is transient in nature and therefore is reversible. After the Extension is closed and restored, no residual impacts are anticipated.	Odour impact is transient in nature and therefore is reversible. After the Extension is closed and restored, no residual impacts are anticipated.
Ecological context	N/A - Odour nuisance will not cause adverse ecological impacts.	N/A - Odour nuisance will not cause adverse ecological impacts.
Degree of disruption to sites of cultural heritage	N/A – The Project will not impact on cultural heritage resources.	N/A – The Project will not impact on cultural heritage resources.

Factors to Evaluate Residual Impacts	TKO Area 137 (A1-1, A1-2 (1), A1-2 (2), A1-3 (1) and A1-3 (2))	TVB City (A2)
International and regional importance	It is not anticipated that the residual odour impact will affect an issues of international and regional concern.	It is not anticipated that the residual odour impact will affect an issues of international and regional concern.
Both likelihood and degree of uncertainty of adverse environmental impacts	As the odour impact assessment (including the odour modeling and odour sampling) has adopted a number of conservative assumptions, it is considered that the predicted odour impacts are overstated. The odour emission rate of construction waste tipping is conservative. The construction waste comprises mainly wood and some inert materials and the odour generated from this kind of waste is low compared to that generated from the MSW covered with 300mm soil. The number of exceedances may vary due to the different meteorological condition in the future six years of operation. The odour emission rate of the trench adopted in the assessment is conservative and the emissions will be much lower as the trench will be covered and the air trapped inside the trench will be scrubbed prior to discharge to the air as well as no sludge will be received in the Extension. Hence, the level and number of exceedances will be less than the predicted in reality. In *Annex A3*, the sensitivity test demonstrated that doubling the odour emission rate of the trench will only cause a slightly increase of the residual impact. Therefore, the uncertainty in the odour emission rate of the trench at 30 °C would not cause significant increase of residual impact. Resolving uncertainties in the assessment would tend to lead to a lowering of the predicted impacts.	As the odour impact assessment (including the odour modeling and odour sampling) has adopted a number of conservative assumptions, it is considered that the predicted odour impacts are overstated. The odour emission rate of construction waste tipping is conservative. The construction waste comprises mainly wood and some inert materials and the odour generated from this kind of waste is low compared to that generated from the MSW covered with 300mm soil. The number of exceedances may vary due to the different meteorological condition in the future six years of operation. The odour emission rate of the trench adopted in the assessment is conservative and the emissions will be much lower as the trench will be covered up and the air trapped inside the trench will be scrubbed prior to discharge to the air as well as no sludge will be received in the Extension. Hence, the level and number of exceedances will be less than the predicted in reality. In *Annex A3*, the sensitivity test demonstrated that doubling the odour emission rate of the trench will only cause a slightly increase of the residual impact. Therefore, the uncertainty in the odour emission rate of the trench at 30 °C would not cause significant increase of residual impact. Resolving uncertainties in the assessment would tend to lead to a lowering of the predicted impacts.

4.9.3 *Aftercare Phase*

No adverse residual impacts are anticipated.

4.10 ENVIRONMENTAL MONITORING AND AUDIT

4.10.1 *Construction Phase*

Excavation and filling activities for site formation and blasting works are the major sources of dust nuisance. Dust levels, in terms of Total Suspended Particulates (TSP) will be monitored, at A2 (TVB City) and the A1-3 (Planned Industrial Uses in TKO 137 (south of TVB City) – 1) if industrial premise is occupied during construction phase. The proposed dust monitoring stations are illustrated in *Figure 4.10a*. Dust monitoring will be conducted once every six days throughout the site formation and blasting works to ensure that there will be no exceedance of dust criteria at the ASRs. Detailed EM&A requirements for dust monitoring are presented in the EM&A Manual.

4.10.2 *Operation/Restoration Phase*

During operation/restoration phase, the following monitoring activities should be undertaken:

Ambient TSP Monitoring at Site Boundary

24-hour TSP concentrations will be monitored at the four designated air monitoring stations along the Extension Site boundary (as shown in *Figure 4.10a*) once every six days throughout the landfill operation/restoration phase.

Ambient VOC, Ammonia and Hydrogen Sulphide (H_2S) Monitoring at Site Boundary

Ambient VOCs (a suite of VOCs same as identified in the existing SENT Landfill, listed in EM&A Manual), ammonia and hydrogen sulphide (H_2S) concentrations will be monitored at the designated air monitoring stations (see *Figure 4.10a*) along the site boundary at quarterly intervals throughout the operation/restoration and aftercare phases.

Monitoring of Flares and Thermal Oxidizer Stacks

The NO_2, CO, SO_2, benzene, vinyl chloride and NMOC concentrations in flue gas of the flares and thermal oxidiser stack will be monitored at monthly intervals for the first 12 months of operation and thereafter at quarterly intervals throughout the operation/restoration phase. Gas combustion temperature, exhaust gas temperature and exhaust gas velocity will be monitored continuously.

Under the combustion temperature of the thermal oxidiser, all ammonia will be destroyed. To confirm this design assumption, it is recommended that the ammonia concentration in the flue gas of the thermal oxidiser be monitored

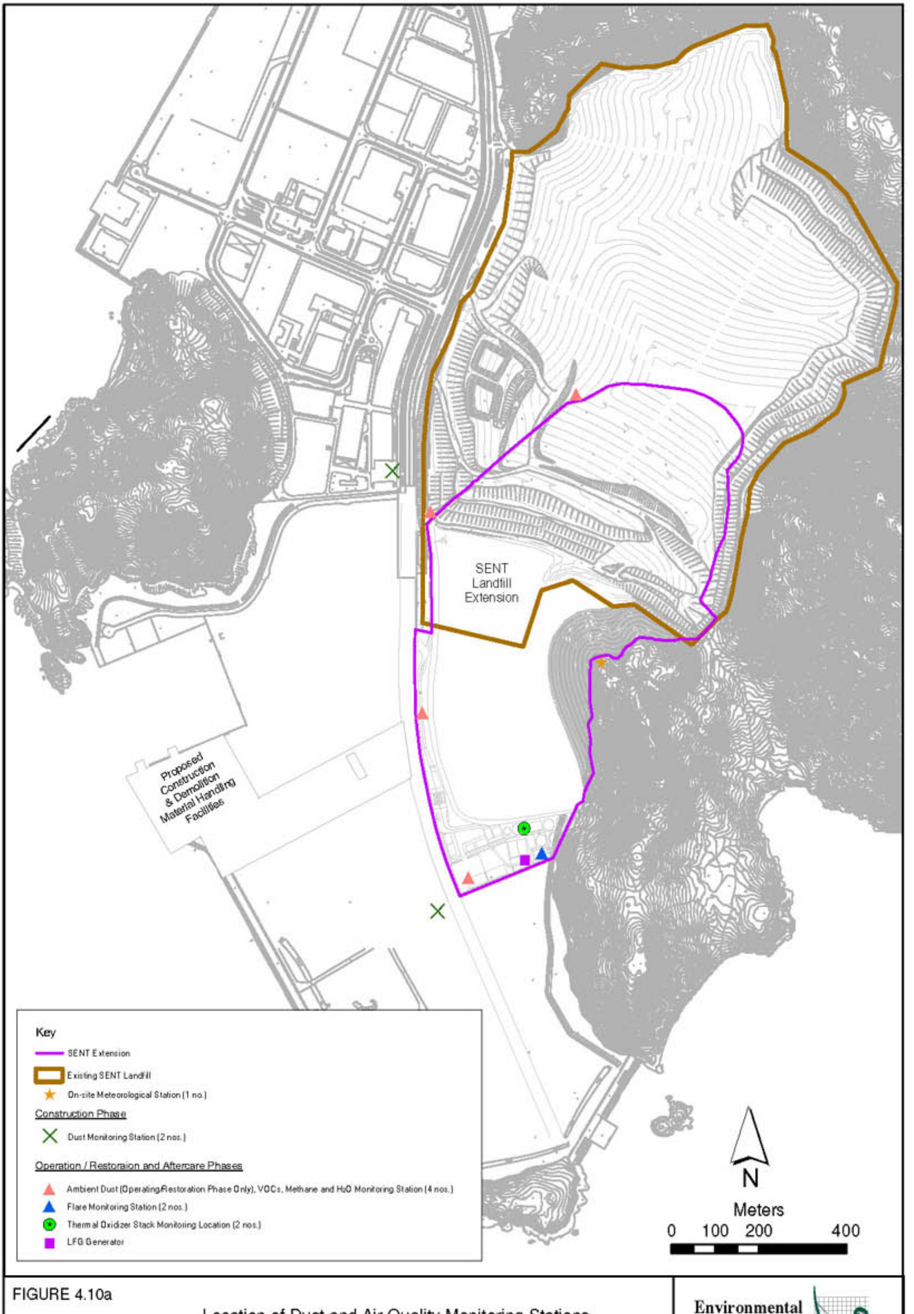

FIGURE 4.10a

Location of Dust and Air Quality Monitoring Stations during Construction, Operation / Restoration and Aftercare Phases

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during the commissioning stage of the thermal oxidiser. If required, an emission standard will be set for ammonia for the thermal oxidiser based on the monitoring results. If no ammonia is detected in the flue gas during the decommissioning stage, the monitoring of ammonia in the flue gas of the thermal oxidiser could be discontinued.

Monitoring of LFG Generator Stack

The NO_2, CO, SO_2, benzene and vinyl chloride concentrations in flue gas of the LFG generator stack will be monitored at monthly intervals for the first 12 months of operation and thereafter at quarterly intervals throughout the operation/restoration phase. Exhaust gas temperature and exhaust gas velocity will be monitored continuously.

Odour Patrol

Odour patrols along the Extension site boundary will be conducted on daily basis to detect any odour nuisance caused by the operation of the Extension. Detailed odour patrol requirement is presented in the *Environmental Monitoring & Audit (EM&A) Manual*.

On-site Meteorological Station

A meteorological station will be constructed on site to capture the wind data (wind speed and wind direction), air temperature, rainfall and relative humidity as supporting information for the EM&A data analysis. The meteorological station will be erected at least 10m above ground located at the highest point of the Extension and will not be obstructed by surrounding structures.

Detailed EM&A requirements during operation/restoration phase are presented in the EM&A Manual.

4.10.3 Aftercare Phase

Periodic inspections of the final cover will be undertaken to ensure that the capping layer is in good conditions at all times. As LFG and leachate will still be generated from the landfill, the monitoring, summarized in *Table 4.10a* will be conducted.

Table 4.10a Monitoring Programme During Aftercare Phase

Parameter	Monitoring Programme
24-hr TSP	• once every 6 days at four designated locations along the site boundary when major maintenance works is required
Ambient VOCs, Ammonia and H_2S	• VOCs, ammonia and H_2S • Monitoring frequency : quarterly
Stack emission from flares	• NO_2, CO, SO_2, benzene, vinyl chloride and NMOC • Monitoring frequency : quarterly • Gas combustion temperature, exhaust gas temperature and exhaust gas velocity will be monitored continuously

Parameter	Monitoring Programme
Stack emission from LFG generator	• NO_2, CO, SO_2, benzene, and vinyl chloride • Exhaust gas temperature and velocity • Monitoring frequency : quarterly
Odour Patrol	• weekly patrol along the Extension site boundary when major maintenance works is required
Meteorological Station	• continue to operate

Detailed monitoring and audits requirements are presented in the EM&A Manual.

4.11 CONCLUSIONS

4.11.1 *Construction Phase*

Potential dust nuisance from blasting, rock crushing, excavation and filling and gaseous emissions from construction plant during construction of the Extension have been evaluated. With the implementation of the recommended dust control measures and good construction site practices as recommended in *Section 4.8.1*, it is not anticipated that the construction of the Extension will cause adverse dust and air quality impacts.

4.11.2 *Operation/Restoration Phase*

Gaseous Emissions

NO_2, CO, SO_2, and benzene and vinyl chloride are the key air pollutants of concerns from the operation of the LFG treatment facility, LTP and LFG generator. Taking account of the emissions from HAESL and the general background, the predicted cumulative NO_2, CO, SO_2, benzene and vinyl chloride are well within relevant AQOs, international chronic/acute reference and health risk guidelines at different elevations of the identified ASRs throughout the operation/restoration phase of the Extension. The predicted total cancer health risks of benzene and vinyl chloride at the identified ASRs are very low.

The past 5-year monitoring data of the ambient VOC concentrations at the site boundary of the existing SENT Landfill indicates that the ambient VOC concentrations are low and within the respective trigger levels. As the types waste to be received at the Extension; the operation of the Extension will be similar to the existing SENT Landfill; and the non-active tipping area will be covered with 600 mm of soil and an impermeable liner which couples with a comprehensive LFG collection system, it is anticipated that VOC emission will be lower. It is therefore not envisaged that the operation of the Extension will cause adverse air quality impact to the identified ASRs with respect to potential VOC emissions from the landfill.

Odour Impacts

The outline design of the Extension has incorporated a number of good odour management and control measures (see *Table 4.8a*) which aim to minimise the potential odour emissions during the operation/restoration phase of the Extension. During the operation/restoration phase, the landfilling activities at the active tipping face and the special waste trench; and the operation of the SBR tanks of the LTP have the potential to cause odour impacts to the identified ASRs.

With the implementation of odour management and control measures recommended in *Table 4.8a*, the maximum 5-second odour concentrations at various heights (from 1.5m to 90m above ground) of all identified ASRs were predicted. No exceedances of the odour criterion were predicted except those ASRs in the close vicinity of the Extension site boundary (within 350m). Residual impacts were predicted in a small area zoned for industrial development covering part of TKO Area 137 and TVB City (A2) adjacent to the Extension boundary. The frequency of the exceedances at TVB City will be reduced through the adoption of rephrasing of waste tipping activity (1). Over the six year operation period, the number of exceedances at this ASR is expected to diminish to zero as the separation distances and heights between the active tipping face and the ASR increases. It should be noted that the odour emission rate of the special waste trench adopted in the assessment is conservative and the emissions will be much lower as the trench will be covered and the air trapped inside the trench will be scrubbed prior to discharge to the atmosphere (2). Hence, it is anticipated that the actual odour level and number of exceedances will be less than the predicted in this assessment.

The residual impacts will be infrequent, transient and limited to the areas within 350m from the Extension and will not affect any residential developments. Taking account of the nature of the developments affected (industrial and commercial premises), the number of people impacted, the transient nature, low frequency, magnitude of the exceedances, and odour assessment criteria adopted by other countries the residual impacts are considered acceptable.

EM&A Requirement

Ambient TSP, VOC, ammonia and H_2S concentrations will be monitored at the Extension Site boundary; stack emissions from flares, thermal oxidizers and LFG generator will also be monitored and odour patrols will be conducted along the Extension Site boundary on daily basis to detect any odour nuisance caused throughout this phase.

(1) No waste tipping activity at the northern sector of the Extension between July and November.

(2) It should be noted that the odour measurement that formed the basic for the emission rates were made in area in which sludge has been disposed. This is not planned at the Extension.

4.11.3 *Aftercare Phase*

During aftercare phase, air emission sources are primarily associated with the LFG treatment facility and LTP. The Extension will be sealed with a capping system (including an impermeable liner) and LFG will be extracted and flared or utilised. The vent gas produced in the enclosed tanks will be either diverted to the flares or to an air scrubber prior to discharge to the atmosphere. If the vent gas is treated at the flare (combusted at a temperature of 850^{o}C), the odour compounds (including ammonia) in the vent gas will be destroyed (similar to the situation when the thermal oxidiser is in operation). If the flare is not in operation, the vent gas will be treated by an air scrubber. The designed odour (including ammonia gas) removal efficiency of the air scrubber will be at least 95%. The anticipated odour impact from the scrubber emissions will be minimal. In order to further minimise potential odour impacts, the scrubbed air will be diverted to the air blower of the SBR tanks and used it as part of the air source for the aeration process. The odour source will be limited to the SBR tanks of the LTP. As the emission strength and scale of the Extension operation during this phase are significantly reduced compared to the operation/restoration phase, no adverse odour impact is therefore, anticipated.

The potential air quality impact due to the emissions from the LFG treatment facility and LFG generator has been evaluated. No exceedances of AQO criteria, reference acute/chronic concentrations and health risk guidelines are predicted at any of the identified ASRs. It is therefore concluded that the aftercare of the Extension will not cause adverse air quality impacts to the identified ASRs.

The monitoring activities for ambient VOCs, ammonia and H_2S, and stack emissions from flares and LFG generator will be continued into the aftercare period whereas the ambient TSP monitoring and odour patrol will be conducted when major maintenance works will be required.

5 NOISE

5.1 INTRODUCTION

This *Section* assesses the potential noise impacts associated with the construction, operation, restoration and aftercare of the Extension.

5.2 RELEVANT LEGISLATION AND GUIDELINES

5.2.1 *Construction, Restoration & Aftercare Noise*

The principal legislation relating to the control of construction, restoration and aftercare noise is the *Environmental Impact Assessment Ordinance* (*EIAO*) *(Cap. 499)*. The *Technical Memorandum on Environmental Impact Assessment Process* (*EIAO-TM*), issued under the *EIAO*, provides guidelines and noise criteria for evaluating the noise impacts.

The *Noise Control Ordinance (Cap. 400)* (*NCO*) also provides means to assess construction, restoration and aftercare noise impacts. Various Technical Memoranda (TMs), which stipulate control approaches and criteria, have been issued under the *NCO*. The following TMs are applicable to the control of noise impacts from construction activities:

- *Technical Memorandum on Noise from Construction Work other than Percussive Piling* (*GW-TM*); and
- *Technical Memorandum on Noise from Construction Work in Designated Areas* (*DA-TM*).

General Construction Works

Under the *EIAO*, potential noise impact arising from general construction works during normal working hours (ie 07:00 to 19:00 hrs on any day not being a Sunday or public holiday) at the openable windows of buildings, which rely on opened windows for ventilation, is to be assessed in accordance with the noise criteria specified in the *EIAO-TM*. The *EIAO-TM* noise standards are presented in *Table 5.2a*.

Table 5.2a EIAO-TM Day-time Construction Noise Standards ($L_{eq,\ 30\ min}$ dB(A))

Use	**Noise Standard (dB(A))**
Domestic Premises	75
Educational Institutions (normal periods)	70
Educational Institutions (during examination periods)	65

Notes:

(1) The above standards apply to uses which reply on opened windows for ventilation.

(2) The above standards shall be viewed as the maximum permissible noise levels assessed at 1m from the external façade.

When assessing a Construction Noise Permit (CNP) application for the use of Powered Mechanical Equipment (PME) during the restricted hours, the Noise Control Authority will compare the Acceptable Noise Levels (ANLs), as promulgated in *GW-TM*, and the Corrected Noise Levels (CNLs) (ie after accounting for factors such as barrier effects and reflections) associated with the proposed PME operations. The ANLs are related to the noise sensitivity of the area in question and different Area Sensitivity Ratings (ASR) have been established to reflect the background characteristics of different areas. The appropriate ASR for the Noise Sensitive Receiver (NSR) is determined with reference to *Table 5.2b*.

Table 5.2b ***Area Sensitivity Ratings***

Types of Area Containing NSR	**Degree to which NSR is affected by Influencing Factor (IF)**		
	Not Affected	**Indirectly Affected**	**Directly Affected**
Rural area, including Country Parks or village type developments	A	B	B
Low density residential area consisting of low-rise or isolated high-rise developments	A	B	C
Urban area	B	C	C
Area other than those above	B	B	C

Notes:
The following definitions apply:
(a) "Country Park" means an area that is designated as a country park pursuant to section 14 of the *Country Parks Ordinance*;
(b) "directly affected" means that the NSR is at such a location that noise generated by the IF is readily noticeable at the NSR and is a dominant feature of the noise climate of the NSR;
(c) "indirectly affected" means that the NSR is at such a location that noise generated by the IF, whilst noticeable at the NSR, is not a dominant feature of the noise climate of the NSR;
(d) "not affected" means that the NSR is at such a location that noise generated by the IF is not noticeable at the NSR; and
(e) "urban area" means an area of high density, diverse development including a mixture of such elements as industrial activities, major trade or commercial activities and residential premises.

The relevant ANLs are shown in *Table 5.2c*.

Table 5.2c ***Acceptable Noise Levels for General Construction Works (ANL, $L_{eq,\,5\,min}$ dB(A))***

Time period	**Area Sensitivity Rating (dB(A))**		
	A	B	C
All days during the evening (ie 19:00-23:00 hrs) and general holidays (including Sundays) during the day and evening (ie 07:00-23:00 hrs)	60	65	70
All days during the night-time (ie 23:00-07:00 hrs)	45	50	55

The Noise Control Authority will consider a well-justified CNP application, for construction works within restricted hours as guided by the relevant Technical Memorandum issued under the *NCO*. The Noise Control Authority will take into account adjoining land uses and any previous complaints against construction activities at the site before making a decision. Nothing in this *EIA Report* shall bind the Noise Control Authority in making its decision. The Noise Control Authority may include any conditions in a CNP that it considers appropriate. Failure to comply with any such conditions may lead to cancellation of the CNP and prosecution action under the *NCO*.

5.2.2 Operational Noise

On-site Operational Noise

The *EIAO-TM* and *Technical Memorandum on Noise From Places Other than Domestic Premises, Public Places or Construction Sites* (*IND-TM*) specifies the applicable ANLs for the operation of the Extension. The ANLs are dependent on the ASR and the time of the day and are presented in *Table 5.2d.*

Table 5.2d ANLs to be used as Fixed Plant Noise Criteria

Time Period	**$L_{eq\ 30min}$ (dB(A))**		
	ASR "A"	**ASR "B"**	**ASR "C"**
Day-time (ie 07:00-19:00 hrs)	60	65	70
Evening (ie 19:00-23:00 hrs)	60	65	70
Night-time (ie 23:00-07:00 hrs)	50	55	60

Fixed plant noise is controlled under Section 13 of the *NCO* and the predictions will be undertaken in accordance with the *IND-TM*. The noise criteria for planning and design of Designated Projects are set out in the *EIAO-TM* as follows:

- the noise level at the facade of the nearest NSR is at least 5 dB(A) lower than the appropriate ANL (as shown in *Table 5.2d*) as specified in the *IND-TM*; or,

- the prevailing background noise level (for quiet areas with a noise level 5 dB(A) below the appropriate ANL).

The noise criteria stipulated in the *IND-TM* are also dependent on the ASR of the NSR, as shown in *Table 5.2d*. For this assessment, the ASR assumed for the NSR and the associated ANL are discussed in *Section 5.3.2*.

Road Traffic Noise

The traffic noise standards for planning purposes specified in Table 1 under Annex 5 of the *EIAO-TM* was employed as the noise limits for the road traffic noise impact assessment. The applicable road traffic noise standards are 70dB(A) $L_{10,\ 1hr}$ for domestic premises and 65dB(A) $L_{10,\ 1hr}$ for education institutions and church, respectively. These noise limits were applied for the peak hour traffic flows and for uses that rely on opened windows for ventilation.

5.3 *BASELINE ENVIRONMENTAL CONDITIONS AND NOISE SENSITIVE RECEIVERS*

5.3.1 *Baseline Environmental Conditions*

The Extension Site is located near the southern end of Wan Po Road. The nearest existing high-rise residential developments are located at more than 2.4km and 3.5km away in the Eastern District of Hong Kong Island and Tseung Kwan O (TKO), respectively. Background noise levels are typical of a general rural environment and there are limited numbers of vehicles or noisy plant items operating during evening and night-time periods. The major existing noise sources were identified as the general noise from the existing SENT Landfill, Tseung Kwan O Industrial Estate and the traffic noise in the vicinity.

5.3.2 *Noise Sensitive Receivers*

In accordance with the requirements given in Section 3.4.2.2 of the EIA Study Brief, the Study Area for the noise impact assessment covered a distance of 300m from the roads with traffic generated by the Extension. Only the first layer of the NSRs located along Wan Po Road and Chiu Shun Road were included in the assessment as the NSRs behind were located further away from the road and were screened. The area considered in the assessment is shown in *Figure 5.3a*.

Existing NSRs that would potentially affected by the Extension are identified as the Island Resort at Siu Sai Wan which is located at more than 2.4km to the south-west of the Extension Site boundary, and Oscar By the Sea in Tseung Kwan O which is located at more than 3.2km to the north of the Extension Site. Other existing NSRs, including residential developments and schools, are located at a further distance away to the north. Planned residential developments and schools in TKO Area 85 and Area 86 are located at more than 1.5km to the north of the Extension Site boundary. The locations of the identified representative NSRs and photographs showing the existing representative NSRs are presented in *Figures 5.3b* to *5.3e*. The locations of the identified representative planned NSRs for assessment are presented in *Figure 5.3f*.

As the NSRs are located in an isolated high-rise development area and are indirectly affected by Wan Po Road or the Tseung Kwan O Industrial Estate, an ASR of "B" was assigned. Background noise measurements were conducted to investigate the prevailing noise level in the Study Area. With the inclusion of façade correction, the measured prevailing noise levels were 60 dB(A) $L_{eq,\,30min}$ and 55 dB(A) $L_{eq,\,30min}$ during day-time and night-time respectively. Therefore, the (ANL – 5) criteria of 60 dB(A) $L_{eq,\,30min}$ and 50 dB(A) $L_{eq,\,30min}$ for day-time and night-time periods, respectively were considered as the stipulated noise limits for the assessment of operational noise impact. Details of the background noise measurements are provided in *Section 5.3.3*.

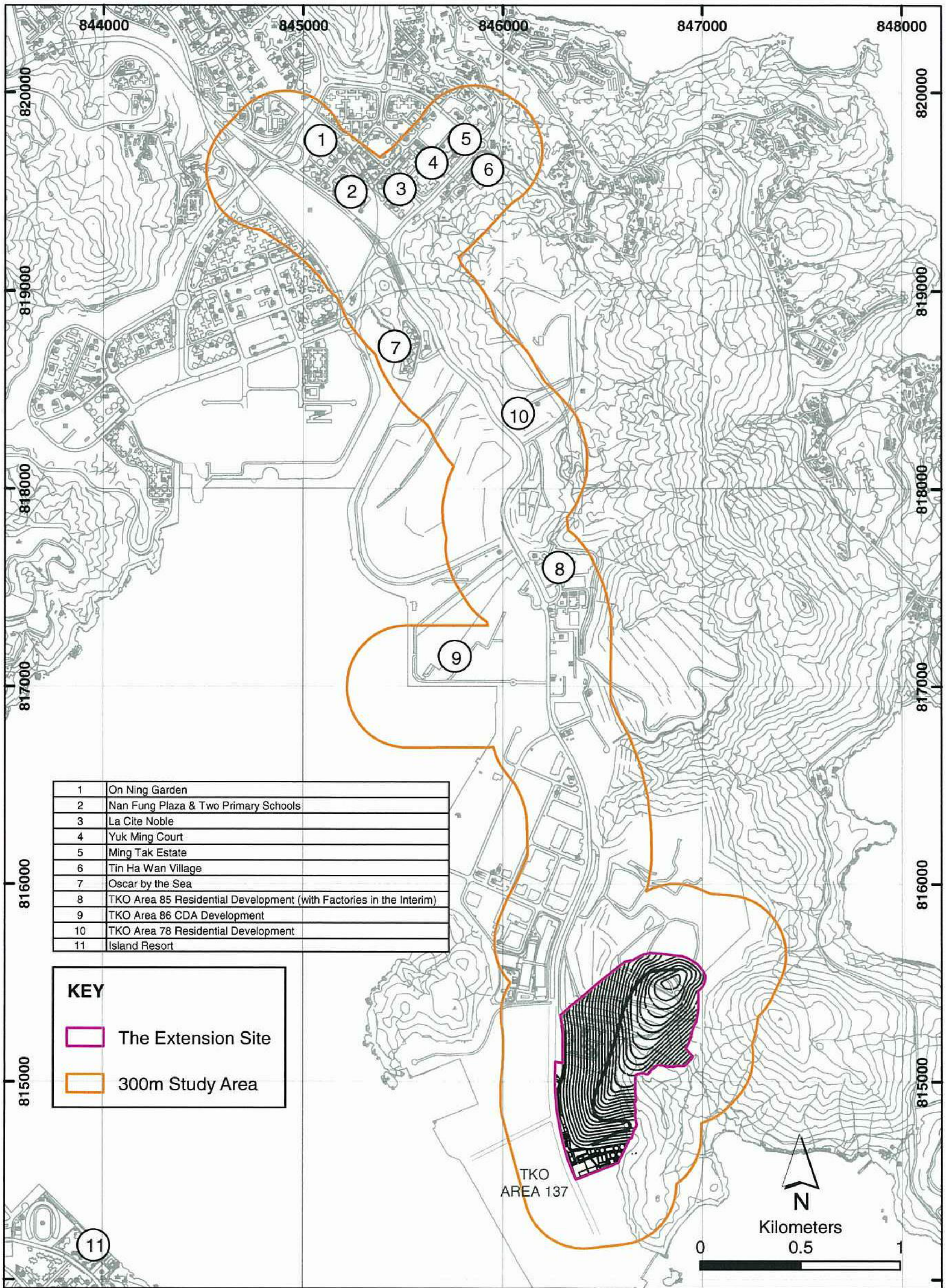

FIGURE 5.3a

The 300m Study Area for Noise Impact Assessment and Representative Noise Sensitive Receivers along Wan Po Road and Chiu Shun Road

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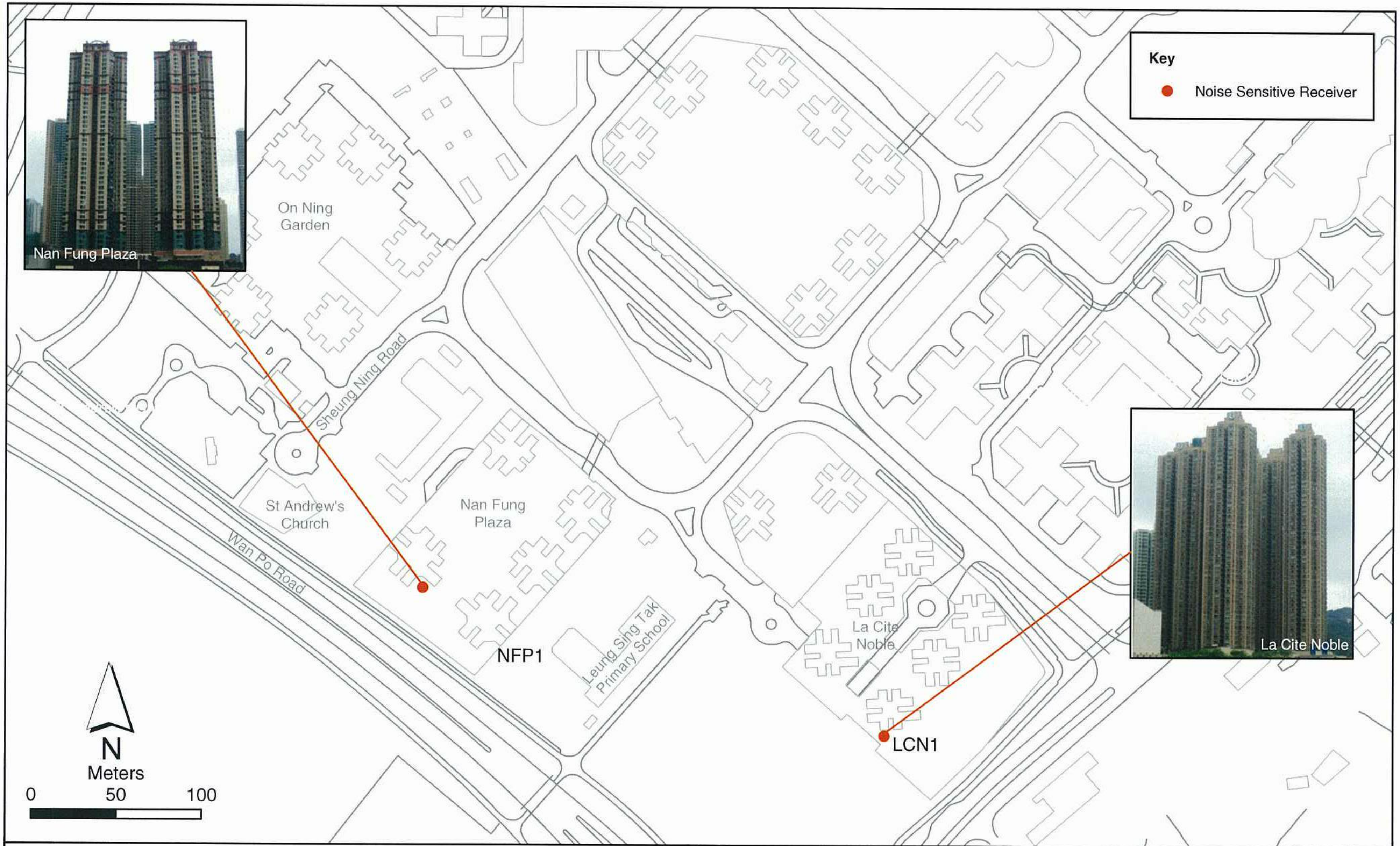

Figure 5.3b

Locations of the Noise Sensitive Receivers for Assessment (Page 1 of 4)

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Date: 07/12/2006

Environmental Resources Management

ERM

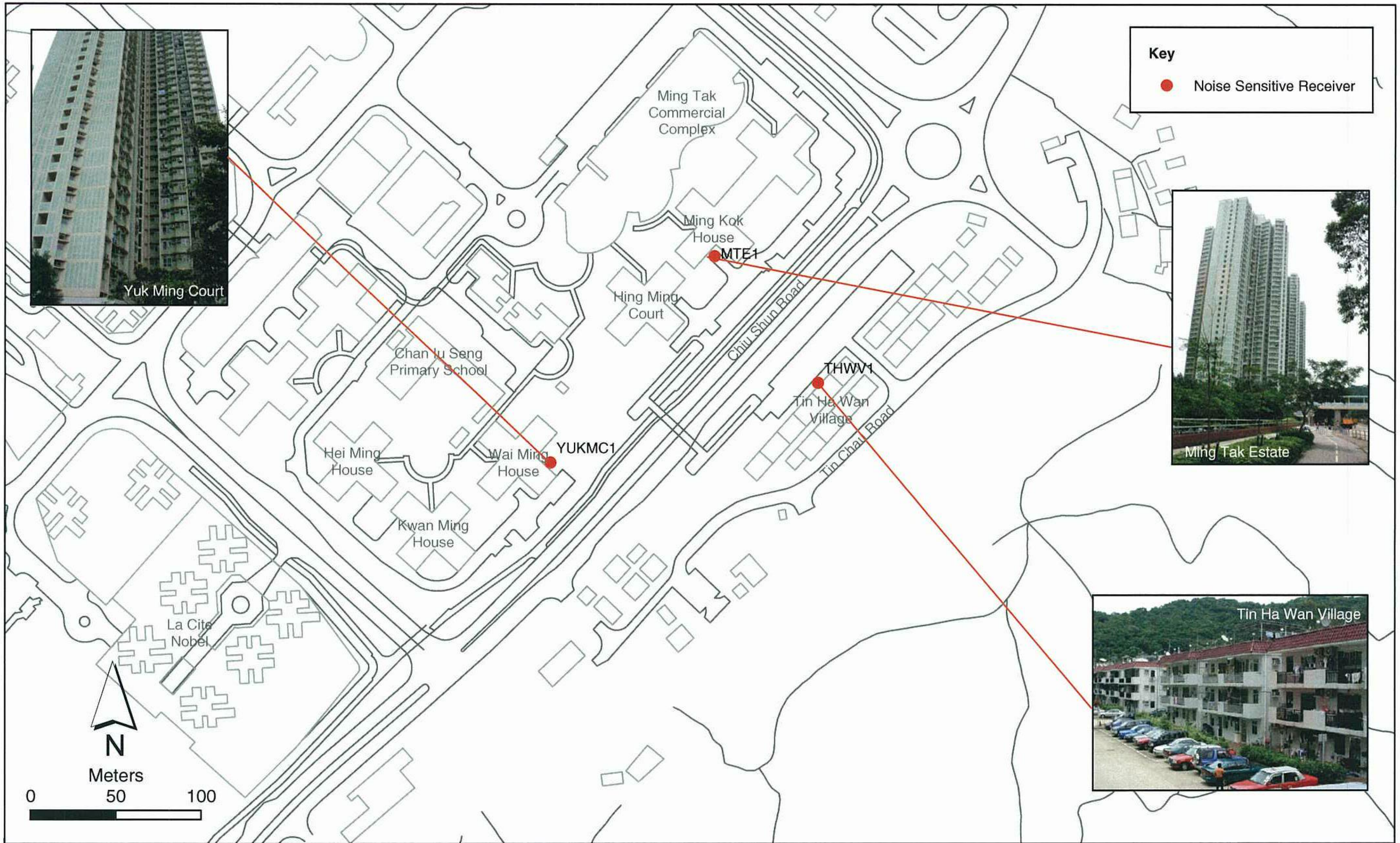

Figure 5.3c

Locations of the Noise Sensitive Receivers for Assessment (Page 2 of 4)

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Date: 25/06/2007

Environmental Resources Management

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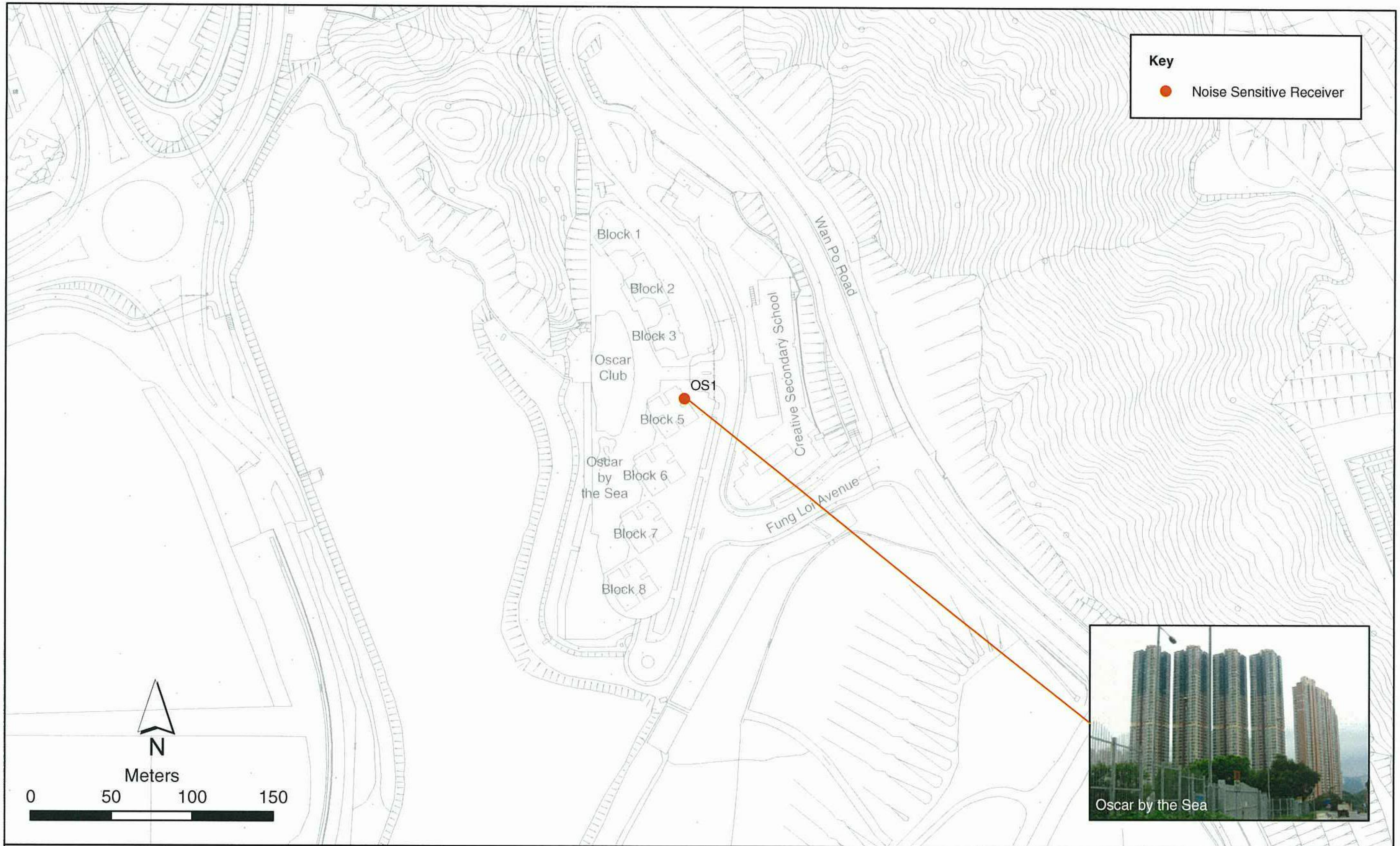

Figure 5.3d

Locations of the Noise Sensitive Receivers for Assessment (Page 3 of 4)

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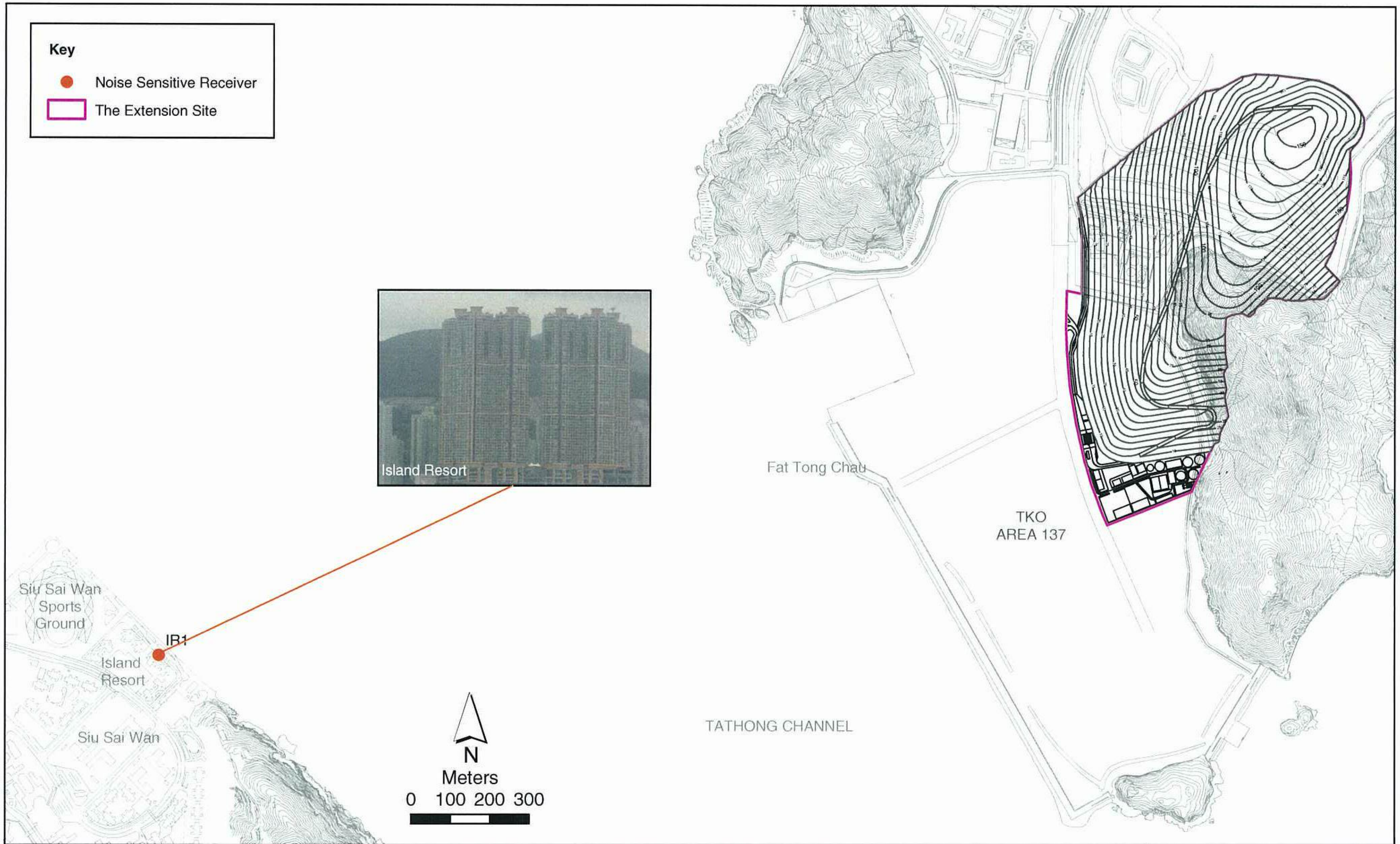

Figure 5.3e

Locations of the Noise Sensitive Receivers for Assessment (Page 4 of 4)

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Date: 28/09/2007

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Figure 5.3f

Locations of the Planned Noise Sensitive Receivers for Assessment

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Date: 22/11/2006

Environmental Resources Management

ERM

The representative NSRs located along Wan Po Road, and the separation distances between the representative NSRs and the Extension Site are listed in *Table 5.3a*. Potential construction noise impact, on-site operational noise and traffic noise impact generated by the operation of the Extension at the representative existing and planned NSRs were assessed according to the matrix in *Table 5.3a*.

Table 5.3a ***Representative Noise Sensitive Receivers Selected for Assessment***

NSR	**Location**	**Use**	**No. of Floors**	**Distance to the Extension Site (km) (Approx.)**	**Selected for Noise Impact Assessment**		
					Construction	**On-site Operational**	**Road Traffic**
NFP1	Nan Fung Plaza	Residential	39 – 43	4.0			✓
LCN1	La Cite Noble	Residential	44 – 47	3.9			✓
YUKMC1	Yuk Ming Court	Residential	38	4.1			✓
THWV1	Tin Ha Wan Village	Residential	3	4.0			✓
MTE1	Ming Tak Estate	Residential	38	4.0			✓
OS1	Oscar By the Sea	Residential	32 - 49	3.2			✓
IR1	Island Resort	Residential	50 - 51	2.4	✓	✓	
A86R1[(a)]	Planned Residential Development in Area 86	Residential	40 – 50	1.5	✓	✓	✓
A86R2[(a, b)]	Planned Residential Development in Area 86	Residential	40 – 50	1.7			✓

Notes:
(a) Under construction
(b) Only applicable to road traffic noise assessment with Cross Bay Link.

5.3.3 *Prevailing Noise Measurement*

To investigate the prevailing noise levels in the Extension Site, noise measurements were made from 23 to 24 August 2006 near the office of Green Valley Landfill Limited at the existing SENT Landfill. The noise measurements were conducted using a 01dB Sound Level Meter (Type 1), which had been calibrated using a SVAN Sound Level Calibrator Type 4231 with a calibration signal of 94.0 dB(A) at 1kHz. The measurements were conducted with reference to the calibration and measurement procedures stated in the *IND-TM*.

As the background noise in the Extension Site is generally low, especially during night-time, the prevailing noise measurement represents the quietest acoustic environment in the vicinity of the NSRs. Since the microphone was set in the free field measurement mode, a façade correction of 3dB(A) was applied to the noise measurement results. The measured prevailing background noise levels including façade correction were in the range of 60 – 75 dB(A) $L_{eq, 30min}$ and 55 – 64 dB(A) $L_{eq, 30min}$ during 13:00 to 20:00 hrs and 23:00 to 07:00 hrs, respectively.

5.4 POTENTIAL SOURCES OF IMPACT

5.4.1 *Construction/Restoration Phase*

The major activities associated with the construction phase will involve the use of PME and they are summarised as follows:

- *Foundation and building structure construction for the infrastructure area* – transportation of plant and equipment, excavation, installation of formwork and reinforcement, concreting, and construction of monitoring wells;
- *Demolition of existing structures at the infrastructure area* – concrete breaking and crushing;
- *Site formation and installation of liner* – site formation, installation of liner, provision of leachate and landfill gas collection system, construction of drainage channels and sumps, construction of drainage tunnel and road construction;
- *Construction activities associated with the construction/operation in the Extension* - construction of drainage channels and sumps, construction of drainage tunnel and road construction during each phase of the Extension;
- *Capping and Landscaping (progressive restoration)* – the use of excavator, bulldozer, dump truck, vibratory roller, loader and mobile crane; and
- *Construction of permanent gas wells – the use of drilling rig, mobile crane and small excavator.*

The construction noise assessment was undertaken based on the proposed construction works programme (see *Figure 3.4a*), phasing plans (see *Figure 3.6a* to *3.6k*) and plant inventory presented in *Annex B1*. The plant inventory was reviewed by the Design Engineer and was confirmed to be suitable for completing the Assignment within the scheduled timeframe.

The normal working hours of the Contractor will be between 07:00 and 19:00 hrs from Monday to Saturday (except public holidays). Construction activities during restricted hours are not expected. Should evening and night works between 19:00 and 07:00 hrs or on public holidays (including Sundays) be required, the Contractor will submit a CNP application which will be assessed by the Noise Control Authority.

5.4.2 *Operational Phase*

Landfilling Operation

The Extension will be operated from Year 2013 to Year 2018 and will involve deposition and compaction of waste, placement of intermediate cover, removal of intermediate cover, capping and landscaping. The Extension will be operated in six phases starting from the south and filling progressively to the north as shown in *Annexes B1* and *B4*. The major activities associated with the operational phase will involve the use of PME and they are summarised as follows:

- *Deposition and compaction of waste* – transportation and deposition of waste, and compaction; and
- *Placement and removal of daily and intermediate cover* – with the use of excavator, bulldozer, dump truck, vibratory roller and loader.

The landfill operates daily from 08:00 to 23:00 hrs. However, the placement of daily cover will be undertaken for about 25 minutes after 23:00 hrs. The noise levels due to the use of PME were predicted and compared with the day-time and night-time noise criteria as per the *EIAO-TM*.

Fixed Plant Operation

The Extension also involves the operation of a new leachate treatment plant (LTP) and a landfill gas treatment plant on-site. The new LTP and landfill gas treatment plant will be constructed at the new infrastructure area as shown in *Figure 5.3g*. The Design Engineer has confirmed that the type and power of the new LTP will be of a scale similar to that of the Bioplant at the existing SENT Landfill and similar building envelopes currently provided for the fixed equipment will also be provided for the LTP and landfill gas treatment plant at the new infrastructure (*Annex B4*). Additional number of equipment will not be required for the operation of the Extension.

Reference was made to the *GW-TM* for the sound power levels (SWLs) of the fixed plant items that were similar in nature to certain PME in the aforementioned *GW-TM*. Comparing with the sound data provided by the operator of the existing SENT Landfill for the equipment currently being used (*Annex B4*), the noise assessment based on the SWLs from the *GW-TM* would have represented the worst scenario as the sound data for the equipment currently being used is far lower than that from the *GW-TM*. Similarly, reference was made to the EIA Report for North East New Territories (NENT) Landfill Extension [1].

(1) EIA Report for North East New Territories (NENT) Landfill Extension (Register No.: AEIAR-111/2007).

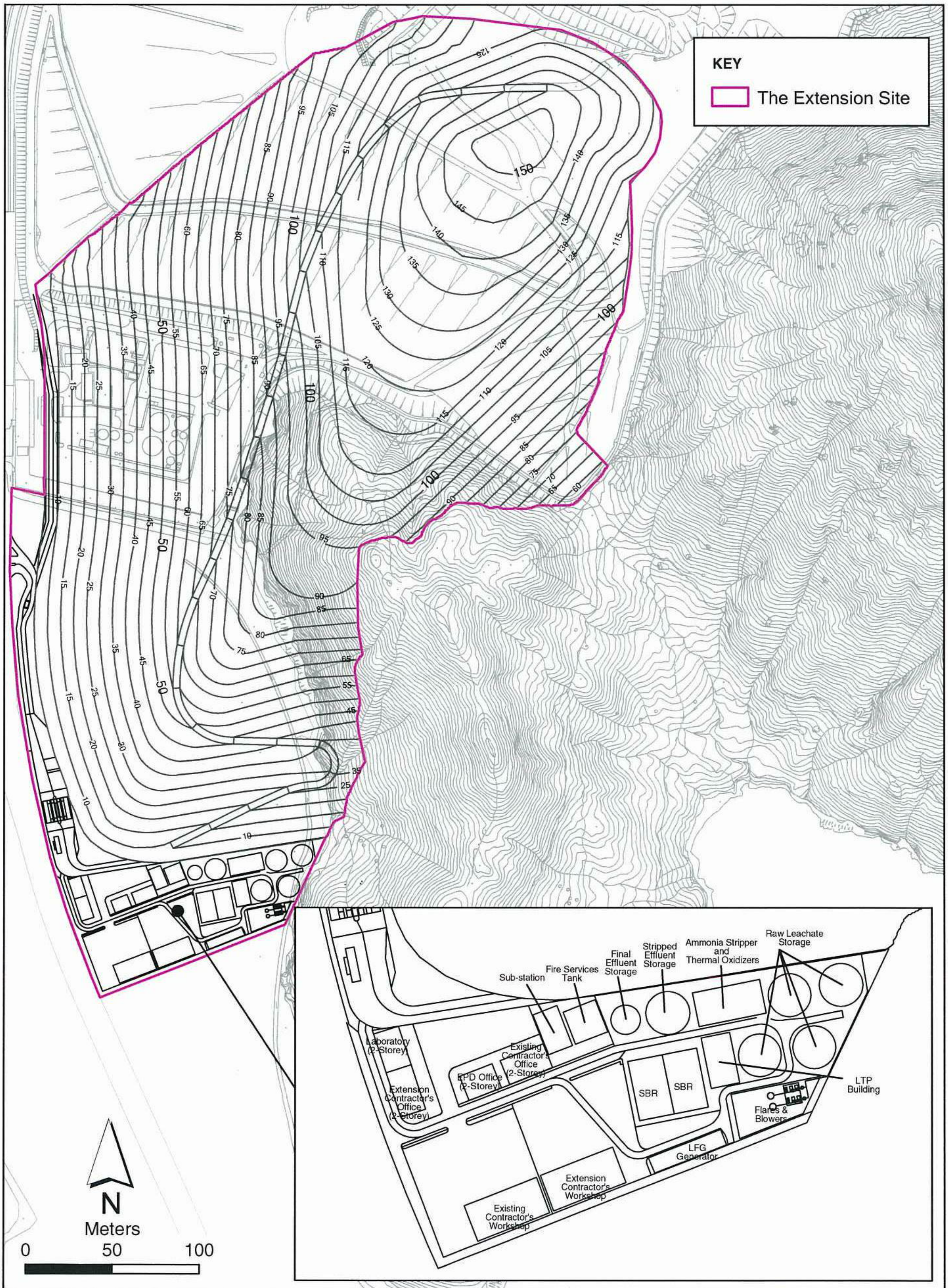

FIGURE 5.3g

Proposed Infrastructure Area of the Extension

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Environmental Resources Management

ERM

A survey was undertaken on 23 August 2006 to identify the major noise sources of the Bioplant and landfill gas treatment plant. The new LTP and landfill gas treatment plant will operate on a 24-hour basis.

Road Traffic Noise

The Extension peak operating hour (ie the hour with the maximum number of trucks associated with the operation of the Extension) is expected to be 14:00 to 15:00 hrs (SENT Peak) and 17:15 to 18:15 hrs (PM Peak) based on the traffic survey conducted for the operation of the existing SENT Landfill. There will not be any potential traffic noise impact during the night-time period as the landfill will be closed after 23:00 hrs.

According to the Civil Engineering and Development Department (CEDD), the Cross Bay Link (CBL) connecting Tiu Keng Leng and Wan O Road is currently scheduled for completion in Year 2016, ie before the anticipated date of completion and closure of the Extension.

To enable identification of the traffic noise contribution from the operation of the Extension and the prevailing situation, traffic noise impact assessment was undertaken for the scenarios shown in *Table 5.4b*.

Table 5.4b ***Scenarios of Traffic Noise Impact Assessment***

Peak Hour Scenario	Traffic Noise Impact Assessment Scenario	
2006 AM peak hour	With Existing SENT Landfill	Without Existing SENT Landfill
2006 PM peak hour	With Existing SENT Landfill	Without Existing SENT Landfill
2006 SENT peak hour	With Existing SENT Landfill	Without Existing SENT Landfill
Without Cross Bay Link		
2018 AM peak hour	With the Extension	Without the Extension
2018 PM peak hour	With the Extension	Without the Extension
2018 SENT peak hour	With the Extension	Without the Extension
With Cross Bay Link		
2018 AM peak hour	With the Extension	Without the Extension
2018 PM peak hour	With the Extension	Without the Extension
2018 SENT peak hour	With the Extension	Without the Extension

Traffic forecasts for each of the scenarios shown in *Table 5.4b* were prepared by the Traffic Consultant for the worst case representative assessments (*Annex B2*). The maximum estimated traffic flows in/out of the existing SENT Landfill during AM, PM and SENT peak hours for the "with existing SENT Landfill" scenarios for Year 2006 were 105/105, 110/110 and 110/110 vehicles, respectively[(1)]. The maximum hourly traffic forecast for the "with the Extension" scenarios in/out of the Extension during AM, PM and SENT peak hours for Year 2018 was 136/136, 143/143 and 143/143 vehicles [(1)], respectively. The traffic flows in/out of the Landfill Extension generated by the scenarios with and without CBL would be the same.

(1) Traffic flow estimated based on the number of vehicles required during peak hour for the quantity of waste estimated in the *Final Technical Note 1 - Waste Arisings Forecast*, August 2006.

The traffic forecast employed for this assessment has been submitted to the Transport Department (TD) and it was confirmed that TD had no comment on the data set.

5.4.3 *Aftercare Phase*

From the Year 2018 when the Extension is full, it will be restored. The Contractor will be responsible for the aftercare of the restored Extension for a period of 30 years. The aftercare of the restored Extension will involve limited construction works and is expected to have insignificant noise impact compared with the construction and operation/restoration of the Extension. The LTP and landfill gas treatment plant will continue to operate during the aftercare period.

The restored Extension (and together with the restored SENT Landfill) may be developed into various beneficial uses (eg as open space, education/ecological park, hiking track, or passive recreational uses (which are referred to as the afteruses) subject to future planning. It should be noted that the afteruse of the restored Extension did not form part of the Extension contract. The potential environmental impacts associated with the development and operation of the afteruse(s) will be subject to a separate EIA Study, where appropriate.

5.5 *ASSESSMENT METHODOLOGY*

5.5.1 *Construction/Restoration Phase*

The construction noise impact assessment was undertaken in accordance with the procedures outlined in the *GW-TM,* which is issued under the *NCO* and the *EIAO-TM.* The assessment methodology is summarised as follows:

- Locate representative NSRs that may be affected by the Extension;
- Determine the plant teams for corresponding activities, based on the agreed plant inventory;
- Assign sound power levels (SWLs) to the PME proposed based on the *GW-TM*, *British Standard BS 5228*[(1)] and list of SWLs of other commonly used PME[(2)];
- Calculate the correction factors based on the distance between the NSRs and the notional noise source position of the work sites;
- Apply corrections in the calculations, such as potential screening effects and acoustic reflection, if any; and
- Predict the construction noise levels at NSRs in the absence of any

(1) British Standard "Noise and Vibration Control on Construction and Open Sites – Part I", BS 5228: Part I

(2) "Sound power levels of other commonly used PME" prepared by the Noise Control Authority (http://www.epd.gov.hk/epd/english/application_for_licences/guidance/files/OtherSWLe.pdf)

mitigation measures.

The total SWL associated with each construction activity was established based on an assumed plant inventory. The notional source position was established in accordance with the procedures stated in the *GW-TM*. The potential noise impacts at NSRs were subsequently evaluated by comparing the predicted noise levels with the *EIAO-TM* day-time construction noise limits ($L_{eq,\,30min}$ dB(A)), as outlined in *Section 5.2.1*.

5.5.2 *Operational Phase*

The potential sources of noise impacts that may arise from the operation of the Extension include the use of PME for waste placement, operation of the LTP and landfill gas treatment plant and the noise impact due to the traffic generated by the Extension. The assessment methodologies employed for the on-site operational noise impact assessment are summarised below.

On-site Operational Noise

Noise impact assessment due to the on-site operation of the Extension was undertaken based on standard acoustic principles as per the requirements of the *EIAO-TM*. The assessment took into account typical SWLs for the plant items, including the EIA Report for North East New Territories (NENT) Landfill Extension (1), distance attenuation, topography attenuation and façade reflection. Based on the site survey conducted on 23 August 2006, it was indicated that except two small compressors placed outdoors, all noisy equipment was fully enclosed within the concrete building structures of two blower rooms and a landfill gas power plant room. Noise was emitted to the external environment through lourves or openings for exhaust fans only. The Design Engineer has confirmed that the type and power of the new LTP will be of a scale similar to that of the existing SENT Landfill and similar building envelopes currently provided for the fixed equipment will also be provided for the LTP and landfill gas treatment plant at the new infrastructure area.

The noise impact due to the waste filling and the operation of the LTP and the landfill gas treatment plant was assessed and compared with the noise criteria as outlined in *Section 5.2.2*.

Road Traffic Noise

The noise impact assessment due the truck movements at Wan Po Road and Chiu Shun Road during the peak hours, was based on the procedures given in *The Calculation of Road Traffic Noise* (*CRTN*) prepared by the *UK Department of Transport*. The assessment has been undertaken for the scenarios of with and without the existing SENT Landfill during AM, PM and SENT peak hours at the prevailing Year 2006 and with and without the Extension during AM, PM and SENT peak hours at the worst assessment Year 2018 (for both scenarios

(1) EIA Report for North East New Territories (NENT) Landfill Extension (Register No.: AEIAR-111/2007)

with and without Cross Bay Link). The traffic forecast provided by the Traffic Consultant is given in *Annex B2*.

In accordance with the Environmental Permit (EP-073/2000/D) issued by the EPD based on the Tseung Kwan O Development Contract F - Grade Separated Interchange T1/P1/P2, Environmental Impact Assessment (EIA) Study (Register No. AEIAR – 017/1999), an absorptive 5.5m inverted L-shaped barrier of about 175m length along the central divider and an absorptive 5.5m inverted L-shaped barrier of about 450m length alongside the southbound verge of Wan Po Road (referred as Road P1 in the above EP) near On Ning Garden and Nan Fung Plaza have been constructed. The noise barriers were taken into account in the traffic noise impact assessment.

Other existing noise mitigation measures, including a cantilevered noise barrier near the junction of Wan Po Road and Chiu Shun Road, and two sections of concrete noise barriers in front of Tin Ha Wan Village facing Chiu Shun Road, were also taken into account in the traffic noise impact assessment.

With reference to the EIA Report for Further Development of Tseung Kwan O – Feasibility Study (1), a 120 m long cantilevered barrier (5.5 m high vertical barrier with 3 m cantilever) located at the kerb of the eastbound carriageway, three sections of 100 m, 200 m and 168m long cantilevered barriers (5.5 m high vertical barriers with 5m, 4.5m and 5m cantilevers) located at the central divider, have been proposed for CBL to protect the NSRs at Area 86. The above-mentioned noise barriers have been included in the traffic noise impact assessment for the scenarios with CBL.

Information on low noise surfacing for the roads within the Study Area has been reviewed. Low noise surfacing has been included in the traffic noise impact assessment for the roads, including sections of Wan Po Road between Po Shun Road and Chiu Shun Road, Chiu Shun Road and Pak Shing Kok, and between Road D10 and Wan O Road, and Chiu Shun Road between Ngan O Road and Po Ning Road.

The predicted noise levels due to the traffic generated on Wan Po Road and Chiu Shun Road were evaluated by comparing with the *EIAO-TM* traffic noise limits ($L_{10, 1hr}$ dB(A)), as outlined in *Section 5.2.2*.

5.6 *EVALUATION OF IMPACTS*

5.6.1 *Construction/Restoration Phase*

As the representative NSRs are located at more than 1.6km away from the Notional Source Position, the predicted noise levels at the representative NSRs would comply with the stipulated construction noise criteria. A summary of

(1) EIA Report for Further Development of Tseung Kwan O – Feasibility Study (Register No.: AEIAR-092/2005).

the predicted construction noise levels is presented in *Table 5.6a*. Details of the noise calculations are presented in *Annex B3*.

Table 5.6a ***Predicted Construction Noise Levels at Representative NSRs***

NSR	Description	Approx. Horizontal Distance to Notional Source Position[(a)] (km)	Predicted Construction Noise Levels[(b)], $L_{eq, 30 min}$ dB(A)
A86R1	Planned Residential Development in Area 86	1.6	41 - 59
IR1	Island Resort	2.6	37 - 55

Notes:

(a) According to the GW-TM, notional source position refers to the position mid-way between the approximate geographical centre of the construction site and its boundary nearest to the NSR.

(b) All predicted noise levels were corrected with 3dB(A) for façade reflection.

(c) Assessment criterion for construction noise impact is 75 dB(A) for domestic premises.

The predicted construction noise levels at the representative NSRs are well below the noise criteria, the NSRs will not be adversely affected by the construction of the Extension.

5.6.2 Operational Phase

On-site Operational Noise

The noise levels due to the operation of the landfilling works, new LTP and the landfill gas treatment plant at the representative NSRs were predicted and are summarised in *Table 5.6b*. The predicted noise levels are well within both the stipulated day-time and night-time (ANL-5) noise criteria. Details of the noise calculations are presented in *Annex B5*.

Table 5.6b ***Predicted Operational Noise Levels at Representative NSRs***

NSR	Description	Predicted Facade Noise Level[(a)], $L_{eq, 30 min}$ dB(A)	
		Day-time (07:00 – 23:00hrs)	Night-time (23:00 – 07:00hrs)
A86R1	Planned Residential Development in Area 86	41 – 53	33 - 47
IR1	Island Resort	44 - 50	43 - 46

Notes:

(a) All predicted noise levels were corrected with 3dB(A) for façade reflection..

(b) According to *EIAO-TM*, day-time and night-time (ANL-5) noise criteria are 60 dB(A) and 50 dB(A), respectively.

As NSR A86R1 will be screened from the LTP and landfill gas treatment plant by the buildings in Tseung Kwan O Industrial Estate and the existing topography near the SENT Landfill, a 10dB(A) attenuation was included in the assessment.

The noise assessment for landfilling and fixed plant operation did not account for the atmospheric absorption and the realistic utilisation rates of the PME (ie not operating for 100% of the time). Screening by building envelopes and attenuation by acoustic treatment for the fixed plant items were not included in the assessment. The Design Engineer has confirmed that building envelopes and acoustic treatment similar to the existing SENT Landfill will be provided for the new equipment. Therefore, the noise levels at the NSRs in real situation will be less than the predicted noise levels presented in *Table 5.6b*.

Road Traffic Noise

The predicted façade noise levels at the representative NSRs for the Years 2006 and 2018 (with and without CBL in operation) are presented in Annex B6. The noise levels are predicted for the purpose of assessing the road traffic noise impact due to the Extension, and therefore, the predicted noise levels are for indicative uses only. Detailed road traffic noise impact assessments should be referred to corresponding EIA Reports or Planning Submissions for individual developments.

Results indicate that the predicted façade noise levels complied the stipulated noise limit of 70dB(A) for domestic premises at all NSR locations, except A86R1. This exceedance would mainly be due to the background traffic at Wan Po Road, as indicated by the predictions for the scenario of "without the Extension" for Year 2018. It was noted that A86R1 is a planned NSR. Planned noise mitigation measures at the NSR, if any, eg fins, window insulation, etc, were not included in this assessment. The noise levels predicted for A86R1 are indicative only for the purpose of estimating the noise contributions due to the Extension.

The noise contributions due to the traffic generated by the Extension were predicted to be less than 0.4dB(A). In view of the fact that the noise contributions due to the Extension are less than 1.0dB(A) for Year 2018 with and without CBL in operation, the traffic noise impact is considered insignificant. Detailed results of the road traffic noise impact assessment are given in *Annex B6*. The computer road plots and input files of the model are provided in *Annexes B7* and *B8*, respectively.

5.7 MITIGATION MEASURES

5.7.1 Construction /Restoration Phase

While adverse noise impact is not expected during the construction/restoration phase of the Extension, good site practices should be implemented by the Contractor to minimise the construction noise impact. The site practices listed below should be adopted during the construction phase:

- Only well-maintained plant should be operated on-site and plant should be serviced regularly during the construction program;

- Silencers or mufflers on construction equipment should be utilized and should be properly maintained during the construction program;

- Mobile plant, if any, should be sited as far from NSRs as possible;

- Machines and plant (such as trucks) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum;

- Plant known to emit noise strongly in one direction should, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and

- Material stockpiles and other structures should be effectively utilised, wherever practicable, in screening noise from on-site construction activities.

5.7.2 *Operational Phase*

While no adverse noise impact is expected during the operational phase of the Extension, it is still recommended that the following measures be implemented as far as practicable:

- Choose quieter PME;

- Include noise levels specification when ordering new plant items;

- Locate fixed plant items or noise emission points away from the NSRs as far as practicable;

- Locate noisy machines in completely enclosed plant rooms or buildings; and

- Develop and implement a regularly scheduled plant maintenance programme so that plant items are properly operated and serviced. The programme should be implemented by properly trained personnel.

5.8 *ENVIRONMENTAL MONITORING AND AUDIT*

Notwithstanding the prediction that the NSRs will not be subject to adverse noise impact during the construction and operational phases, noise monitoring is recommended to be carried out during the construction, operational and restoration stages of the Extension to ensure noise compliance. In addition, site audits are recommended to be undertaken regularly during the construction, operation/restoration and aftercare phases to ensure that appropriate environmental protection and pollution control mitigation measures are properly implemented. Details of the EM&A requirements are provided in *Section 11* and the *EM&A Manual*.

5.9 *Conclusions*

No adverse noise impacts are anticipated at the representative NSRs during the construction, operational, restoration and aftercare phases due to the Extension because of the large horizontal separation. To further minimise the noise impacts, good site practices and noise reduction measures are recommended during the construction and operational/restoration phases of the Extension.

6 WATER QUALITY ASSESSMENT

6.1 INTRODUCTION

The construction, operation, restoration and aftercare of the Extension have the potential to cause adverse water quality impacts if not properly managed. This section examines the potential impacts on the nearby water resources due to discharge of construction runoff into the watercourses and marine waters, the potential discharge of leachate into the surface and groundwater systems. The impacts are evaluated through a review of the surface water and leachate management systems for the Extension.

6.2 LEGISLATION AND STANDARDS

The regulatory requirements and standards to protect water quality are as follows:

- *Water Pollution Control Ordinance (WPCO) (Cap. 358);*
- *Environmental Impact Assessment Ordinance (Cap. 499. S.16), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annexes 6* and *14*;
- *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Inshore Waters (TM)*;
- *Practice Note for Professional Persons on Construction Site Drainage (Prop PECC PN 1/94)*; and,
- *Hong Kong Planning Standards and Guidelines (HKPSG).*

6.2.1 Water Pollution Control Ordinance (WPCO)

The *WPCO* is the legislation for the control of water pollution and water quality in Hong Kong. Under the *WPCO,* Hong Kong waters are divided into 10 Water Control Zones (WCZs). Each WCZ has a designated set of statutory Water Quality Objectives (WQOs). The WQOs set limits for different parameters that should be achieved in order to maintain the water quality within the WCZs. Corresponding statements of WQO are stipulated for different water regimes, i.e. marine waters, inland waters, bathing beaches subzones, secondary contact recreation subzones and fish culture subzones, in the WCZ based on their beneficial uses.

The assessment area (thereafter referred to as the Study Area) is defined in the *EIA Study Brief* (No. ESB-119/2004) as all areas within 500m from the boundary of the Extension Site (see *Figure 6.2a*). In accordance with the *WPCO*, the Study Area is located inside the Junk Bay WCZ and is in close proximity to the Eastern Buffer WCZ.

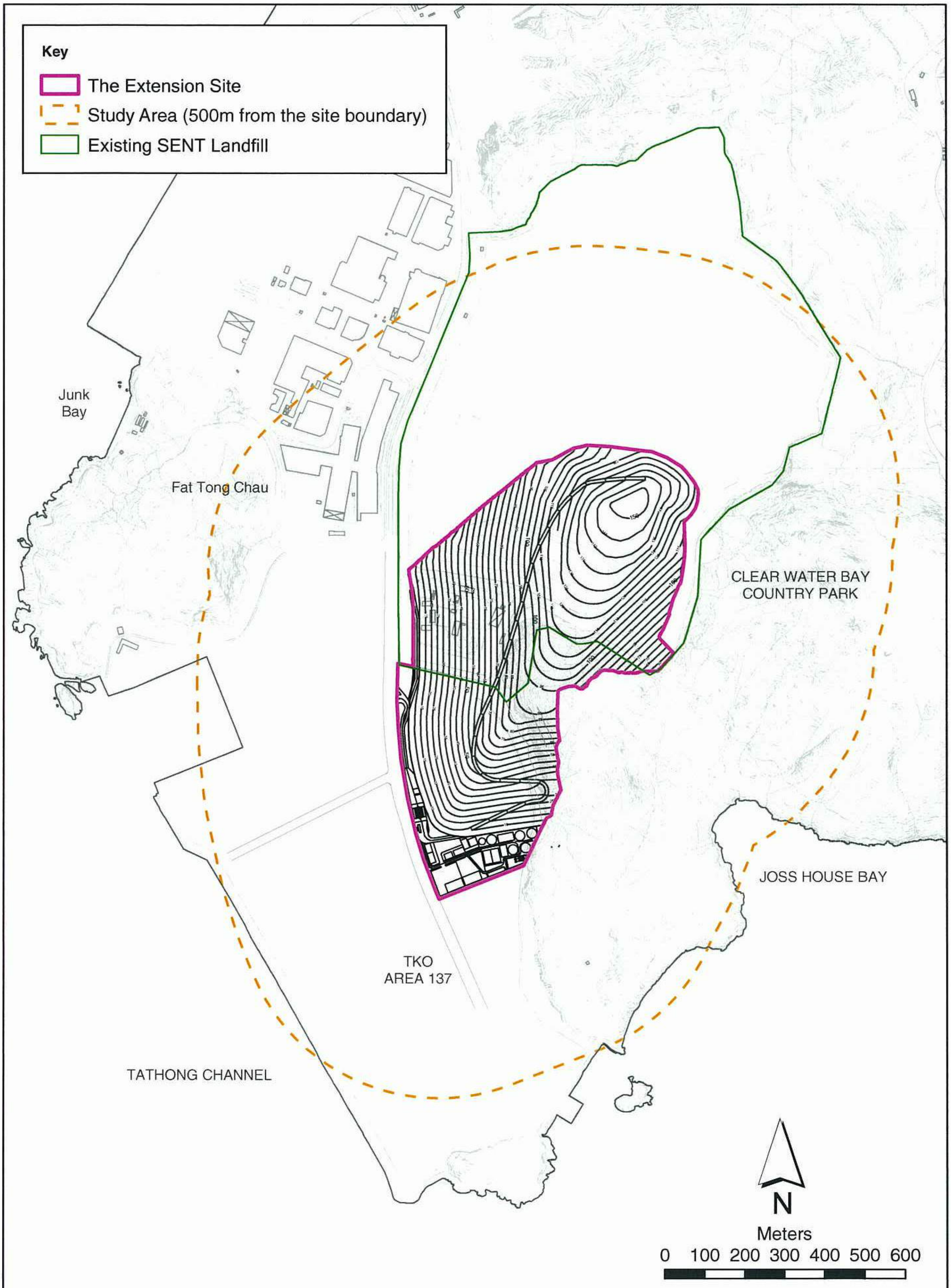

FIGURE 6.2a

Assessment Area for the Water Quality Impact Assessment

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The WQOs for the Junk Bay WCZ and Eastern Buffer WCZ, which are presented in *Tables 6.2a* and *6.2b*, respectively, are applicable as evaluation criteria for assessing compliance of any effects from the discharges of the Project.

Table 6.2a Water Quality Objectives for Junk Bay Water Control Zone

Water Quality Objectives		**Junk Bay WCZ**
A.	AESTHETIC APPEARANCE	
(a)	Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole Zone
(b)	Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substance should be absent.	Whole Zone
(c)	Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole Zone
(d)	There should be no recognisable sewage-derived debris.	Whole Zone
(e)	Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole Zone
(f)	Waste discharges shall not cause the water to Whole Zone contain substances which settle to form objectionable deposits.	Whole Zone
B.	BACTERIA	
(a)	The level of Escherichia coli should not exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in one calendar year.	Secondary Contact Recreation Subzones and Fish Culture Subzones (L.N. 451 of 1991)
(b)	(Repealed L.N. 451 of 1991)	-
(c)	The level of Escherichia coli should not exceed 1000 per 100 ml, calculated as the running median of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Inland waters
C.	COLOUR	
Waste discharges shall not cause the colour of water to exceed 50 Hazen units.		Inland waters
D.	DISSOLVED OXYGEN	
(a)	Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg L^{-1} for 90% of the sampling occasions during the year; values should be calculated as the water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 mg L^{-1} within 2 m of the seabed for 90% of the sampling occasions during the year.	Marine waters excepting Fish Culture Subzones
(b)	The dissolved oxygen level should not be less than 5 mg L^{-1} for 90% of the sampling occasions during the year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed). In addition, the concentration of dissolved oxygen should not be less	Fish Culture Subzones

Water Quality Objectives	Junk Bay WCZ
than 2 mg L^{-1} within 2 m of the seabed for 90% of the sampling occasions during the year.	
(c) Waste discharges shall not cause the level of dissolved oxygen to be less than 4 mg L^{-1}.	Inland waters
E. pH	
(a) The pH of the water should be within the range of 6.5-8.5 units. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.2 units.	Marine waters (L.N. 451 of 1991)
(b) (Repealed L.N. 451 of 1991)	-
(c) The pH of the water should be within the range of 6.0-9.0 units.	Inland waters
F. TEMPERATURE	
Waste discharges shall not cause the natural daily temperature range to change by more than 2.0°C.	Whole Zone
G. SALINITY	
Waste discharges shall not cause the natural ambient salinity level to change by more than 10%.	Whole Zone
H. SUSPENDED SOLIDS	
(a) Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters
(b) Waste discharges shall not cause the annual median of suspended solids to exceed 25 mg L^{-1}.	Inland waters
I. AMMONIA	
The ammonia nitrogen level should not be more than 0.021 mg L^{-1}, calculated as the annual average (arithmetic mean), as unionized form.	Whole Zone
J. NUTRIENTS	
(a) Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Marine waters
(b) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 mg L^{-1}, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed).	Marine waters
K. 5-DAY BIOCHEMICAL OXYGEN DEMAND	
Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 mg L^{-1}.	Inland waters
L. CHEMICAL OXYGEN DEMAND	
Waste discharges shall not cause the chemical oxygen demand to exceed 30 mg L^{-1}.	Inland waters
M. DANGEROUS SUBSTANCES	
(a) Waste discharges shall not cause the concentrations of dangerous substances in the water to attain such levels	Whole Zone

Water Quality Objectives		Junk Bay WCZ
	as to produce significant toxic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to toxicant interactions with each other.	
(b)	Waste discharges of dangerous substances shall not put a risk to any beneficial uses of the aquatic environment.	Whole Zone
N-O (Repealed L.N. 451 of 1991)		Whole Zone

Table 6.2b *Water Quality Objectives for Eastern Buffer Water Control Zone*

Water Quality Objectives		Eastern Buffer WCZ
A.	AESTHETIC APPEARANCE	
(a)	There should be no objectionable odours or discolouration of the water.	Whole Zone
(b)	Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole Zone
(c)	Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole Zone
(d)	There should be no recognisable sewage-derived debris.	Whole Zone
(e)	Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole Zone
(f)	The water should not contain substances which settle to form objectionable deposits.	Whole Zone
B.	BACTERIA	
(a)	The level of Escherichia coli should not exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in a calendar year.	Fish Culture Subzones
(b)	The level of Escherichia coli should be less than 1 per 100 mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Water Gathering Ground Subzones
(c)	The level of Escherichia coli should not exceed 1000 per 100 mL, calculated as the geometric mean of the most recent 5 consecutive samples taken at intervals of between 7 and 21 days.	Other inland waters
C.	COLOUR	
(a)	Human activity should not cause the colour of water to exceed 30 Hazen units.	Water Gathering Ground Subzones
(b)	Human activity should not cause the colour of water to exceed 50 Hazen units.	Other inland waters

Water Quality Objectives		Eastern Buffer WCZ
D.	DISSOLVED OXYGEN	
(a)	The level of dissolved oxygen should not fall below 4 mg L^{-1} for 90% of the sampling occasions during the whole year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 mg L^{-1} within 2 m of the seabed for 90% of the sampling occasions during the whole year.	Marine waters excepting Fish Culture Subzones
(b)	The level of dissolved oxygen should not be less than 5 mg L^{-1} for 90% of the sampling occasions during the year; values should be calculated as water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed). In addition, the concentration of dissolved oxygen should not be less than 2 mg L^{-1} within 2 m of the seabed for 90% of the sampling occasions during the whole year.	Fish Culture Subzones
(c)	The level of dissolved oxygen should not be less than 4 mg L^{-1}.	Water Gathering Ground Subzones and other inland waters
E.	pH	
(a)	The pH of the water should be within the range of 6.5-8.5 units. In addition, human activity should not cause the natural pH range to be extended by more than 0.2 units.	Marine waters
(b)	Human activity should not cause the pH of the water to exceed the range of 6.5-8.5 units.	Water Gathering Ground Subzones
(c)	Human activity should not cause the pH of the water to exceed the range of 6.0-9.0 units.	Other inland waters
F.	TEMPERATURE	
Human activity should not cause the natural daily temperature range to change by more than 2.0°C.		Whole Zone
G.	SALINITY	
Human activity should not cause the natural ambient salinity level to change by more than 10%.		Whole Zone
H.	SUSPENDED SOLIDS	
(a)	Human activity should neither cause the natural ambient level to be raise by more than 30 % nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters
(b)	Human activity should not cause the annual median of suspended solids to exceed 20 mg L^{-1}.	Water Gathering Ground Subzones
(c)	Human activity should not cause the annual median of suspended solids to exceed 25 mg L^{-1}.	Other inland waters
I.	AMMONIA	
	The un-ionized ammoniacal nitrogen level should not be more than 0.021 mg L^{-1}, calculated as the annual average (arithmetic mean).	Whole Zone

Water Quality Objectives	Eastern Buffer WCZ
J. NUTRIENTS	
(a) Nutrients should not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Marine waters
(b) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.4 mg L^{-1}, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1 m below surface, mid-depth and 1 m above seabed).	Marine waters
K. 5-DAY BIOCHEMICAL OXYGEN DEMAND	
(a) The 5-day biochemical oxygen demand should not exceed 3 mg L^{-1}.	Water Gathering Ground Subzones
(b) The 5-day biochemical oxygen demand should not exceed 5 mg L^{-1}.	Other inland waters
L. CHEMICAL OXYGEN DEMAND	
(a) The chemical oxygen demand should not exceed 15 mg L^{-1}.	Water Gathering Ground Subzones
(b) The chemical oxygen demand should not exceed 30 mg per litre.	Other inland waters
M. TOXIC SUBSTANCES	
(a) Toxic substances in the water should not attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms with due regard to biologically cumulative effects in food chains and to interactions of toxic substances with each other.	Whole Zone
(b) Human activity should not cause a risk to any beneficial use of the aquatic environment.	Whole Zone

6.2.2 *Technical Memorandum for Effluent Discharges into Drainage and Sewerage Systems, Inland and Inshore Waters (TM)*

All discharges from the Project are required to comply with the *Technical Memorandum for Effluents Discharged into Drainage and Sewerage Systems, Inland and Inshore Waters* (TM) issued under Section 21 of the *WPCO*. The *TM* defines discharge limits for different types of receiving waters. Under the *TM*, effluents discharged into the drainage and sewerage systems, inshore and inshore waters of the WCZs are subject to pollutant concentration standards for particular discharge volumes. Any new discharges within a WCZ are subject to licence conditions and the *TM* acts as a guideline for setting discharge standards for inclusion in the licence. Any sewage from the proposed construction and operational activities should comply with the standards for effluent discharged into the foul sewers, inshore waters or marine waters of the Junk Bay and Eastern Buffer WCZs, shown in Tables 1, 10a and 10b of the *TM*, respectively.

Currently, the treated effluent from the existing leachate treatment plant of the existing SENT Landfill (thereafter referred to as the Bioplant) is discharged to the Tseung Kwan O Sewage Treatment Works (TKO STW). The quantity and composition of any effluent discharged from the landfill shall not exceed any of the regulatory limits as stipulated in the existing discharge license.

6.2.3 *Environmental Impact Assessment Ordinance (Cap. 499. S.16), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM)*

Annexes 6 and *14* of the *Environmental Impact Assessment Ordinance (Cap. 499. S.16), Technical Memorandum on Environmental Impact Assessment Process* (*EIAO-TM*) provide general guidelines and criteria to be used in assessing water quality issues.

6.2.4 *Practice Note for Professional Persons on Construction Site Drainage (ProPECC PN 1/94)*

The *ProPECC PN 1/94* issued by the EPD provides some basic environmental guidelines for the handling and disposal of construction site discharges to prevent or minimise construction impacts on water quality.

Whilst the technical circulars are non-statutory, they are generally accepted as best guidelines in Hong Kong and have been adopted as relevant for this assessment.

6.2.5 *Hong Kong Planning Standards and Guidelines (HKPSG)*

Chapter 9 of the *Hong Kong Planning Standards and Guidelines* (*HKPSG*) provides guidance for including environmental considerations in the planning of both public and private developments. It applies both to the planning of permanent or temporary uses which will have potential to cause significant changes to the biophysical environment or which are sensitive to environmental impacts. *Section 5* in *Chapter 9* of the *HKPSG* provides additional information on regulatory guidelines against water pollution for sensitive uses such as aquaculture and fisheries zones, bathing waters and other contact recreational waters.

6.3 ASSESSMENT METHODOLOGY

The construction method and sequence described in *Section 3* were reviewed to assess the remoteness of the construction works from existing and committed Water Sensitive Receivers (WSRs). The WSRs were identified according to guidance provided in the *EIAO-TM* and *HKPSG.*

The design of the Extension, construction sequence, duration and activities, and the operation, restoration and aftercare activities were reviewed to identify activities with the potential to impact upon identified WSRs and other water courses.

Following the identification of WSRs and potential water quality impacts, the scale, extent and severity of potential net (ie unmitigated) construction, operation/restoration and aftercare impacts were evaluated, taking into account all potential cumulative effects including those of adjacent projects, with reference to the *WPCO* criteria.

Where net water quality impacts exceed the appropriate *WPCO* criteria, practical water pollution control measures/mitigation proposals were identified to ensure compliance with reference to the *WPCO* criteria. Water quality monitoring and audit requirements were developed, if necessary, to ensure the effectiveness of the water pollution control and mitigation measures.

6.4 *WATER QUALITY SENSITIVE RECEIVERS AND BASELINE CONDITIONS*

6.4.1 *Existing Conditions*

The south-western part of the Extension Site will be located on formed land at TKO Area 137 (see *Figure 6.4a*). It is currently occupied by a temporary fill bank, where the stormwater drainage channels have been well established. The potential water quality impacts arising from decommissioning the fill bank has been assessed under the EIA for the Fill Bank (1) which concluded that no unacceptable residual water quality impacts were expected during the decommissioning period.

The northern part of the Extension Site will be piggybacked onto the southern slopes of the existing SENT Landfill and the infrastructure area which includes the site office, the Bioplant and the landfill gas treatment plant (see *Figure 6.4a*). These facilities will be demolished after those for the Extension have been constructed and commissioned (2).

The eastern part of the Extension will occupy a small part of the Clear Water Bay Country Park (CWBCP) (see *Figure 6.4a*).

Two seasonal streams, namely S1 and S2, were recorded within the Study Area. As shown in *Figure 6.4a*, S1 and S2 are located at Ha Shan Tuk and Hin Ha Au respectively. They are small in size, S1 and S2 are approximately 56 m and 98 m in length respectively. Both of them are classified as seasonal streams because they were found to have limited water flows during the wet season and no water flows during the dry season. Photographic records of the streams are illustrated in *Figure 9.7d* in *Section 9 – Ecology Impact Assessment* and it is concluded in *Section 9* that the ecological significance of these two seasonal streams is considered to be low.

6.4.2 *Existing Landfill Liner System*

The existing SENT Landfill has been designed and constructed, as a secure containment facility incorporating a leachate containment system and a leachate collection system covering the entire waste boundary of the landfill. As the site is lined, leachate within the landfill is collected and treated to ensure that there will be no off-site migration of leachate from the landfill to the environment. The leachate containment and collection system comprises,

(1) CH2M Hill (China) Ltd (2002). Environmental Impact Assessment for the Proposed Fill Bank at Tseung Kwan O Area 137. For Civil Engineering Department. Final EIA Report.

(2) The facilities for the existing SENT Landfill will be re-provided either as new separate facilities or a combined facilities with those of the Extension at the new infrastructure area.

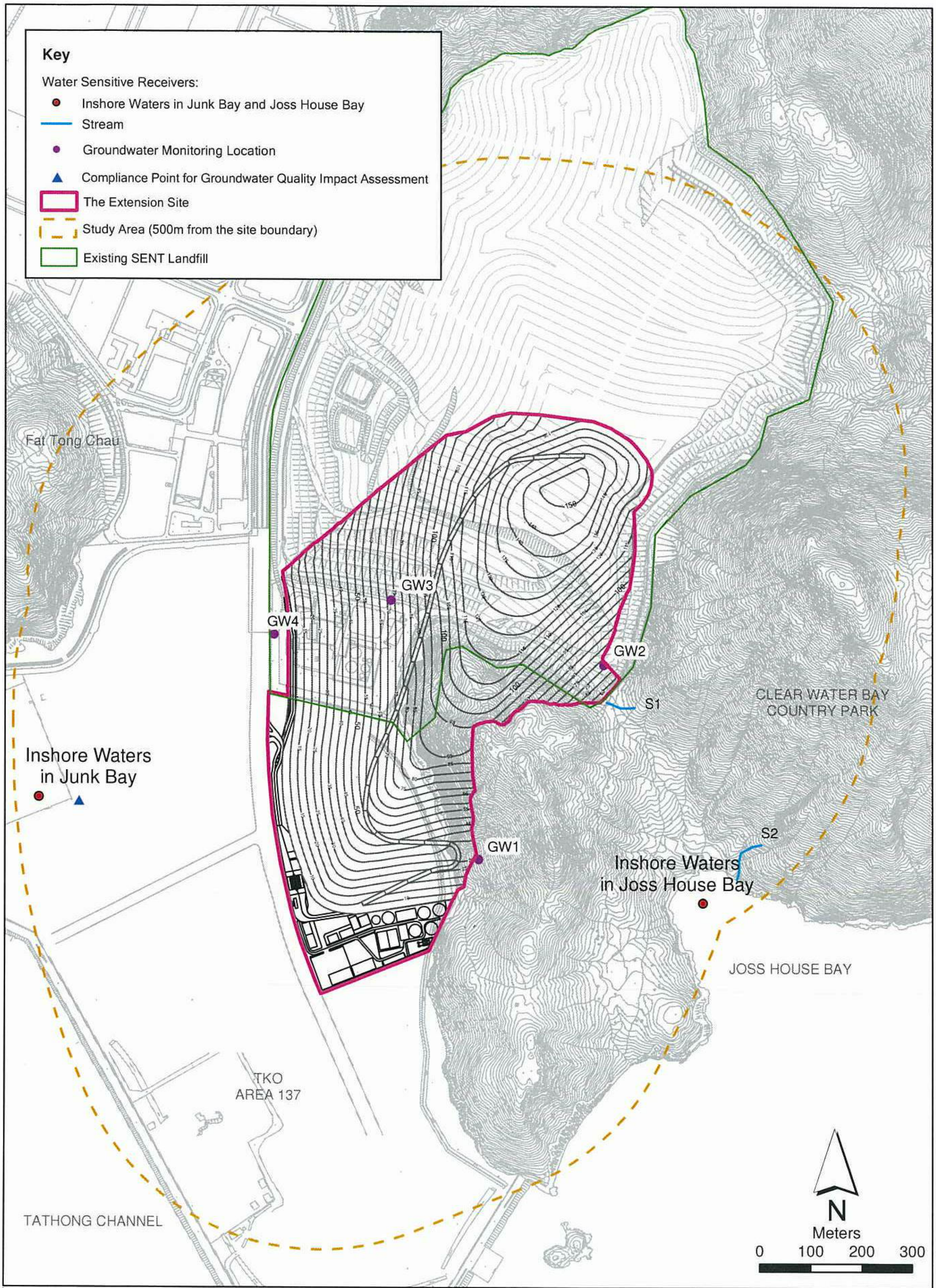

FIGURE 6.4a

Identified Water Sensitive Receivers and Groundwater Monitoring Location

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from the bottom to the top, a layer of geocomposite groundwater drainage layer, a 1.5 mm of textured High Density Polyethylene (HDPE) Secondary liner, a 6 mm of geocomposite clay liner (GCL), a 2 mm of textured HDPE primary liner, a layer of non-woven geotextile cushion, a 200 mm granular leachate drainage layer, and a layer of woven geotextile filter.

6.4.3 Existing Leachate/Wastewater Treatment Facilities

At present, the leachate/wastewater generated from the SENT Landfill is collected and delivered to the Bioplant for treatment prior to discharge to a sewer connecting to the TKO STW. Landfill leachate is the predominant load whereas wastewater from the administrative office as well as laboratory and maintenance building is also collected and treated at the Bioplant. The Bioplant comprises an equalization tank, a metals precipitation system, a leachate heater and heat exchanger, an ammonia stripping system, a pH adjustment system, a sequencing batch reactor (SBR) and sludge handling system. Wastewater is pumped into the Bioplant and stored in the equalization tank. The pH of the effluent from the equalization tank is elevated by adding lime slurry in order to precipitate out heavy metals. After gravity clarification and filtration, the wastewater is heated and sprayed through the ammonia strippers. In the ammonia strippers, hot air is blown through and it separates the ammonia from the wastewater. The thermal catalytic unit will completely oxidise the off-gas that contains ammonia. The pH of the wastewater is then adjusted and consequently pumped to the SBR to remove the remaining organic pollutants and ammonia. The treated effluent is stored in an effluent holding tank and then discharged to the sewer at a rate not exceeding 210 $m^3 hr^{-1}$.

6.4.4 Water Sensitive Receivers (WSRs)

In order to evaluate the water quality impacts resulting from the construction and operation/restoration and aftercare of the Extension, the WSRs have been identified in accordance with the *EIAO-TM* and *HKPSG*.

The WSRs in the Study Area are identified and presented below:

- Inshore waters in Junk Bay and Joss House Bay;
- Clear Water Bay Country Park;
- Surface water including two seasonal streams S1 and S2; and
- Groundwater.

6.4.5 *Baseline Groundwater Conditions*

Groundwater samples were collected from the locations GW1, GW2, GW3, and GW4 of the SENT landfill as shown in *Figure 6.4a* where GW1 and GW2 are up-gradient, and GW3 and GW4 are down-gradient. Water samples from each location were collected once per week for a total of four consecutive weeks between June and July 2007. The results of the groundwater baseline monitoring are presented in *Annex F*.

By comparing the groundwater quality of the up-gradient and the down-gradient monitoring wells, it is evident that the groundwater quality of the down-gradient wells is influenced by the influx of seawater.

6.5 *CONSTRUCTION PHASE IMPACT ASSESSMENT*

6.5.1 *Potential Impacts*

Potential sources of impacts to water quality from the construction activities are:

- construction runoff;
- wastewater generated from construction activities; and
- sewage generated from the workforce.

6.5.2 *Construction Runoff*

Construction runoff from site areas may contain high loading of SS and contaminants. Potential water pollution sources from construction site runoff include:

- runoff and erosion from site surfaces, earth working areas and stockpiles;
- demolition of existing infrastructure for the SENT Landfill; and
- tunnel excavation for the twin drainage tunnel.

Construction runoff may cause physical, biological and chemical effects. Its physical effect can cause blockage of drainage channels due to the deposits of increasing SS from the site. Chemical and biological effects are however highly dependent on its chemical and nutritional contents. Runoff containing significant amount of concrete and cement-derived materials would lead to increasing turbidity and discoloration, elevation in pH, and accretion of pH solids.

During the first year of construction, works including site formation and construction of site office buildings, workshops, landfill gas and leachate treatment plants will be carried out. Excavation is necessary for the construction of the new infrastructure. A perimeter cut-off channel will be constructed around the Extension Site to divert water from outside the site boundary before commencement of site formation works. In addition, intercepting channels will be provided, for example along the edge of excavation to prevent stormwater runoff from washing across exposed soil surfaces. The construction runoff will be discharged off site after passing through a sedimentation tank or silt traps. It is anticipated that, with the implementation of good construction practice, as stated in *ProPECC PN1/4,* and appropriate mitigation measures (see *Section 6.8*), contamination of construction runoff will be minimal and there will be no unacceptable water quality impacts to the receiving water bodies, ie surface water including two seasonal streams S1 and S2, inshore waters in Junk Bay and Joss House Bay, and Clear Water Bay Country Park.

Modification of the landfill gas wells of the existing SENT Landfill is required for the accommodation of the new basal liners of the Extension. No leachate leak will occur as the works will be carried out above the impermeable liner of the capping system.

In the second year, the demolition of the existing infrastructure at the existing SENT Landfill will be carried out. There will be no wastewater generated by the demolition of existing facilities. As a preventive measure, all sewers and drains will be sealed to prevent building debris, soil and etc from entering public sewers/drains before commencing any demolition works.

The fuel and waste lubricant oil from the on-site maintenance of machinery and equipment will be collected by a licensed chemical waste collector. The runoff containing oil and grease will pass through the oil interceptor before being discharged off-site.

6.5.3 *Wastewater Generated from Construction Activities*

In order to drain the surface water collected at the south-eastern corner of the Extension to the side slope near TKO Area 137, a 2 m-diameter twin drainage tunnel will be constructed near the side slope of the landfill, separated from the side slope liner system of the Extension by a considerable thickness of *in-situ* rock (see *Figure 3.3i*). A micro-tunnel boring machine (TBM) will be used for the main tunnel excavation.

There will be no wastewater generated from tunnel excavation, except the recycle water and bentonite slurry required for the cooling of the cutter head during boring rocks and soil respectively. The recycle water will be conveyed to the sedimentation tanks for treatment and most of the treated water will be reused in the boring operations. Similarly, the bentonite slurry will be recirculated, wherever practicable, following settlement of cuttings. Only limited amount of excess water will be disposed to the surface drains in TKO Area 137 after proper treatment. The disposal of the treated water in compliance with the discharge license granted at the later stage will be required and hence no adverse impact to the nearby water bodies is expected. Prior to tunnel excavation, ground treatment works will be carried out and hence the tunnel excavation is unlikely to cause any unacceptable variation of the groundwater table.

Used bentonite slurries will be reconditioned and reused on-site as far as possible. The residual bentonite slurry will be mixed with dry excavated material for disposal at the designated public filling facilities. In accordance with *ProPECC PN 1/94*, if the used bentonite slurry is intended to be disposed of through the public drainage system, it should be treated to the respective effluent standards applicable to foul sewers, storm drains or the receiving waters as set out in the *TM* under the *WPCO*.

6.5.4 *Sewage Generated from the Workforce*

Sewage will arise from the sanitary facilities provided for the on-site workforce. The characteristics of sewage would include high levels of 5-day Biochemical Oxygen Demand (BOD_5), ammonia and *E.coli* counts. It is estimated maximum of 170 workers will be working simultaneously at the construction site during construction phase. Sufficient chemical toilets will be provided for use by the workforce. In addition, no sewage will be allowed to discharge directly into the surrounding water body without treatment. With this regard, adverse impacts to water quality as a result of handling and disposal of sewage generated by the workforce are not expected.

6.6 *OPERATION/ RESTORATION PHASE IMPACT ASSESSMENT*

6.6.1 *Potential Impacts*

During the operation/restoration phase of the Extension, solid wastes deposited in the landfill will decompose by a combination of chemical, physical and biological processes through which solid, liquid and gaseous by-products are produced and all of them would be of concern in the overall management of a landfill. The liquid by-product is referred to as leachate and is the main concern for the water quality impact of the Extension.

Figure 6.6a shows the leachate generation processes. There are two sources of water in the landfill, ie, the water present in the waste when landfilled (primary leachate) and the water added to the landfill from rainfall and groundwater inputs (secondary leachate). During rainy days, the primary leachate is soon overshadowed by secondary leachate, which will control the long-term leachate generation. Secondary leachate arises from infiltration of rainwater through the active tipping face and daily cover area. As the landfill will be fully lined, no leachate will be generated from groundwater infiltration.

Other potential impacts may include the wastewater produced during the daily operation of the office buildings and associated facilities.

To summarise, the potential sources of impacts to water quality from the operation/restoration activities include:

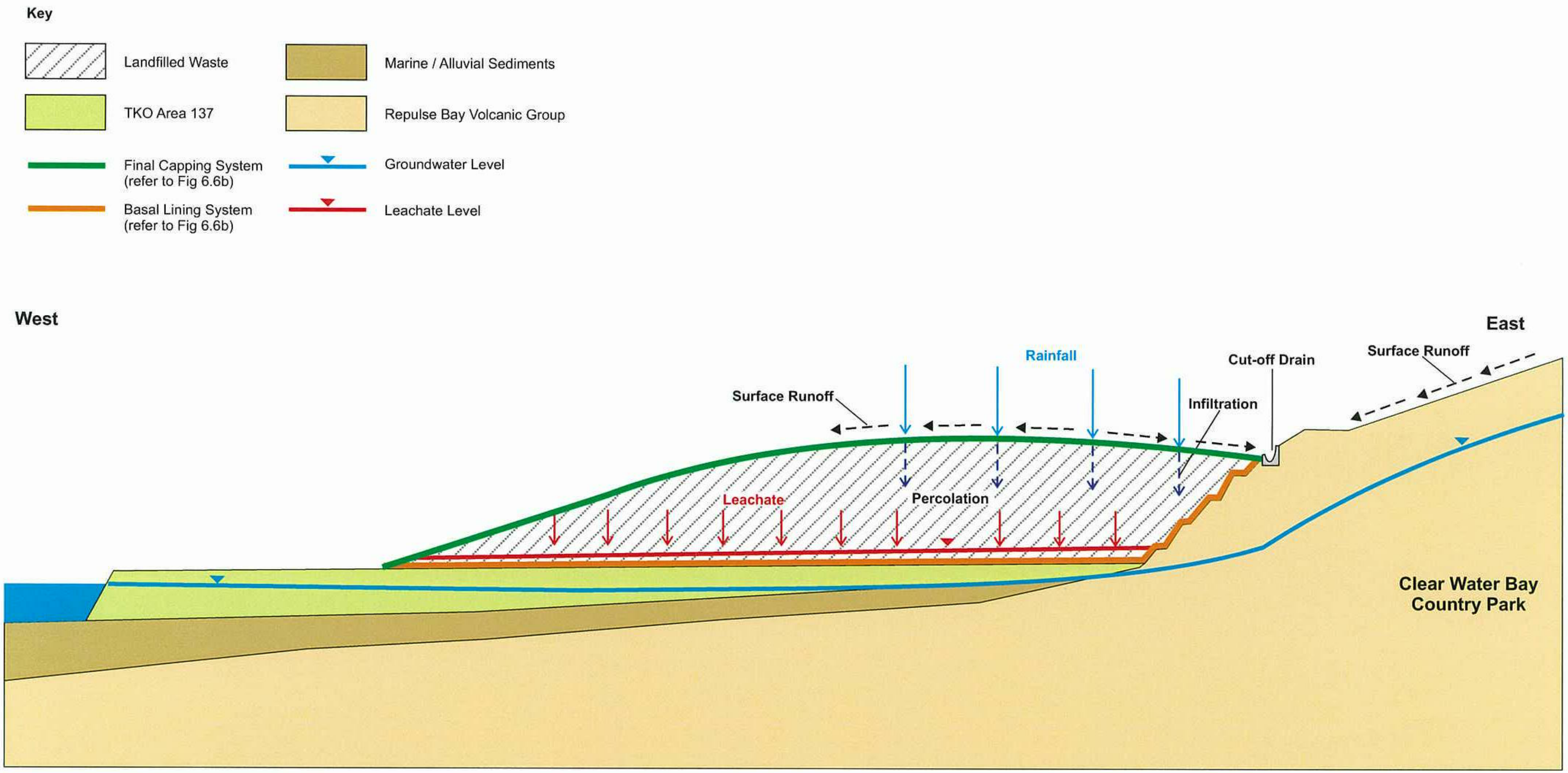

Figure 6.6a

Leachate Generation in SENT Landfill Extension

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- uncontrolled discharge of leachate from the active tipping area into surface water;
- sub-surface off-site migration of leachate into groundwater and marine water due to potential pin holes and defected seams in the liner;
- discharge of improper treated effluent leachate from the LTP; and
- wastewater generated from workforce.

To evaluate the above potential impacts, it is necessary to examine in considerable detail of the surface water, groundwater and leachate management systems proposed for the Extension. This will also facilitate the design of a monitoring programme which could determine the degree to which the Extension and any associated containment system is functioning in accordance with design objectives and in compliance with the legislative criteria/standards.

The potential impact to groundwater quality due to leakage of leachate is discussed as a whole for operation/restoration, and aftercare phases in *Section 6.7*.

6.6.2 *Surface Water Management*

As discussed in *Section 6.6.1*, leachate generated from rainfall infiltration will control the long-term leachate generation. Surface water management, which relates to the infiltration of rainfall through the landfill surface, is discussed in this section.

The overall design objectives for the surface water management system are to:

- avoid any surface water runoff from outside the Extension (including runoff from the natural slopes of CWBCP and from restored slopes of the existing SENT Landfill) from entering the waste boundary;
- ensure all runoff from the Extension site drains to Junk Bay (to the west), rather than streams S1 and S2, CWBCP and Clear Water Bay (to the east); and
- ensure segregation between clean rainwater, and water which has come into contact with waste and therefore will be treated as leachate.

The following design features have been incorporated in the outline design of the surface water management to minimise leachate generation and control the discharge of leachate into surface water channels.

- Clean surface water runoff will be separated from contact with waste by use of temporary bunds, diversion channels and cut-off drains;
- Areas that have been filled with waste, but not yet reached final grade, will be covered by intermediate cover (with an impermeable liner) to minimise rainwater infiltration into the waste and prevent erosion of the

intermediate cover soil;

- The final cap (see *Figure 3.3c*) will include the following main features or similar materials to minimise rainwater infiltration into the waste:

  (a) A layer of CDV and topsoil mix - reduces infiltration into the waste and wind erosion and provides temporary moisture retention;

  (b) A layer of compacted fill - minimise infiltration into the waste through the cover;

  (c) A layer of geocomposite drainage layer - provides a lateral path for water to exit rapidly;

  (d) A layer of HDPE liner - an impermeable membrane effectively minimises infiltration into the waste and greatly reduces the volume of leachate to be generated from restored areas and seeping of leachate from waste slopes into surface water channels; and

  (e) A layer of non-woven geotextile - separates soil grading layer from HDPE liner.

- Placement of the final capping system will be implemented in phases throughout the life of the Extension.

Detailed design of site drainage will be based on the appropriate Hong Kong Government codes, including the DSD Stormwater Drainage Manual (1994).

A Drainage Impact Assessment (DIA) has been carried out for the Extension. The DIA has concluded that the existing and planned surface water drainage infrastructure in TKO Area 137 and the surrounding area is adequate to convey surface water flows from the Extension and surrounding catchments to the existing and planned discharge points. The estimated daily flow rates under normal and extreme conditions at different operational phases (refer to *Section 3.6* for the details of each phase) of the Extension are summarised in *Table 6.6a*.

Table 6.6a ***Predicted Daily Flow Rates During Operational Phases***

Phase	Under Normal Conditions	Under Extreme Conditions
	$m^3\ d^{-1}$	$m^3\ d^{-1}$
1	732	1,058
2	1,354	1,952
3	1,602	2,306
4	1,893	2,722
5	2,108	3,027
6	2,366	3,390

Surface Runoff from Clear Water Bay Country Park

In order to avoid surface runoff from CWBCP from entering the Extension Site, a permanent cut-off channel will be constructed along the crest of the eastern side slope. The southern part of this cut-off channel will drain by gravity to the south-eastern corner of the Extension. The northern part of this cut-off channel falls to the north, where it will meet up with the cut-off channel for the existing SENT Landfill.

At present, the existing SENT Landfill cut-off channel traverses the eastern edge of the landfill, and then turns to the west, towards the existing SENT Landfill infrastructure area. As part of the Extension development, this portion of the channel will be covered by waste and could not be used during the operation/restoration phase of the Extension. A 2 m-diameter twin drainage tunnel will be constructed near the side slope of the landfill, separated from the side slope liner system of the Extension by a considerable thickness of *in-situ* rock (see *Figure 3.3i*). This twin tunnel will drain water collected at the south-eastern corner of the Extension to the side slope near TKO Area 137 where it joins the eastern boundary channel (see *Figure 3.3i*).

Run-off from Existing SENT Landfill

Runoff from the restored slopes of the existing SENT Landfill will be uncontaminated but should be prevented from entering the Extension Site. A perimeter cut-off channel will be constructed around the Extension Site, and it will be connected to the surface water drainage system to be incorporated into the existing SENT Landfill restoration design. Following completion of the Extension, an additional channel (see *Figure 3.3i*) will be constructed around the eastern flank of the Extension and then to the west, to convey flows directly to the western boundary of the Extension Site avoiding the flow to the east to the Clear Water Bay. Prior to completion of the Extension, collection and pumping of surface water will be required as part of the surface water management plan, to avoid any discharge of stormwater eastwards into CWBCP.

Rainfall within Extension Site

Rainfall within the Extension Site will be segregated depending on whether it has been in contact with waste (in which case it will be treated as leachate), or it is uncontaminated (in which case it will be dealt with as clean surface water).

A series of cut-off channels will be formed in the side slopes and on the southern waste slopes of the existing SENT Landfill that lie within the Extension Site boundary. These channels will intercept rainwater falling on areas above the current level of waste placement, and divert it to the perimeter cut-off channels.

Areas outside the active tipping faces and daily cover area will be covered with an intermediate cover. In order to minimise leachate generation and control seepage of leachate from waste slopes into the surface water drainage channels, the intermediate cover will include a layer of impermeable geomembrane. Surface water management will be implemented to collect clean rainwater falling onto intermediate cover area, and divert it to the perimeter cut-off channels.

Rainwater falling onto the restored slopes of the Extension will be collected by surface water channels on the slopes, and drained to the perimeter of the site. Rain falling onto the active tipping and daily cover areas will infiltrate through the waste and be collected by the leachate collection system, for treatment and discharge (see *Section 6.6.5* for the details of leachate collection system).

Sediment Traps and Oil Separation

All surface water drainage channels that discharge either directly or indirectly to surface watercourses or to the sea will be provided with sediment traps, silting basins and oil separators (where necessary) to minimise the potential for contamination.

To conclude, the design of the Extension has comprehensively considered minimising the infiltration of surface water into the landfill and avoiding seepage of leachate from the waste slopes into the surface water drainage system.

6.6.3 Groundwater Management

Generation of Leachate due to Groundwater Infiltration

As discussed in *Section 3.3.1*, the Extension will be designed and constructed as a containment facility incorporating a multi-layer composite liner system covering the entire land formation (compacted soil) of the Extension Site where waste will be deposited. This will not only prevent infiltration of groundwater into the waste and hence minimising leachate generation, and also prevent off-site migration of leachate and contamination of the groundwater. Construction quality assurance/control procedures will be implemented to ensure that the liner system is proper constructed (ie avoiding puncture of the impermeable HDPE liner by construction equipment during installation, and proper seaming of the joints, etc). It is hence expected that the groundwater will be isolated from the Extension Site and as a result leachate generation from groundwater infiltration will be negligible.

Groundwater Contamination due to Leachate Seepage

A geocomposite groundwater drainage layer (as shown in *Figure 3.3c*) will be constructed underneath the basal lining system. The compacted soil underneath the groundwater drainage layer will inhibit the downward infiltration of leachate into the groundwater and hence the drainage layer (with an adequate gradient) could allow the collected groundwater to flow horizontally by gravity. Since the groundwater drainage layer of the Extension will be connected to groundwater diversion pipe trenches, the groundwater flows will be diverted to a series of groundwater collection sumps along the western boundary of the Extension adjacent to the leachate collection sumps. The groundwater collection sumps (see *Figure 3.3j*) will be fitted with overflows to soakaways, and also with submersible pumps.

The following measures will be implemented to avoid any groundwater contamination:

- At present, groundwater monitoring is carried out at the monitoring wells and discharge manholes. In order to much closely monitor the groundwater quality, it is proposed that groundwater quality at both the groundwater collection sumps and groundwater monitoring wells will be regularly monitored to check for contamination due to leakage of leachate from the Extension (details refer to *Section 11 – EM&A*).

- If the monitoring data at the collection sumps show that there are no exceedences of the trigger levels, the groundwater retained in the sump will be discharged of from the sump to the soakaway and hence will percolate back into the groundwater. Similar procedures are currently implemented in the existing SENT landfill for which the groundwater collected in the discharge manholes (if any) is pumped to the surface drains for disposal. In accordance with the contractor of the existing SENT Landfill, only small amount of groundwater was found in the manhole over the past operational years and no overflows have ever been occurred. In this regard, the monitoring frequency on a month basis is reasonably sufficient to determine the groundwater quality prior to the discharge to the soakaway.

- In the event that the trigger levels are exceeded, the submersible pumps will pump groundwater into the leachate collection sumps, from where it will be transferred to the leachate treatment plant along with the leachate collected from the landfill. Again, a similar mechanism is currently utilised in the existing SENT landfill.

In the presence of these proactive prevention measures in place, the operation/restoration of the Extension would not impact the groundwater quality.

6.6.4 Leachate Management

As discussed above, the generation of leachate is mainly from the moisture content of the waste and rainwater infiltration. As discussed in *Sections 6.6.2* and *6.6.3*, effective measures and facilities will be provided in the Extension to control surface water and groundwater entering the Extension and hence the leachate production will be reduced to minimal level. This section assesses the effectiveness of the proposed leachate management system and the potential water quality impacts due to the handling, treatment and disposal of leachate.

The design objectives of the leachate management system are:

- to contain all leachate within the waste boundary by the use of engineered barriers;

- to collect and drain leachate for treatment and disposal; and

- to facilitate the control of leachate levels within the Extension.

The leachate management system comprises the following components:

- a leachate collection system;
- a leachate extraction system; and
- a leachate treatment system.

Each of these components is discussed below.

6.6.5 *Leachate Collection System*

A low permeability composite liner system will be placed at the base of the Extension to reduce the discharge to the underlying hydrogeologic environment. The liner system will be designed as a barrier to intercept leachate so that the contained leachate can be abstracted for treatment prior to discharge from the Extension Site.

Basal Lining System

The basal lining system of the Extension will consist of the following features or similar materials (from top to bottom) (see *Figure 3.3c*):

- a layer of filter geotextile;
- a layer of leachate collection layer;
- a layer of cushion geotextile;
- an impermeable, such as the HDPE liner;
- a geosynthetic clay liner (GCL);
- a HDPE liner; and
- a geocomposite groundwater drainage layer.

The leachate collection layer will be designed to effectively collect and drain leachate which percolates downwards from the waste. This is important as to reduce the leachate head above the liner system. In order to fulfill these objectives, the leachate collection layer should:

- have adequate hydraulic conductivity;
- be resistant to physical and chemical damage;
- have a sufficient gradient to allow drainage; and
- contain pipework with appropriate spacing to facilitate removal of leachate.

The leachate collection layer will comprise a minimum depth of 500 mm crushed non-calcareous aggregate (10–20 mm size) of sufficient physical strength to withstand the likely loadings from the overlying waste (as determined by soaked 10% fines value). The aggregate used will be rounded to minimise pressure on and damage to the liner system. A layer of cushion geotextile will be placed between the leachate collection layer and the top of the impermeable liner. A geotextile filter layer will be placed above the leachate collection layer to prevent downwards migration of fines from the waste.

The leachate collection layer will have a hydraulic conductivity of at least $1x10^{-4}$ m s^{-1}, and a minimum gradient (vertical to horizontal) of 1:50. The leachate collection layer will be placed on the basal liner with care, using a hydraulic excavator, to ensure that no damage is caused to the basal liner. The pipework will be of sufficient physical strength to limit deflection to no more than 5%. The thickness of drainage stone above the pipe will be at least equal to the diameter of the pipe. Pipework will be jointed by butt-fusion welding to prevent leakage. Access points will be maintained to enable jetting of the pipework to maintain its flow characteristics throughout the life of the Extension.

Drainage pipework will be installed within the leachate collection layer. The pipework will be manufactured from either HDPE, u-PVC or polypropylene, and will be perforated (with slots or holes) except for the lower 120° of the pipe cross-section, which should be solid to allow for flow of leachate. The pipe diameter will be determined based on the predicted flow (a minimum diameter of 200 mm is recommended to minimise clogging and allow for inspection and cleaning).

The leachate drainage pipework will be designed such that the maximum head of leachate does not exceed 1m. In order to control the leachate head below this level, the maximum spacing of the collection pipes should be about 50m. Otherwise, the leachate level may increase which may cause seepage of leachate through the side slopes and contamination of surface water. Minimising the leachate head above the basal liner will also reduce the potential for leachate seepage through any potential pin holes/defective seams on the basal liner and hence reduce the potential for groundwater contamination.

Piggyback and Side Slope Lining System

At the piggyback and side slope areas, the leachate collection layer would comprise a geosynthetic drainage layer rather than crushed stone, and pipework would not be required. Leachate collected at the geosynthetic drainage layer will flow down by gravity to the basal lining system, as described above, where leachate will be collected by the pipework.

6.6.6 *Leachate Extraction System*

Leachate will be extracted from the Extension via a series of four collection sumps around the western and southern perimeters of the Extension Site.

The leachate collection sumps will be constructed of pre-cast concrete and will be equipped with submersible pumps to enable leachate to be pumped from the base of the landfill to the leachate collection main, which will transfer leachate to the leachate treatment plant in the infrastructure area.

The leachate collection sumps will be accessed by upslope risers along the toe bund of the Extension, and therefore will not be prone to damage due to movements of the waste mass.

6.6.7 Leachate Treatment System

Leachate Quantity

As discussed in *Section 6.4.3*, a Bioplant is currently operated at the existing SENT Landfill to treat the leachate as well as other wastewater generated from the SENT Landfill. Before the commencement of the Extension, a new LTP will be constructed to handle the leachate and wastewater generated from the existing SENT Landfill. The Bioplant will be demolished after all the leachate and wastewater from the existing SENT Landfill are diverted to the new LTP. This LTP has a maximum design flow rate of 1,500 $m^3\ d^{-1}$, coupled with a buffer storage capacity of 22,000 m^3. This design capacity is able to cope with the anticipated peak leachate treatment requirement during the last year of operation of the existing SENT Landfill. The LTP is also capable of treating leachate to comply with the discharge standard stipulated in the discharge license of the existing SENT Landfill.

Following full restoration and closure of the existing SENT Landfill, the leachate generation from the Extension will reduce significantly. The buffer storage capacity could be reduced, subject to further review, as the leachate generation from the Extension is smaller. It is estimated that the averaged combined leachate flow from the restored SENT Landfill and the operating Extension will be approximately 355 $m^3\ d^{-1}$. The peak treated effluent flow will be limited to 1,000 $m^3\ d^{-1}$. The treated effluent from the new LTP will be discharged to a foul sewer leading to TKO STW and the effluent should comply with the discharge standards stipulated in EPD's *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewage Systems, Inland and Coastal Waters*.

Leachate Quality

The quality of leachate has been estimated based on the known composition of leachate at the existing Hong Kong landfills as well as the implementation of Sludge Treatment Facilities (STF) and the Integrated Waste Management Facilities (IWMF). It is expected that the STF will commence operation in 2012 (before the commissioning of the Extension) whilst the IWMF is planned to be in operation by 2014. It is understood that the residues (ie the incineration ash) of the STF and IWMF may be disposed of at other landfills in the future depending on the location of the STF and the IWMF which is under planning. In order to provide a conservative impact evaluation, it is assumed that the Extension will receive the residues from STF and the IWMF in addition to the currently received waste, ie municipal solid waste and construction waste.

It is not expected that the quality of leachate will be significantly affected by the implementation of STF and IWMF for the following reasons:

- At present the existing SENT Landfill among the three strategic landfills in Hong Kong is the only one to accept stabilised incineration residues from thermal treatment facilities. The existing SENT Landfill has proved capable of taking these residues without compromising its performance.

- Similar to the existing SENT Landfill Contract, the stabilised incineration residues have to meet the landfill disposal criteria before disposal to the landfill is allowed. The criteria are set primary in terms of the Toxicity Characteristic Leaching Procedure (TCLP) limits as presented in Table E1 of the EPD"s *Guidance Notes for Investigation and Remediation of Contaminated Sites of Petrol Filling Stations, Boatyards and Car Repair/Dismantling Workshops*. Although the volume the stabilised residues received by the Extension may be increased once the STF and IWMF are put into operation, the residues will have to pass the TCLP prior to disposal at the Extension. The TCLP aims at stabilising the residues and minimising the leaching potential of heavy metals and other potentially toxic substances. The potential of heavy metals leaching from the stabilised residues are expected to be low and hence will not adversely affect the leachate quality.

- Although the stabilised residues would produce inorganic leachate, the residues only form a portion of the total waste expected to be received by the Extension. As a significant portion of the waste disposed of at the Extension will be MSW, it is expected that the leachate will consist of high levels of COD, BOD and ammoniacal-nitrogen similar to the leachate generated from the existing SENT Landfill.

Based on the available information, it is concluded that treatment requirements will be dictated by the removal of COD and nitrogen. With reference to the performance of the existing SENT Landfill, when these parameters are properly treated, others such as heavy metals are usually found to be satisfactory in the effluent. The predicted concentrations of the main design parameters of the raw leachate are shown in *Table 6.6b*.

Table 6.6b Predicted Concentrations of the Main Design Parameters

Parameter	Unit	Mean	Maximum	Minimum
Influent NH_4-N	mg L^{-1}	2,500	4,500	1,500
Influent COD	mg L^{-1}	3,000	4,500	2,000
Hard COD	mg L^{-1}	1,000	1,500	650
Hard TKN	mg L^{-1}	75	125	40

The treated effluent from the LTP will be discharged to the foul sewer leading to the TKO STW. Effluent quality will be governed by the discharge standards stipulated in the *TM*. The applicable limits for the averaged predicted flow of 355 m^3 d^{-1} and the peak flow of 1,000 m^3 d^{-1} are shown in *Table 6.6c*.

Table 6.6c Effluent Discharge Standards Stipulated in the TM

Parameter	Unit	Flow rate, $m^3\ d^{-1}$			
		>200 to ≤400	>400 to ≤600	>600 to ≤800	>800 to ≤1000
pH	-	6 - 10	6 - 10	6 - 10	6 - 10
Temperature	°C	43	43	43	43
Suspended solids	mg L^{-1}	800	800	800	800
Settleable solids	mg L^{-1}	100	100	100	100
BOD	mg L^{-1}	800	800	800	800
COD	mg L^{-1}	2,000	2,000	2,000	2,000
Oil & Grease	mg L^{-1}	50	50	40	30
Iron	mg L^{-1}	25	15	12.5	10
Boron	mg L^{-1}	5	4	3	2.4
Mercury	mg L^{-1}	0.1	0.001	0.001	0.001
Cadmium	mg L^{-1}	0.1	0.001	0.001	0.001
Copper	mg L^{-1}	3	1.5	1.5	1
Nickel	mg L^{-1}	2	1.5	1.5	1
Chromium	mg L^{-1}	2	1	0.7	0.6
Zinc	mg L^{-1}	3	1.5	1.5	1
Silver	mg L^{-1}	2	1.5	1.5	1
Other toxic metals individually	mg L^{-1}	1.5	1	0.7	0.6
Total toxic metals	mg L^{-1}	7	3	2	2
Cyanide	mg L^{-1}	1	0.7	0.5	0.4
Phenols	mg L^{-1}	1	0.7	0.5	0.4
Sulphide	mg L^{-1}	10	5	5	4
Sulphate	mg L^{-1}	1,000	1,000	1,000	1,000
Total nitrogen	mg L^{-1}	200	200	200	200
Total phosphorus	mg L^{-1}	50	50	50	50
Surfactants (total)	mg L^{-1}	40	30	25	25

Source: Table 1 - Standards for effluent discharged into foul sewers leading into Government sewage treatment plants, *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Inshore waters*

Leachate Treatment Options

Technical feasibility, space requirements as well as the implementation of STF and IWMF were considered to decide the treatment option. Based on these considerations, it is proposed to treat leachate using a metal precipitation system, ammonia stripping towers (to remove the majority of ammoniacal nitrogen), followed by a sequencing batch reactor (SBR) operating in a "pre-denitrification" mode (for nitrification of the remaining ammoniacal nitrogen and subsequent COD removal and denitrification).

Buffer storage tanks prior to the metal precipitation system and ammonia stripping. Stripped effluent will be stored in a separate holding tank from where it is fed into the SBR tanks. Effluent from the SBR tanks will be stored in a final effluent holding tanks, from where it will be discharged to foul sewer.

As mentioned above, the leachate characteristics are not expected to be substantially changed during the operation of the Extension. The stabilised incineration residues to be disposed of at the Extension are expected to be complied with TCLP limits [(1)] before disposal to the Extension and hence will not adversely affect the leachate quality. Nevertheless, it is recommended, as a precaution, that a lysimeter study [(2)] be undertaken to confirm the metals concentrations that may occur at the proposed rates of disposal of stabilised incineration residues. The aim of the lysimeter study is to study the change of leachate quality due to co-disposal of the IWMF residues at the SENT Extension. If leachate from the lysimeter study does contain increased metals, it should be subjected to treatability trials to confirm if additional treatment process would be required (eg a metal precipitation system) to meet the *TM* effluent standards. The metal precipitation system could be easily installed and there is available space at the LTP to install such system, if required.

In addition, the quality of LTP influents will be continuously monitored by the DBO Contractor to capture any change in the characteristics of the raw leachate. Concurrently, the effluent quality will be monitored by the ET and the monitoring results will be sent to the DBO Contractor. The DBO Contractor will review all the monitoring data to determine the removal efficiency of the treatment process and will decide whether modifications to the leachate treatment process are needed.

Leachate Disposal

Treated leachate will be disposed of to the foul sewer leading to the TKO STW. A Sewerage Impact Assessment (SIA) has been carried out as part of the Feasibility Study to confirm the capacity of the existing and planned sewage collection and treatment infrastructure in the surrounding area. The SIA has confirmed that the existing and planned infrastructure is adequate for the predicted flows.

The disposal of treatment effluent, which meets the discharge standards stipulated in the *TM*, from the LTP into the foul sewer leading to the TKO STW will not cause adverse water quality impacts to the identified WSRs and the operations of the TKO STW.

6.6.8 *Wastewater Generated from the Workforce*

Similar to the existing SENT Landfill, the wastewater from the administrative office as well as laboratory and maintenance buildings will be collected (about 22.5 m^3) and treated together with leachate at the new LTP prior to disposal at the TKO STW. Details of the treatment of the wastewater are presented in

(1) Guidance Notes for Investigation and Remediation of Contaminated Sites of: Petrol Filling STations, Boatyards and Car Repair/Dismantling Worship, EPD, 1999.

(2) A small cell (with separated containment and leachate collection system) will be constructed at the landfill. The cell will be filled with the anticipated ratio of the stabilized IWMF residues and MSW to be disposed at the Extension. The leachate collected from the lysimeter cell will be analysed (particularly for heavy metals) to see if there is any significant change in leachate quality due to the co-disposal arrangement. The monitoring data will help to refine the treatment process and if necessary modify the treatment process of the LTP to ensure that the effluent will comply with the required discharge standards.

Section 6.6.7.

It is anticipated that no adverse impacts on the surrounding aquatic environment due to the wastewater will arise.

6.6.9 *Potential Risk Associated with Leakage of Leachate*

A hydrogeological assessment has been undertaken as part of the Feasibility Study to evaluate the potential impact on groundwater quality and coastal water quality due to potential off-site migration of leachate from the Extension during the operation/restoration and aftercare phases. The hydrogeological assessment takes into account the risk associated with leakage of leachate throughout the project lifetime. As with all groundwater risk assessments for landfills, it is expected that a stringent Construction Quality Assurance Programme will be adopted during the installation of the liner system but for conservative assessment, it is assumed that there is still some degree of leakage through the geomembrane due to installation and manufacturing defects. This is represented by a probability density function in the LandSim model representing numbers of pinholes, tears and holes in the geomembrane, initially starting at a minimum value and gradually increasing over time.

The operation phase of the Extension (i.e. whilst it is still receiving waste) was included in the model. Based on the modelling results for a double liner system, it will take considerable time for any leachate leakage, due to manufacturing defects and installation defect, to migrate through the engineered barrier layers and the unsaturated zone. Risks to groundwater quality generally only occur during the post-closure period (this is discussed in *Sections 6.7.3* and *6.7.4*). This approach is accepted by the UK Environment Agency for meeting the requirements of the European Union Groundwater Directive and Landfill Directive.

Rather than model the potential impacts of all possible contaminants in landfill leachate, UK Environment Agency Guidance (1) recommends modelling of representative parameters only to assess the worst case. Typically, these modelled parameters are present in the highest concentrations in leachate and/or are most mobile in the subsurface. In this EIA study, the choice of contaminants to be modelled was referenced to the available data on leachate quality at SENT Landfill. The modelled parameters were chosen to be representative of the key contaminants in leachate, which are widely accepted as being ammoniacal nitrogen, chloride, COD and toxic metals and they are listed below:

- inorganic cations (ammoniacal nitrogen);
- inorganic anions (chloride);
- highly mobile metallic ions (zinc);

(1) Hydrogeological Risk Assessment for Landfills (Environment Agency, March 2003)

- less mobile metallic ions (cadmium, mercury); and
- representative of organic species in leachate (COD).

For Cadimum and Mercury, where no existing information is available, the concentrations of these contaminants in leachate are taken from the UK default leachate inventory.

The background concentrations of contaminants are taken from the down-gradient groundwater monitoring undertaken in June and July 2007 (see *Annex F*), and the concentrations in leachate taken from leachate monitoring at existing SENT Landfill.

Model Assumptions for LandSim Model are summarised in *Table 6.6d*.

Table 6.6d Model Assumptions for LandSim Model

Leachate Composition and Groundwater Concentrations

Parameter	Leachate Composition ($mg\ L^{-1}$) (a)	Mean Groundwater Concentrations ($mg\ L^{-1}$) (b)
Ammonia as N	1,788 – 2,460	2.15
Cadmium	0.0019 - 0.105 (d)	<0.1
Chloride	1,971 – 2,558	14,588
Mercury	0.00004 – 0.00195 (d)	- (c)
Zinc	0.34 – 3.83	<0.1
COD	2,420 – 3,201	27

Sources:

(a) With reference to the leachate composition at the existing SENT Landfill.

(b) The mean value of groundwater data taken at the down-gradient groundwater stations (GW3 and GW4 as shown in *Table 6.4b*) during June – July 2007.

(c) The background concentrations for mercury are not currently available.

(d) The leachate concentrations of cadmium and mercury are currently not available and hence the UK default leachate inventory was used.

Defects at Barrier (a)

Defects (b)	Nnumber per hectare
Upper Layer (design thickness of 0.002m)	
Pin Holes	Minimum 0, Maximum 25
Holes	Minimum 0, Maximum 5
Tears	Minimum 0, Most Likely 0.1, Maximum 5
Lower Layer (design thickness of 0.002m)	
Pin Holes	Minimum 0, Maximum 25
Holes	Minimum 0, Maximum 5
Tears	Minimum 0, Most Likely 0.1, Maximum 2

Notes:

(a) The actual proposed lining is not one of the default systems in the LandSim Model and hence it was necessary to simulate a double composite lining system, which is considered to be comparable to the actual proposed design in view of a similar total thickness of GCL and two layers of HDPE.

(b) The defects include manufacturing defects and installation defects.

The modelled flow rates of leakage through the basal liners and the flow characteristics of the aquifer (including contaminant transport) are calculated by the LandSim model on a probabilistic basis. Since the parameters are represented by probability density functions rather than single values, it is not appropriate to refer to single values for leakage through the basal liners or aquifer flow. Rather, results are expressed as a percentile (usually 95th) of the output distribution at a particular time. In addition, certain parameters (including those influencing leakage through the engineered barrier system) change with time. Based on the model results, the flow rates of leakage through the basal liners for the 1st through to the 100th year after the operation of the Extension commenced were predicted to be negligibly small (ie in a range of 0 to 1.32E-278 L day^{-1}). The negligible leakage flow rate over this period reflects the leachate level within the landfill. As mentioned in *Section 6.6.5*, the leachate heads in the landfill will be maintained at a minimum level (below 1 m) by leachate extraction and treatment during the Extension contract (1) and consequently this will minimise the leakage flow rate.

The groundwater within the fill deposits in the TKO Area 137 will flow westerly and eventually enter the inshore waters in Junk Bay, as shown in *Figure 6.6a*. Any contaminated groundwater discharged from the Extension may potentially cause a water quality impact in the Junk Bay. The development of the Extension will not have adverse impact to the groundwater flow to Joss House Bay which is located to the east of the Extension Site.

The LandSim model was used to evaluate the potential water quality impacts of the leachate leakage from the Extension through the groundwater to the Junk Bay. Concentrations of the key pollutants at the Junk Bay inshore waters 1 year and 5 years after commencement of the Extension, were modelled without retardation during transport (see *Table 6.6e*). The results are compared against the *TM* standards for effluents discharged into the inshore waters of Southern, Mirs Bay, Junk Bay, North Western, Eastern Buffer and Western Buffer Water Control Zones, with an estimated flow rate in the aquifer at TKO Area 137 of 500 m^3 d^{-1}.

(1) Incluidng a 30-year aftercare period after the closure of the Extension. Further restoration contracts may be let for continuous management of the restored Extension until the landfill is stablised.

Table 6.6e ***Predicted Contaminant Concentrations at the Inshore Waters in Junk Bay during Operation Phase***

Parameter	**Concentration after 1 year (mg L-1)**		**Concentration after 5 years (mg L-1)**		**Water quality standard (b) (mg L-1)**
	Without Groundwater Background	**With Groundwater Background**	**Without Groundwater Background**	**With Groundwater Background**	
Ammonia as N	0 (a)	2.15 (c)	0 (a)	2.15 (c)	80 (as total N)
Cadmium	0 (a)	<0.1 (c) (e)	0 (a)	<0.1 (c) (e)	0.001
Chloride	0 (a)	14,588 (c)	0 (a)	14,588 (c)	N/A
Zinc	0 (a)	<0.1 (c)	0 (a)	<0.1 (c)	N/A
Mercury	0 (a)	- (d) (e)	0 (a)	- (d) (e)	0.001
COD	0 (a)	27 (c)	0 (a)	27 (c)	80

Notes:

(a) The LandSim model does not predict the presence of any contaminants at the Junk Bay inshore water (see *Figure 6.4a*) within the timeframe modelled, hence the concentrations are expressed as zero rather than as being below a certain detection limit.

(b) It is based on the predicted groundwater flow rate of 500 m^3 d^{-1} in the aquifer at TKO Area 137 and in accordance with *Table 10a* - Standards for effluent discharged into inshore waters of Southern, Mirs Bay, Junk Bay, North Western, Eastern Buffer and Western Buffer Water Control Zones.

(c) The mean value of groundwater data taken at the down-gradient groundwater stations (GW3 and GW4 as shown in *Annex F*) during June – July 2007.

(d) The background concentrations for mercury are currently not available.

(e) For the EM&A for the Extension, the detection limit of cadmium and mercury will be revised in order to allow a direct comparison with the *TM* standards.

Table 6.6e shows that no pollutants released from the Extension will be observed at the Junk Bay inshore waters after 1 and 5 years operation, ie during the operation phase of the Extension. It indicates that the operation of the Extension is not expected to impact the surrounding water bodies. It also indicates that the environmental risks associated with leakage of leachate posed to the aquatic environment are very low.

Contingency Plan for Accidental Leakage of Leachate

As discussed above, the modelling results show that the environmental risks due to leachate leakage, under the predictable situation such as degradation of the cap or basal liners, are very low. For the accidental leakages due to, for example, rupture of leachate pipelines, failure of pipe joint sealing and damage of geomembrane, their impacts on the groundwater could be substantially reduced if the contingency plan is well-developed before the operation of the Extension and followed efficiently by the DBO Contractor during the operation.

Monitoring for surface water, groundwater, leachate levels and treated effluent will be implemented throughout the operation/restoration phase. The objective of the monitoring programme is to continuously check the performance of the Extension and the effectiveness of mitigation measures. The monitoring programme will also effectively provide an early indication should any accidental leakage of leachate occur. The contingency plan will be implemented once the monitoring results indicate any exceedances of pre-defined trigger levels. Details of the determination of the trigger levels should refer to the *EM&A Manual*.

A comprehensive contingency plan has been established for the existing SENT Landfill. Wherever applicable, the contingency plan is recommended to adopt the existing contingency plan as the basis for the Extension's. The contingency procedures include:

- To establish a Special Environmental Monitoring Plan (SEMP) to determine the likely cause or reason for exceedances or non-compliances, any alterations and modifications to the works, operations and aftercare to reduce the likelihood of the violations, the anticipated outcome of any corrective action programme;

- To identify the source that causes the exceedances and implement a corrective action programme should the Extension cause the exceedance;

- To notify in writing all relevant parties and persons including those are being affected by the incidents.

The following modifications are, however, recommended in order to developing a contingency plan particularly suitable for the Extension:

- At present, groundwater monitoring is carried out at the monitoring wells and discharge manholes. In order to much closely monitor the groundwater quality, it is proposed that groundwater quality at both the groundwater collection sumps and groundwater monitoring wells will be regularly monitored to check for contamination due to leakage of leachate from the Extension.

- Groundwater monitoring wells will be installed at up-gradient and down-gradient of the Extension.

- In the event that the trigger levels are exceeded, the submersible pumps will pump groundwater into the leachate collection sumps, from where it will be transferred to the LTP along with the leachate collected from the landfill.

- Surface water monitoring stations will be located at three discharge points at western side of the Extension.

With the prompt and effective implementation of the contingency plan, it is not expected that adverse impact on groundwater and hence coastal water will arise from the Extension operation.

6.7 *AFTERCARE PHASE IMPACT ASSESSMENT*

6.7.1 *Potential Impacts*

Upon completion of final filling and site restoration, the period of aftercare will begin and last for 30 years. During this period, leachate will continue to be generated. The established leachate control measures and treatment will continue to operate throughout the aftercare period.

In the previous sections, it has been mentioned that the components of the leachate management system will prevent leachate from seeping from the side slopes to the surface drainage channels and off-site migration from the basal and side slope containment systems. In addition, proper site maintenance will be undertaken during the aftercare period to ensure that the capping system, leachate collection system and treatment system will be performed to comply with the design requirements. Surface water, groundwater and effluent quality monitoring will also be undertaken during the aftercare period in accordance to the monitoring plan.

With the presence of the muti-layer capping and basal liner systems, proper site maintenance and regular monitoring, the probability of the leachate leakage from the capping system and containment system is expected to be very low. Nevertheless, the water quality impacts of potential leakage of leachate have been assessed and are discussed below.

A hydrogeological model (using the latest version of the LandSim model, version 2.2.15, Environment Agency of England and Wales, 2004) was used to assess the potential impacts of the Extension on surface water and groundwater quality using a number of very conservative assumptions, based on Hong Kong and overseas experience.

6.7.2 *Evaluation of Potential Impacts on Surface Water*

The latest version of the LandSim model allows for long-term degradation of the performance of capping systems and for ultimate cessation of active leachate control measures. In the Hong Kong context, these factors can be negated by ensuring adequate aftercare, and following expiry of the aftercare period, by regular monitoring and maintenance of the capping system and extraction and treatment of leachate from the Extension until the landfill is stabilised. The LandSim model has also used a conservative figure for estimating initial infiltration through the landfill cap, based on the requirements of groundwater modelling in the UK. The application of these conservative approaches in this case ensures a robust and conservative assessment.

The hydrogeological assessment concludes that, whilst the cap remains intact (for more than 100 years) and leachate control is maintained, there are no significant impacts on surface water quality.

The surface breakout could be avoided by mitigation measures such as necessary maintenance or replacement of the HDPE cap to prevent degradation and by on-going active management of leachate to control the leachate head at a maximum of 1 m.

Based on the above, the potential surface breakwater is unlikely to occur in the presence of the active leachate management and mitigation measures.

6.7.3 *Evaluation of Potential Impacts on Groundwater*

Potential risks to groundwater quality will be associated with leakage of leachate from the Extension Site through the basal and side slope lining systems into the underlying fill deposits of the TKO Area 137 (see *Figure 6.6a*).

Based on the geology and topography of the Study Area, it is likely that almost all groundwater flow will be occurring within the TKO Area 137 fill rather than in the underlying saturated marine or alluvial deposits. The base of the landfill has been kept above the groundwater level to minimise the consequences of any leakage from the lining system. With addition of the multi-layer basal liner system on top of compacted soil isolating the Site from the groundwater, the likelihood of the leachate leakage to the groundwater system is considered to be very low.

In addition, the down-gradient groundwater within the fill deposits is not considered a resource and it is not generally used as a potable water supply. In the vicinity of the Extension, potable water supplies are not extracted from the groundwater. Water is supplied to the villages at Shek Miu Wan via a pipeline from Clear Water Bay and natural stream flows are used at the villages of Po Toi O. Hence in the unlikely event of any leachate leakage to groundwater, the severity of such impacts is considered to be very low.

The leachate leakage to the groundwater will be prevented by effective leachate management (see *Sections 6.6.4* to *6.6.7*) as well as full implementation of a monitoring programme. Routine monitoring of the groundwater quality is recommended to detect any leachate leakage and if it is the case, appropriate and adequate remedial measures should be implemented.

6.7.4 *Evaluation of Potential Impacts on Coastal Waters*

The groundwater within the fill deposits in the TKO Area 137 will flow westerly and eventually enter the inshore waters in Junk Bay, as shown in *Figure 6.6a*. Any contaminated groundwater discharged from the Extension may cause a water quality impact in the Junk Bay. The development of the Extension will not have adverse impact to the groundwater flow to Joss House Bay which is located to the east of the Extension Site.

A hydrogeology assessment using the LandSim model has been carried out to evaluate the potential water quality impacts of the leachate leakage from the Extension through the groundwater to the Junk Bay.

The quality of leachate from the existing SENT Landfill was used as a basis for the assessment. The baseline groundwater condition was determined from the groundwater baseline monitoring results for the Extension, as presented in *Section 6.4.5*, by taking the mean of the groundwater data at two down-gradient stations. Both leachate composition and groundwater concentrations were used for the LandSim model as the model assumptions and are summarised in *Table 6.6d*. Leachate monitoring at the existing SENT Landfill does not include toxic metals (other than zinc), which are included in the *TM* effluent discharge standards. The concentration of cadmium is hence referred to the UK commonly used leachate inventory, ie 0.0019 to 0.105 mg L^{-1}.

Concentrations of the key pollutants at the Junk Bay inshore waters 10 years and 50 years after commencement of the Extension, were modelled without retardation during transport (see *Table 6.7a*). The results are compared against the *TM* standards for effluents discharged into the inshore waters of Southern, Mirs Bay, Junk Bay, North Western, Eastern Buffer and Western Buffer Water Control Zones, with an estimated flow rate in the aquifer at TKO Area 137 of 500 m^3 d^{-1}.

Table 6.7a shows that no pollutants released from the Extension will be observed at the Junk Bay inshore waters after 10 and 50 years operation. The hydrogeological assessment concludes that, whilst the cap remains intact and leachate control is maintained, there are no significant impacts on groundwater quality. Even in the very long term (on a timescale of several hundred years), and assuming cap degradation and cessation of active leachate control, the impacts on groundwater are still predicted to be slight, and groundwater discharges to Junk Bay would still remain within the effluent discharge standards stipulated in the *Water Pollution Control Ordinance* for the relevant estimated flow rates.

Table 6.7a ***Predicted Contaminant Concentrations at the Inshore Waters in Junk Bay after 10 year and 50 years since the commencement of the Extension***

Parameter	**Concentration after 10 years ($mg\ L^{-1}$)**		**Concentration after 50 years ($mg\ L^{-1}$)**		**Water quality standard [(b)] ($mg\ L^{-1}$)**
	Without Groundwater Background	**With Groundwater Background**	**Without Groundwater Background**	**With Groundwater Background**	
Ammonia as N	0 [(a)]	2.15 [(c)]	0 [(a)]	2.15 [(c)]	80 (as total N)
Cadmium	0 [(a)]	<0.1 [(c) (e)]	0 [(a)]	<0.1 [(c) (e)]	0.001
Chloride	0 [(a)]	14,588 [(c)]	0 [(a)]	14,588 [(c)]	N/A
Zinc	0 [(a)]	<0.1 [(c)]	0 [(a)]	<0.1 [(c)]	N/A
Mercury	0 [(a)]	- [(d) (e)]	0 [(a)]	- [(d) (e)]	0.001
COD	0 [(a)]	27 [(c)]	0 [(a)]	27 [(c)]	80

Notes:

(a) The LandSim model does not predict the presence of any contaminants at the Junk Bay inshore waters (see *Figure 6.4a*) within the timeframe modelled, hence the concentrations are expressed as zero rather than as being below a certain detection limit.

(b) It is based on the predicted groundwater flow rate of 500 $m^3\ d^{-1}$ in the aquifer at TKO Area 137 and in accordance with *Table 10a* - Standards for effluent discharged into inshore waters of Southern, Mirs Bay, Junk Bay, North Western, Eastern Buffer and Western Buffer Water Control Zones.

(c) The mean value of groundwater data taken at the down-gradient groundwater stations (GW3 and GW4 as shown in *Annex F*) during June – July 2007.

(d) Mercury is not included in the table since the background concentrations for mercury are not available.

(e) For the EM&A for the Extension, the detection limit of cadmium and mercury will be revised in order to allow a direct comparison with the *TM* standards.

6.8 CONSTRUCTION PHASE MITIGATION MEASURES

6.8.1 Construction Runoff

Exposed soil areas will be minimised to reduce the contamination of runoff and erosion. As mentioned in *Section 6.5.2,* site formation and excavation for the new infrastructures is required. To prevent stormwater runoff from washing across exposed soil surfaces, perimeter channels will be constructed in advance of site formation works and earthworks and intercepting channels will be provided for example along the edge of excavation. Silt removal facilities, channels and manholes should be maintained and the deposited silt and grit should be removed regularly to ensure they are functioning properly at all times. Temporary covers such as tarpaulin will also be provided to minimise the generation of high SS runoff. The surface runoff contained any oil and grease will pass through the oil interceptors.

In the second year, the demolition of the existing infrastructure at the existing SENT Landfill will be carried out. There will be no wastewater generated by the demolition of existing facilities. As a preventive measure, all sewer and drains will be sealed to prevent building debris, soil and etc from entering public sewers/drains before commencing any demolition works.

During the excavation works for the twin drainage tunnels, the recycle water for cooling the cutter head of the TBM will be conveyed to the sedimentation tanks for treatment and most of the treated water will be reused, where applicable and as much as possible, in the boring operations. The disposal of the treated water in compliance with the discharge license granted at the later stage will be required.

The fuel and waste lubricant oil from the on-site maintenance of machinery and equipment will be collected by a licensed chemical waste collector.

The runoff contained oil and grease will pass through the oil interceptor before being discharged off-site. In addition, control measures, including implementation of excavation schedules, lining and covering of excavated stockpiles will be implemented to minimise contaminated stormwater run-off from the Extension site.

6.8.2 Sewage Effluents

Sufficient chemical toilets should be provided for the construction workforce. Untreated sewage should not be allowed to discharge into the surrounding water body. A licensed waste collector should be employed to clean the chemical toilets on a regular basis.

6.9 OPERATION/RESTORATION PHASE MITIGATION MEASURES

6.9.1 Surface Water Management

Inspections of the drainage system, sand traps, settlement ponds and surface water channels should be performed regularly to identify areas necessary for maintenance, cleaning or repair. Regular maintenance and replacement, if required, of the HDPE liner should be conducted to prevent degradation from affecting the performance of the capping system. Monitoring of surface water quality should be conducted on a regular basis (see *Section 11* for the monitoring requirements).

6.9.2 Groundwater Management

The groundwater management facilities including the groundwater monitoring wells and the groundwater collection sumps will be inspected regularly during the routine groundwater monitoring programme. Monitoring of groundwater quality will be conducted on a regular basis (see *Section 11* for the monitoring requirements).

6.9.3 Leachate Management

The leachate pump houses and related ancillary equipment should be inspected regularly and repaired, if necessary. For equipment such as pumps that require routine scheduled maintenance, the maintenance should be performed following the manufacturer's recommended frequency. Monitoring of leachate levels above the basal liner and leachate quality should be conducted on a regular basis (see *Section 11* for the monitoring requirements).

The design of the LTP has included two identical treatment trains (each with a treatment capacity of 750 m^3 d^{-1}). Taking account of the predicted average combined leachate flow (about 355 m^3 d^{-1}) from the Extension and the restored SENT Landfill, there will be sufficient redundancy in the system to handle the anticipated leachate flow even if one treatment train is down for maintenance. Preventive maintenance will be implemented so that the possibility for forced shutdown during the wet season will be kept to minimum. However, emergency procedures or a contingency plan should be established should the LTP malfunction. It may require that the leachate be stored temporarily within the landfill if the leachate buffer tanks are full and leachate cannot be transported to the LTP for treatment. However, it is considered that the likelihood of this situation is very remote.

6.10 AFTERCARE PHASE MITIGATION MEASURES

6.10.1 Potential Leakage of Leachate

As discussed in *Section 6.7.4*, the assessment indicates that there will be no adverse impact on groundwater quality entering Junk Bay as a result of potential leachate leakage from the Extension. Regular groundwater quality monitoring should be carried out to monitor the performance of the leachate containment system. Maintenance and replacement of the capping system should be carried out, if necessary, to prevent leachate seepage in the event of a damaged cap.

In addition, long term measures to prevent any surface breakout of leachate include maintaining control of the leachate level through extraction; and/or maintaining the engineered capped system to control infiltration.

6.11 CUMULATIVE IMPACT ASSESSMENT

The confirmed concurrent project in the vicinity of the Extension is the existing SENT Landfill and hence the following cumulative impact assessment will focus on the concurrent activities of the two landfills during different phases of the Extension.

On the other hand, neither sufficient project details nor consolidated programme for the TKO Area 137 is available at the completion of this EIA Study. It is uncertain whether any activities or what kind of activities, if any, will occur concurrently with the Extension activities and hence it will not be further discussed.

6.11.1 Construction Phase

As discussed in *Section 6.5*, the construction runoff and the sewage generated by the construction activities and workforce will be well controlled with full implementation of mitigation measures. No cumulative impacts are hence expected to occur during the construction phase.

6.11.2 Operation Phase and Restoration Phase

During the first quarter of the operation at the Extension, restoration at the last filling area at the existing SENT Landfill will be undertaken. In other words, the two landfills will not receive waste simultaneously. It is hence not anticipated that cumulative impact will result from the concurrent operation of two landfills.

The clean surface runoff from the restored SENT Landfill will be intercepted and diverted away from the Extension. As mentioned in *Section 6.6.2*, the surface runoffs generated at the Extension will be well managed by the proposed systems such as the perimeter drains to be provided surrounding the Extension and twin drainage channels to divert the collected surface water to the western side of the Extension. The surface runoffs from the Extension will not flow into and influence the existing SENT Landfill. Cumulative impacts on the surface water are hence not expected to be resulted by the operation of the Extension.

Cumulative impact on leachate treatment has also been assessed and discussed in *Section 6.6.7*. The new LTP will be commissioned during the last year of operation at the existing SENT Landfill and will replace the existing Bioplant of the SENT Landfill. A buffer storage tank with a capacity of 22,000 m^3 will be provided and it will be able to cope with the anticipated peak leachate volume during the last year operation of the existing SENT Landfill when the existing Bioplant will be demolished, and subsequently during the Extension operation. The LTP is capable of treating leachate generated from the existing SENT Landfill to comply with the discharge standards stipulated in the existing discharge license of the SENT Landfill. Following closure and restoration of the existing SENT Landfill, leachate generation at the existing SENT Landfill will be reduced significantly. It is estimated that the averaged combined leachate flow from the restored SENT Landfill and the operating Extension will be around 355 $m^3\ d^{-1}$ while the peak flow will be less than 1,000 $m^3\ d^{-1}$. The LTP is capable of treating leachate to comply with discharge standards stipulated in EPD's Technical Memorandum Standards for Effluents Discharged into Drainage and Sewage Systems, Inland and Coastal Waters. It is therefore not expected that any cumulative impacts on leachate treatment will occur.

6.11.3 Aftercare Phase

During the aftercare phase of the Extension, leachate will continue to be generated from both landfills but the leachate generated from the Extension is expected to be sufficiently reduced (see *Section 6.6.7*). The established leachate control measures and treatment will continue to operate throughout the aftercare period of the Extension. As discussed in *Section 6.7*, proper site maintenance will be undertaken during the aftercare period to ensure that the capping system, leachate collection and treatment systems will be performed to comply with the design requirements. Surface water, groundwater and effluent quality monitoring will also be undertaken during the aftercare period in accordance to the monitoring plan. With the provisions of all these control and monitoring systems, no cumulative impacts are expected to occur during the aftercare phase.

6.12 SUMMARY OF ENVIRONMENTAL OUTCOMES AND CONCLUSION

The potential impacts due to construction operation/restoration and aftercare of the Extension on surface water, groundwater and marine water quality have been assessed.

The assessment indicates that with the implementation of the proposed design for surface water management system and recommended mitigation measures, there will be no unacceptable water quality impacts due to the construction activities.

With the proposed surface water, leachate and groundwater management systems and international good practice for landfill operation, the operation and restoration of the Extension will not result in adverse water quality impacts on the identified water sensitive receivers. Discharge of treated effluent, which complies with the *TM* standards, to the foul sewer leading to the TKO STW will not cause adverse water quality impacts.

During the aftercare phase, the Extension Contractor will be responsible for operating the leachate collection system and LTP, and maintenance of the final capping system for 30 years. Regular inspection of the capping system should be carried out to ensure that its integrity and performance meet the design requirements and that there is no leachate seepage from the cap.

The hydrogeological assessment concludes that, whilst the cap remains intact and leachate control is maintained, there are no significant impacts on groundwater quality. Even in the very long term (on a timescale of several hundred years), assuming cap degradation and cessation of leachate control, the impacts on groundwater are predicted to be slight, and groundwater discharges to Junk Bay will remain within the limits.

6.13 ENVIRONMENTAL MONITORING AND AUDIT (EM&A) REQUIREMENTS

Based on the impact assessment as detailed in *Section 6.5*, no adverse impacts are predicted provided that mitigation measures as recommended in *Section 6.8* are fully implemented. Monitoring of surface water and site inspections are recommended to be carried out during the construction phase in order to check the environmental performance of the construction works on a regular basis.

To monitor the performance of the operation/restoration and aftercare of the Extension, it is recommended to monitor the quality of surface water and groundwater at the monitoring wells and collection sumps at the Extension, and the effluent discharged from the LTP. Detailed of the monitoring requirements are described in *Section 11* of this Report and in the Environmental Monitoring and Audit Manual.

7 WASTE MANAGEMENT ASSESSMENT

7.1 INTRODUCTION

This section identifies the potential wastes arising from the construction, operation, restoration and aftercare of the Extension and potential environmental impacts associated with the handling and disposal of waste. The assessment was undertaken in accordance with the criteria presented in *Annexes 7* and *15* of the *EIAO-TM*, which are summarised as follows:

- Evaluate opportunities to reduce, reuse and recycle waste;
- Estimate the types and quantities of the wastes to be generated; and
- Assess the secondary environmental impacts due to the management of waste with respect to potential hazards, air and odour emissions, noise, wastewater discharges and traffic.

7.2 LEGISLATION REQUIREMENTS AND EVALUATION CRITERIA

The following legislation covers, or has some bearing upon, the handling, treatment and disposal of wastes in Hong Kong, and has been considered in the assessment.

- *Waste Disposal Ordinance (Cap 354);*
- *Waste Disposal (Chemical Waste) (General) Regulation (Cap 354C);*
- *Land (Miscellaneous Provisions) Ordinance (Cap 28)*; and
- *Public Health and Municipal Services Ordinance (Cap 132) - Public Cleansing and Prevention of Nuisances Regulation.*

7.2.1 *Waste Disposal Ordinance (Cap 354)*

The *Waste Disposal Ordinance* (WDO) prohibits the unauthorised disposal of wastes, with waste defined as any substance or article, which is abandoned. Under the *WDO*, wastes can only be disposed of at a licensed site. A breach of these regulations can lead to the imposition of a fine and/or a prison sentence. The *WDO* also provides for the issuing of licences for the collection and transport of wastes. Licences are not, however, currently issued for the collection and transport of construction waste or trade waste.

The *Waste Disposal (Charges for Disposal of Construction Waste) Regulation* defined construction waste as any substance, matters or things that is generated from construction work and abandoned, whether or not it has been processed or stockpiled before being abandoned, but does not include any sludge, screening or matter removed in or generated from any desludging, desilting or dredging works.

The Construction Waste Disposal Charging Scheme came into operation on 1 December 2005. Processing of account applications by the EPD started on the same day. A contractor who undertakes construction work with value of HK$1 million or above is required to open a billing account solely for the contract. Charging for the disposal of construction waste started on 20 January 2006.

Depending on the percentage of inert materials in the material, construction waste can be disposed of at public fill reception facilities, landfills and outlying islands transfer facilities, where differing disposal costs would be applied. The scheme encourages waste reduction so that the contractor or Project Proponent can minimise their costs. *Table 7.2a* summarises the Government's construction waste disposal facilities, the types of waste accepted and disposal the associated costs.

Table 7.2a Government Waste Disposal Facilities for Construction Waste

Government Waste Disposal Facilities	Type of Construction Waste Accepted	Charge Per Tonne
Public fill reception facilities	Consisting entirely of inert construction waste	$27
Sorting facilities	Containing more than 50% by weight of inert construction waste	$100
Landfills	Containing not more than 50% by weight of inert construction waste	$125
Outlying Islands Transfer Facilities	Containing any percentage of inert construction waste	$125

7.2.2 Waste Disposal (Chemical Waste) (General) Regulation

Chemical waste as defined under the *Waste Disposal (Chemical Waste) (General) Regulation* includes any substance being scrap material, or unwanted substances specified under *Schedule 1* of the *Regulation*, if such a substance or chemical occurs in such a form, quantity or concentration so as to cause pollution or constitute a danger to health or risk of pollution to the environment.

Chemical waste producers shall register with the EPD. Any person who contravenes this requirement commits an offence and is liable to a fine and imprisonment. Producers of chemical wastes must treat their wastes, utilising on-site plant licensed by the EPD or have a licensed collector take the wastes to a licensed facility. For each consignment of wastes, the waste producer, collector and disposer of the wastes must sign all relevant parts of a computerised trip ticket. The system is designed to allow the transfer of wastes to be traced from cradle-to-grave.

The *Regulation* prescribes the storage facilities to be provided on site including labelling and warning signs. To minimise the risks of pollution and danger to human health or life, the waste producer is required to prepare and make available written procedures to be observed in the case of emergencies due to spillage, leakage or accidents arising from the storage of chemical wastes. He/she must also provide employees with training in such procedures.

7.2.3 *Land (Miscellaneous Provisions) Ordinance (Cap 28)*

The inert portion of construction waste [(1)] (also called public fill) may be taken to public fill reception facilities. Public fill reception facilities are operated by the Civil Engineering and Development Department (CEDD). The *Land (Miscellaneous Provisions) Ordinance* requires that individuals or companies who deliver public fill to the public fill reception facilities obtain Dumping Licences. The licences are issued by the CEDD under delegated authority from the Director of Lands.

Individual licences and windscreen stickers are issued for each vehicle involved. Under the licence conditions, public fill reception facilities will only accept inert earth, soil, sand, rock, boulder, rubble, brick, tile, concrete, asphalt, masonry or used bentonite. In addition, in accordance with paragraph 11 of ETWB-TC (Works) No. 31/2004, Public Fill Committee will advise on the acceptance criteria (eg no mixing of construction waste, norminal size of the materials less than 250mm, etc. The material should, however, be free from marine mud, household refuse, plastic, metal, industrial and chemical wastes, animal and vegetable matter and any other materials considered unsuitable by the public fill reception facility.

7.2.4 *Public Cleansing and Prevention of Nuisances Regulation*

This *Regulation* provides further control on the illegal dumping of wastes on unauthorised (unlicensed) sites. The illegal dumping of wastes can lead to a fine and/or imprisonment.

7.2.5 *Other Relevant Guidelines*

Other 'guideline' documents, which detail how the project proponent or contractor should comply with the local regulations, are as follows:

- *Waste Disposal Plan for Hong Kong* (December 1989), Planning, Environment and Lands Branch Government Secretariat, Hong Kong Government;
- *Environmental Guidelines for Planning In Hong Kong* (1990), Hong Kong Planning Standards and Guidelines, Hong Kong Government;

(1) "Construction waste" refers to materials arising from any land excavation or formation, civil/building construction, road works, building renovation or demolition activities. It includes various types of reusable materials, building debris, rubble, earth, concrete, timber and mixed site clearance materials. When sorted properly, materials suitable for land reclamation and site formation (known as public fill) should be reused at public fill reception facilities. The rock and concrete can be crushed and processed to produce aggregates for various civil and building engineering applications. The remaining construction waste (comprising timber, paper, plastics, and general refuse) are to be disposed of at landfills.

- *New Disposal Arrangements for Construction Waste* (1992), EPD & CED, Hong Kong Government;
- *Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes* (1992), EPD, Hong Kong Government;
- *Works Branch Technical Circular (WBTC) No. 32/92, The Use of Tropical Hard Wood on Construction Site*; Works Branch, Hong Kong Government;
- *WBTC No. 2/93, Public Dumps.* Works Branch, Hong Kong Government;
- *WBTC No. 2/93B, Public Filling Facilities*, Works Branch, Hong Kong Government;
- *Waste Reduction Framework Plan, 1998 to 2007*, Planning, Environment and Lands Bureau, Government Secretariat, 5 November 1998;
- *WBTC Nos. 25/99, 25/99A* and *25/99C, Incorporation of Information on Construction and Demolition Material Management in Public Works Sub-committee Papers*; Works Bureau, Hong Kong SAR Government;
- *WBTC No. 12/2000, Fill Management*; Works Bureau, Hong Kong SAR Government;
- *ETWBTC No. 33/2002, Management of Construction and Demolition Material Including Rock*; Environment, Transport and Works Bureau, Hong Kong SAR Government;
- *ETWBTC No. 31/2004, Trip Ticket System for Disposal of Construction & Demolition Materials*, Environment, Transport and Works Bureau, Hong Kong SAR Government; and
- Environment, Transport and Works Bureau (ETWB) Technical Circular (Works) No. 19/2005, *Environmental Management on Construction Sites*, Hong Kong SAR.

7.3 EXPECTED WASTE ARISINGS DURING THE CONSTRUCTION PHASE

During the construction phase, the main activities, which will potentially result in the generation of waste, include site clearance, site formation, demolition of infrastructure at the existing SENT Landfill and construction of new infrastructure. The typical waste types associated with these activities include:

- excavated material;
- construction waste;
- chemical waste;
- sewage; and
- general refuse.

7.3.1 *Excavated Material*

The Extension Site is currently occupied by CEDD's fill bank operation in TKO Area 137 and the existing infrastructure area of the SENT Landfill. It is anticipated that CEDD's contractor will be responsible for removal of the fill material, which is currently being piled up to about 15 mPD, before handing over the site to EPD. The existing infrastructure of the SENT Landfill will be demolished after the new infrastructure at the Extension has been constructed and commissioned. The Extension Site will also occupy approximately 5 ha of natural hill slope and require the construction of two 2,000mm diameter drainage tunnels underneath the hill next to TKO Area 137. To form the slope suitable for use by the Extension, blasting will be required.

The quantity of excavated material to be generated during the 2-year construction period is around 1.1 Mm^3 (approximately 0.8 Mm^3 is soil and 0.3 Mm^3 is rock), mainly from the slope formation work.

Approximately 563,000 m^3 of the excavated materials generated from the slope works will be reused on-site for formation of the landfill base and the leachate drainage layer. The excavated rock will be reused as leachate drainage stone and fill material after crushing at the on-site stone crushing plant. It is estimated that a surplus of 527,000 m^3 of excavated material (including soil and rock) will be generated during the construction period. The total fill requirement during the construction phase can be met by reuse of excavated material. Import of fill material is not required during the construction phase.

Fill material will be required for the operation/restoration phase of the Extension for daily, intermediate and final covers and engineering works. The estimated volume of fill material required is shown in *Table 7.3a*.

Table 7.3a Cut & Fill Requirement by the Extension

Phases	**Volume of Excavated Material Generated (Mm^3)**	**Volume of Fill Material Required (Mm^3) [a]**
Construction	1.1	0.6
Phase 1	-	0.4
Phase 2	-	0.5
Phase 3	-	0.5
Phase 4	-	0.6
Phase 5	-	0.7
Phase 6	-	0.7
Total	**1.1**	**4.0**

Note:

(a) During the construction period, the excavated material will be used for site formation and construction of leachate collection layer. For Phases 1 to 6, the fill material will be required for landfill cover and miscellaneous engineering works.

It can be seen from *Table 7.3a* that the overall quantity of fill material required is in excess of the quantity of excavated material generated. Ideally, all excavated materials will be reused on-site for site formation, engineering works, lining, and daily/intermediate/final cover. However, in view of the relatively small size of the Site and the construction and operation sequence, it would be difficult to stockpile all the surplus material within the site boundary as frequent relocation of the stockpile would be required in order to carry out site formation work. Due to the shape and size of the Extension Site, it is necessary to form and line the entire base of the landfill prior to commencement of waste placement. Frequent relocation of the stockpile material on top of the liner and drainage layer in the first year (Phase 1) of landfill operation may damage the liner.

Given the Site constraints discussed above, approximately 10,000 m^3 of excavated material will be stored on site during the construction period and the initial period of Phase 1. The surplus 517,000 m^3 of excavated materials will be transported off-site to other construction sites for reuse. As a last resort, the surplus material will be disposed of at the planned Construction and Demolition (C&D) Material Handling Facility at TKO Area 137 or the Anderson Road Quarry, subject to agreement with the quarry operator and permission from the Mines Division of CEDD. As shown in *Table 7.3a*, import of fill material will be required throughout the operation of the Extension. Similar to the practice at the existing SENT Landfill, fill material can be obtained from local construction industries. Another option is to obtain fill material from the C&D Material Handling Facilities and quarries, subject to review and the prevailing operational condition at these facilities.

Approximately 1,500 tonnes of non-inert waste (comprising mainly vegetation) which generated from the site clearance works will be disposed of at the SENT Landfill.

7.3.2 *Construction Waste*

C&D material (consisting of concrete, brick, wood, packing materials, plastics, metal, steel and general refuse) will be generated from the demolition of existing structures at the infrastructure area of SENT Landfill and the construction of new buildings in the infrastructure area of the Extension. The main structures including its gross floor area (GFA) to be demolished and constructed during the construction phase are summarised in *Table 7.3b*.

Table 7.3b GFA of Major Buildings to be Demolished and Constructed

Demolished / Constructed Buildings	**GFA (m^2)**
Buildings to be demolished at the existing infrastructure area of SENT Landfill	
Offices and Laboratory	1,361
Gasoline Equipment Room	112
Bioplant Building	973
Genset Building	422
Maintenance Building	1,242
Total	**4,110**
Buildings to be constructed at the new infrastructure area of the Extension	
Offices and Laboratory	2,820
LTP Building	1,020

Demolished / Constructed Buildings	GFA (m^2)
Genset Building	420
Maintenance Workshop	1,980
Total	**6,240**

Based on the generation rate of 0.7 m^3 per m^2 of GFA demolished (1), it is estimated that a total of about 2,877 m^3 of construction waste will be generated from the demolition work at the existing SENT Landfill. Based on the generation rate of 0.1 m^3 per m^2 of GFA constructed (2), it is estimated that a total of about 624 m^3 of construction waste will be generated from the construction of new buildings at the Extension. The construction waste will be sorted on-site into an inert portion (also referred to as public fill, about 2,800 m^3) and a non-inert portion (referred to as construction waste, about 700 m^3) (3) in order to reduce the amount of construction waste to be disposed of at SENT Landfill. The public fill will be reused on-site as fill material and miscellaneous engineering works while the 700m^3 of construction waste will be disposed of at the SENT Landfill.

The construction waste will be transported to the SENT Landfill via an internal road linking the two landfills. With the proper implementation of good construction site practice, the handling and transportation of construction waste to the SENT Landfill will not cause adverse dust, noise or water quality impacts.

7.3.3 *Chemical Wastes*

Chemical waste, as defined under the *Waste Disposal (Chemical Waste) (General) Regulation*, includes any unwanted substances specified under *Schedule 1* of the *Regulation*. Substances likely to be generated from the construction of the Extension will include:

- Used paint, engine oils, hydraulic fluids and waste fuel;
- Spent mineral oils/cleaning fluids from mechanical machinery; and
- Spent solvents/solutions from equipment cleaning activities.

Chemical wastes may pose environmental, health and safety hazards if not stored and disposed of in an appropriate manner as outlined in the *Waste Disposal (Chemical Waste) (General) Regulation* and the *Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes*. These hazards may include:

- Toxic effects to workers;
- Adverse effects on air, water and land from spills; and

(1) Hong Kong Polytechnics (March 1993) Reduction of Construction Waste Final Report.

(2) Hong Kong Polytechnics (March 1993) Reduction of Construction Waste Final Report.

(3) Approximate ratio for (inert waste): (non-inert waste) is 8:2 (Source: Monitoring of Solid Waste in Hong Kong 1997).

- Fire hazards.

The amount of chemical waste that will arise from the construction activities will be highly dependent on the Contractor's on-site maintenance activities and the quantity of plant and equipment utilised. With respect to the scale of the construction activities, it is anticipated that the quantity of chemical waste to be generated will be small (less than a hundred litres per month during the construction phase).

With the incorporation of suitable arrangements for the storage, handling, transportation and disposal of chemical wastes under the requirements stated in the *Waste Disposal (Chemical Waste) (General) Regulation* and the *Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes*, no adverse environmental and health impacts, and hazards will result from the handling, transportation and disposal of chemical waste arising from the Extension.

7.3.4 Sewage

Sewage will arise from the construction workforce. It is estimated that a maximum of about 170 workers will be working at the site at any one time. With a sewage generation rate of 0.15 m^3 per worker per day, about 25.5 m^3 of sewage will be generated per day. An adequate number of portable toilets will be provided at the site to ensure that sewage from site staff is properly collected. The portable toilets will be desludged and maintained regularly by a specialist contractor. No adverse environmental impacts are envisaged.

7.3.5 General Refuse

The presence of a construction site with workers and associate site office will result in the generation of general refuse (mainly consists of food waste, aluminium cans and waste paper) which requires off-site disposal. The storage of general refuse has the potential to give rise to adverse environmental impacts. These include odour if the waste is not collected frequently, windblown litter and visual impact.

Assuming up to 170 construction workers will be working on site at any one time, with a general refuse generation rate of 0.65 kg per worker per day, the maximum amount of general refuse to be generated will be about 110.5 kg per day.

Recyclable materials (ie paper, plastic bottles and aluminium cans) will be separated for recycling, in order to reduce the amount of general refuse to be disposed of at landfill. Adequate number of enclosed waste containers will be provided to avoid over-spillage of waste.

The non-recyclable refuse will be placed in bags and stored in enclosed containers, and disposed of on a daily basis to the SENT Landfill. Given that the quantity of general refuse to be disposed of at SENT Landfill is small, no adverse impact on the operation of the landfill is anticipated.

With the implementation of the mitigation measures recommended in *Section 7.6.1*, no adverse environmental impacts caused by the storage, handling, transport and disposal of general refuse are expected.

7.4 EXPECTED WASTE ARISINGS DURING OPERATIONAL/RESTORATION PHASE

Landfill operation and restoration are not waste generating activities. Waste generated during the operational and restoration phases is mainly confined to:

- sludge from the LTP;
- chemical waste;
- sewage; and
- general refuse.

7.4.1 Sludge

Sludge will be generated from the LTP. It is estimated that at the maximum design flow rate during the 1st year of the LTP operation, approximately 72.8 m^3 of sludge (at 2% solids) will be generated per day. It is recommended to dewater the sludge to about 30% dry solids (about 4.9 $m^3\ d^{-1}$) prior to disposal at the SENT Landfill tipping face. The dewatered sludge will be transported by truck to the tipping face. Following the closure of the existing SENT Landfill, the volume of leachate will be reduced and the quantity of sludge generated will be reduced to about 1.2 m^3d^{-1}. The sludge will be disposed of at the Extension tipping face. It is not expected that this small quantity of sludge will affect the landfill operation or result in adverse environmental impacts.

7.4.2 Chemical Waste

The operation and restoration work will involve the use of mechanical machinery. Similar to the construction activities, the chemical waste likely to be generated during the operation and restoration of the Extension may include:

- Used paint, engine oils, hydraulic fluids and waste fuel;
- Spent mineral oils/cleaning fluids from mechanical machinery; and
- Spent solvents/solutions from equipment cleaning activities.

The amount of chemical waste (mainly waste lube oil from maintenance of plant and equipment) that will arise from the operation and restoration activities will vary on monthly basis depending on the maintenance schedule. With reference to the existing SENT Landfill operation, it is anticipated that the quantity of chemical waste to be generated during the operation/ restoration phase will be small (on average less than a hundred litres per month).

With the incorporation of suitable arrangements for the storage, handling, transportation and disposal of chemical wastes in accordance with the requirements stated in the *Waste Disposal (Chemical Waste) (General) Regulation* and the *Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes*, no adverse environmental and health impacts, and hazards will result from the handling, transportation and disposal of chemical waste arising from the Extension.

It should be noted that the operations of the existing strategic landfills have demonstrated that with proper management of the chemical wastes generated on-site, there are no adverse environmental impacts.

7.4.3 Sewage

Sewage will arise from the operation staff. It is estimated that a maximum of about 150 staff will be working at the site at any one time. With a sewage generation rate of 0.15 m^3 per person per day, about 22.5 m^3 of sewage will be generated per day. The sewage will be treated at the LTP. No adverse environmental impacts are envisaged.

7.4.4 General Refuse

General refuse will arise from the operation staff and administrative activities. General refuse may consist of food waste, plastic, aluminium can and waste paper. With a general refuse generation rate of 0.65 kg per person per day, the amount of general refuse to be generated will be about 97.5 kg per day.

Recyclable materials (ie paper, plastic bottles and aluminium cans) will be separated for recycling, in order to reduce the amount of general refuse to be disposed of at the landfill. Adequate number of enclosed waste containers will be provided to avoid over-spillage of waste. The non-recyclable refuse will be placed in bags and disposed of at the tipping face on a daily basis. With respect to the small quantity of general refuse to be disposed of at the Extension, no adverse impact on the operation of the Extension is anticipated.

7.5 EXPECTED WASTE ARISINGS DURING AFTERCARE PHASE

During the aftercare phase, the main activities at the Extension will be the continual operation of the landfill gas and leachate management facilities and some minor maintenance work, if necessary. A small quantity of wastes will be generated during this phase which mainly consist of:

- sludge from the LTP;
- sewage; and
- general refuse.

7.5.1 *Sludge*

Sludge will be generated from the continual operation of the LTP during the aftercare phase. Once the landfill is restored, the leachate generation will be significantly reduced and hence a decrease in the quantity of sludge. It is estimated that approximately 0.33 m^3 of sludge (at 30% solids) will be generated per day. The dewatered sludge will be delivered in enclosed containers to other waste disposal facilities, eg other landfills or the sludge treatment facility for disposal. It is not expected that this small quantity of sludge will affect the operation of other waste disposal facilities or result in adverse environmental impacts.

7.5.2 *Sewage*

Sewage will arise from the operation staff. It is estimated that a maximum of about 20 staff will be working at the site at any one time. With a sewage generation rate of 0.15 m^3 per person per day, about 3 m^3 of sewage will be generated per day. The sewage will be treated at the LTP. No adverse environmental impacts are envisaged.

7.5.3 *General Refuse*

General refuse will arise from the operation staff and administrative activities. General refuse may consist of food waste, plastic, aluminium can and waste paper. With a general refuse generation rate of 0.65 kg per person per day, the amount of general refuse to be generated will be about 13 kg per day.

Recyclable materials (ie paper, plastic bottles and aluminium cans) will be separated for recycling, in order to reduce the amount of general refuse to be disposed of at the landfill. Adequate number of enclosed waste containers will be provided to avoid over-spillage of waste. The non-recyclable refuse will be placed in bags and disposed of at other waste disposal facility eg other landfills or transfer station on a daily basis. With respect to the small quantity of general refuse to be disposed of at the waste disposal facility, no adverse impact environmental impact is anticipated.

7.6 *MITIGATION MEASURES*

7.6.1 *Construction Phase*

The assessment indicates that with the implementation of the proposed waste management practices at the work sites, no adverse environmental impacts are envisaged for the handling, collection and disposal of waste arising from the construction of the Extension.

This section further describes the good construction site practices to avoid or further reduce the potential environmental impacts associated with the handling, collection and disposal of construction and chemical wastes arising from the construction of the Extension.

The Contractor must ensure that all the necessary waste disposal permits or licences are obtained prior to the commencement of the construction works.

Management of Waste Disposal

The construction contractor will open a billing account with the EPD in accordance with the *Waste Disposal (Charges for Disposal of Construction Waste) Regulation*. Every construction waste or public fill load to be transferred to the Government waste disposal facilities such as public fill reception facilities, sorting facilities, landfills will require a valid "chit" which contains the information of the account holder to facilitate waste transaction recording and billing to the waste producer. A trip-ticket system will also be established in accordance with *ETWB-TC (Works) No.31/2004* to monitor the disposal of construction waste at the SENT Landfill and to control fly-tipping. The trip-ticket system will be included as one of the contractual requirements and implemented by the contractor.

A recording system (similar to summary table as shown in Annex 5 and Annex 6 of Appendix G of *ETWBTC No. 19/2005*) for the amount of waste generated, recycled and disposed of (including the disposal sites) will be established during the construction phase.

Measures for the Reduction of Construction Waste Generation

Construction waste will be segregated on-site into inert and non-inert materials and stored in different containers or skips to facilitate reuse of the inert materials and proper disposal of the non-inert construction waste. Specific areas of the work site will be designated for such segregation and storage if immediate use is not practicable.

Chemical Waste

The contractor will register as a chemical waste producer with the EPD. Chemical waste will be handled in accordance with the *Code of Practice on the Packaging, Handling and Storage of Chemical Wastes* as follows.

Containers used for storage of chemical wastes will:

- Be suitable for the substance they are holding, resistant to corrosion, maintained in a good condition, and securely closed;
- Have a capacity of less than 450 L unless the specifications have been approved by the EPD; and
- Display a label in English and Chinese in accordance with instructions prescribed in *Schedule 2* of the *Regulations*.

The storage area for chemical wastes will:

- Be clearly labelled and used solely for the storage of chemical waste;
- Be enclosed on at least 3 sides;

- Have an impermeable floor and bunding, of capacity to accommodate 110% of the volume of the largest container or 20% by volume of the chemical waste stored in that area, whichever is the greatest;
- Have adequate ventilation;
- Be covered to prevent rainfall entering (water collected within the bund must be tested and disposed of as chemical waste, if necessary); and
- Be arranged so that incompatible materials are appropriately separated.

Chemical waste will be disposed of:

- Via a licensed waste collector; and
- To a facility licensed to receive chemical waste, such as the Chemical Waste Treatment Facility which also offers a chemical waste collection service and can supply the necessary storage containers.

Sewage

An adequate number of portable toilets will be provided at the site to ensure that sewage from site staff is properly collected. The portable toilets will be desludged and maintained regularly by a specialist contractor.

General Refuse

General refuse will be stored in enclosed bins separately from construction and chemical wastes. The general refuse will be delivered to the SENT Landfill, separately from construction and chemical wastes, on a daily basis to reduce odour, pest and litter impacts.

Recycling bins will be provided at strategic locations to facilitate recovery of aluminium can and waste paper from the Extension Site. Materials recovered will be sold for recycling.

Staff Training

At the commencement of the construction works, training will be provided to workers on the concepts of site cleanliness and on appropriate waste management procedures, including waste reduction, reuse and recycling.

7.6.2 Operation/ Restoration Phase

Sludge

The Contractor will ensure that all sludge generated from the LTP will be transported to the tipping face in enclosed containers. The small quantity of sludge will be mixed with MSW and covered by construction waste immediately after tipping.

Chemical Waste

Measures are similar to those outlined in *Section 7.6.1*.

Sewage

All sewage from the operation staff will be diverted to the LTP for treatment or the foul sewer if available.

General Refuse

General refuse will be stored in enclosed bins and disposed of at the tipping area on a daily basis to reduce odour, pest and litter impacts.

Recycling bins will be provided at strategic locations to facilitate recovery of aluminium can and waste paper from the Extension Site. Materials recovered will be sold for recycling.

7.6.3 *Aftercare Phase*

Sludge

The Contractor will ensure that all dewatered sludge (>30% dry solids) generated from the LTP be transported to a waste disposal facility, eg other landfills or a sludge treatment facility, for proper disposal on a daily basis.

Sewage

All sewage from the aftercare staff will be treated at the LTP or the foul sewer if available.

General Refuse

General refuse will be stored in enclosed bins and disposed of at a waste disposal facility eg other landfills or transfer stations on a daily basis to reduce odour, pest and litter impacts.

Recycling bins will be provided at strategic locations to facilitate recovery of aluminium can and waste paper from the Extension Site. Materials recovered will be sold for recycling.

7.7 *RESIDUAL ENVIRONMENTAL IMPACTS*

No residual waste management impact is envisaged during the construction, operation, restoration and aftercare of the Extension.

7.8 *ENVIRONMENTAL MONITORING AND AUDIT*

It is recommended that weekly audits of the waste management practices be carried out during the construction and operation/restoration phases to determine if wastes are being managed in accordance with the recommended good site practices. The audits will examine all aspects of waste management including waste generation, storage, recycling, transport and disposal. Audit of waste management practices during the aftercare phase is not considered necessary given that the amount of waste to be handled is small.

7.9 CONCLUSIONS

7.9.1 *Construction Phase*

The key potential impacts during the construction phase are related to wastes generated from site clearance, site formation, demolition of the existing SENT Landfill infrastructure and construction of new infrastructure.

It is estimated that approximately 1.1 Mm^3 of excavated material (consisting of about 0.8 Mm^3 of soil and 0.3 Mm^3 of rock) will be generated, mainly from the slope formation work. Approximately 563,000m^3 of the excavated materials will be reused on-site for the site formation work during the construction phase. A further 10,000m^3 of the excavated material will be stockpiled on-site for reuse during the Phase 1 landfill operation. The remaining excavated materials (517,000 m^3) will be delivered to other construction sites for reuse or the C&D Material Handling Facility and the Anderson Road Quarry, subject to agreement with the quarry operator and permission from the Mines Division of CEDD. Import of fill material will be required throughout the operation of the Extension. These materials could be obtained from the local construction industries, C&D Material Handling Facilities and the quarry, subject to review and the prevailing operational condition at these facilities.

It is estimated that approximately 2,800 m^3 of inert construction waste (public fill) will be generated from the construction and demolition of infrastructure. These materials will be reused on-site for fill material and miscellaneous engineering works.

Approximately 1,500 tonnes of construction waste will be generated from site clearance and 700 m^3 of construction waste will be generated from the construction and demolition of infrastructure and will be disposed of at the SENT Landfill. Small amounts of chemical waste (less than a hundred litres per month), sewage (about 25.5 m^3 per day) and general refuse (about 110.5 kg per day) will be generated during the construction phase.

With the implementation of general good construction site practices, the construction of the Extension will not cause adverse waste management or environmental impacts.

7.9.2 *Operation/Restoration Phase*

It is estimated that dewatered sludge (maximum at about 4.9 m^3 per day at 30% dry solids), chemical waste (less than a hundred litres per month), sewage (22.5 m^3 per day) and general refuse (97.5 kg per day) will be generated during the operation/restoration phase. With good site practices, the potential environmental impacts associated with the storage, handling, collection, transport and disposal of waste arising from the operation and restoration of the Extension will meet the criteria specified in the *EIAO-TM* and no adverse waste management impacts are anticipated.

7.9.3 Aftercare Phase

Small quantities of dewatered sludge (about 0.33 m^3 per day), sewage (3 m^3 per day) and general refuse (13 kg per day) will be generated during the aftercare of the Extension. While the sewage will be treated in the LTP, the dewatered sludge and general refuse will be disposed at other waste disposal facilities.

With good site practices, the potential environmental impacts associated with the storage, handling, collection, transport and disposal of the small quantity of waste arising from the aftercare of the Extension will meet the criteria specified in the *EIAO-TM* and no adverse waste management impacts are anticipated.

8 LANDFILL GAS HAZARDS

8.1 BACKGROUND TO THE STUDY

The Extension will be located adjacent to the SENT Landfill with a portion piggybacking onto the south slope of the SENT Landfill. *Figure 3.1a* shows the location of the SENT Landfill and the Extension. The Extension will be a new source of landfill gas generation.

There are potential risks associated with developments close to a landfill site due to sub-surface migration of landfill gas. This Section describes the methodology and presents the findings of a qualitative landfill gas hazard assessment of the Extension.

8.2 PROCEDURES AND GUIDELINES

Under *Annex 7* of the *EIAO-TM*, an evaluation of the potential risk posed by landfill gas is required for any development which is proposed within 250m of the edge of waste, known as Landfill Consultation Zone. As the Extension Site falls within the SENT Landfill Consultation Zone (see *Figure 8.2a*), a Qualitative Landfill Gas Hazards Assessment (QLFGHA) is required to assess the potential risk due to landfill gas migration from the SENT Landfill to the Extension.

A *Practice Note for Professional Person* (*ProPECC PN 3/96*) [1] and *Guidance Note*[2] for the assessment of the hazards which landfill gas may present to developments close to landfills have been issued by the EPD. 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*. The *ProPECC PN 3/96* and *Guidance Note* apply to all developments proposed within 250m of the edge of the waste boundary, known as the Landfill Consultation Zone.

As the Extension is located adjacent to the existing development in the TKOIE and future industrial development in TKO Area 137, a QLFGHA will be required for developments within 250m of the Extension (see *Figure 8.2a*).

8.3 SCOPE OF THIS STUDY

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

- review of background information (including landfill gas monitoring data) and studies related to the SENT Landfill and the Extension;

(1) ProPECC PN3/96 Landfill Gas Hazard Assessment for Developments adjacent to Landfills, Dec 1996, EPD.

(2) Landfill Gas Hazard Assessment Guidance Note, 1997, EPD.

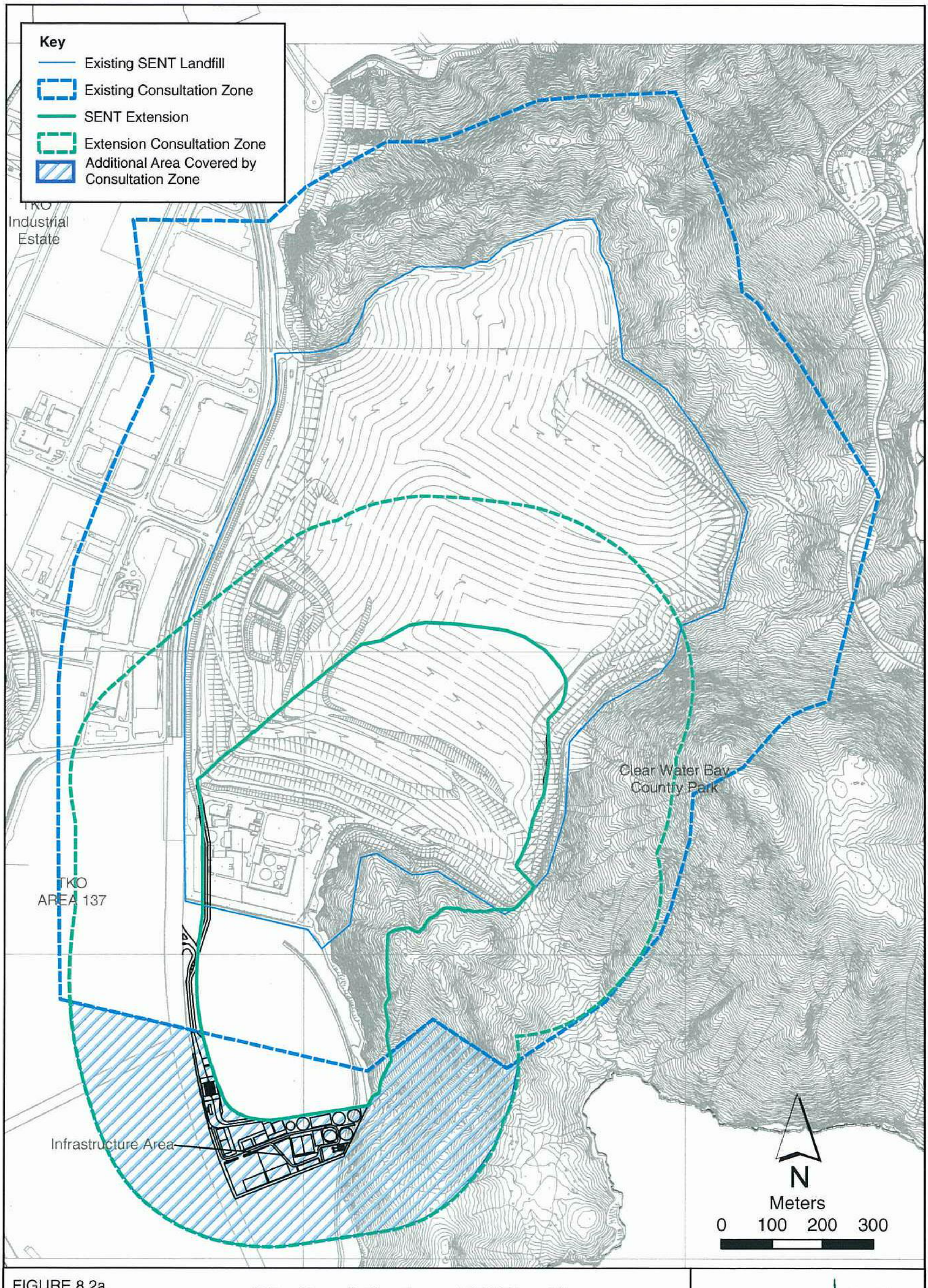

FIGURE 8.2a

250m Consultation Zone of SENT Landfill and the Extension

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Environmental Resources Management
ERM

- identification of the nature and extent of the sources, including the likely concentrations and/or amounts of landfill gas emissions which might have the potential for impacts on the Extension and impacts from the Extension to the potential receivers;

- identification of possible pathways through the ground, underground cavities, utilities or groundwater, and the nature of these pathways through which the landfill gas must traverse if they were to reach the Extension and the new consultation zone;

- identification of the potential receivers associated with the Extension which are sensitive to the impacts of landfill gas emissions;

- qualitative assessment on the degree of risk which the landfill gas emissions may impose on the receivers for each of the source-pathway-receiver combinations; and

- design of suitable level of precautionary measures and contingency plan for the Extension and the potential receivers, if needed.

8.4 LANDFILL GAS ASSESSMENT CRITERIA AND METHODOLOGY

In accordance with the *Guidance Note on Landfill Gas Hazard Assessment,* the risk due to landfill gas may be evaluated based upon the following three criteria:

- *Source* - the rate and concentration of gas generation by the landfill;

- *Pathway* - the nature of and length of potential pathways through which landfill gas can migrate and leachate flow, such as geological strata, utility services; and

- *Target* - the level of vulnerability of various elements of the development to landfill gas.

Each of these criteria is further described in the sub-sections below.

8.4.1 Source

The classification of the Source (ie the landfill) is determined as follows:

Major Recently filled landfill site at which there is little or no control to prevent migration of gas or at which the efficacy of the gas control measures has not been assessed; or

Any landfill site at which monitoring has demonstrated that there is significant migration of gas beyond the site boundary.

Medium	Landfill site at which some form of gas control has been installed (eg lined site or one where vents or barriers have been retrospectively installed) but where there are only limited monitoring data to demonstrate its efficacy to prevent migration of gas; or Landfill site where comprehensive monitoring has demonstrated that there is no migration of gas beyond the landfill boundary but where the control of gas relies solely on an active gas extraction system or any other single control system which is vulnerable to failure.
Minor	Landfill sites at which gas controls have been installed and proven to be effective by comprehensive monitoring which has demonstrated that there is no migration of gas beyond the landfill boundary (or any specific control measures) and at which control of gas does not rely solely on an active gas extraction system or any other single control measure which is vulnerable to failure; or Old landfill sites where the maximum concentration of methane within the waste, as measured at several locations across the landfill and on at least four occasions over a period of at least 6 months, is less than 5% (v/v).

8.4.2 Pathway

Generally, three types of pathway are considered for the transmission of landfill gas. They are:

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

The broad classification of a Pathway is as follows:

Very short/direct	Path length of less than 50m for unsaturated permeable strata and fissured rock or less than 100m for man-made conduits
Moderately short/direct	Path length of 50 to 100m for unsaturated permeable soil or fissured rock or 100 to 250 m for man-made conduits
Long/indirect	Path length of 100 to 250m for unsaturated permeable soils and fissured rock

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

- a broad assessment of the specific permeability of the soil;
- spacing, tightness and direction of the fissures/joints;
- topography;
- depth and thickness of the medium through which the gas may migrate (which may be affected by groundwater level);
- the nature of the strata over the potential pathway;
- the number of different media involved; and
- depth to groundwater table and groundwater flow patterns.

8.4.3 Target

Different levels of vulnerability or sensitivity of potential targets for landfill gas have been classified as follows:

High Sensitivity

- Buildings and structures with ground level or below ground rooms/voids or into which services enter directly from the ground and to which members of the general public have-unrestricted access or which contain sources of ignition.
- This would include any developments where there is a possibility of additional structures being erected directly on the ground on an *ad hoc* basis and thereby without due regard to the potential risks.

Medium Sensitivity

- Other buildings, structures or service voids where there is access only by authorised, well trained personnel, such as the staff of utility companies, who have been briefed on the potential hazards relating to landfill gas 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.

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

8.4.4 *Assessment of Risk Criteria*

Following the determination of the categories for the source, pathway and target in which the landfill, pathway and development fall, a qualitative assessment of the overall risk may be made by reference to *Table 8.4a* which is extracted from the *EPD's Guidance Note on Landfill Gas Hazard Assessment*. The potential implications associated with the various qualitative risk categories are summarised in *Table 8.4b*. It should be noted that the different levels of risk determine the likely extent of the protection measures required to ensure the safety of a development, but with the possible exception of the very high risk category, development is not precluded for any of the assessed levels of risk.

Table 8.4a Classification of Risk Category

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

Table 8.4b Summary of General Categorisations of Risk

Level of Risk	Implication
Very high	At the very least, extensive engineering measures and alarm systems are likely to be required. An emergency actions plan should also be developed so that appropriate actions may be immediately taken in the event of high gas concentrations being detected within the development.
High	Significant engineering measures will be required to protect the planned development.
Medium	Engineering measures required to protect the development.
Low	Some precautionary measures will be required to ensure that the planned development is safe.
Very low	No protection or precautionary measures are required.

8.5 ASSESSMENT OF POTENTIAL RISK

8.5.1 *The Source*

SENT Landfill - History

SENT landfill is located on the western edge of Clear Water Bay Peninsula in the south-eastern corner of the New Territories. The site covers an area of about 100 ha, half of which has been reclaimed from Shek Biu Wan (Junk Bay). To the north and east of the site lies Clear Water Bay Country Park; to the west lies land reclaimed as industrial estate and to the south a reclamation (TKO Area 137) intended for industrial uses.

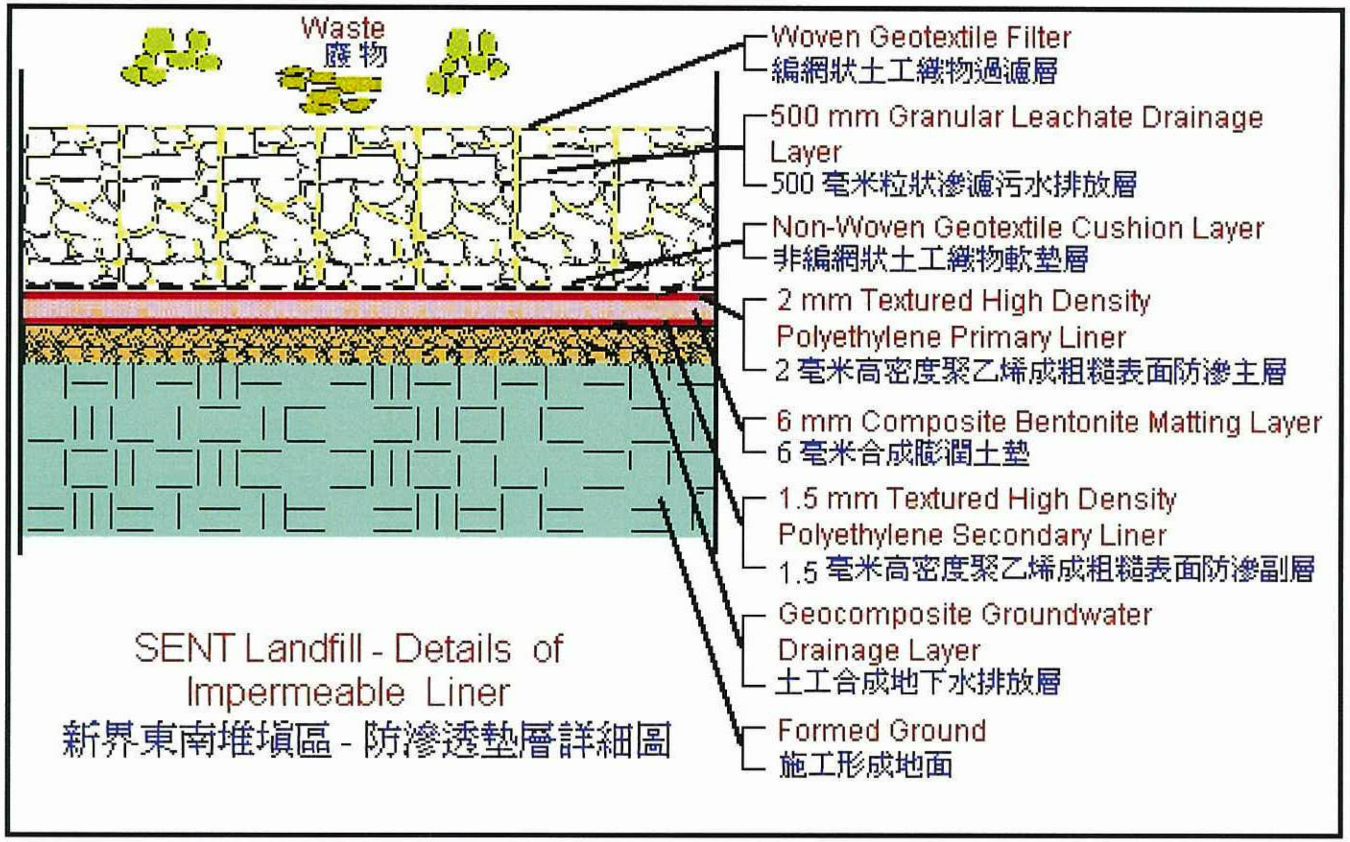
The landfill is one of the three strategic landfills in operation in the SAR and was designed to receive approximately 43 Mm^3 of waste over a period initially projected as 15 to 17 years. The landfill commenced operation in 1994 and accepts domestic, commercial & industrial (C&I), construction, and clinical wastes, sewage sludge and stablised incineration residues. However, the landfill is filling faster than originally projected and the latest forecast shows that the landfill will be full by around 2012.

In the landfill gas generation forecast undertaken as part of this Study, it has been estimated that the landfill will typically generate between 100 and 140 Mm^3 of gas per year throughout its operational life. Gas generation was predicted to peak at about 150 Mm^3 per year in 2014, approximately 2 years after the landfill is closed.

SENT Landfill - Landfill Gas Control

The landfill has been designed to incorporate extensive measures to contain, collect, and treat/utilise landfill gas. Such measures include the state-of-the-art technologies (including a composite liner systems, active landfill gas extraction and landfill gas treatment and utilisation) in accordance with international best practices for landfill operations. The landfill gas extraction system contains two skids, each with spare parts. While only one skid is in operation at one time, the other skid serves as an emergency backup. The landfill contractor is undertaking routine maintenance and checking of the landfill gas extraction system to ensure it is operating satisfactorily. As the site is lined and landfill gas is collected and treated, it effectively controls sub-surface off-site migration of landfill gas. Typical details of the composite liner system (including an impermeable liner) installed at the SENT Landfill are presented in *Figure 8.5a*.

A comprehensive environmental monitoring programme has been implemented to monitor landfill gas generated within the landfill and at the perimeter boreholes around the landfill. Under the existing contract, the landfill contractor will be required to continue the control and monitoring of landfill gas following closure of the landfill for a period of 30 years. Recent monitoring results from the boreholes located along the southern boundary of SENT Landfill have been reviewed. *Figure 8.5b* shows the locations of these



Source : EPD Website

Figure 8.5a

Typical Details of Impermeable Liner at SENT Landfill

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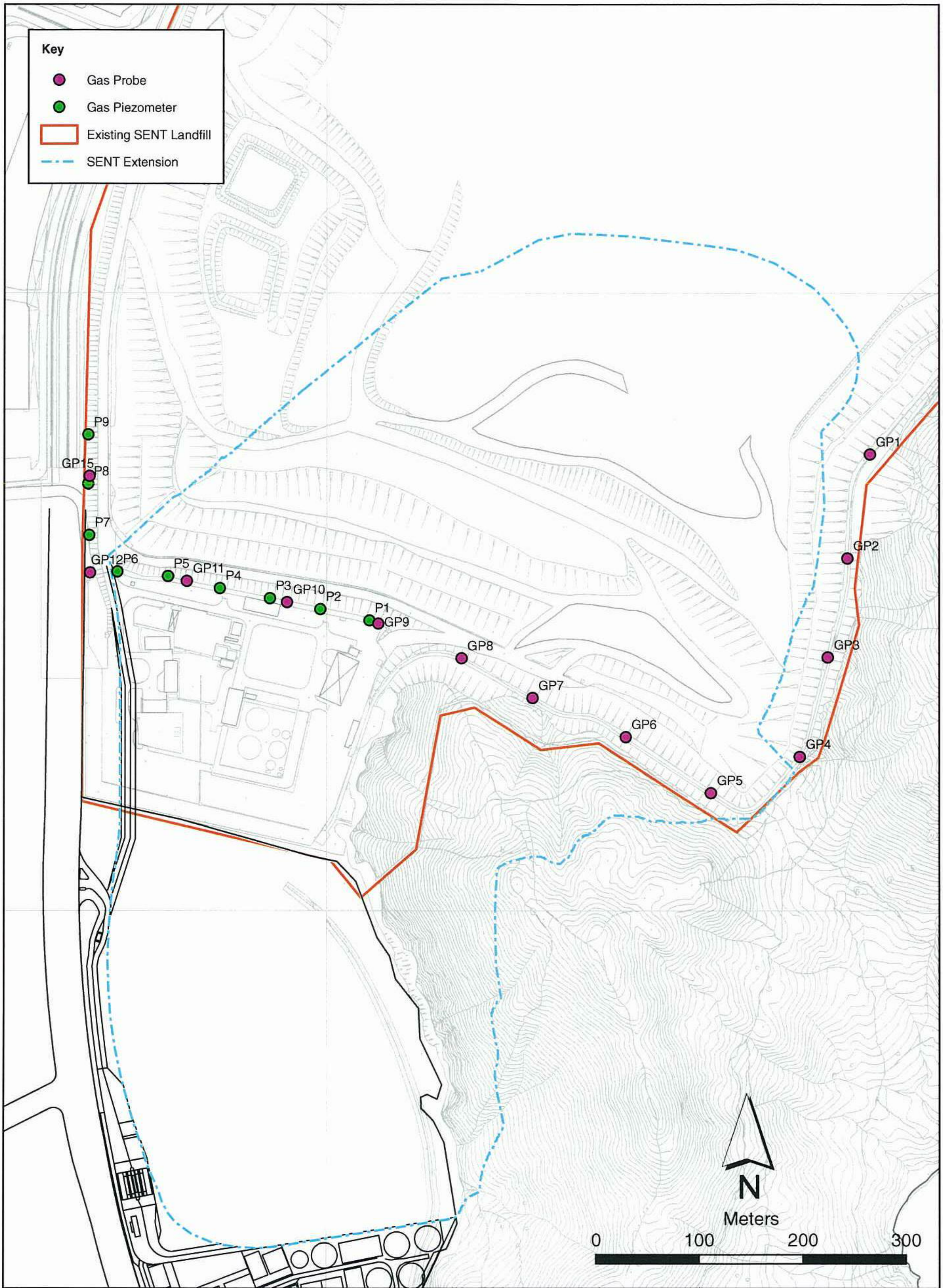

FIGURE 8.5b

Location of Landfill Gas Monitoring Boreholes at SENT Landfill

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boreholes and the monitoring results are summarised in *Table 8.5a* (see *Annex C* for details). The monitoring results indicate that there is no sub-surface off-site migration of methane at the southern part of the landfill. Elevated carbon dioxide concentrations (over 15% v/v) were recorded in GP-4 (deep), GP-9, GP-10, GP-11, P-1, P-2, P-3, P-4 and P-5.

Table 8.5a Landfill Gas Monitoring Results at SENT Landfill (Jan 2006 – Jul 2007)

Location	Methane (% gas)		Carbon Dioxide (% gas)	
	Range	Average	Range	Average
GP-1	0.0 – 0.0	0.0	0.0 – 3.1	0.9
GP-2 (deep)	0.0 – 0.0	0.0	0.0 – 2.4	1.0
GP-2 (shallow)	0.0 – 0.1	0.0	0.0 – 3.5	2.2
GP-3 (deep)	0.0 – 0.0	0.0	0.0 – 0.3	0.0
GP-3 (shallow)	0.0 – 0.0	0.0	0.0 – 3.3	0.2
GP-4 (deep)	0.0 – 0.0	0.0	0.0 – 12.6	1.8
GP-4 (shallow)	0.0 – 0.1	0.0	0.0 – 5.2	1.6
GP-5 (deep)	0.0 – 0.0	0.0	0.0 – 0.1	0.0
GP-5 (shallow)	0.0 – 0.1	0.0	0.0 – 1.9	0.5
GP-6	0.0 – 0.0	0.0	0.0 – 2.6	1.1
GP-7	0.0 – 0.1	0.0	0.0 – 0.9	0.2
GP-8	0.0 – 0.0	0.0	0.0 – 5.2	1.2
GP-9	0.0 – 0.0	0.0	0.0 – 12.3	4.5
GP-10	0.0 – 0.1	0.0	0.0 – 21.1	7.1
GP-11	0.0 – 0.1	0.0	0.0 – 16.0	7.7
GP-15	0.0 – 0.0	0.0	0.0 – 0.2	0.0
P-1	0.0 – 0.1	0.0	0.0 – 15.0	8.0
P-2	0.0 – 0.1	0.0	0.0 – 10.2	5.2
P-3	0.0 – 0.0	0.0	0.0 – 16.8	6.8
P-4	0.0 – 0.1	0.0	6.2 – 19.2	15.0
P-5	0.0 – 0.0	0.0	0.0 – 13.8	4.3
P-6	0.0 – 0.1	0.0	0.0 – 1.7	0.5
P-7	0.0 – 0.1	0.0	0.0 – 0.0	0.0
P-8	0.0 – 0.0	0.0	0.0 – 0.0	0.0
P-9	0.0 – 0.0	0.0	0.0 – 0.2	0.0

SENT Landfill - Classification of Source

As SENT Landfill is a large operating landfill, the facility must be acknowledged as a significant potential source of landfill gas. SENT Landfill was designed and constructed to incorporate international best practices to contain, manage and control waste, leachate, and landfill gas. It is operated by an experienced international reputable waste management contractor.

The potential off-site migration of landfill gas should be assessed taking into account the comprehensive and highly effective collection and management system installed and operated. The regular landfill gas monitoring results at the perimeter boreholes undertaken by the landfill contractor indicate that an insignificant amount of methane was recorded in the perimeter boreholes along the southern boundary. However, according to the *Guidance Note*, a carbon dioxide concentration greater than 5% v/v above background levels in any monitoring well indicates significant migration. Hence the potential of off-site migration of landfill gas cannot be eliminated.

Given the size of the SENT Landfill, the multiple landfill gas controls and the recent landfill gas monitoring data, it would be reasonable to classify it as a "medium" source.

The Extension

The Extension will occupy 15 ha in TKO Area 137 located immediately south of the existing infrastructure area of SENT Landfill. The Extension will piggyback onto the southern slope of the existing SENT Landfill and will occupy approximately 5 ha of the natural slope at the edge of the Clear Water Bay Country Park (CWBCP). The two landfills will be separated by the cap of the SENT Landfill and the liner of the Extension.

The Extension is designed to receive approximately 17 Mm^3 of waste over a period of approximately 6 years. It is anticipated that the Extension will commence operation in 2013 and will accept similar waste types to those currently disposed of at SENT Landfill.

It has been estimated that the landfill will typically generate between 14 and 52 Mm^3 of gas per year throughout its operational life. Gas generation is predicted to peak at 73 Mm^3 per year in 2020, around two years after the Extension is closed.

The Extension – Landfill Gas Control

Similar to the SENT Landfill, the Extension will be designed to incorporate extensive measures to contain, collect, and treat/utilise landfill gas. These measures include a composite liner systems, active landfill gas extraction and landfill gas treatment and utilisation system in accordance with international best practices for landfill operation. These measures can effectively control sub-surface off-site migration of landfill gas, as demonstrated by the monitoring data at the SENT Landfill. The design of the composite liner system for the Extension will be similar to those currently being used in the SENT Landfill. Details of the composite liner system designed for the Extension is shown in *Figure 3.3c*.

A comprehensive environmental monitoring programme will be implemented during the construction, operation, restoration and aftercare of the Extension to monitor landfill gas generated within the Extension and at the perimeter boreholes around the Extension. With reference to the performance standard stipulated in the SENT Landfill contract, the landfill contractor is required to control the migration of landfill gas such that the concentration of methane and carbon dioxide at the perimeter boreholes shall not exceed 1% v/v and 1.5% v/v, respectively. The Extension contract will adopt the same standard. Since the Extension Site is formed by reclamation of public fill, carbon dioxide may occur naturally in the fill material. It is thus more reasonable to adopt 1.5% v/v above the background concentration as the standard. The Extension contractor will be required to continue the control and monitoring of landfill gas following closure of the landfill for a period of 30 years.

The Extension – Classification of Source

Although the Extension is not as large as the SENT Landfill, the facility should still be acknowledged as a potential source of landfill gas. Similar to the SENT Landfill, the Extension will be designed and constructed to incorporate international best practices to contain, manage and control waste, leachate, and landfill gas. It will be operated by an experienced waste management contractor.

Under the Extension contract requirement, the Extension contractor will be required to control off-site landfill gas migration such that the methane and carbon dioxide concentration at the perimeter wells will not exceed 1% v/v and 1.5% v/v above background level, respectively. The potential off-site migration of landfill gas should be assessed taking into account the comprehensive and highly effective collection and management system to be installed and operated.

Taking into account the multiple landfill gas control measures to be installed, the recent landfill gas monitoring data of the SENT Landfill, and stringent contract requirements for controlling off-site landfill gas migration, it would be reasonably conservative to classify the Extension as a "medium" source.

8.5.2 *The Pathways*

General

The potential pathways through which landfill gas may enter the Extension Site and the developments adjacent to the Extension are threefold; namely:

- through transmission along natural pathways such as fissures or joints in rock;
- man-made pathways such as through permeable backfill in utilities trenches; or
- a combination of both.

The likely potential for each mode of transmission are clearly dependent on the geological and hydrogeological conditions, which are discussed below.

Geology and Hydrogeology

The Extension is located partly on reclaimed land in TKO Area 137, partly on the southern slope of the SENT Landfill and partly on the natural slope of CWBCP.

It is understood that TKO Area 137 was formed by public fill generated from construction projects in Hong Kong as it has been operating as a fill bank since 2002. The future final level of TKO Area 137 is at approximately +5.5mPD. Based on records of the ground investigation undertaken as part of this Study, the level of groundwater table is approximately at +2.8mPD, leaving an unsaturated layer of 2.7m. It is considered that this permeable layer between the SENT Landfill, the Extension and the adjacent existing and future development must be conservatively considered as conducive to landfill gas migration. Sections through the SENT Landfill and the Extension site is presented in *Figures 8.5c* and *8.5d*.

Utilities

It is known that underground utilities (leachate and landfill gas collection pipes, electricity, telecommunications and Towngas) exist in the existing infrastructure area of SENT Landfill. However, these underground utilities do not connect to TKO Area 137 or the TKOIE. It is also understood that there are no man-made underground utilities in TKO Area 137, except a box culvert connect the existing SENT Landfill and the berthing area in TKO Area 137. A layout plan for the utility services in the infrastructure area is presented in *Figure 8.5e*.

It is known that services (electricity, telecommunications and Towngas) exist running parallel to Wan Po Road near TKOIE and there are no man-made underground service channels, tunnels or culverts run contiguously between the Extension and the TKOIE.

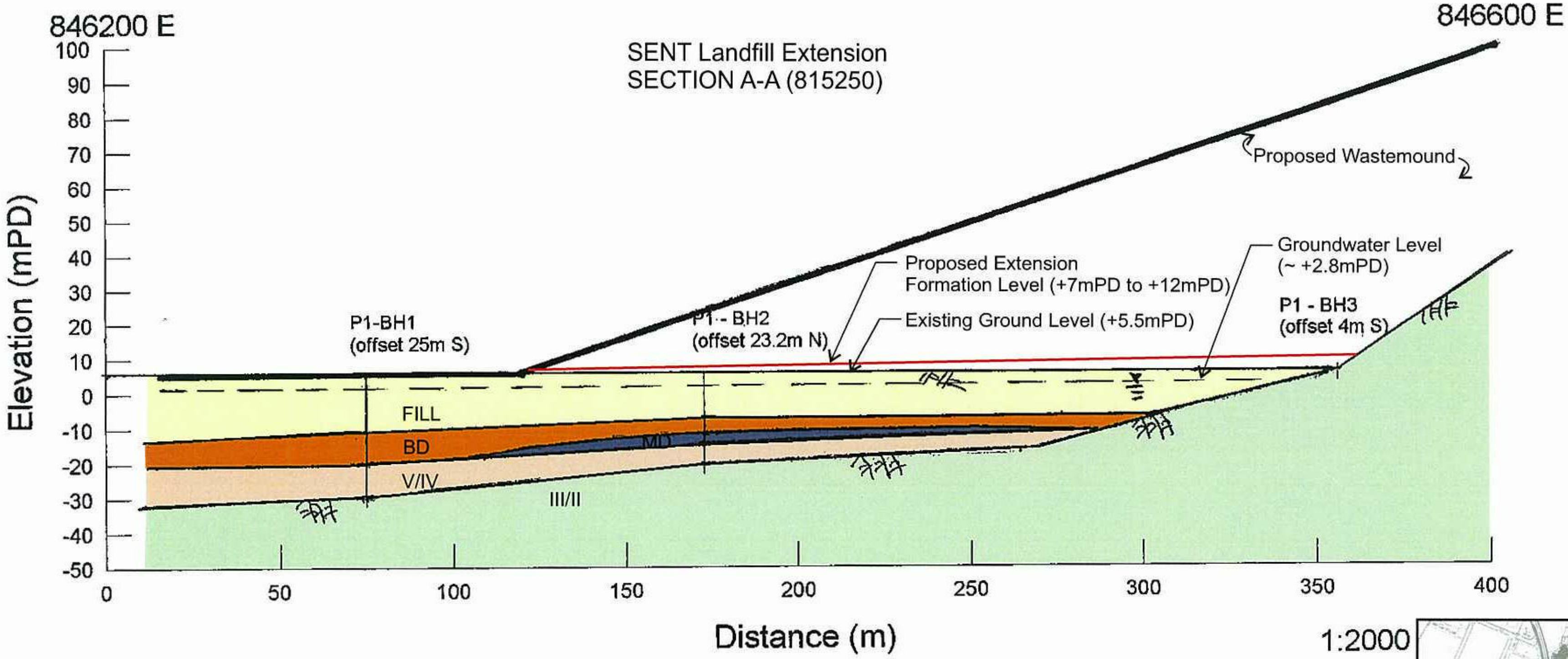
In future, leachate and landfill gas pipes at the existing SENT Landfill will be connected to the infrastructure area of the Extension.

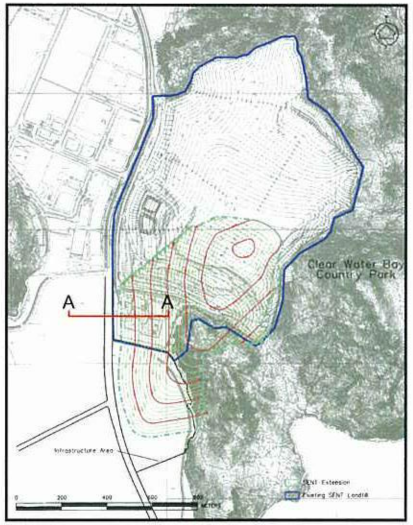
Classification of Pathways – from SENT Landfill to the Extension

At present, the potential pathways for migration of landfill gas from the SENT Landfill to the Extension Site in TKO Area 137 are considered to comprise only natural features and reclamation fill. No direct anthropogenic migration pathways (man-made underground utilities) have been identified as connecting the SENT Landfill to the Extension site in TKO Area 137. As the design of the Extension will piggyback onto the southern slope of the SENT Landfill, gaps in the SENT Landfill capping system, if any, and the underground utilities at the infrastructure area may form migration pathways for landfill gas to migrate to the portion of Extension directly over the infrastructure area and the southern slope of the SENT Landfill. Taking into account the distance between the SENT Landfill and the Extension and the presence of possible migration pathways between the two landfills, the pathway for landfill gas migration from the SENT Landfill to the Extension should be classified as "very short/direct".

Classification of Pathways – from the Extension to the Future Infrastructure Area

The potential pathways for sub-surface migration of landfill gas from the Extension to the future infrastructure area are considered to comprise both reclamation fill and the future utilities connecting the infrastructure area. At present, no direct anthropogenic migration pathways (man-made underground utilities) have been identified as connecting the Extension to the adjacent existing and future development in TKO Area 137. Taking into account the distance and the presence of possible migration pathways





Legend

FILL	Reclamation Fill
BD	Beach Deposit
MD	Marine Deposit
V/IV	Completely/Highly Decomposed Tuff
III/II	Moderately/Slightly Decomposed Tudd (Bedrock)

Figure 8.5c

Geological Profile (1/2)

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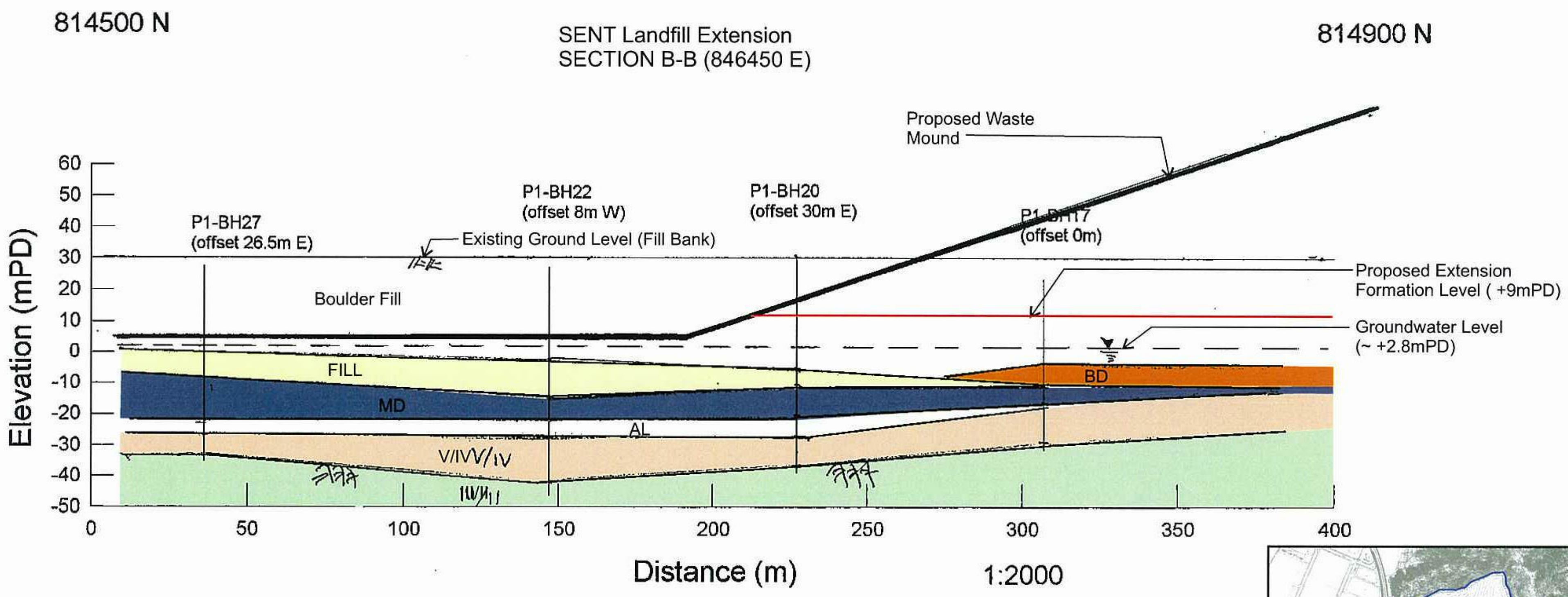

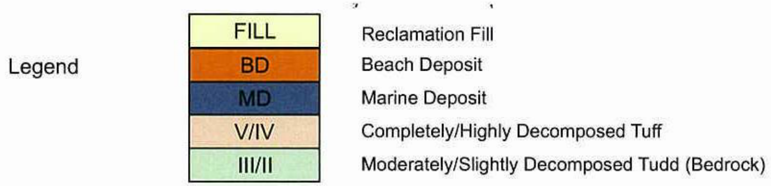

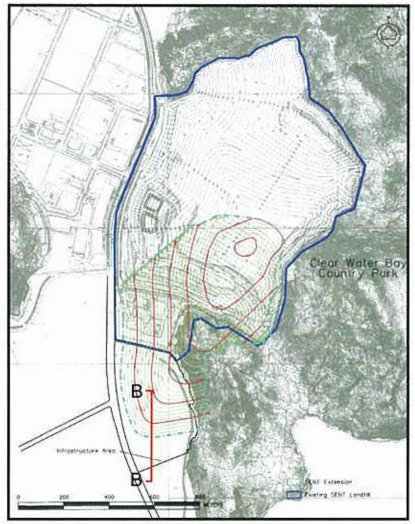

Figure 8.5d

Geological Profile (2/2)

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Figure 8.5e

Underground Utilities at SENT Landfill Infrastructure Area

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between the Extension and the future infrastructure area, the pathway for landfill gas migration from the Extension to the future infrastructure area should be classified as "very short/direct".

Classification of Pathways – from the Extension to the Adjacent Developments

The potential pathways for sub-surface migration of landfill gas from the Extension to the adjacent existing and future developments in TKO Area 137 are considered to comprise only natural features and reclamation fill. At present, no direct anthropogenic migration pathways (man-made underground utilities) have been identified as connecting the Extension to the adjacent existing and future development in TKO Area 137. Taking into account the distance between the Extension and the adjacent existing and future development, and the presence of possible migration pathways, the pathway for landfill gas migration from the Extension to the adjacent existing and future developments in Area 137 should be classified as according to the distance between the development and the Extension: <50m as very short/direct, 50-100m as moderately short/indirect, 100-250m as long/indirect.

8.5.3 The Targets

Landfill gas related impacts may occur in areas at or below ground, at the Extension and the adjacent existing and future development in TKO Area 137.

Target 1 - Construction Site of the Extension

As shown in *Figure 8.2a*, the majority of the Extension Site falls within the 250m Landfill Consultation Zone of the SENT Landfill. Demolition and minor excavation at the existing infrastructure area are expected. The excavation area and the areas of confined space and trenches, if any, are at a higher risk of exposure to landfill gas. However, in general, any excavation work or work involving the construction of trenches will use the open cut method, although there may be deep excavations. Any migration of landfill gas will easily be dispersed and diluted upon contact with the atmosphere. Tunnel construction will involve working in confined spaces by trained workers. This target is thus classified as "medium sensitivity".

Target 2 - Operation of the Extension (Tipping Face)

As discussed earlier, the SENT Landfill and the Extension are separated by the capping system of the SENT Landfill and the liner system of the Extension. It is not expected that there will be landfill gas migration from the SENT Landfill to the tipping face. In addition, all landfill equipment is designed to work under conditions where flammable gas may present.

The majority the waste tipping face will be carried out within the 250m Landfill Consultation Zone of the SENT Landfill. Waste tipping will be in the open air which will not involve working at confined spaces and by definition, the Extension is also a source of landfill gas, thus any migration of landfill gas to the Extension will either be dispersed and diluted upon contact with the atmosphere or be captured in the landfill gas collection system of the Extension. However, it is also noted that drivers/operators of waste collection vehicles will have access to the waste tipping face for disposal of waste and they may not have knowledge on landfill gas hazards. In view of the above, this target is thus classified as "medium sensitivity".

Target 3 – Operation of the Extension (Infrastructure Area)

The proposed infrastructure area of the Extension will be outside the 250m Landfill Consultation Zone of the SENT Landfill but within the 250m Landfill Consultation Zone of the Extension. Underground confined spaces (such as manhole and utility pits) and ground level offices and pump rooms with underground utility connections are places where landfill gas can potentially accumulate and may have sources of ignition (e.g. electrical or other equipment). Restricted access to the manhole, utility pits and pump rooms by authorised and well trained personnel is expected. These rooms/voids are thus considered to have "medium" sensitivity. Ground level offices and some ground level rooms are generally of unrestricted staff access or public access accompanied by site staff. These rooms/voids are thus considered to have "high" sensitivity. Nevertheless, the landfill will be operated by an experienced landfill contractor who is fully aware of the potential landfill gas hazards and with their staff well trained on the potential hazards relating to landfill gas and the specific safety procedures. All ground floor rooms of the buildings on-site will be equipped with a gas detection and alarm system. This target is classified as "medium to high sensitivity".

Target 4 – Adjacent Existing and New Development in TKOIE and TKO Area 137

Parts of the TKOIE and TKO Area 137 are within the existing Landfill Consultation Zone of the SENT Landfill and the new Landfill Consultation Zone of the Extension. The additional Landfill Consultation Zone, not covered by the existing one, is shown in *Figure 8.2a*. The area within this additional consultation zone is located at TKO Area 137, which is planned for industrial uses.

The potential hazards posed by landfill gas migration and the need for protection measures for developments close to landfill sites are outlined in Chapter 9 of the HKPSG. It is a requirement that project proponents of developments adjacent to landfills undertake a landfill gas hazard assessment and submit the findings to EPD for vetting. As recommended in *ProPECC PN 3/96*, the project proponents and professionals (Authorised Persons) responsible for the developments adjacent to landfills should:

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

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

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

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

Design information for the uses located within the 250m Landfill Consultation Zone of the Extension is not available at this stage. The Extension will impose constraints on the landuse and suitable landfill gas protection measures will/may be required depending on the landuse.

With consideration of these above requirements, this target is classified as "low sensitivity".

8.5.4 Source-Pathway-Target Analysis

On the basis of the source, pathways and targets identified above, a source-pathway-target analysis has been undertaken and is presented in *Table 8.5b* according to EPD's assessment framework. Different combination of source, pathway and target result in a range of overall potential hazards.

Table 8.5b Qualitative Assessment of Landfill Gas Hazard Associated with the Extension

Source	Pathway	Target	Qualitative Risk
SENT landfill - potential for gas generation over time, but comprehensive and proven mitigation installed **(category: medium)**	Surface soil, reclamation fill materials, part of the work site piggyback onto the waste slope of SENT Landfill and the existing infrastructure area with potential direct anthropogenic conducts, distance to waste boundary <50m **(category: very short/direct)**	Target 1 (Construction site of the Extension) – Open cut construction method, may have deep excavation, working in confined space by trained workers **(category: medium sensitivity target)**	**Medium**
SENT landfill - potential for gas generation over time, but comprehensive and proven mitigation installed The Extension - potential for gas generation over time, comprehensive and proven mitigation to be installed **(category: medium)**	Surface soil, reclamation fill materials, part of the tipping face piggyback onto the waste slope of SENT Landfill and the existing infrastructure area with potential direct anthropogenic conducts, distance to waste boundary <50m **(category: very short/direct)**	Target 2 (Tipping face of the Extension) – waste tipping in the open air, absence of confined space, access by drivers/operators of waste collection vehicles who may not have knowledge on landfill gas hazards **(category: medium sensitivity)**	**Medium**
The Extension - potential for gas generation over time, comprehensive and proven mitigation to be installed **(category: medium)**	Surface soil, reclamation fill materials, potential direct anthropogenic conducts, distance to waste boundary <50m **(category: very short/direct)**	Target 3 (Infrastructure area of the Extension) – Ground level offices and pump rooms of unrestricted staff access, underground confined spaces with restricted access, some with source of ignition **(category: medium to high sensitivity)**	**Medium to High**

Source	Pathway	Target	Qualitative Risk
	Surface soil, reclamation fill materials, no direct anthropogenic conducts - Distance to waste boundary <50m **(category: very short/direct)** - Distance to waste boundary between 50m to 100m **(category: moderate short/direct)** - Distance to waste boundary >100m **(category: long/indirect)**	Target 4 (Adjacent existing and new development) – according to *ProPECC PN 3/96*, project proponents and are required to carry out landfill gas hazard assessment and implement suitable landfill gas protection measures **(category: low sensitivity)**	**Very Low to Low**

8.6 Recommendations

The source-pathway-target analysis shows that landfill gas risk posed by the SENT Landfill and the Extension is medium to high within the Extension Site boundary during both the construction and operation phases. Whereas the risk posed by the Extension to the adjacent developments ranges from very low to low depending on the nature and location of the adjacent developments.

This section of the report provides general advice and recommendations for the avoidance of environmental impacts related to landfill gas during the construction and operation of the Extension. It is recommended that the project proponent of any development within the 250m Landfill Consultation Zone of the Extension should strictly follow the requirements for landfill gas hazard assessment stipulated in the *ProPECC 3/96* and the *Guidance Note* and undertake a detailed QLFGHA to assess the hazard potential and to identify the precautionary measures.

Implementation of the landfill gas control measures, and restoration works undertaken will also significantly reduce the potential for off-site migration of landfill gas to the adjacent developments.

8.6.1 General Hazards Related to Landfill Gas

Landfill Gas

All contractors participating in the works and operational staff should be aware that potential of methane and carbon dioxide present in the soil and all works should be undertaken on the basis of an "assumed presence of landfill gas". In addition the following properties of landfill gas should be noted.

- *Methane* is odourless and colourless, although in landfill gas it is typically associated with numerous highly odoriferous compounds which gives some warning of its presence. However, the absence of odour should not be taken to mean that there is no methane. Methane levels can only be reliably confirmed by using appropriately calibrated portable methane detectors.

- *Methane* is a flammable gas and will burn when mixed with air between approximately 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.

- *Carbon dioxide*, the other major component of landfill gas 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.

- *Gas density.* Methane is lighter than air whereas carbon dioxide is heavier than air. Typical mixtures of landfill gas 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, landfill gas may accumulate in either the base or top of any voids or confined spaces.

8.6.2 General Recommended Precautionary and Protection Measures – Construction Phase

The construction works to be undertaken at the Extension Site and the adjacent developments present construction workers and others with risks resulting from contact with landfill gas. For example, when laying of underground pipes/utilities in trenches or other situations, personnel may have to enter confined spaces. Precautionary measures to be adopted by the contractors at the Extension Site and the adjacent development site within the landfill consultation zone are outlined in Paragraphs 8.3 to 8.49 of EPD's *Guidance Note.* The following guidance has been extracted from and appended to this and to ensure a robust and comprehensive set of measures to protect workers are provided.

- During all works, safety procedures will be implemented to minimise the risks of fires and explosions and asphyxiation of workers (especially in confined space).

- Safety officers, specifically trained with regard to landfill gas related hazards and the appropriate actions to take in adverse circumstances, will be present on all worksites throughout the works.

- All personnel who work on site and all visitors to the site will be made aware of the possibility of ignition of gas in the vicinity of the works.

- Those staff who work in, or have responsibility for 'at risk' areas, including bore piling and excavation works, will receive appropriate training on working in areas susceptible to landfill gas.

- Any offices/quarters set up on site will take precautions against landfill gas ingress, such as being raised off the ground. Other storage premises, e.g. shipping containers, where this is not possible will be well ventilated prior to entry.

- Adequate precautions to prevent the accumulation of landfill gas under site buildings and within storage shed will be taken by raising buildings off the ground where appropriate and 'airing' storage containers prior to entry by personnel and ensuring adequate ventilation at all times.

- Smoking and naked flames will be prohibited within confined spaces. 'No Smoking' and 'No Naked Flame' notices in Chinese and English will be posted prominently around the construction site. Safety notices should be posted warning of the potential hazards.

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

- During the construction works, adequate fire extinguishers and breathing apparatus sets will be made available on site and appropriate training given in their use.

Monitoring

Monitoring will be undertaken when construction works are carried out in confined space within the consultation zone. The monitoring requirements and procedures specified in Paragraphs 8.23 to 8.28 of EPD's *Guidance Note* are highlighted below:

- The monitoring equipment used will be capable of measuring methane, carbon dioxide and oxygen concentrations. The equipment will be intrinsically safe and calibrated according to the manufacturers instructions.

- When portable monitoring equipment is to be used, the frequency and areas to be monitored will be set down prior to commencement of the works either by the Safety Officer or by an appropriately qualified person.

- All measurements will be made with the monitoring tube located not more than 10 mm from the surface.

- A standard form, detailing the location, time of monitoring and equipment used together with the gas concentrations measured, will be used when undertaking manual monitoring to ensure that all relevant data are recorded.

- Monitoring of excavations will be undertaken as follows:

  For excavations deeper than 1m, measurements will be made:

  (i) At the ground surface before excavation commences;

  (ii) Immediately before any worker enters the excavation;

  (iii) At the beginning of each working day for the entire period the excavation remains open; and

  (iv) Periodically through the working day whilst workers are in the excavation.

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

  (i) Directly after the excavation has been completed; and
  (ii) Periodically whilst the excavation remains open.

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

- If methane (flammable gas) or carbon dioxide concentrations are in excess of the trigger levels or that of oxygen is below the level specified in the *Emergency Management* in the following section, then evacuation will be initiated.

Actions in the Event of Gas Being Detected

Depending on the results of the measurements, actions required will vary and will be set down by the Safety Officer or another appropriately qualified person. As a minimum these should encompass those actions specified in *Table 8.6a*.

Table 8.6a Actions in the Event of Gas Being Detected

Parameter	Measurement	Action
O_2	< 19% v/v	Increase underground ventilation to restore O_2 to >19% v/v
	< 18% v/v	Stop works
		Evacuate all personnel
		Increase ventilation further to restore O_2 to >19% v/v
CH_4	> 10% LEL	Prohibit hot works
		Increase ventilation to restore CH_4 to <10% LEL
	>20% LEL	Stop works
		Evacuate all personnel
		Increase ventilation further to restore CH_4 to <10% LEL
CO_2	>0.5% v/v	Increase ventilation to restore CO_2 to <0.5% v/v
	> 1.5% v/v	Stop works
		Evacuate all personnel
		Increase ventilation further to restore CO_2 to <0.5%

Emergency Management

In order to ensure that evacuation procedures are implemented in the event of the trigger levels specified in *Table 8.6a* above being exceeded, it is recommended that a person, such as the Safety Officer, is nominated, with deputies, to be responsible for dealing with any emergency which may occur due to landfill gas.

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

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

8.6.3 *General Recommended Precautionary and Protection Measures - Design Phase*

The design of the landfill gas management system and the landfill gas precautionary measures to be adopted on-site will be performed by a landfill gas specialist consultant appointed by the Extension contractor, who has comprehensive knowledge on landfill characteristics, potential landfill gas hazards and appropriate precautionary measures to minimise hazards. Moreover, the landfill gas management system and landfill gas precautionary measures will be checked and certified by a qualified independent consultant The potential implications associated with the various qualitative risk categories are summarised in *Table 8.4b*. During the detailed design stage, a review of this preliminary qualitative risk assessment will be carried out, a detailed qualitative landfill gas risk assessment will be prepared and the report together with the detailed design of gas protection measures will be submitted to EPD for vetting.

For the Construction and Operation of the Extension

According to the source-path-target analysis in *Section 8.5*, the risk category at the Extension during construction and operation (waste tipping) is medium. This implies that engineering measures will be required during the design stage to ensure that the construction and waste tipping at the Extension is safe. As the Extension will be designed, built and operated by an experienced landfill contractor, it is anticipated that relevant engineering measures will be identified and implemented in accordance with the Extension Contract Specification requirements. These measures will include the placement of liner and installation of landfill gas management system to contain, manage and control landfill gas. Migration of landfill gas from the SENT Landfill to the Extension, if any, will be captured by the landfill gas management system at the Extension.

For the Operation of the Infrastructure Area at the Extension

The infrastructure area at the Extension is considered to have medium to high risk. According to *Table 8.4b*, engineering measures to significant engineering measures will be required to protect the staff working in the infrastructure area. These measures include a combination of passive and active systems. Examples of these measures as recommended in EPD's *Guidance Notes* are listed below for reference.

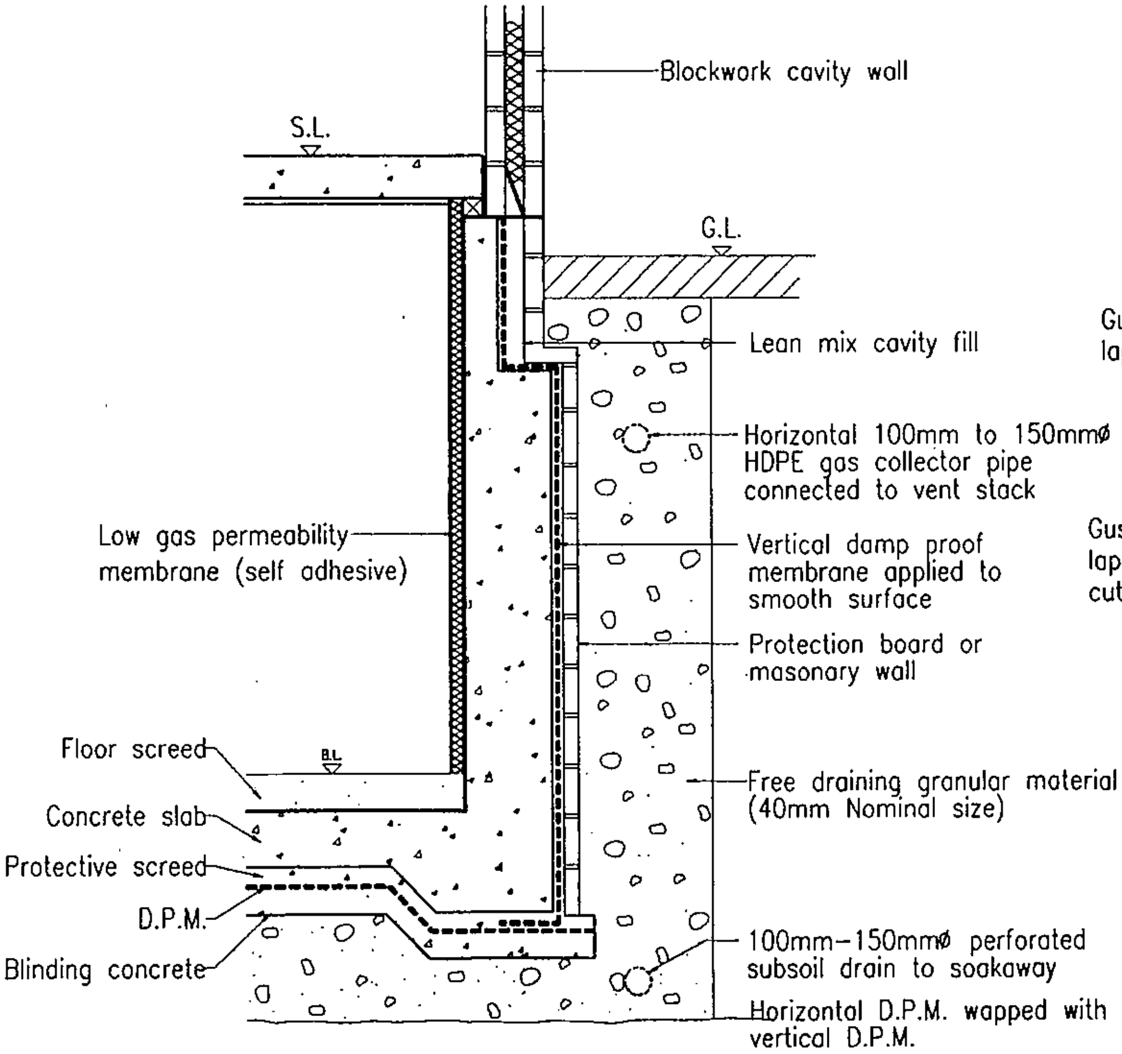
- *Passive control measures:*

  - Gas-resistant polymeric membranes which can be incorporated into floor or wall construction as continuous sealed layer (see *Figure 8.6a*). Membranes should be able to demonstrate low gas permeability and resistance to possible chemical attack, and may incorporate aluminium wafers to improve performance.

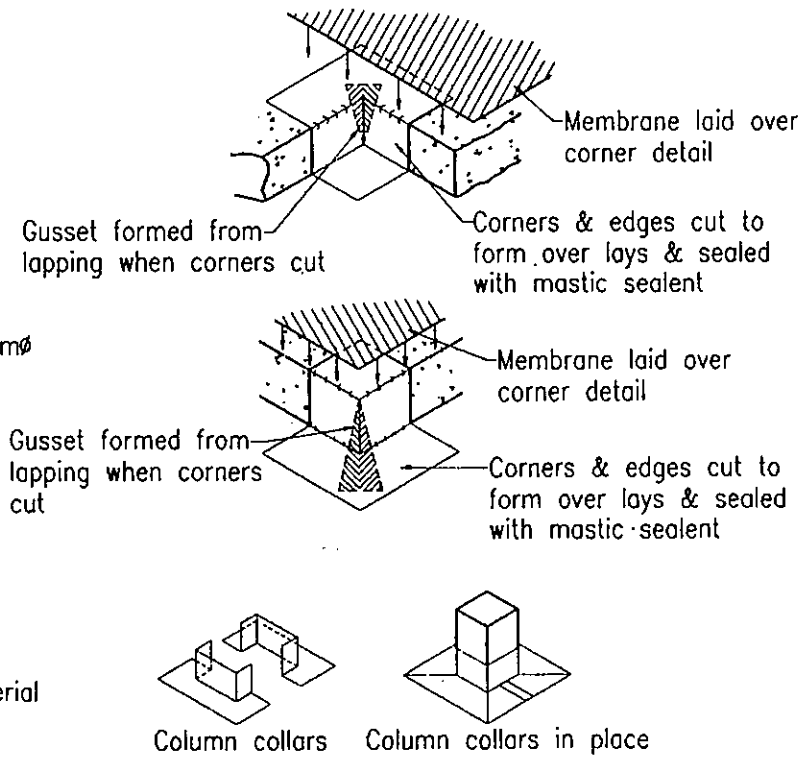
  - Other building materials such as dense well-compacted concrete or steel shuttering which provide a measure of resistance to gas permeation.

  - Creation of a clear void under the structure which is ventilated by natural air movements such that any emissions of gas from the ground are mixed and diluted by air (see *Figure 8.6b*).

  - Synthetic composite geotextiles which provide a free-venting cellular structure and provide preferential pathways for release of gas



Horizontal gas drainage



Details for ensuring integrity of membrane at corner and column features

Source: EPD's Landfill Gas Hazard Assessment Guidance Note

Not to Scale

Figure 8.6a

Typical Details of Flexible Membrane Protection for Buildings

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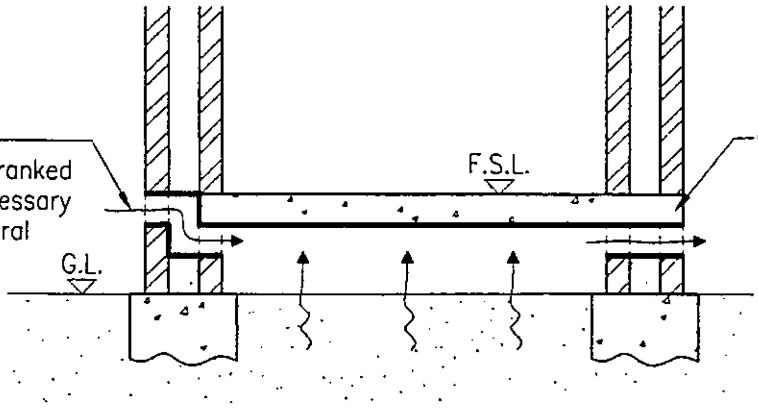
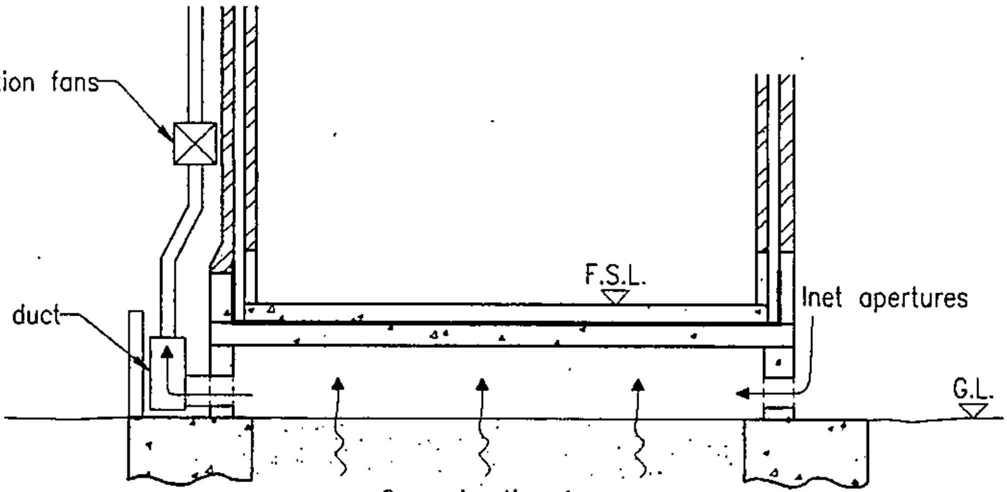


(a) PASSIVE



(b) ACTIVE

Source: EPD's Landfill Gas Hazard Assessment Guidance Note

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Figure 8.6b

Subfloor Venting

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- *Active control measures:*

    - A void under the structure, as discussed for passive control, but which is continuously ventilated by a fan, such that any emissions of gas from the ground are mixed and diluted in the air flow before discharge to atmosphere (see *Figure 8.6b)*. The rate of ventilation is usually expressed in terms of the number of air changes (volume of the void) per hour and is designed to ensure that, based on the estimated rate at which gas will enter the void, the landfill gas will be diluted to safe concentrations. Discharge to atmosphere usually takes place above the eaves level of the building or, in the case of high rise structures, at a minimum height of 10 m above ground and away from air intakes to the building.

    - Construction of a granular layer incorporating perforated collector pipes which is continually ventilated by a fan, such that any emissions of gas from the ground are drawn towards the end of the pipes and diluted in the air flow before discharge to atmosphere above the eaves level of the building, or in the case of high rise structures, at a minimum height of 10 m above ground and away from air intakes to the building.

    - Creation of a positive pressure zone below the building structure by injection of air from a blower into the granular layer.

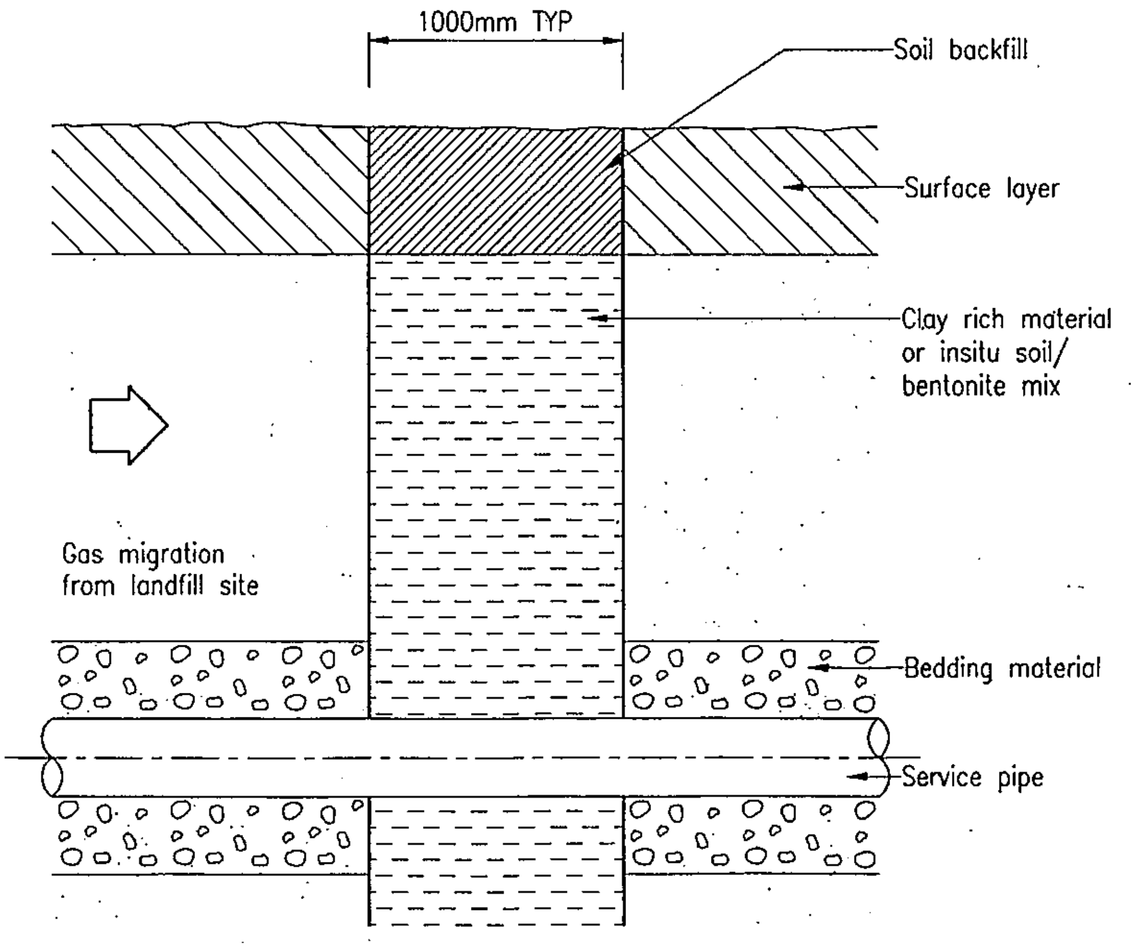
    - Creation of a positive air pressure zones within building structures to counteract possible leakage of gas into the building from the ground.

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

Landfill gas may also enter the building/void via service entries. Measures to prevent gas migration through service entries are listed below:

- *Gas Barriers*

    - Barriers used to prevent movement of landfill gas through service entries may be made of clay (or clay-rich soils), bentonite or polymeric membranes (such as HDPE). The design detail at the point where the service penetrates the membrane is important and, in the case of HDPE membranes, pre-formed shrouds are available. The design detail at the point where the service penetrates the membrane is important and use should be made of pre-formed shrounds (orr cloaks), skirts and fillets. A schematic for an HDPE flexible membrane cut-off is shown in *Figure 8.6c.*



Source: EPD's Landfill Gas Hazard Assessment Guidance Note

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Figure 8.6c

Natural Material Cut-off Barrier

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    - It may be appropriate to consider routing all services through a sealed culvert or duct which is either completely lined in naturally gas-resistant material (e.g. clay) or which is lined with an HDPE membrane.

    - In the case of water pipes and sewers which are not always fully filled, water traps, such as U-bends, should be provided to effectively seal off the conduit and prevent gas-phase transport.

    - In order to prevent the ingress of landfill gas into a building via the interface between the service pipe and the backfilled soil, 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 8.6d*)

- *Gas Vents*

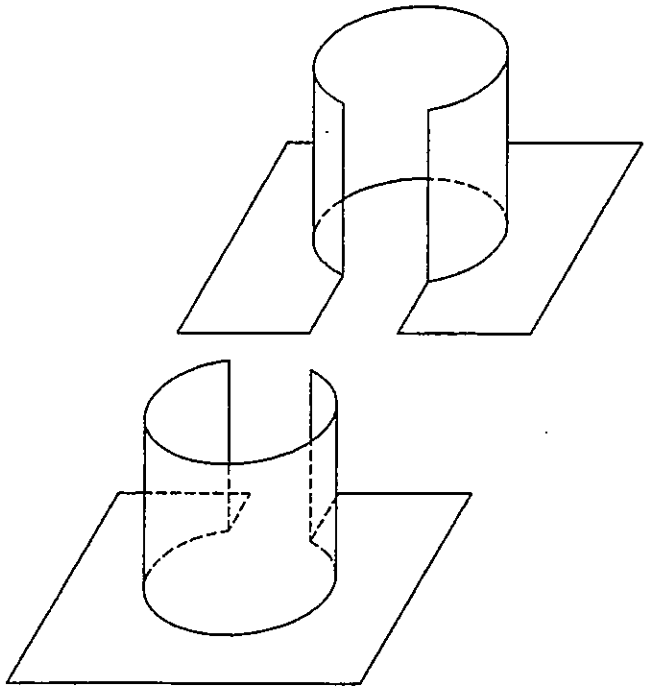
    - Vent pipes or griddled manhole covers may be used to avoid build-up of landfill gas in underground utilities manholes. Venting stacks may be built into inspection chambers or connected to collection pipes within high permeability drainage layers adjacent to landfill gas barriers. A typical vented manhole arrangement is shown in *Figure 8.6e*.

    - 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 8.6f*. 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.

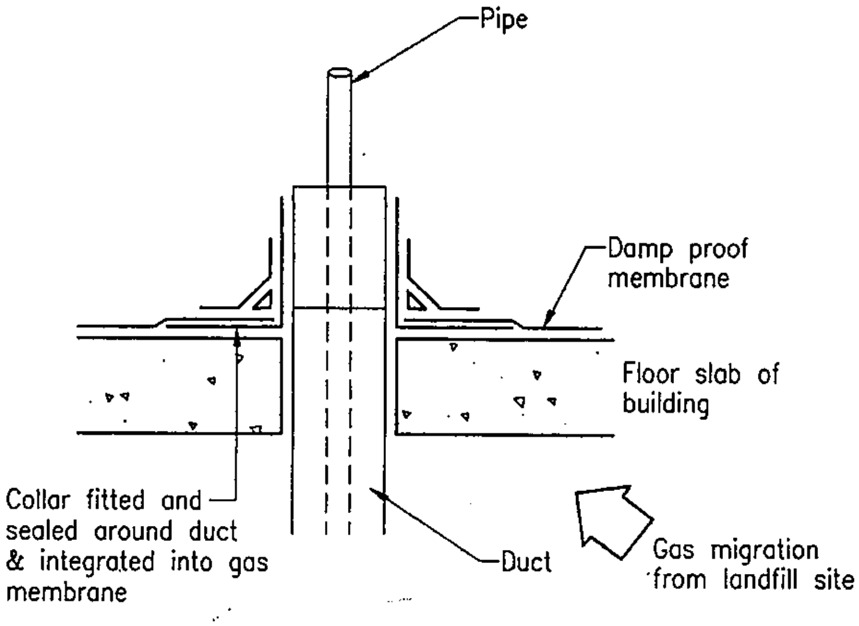
In addition to the above precautionary measures, landfill gas monitoring boreholes will be installed at the edge of the waste slope between the waste and the new infrastructure area to monitor the migration of landfill gas, if any.

For Future Developments in TKO Industrial Estate and TKO Area 137

For future developments in TKOIE and TKO Area 137 which fall into the Landfill Consultation Zone of the Extension as shown in *Figure 8.2a*, the project proponents should strictly follow the recommendations in the HKPSG and the *ProPECC PN 3/96* to carry out landfill gas hazard assessment for the developments and design/implement suitable precautionary and protection measures to render the development as safe as practicable. These adjacent developments are considered to have very low to low risk.



Collar components



Source: EPD's Landfill Gas Hazard Assessment Guidance Note

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Figure 8.6d

Typical Detail of Collar Seal (Cross-section)

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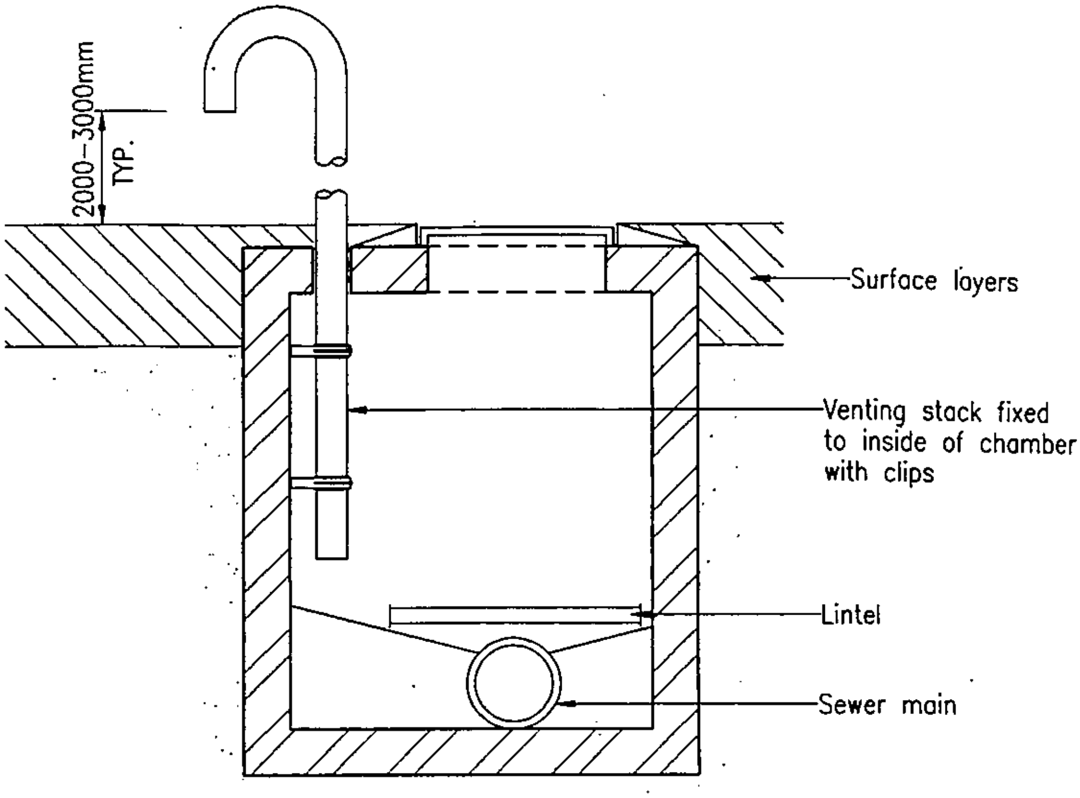

Source: EPD's Landfill Gas Hazard Assessment Guidance Note

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Figure 8.6e

Vented Manhole (Cross-section)

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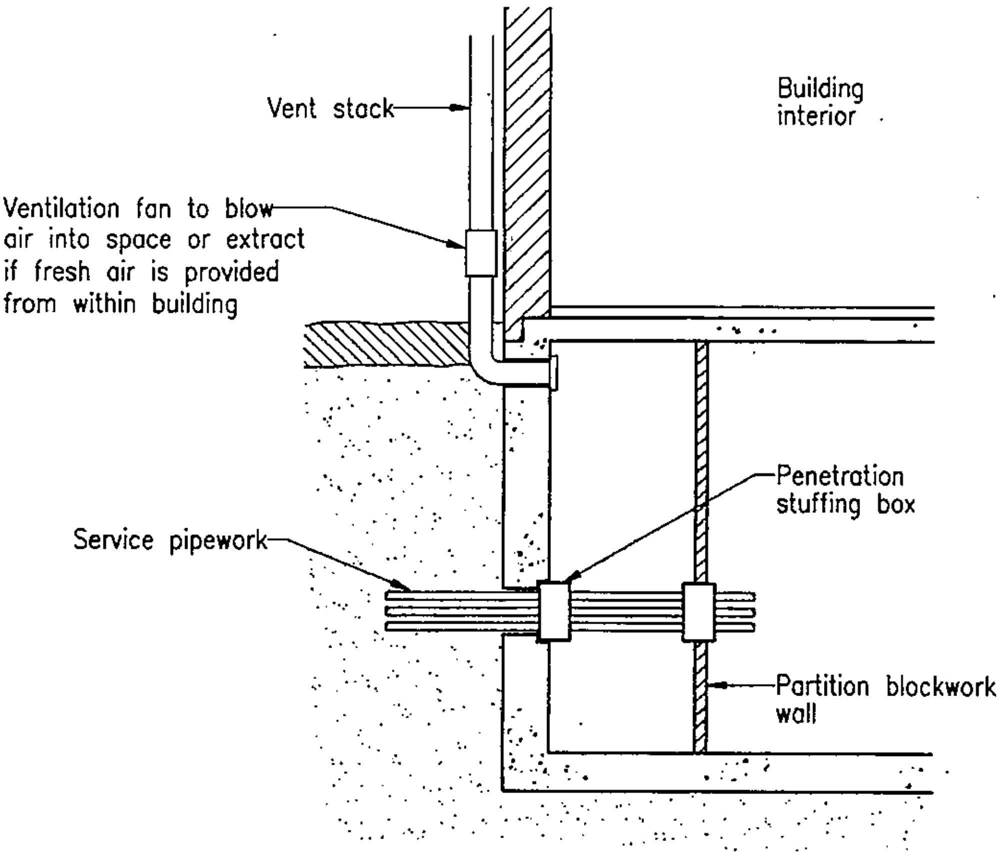

Source: EPD's Landfill Gas Hazard Assessment Guidance Note

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Figure 8.6f

Vented Gas Interceptor Cavity (Cross-section)

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8.6.4 *General Recommended Precautionary and Protection Measures - Operational, Restoration and Aftercare Phases*

The Extension Contractor

The Extension Contractor will have a responsibility to train and to ensure that their staff take appropriate precautions at all times when entering enclosed spaces or plant rooms. The Extension Contractor will also undertake regular monitoring of landfill gas at the perimeter boreholes to detect if there are any signs of off-site landfill gas migration. The Extension Contractor will be responsible to prepare and implement emergency plan in case off-site landfill gas migration is detected.

A permanent gas monitoring system with alarms will be installed and operated in all occupied on-site buildings.

Utility Companies

All utility companies should be made aware of the location and features of the development site within the Extension Landfill Consultation Zone by the future developers of the site during the respective detailed design stage as part of the QLFGHA. The utilities companies should have a responsibility to train and ensure their staff to take appropriate precautions at all times when entering enclosed spaces or plant rooms.

8.7 *ENVIRONMENTAL MONITORING AND AUDIT*

The Extension Contractor will be required to undertake regular monitoring of landfill gas within the Extension and the Extension boundary as required by the Extension Contract Specification.

Similar to the Contract Specification of the existing SENT Landfill, monitoring of landfill gas at the perimeter landfill gas monitoring wells will be required at weekly (where there is development within 250m of the Extension Site Boundary) or monthly intervals (for the other monitoring wells) during the operation and restoration of the Extension. During the aftercare phase, monitoring at all perimeter wells will be at monthly intervals. Bulk gas analysis for at least 2 of the perimeter wells will be required at quarterly intervals throughout the operation, restoration and aftercare of the Extension. In addition, monitoring of service voids along the Site boundary and within the Extension Site will be required at monthly intervals throughout the operation, restoration and aftercare of the Extension. The Extension Contractor will also be required to undertake surface emission monitoring of methane gas (or flammable gas) in areas between the waste boundary and the Extension Site boundary at quarterly intervals throughout the operation, restoration and aftercare phases. Actions will be taken if an abnormal level of landfill gas is detected.

8.8 SUMMARY AND CONCLUSIONS

This section has provided a qualitative assessment on potential hazards associated with landfill gas migration from the SENT Landfill to the Extension and from the Extension to the adjacent existing and future developments. Both landfills are considered as a "medium" source of gas migration due to the comprehensive and proven landfill gas control measures installed or to be installed. The source-pathway-target analysis shows that landfill gas risk posed by the SENT Landfill and the Extension is medium to high during both construction and operation phases within the Extension Site. Whereas the risk posed by the Extension to the adjacent developments ranges from very low to low depending on the nature and location of the these developments.

In general, underground rooms or void spaces should be avoided as far as practicable at the infrastructure area of the Extension site. Other precautionary and protection measures during construction, design and operation/restoration phases of the Extension have been recommended. It is expected that with the proposed precautionary measures in place, the potential risk of landfill gas migration to the respective targets will be minimal.

9 ECOLOGY

9.1 INTRODUCTION

This *Section* presents the baseline condition of ecological resources within the Study Area [(1)], and the results of an assessment of the potential ecological impacts due to the construction, operation, restoration and aftercare of the Extension.

Baseline conditions for ecological components of the terrestrial and associated aquatic environment were evaluated based on information from available literature sources and focussed field surveys conducted for the purposes of this EIA. Measures required to mitigate any identified adverse impacts are recommended, where appropriate.

9.2 RELEVANT LEGISLATION AND GUIDELINES

A number of international conventions and local legislation and guidelines provide the framework for the protection of species and habitats of ecological importance. Those related to the Extension are as follows:

- *Forests and Countryside Ordinance* (Cap 96);
- *Town Planning Ordinance* (Cap 131);
- *Wild Animals Protection Ordinance* (Cap 170);
- *Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586);
- *Hong Kong Planning Standards and Guidelines Chapter 10* (HKPSG);
- *The Technical Memorandum on Environmental Impact Assessment Process under the Environmental Impact Assessment Ordinance (EIAO-TM)*;
- *United Nations Convention on Biodiversity* (1992); and
- *PRC Regulations and Guidelines*.

The *Forests and Countryside Ordinance* prohibits felling, cutting, burning or destroying of trees and growing plants in forests and plantations on Government land. The subsidiary *Forestry Regulations* prohibit the picking, felling or possession of listed rare and protected plant species. The list of protected species in Hong Kong which comes under the *Forestry Regulations* was last amended on 11 June 1993 under the *Forestry (Amendment) Regulation 1993* made under Section 3 of the *Forests and Countryside Ordinance*.

Under the *Wild Animals Protection Ordinance*, designated wild animals are protected from being hunted, whilst their nests and eggs are protected from destruction and removal. All birds and most mammals including all

(1) Area includes 500m from the boundary of the Extension Site.

cetaceans are protected under this Ordinance, as well as certain reptiles, amphibians and invertebrates. The Second Schedule of the Ordinance that lists all the animals protected was last revised in June 1997.

The *Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586) was enacted to align Hong Kong to control regime with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). With effect from 1 July 2006, it replaces the *Animals and Plants (Protection of Endangered Species) Ordinance* (Cap 187). The purpose of the *Protection of Endangered Species of Animals and Plants Ordinance* is to restrict the import and export of species listed in CITES Appendices so as to protect wildlife from overexploitation or extinction. The Ordinance is primarily related to controlling trade in threatened and endangered species and restricting the local possession of them.

The recently amended *Town Planning Ordinance* provides for the designation of areas such as "Coastal Protection Areas", "Sites of Special Scientific Interest (SSSIs)", "Green Belt" and "Conservation Area" to promote conservation or protection or protect significant habitat. Chapter 10 of the *HKPSG* covers planning considerations relevant to conservation. This chapter details the principles of conservation, the conservation of natural landscape and habitats, historic buildings, archaeological sites and other antiquities. It also addresses the issue of enforcement. The appendices list the legislation and administrative controls for conservation, other conservation related measures in Hong Kong, and Government departments involved in conservation.

Annex 16 of the *EIAO-TM* sets out the general approach and methodology for assessment of ecological impacts arising from a project or proposal, to allow a complete and objective identification, prediction and evaluation of the potential ecological impacts. *Annex 8* recommends the criteria that can be used for evaluating ecological impacts.

The Peoples' Republic of China (PRC) is a Contracting Party to the *United Nations Convention on Biological Diversity* of 1992. The Convention requires signatories to make active efforts to protect and manage their biodiversity resources. The Government of the Hong Kong SAR has stated that it will be "committed to meeting the environmental objectives" of the Convention (PELB 1996).

In 1988 the PRC ratified the *Wild Animal Protection Law*, which lays down basic principles for protecting wild animals. The Law prohibits killing of protected animals, controls hunting, and protects the habitats of wild animals, both protected and non-protected. The Law also provides for the creation of lists of animals protected at the state level, under Class I and Class II. There are 96 animal species in Class I and 156 in Class II. Class I provides a higher level of protection for animals considered to be more threatened.

9.3 *STUDY AREA FOR THE ECOLOGICAL IMPACT ASSESSMENT*

The Study Area for the purpose of the terrestrial ecological assessment included all areas within 500m of the boundary of the Extension Site, including part of the existing SENT Landfill, Tseung Kwan O (TKO) Area 137 and Clear Water Bay Country Park (CWBCP). For aquatic ecology, the Study Area also covered Fat Tong Tsui, Ti Cham Chau, Kwun Tsai and Tai Miu Wan.

9.4 *LITERATURE REVIEW OF ECOLOGICAL CHARACTERISTICS OF STUDY AREA*

9.4.1 *Methodology*

A literature review was conducted to determine the existing ecological conditions within the Study Area as well as the associated aquatic habitats to identify habitat resources and species of potential importance. The local literature reviewed included:

- *Porcupine!* (Newsletter of Department of Ecology & Biodiversity, University of Hong Kong) (1);
- AFCD Biodiversity Newsletters (2);
- A Field Guide to the Terrestrial Mammals of Hong Kong (3).
- Annual Reports of Hong Kong Bird Watching Society (4);
- Hong Kong Amphibians and Reptiles (5) ;
- A Field Guide to the Amphibians of Hong Kong (6);
- A Field Guide to the Dragonflies of Hong Kong (7);
- A Field Guide to Butterfly Watching in Hong Kong (8) ;
- The Avifauna of Hong Kong (9);
- Gymnosperms and Angiosperms of Hong Kong (10);

(1) *Newsletter of Department of Ecology & Biodiversity*, University of Hong Kong Issues 1 to 33.
(2) *AFCD Biodiversity Newsletters*. Issues 1-12
(3) Chen S K., Cheung K.S., Ho C. Y, Lam F. N., Tang W, S (2006). *A Field Guide to the Terrestrial Mammals of Hong Kong*. AFCD.
(4) Hong Kong Bird Watching Society (1990 -2000). Annual Reports.
(5) Karsen, S. J., Lau, M. W. N. and Bogadek, A. (1998). *Hong Kong Amphibians and Reptiles*. Urban Council, Hong Kong
(6) AFCD (2005). A Field Guide to the Amphibians of Hong Kong. Friends of Country Park.
(7) Wilson, K.D.P. (2004). *Fuide Guide to the Dragonflies of Hong Kong*. Friends of Country Park.
(8) Yiu V (2004). *Field Guide to the butterflies of Hong Kong*. Friends of Country Park.
(9) Carey, G.J., Chalmers, M.L., Diskin, D.A., Kennerley, P.R., Leader, P.J., Leven, M.R., Lewthwaite, R.W., Melville, D.S., Turnbull, M., and Young, L. (2001). *The Avifauna of Hong Kong*. Hong Kong Bird Watching Society, Hong Kong.
(10) Xing, F.W., Ng, S.C., Chau, L.K.C. (2000). Gymnosperms and angiosperms of Hong Kong. *Memoirs of the Hong Kong Natural History Society*. 23: 21-136.

- Orchidaceae of Hong Kong [1];
- A Field Guide to the Venomous Land Snakes of Hong Kong [2]
- Ecological Study for SENT Landfill Extension - Final Report [3];
- Further Development of Tseung Kwan O Feasibility Study [4];
- SENT Landfill Study - Final Report [5]; and
- Field Guide to Hard Corals of Hong Kong [6].
- SENT Operations and Environmental Monitoring Annual Report and Audit (from years 2003 to 2006) [7] .

9.4.2 *Results*

Habitat and Vegetation

From the aerial photo taken in 2004 [8], habitats found within the Study Area included plantation, shrubland, grassland and disturbed/developed area. Shrubland and grassland were found at the Extension Site within CWBCP (approximately 5.1 ha). Plantation and developed areas were mainly found within the existing SENT Landfill. Tseung Kwan O Area 137 is a newly reclaimed area located between the existing CWBCP, Fat Tong Chau and Tit Cham Chau.

An ecological study for the Extension undertaken in January 2003 [9] and covered only 3 ha of the area within the CWBCP. The results indicated that the surveyed CWBCP area was a mosaic habitat of grassland and shrubland. The area was rocky and scattered with bare ground especially in the middle of the hillsides. Most of the plants recorded within the surveyed area were of 1 to 2m in height. The grassland and shrubland mosaic consisted of 12 plant species, including: *Rhodomyrtus tomentosa, Lygodium japonicum, Schefflera octophylla, Dicranopteris pedata, Phoenix hanceana, Miscanthus floridulus, Marcaranga tanarius, Inula cappa, Breynia fruticosa, Litsea rotundifolia, Cratoxylum cochinchinense* and *Scleria chinensis*. They were dominated by *Dicranopteris pedata, Rhodomyrthus tomemtosa, Macaranga tanarius, Schefflera heptaphylla, Miscanthus sinensis* and *Miscanthus floridulus*. All of these plant species are commonly found in Hong Kong.

(1) Siu L P (2000). Orchidaceae of Hong Kong. *Memoirs of the Hong Kong Natural History Society*. 23: 137-147.

(2) Simon Chan Kin-fung, Cheung Ka-shing, Ho Ching-yee, Lam Fung-ngai, Tang Wing-sze - Herpetofauna Working Group(AFCD). *A Field Guide to the Venomous Land Snakes of Hong Kong.*

(3) Hong Kong Baptist University (2005). Ecological Study for SENT Landfill Extension - Final Report. For EPD.

(4) Maunsell Consultant Asia Ltd (2005). *Further Development of Tseung Kwan O Feasibility Study-EIA*. For CEDD.

(5) Scott Wilson Kirkpatrick (1991). SENT Landfill Study-Final Report. For EPD.

(6) Alan Chan, Choyce Choi, Denise McCorry, Khaki Chan, M W Lee and Ang Put Jr. (2005). Field Guide to Hard Coral of Hong Kong. Friends of the Country Parks.

(7) Green Valley Landfill, Limited. 2003 to 2006. *SENT Operations and Environmental Monitoring Annual Report and Audit from years 2003 to 2006..*

(8) Lands Department (2004). CW 55704 Aerial photograph taken on 4 March 2004, 4,000'.

(9) Hong Kong Baptist University (2005). Ecological Study for SENT Landfill Extension - Final Report. For EPD.

An ecological study for the Further Development of Tseung Kwan O [1] indicated that the habitats within the CWBCP (outside the Study Area of this EIA) are dominated by grassland/shrubland mosaic, with small patches of plantation at the valleys. Plant species of conservation interest included the Yellow-eyed Grass *Xyris indica*.

SENT Operations and Environmental Monitoring reports for the period 2003 to 2006 [2] indicated that native plant species, including *Celtis sinensis, Leucaena leucocephhala, Bidens bipinnata, Litsea rotundifolia, Triumfetta bartramia, Uraria crinita, Phyllodium pulchellum* and *Glochidon ericarpum,* have been recorded within the SENT Landfill plantation , although exotic trees dominated the plantation.

Terrestrial Mammals

Six terrestrial mammal species, including Wild Boar, Japanese Pipistrelle, Small Indian Civet, Palla's Squirrel, Chestnut Spatial and Black Rat, were recorded in the Tseung Kwan O areas (Tseung Kwan O, Tiu Keng Leng and Hang Hau) [3] but no records are available for the Study Area. All of the recorded mammal species are common and widespread in Hong Kong. However, both Japanese Pipestrelle and Palla's Squirrel are protected under the *Wild Animals Protection Ordinance (Cap 170)*. They were observed foraging in various habitats including shrubland, plantation and native secondary woodlands, including Hang Hau and CWBCP.

Birds

From the Ecological Study of SENT Landfill Extension - Final Report [4] and the Annual Report of Bird Watching [5], there were 47 species recorded in the existing SENT Landfill area and in the vicinity (including the Extension Site), these are shown in *Table 1* of *Annex D*. Most of the birds recorded were residential birds (eg bulbuls *Pycnonotus* spp. prinias *Prinia* spp.) or common visitors or migrants (eg Swifts *Apus* spp.).

There were 6 Class II national protected species recorded in the Annual Report of Bird Watching Society, including the Pacific Reef Egret *Egretta sacra*, Black Bittern *Dupetor flavicollis*, Black-eared Kite *Milvus lineatus*, White-bellied Sea Eagle *Haliaeetus leucogaster*, Lesser Coucal *Centropus bengalensis* and Eurasian Eagle Owl *Bubo bubo*.

Herpetofauna

There is limited information on herpetofauna within the Study Area.

(1) Maunsell Consultant Asia Ltd (2005). *Further Development of Tseung Kwan O Feasibility Study-EIA*. For CEDD

(2) Green Valley Landfill, Limited. 2003 to 2006. *SENT Operations and Environmental Monitoring Annual Report and Audit from years 2003 to 2006*.

(3) Maunsell Consultant Asia Ltd (2005). *Further Development of Tseung Kwan O Feasibility Study-EIA*.. For CEDD

(4) Hong Kong Baptist University (2005). Ecological Study for SENT Landfill Extension - Final Report. For EPD.

(5) Hong Kong Bird Watching Society (1990 -2000). *Annual Reports*.

Seven amphibian and nine reptile species were recorded in the Tseung Kwan O area (but outside the Study Area of this EIA) during the Ecological Study of Further Development of Tseung Kwan O (1). Most of the recorded species are common and widespread in Hong Kong, except Chinese Cobra (*Naja atra*) and Common Rat Snake (*Ptyas mucosus*) which are considered to be of conservation interest.

Butterflies and Dragonflies

There is limited information on dragonfly and butterfly species within the Study Area.

There were 15 dragonfly and 44 butterfly species recorded in the Tseung Kwan O area (but outside the Study Area of this EIA) during the Ecological Study of Further Development of Tseung Kwan O (2). The majority of the recorded species are common and widespread in Hong Kong, and none are considered to be of conservation interest.

Stream Fauna

There is limited information on aquatic fauna within the Study Area.

Clear Water Bay Country Park

The CWBCP is located at the Clear Water Bay Peninsula, covering about 615 ha of natural habitats (3). The CWBCP is dominated by shrubland, with small area of woodland and feng shui woods. Plant species of conservation interest recorded in the CWBCP including the Chinese New Year Flowers, Wild Lily, Azaleas and species of orchid, such as Rattlesnake, Lady's Slipper and Bamboo orchids. The wildlife recorded in the CWBCP included bird species Francolin, Black Kite, Tree Sparrow, Chinese Bulbul, Greater Coucal, Great Tit and Japanese White-eye (4).

Coral Communities

The underwater dive surveys conducted in 1999 and 2003, with findings presented in the Area 131 Further Ecological Study Report and the HATS Dive Survey Report respectively (5), indicated that Fat Tong Chau harboured very few hard corals (ie, *Porites* sp. and *Cyphastrea* sp.). Nevertheless, soft corals and gorgonians including *Echinomuricea* sp., *Euplexaura* sp., *Anthogorgia* sp., *Dendronephthya* sp., *Menella* sp. and *Echinogorgia* sp., were frequent and occurred in moderate abundance.

As reported in the HATS coral dive surveys in 2003, in East Joss House Bay the coastal shallow areas had a rich community with 10 – 25% hard corals

(1) Maunsell Consultant Asia Ltd (2005). *Further Development of Tseung Kwan O Feasibility Study-EIA.*. For CEDD

(2) Maunsell Consultant Asia Ltd (2005). *Further Development of Tseung Kwan O Feasibility Study-EIA*. For CEDD.

(3) AFCD (2003). *New Viewpoints-Country Parks in Focus*. Friends of Country Parks.

(4) AFCD (2003). *New Viewpoints-Country Parks in Focus*. Friends of Country Parks.

(5) Details presented in the *Further Development of Tseung Kwan O Feasibility Study-EIA Report*.

cover. There was a total of 23 species hard coral recorded and *Platygyra acuta* was the most common hard coral. However, there was relatively small amount of soft /gorgonian coral recorded at this location (<5% cover).

The surveys in 2003 also indicated that there was low coral abundance (<5% cover) and diversity (8 species of hard coral and dominated by *Cyphastrea seralia*) recorded in the shallow coastal waters of West Joss House Bay.

9.5 IDENTIFICATION OF INFORMATION GAPS

9.5.1 *Introduction*

Although there are some ecological baseline information available in the Tseung Kwan O area as well as the CWBCP, the current Study Area, in particular the additional 5.1 ha of the Extension Site within CWBCP, has limited information. As a consequence, detailed ecological surveys in this area were required.

9.5.2 *Scope of Field Surveys*

To supplement the limited available information, more than 9 months of terrestrial and aquatic ecology baseline surveys were conducted to collect baseline information of the Study Area. The surveys were conducted during November 2005 to March 2006 (dry season) and April to July 2006 (wet season), which included habitat/vegetation, terrestrial mammal, bird, herpetofauna, invertebrates (butterfly and dragonfly) and stream fauna surveys for terrestrial ecology, and subtidal (dive) surveys along the coastal habitats in the close proximity to the Study Area, including Fat Tong Mun, Tit Cham Chau, Tai Miu Wan and Kwun Tsai.

9.6 ASSESSMENT METHODOLOGY

9.6.1 *Ecological Baseline Surveys*

A reconnaissance survey was undertaken in October 2005 to update and field check the validity of the information gathered in the literature review. A number of more focussed baseline field surveys were then identified and carried out to characterise the existing ecological conditions of the Study Area. The surveys were designed to fill the data gaps identified in literature review. Special attention was paid to the remaining natural habitats and those areas which will be directly impacted by the proposed Extension, especially the habitat and wildlife within the 5.1 ha of land to be developed into the CWBCP. It should be noted that there were some limitations to take surveys within the existing SENT Landfill and TKO Area 137 due to safety concerns, and given that the areas are highly disturbed due to the busy traffic and the current working activities.

The following baseline ecological surveys were undertaken:

- Terrestrial habitat and vegetation surveys;

- Bird surveys (including night survey);
- Mammal surveys (including night survey);
- Invertebrates (butterflies and dragonflies) surveys;
- Herpetofauna surveys (including night surveys);
- Stream macro-fauna survey; and
- Subtidal (dive) surveys.

Habitats and Vegetation

Habitat and vegetation surveys were performed on 17 November 2005, 12 December 2005, 24 February 2006, 16 March 2006 and 21 July 2006. The aim of the surveys was to establish the ecological profile of habitat and vegetation within the Study Area. A habitat map of the Study Area is shown in *Figure 9.6a*.

Habitats were mapped based on Government aerial photographs (year 2004)(1) and field ground truthing. Representative areas of each habitat type were surveyed on foot. Plant species within each habitat type and their relative abundance were recorded with special attention to rare or protected species. Nomenclature and conservation status of plant species follow Xing *et al* (2), Siu 2000 (3) and AFCD 2001 (4).

Terrestrial Mammal

Surveys of terrestrial mammals within the Study Area were conducted on 17 November 2005, 14 January, 24 February, 27 April, 26 May and 21 July 2006 to cover both dry and wet seasons. Night surveys for mammals were carried out on 14 January and 21 July 2006.

As most mammals occur at low densities, all sightings, tracks, and signs of mammals were actively searched along the survey transects (see *Figure 9.6b*). Nomenclature for mammals followed AFCD (2006) (5). No quantification of abundance of mammals in the Study Area was made, due to the difficulties in translating sights and tracks (eg burrows) to actual abundance.

Birds

Habitats and areas of potential ecological importance for birds within the Study Area were identified in a reconnaissance survey. Baseline surveys of bird populations were undertaken within those selected habitats using

(1) Lands Department (2004). CW55704 8,000 feet, 4 March 2004.

(2) Xing, F.W., Ng, S.C., Chau, L.K.C. (2000). Gymnosperms and angiosperms of Hong Kong. *Memoirs of the Hong Kong Natural History Society*. 23: 21-136.

(3) Siu L P (2000). Orchidaceae of Hong Kong. *Memoirs of the Hong Kong Natural History Society*. 23: 137-147.

(4) AFCD (2001). Check List of Hong Kong Plants. Dong Sheng Printing Company.

(5) Chen S K., Cheung K.S., Ho C. Y, Lam F. N., Tang W, S (2006). *A Field Guide to the Terretrial Mammals of Hong Kong*. AFCD.

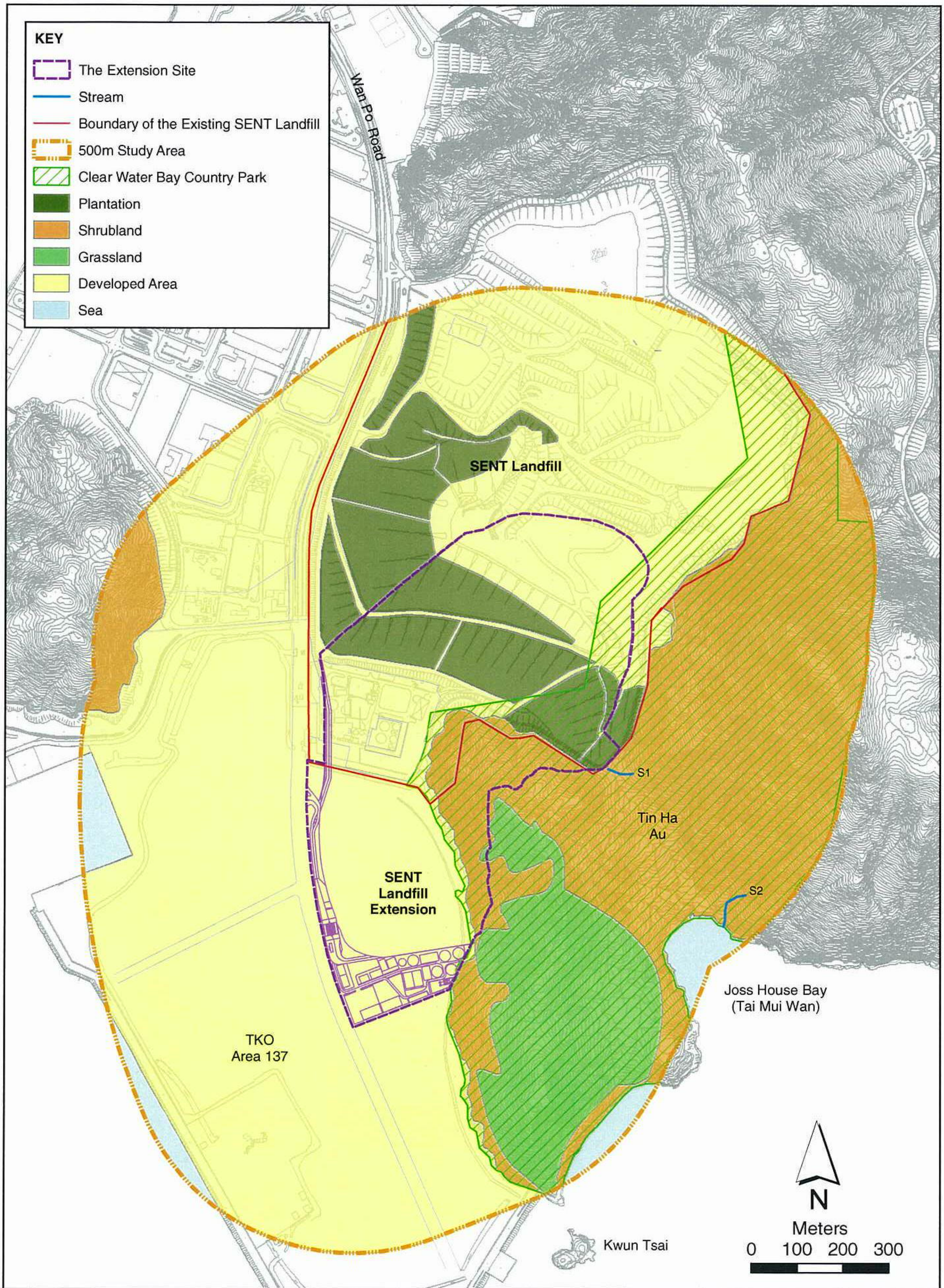

FIGURE 9.6a

Habitat Map of the Study Area

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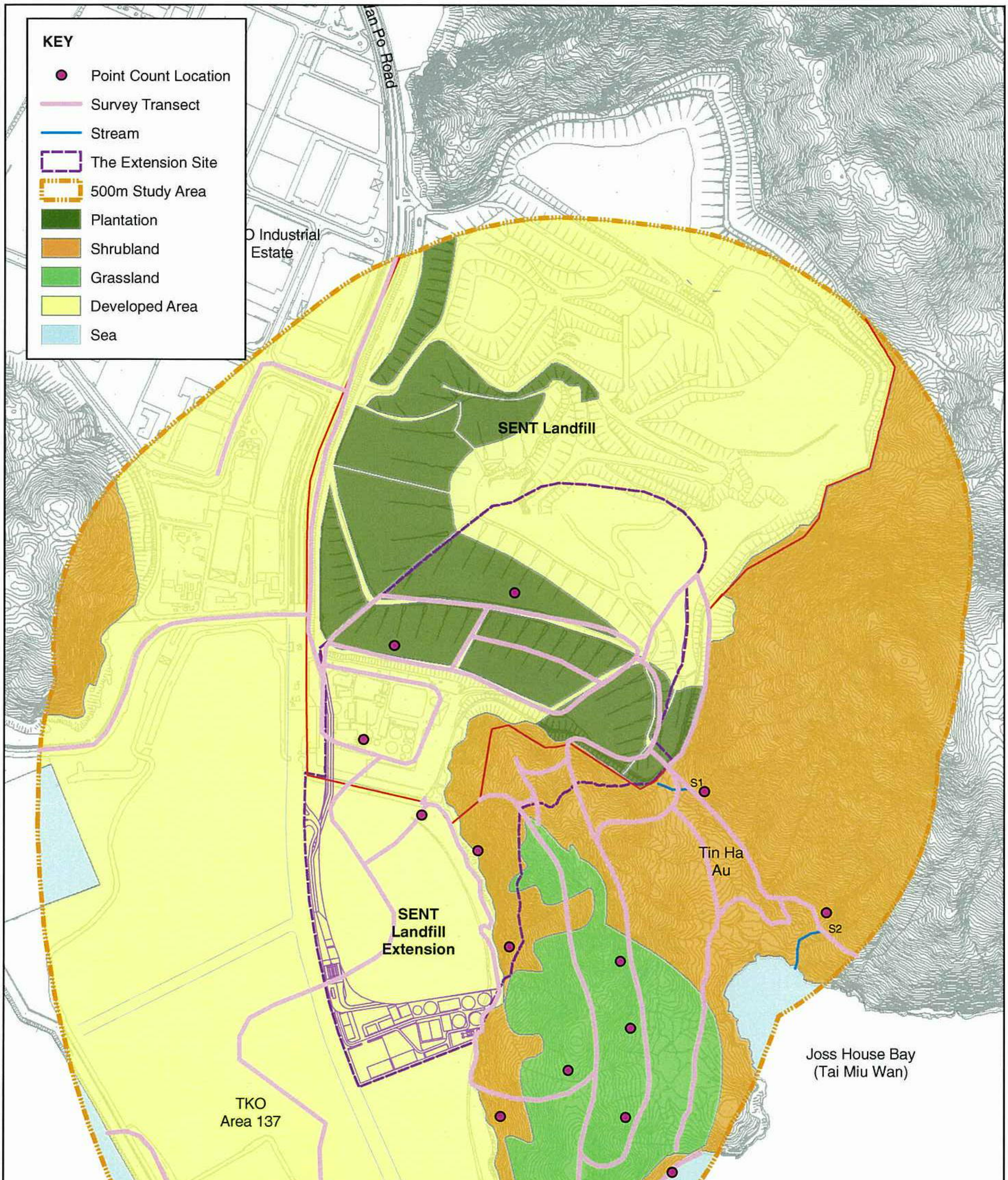

FIGURE 9.6b

Survey Transects and Point Count Location for Wildlife Survey

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quantitative (point count) and qualitative (transect survey) methods. Bird surveys were conducted on 17 November, 12 December 2005, 14 January, 27 April, 26 May and 29 June, 2006 to cover both dry and wet seasons. Night surveys were conducted on 14 January 2006 and 26 May 2006.

Bird communities in each major habitat type recorded within the Study Area, including plantation, shrubland, grassland and disturbed/developed area were surveyed using the point count method. A total of 18 sampling points at the Study Area were selected and their locations are shown in *Figure 9.6b*. Ten minutes were spent counting birds at each sampling point. All birds seen or heard within 30m of the sampling points were counted.

Signs of breeding (eg nests, recently fledged juveniles) within the Study Area were also recorded. Observations were made using 8x binoculars and photographic records were taken, if possible. Bird abundance in each major habitat type was expressed in number of birds per hectare (total birds counted divided by total surveyed area).

Bird species encountered outside counting points but within the Study Area were also recorded to produce a complete species list. Signs of breeding (eg nests, recently fledged juveniles) were also recorded. Ornithological nomenclature followed Carey *et al* (1).

Herpetofauna (Amphibians and Reptiles)

Surveys of herpetofauna within the Study Area were conducted on 17 November 2005, 14 January, 24 February, 27 April, 26 May and 21 July 2006 to cover both dry and wet seasons. Night surveys of the amphibians were carried out on 14 January and 21 July 2006. Herpetofauna surveys were conducted through direct observation and active searching in all major habitat types along the survey transects (see *Figure 9.6b*) and in potential hiding places such as among leaf litter, inside holes and under stones and logs within the Study Area. Auditory detection of species-specific calls was also used to survey frogs and toads. During the surveys, all reptiles and amphibians sighted and heard were recorded. Nomenclature and status used for reptiles follows Karen *et al* 1998 (2) while that of amphibians follows AFCD 2005 (3).

Invertebrate (Butterflies and Dragonflies)

Surveys of butterfly and dragonfly species within the Study Area were conducted on 17 November 2005, 14 January, 24 February, 27 April, 26 May and 21 July 2006 covering both dry and wet seasons, along the survey

(1) Carey, G.J., Chalmers, M.L., Diskin, D.A., Kennerley, P.R., Leader, P.J., Leven, M.R., Lewthwaite, R.W., Melville, D.S., Turnbull, M., and Young, L. (2001). The Avifauna of Hong Kong. Hong Kong Bird Watching Society, Hong Kong.

(2) Karsen, S. J., Lau, M. W. N. and Bogadek, A. (1998). Hong Kong Amphibians and Reptiles. Urban Council, Hong Kong

(3) AFCD (2005). A Field Guide to the Amphibians of Hong Kong. Friends of Country Park.

transects (see *Figure 9.6b*). Nomenclature for butterflies follows Yiu 2004 (1) and dragonfly nomenclature followed AFCD 2004 (2).

Stream Macro-fauna

Stream fauna surveys were undertaken on 17 November 2005, 26 May and 21 July 2006 to identify the water bodies and aquatic resources in the Study Area. Streams identified within the Study Area were visited and stream fauna were studied by direct observation and active searching for sensitive species or individuals using hand nets.

Subtidal Survey

In order to investigate the subtidal hard surface assemblages, as well as confirming the abundance and diversity of corals, along the coastlines potentially affected by the Landfill Extension, dive surveys in the form of Rapid Ecological Assessment (REA) (3) were conducted on 29 and 30 December 2005. The REA technique allows semi-quantitative information on the ecological attributes of a subtidal habitat to be obtained relatively simply without compromising scientific rigour. The survey was divided into five zones and each zone had one 100m transect, running parallel to the shoreline (see *Figure 9.6c*). An initial qualitative reconnaissance surveys were conducted along the coastlines of Zones A to E. During the survey, the position and number of transects were decided on site. The preferred location would be having high coral abundance, or area of high epifaunal density. The depth of transects was adjusted accordingly based on the substrate habitat and the presence or absence of hard and soft corals.

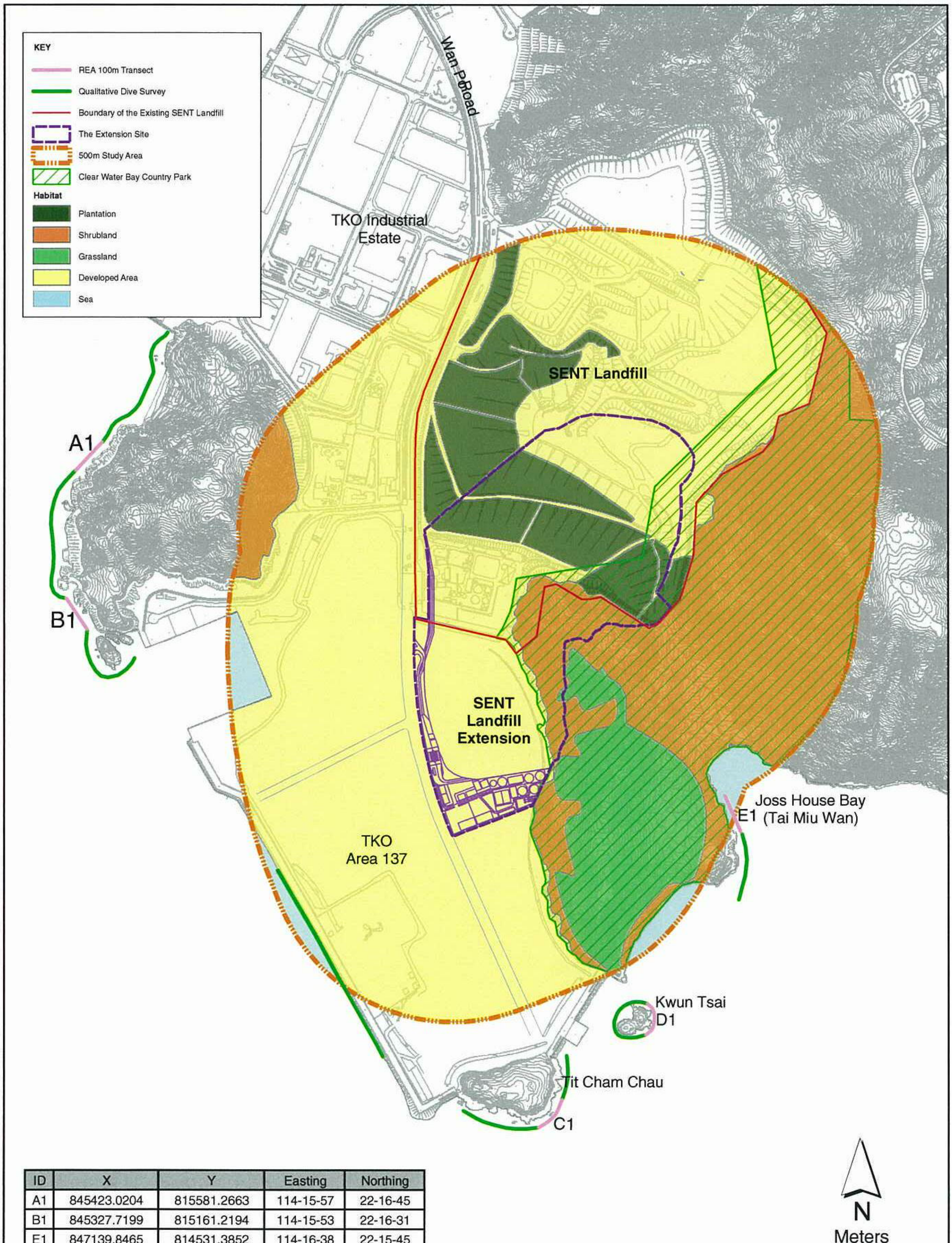
Zone A to E were surveyed referring to the Rapid Ecological Assessment. Information was recorded by observers experienced in the field identification of sessile benthic taxa, swimming down-current at each location using SCUBA gear. Transects were determined with a portable geographic positioning system (GPS) unit. A 100m transect was laid out and video footage taken of the benthos along the transect/survey route followed by an assessment of the benthic cover (Tier I) and taxon abundance (Tier II) in a swathe ~ 4m wide, 2m either side of each transect.

Positioning: The exact location of each transect were determined with a portable Global Positioning System (GPS) unit and are provided in *Table 9.6a*.

(1) Yiu V (2004). *Field Guide to the Butterflies of Hong Kong*. Hong Kong Discovery Ltd.

(2) AFCD (2004). *Field Guide to the Dragonflies of Hong Kong*. Friends of the Country Parks

(3) De Vantier LM, De'ath G, Done TJ and Turak E (1998). Ecological Assessment of a Complex Natural System: A Case Study from the Great Barrier Reef. Ecological Applications 8:480-96.



ID	X	Y	Easting	Northing
A1	845423.0204	815581.2663	114-15-57	22-16-45
B1	845327.7199	815161.2194	114-15-53	22-16-31
E1	847139.8465	814531.3852	114-16-38	22-15-45
D1	846884.2577	813983.3509	114-16-48	22-15-53
C1	846596.0307	813732.7674	114-17-2	22-16-11

FIGURE 9.6c

Location of Subtidal Survey

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Table 9.6a *Co-ordination of Survey Transects (Starting Point)*

Transects	Easting	Northing	Latitude	Longitude
A1	114-15-57	22-16-45	845423	815581
B1	114-15-53	22-16-31	845327	815161
C1	114-16-38	22-15-45	846596	813732
D1	114-16-48	22-15-53	846884	813983
E1	114-17-2	22-16-11	847139	814531

Tier I - Categorisation of Benthic Cover

Upon the completion of each transect, seven substratum and six ecological attributes were assigned to one of seven standard ranked (ordinal) categories (*Tables 9.6b* and *9.6c*).

Table 9.6b *Categories Used in the Surveys - Benthic Attributes*

Ecological	Substratum
Hard coral	Hard substrate
Dead standing coral	Continuous pavement
Soft coral	Bedrock
Antipatharia	Rubble
Macroalgae	Sand
Turf algae	Silt
	Boulders – large (>50cm), small (<50cm)

Table 9.6c *Categories Used in the Surveys - Ordinal Ranks of Percentage Cover*

Rank	Percentage Cover (%)
0	None recorded
1	<5
2	6-10
3	11-30
4	31-50
5	51-75
6	76-100

Tier II - Taxonomic Inventories to Define Types of Benthic Communities

An inventory of benthic taxa was compiled during each dive (ie each transect). Taxa were identified *in situ* to the following levels:

- Scleractinian (hard) corals to species wherever possible;
- Soft corals, anemones and conspicuous macroalgae were recorded according to morphological features and to genus level if possible; and

- Other benthos (including sponges, zoanthids, ascidians and bryozoans) were recorded to genus level wherever possible but more typically to phylum plus growth form.

At the end of each dive, each taxon in the inventory was ranked in terms of abundance in the community (see *Table 9.6d*). These broad categories rank taxa in terms of relative abundance of individuals, rather than the contribution to benthic cover along each transect. The ranks are subjective assessments of abundance, rather than quantitative counts of each taxon.

Table 9.6d Ordinal Ranks of Taxon Abundance

Rank	Abundance
0	Absent
1	Rare
2	Uncommon
3	Common
4	Abundant
5	Dominant

Photographs of representative coral species located in the surveyed areas were taken and, where possible, photographs of the seabed composition were taken. Video footage and photographs are taken for all transects.

9.6.2 Assessment Methodology

The information presented in the following sections has been based on the findings of baseline surveys performed and the requirement of the EIA Study Brief (*ESB-119/2004, Clause 3.4.7*). The importance of potentially impacted ecological resources identified within the Study Area was assessed using the *EIAO-TM* methodology. The potential impacts (following the guideline of *Annex 16* of the *EIAO-TM*) due to the construction, operation and restoration, and aftercare of the Extension were evaluated with respect to the criteria stipulated in *Annex 8* in the *EIAO-TM*.

9.7 ECOLOGICAL BASELINE CONDITIONS

9.7.1 Existing Terrestrial Habitat and Vegetation

The Study Area consisted of highly disturbed area (such as the TKO Area 137 and the existing SENT Landfill) at the south, west and north, and natural habitats (within CWBCP) at the east. Terrestrial habitats found within the Study Area include plantation, shrubland, grassland, disturbed/ developed area and seasonal streams (see *Figure 9.6a*). A narrow strip of sandy beach was also recorded at the south of the Study Area. Colour photographs of all recorded habitat types, as well as other features and species of conservation interest, are presented in *Figures 9.7a* to *9.7g*. The photographs showing the current conditions of the proposed Extension Site are presented in *Figure 9.7h*.

Exotic plantation dominated by a few exotic plant species such as *Acacia auriculiformis* and *Acacia confusa* were found at the existing SENT Landfill.

Some of the area within the existing SENT Landfill was hydroseeded as grassland.

The understorey of the exotic plantation at the existing SENT Landfill was sparsely occupied by grasses and a few native shrubs such as *Lantana camara* and *Miscanthus sinensis*.

Weed species *Leucaena leucocephala* is the dominant plant species found within the understory of exotic plantation.

Figure 9.7a

Photographic Records of Plantation Within the Study Area

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The Shrubland habitat was dominated by several native plant species including *Rhaphiolepis indica*, *Rhodomrytus tomentosa* and *Cratoxylum cochinchinensis.*

Shrubland patches found in the valleys are usually taller, with an average 2 - 3 m in height, while those on the hill slopes are generaly, shorter with 0.3 to 1.5 m in height.

Plant species *Rhodomrytus tomentosa* is one of the dominant species within shrubland habitat, which is very common in Hong Kong.

Shrubland was mainly found at the wind sheltered and with area.

Figure 9.7b

Photographic Records of Shrubland Within the Study Area

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DATE: 16/12/2006

Grassland was found as a continuous patch at the hill ridges and located at the windy areas within the CWBCP.

Shrubs were sparsely found within the grassland, especially the windy and hilly areas.

Grass species *Neyraudia arundinacea* is one of the plant species commonly found within the grassland.

Grass species *Rhynchelytrum repens* is one of the dominant plant species within the grassland.

Figure 9.7c

Photographic Records of Grassland Within the Study Area

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FILE: 0036286v9
DATE: 16/12/2006

Seasonal stream S1 was recorded at Tin Ha Au, which was fully covered by riparian vegetation.
No stream fauna were recorded.

Seasonal stream S2 was recorded at Tin Ha Au. No stream fauna were recorded.

Figure 9.7d

Photographic Records of the Seasonal Streams Within the Study Area

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Tseung Kwan O Area 137 is a newly reclaimed area and is highly disturbed in nature.

The existing SENT Landfill was highly disturbed area with limited vegetation cover.

The management centre of the existing SENT Landfill was occupied by buildings and carparks. Vegetation found within the area was dominated by plant species of landscape purposes such as exotic tree *Acacia confusa*.

Limited vegetation was recorded within the Tseung Kwan O Area 137, which was dominated by grasses and sedges such as *Ischaemum aristatum* and *Rhynchelytrum repens*.

Figure 9.7e

Photographic Records of Disturbed/Developed Area Within the Study Area

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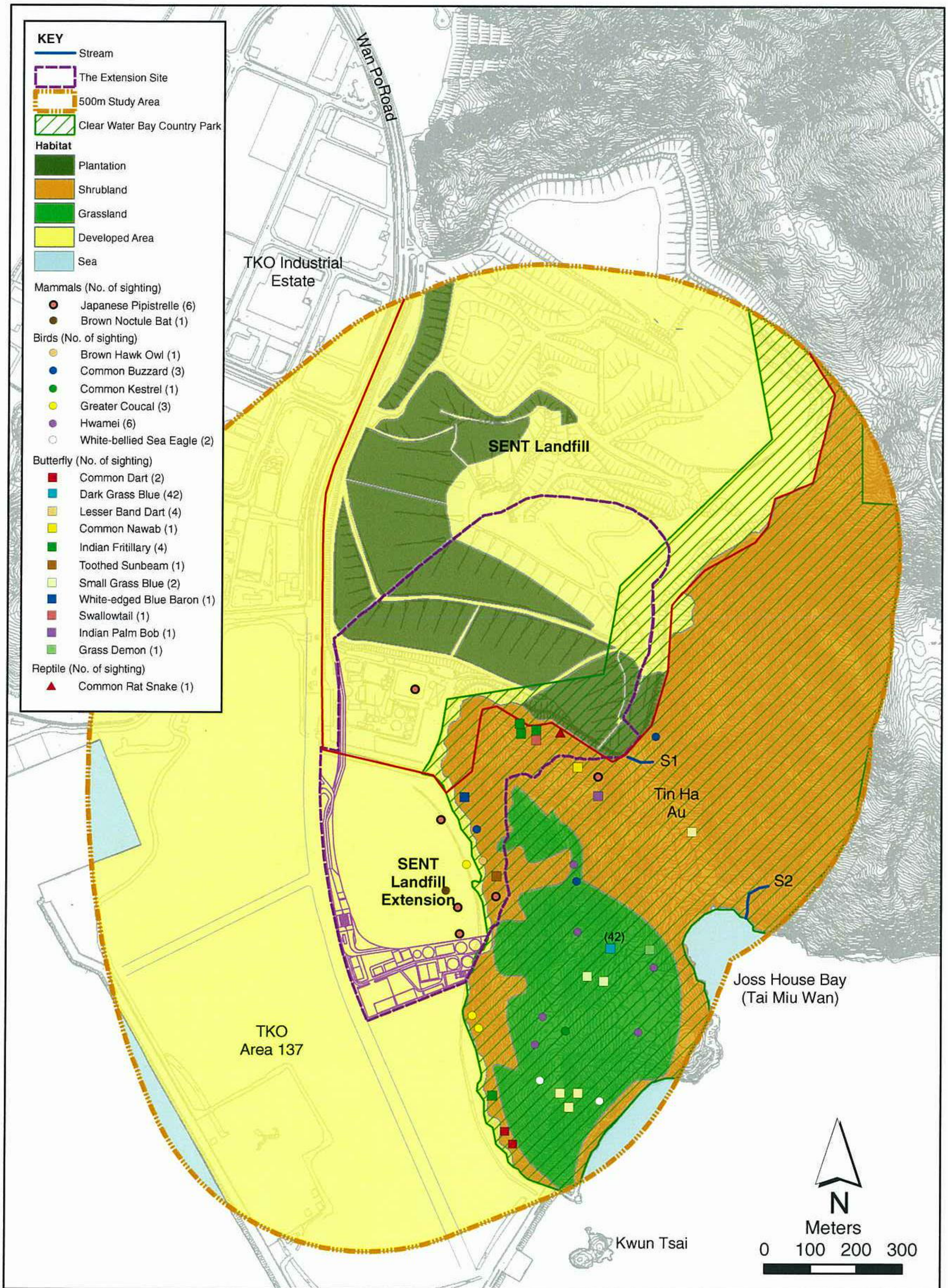

FIGURE 9.7f

Location of Species of Conservation Interest within the Study Area (exclude Black Kite)

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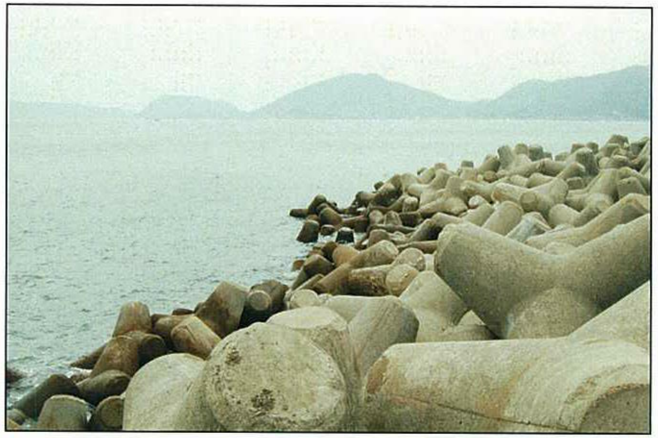
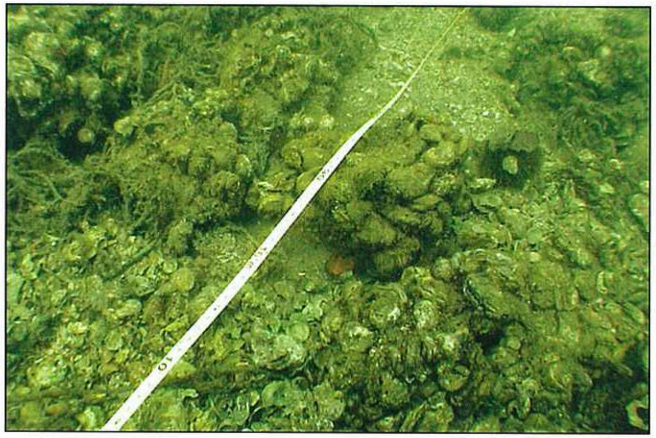
A small patch of sandy beach was found at the South of the Study Area

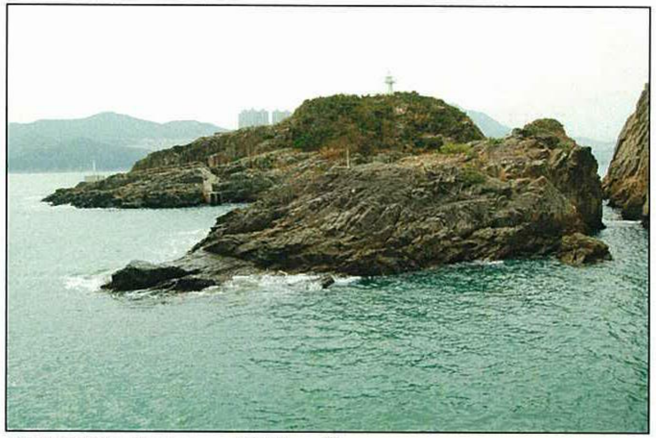
Artificial shore with boulders were found along the shore of TKO Area 137 near to Kwun Tsai.



Artificial shore with concrete blocks was found along the shore of TKO Area 137



Survey transect and subtidal habtiat at Kwun Tsai



Natural rocky shore around Fat Tong Chau.

Survey transect and subtidal habitat at Tit Cham Chau

Figure 9.7g

Photographic Records of Sandy Beach Within the Study Area and the Current Conditions of the Subtidal Dive Survey Sites

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Extension Site comprises of TKO Area 137, which is highly disturbed area with limited vegetation and wildlife recorded.


Extension site comprises of SENT Landfill. The management centre of the existing SENT Landfill comprises of developed area with landscape plants and limited wildlife recorded.


Exotic plantation was established on the restored area of the existing SENT Landfill.


The encroached area within CWBCP was steep in terrace, which is not a favourite habitat for butterflies, dragonflies and herpetofauna.


The Exension Site comprises of shrubland, which was dominated by native shrubs of 0.5 to 1.5 m high.

Figure 9.7h

Photographic Records of the Extension Site

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FILE: 0036286v13
DATE: 16/12/2006

A total of 124 plant species were recorded (see *Table 2* of *Annex D).* The number of plant species and the size of each identified habitat type are presented in *Table 9.7a*.

Table 9.7a Habitat Types Recorded Within the Study Area

Habitat type	Area or Length (hectare or m)	Number of Plant Species Recorded
Plantation	25.0 ha	14
Shrubland	75.3 ha	80
Grassland	19.7 ha	30
Disturbed/ Developed Area	171.2 ha	22
Seasonal Stream	154 m	12

Plantation

Exotic plantation was found at the north of the Study Area, within the boundary of the existing SENT Landfill. A total of 14 plant species were recorded in the plantation and all of them are commonly found in Hong Kong.

The plantation is exotic woodland, dominated by the tree species *Acacia confusa* with a canopy height of 3 to 5m. They were planted in the restored part of the existing SENT Landfill. They are young in age and the understorey was sparsely occupied by weeds (expected to have invaded naturally), including *Leucaena leucocephala*, *Bridelia tomentosa*, *Lantana camara* and *Miscanthus sinensis*. The plant species diversity and structural complexity of the plantation are considered to be low. The photographic records of plantation are shown in *Figure 9.7a*.

Shrubland

Shrubland was found on the hill and mainly located within the CWBCP, in forms of continuous patch and comprised a total area of approximately 75.3 ha. The shrubland has rocky substrate, and shows evidence of occasional disturbance by hill fires. Shrubland patches found in the valleys are usually taller, with an average 2 to 3m in height, while those on the hill slopes are generally shorter, 0.3 to 1.5m in height. A total of 80 plant species, which are commonly found in shrubland habitat in Hong Kong, were recorded. The shrublands were dominated by several native shrub species, including *Rhaphiolepis indica, Rhodomrytus tomentosa*, *Cratoxylum cochinchinensis*, *Eurya nitida*, *Embelia laeta*, *Embelia ribes* and *Gardenia jasminoides*. The species diversity of shrubland is considered to be moderate and the structural complexity is considered low to moderate. The photographic records of shrubland are shown in *Figure 9.7b*.

Grassland

Grassland was recorded at the southeast of the Study Area, mainly located within the CWBCP, comprising 19.7 ha. The grassland was found on the hill ridges with rocky substrate, and exposed to the winds. It was disturbed by hill fires occasional. A total of 30 grassy and shrubby plant species were recorded in the habitat and all of them are commonly recorded in Hong Kong. The grassland was dominated by *Ischaemum aristatum, Rhynchelytrum repens* and *Scleria harlandi*, with shrub species *Wikstroemia chinensis, Rhus succedanea* and *Mimosa pudica* intermingled with each other. The species diversity and structural complexity of grassland are considered to be low. The photographic records of grassland are shown in *Figure 9.7c*.

Seasonal Stream

Two seasonal streams named S1 to S2 were recorded within the Study Area. S1 (approximately 56m in length, with silty bottom) was located at Ha Shan Tuk and S2 (approximately 98m in length, with rocky bottom) was located at Hin Ha Au. The photographic records of streams are shown in *Figure 9.7d*. Both of them are small seasonal streams with limited water flows during the wet season and no water flow during the dry season. The riparian vegetation of the two seasonal streams was densely vegetated and intermingled with the shrubland vegetation in the close vicinity. No stream fauna was recorded during the survey. The ecological significance of these two seasonal streams therefore considered to be low.

Disturbed/ Developed Areas

Disturbed/developed area was the dominant habitat within the Study Area, comprising TKO Area 137, TKOIE and the existing SENT Landfill with a total area of approximately 171.2 ha. The habitat was highly disturbed with limited vegetation cover and all the recorded plant species are common in Hong Kong and mainly for landscape purposes. A total of 22 plant species, dominated by weeds and landscape species, such as *Acacia auriculiformis* and *Leucaena leucocephala* were recorded within the disturbed/ developed area. The species diversity and structural complexity of the disturbed/ developed area are considered to be low. The photographic records of the developed areas are shown in *Figure 9.7e*.

9.7.2 Wildlife

Terrestrial Mammals

Four mammal species, including two bat species, Japanese Pipistrelle *Pipistrellus abramus* and the Brown Noctule Bat *Nyctalus noctula*, Tanezumi Rat *Rattus tanezumi* and Wild Boar *Sus scrofa*, were recorded within the Study Area (see *Tables 3* and 4 of *Annex D*). Only the Japanese Pipistrelle and Tanezumi Rat were recorded within the 5.1 ha of the Extension Site within the CWBCP. All bats are protected in Hong Kong (*Wild Animals Protected Ordinance Cap 170*) but the two recorded bat species (Japanese Pipistrelle and the Brown Noctule Bat) are very common locally [(1)]. The locations of the two bats

(1) Shek, C.t. & Chan, C.S.M. (2006) *Mist net survey of bats with three new bat species records for Hong Kong. Hong Kong Biodiversity* 11:1-7.

recorded during the surveys are shown in *Figure 9.7f*. The other two mammal species are common, widespread in Hong Kong and without any conservation interest.

Birds

Fifty-five bird species were recorded during the quantitative and qualitative surveys (see *Table 5* of *Annex D*). Four of them were recorded outside the survey points but within the Study Area. Thirty-three species were recorded during the dry season and 36 species during the wet season (see *Tables 6* and *7* of *Annex D*). No birds were recorded during the night survey. There were seven bird species of conservation interest, including Black Kite *Milvus migran*, Greater Coucal *Centropus sinensis,* Commom Buzzard *Buteo buteo*, Common Kestrel *Falco tinnunculus,* Hwamei *Garrulax canorus*, Brown Hawk Owl *Ninox scutulata* and White-bellied Sea Eagle *Haliaeetus leucogaster*, encountered during the surveys, and they were mainly perching or soaring in the sky within the Study Area. With the exception of Hwamei, all of them are recognised as Class II protected species in the PRC. White-bellied Sea Eagle and Hwamei are listed in CITES Appendix II. The locations of bird species of conservation value are shown in *Figure 9.7f.* Since the Black Kites were commonly found soaring in the sky within the Study Area, the exact locations of the bird were not shown.

Thirty of the species encountered were resident to Hong Kong. Estimated bird abundance and the recorded numbers of bird species in major habitats are summarised in *Table 9.7b*. The highest bird abundance and bird species were recorded at the shrubland.

Table 9.7b Mean Abundance and Number of Bird Species in Different Types of Habitat in the Study Area

Habitat	Season	Plantation	Shrubland	Grassland	Disturbed/ Developed Area
Survey days	Dry	3	3	3	3
	Wet	3	3	3	3
	Overall	6	6	6	6
Number of individuals	Dry	65	280	57	90
	Wet	49	148	97	66
	Overall	114	428	154	156
Abundance (no. of individuals/ ha/survey point/survey day)	Dry	4.3	18.5	3.76	5.95
	Wet	3.23	9.78	6.41	4.36
	Overall	3.77	14.2	5.09	5.15
No. of species	Dry	19	26	15	17
	Wet	14	20	21	17
	Overall	**26**	**33**	**28**	**24**

Invertebrates

- **Butterflies:** A total of 50 species of butterflies were recorded during the surveys (see *Table 8* of *Annex D*). Thirty-three of which were recorded in the dry season and 34 in the wet season (see *Tables 9* and *10* of *Annex D*). Grassland habitats have the highest number of butterfly species recorded (23 out of the 50 species) in the wet season while shrubland has the highest number of butterfly species in the dry season (21 out of the 50 species). Grassland was also recorded to have the highest number of individual butterflies for both the dry and wet seasons. The number of butterfly species and total number of individuals recorded in each habitat of the Study Area are summarised in *Table 9.7c.*

Table 9.7c ***Butterfly Species Recorded in Each Habitat of the Study Area***

Habitat	Season	Plantation	Shrubland	Grassland	Disturbed/ Developed Area
No. of species	Dry	9	21	14	11
	Wet	14	17	23	2
	Overall				
No. of individuals	Dry	15	75	110	65
	Wet	98	101	178	3
	Overall	113	176	288	68
No. of uncommon species			5	2	
No. of rare species			3	3	

Among the 50 butterfly species, 6 are uncommon, 5 are rare species and the rest are either common or abundant in Hong Kong (*Table 9.7d*). None of them have protection status. Six uncommon species include Toothed Sunbeam *Curetis dentate,* Small Grass Blue *Famegana alsulus*, Indian Palm Bob *Suastus gremius*, Common Nawab *Polyura athamas*, Indian Fritillary *Argyreus hyperbius* and White-edged Blue Baron *Euthalia phemius.* Rare species are Common Dart *Potanthus pseudomaesa,* Grass Demon *Udaspes folus,* Dark Grass Blue *Zizeeria karsandra,* Swallowtail *Papilio xuthus* and Lesser Band Dart *Pothanthus trachala.* The locations of butterfly species of conservation interests recorded within the Study Area are shown in *Figure 9.7f.*

Table 9.7d ***Larval Food Plants of Butterfly Species of Conservation Interests***

Common Name	Species Name	Status	Food Plant as Reported in Bascombe et al 1999 (1)
Grass Demon	*Udaspes folus*	Rare	*Zingiber officinale, Hedychium coronarium*
Common Dart	*Potanthus pseudomaesa*	Rare	*Cymbopogon tortilis, Miscanthus floridulus*
Lesser Band Dart	*Potanthus trachala*	Rare	*Ischaemum indicum, Miscanthus floridulus, M. sinensis, Phragmites karka*
Swallowtail	*Papilio xuthus*	Rare	*Zanthoxylum nitidum, Z. myriacanthum, Citrus microcarpa, Fortunellla hindsii, F japonica*
Dark Grass Blue	*Zizeeria karsandra*	Rare	*Amaranthus spinosus, A. tricolor, A. viridis*
Indian Palm Bob	*Suastus gremius*	Uncommon	*Phoenix hanceana, P. roebelinii, Rhapis excelsa*
Toothed Sunbeam	*Curetis dentate*	Uncommon	*Millettia reticulata, Pongamia pinnata*
Small Grass Blue	*Famegana alsulus*	Uncommon	*Desmodium elegans, Flemingia macrophylla, Phyllodium pulchellum*
Common Nawab	*Polyura athamas*	Uncommon	*Acacia sinuate, Albizia corniculata, A. lebbeck, Archidendron clypearia, Leucaena leucocephala*
Indian Fritillary	*Argyreus hyperbius*	Uncommon	*Viola betonicifolia, V. odorata*
White-edged Blue Baron	*Euthalia phemius*	Uncommon	M*angifera indica*

- **Dragonflies:** Six dragonfly species including Common Bluetail, Amber-winged Glider, Common Blue Skimmer, Common Red Skimmer, Green Skimmer and Wandering Glider were recorded in the Study Area during the survey (see *Tables 11* to *13* of *Annex D*). All of the dragonfly species are abundant or commonly found in Hong Kong.

  Grassland has the highest number of individuals of dragonflies while disturbed/developed area and plantation has the highest number of species during the survey. The number of dragonfly species and total number of individuals recorded in each habitat are summarised in *Table 9.7e*.

Table 9.7e ***Dragonfly Species Recorded in Each Habitat of the Study Area***

Habitat	Season	Plantation	Shrubland	Grassland	Disturbed/ Developed Area
No. of species	Dry		2		3
	Wet	3	2	2	3
	Overall	3	3	2	4
No. of individuals	Dry		31		3
	Wet	17	15	36	5
	Overall	17	46	36	8

(1) M.J. Bascombe, G. Johnston, F.S. Bascombe (1999), *The butterflies of Hong Kong*. Academic Press, London.

Herpetofauna

A total of five species of amphibian (Asian Common Toad, Gunther's Frog, Paddy Frog, Brown Tree Frog and Ornate Pygmy Frog), two species of reptiles (Changeable Lizard and Common Rat Snake) were recorded in the Study Area (see *Tables 14* to *16* of *Annex D*). The location of the common and widespread reptile, but listed in CITES Appendix II, the Common Rat Snake *Ptyas mucosus* was presented in *Figure 9.7f*. The remaining species are common locally.

Stream Macro-fauna

No aquatic fauna was recorded within the seasonal streams, which may be due to the limited water flow during the surveys.

9.7.3 Sub-tidal Habitat

Seabed condition

The survey was performed on 29 and 30 December 2005. The weather was sunny and the sea was calm. The visibility was poor, ranging between 0.5m and 1.5m. The photographic records of the sub-tidal dive habitats are shown in *Figure 9.7g*. The results of the qualitative survey are shown in *Table 17* of *Annex D*. Along each transect the seabed composition was identified and conditions were shown in *Table 18* of *Annex D.* The seabed attributes of the transects are shown in *Table 19* of *Annex D*.

Coral Assemblages

A total of nineteen species of hard coral and five species of soft coral were recorded along the survey transects and in their vicinity. All of them are commonly found in Hong Kong except the hard coral species *Acropora solitaryensis* which is uncommon in Hong Kong. The relative positions and estimated sizes (soft coral in length while hard coral in diameter) of the hard and soft corals are listed in *Table 20* of *Annex D*. The relative abundance (percentage cover) of each hard coral species at Transects A1 to E1 are shown in *Table 9.7f* and the relative abundance of soft corals are shown in *Table 9.7g*.

Table 9.7f *Hard Coral Species Recorded in Transects A1 – E1*

Hard Coral Species	**Percentage Cover**				
	A1	**B1**	**C1**	**D1**	**E1**
Acropora solitaryensis	-	-	-	1	-
Coscinaraea n sp.	1	1	-	-	1
Cyphastrea serailia	-	-	1	-	-
Favia favus	1	-	-	-	1
Favia lizardensis	-	-	-	-	1
Favia rotumana	-	-	-	-	1
Favia speciosa	-	-	1	1	1
Favites abdita	-	-	1	1	-
Goniastrea aspera	1	-	-	1	-
Goniopora stutchburyi	-	1	-	-	1
Hydnophora exesa	1	-	-	-	-
Leptastrea purpurea	-	-	-	1	-
Oulastrea crispata	-	-	1	-	1
Pavona decussata	-	-	-	1	-
Platygyra acuta	-	-	-	1	-
Plesiastrea versipora	1	1	1	1	1
Porites sp.	1	1	1	1	-
Psammocora superficialis	1	-	1	1	1
Turbinaria peltata	-	-	1	1	-
Total Number of Species	**7**	**4**	**8**	**11**	**9**

Note:
(a) 1 = 1-10% Cover, 2 = 11-30% Cover, 3 = 31-50% Cover, 4 = 51-75% Cover, 5 = 76-100% cover.

Table 9.7g *Soft Coral Species Recorded in Transects A1 – E1*

Soft Coral Species	**Percentage Cover**				
	A1	**B1**	**C1**	**D1**	**E1**
Cladiella sp.	1	-	-	-	-
Dendronephtha sp.	-	1	-	-	-
Echinomuricea sp.	3	-	-	-	-
Euplexaura sp.	2	1	1	-	-
Tubastrea sp.	1	-	-	-	-
Total Number of Species	**4**	**2**	**1**	**0**	**0**

Note:
(a) 1 = 1-10% Cover, 2 = 11-30% Cover, 3 = 31-50% Cover, 4 = 51-75% Cover, 5 = 76-100% cover.

The benthic fauna recorded along the survey transect included sponges, ascidians, rock oyster *Saccostrea cucullata*, *Pinctada* sp., the sea cucumber *Holothuria leucospilota*, decorator urchins *Temnopleura reevesi*, sea urchin *Anthocidaris crassispina* and the long-spined sea urchins *Diadema setosum*.

The results of the sub-tidal habitat surveys indicated that hard corals were in low abundance and diversity, and dominated by species which are commonly found in Hong Kong. Zone A found to have relatively high abundance of soft coral and dominated by *Echinomuricea* sp. and *Euplexaura* sp. which are quite common in Hong Kong. The ecological values of the sub-tidal habitats are considered to be low to moderate.

9.7.4 Existing Conditions of the Extension Site

The Extension Site comprised part of the TKO Area 137, the existing SENT Landfill and the CWBCP area. Based on the literature review and the field surveys, it was found that the habitats recorded in the Extension Site are dominated by disturbed/developed areas (34.6 ha) and plantation (12.2 ha), with small patches of shrubland (6 ha) and grassland (0.1 ha). For the areas within the CWBCP, 5.1 ha of the existing habitats, including approximately 4.6 ha of shrubland, 0.1 ha of grassland and 0.4 ha of disturbed/developed areas will be affected. The photographic records of habitats within the Extension Site are shown in *Figure 9.7h*.

Plantation was recorded within the existing SENT Landfill, which is dominated by exotic plants *Acacia auriculiformis* with a height of 3 to 5m. The under-storey was sparsely occupied by weeds and native shrubs, dominated by *Leucaena leucocephala, Rhus succedanea Rhaphiolepis indica* and *Ficus microcarpa.* The species diversity and structural complexity of the plantation are considered to be low.

The shrubland was dominated by native shrubs at a height of 1.5 to 2m, with native shrubs such as *Breynia fruticosa, Bridelia tomentosa, Cratoxylum cochinchinensis* and *Rhodomrytus tomentosa*. The species diversity of the shrubland is considered as moderate and the structural diversity to be low to moderate.

The grassland was dominated by grasses and sedges including *Miscanthus sinensis* and *Rhynchelytrum repens* at a height of 0.5 to 1m. The species diversity and the structural complexity of grassland are considered as low.

The disturbed/developed area is highly disturbed by human activities and limited vegetation cover was recorded. The vegetation was dominated by sedges and climbers such as *Cyperus rutondus*, *Leucaena leucocephala* and *Mikania micrantha* and plants for landscape purposes (see *Table 2* of *Annex D).* The species diversity and structural complexity of the disturbed/developed area are considered to be low.

A total of 88 plant species were recorded within the Extension Site, in which 62 plant species were recorded within the 5.1 ha of the Extension Site within the CWBCP. All of the recorded plant species are common or very common in Hong Kong.

The results of the field surveys indicated that the wildlife abundance and species diversity recorded within the Extension Site were relatively low in the plantation and developed areas, but moderate in shrubland and grassland.

The species diversity and wildlife abundance recorded within the CWBCP area were low to moderate in the shrubland. Species of conservation interests found within the Extension Site are shown in *Table 9.7h*.

Table 9.7h ***Faunal Species with Ecological Interest within the Extension Site***

Species	**Location**	**Activity**	**Protection Status**
Mammals			
Japanese Pipistrelle *Pipistrellus abramus*	Shrubland within the encroached area of CWBCP and developed area of the Extension Site	Soaring	Wild Animals and Plants (Cap 170)
Brown Noctule Bat *Nyctalus noctula*	Developed area within the Extension Site	Flying fast above the habitat	Wild Animals and Plants (Cap 170)
Birds			
Black Kite *Milvus lineatus*	Shrubland, developed area and plantation within the Extension Site, and shrubland within the encroached area of the CWBCP	Soaring	*Class 2 Protected Animal of PRC;*
Common Buzzard *Buteo buteo*	Shrubland within the encroached area of the CWBCP	Perching, flight over	*Class 2 Protected Animal of PRC;*
Greater Coucal *Centropus sinensis*	Developed area within the Extension Site	Perching	*Class 2 Protected Animal of PRC*
Brown Hawk Owl *Ninox scutulata*	Shrubland within the encroached area of the CWBCP	Perching	*Class 2 Protected Animal of PRC*
Butterflies			
Swallowtail *Papilio xuthus*	Shrubland near the top of the hill within the encroached area of the CWBCP	Flying over	Not protected
Indian Fritillary *Argyreus hyperbius*	Shrubland near the top of the hill within the encroached area of the CWBCP	Flying over	Not protected
Toothed Sunbeam *Curetis dentate*	Shrubland within the encroached area of CWBCP.	Flying over	Not protected
White-edged Blue Baron *Euthalia phemius*	Shrubland within the encroached area of the CWBCP	Flying over	Not protected
Reptiles			
Common Rat Snake *Ptyas mucosus*	Shrubland within the encroached area of the CWBCP	Resting	Not protected in Hong Kong; *CITES Appendix II*

In conclusion, the ecological value of shrubland is considered to be moderate, low to moderate for grassland, low for plantation and negligible for the disturbed/developed area.

9.8 ECOLOGICAL EVALUATION

In this section the ecological importance of the habitats and wildlife identified within the Study Area are evaluated in accordance with the criteria stipulated in *Annex 8* of the *EIAO-TM*. The evaluation is based upon the information presented in *Section 9.7*. The ecological importance of each habitat type within the Study Area and the habitats within the Extension Site are presented in *Tables 9.8a* to *9.8g*.

Table 9.8a Ecological Evaluation of Plantation

Criteria	**Plantation**
Naturalness	Man-made habitat dominated by exotic plants.
Size	Exotic plantation with the overall size of 25.0 ha. Approximately 12.2 ha of plantation located within the Extension Site.
Diversity	Low diversity of plant (14 species), low diversity of birds (26 species), butterfly (18 species) and other fauna.
Rarity	Bird species Black Kite was recorded soaring in the sky.
Re-creatability	Habitat characteristics and species composition are easy to recreate. It will take around 5 to 10 years for the plantation to be re-created.
Fragmentation	Not applicable.
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity.
Potential Value	Low
Nursery/ Breeding Ground	None.
Age	Young (10 years) based on tree size, woodland structure and species composition.
Abundance/ Richness of Wildlife	Low abundance for wildlife.
Overall Ecological Value	**Low**

Table 9.8b Ecological Evaluation of Shrubland

Criteria	Shrubland
Naturalness	Natural habitat with disturbance of hill fires
Size	Shrubland has the overall size of approximately 75.3 ha. Approximately 6 ha of shrubland were found within the Extension Site in which approximately 4.6 ha located within the CWBCP and outside of the existing SENT Landfill.
Diversity	Moderate for vegetation (totally 80 species for the whole area, mostly native shrubs and climbers), moderate for faunal diversity
Rarity	Species of conservation interest included Japanese Pipistrelle, Black Kite, Brown Hawk Owl, Common Buzzard, Greater Coucal, Hwamei, Common Rat Snake, Lesser Band Dart, Swallowtail, Common Nawab, Common Dart, Indian Fritillary, Toothed Sunbeam, White-edged Blue Baron and Indian Palm Bob
Re-creatability	Habitat characteristics and species composition are easy to recreate. It will take more than 10 years for the shrubland to be re-created.
Fragmentation	Shrubland mainly exists as a continuous patch
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity
Potential Value	Medium to high
Nursery /Breeding Ground	No significant nursery/breeding ground recorded.
Age	Young to moderate
Abundance/ Richness of Wildlife	Moderate for avifauna and butterflies, low for dragonfly
Overall Ecological Value	**Moderate**

Table 9.8c Ecological Evaluation of Grassland

Criteria	Grassland
Naturalness	Semi-natural, disturbed by hill fire and dominated by grasses and sedges
Size	Grassland was approximately 19.7ha, with 0.1 ha encroached within the CWBCP and outside the existing SENT Landfill
Diversity	Low for vegetation and low to moderate for fauna
Rarity	Species of conservation interests included Black Kite, Hwamei, Common Buzzard, Common Kestrel, White-bellied Sea Eagle, Dark Grass Blue, Small Grass Blue, Lesser Band Dart and Grass Demon
Re-creatability	Readily creatable
Fragmentation	Not applicable
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity
Potential Value	Low
Nursery/ Breeding Ground	No significant nursery/breeding ground recorded
Age	Young
Abundance/ Richness of Wildlife	Wildlife abundance was low to moderate
Overall Ecological Value	**Low to moderate**

Table 9.8d Ecological Evaluation of Seasonal Streams

Criteria	Seasonal Stream S1 at Tin Ha Au	Seasonal Stream S2 at Tin Ha Au
Naturalness	Natural	Natural
Size	The total length was 56 m with silty substratum	The total length was 98 m with rocky substratum.
Diversity	Low for plant and no aquatic fauna recorded	Low for plant and no aquatic fauna recorded
Rarity	Nil	Nil
Re-creatability	Re-creatable	Re-creatable
Fragmentation	Not applicable	Not applicable
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity	Not functionally linked to any highly valued habitat in close proximity
Potential Value	Low ecological potential	Low ecological potential
Nursery/Breeding Ground	None	None
Age	Not applicable	Not applicable
Abundance/ Richness of Wildlife	Nil	Nil
Overall Ecological Value	**Low**	**Low**

Table 9.8e Ecological Evaluation of Disturbed/ Developed Area

Criteria	Disturbed / Developed Area
Naturalness	Man-made habitat
Size	The overall size was approximately 171.2 ha. This habitat was dominant within the Extension Site with approximately 34.6 ha. 0.4 ha of this habitat is located within the encroached area of CWBCP.
Diversity	Low for flora and fauna.
Rarity	Species of conservation interests included Japanese Pipistrelle, Brown Noctule Bat, Black Kite and Greater Coucal
Re-creatability	Readily re-creatable
Fragmentation	Not applicable
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity
Potential Value	Low
Nursery/Breeding Ground	None
Age	Not applicable
Abundance/Richness of Wildlife	Low
Overall Ecological Value	**Negligible**

Table 9.8f Ecological Evaluation of Subtidal Habitats

Criteria	Subtidal Habitats
Naturalness	Natural
Size	Overall 500 m of survey transects were done for Zones A to E. None of the subtidal habitats were found within the Project Site.
Diversity	Hard corals were in low abundance and diversity. Zone A found to have relatively high abundance of soft coral
Rarity	Uncommon coral species *Acropora solitaryensis.*
Re-creatability	The subtidal habitat may take 5 to 10 years to re-establish.
Fragmentation	Not applicable
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity
Potential Value	Low
Nursery/Breeding Ground	None
Age	Not applicable
Abundance/Richness of Wildlife	Low
Overall Ecological Value	**Low to moderate**

Table 9.8g Ecological Evaluation of the Extension Site

Criteria	Extension Site
Naturalness	Dominated by man-made habitat (disturbed/developed area and plantation). Natural habitats included shrubland and grassland but with certain degree of disturbance (ie, hill fire) were recorded.
Size	Approximately 34.6 ha of disturbed/ developed area, 12.2 plantation, 6 ha of shrubland and 0.1 ha of grassland recorded within the Extension Site. 4.6 ha of shrubland, 0.1 ha of grassland and 0.4 ha of disturbed/developed area were encroached upon the CWBCP.
Diversity	Low to moderate for vegetation and fauna
Rarity	Species of conservation interest included Japanese Pipistrelle, Brown Noctule Bat, Black Kite, Greater Coucal, Brown Hawk Owl, Common Buzzard, Common Rat Snake, Swallowtail, Tooted Sunbeam, White-edged Blue Baron and Indian Fritillary
Re-creatability	The shrubland may take 10 years to be recreated, plantation may take 10 years to be recreated, grassland may take 5 years to re-created
Fragmentation	Not applicable
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity
Potential Value	Low
Nursery/Breeding Ground	No significant nursery/breeding ground recorded
Age	Young
Abundance/Richness of Wildlife	Abundance and richness of wildlife was low.
Overall Ecological Value	**Low to moderate**

The lists and evaluations of the floral and faunal species of ecological interest recorded within the Study Area, according to the *EIAO-TM*, are given in *Table 9.8h.*

Table 9.8h Evaluation of Faunal Species with Ecological Interest within the Study Area

Species	Location	Protection Status	Distribution	Rarity
Mammals				
Japanese Pipistrelle *Pipistrellus abramus*	Shrubland and disturbed/developed area within Study Area and the shrubland encroached within the CWBCP	Wild Animals and Plants (Cap 170)	Widespread	Very Common
Brown Noctule Bat *Nyctalus noctula*	Flying fast above the developed area within the Study Area	Wild Animals and Plants (Cap 170)	Scattered records in New Territories and Lantau	Common
Birds				
White-bellied Sea Eagle *Haliaeetus leucogaster*	Flying above the grassland of Study Area, perching	Class 2 of Protected Animal of PRC; Appendix 2 in CITES	Found in coastal area of Hong Kong, Oriental and Australasian	An uncommon resident in HK
Black-eared Kite *Milvus lineatus*	In various habitats of the Study Area; Soaring	*Class 2 Protected Animal of PRC*	Found in many types of habitats; East Eurasia	Common and widespread in HK
Common Kestrel *Falco tinnunculus*	Recorded in flight over grassland of Study Area, perching	*Class 2 Protected Animal of PRC*	Widespread in China; Eurasian and African	Common and widespread autumn migrant, less common winter visitor
Common Buzzard *Buteo buteo*	Recorded in flight over shrubland within the encroached area of CWBCP and grassland within the Study Area, perching	*Class 2 Protected Animal of PRC*	Widespread in Eurasia	Common winter visitor to HK
Greater Coucal *Centropus sinensis*	Recorded in disturbed/developed area of the Study Area, perching	*Class 2 Protected Animal of PRC*	Found in many types of habitats in Hong Kong; Oriental	Common and widespread in HK; Very rare in China
Hwamei *Garrulax canorus*	Recorded in grassland of the Study Area, perching	*Appendix 2 in CITES*	Found in shrubland in Hong Kong	An uncommon resident in HK; uncommon in China
Brown Hawk Owl	In shrubland	*Class 2 Protected*	Can turn up	Very rare

Species	Location	Protection Status	Distribution	Rarity
Ninox scutulata	within the encroached area of CWBCP, perching	*Animal of PRC*	in various vegetated habitats during migration, Oriental	passage migrant in HK
Butterflies				
Common Dart *Potanthus pseudomaesa*	Shrubland within the encroached area of CWBCP	Not protected	Found in Hok Tau, Uk Tau, Ma On Shan and Victoria Peak	Rare
Grass Demon *Udaspes folus*	Grassland in the valley within the Study Area	Not protected	Found in most country parks	Rare
Lesser Band Dart *Potanthus trachala*	Grassland within the Study Area and the shrubland at the southern part of the Study Area	Not protected	Found in most country parks	Rare
Swallowtail *Papilio xuthus*	Shrubland near the top of the hill within encroached area of CWBCP	Not protected	Ma On Shan, Plover Cove, Tai Tam, Tai Lam, Pat Sin Leng, Sha Lo Wan, Kat O, Lung Kwu Tan	Rare
Dark Grass Blue *Zizeeria karsandra*	Grassland within the Study Area	Not Protected	Most country parks	Rare
Common Nawab *Polyura athamas*	Shrubland near the top of the hill within the Study Area	Not protected	Most country parks	Uncommon
Indian Fritillary *Argyreus hyperbius*	Shrubland near the top of the hill within the encroached area of CWBCP and the shrubland at the southern part of the Study Area	Not protected	Found in most country parks	Uncommon
Indian Palm Bob *Suastus gremius*	Shrubland near the top of the hill within the Study Area	Not protected	Found in most country parks	Uncommon
Small Grass Blue *Famegana alsulus*	Grassland along the ridge within the Study Area	Not protected	Plover Cove. Sai Kung West Country Park, Pokfulam, Lamma	Uncommon
Toothed Sunbeam *Curetis dentate*	Shrubland within the encroached area of CWBCP	Not protected	Most country parks	Uncommon

Species	Location	Protection Status	Distribution	Rarity
White-edged Blue Baron *Euthalia phemius*	Shrubland within the encroached area of CWBCP	Not protected	Found in most country parks	Uncommon
Reptiles				
Common Rat Snake *Ptyas mucosus*	Shrubland near the top of the hill within the encroached area of CWBCP	Not protected in Hong Kong; *CITES Appendix II*	Widespread in HK	Common
Corals				
Acropora solitaryensis	Shore of Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Predominant distribution in the southeastern sector of Hong Kong's coastal waters.	Uncommon
Coscinaraea n sp.	Shore of Fat Tong Chau and Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	In northeastern, eastern, southeastern and western waters of Hong Kong.	Common
Cyphastrea serailia	Shore of Tit Cham Chau	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Dominant
Favia favus	Shore of Fat Tong Chau and Tit Cham Chau	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Favia lizardensis	Shore of Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Common
Favia rotumana	Shore of Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Favia speciosa	Shore of Tit Cham Chau, Kwun Tsai and Tin Ha Au	*Protection of Endangered Species of Animals and*	Widespread in Hong Kong	Abundant

Species	Location	Protection Status	Distribution	Rarity
		Plants Ordinance (Cap 586), *Marine Park Ordinance* (Cap 476)		
Favites abdita	Shore of Tit Cham Chau and Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Dominant
Goniastrea aspera	Shore of Fat Tong Chau and Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Common
Goniopora stutchburyi	Shore of Fat Tong Chau and Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Common
Hydnophora exesa	Shore of Fat Tong Chau	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Leptastrea purpurea	Shore of Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Oulastrea crispata	Shore of Tit Cham Chau and Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Common
Pavona decussata	Shore of Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Platygyra acuta	Shore of Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine*	Widespread in Hong Kong	Dominant

Species	Location	Protection Status	Distribution	Rarity
		Park Ordinance (Cap 476)		
Plesiastrea versipora	Shore of Fat Tong Chau, Tit Cham Chau, Kwun Tsai and Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Porites sp.	Shore of Shore of Fat Tong Chau, Tit Cham Chau and Kwun Tsai	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	*Porites* sp. recorded in Hong Kong included *Porites lobata*, *Porites lutea*, *Porites aranetai*, *Porites deformis* and *Porites solida*. They are wildspread in Hong Kong, especially the east and northeastern waters.	*Porites* sp. recorded in Hong Kong included *Porites lobata*, *Porites lutea*, *Porites aranetai*, *Porites deformis* and *Porites solida*. All of the species are common or abundantly found in Hong Kong except *Porites aranetai* and *Porites deformis* are uncommon and *Porites solida* is rare.
Psammocora superficialis	Shore of Fat Tong Chau, Tit Cham Chau, Kwun Tsai and Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Abundant
Turbinaria peltata	Shore of Tit Cham Chau and Tin Ha Au	*Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586), *Marine Park Ordinance* (Cap 476)	Widespread in Hong Kong	Common

9.9 POTENTIAL IMPACTS AND IMPACT ASSESSMENT

The construction of the Extension involves removal of vegetation and land excavation for the construction of desired landform. The construction works are expected to be completed within 2 years and the operation/restoration period will last for about 6 years. The aftercare period for the Extension is estimated to last up to 30 years. During the Aftercare period, the landfill contractor will continue to manage the final cap (including the vegetation of top of the cap) and the leachate and landfill gas generated from the Extension.

9.9.1 Construction Phase

The potential ecological impacts due to the construction of the Extension are described below.

Habitat Loss

- Permanent loss of plantation (approximately 12.2 ha), shrubland (approximately 1.4 ha) and disturbed/developed area (approximately 34.2 ha) within the existing SENT Landfill and TKO Area 137 during construction of the Extension Site;

- Permanent loss of shrubland (approximately 4.6 ha), grassland (approximately 0.1 ha) and disturbed/developed area (approximately 0.4 ha), which are located within the CWBCP and outside the existing SENT Landfill, due to the construction of the Extension;

- Loss of foraging and feeding ground of the associated wildlife, particularly the natural habitats; and

- No direct loss of subtidal habitats is expected as it is a land based project that no marine works would be involved and no marine habitat/species would be affected.

Details are presented in *Figure 9.9a* and *Table 9.9a*.

Table 9.9a Overall Habitat Loss due to the Construction of the Extension

Impacted Habitats	Permanent Loss (ha)	Ecological Value of the Affected Habitat
Plantation	12.2	Low
Shrubland	6 (4.6 ha)	Moderate
Grassland	0.1 (0.1 ha)	Low to moderate
Disturbed/ Developed Area	34.6 (0.4 ha)	Nil

Note:

(a) Habitats located within the CWBCP and outside the existing SENT Landfill to be affected are presented in bracket.

Impacts to Wildlife

- Reduction of wildlife species abundance/diversity and ecological carrying capacity is expected to be minimal due to the loss of a relatively small area of natural habitat (as compared with the large extent of similar habitats in the immediate vicinity), and steep slope of the affected area limits the wildlife usage. Although species of conservation interest including Japanese Pipistrelle, Brown Noctule Bat, Greater Coucal, Brown Hawk Owl, Common Buzzard, Black Kite, Common Rat Snake, Swallowtail, Tooted Sunbeam, White-edged Blue Baron and Indian

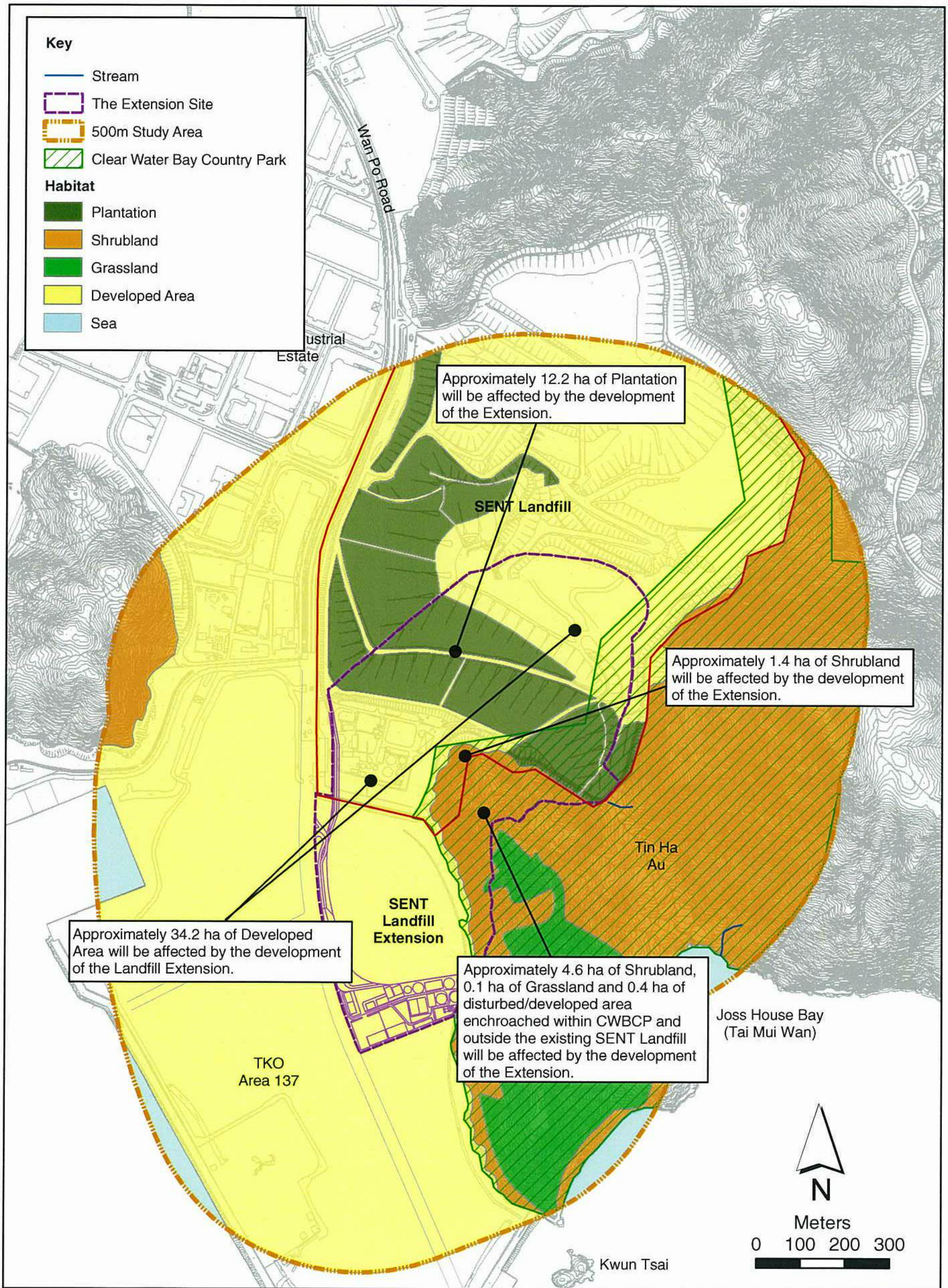

FIGURE 9.9a

Impacts of Construction of SENT Landfill Extension on Existing Habitats within the Project Area

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Date: 28/09/2007

Environmental Resources Management

ERM

Fritillary were recorded within the Extension Site, the majority of the Extension Site is not the preferred habitat of these species.

- Impacts to wildlife with high mobility such as birds, butterflies, dragonflies and herpetofauna is expected to be minimal as there is relatively large area of similar natural habitats in the close vicinity. Impacts to wildlife with low mobility such as insects will be a concern as the loss of habitat may reduce their abundance and diversity. However, with the compensatory planting of mixed woodland and shrubland, the impacts to wildlife is expected to be minimal.

- The impacts due to the loss of foraging ground are also considered to be minimal given that the large extent of similar habitats in the vicinity, and the affected areas located next to the currently highly disturbed areas.

- Given that there was no aquatic fauna recorded in the seasonal streams and cut-off channel will be effectively operated to avoid any discharge outside the Extension Site prior to the extension works, impacts to aquatic life (in particular corals in the surrounding coastal areas) due to the change in water quality, sedimentation rate and pattern is expected to be minimal.

Habitat Fragmentation and Isolation

- Habitat fragmentation and isolation are not expected as the majority of the affected habitats are either disturbed or located next to the developed areas, and the natural habitats (mainly shrubland) are located at the western end of the headland and most of the upland and surrounding habitats will remain untouched. It should be noted that the areas within the CWBCP are generally steep and are expected to be mainly utilized by highly mobile wildlife such as birds and butterflies, which are less affected by such fragmentation and isolation effects.

Other Impacts

- As no streams or water gathering areas will be affected due to the Extension, and no marine works are involved, the hydrology and hydrodynamic properties would not be affected.

- During the first year of construction, works including site formation and construction of site office buildings, workshops, landfill gas and leachate treatment plant will be carried out. Excavation is necessary for the construction of the new infrastructure. It is anticipated that, with the implementation of good construction practices, as stated in *ProPECC PN1/4*, and appropriate mitigation measures including provision of a perimeter cut-off channel around the Extension Site, intercepting channels and silt removal facilities (see *Section 6.8*), contamination of construction runoff will be minimal and there will be no unacceptable water quality and ecological impacts to the receiving water bodies (ie surface water including two seasonal streams S1 and S2, inshore waters in Junk Bay and

Joss House Bay, as well as the coral communities recorded in the subtidal habitats along the coastlines in particular at Kwun Tsai where the uncommon coral species *Acropora solitaryensis* recorded).

- The base of the landfill (either existing SENT Landfill or the Extension) has been designed to be above the groundwater level (see *Section 3*), the hydrogeology of the area is not expected to be influenced.

- The blasting works which generate very short-term instantaneous impacts, may affect the wildlife, in particular birds, associated with the natural habitats in the immediate vicinity. It should be noted that the quantity of explosive used and the dimensions and spacings of shotholes will be carefully designed to minimise air overpressure, flyrock generation and ground-borne vibration. The loose material and stones in the site will be removed before blasting to minimise the potential for flying fragments to affect the surrounding areas. The blasting area will also be wetted prior to blasting to minimise dust generation. With the use of fine blast nets, screens and other protective covers, the impacts to the wildlife associated with the surrounding habitats due to blasting are expected to be low. It should be noted that the formation of rock slopes of the existing SENT Landfill adopted similar blasting works. No adverse ecological impacts were observed due to the blasting works.

- Secondary impacts to the surrounding habitats (generally with low to moderate ecological value, including the sub-tidal habitats in the vicinity) and associated wildlife may arise from the potential for increased noise impact, human activities and disturbance such as hill fire, import, storage or dumping of construction materials and construction site runoff. The impacts are expected to be low owing to the existing disturbed nature of the majority of the site, and given that regular site audits on good construction practice (including the provision of chain-link fence around the site boundary to restrict construction activities within the site boundary) and surface water management systems will be employed during the construction phase.

9.9.2 Operation/Restoration Phase

The operation and restoration of the Extension will be implemented concurrently. The main ecological concern during this phase is related to the accidental leakage of leachate, other wastewaters and landfill gas, which may result in:

- potential impacts to water quality and aquatic life particularly corals in the vicinity due to leakage of leachate and wastewater; and

- potential impacts to the surrounding natural habitat in CWBCP and associated wildlife due to an accidental fire caused by accidental leakage of landfill gas.

With the incorporation of well designed and properly implemented pollution control measures and systems, including landfill gas management system, leachate management system and surface water/groundwater system (see *Section 3*), as well as implementing a comprehensive environmental monitoring and audit programme, accidental discharge of leachate into surface water, and subsurface off-site migration of leachate and landfill gas will be adequately controlled and the associated impacts to the surrounding natural habitats, associated wildlife and aquatic life particularly corals in the vicinity are not expected.

Operation/restoration phase impacts to terrestrial ecology may arise from increased human activities in the area resulting in disturbance to the surrounding natural habitats in CWBCP and associated wildlife, if uncontrolled. Chain-link fence or boundary wall will be erected around the Extension Site boundary to restrict the construction and operation/restoration activities within the site boundary. Given that general wildlife including species of conservation interest can still be observed around the area of the existing SENT Landfill during the ecological baseline surveys for this EIA it is not expected that unacceptable operation/restoration phase impacts will occur.

9.9.3 Aftercare Phase

The aftercare phase will begin when the final filling and restoration of the Extension are completed, and is estimated to last up to 30 years. The works to be performed during this aftercare period will include maintaining the control measures and systems functioning as designed and undertaking routine environmental monitoring. Similar to the operation/restoration phase, impacts to terrestrial ecology may arise from increased human activities (ie, vegetation management) in the area resulting in disturbance to the restored habitats and the surrounding natural habitats in CWBCP and associated wildlife, if uncontrolled. Impacts to subtidal habitats particularly the corals are not expected during the aftercare phase with the proper control of landfill leachate. Given the generally low level of disturbance required to manage the Extension Site it is not expected that the aftercare of the Extension will cause adverse ecological impacts.

9.9.4 Cumulative Impact

TKO Area 137 is planned to be developed for deep waterfront industrial uses. A C&D Material Handling Facility is currently committed to be developed in the area. No adverse cumulative ecological impacts are expected as the TKO Area is a disturbed/developed area with negligible ecological value.

9.9.5 Impact Evaluation

Construction Phase

Habitat Loss – Potential impacts to ecology have been evaluated according to *Table 1* of *Annex 8* of the *EIAO-TM*. *Tables 9.9a* to *9.9e* present an evaluation of the habitat loss due to the proposed Extension.

Table 9.9a Overall Impact Evaluation for Plantation within the Extension Site

Evaluation Criteria	Plantation
Habitat quality	Low
Species	The potential exists for direct and indirect impacts to the wildlife, particular species of less mobility
Size/Abundance	Area loss is approximately 12.2 ha permanently
Duration	The impact will persist during the construction and operation phases. Compensatory planting will expect to be provided during restoration and aftercare phases.
Reversibility	The plantation may take approximately 5-10 years to be re-created
Magnitude	The scale of the habitat loss is moderate in the context of the surrounding similar habitats
Overall Impact Conclusion	**Low**

Table 9.9b Overall Impact Evaluation for Shrubland within the Extension Site (Excluded Areas located within the CWBCP and Outside the Existing SENT Landfill)

Evaluation Criteria	Shrubland
Habitat quality	Moderate
Species	The potential exists for direct and indirect impacts to the wildlife, particular species of less mobility
Size/Abundance	Area loss is approximately 1.4 ha
Duration	The impact will be temporary during the construction and operation phases. Compensatory planting will expect to be provided during restoration and aftercare phases.
Reversibility	The shrubland may take approximately 10 years to be re-created
Magnitude	The scale of the habitat loss is small in the context of the surrounding similar habitats
Overall Impact Conclusion	**Low to moderate**

Table 9.9d ***Overall Impact Evaluation for Disturbed/ Developed Area within the Extension Site (Excluded Areas located within the CWBCP and Outside the Existing SENT Landfill)***

Evaluation Criteria	**Disturbed/ Developed Area**
Habitat quality	Nil
Species	The potential exists for direct and indirect impacts to the wildlife, particular species of less mobility and species of conservation interests including Japanese Pipistrelle
Size/Abundance	Area loss is approximately 34.2 ha permanently
Duration	The impact will persist during the construction and operation phases
Reversibility	The disturbed/ developed area is readily re-creatable
Magnitude	The scale of the habitat loss is small in the context of the surrounding similar habitats
Overall Impact Conclusion	**Negligible**

Table 9.9e *Overall Impact Evaluation for Shrubland, Grassland and Developed Area within the CWBCP (Outside the Existing SENT Landfill)*

Evaluation Criteria	**Shrubland Encroached within the CWBCP**	**Grassland Encroached within the CWBCP**	**Disturbed/ Developed Area Encroached within the CWBCP**
Habitat quality	Moderate	Low to moderate	Negligible
Species	The potential exists for direct and indirect impacts to the wildlife, particular species of less mobility and species of conservation interests including Japanese Pipistrelle, Common Buzzard, Brown Hawk Owl, White-edged Blue Baron, Indian Fritillary, Swallowtail and Common Rat Snake.	The potential exists for direct and indirect impacts to the wildlife, particular species of less mobility	The potential exists for direct and indirect impacts to the wildlife, particular species of less mobility
Size/Abundance	4.6 ha of shrubland will be lost.	Area loss is approximately 0.1 ha	Area loss is approximately 0.4 ha
Duration	The impact will be temporary during the construction and operation phases. Compensatory planting and habitat enhancement is expected to be provided during restoration and aftercare phases.	The impact will be temporary during the construction and operation phases. Compensatory planting and habitat enhancement is expected to be provided during restoration and aftercare phases.	The impact will be temporary during the construction and operation phases. Compensatory planting and habitat enhancement is expected to be provided during restoration and aftercare phases.
Reversibility	The shrubland may take approximately 10 years to be re-created.	The grassland may take approximately 5 years to be re-created	Readily reversible
Magnitude	The scale of the habitat loss is small in the context of the surrounding similar habitats.	The scale of the habitat loss is small in the context of the surrounding similar habitats	The scale of the habitat loss is small in the context of the surrounding similar habitats
Overall Impact Conclusion	**Low to moderate**	**Low**	**Low**

Impacts on Wildlife: Reduction of wildlife species abundance/diversity and ecological carrying capacity is expected to be minimal due to the loss of a relatively small area of natural habitat. The steep slope of the affected area also limits wildlife usage. In addition, the majority of the Extension Site is highly disturbed and is not the preferred habitat for general wildlife.

The impacts due to the loss of foraging ground are also considered to be minimal given the presence of large area of similar habitats in the vicinity. It should be noted that the affected area is located next to currently highly disturbed areas.

Given that there was no aquatic fauna recorded in the seasonal streams and the perimeter surface water cut-off channel will be effectively operated to avoid any discharge outside the Extension Site, impacts to aquatic life due to the change in water quality, sedimentation rate and pattern are expected to be minimal.

Impacts of species of conservation interest recorded within the Extension Site are summarised in *Table 9.9f*.

Table 9.9f *Overall Impact Evaluation for the Species of Conservation Interest*

Species of Conservation Interest	Impacts	Impacts to Wildlife	Location Recorded
Mammals			
Japanese Pipistrelle	A part of their associated habitat (approximately 34.6 ha of disturbed/developed area and 6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Disturbed/developed area within Extension Site and Shrubland within the encroached area in CWBCP.
Brown Noctule Bat	A part of their associated habitat (approximately 34.6 ha of disturbed/developed area) will be affected. There are extensive similar habitats in proximity.	Low	Disturbed/Development area within the Extension Site
Birds			
Brown Hawk Owl	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP.
Greater Coucal	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP.
Common Buzzard	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP.
Black Kite	A part of their associated habitat (approximately 34.6 ha of disturbed/developed area, 12.2 ha of plantation and 6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Soaring over a variety of habitats within the Study Area.
Butterflies			
White-edged Blue Baron	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP
Indian Fritillary	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP

Species of Conservation Interest	Impacts	Impacts to Wildlife	Location Recorded
Swallowtail	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP
Tooth Sunbeam	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area of CWBCP
Reptiles			
Common Rat Snake	A small part of their associated habitat (approximately 4.6 ha of shrubland) will be affected. There are extensive similar habitats in proximity.	Low	Shrubland within the encroached area in CWBCP
Corals			
A total of nineteen species of hard corals recorded	Indirect impact to coral communities from potential leakage of landfill leachate expect to be minimal	Low	Subtidal habitats along the coastlines in the vicinity

In view of similar habitat in the vicinity and high mobility of the fauna species of conservation interest, it is anticipated that the construction, operation, restoration and aftercare of the Extension will not cause any adverse impacts to these species.

Habitat Fragmentation and Isolation: Habitat fragmentation and isolation are not expected as the majority of the affected habitats are either disturbed or located next to developed areas. It should be noted that the areas within the CWBCP are generally steep and are expected to be mainly utilized by birds and butterflies, which are less affected by such fragmentation and isolation effects.

Impacts on Habitats and Associated Wildlife within Encroached Area of CWBCP and Outside the Existing SENT Landfill: The impacts of the loss of habitats within the encroached area of CWBCP are considered low to moderate in view of the high mobility of the species of conservation interest and general wildlife, and large extent of similar habitat in the vicinity. The construction of the Extension Site will temporarily restrict the habitat utilisation of general wildlife within the encroached area of CWBCP; however, no unacceptable impacts are anticipated. With the provision of enhanced habitats of higher ecological value (ie woodland) after the restoration of the impacted areas and under a proper planting scheme and management, the wildlife diversity and abundance are expected to be enhanced.

Operation/Restoration Phase

Ecological impacts associated with the operation and restoration of the

Extension due to the accidental leakage of leachate, other wastewater and landfill gas are not expected by implementation of properly designed and operated landfill gas, leachate and surface water/groundwater management systems (see *Section 3*). A comprehensive environmental monitoring and audit programme will be implemented.

Other Impacts: As no streams or water gathering areas will be affected due to the Extension, and no marine works will be required, the hydrology and hydrodynamic properties of the Study Area would not be affected.

The base of the landfill (either existing SENT Landfill or the Extension) has been designed to be kept above the groundwater level (see *Section 3*), the hydrogeology of the area is not expected to be influenced.

Secondary impacts to the surrounding habitats (generally with low to moderate ecological value), including the sub-tidal habitats (coral communities) in the vicinity and associated wildlife may arise from the potential for increased noise impact, blasting works, human activities and disturbance such as hill fire, import, storage or dumping of construction materials and construction site runoff. The impacts are expected to be low owing to the current disturbed nature of the majority of the site, and given that regular site audits on good construction practice and surface water management system will be employed during the construction, and operation/restoration phases.

Aftercare Phase

Given the generally low level of disturbance required to manage the restored Extension it is not expected that aftercare activities will cause adverse ecological impacts.

9.10 MITIGATION MEASURES

Annex 16 of the *EIAO-TM* states that the general policy for mitigation of significant ecological impacts, in order of priority, is:

Avoidance: Potential impacts should be avoided to the maximum extent practicable by adopting suitable alternatives;

Minimisation: Unavoidable impacts should be minimised by taking appropriate and practicable measures such as constraints on intensity of works operations or timing of works operations; and

Compensation: The loss of important species and habitats may be provided for elsewhere as compensation. Enhancement and other conservation measures should always be considered whenever possible.

At each stage, residual impacts are to be re-assessed to determine whether there is a need to proceed to the next stage of mitigation. The following measures have been developed in accordance with this approach to mitigate the impacts.

9.10.1 *Avoidance*

Five different extension options have been reviewed (refer to *Section 2.3*). With reference to *Annex 16, Section 3.1(a)* of the EIAO-TM, areas of ecological importance (in this case the Country Park) shall be conserved as far as possible. Options without the encroachment of CWBCP were considered first. However, these options can only provide limited void capacity which will not be able to accommodate the waste generated in the forecast period, even with effective waste reduction and recycling measures as stated in the Policy Framework for the Management of MSW (2005-2014). Extending the SENT Landfill with these options would not enable the Government to make adequate provision for future waste management in the catchment area and at strategic level (see *Section 2.2*). Engineering measures have been considered to maximize the void space offered by these non-encroachment options. However, it was found that massive retaining wall/earth bunds (in the order of 40m) will be required which will be visually intrusive and technically very challenging and would still not increase the void space to meet the demand. Furthermore, the feasibility of this solution is uncertain as there is no precedent of building a sanitary landfill with such a depth of retaining structure. TKO Area 137 is designated for deep waterfront uses and the ongoing landuse planning reveals that the demand for land within this area is high and only 15 ha can be allocated for the landfill extension. With the 15 ha of available land in TKO Area 137 plus using the piggyback approach onto the existing SENT Landfill to maximize the available void space for the Extension, the landfill extension can only provide around $10Mm^3$ (around 4 years of landfill life), which does not allow sufficient time for the new generation of waste management facilities to be developed.

It is understood that there is a public need for both adequate landfill space and Country Parks. Landfill disposal at SENT is necessary until such time as South East Kowloon Transfer Station and Construction Waste Handling Facility are all operational (see *Section 2.2*). Under an optimistic set of conditions to form a target programme at the present stage, they could all be in place by 2017, at the earliest. With SENT expected to be full by 2012, at least six years of additional void space is necessary. This can only be achieved by the encroachment option 3b. It is important to extend the lifespan of the SENT Landfill based on Option 3b so that the Government can have time to plan and develop these new waste handling facilities.

The proposed encroachment area of approximately 5.1 hectares of land into the CWBCP, is primarily a coastal slope that is not easily accessible. The habitats (grassland and shrubland) are not of high ecological value. All of the species of conservation interest recorded within the area were found to be of high mobility and were found to have access to large extent of similar habitats close by and within the CWBCP area. Hence, no adverse ecological impacts are expected. When the encroached area is restored together with the fully restored landfill after the completion of landfilling operation, it is anticipated that the whole restored areas would be enriched to enable a higher amenity value for public enjoyment and higher ecological value under a proper planting scheme and management.

Hence, while encroachment cannot be avoided, an encroachment of 5.1 ha into the CWBCP is considered to be a balanced option, maximizing void capacity to meet the landfill space demand while minimizing disturbance to natural habitats. It should be noted that the boundary of CWBCP will not be changed and access to the affected area will only be temporarily restricted. The habitat quality will be enhanced as a result of habitat enhancement, compensatory planting and proper management which will form an integral part of the SENT Landfill Extension Project.

9.10.2 Minimisation

The previous discussion in *Section 9.9* has indicated that the potential ecological impacts due to the construction, operation, restoration and aftercare of the Extension are considered to be low to moderate. The following measures are recommended to further reduce the potential impacts and disturbance to the surrounding habitats.

Habitat and Wildlife

- According to the option selection for the Extension (for details please refer to *Section 2*), this proposed option involves partial encroachment into areas within the CWBCP in order to maximise the total volume of the Extension. The disturbance of the existing area within CWBCP will comprise 4.6 ha of shrubland, 0.1 ha of grassland and 0.4 ha of disturbed/developed area only.

Measures for Controlling Construction Runoff

- Exposed soil areas will be minimised to reduce the contamination of runoff and erosion;

- To prevent stormwater runoff from washing across exposed soil surfaces, perimeter channels will be constructed in advance of site formation works and earthworks and intercepting channels will be provided, for example along the edge of excavation;

- Silt removal facilities, channels and manholes will be maintained and the deposited silt and grit will be removed regularly to ensure they are functioning properly at all times;

- Temporary covers such as tarpaulin will also be provided to minimise the generation of high suspended solids runoff;

- The surface runoff contained any oil and grease will pass through the oil interceptors; and

- Control measures, including implementation of excavation schedules, lining and covering of excavated stockpiles will be implemented to minimise contaminated stormwater run-off from the Extension site.

Good Construction Practices

- Fences along the boundary of the Extension Site will be erected before the commencement of works to prevent vehicle movements, and encroachment of personnel, onto adjacent areas;

- The work site boundaries will be regularly checked to ensure that they are not breached and that damage does not occur to surrounding areas;

- The quantity of explosive used and the dimensions and spacings of shotholes will be carefully designed to minimise air overpressure, flyrock generation and ground-borne vibration;

- Use of fine blast nets, screens and other protective covers to prevent the projection of flying fragments and material resulting from blasting. The loose material and stones in the site will be removed before blasting to minimise flying fragments affecting the surrounding areas and the blasting area will also be wetted prior to blasting to minimise dust.

Measures for Controlling Leakage of Landfill Leachate

- Leachate will be contained within the Extension by the proposed impermeable leachate containment system and collected by the installation of drainage system to prevent potential leakage of leachate to habitats in the vicinity. The implementation details of managing leachate can be referenced to *Section 5 - Water Quality Assessment*.

Measures for Controlling Leakage of Landfill Gas

- Disturbance to habitat in the vicinity and associated wildlife due to leakage of landfill gas will be prevented by proper management of the landfill gas generated from the Extension. Ignition fires will be prohibited to occur within the boundary of the Extension Site. Surface emission and off-site migration of landfill gas will be regularly monitored, which are detailed in *Section 7 - Landfill Gas Hazard assessment.*

9.10.3 Compensation

As the Extension will encroach into the Country Park, adequate on-site and/or off-site mitigation measures shall be employed in accordance with the requirements of the EIAO-TM. The following compensation planting is recommended as mitigation for the habitats affected due to the proposed Extension.

- Provision of 6 ha of mixed woodland planting to compensate for the loss of shrubland. To enhance the ecological value of the encroached area within CWBCP, mixed woodland will be planted on the affected areas (approximately 6 ha, originally shrubland); and

- Provision of a mosaic of grassland and shrubland in the remaining areas of the Extension Site.

The mixture of grassland, shrubland and woodland habitats is recommended to diversify the habitats to support various wildlife, in particular butterflies, birds and herpetofauna and blend into the existing undisturbed ecological environment. A conceptual planting plan is presented in *Section 10 – Landscape and Visual Impact Assessment section* (see *Figure 10.6a)*. This recommendation also complies with the mitigation measures proposed in the existing SENT Landfill EIA, which suggested compensatory planting of native woodland [(1)].

Indigenous plant species with a shallow root system, softwood in nature and adaptive to sea shore habitat [(2), (3)] are recommended to be used in the restoration plan, such as *Gordonia axillaris, Phyllanthus emblica, Celtis sinensis* and *Macaranga tanarius*, which have been well established in coastal areas with exposure to strong wind and salt spray, and with a sandy soil base. Indigenous tree species *Celtis sinensis* and *Ficus microcarpa* have also been recorded in the SENT Landfill site (from years 2003 to 2006) [(4)] and during the baseline surveys of this Project, although they occurred in low abundance in SENT Landfill and some individuals were distorted in tree form due to competition by exotic tree species on the crown layer. With special care and management in place and the optimal planting matrix with other plant species, native tree species could be used for restoration in landfill site. Taking into consideration the relatively poor substrate and the difficulties of establishment of some native trees in Hong Kong, it is recommended to include approximately 20% of non-native tree species in the compensatory woodland. The non-native tree species can serve as a nurse species to facilitate the establishment of the native tree species, especially the shading, and it can be replaced by established native tree species progressively. Plant species can also make reference to food plants of butterfly species (in particularly butterfly species of conservation interest recorded within the CWBCP) such as *Ischaemum aristatum, Microstegium ciliatum, Miscanthus floridulus, Miscanthus floridulus, Ficus superba, Phoenix hanceana* and *Zanthoxylum nitidum*.

It is also recommended that a trial nursery for native plant species be set up in advance during the construction phase in order to fine tune the planting matrix and management intensity of the recommended indigenous tree species. It should be noted that native shrubs and tree species have been used for restoration of the existing SENT Landfill, native plant species that

(1) Scott Wilson Kirkpatrick (1991). *SENT Landfill Study*. Final Report.

(2) AFCD (2002) *Checklist of Hong Kong Plants*. AFCD.

(3) The Urban Council of Hong Kong (1988). *Hong Kong Trees*. The Urban Council of Hong Kong

(4) Green Valley Landfill, Limited. 2003 to 2006. *SENT Operations and Environmental Monitoring Annual Report and Audit from years 2003 to 2006*.

could not successfully be established on the existing SENT Landfill should be reviewed before the preparation of the compensatory planting list. Special care and intensive management of native plants should be implemented in order to ensure proper establishment of the native plants.

Compensatory planting and restoration of the Extension can be implemented progressively according to the filling plan of the Extension. Planted and restored areas will serve their ecological function once completed.

9.11 *RESIDUAL IMPACTS*

There will be a permanent loss of approximately 6 ha of shrubland, 0.1 ha of grassland, 12.2 ha of plantation and 34.6 ha of developed area due to the Extension. None of habitats is of high ecological value. Due to the loss of low to moderate quality habitats and the high mobility of the faunal species to be impacted, the residual impacts are considered to be low. With the implementation of compensation planting of a mosaic of grassland and shrubland, and mixed woodland plantation (total 6 ha) on the Extension, no adverse residual impact due to the construction, operation, restoration and aftercare of the Extension is expected.

9.12 *ENVIRONMENTAL MONITORING AND AUDIT*

9.12.1 *Construction Phase*

The implementation of the ecological mitigation measures stated in *Section 9.10* will be checked as part of the environmental monitoring and audit procedures during the construction phase.

9.12.2 *Operation/Restoration Phase*

The implementation of the ecological mitigation measures stated in *Sections 9.10* and *9.11* will be checked as part of the environmental monitoring and audit procedures during the operation/restoration phase.

9.13 *CONCLUSIONS*

The ecological resources recorded within the Study Area include plantation shrubland, grassland, disturbed/developed area and seasonal stream, as well as associated wildlife. Of these habitats, shrubland has moderate ecological value. The remaining habitats are of low or low to moderate ecological value with the ecological value of disturbed/developed area as negligible.

A total of 21 terrestrial wildlife species of conservation interest were recorded within the Study Area, including 2 bat species (Japanese Pipistrelle and Brown Noctule Bat), 7 bird species (Black Kite, Common Buzzard, Common Kestrel, Greater Coucal, White-bellied Sea Eagle, Hwamei and Brown Hawk Owl), 5 rare and 6 uncommon butterfly species (Common Dart, White-edged Blue Baron, Lesser Band Dart, Swallowtail, Common Nawab, Dark Grass Blue, Indian Palm Bob, Small Grass Blue, Toothed Sunbeam, Grass Demon and Indian Frilitary), one reptile species (Common Rat Snake) and 19 hard coral species.

The majority of the proposed Extension will be located in habitats which have already disturbed/developed including the existing SENT Landfill and the fill bank in TKO Area 137. The potential impacts on these habitats are considered to be low to moderate. The proposed Extension will encroach into a small strip (5.1 ha) of CWBCP, comprising shrubland and grassland habitats. The potential impacts on these natural habitats within the CWBCP are considered to be low to moderate. Impacts on the wildlife species of conservation interest are expected. However, they are highly mobile and there is a large extent of similar foraging habitats in the vicinity. As no marine works will be involved, no marine habitats/species will be affected. Indirect impacts to the subtidal habitat and coral communities is expected to be minimal. No adverse residual impacts on both habitats including the coral communities and species of conservation interest are expected after the implementation of the recommended mitigation measures. The measures include the adoption of good construction practices, properly designed surface water, leachate, groundwater and landfill gas management systems, and provision of compensatory tree planting. These measures will minimise potential ecological impacts. Regular site inspections as part of the overall environmental monitoring and audit programme of the Extension are recommended.

10 *LANDSCAPE AND VISUAL IMPACTS*

10.1 *INTRODUCTION*

This section identifies the landscape and visual impacts associated with the Extension in accordance with the *Environmental Impact Assessment Ordinance.* Construction, operation / restoration and aftercare phase impacts have been assessed.

The assessment includes:

- A list of the relevant environmental legislation and guidelines;
- a definition of the scope and contents of the Assignment, including a description of the assessment methodology;
- a review of the relevant planning and development control framework;
- a review of comments on landscape and visual issues received during previous consultation with the public and/or advisory bodies and how these have been addressed in the design;
- a baseline study providing a comprehensive and accurate description of the baseline landscape and visual character;
- recommendation of appropriate mitigation measures and associated implementation programmes; and
- identification of potential landscape and visual impacts and prediction of their magnitude and potential significance, before and after the mitigation measures.

All potential impacts and proposed mitigation measures are clearly mapped in colour and illustrated with clear annotation and cross-referencing between text, tables and illustrations. Colour photographs showing baseline conditions, and photomontages and illustrative materials supporting conclusions are provided and the locations of all viewpoints are clearly mapped. Photomontages at representative locations provide comparison between existing views; proposals on day 1 after completion without mitigation; on day 1 after mitigation, and at year 10 after mitigation.

10.2 *ENVIRONMENTAL LEGISLATION AND GUIDELINES*

The following legislation, standards and guidelines are applicable to the assessment of landscape and visual impacts associated with the construction, operation / restoration and aftercare of the Extension:

- *Forests and Countryside Ordinance* (Cap. 96) and its subsidiary legislation the Forestry Regulations;
- *Town Planning Ordinance* (Cap 131);
- *Animals And Plants (Protection of Endangered Species) Ordinance* (Cap 187);
- *Country Parks Ordinance* (Cap 208);
- *Marine Parks Ordinance* (Cap 476) and associated subsidiary legislation;
- *Environmental Impact Assessment Ordinance* (Cap.499, S.16) and the Technical Memorandum on EIA Process (EIAO TM), particularly *Annexes 10, 11, 18, 20* and *21*;
- *EIAO* Guidance Note 8/2002;
- Tseung Kwan O Outline Zoning Plan No.S/TKO/15 (2 November 2004);
- Hong Kong Planning Standards and Guidelines;
- Work Branch Technical Circular (WBTC) No. 25/93 - Control of Visual Impact of Slopes;
- SILTech Publication (1991) – Tree Planting and Maintenance in Hong Kong (Standing Interdepartmental Landscape Technical Group) [11-23];
- WBTC No. 17/2000 – Improvement to the Appearance of slopes in connection with WBTC 25/93;
- WBTC No. 7/2002 – Tree Planting in Public Works;
- ETWB TC (Works) No. 34/2003 – Community Involvement in Greening Works;
- ETWB TC (Works) No. 2/2004 : Maintenance of Vegetation and Hard Landscape Features;
- ETWB TC (Works) No. 29/2004 : Registration of Old and Valuable Trees, and Guidelines for their Preservation;
- ETWB TC (Works) No. 11/2004 – Cyber Manual for Greening;
- ETWB TC (Works) No. 3/2006 - Tree Preservation;
- Land Administration Office Instruction (LAOI) Section D-12 – Tree Preservation;
- Geotechnical Engineering Office (GEO) publication (1999) – Use of Vegetation as Surface Protection on Slopes;

- GEO 1/2000 – Technical Guidelines on Landscape Treatment and Bio-engineering of Man-made Slopes and Retaining Walls;
- Urban Council Publication (1998) - Champion Trees in Urban Hong Kong (Chinese Language Edition);
- Urban Services Department 'Plant Selection Matrix' (1992);
- Housing Department 'Basic Plant List' (1988);
- AFCD 'Check List of Hong Kong Plants 2001' (2002); and
- AFCD 'Rare and Precious Plants of Hong Kong' (2004).

In addition, reference has been made to the South East New Territories (SENT) Landfill Contract EP/SP/10/91 Final Restoration Landscape Masterplan Report (December 1996).

10.3 *SCOPE AND CONTENT OF THE STUDY*

10.3.1 *The SENT Landfill Extension Project*

The nature and extent of the Extension is described in detail in *Section 3* of this Report.

10.3.2 *Limits of the Study Area*

The limit of the landscape impact study is 500m beyond the limit of the works. The limit of the visual impact study is the maximum extent of the Visual Envelope of the works during the construction phase and operation / restoration and aftercare phases, which are illustrated in *Figures 10.3a* and *10.3b*.

10.3.3 *Assessment Methodology*

Landscape and visual impacts have been assessed for the construction, operation, restoration and aftercare phases. However, as the operation and restoration phases occur concurrently in a phased manner, impacts for the operation / restoration phases are assessed together.

Landscape Impacts

The assessment of **landscape impacts** has involved the following procedures.

- **Identification of the baseline landscape resources (physical and cultural) and landscape character found within the Study Area**. This is achieved by site visit and desk-top study of topographical maps, information databases and photographs.
- **Assessment of the degree of sensitivity to change of landscape resources / character**. This is influenced by a number of factors

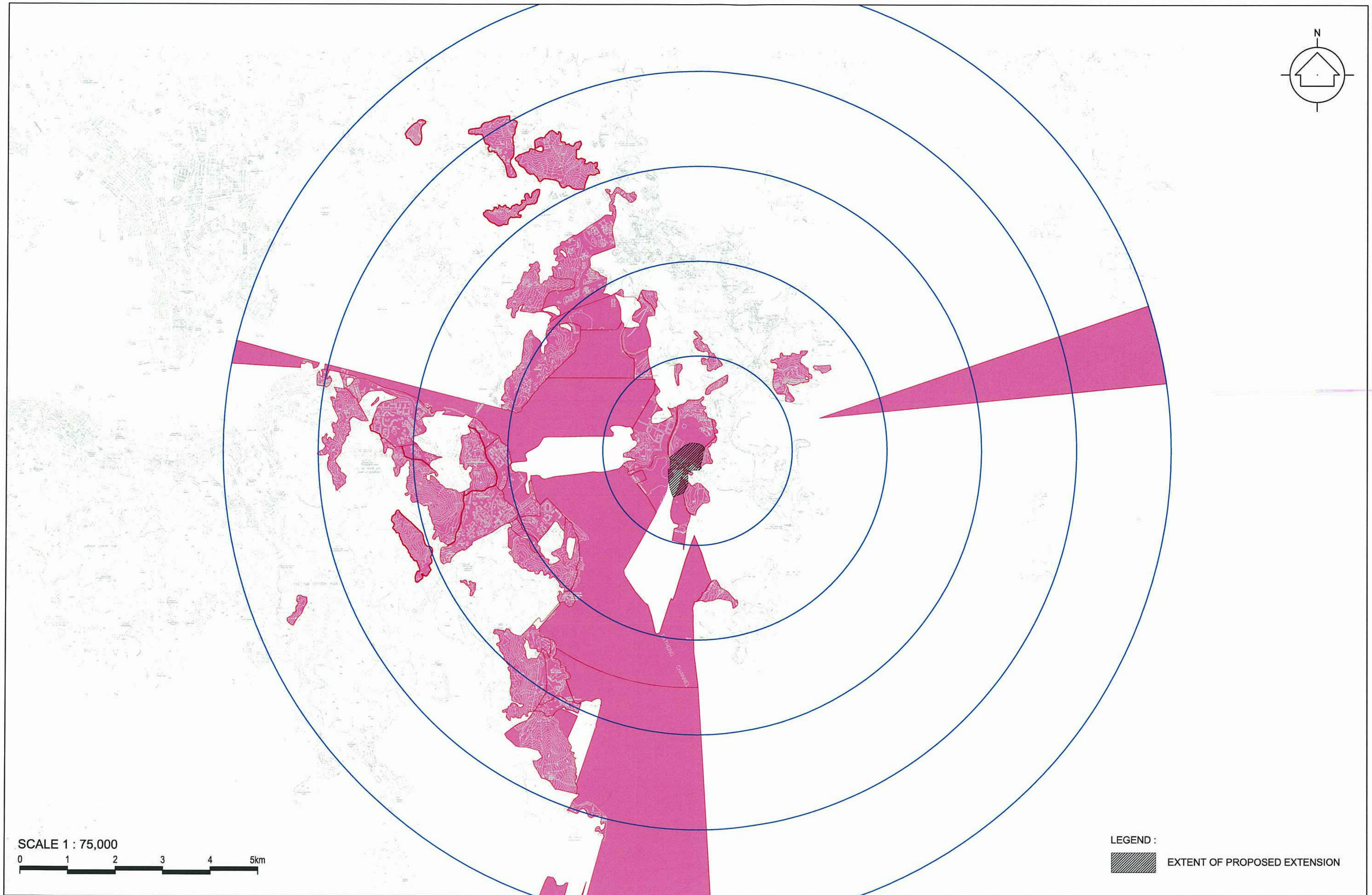

Figure 10.3a

Primary Visual Envelope (Construction Phase)

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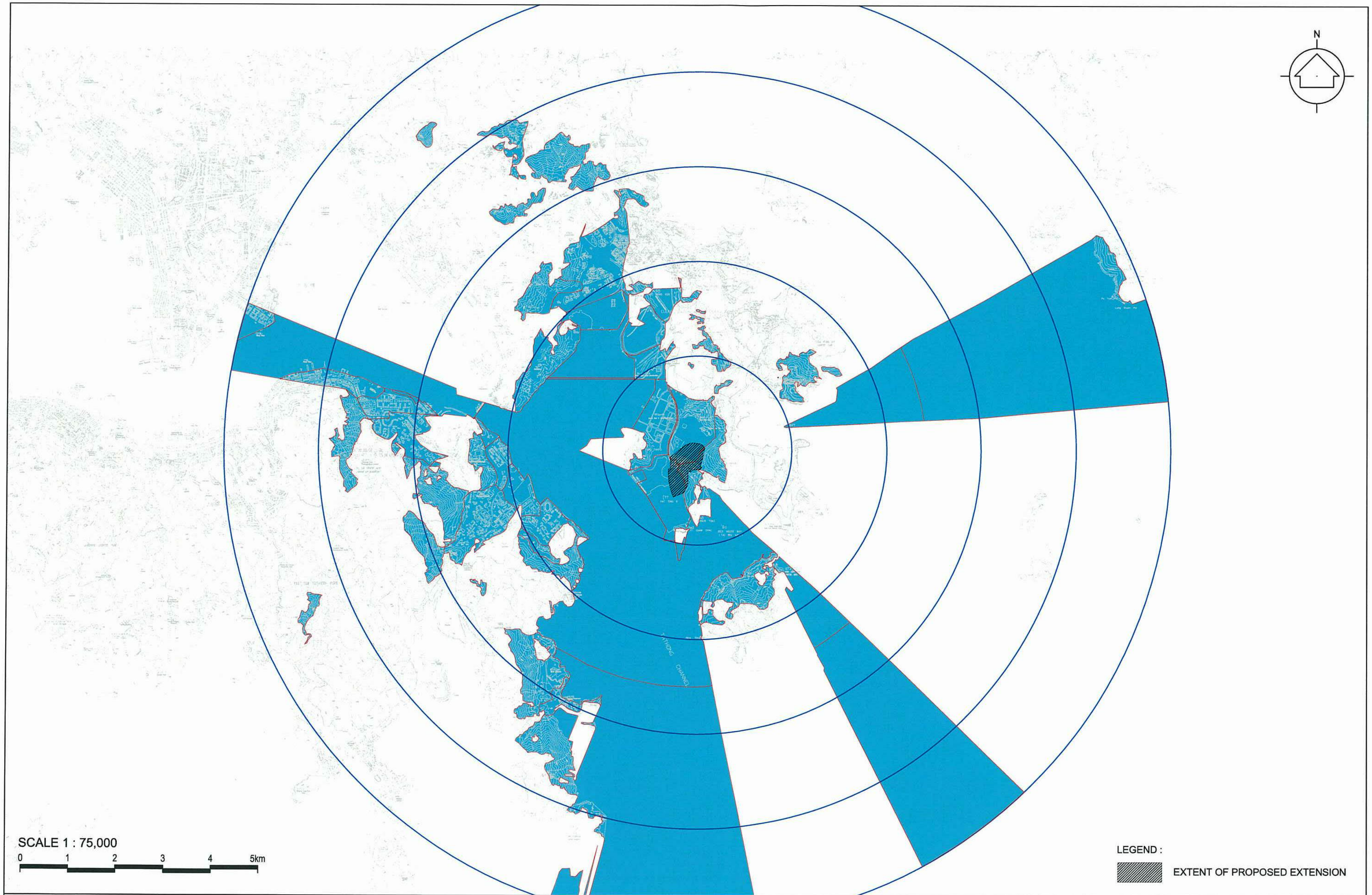

Figure 10.3b

Primary Visual Envelope (Operation / Restoration / Aftercare Phases)

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J:\ERL21\DWG-GA\FIGURE-10_03b.dwg, A3, 20-Jun-2007 15:02:50, san including whether the resource/character is common or rare, whether it is considered to be of local, regional, national or global importance, whether there are any statutory or regulatory limitations / requirements relating to the resource, the quality of the resource/character, the maturity of the resource, and the ability of the resource / character to accommodate change. The sensitivity of each landscape feature and character area is classified as follows:

High:	Important landscape or landscape resource of particularly distinctive character or high importance, sensitive to relatively small changes
Medium:	Landscape or landscape resource of moderately valued landscape characteristics reasonably tolerant to change
Low:	Landscape or landscape resource, the nature of which is largely tolerant to change

- **Identification of potential sources of landscape impacts.** These are the various elements of the construction, operation works and aftercare works that will generate landscape impacts.

- **Identification of the magnitude of landscape impacts.** The magnitude of the impact depends on a number of factors including the physical extent of the impact, the landscape and visual context of the impact, the compatibility of the project with the surrounding landscape; and the time-scale of the impact ie whether it is temporary (short, medium or long term), permanent but potentially reversible, or permanent and irreversible. Landscape impacts have been quantified wherever possible. The magnitude of landscape impacts is classified as follows:

Large:	The landscape or landscape resource will experience a major change
Intermediate:	The landscape or landscape resource will experience a moderate change
Small:	The landscape or landscape resource will experience slight or barely perceptible changes
Negligible:	The landscape or landscape resource will experience no discernible change.

- **Identification of potential landscape mitigation measures.** These may take the form of adopting alternative designs or revisions to the basic engineering and architectural design to prevent and/or minimise adverse impacts; remedial measures such as colour and textural treatment of building features; and compensatory measures such as the implementation of landscape design measures (eg tree planting, creation of new open space etc) to compensate for unavoidable adverse impacts and to attempt to generate potentially beneficial long term impacts. A programme for the mitigation measures is provided. The agencies responsible for the funding, implementation, management and maintenance of the mitigation measures are identified and their approval-in-principle has been sought.

- **Prediction of the significance of landscape impacts before and after the implementation of the mitigation measures.** By synthesising the magnitude of the various impacts and the sensitivity of the various landscape resources it is possible to categorise impacts in a logical, well-reasoned and consistent fashion. *Table 10.3a* shows the rationale for dividing the degree of significance into four thresholds, namely insubstantial, slight, moderate, and substantial, depending on the combination of a negligible-small-intermediate-large magnitude of impact and a low-medium-high degree of sensitivity of landscape resource/character. The significant thresholds are defined as follows:

Substantial:	Adverse / beneficial impact where the proposal will cause significant deterioration or improvement in existing landscape quality
Moderate:	Adverse / beneficial impact where the proposal will cause a noticeable deterioration or improvement in existing landscape quality
Slight:	Adverse / beneficial impact where the proposal will cause a barely perceptible deterioration or improvement in existing landscape quality
Insubstantial:	No discernible change in the existing landscape quality

- **Prediction of Acceptability of Impacts**. An overall assessment of the acceptability, or otherwise, of the impacts according to the five criteria set out in *Annex 10* of the *EIAO-TM*.

Table 10.3a Relationship Between Receptor Sensitivity and Impact Magnitude in Defining Impact Significance

Magnitude of Impact		Receptor Sensitivity (of Landscape Resource, Landscape Character Area or VSR): Low	Medium	High
	Large	**Slight / Moderate***	**Moderate / Substantial***	**Substantial**
	Intermediate	**Slight / Moderate***	**Moderate**	**Moderate / Substantial***
	Small	**Insubstantial / Slight***	**Slight / Moderate***	**Slight / Moderate***
	Negligible	**Insubstantial**	**Insubstantial**	**Insubstantial**
	Positive	**Positive**	**Positive**	**Positive**

* In these instances, if the lower level of impact is predicted, this will be justified in the description of landscape impacts.

Visual Impacts

The assessment of **visual impacts** has involved the following procedures.

- **Identification of the Visual Envelope** during the construction, operation / restoration and aftercare phases of the Extension. This is achieved by site visit and desk-top study of topographic maps and photographs, and preparation of cross-sections to determine visibility of the Extension from various locations.

- **Identification of the Visually Sensitive Receivers (VSRs)** within the Visual Envelope at construction, operation / restoration and aftercare phases. These are the people who reside within, work within, play within, or travel through, the Visual Envelope.

- **Assessment of the degree of sensitivity to change of the VSRs**. Factors considered include:

  - the type of VSRs, which is classified according to whether the person is at home, at work, at play, or travelling. Those who view the impact from their homes are considered to be highly sensitive as the character of views from their home will have a substantial effect on their perception of the quality and acceptability of their home environment and their general quality of life. Those who view the impact from their workplace are considered to be of low sensitivity as the character of views will have a less important effect on their perception of their quality of life. Those who view the impact whilst taking part in an outdoor leisure activity may display varying sensitivity depending on the type of leisure activity, but will generally be high. Those who view the impact whilst travelling on a public thoroughfare will also display varying sensitivity depending on the speed of travel, but will generally be medium.

  - Other factors which are considered (as required by EIAO GN 8/2002) include the value and quality of existing views, the availability and amenity of alternative views, the duration or frequency of view, and the degree of visibility.

The sensitivity of VSRs is classified as follows:

High:	The VSR is highly sensitive to any change in their viewing experience
Medium:	The VSR is moderately sensitive to any change in their viewing experience
Low:	The VSR is only slightly sensitive to any change in their viewing experience

- **Identification of the relative numbers of VSRs.** This is expressed in terms of whether there are very few, few, many or very many VSRs in any one category of VSR.

- **Identification of potential sources of visual impacts.** These are the various elements of the construction, operation/restoration, and aftercare works that will generate visual impacts.

- **Assessment of the potential magnitude of visual impacts.** Factors considered include:

    - compatibility with the surrounding landscape;
    - duration of the impact;
    - reversibility of the impact;
    - scale of the impact and distance of the source of impact from the viewer; and
    - degree of visibility of the impact, and the degree to which the impact dominates the field of vision of the viewer.

The magnitude of visual impact is classified as follows:

Large:	The VSRs will experience a major change in the character of their existing views;
Intermediate:	The VSRs will experience a moderate change in the character of their existing views;
Small:	The VSRs will experience a small change in the character of their existing views;
Negligible:	The VSRs will experience no discernible change in the character of their existing views.

- **Identification of potential visual mitigation measures.** These may take the form of adopting alternative designs or revisions to the basic engineering and architectural design to prevent and/or minimise adverse impacts; remedial measures such as colour and textural treatment of building features; and compensatory measures such as the implementation of landscape design measures (eg tree planting, creation of new open space etc) to compensate for unavoidable adverse impacts and to attempt to generate potentially beneficial long term impacts. A programme for the mitigation measures is provided. The agencies responsible for the funding, implementation, management and maintenance of the mitigation measures are identified and their approval-in-principle has been sought.

- **Prediction of the significance of visual impacts before and after the implementation of the mitigation measures.** By synthesising the magnitude of the various visual impacts and the sensitivity of the VSRs, and the numbers of VSRs that are affected, it is possible to categorise the degree of significance of the impacts in a logical, well-reasoned and consistent fashion. *Table 10.3a* shows the rationale for dividing the degree of significance into four thresholds, namely, Insubstantial, Slight, Moderate, Substantial and Positive, depending on the combination of a negligible-small-intermediate-large magnitude of impact and a low-medium-high degree of sensitivity of VSRs. Consideration is also given to the relative numbers of affected VSRs in predicting the final impact significance - exceptionally low or high numbers of VSRs may change the result that might otherwise be concluded from *Table 10.3a*. The significance of the visual impacts is categorised as follows:

Substantial:	Adverse / beneficial impact where the proposal will cause significant deterioration or improvement in existing visual character;
Moderate:	Adverse / beneficial impact where the proposal will cause a noticeable deterioration or improvement in existing visual character;
Slight:	Adverse / beneficial impact where the proposal will cause a barely perceptible deterioration or improvement in existing visual character;
Insubstantial:	No discernible change in the existing visual character.

- **Prediction of Acceptability of Impacts**. An overall assessment of the acceptability, or otherwise, of the impacts according to the five criteria set out in *Annex 10* of the *EIAOTM*.

In addition, it is assumed that funding, implementation, management and maintenance of the mitigation proposals can be satisfactorily resolved according to the principles in WBTC 14/2002. All mitigation proposals in this Report are practical and achievable within the known parameters of funding, implementation, management and maintenance. The suggested agents for the funding and implementation (and subsequent management and maintenance, if applicable) are indicated in *Tables 10.7a* to *10.7c*. Approval-in-principle to the implementation, management and maintenance of the proposed mitigation measures has been sought from the appropriate authorities.

10.4 PLANNING AND DEVELOPMENT CONTROL FRAMEWORK

A review has been undertaken of the current planning goals and objectives, statutory land-use and landscape planning designations for the Study Area.

10.4.1 Outline Zoning Plan Designations

The statutory designations for the Study Area are shown on the Tseung Kwan O Outline Zoning Plan (S/TKO/15) 2 November 2004 (see extract in *Figure 10.4a*).

The Extension will lie on two OZP planning areas:

- Area 101 - currently the existing SENT Landfill, zoned 'O' – Open Space
- Area 137 - currently a vacant reclamation, zoned 'OU' – Other Uses

The planning intention for Area 101 is stated on Page 18 of the OZP as being:

"This zone is intended primarily for the provision of outdoor open-air space for active and/or passive recreational uses serving the needs of local residents as well as the general public."

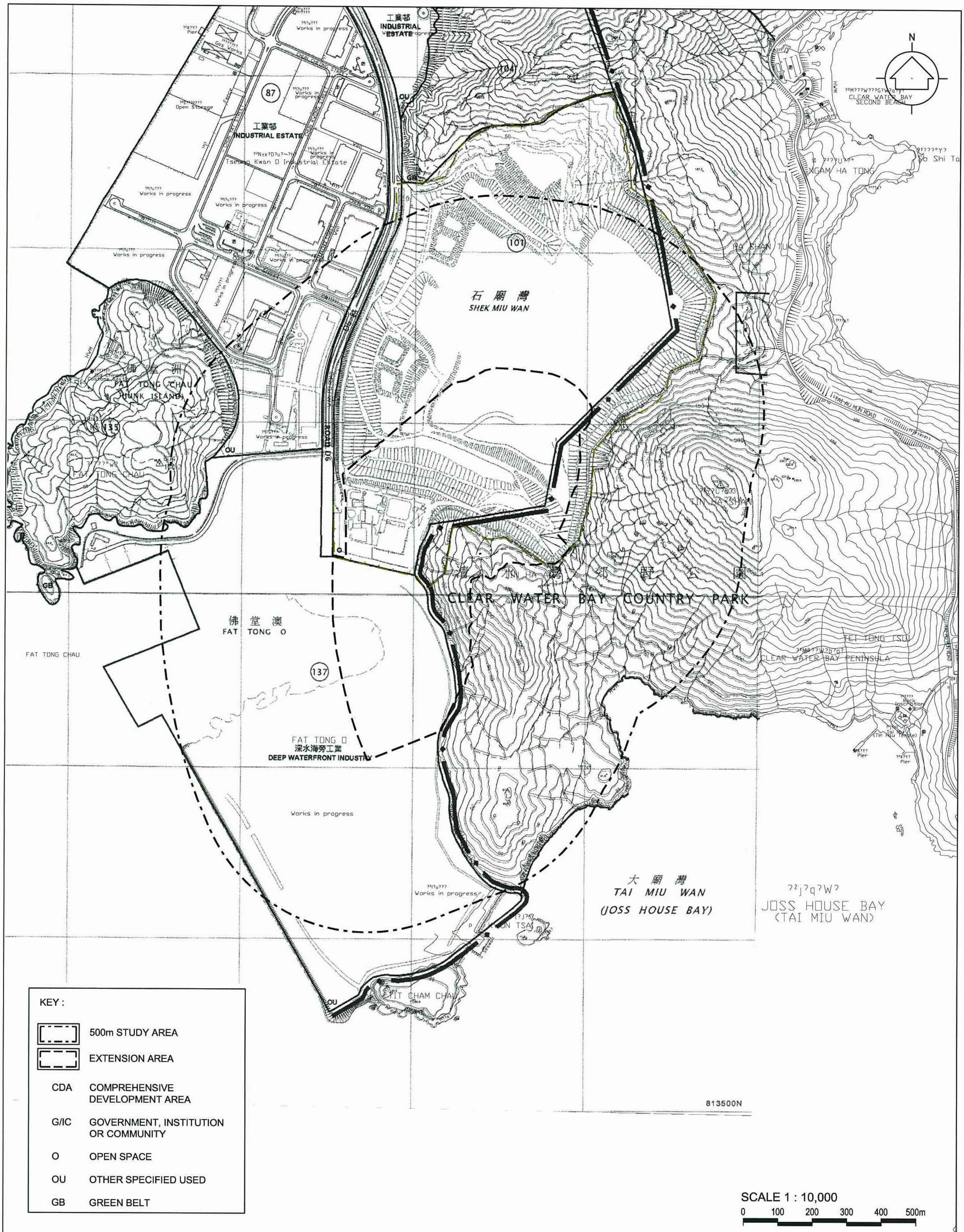

Figure 10.4a

Extract of Outline Zoning Plan

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and at Para 7.9.3 of the OZP as being:

"The landfill sites in Areas 77, 101 and 105 will be developed into major open spaces upon completion of the landfill. However, any development proposals within the 250m Consultation Zone of these landfills will need to include a Landfill Gas Hazard Assessment to the satisfaction of the Environmental Protection Department."

The planning intention for Area 137 is stated on Page 22 of the OZP as being:

"This zone is intended primarily for special industries which require marine access, access to deep water berths or water frontage. Industries to be accommodated within this zone are usually capital intensive, land-intensive and cannot be accommodated in conventional industrial buildings."

and at *Para 7.10(d)* as being:

"deep-waterfront industry in Area 137 for industries which require marine access"

In the short-term, the Extension will not accord with the planning intention for Area 101 (ie the existing SENT Landfill), in that its use as public open space will be delayed until completion of the restoration works of the Extension. However, in the longer term, the area can still be used as public open space after restoration of the Extension.

The use of Area 137 as part of the Extension does not accord with its proposed OZP land use as Deep Waterfront Industry. However, in landscape terms, the possible use of the restored Extension as a public open space would probably be preferable to its use as Deep Waterfront Industry.

10.4.2 Country Park Designation

The proposed Extension will also fall within the Clear Water Bay Country Park. The purposes of Country Parks are stated in *Section 4* of the *Country Parks Ordinance* (Cap.208) as being inter alia:

- To encourage recreation and tourism;
- To protect vegetation and wildlife;
- To preserve and maintain buildings and sites of historic or cultural significance; and
- To provide facilities and services for the public enjoyment.

The planning intention for Country Parks is set out in the Para 3.3.2 of *Section 10* (Conservation) of the *Hong Kong Planning Standards and Guidelines* as being:

"for the purposes of nature conservation, countryside recreation and nature education…criteria for determining whether or not a particular location is suitable for designation as a Country Park…include landscape quality, recreation potential…"

In so far as the planning objectives of Country Parks relate to landscape, the small part of the Extension (approximately 5 ha out of the total 50 ha of the Extension) encroached into the CWBCP will to a certain degree conflict (at least in the short term) with the Country Park objectives relating to 'landscape quality' identified above, and also of allowing the public to enjoy "the countrypark" and also of protection of landscape resources such as flora. However, in the long term when the Extension is restored and landscaped, the landscape quality would be improved and the conflict with landscape planning objectives will diminish.

10.5 BASELINE STUDY

10.5.1 Physical, Human and Cultural Landscape Resources

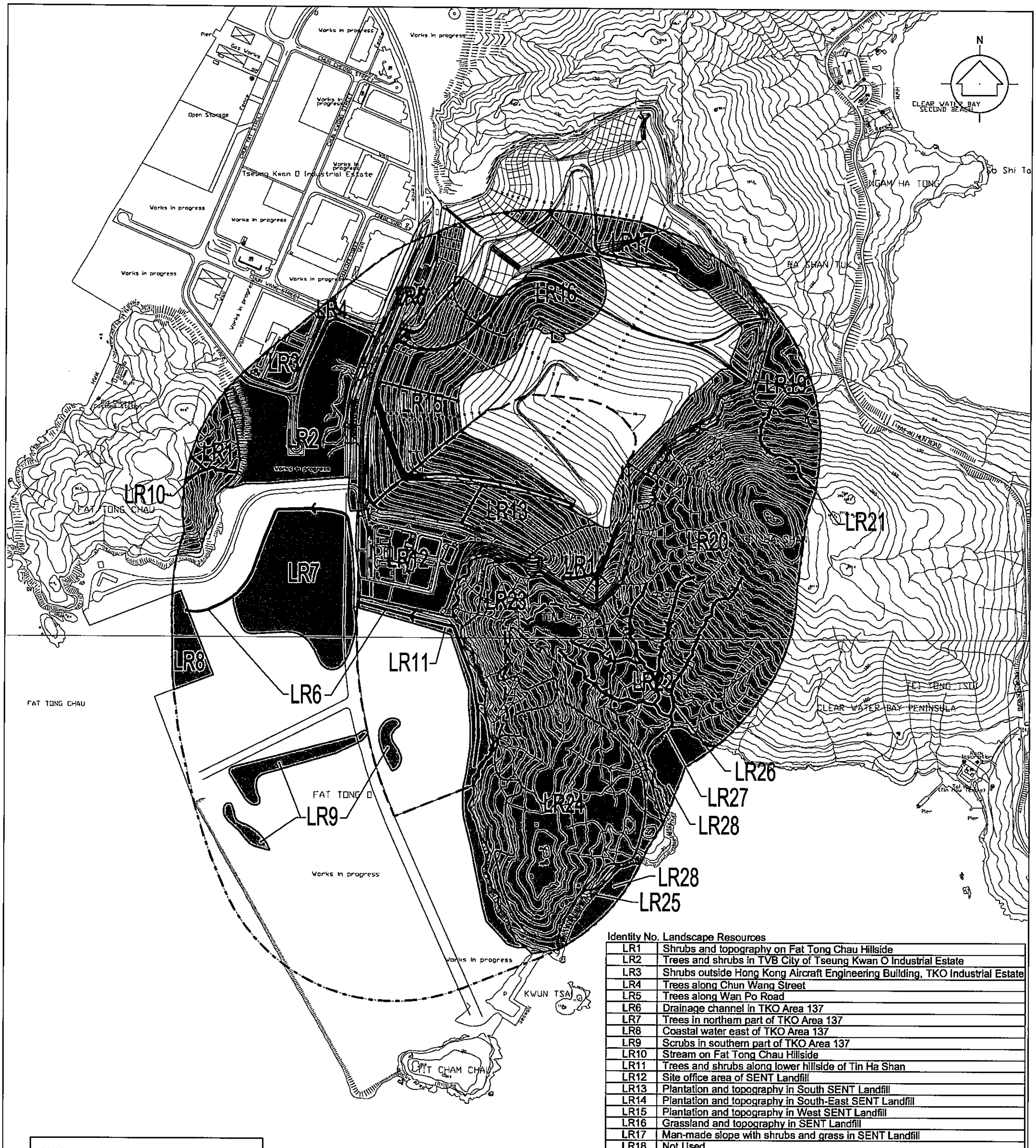
The baseline physical landscape resources that will be affected during the construction, operation / restoration and aftercare phases, together with their sensitivity to change, are described below. The locations of the landscape resources are mapped in *Figure 10.5a*. Photo-views illustrating the landscape resources are shown in *Figures 10.5b* to *10.5e* inclusive. For ease of reference and co-ordination between text, tables and figures each landscape resource is given an identity number.

Geology

The Study Area lies on volcanic rocks (mainly acid lavas and tuffs) of the Repulse Bay formation dating from the Mesozoic period. This geology results in the steep and highly angular and jagged topography of much of the Clear Water Bay Peninsula.

Topography

Topography within the Study Area is highly varied. Most of the Extension Site lies on land reclaimed from Junk Bay or at the interface of this reclaimed land with the natural topography of the Clear Water Bay Peninsula. The Study Area includes the steep coastal uplands of Tin Ha Shan (273mPD) and the valley of Tin Ha Au to the east of the site, which forms part of the upland ridge that runs along the Clear Water Bay Peninsula. To the north of the Extension Site lies the highly disturbed topography of the existing SENT Landfill which lies on reclaimed land. Where the existing SENT Landfill adjoins the Clear Water Bay Peninsula, there are extensive areas of rock cut and soil cut slope. To the west, lies flat reclaimed land on which lies the Tseung Kwan O Industrial Estate as well as the currently vacant Area 137. Further west, the Study Area includes a small part of the steep natural eastern hillsides of Fat Tong Chau (100mPD), formerly an island, but now joined to Clear Water Bay Peninsula by the reclamation works. Topographic features are identified in more detail below.



Identity No.	Landscape Resources
LR1	Shrubs and topography on Fat Tong Chau Hillside
LR2	Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate
LR3	Shrubs outside Hong Kong Aircraft Engineering Building, TKO Industrial Estate
LR4	Trees along Chun Wang Street
LR5	Trees along Wan Po Road
LR6	Drainage channel in TKO Area 137
LR7	Trees in northern part of TKO Area 137
LR8	Coastal water east of TKO Area 137
LR9	Scrubs in southern part of TKO Area 137
LR10	Stream on Fat Tong Chau Hillside
LR11	Trees and shrubs along lower hillside of Tin Ha Shan
LR12	Site office area of SENT Landfill
LR13	Plantation and topography in South SENT Landfill
LR14	Plantation and topography in South-East SENT Landfill
LR15	Plantation and topography in West SENT Landfill
LR16	Grassland and topography in SENT Landfill
LR17	Man-made slope with shrubs and grass in SENT Landfill
LR18	Not Used
LR19	Trees, shrubs and topography in Ha Shan Tuk
LR20	Shrubs and topography in Tin Ha Shan
LR21	Streams in Tin Ha Shan
LR22	Trees, shrubs and topography in Tin Ha Au
LR23	Shrubs and topography on lower ridge east of TKO Area 137
LR24	Grass, shrubs and topography on upper ridge east of TKO Area 137
LR25	Sandy shore south of ridge east of TKO Area 137
LR26	Streams in Tin Ha Au
LR27	Sandy shore off Tin Ha Au
LR28	Coastal water off Tin Ha Au

KEY:

500m STUDY AREA

EXTENSION AREA

LR1 LANDSCAPE RESOURCE

SCALE 1 : 10,000

0 100 200 300 400 500m

Figure 10.5a

Landscape Resources Plan

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Figure 10.5b

Aerial Photo of Extension Site/Context

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LR1 - Shrubs and topography on Fat Tong Chau Hillside

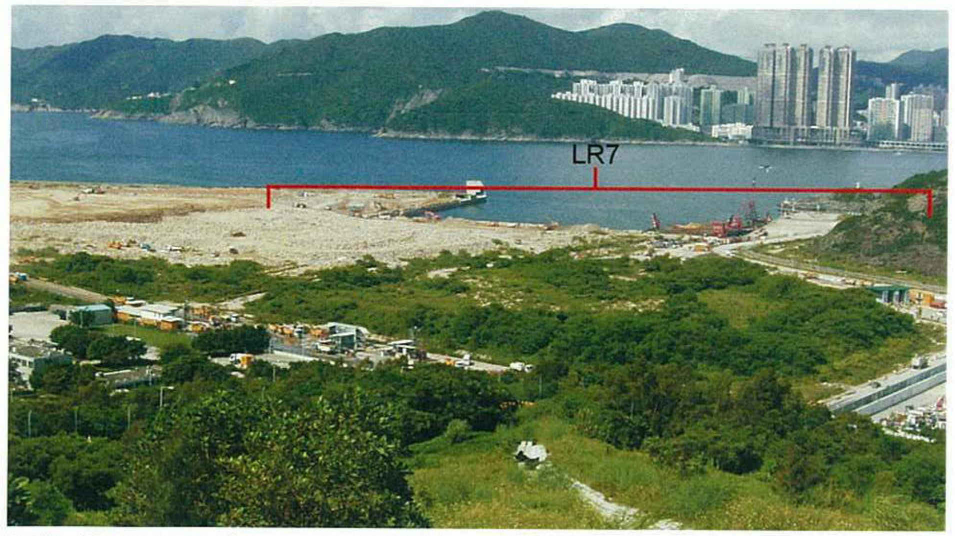

LR2 - Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate


LR3 - Shrubs in Hong Kong Aircraft Engineering Building, TKO Industrial Estate


LR4 - Trees along Chun Wang Street

LR5 - Trees along Wan Po Street


LR6 - Drainage channel in TKO Area 137



LR7 - Trees in northern part of TKO Area 137


LR8 - Coastal water east of TKO Area 137


LR9 - Scrubs in southern part of TKO Area 137

Figure 10.5c

Photo Views of Landscape Resources (Sheet 1 of 3)

Environmental Resources Management

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LR10 - Stream on Fat Tong Chau Hillside

LR11 - Trees and shrubs along lower hillside of Tin Ha Shan

LR12 - Site office area of SENT Landfill

LR13 - Plantation and topography in South SENT Landfill

LR14 - Plantation and topography in South-East SENT Landfill

LR15 - Plantation and topography in West SENT Landfill

LR16 - Grassland and topography in SENT Landfill

LR17 - Man-made slope with shrubs and grass in SENT Landfill

LR18 - **NOT USED**

Figure 10.5d

Photo Views of Landscape Resources (Sheet 2 of 3)

Environmental Resources Management

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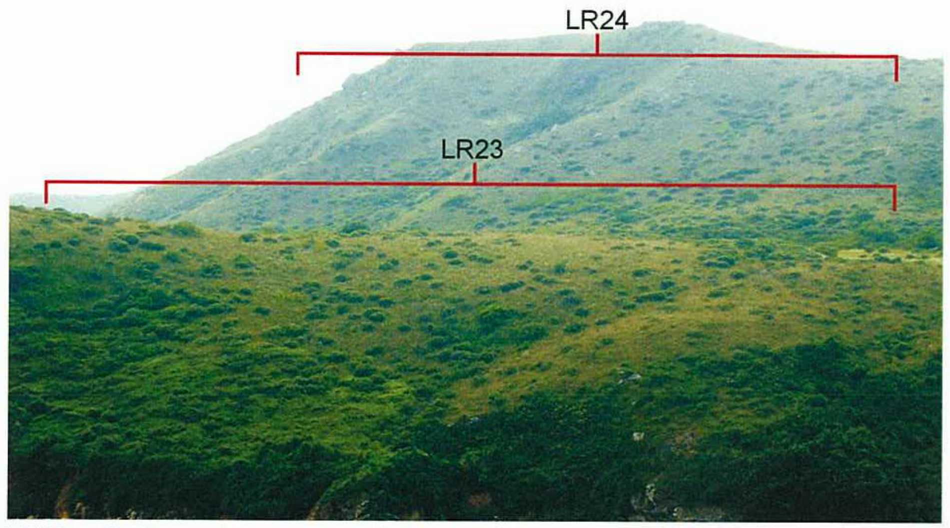
LR19 - Trees, shrubs and topography in Ha Shan Tuk

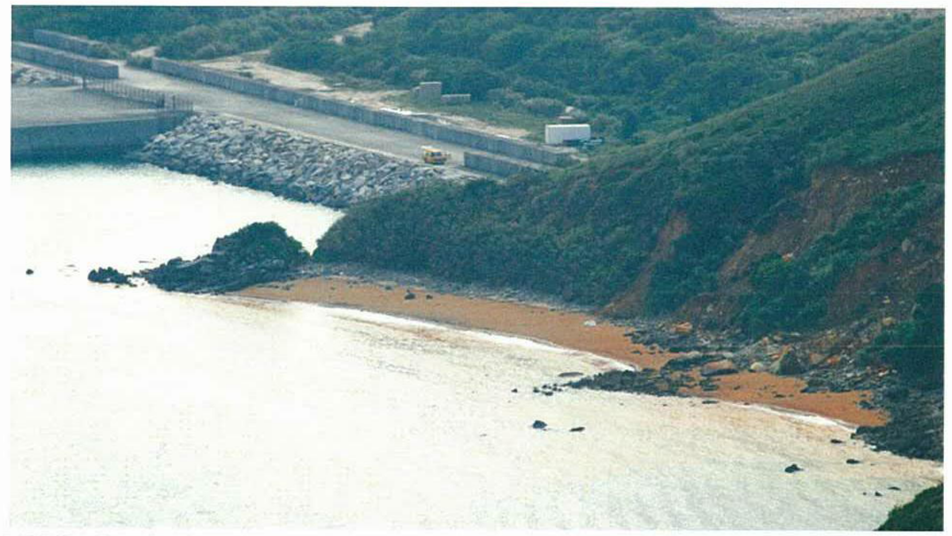
LR20 - Shrubs and topography in Tin Ha Shan

LR21 - Streams in Tin Ha Shan

LR22 - Trees, shrubs and topography in Tin Ha Au



LR23 - Shrubs and topography in lower ridge east of TKO Area 137
LR24 - Grass, shrubs and topography in upper ridge east of TKO Area 137



LR25 - Sandy shore south of ridge east of TKO Area 137

LR26 - Streams in Tin Ha Au

LR27 - Sandy shore off Tin Ha Au

LR28 - Coastal water off Tin Ha Au

Figure 10.5e

Photo Views of Landscape Resources (Sheet 3 of 3)

Environmental Resources Management

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Drainage

The uplands of Clear Water Bay Peninsula act as a natural water shed and a number of streams tumble off Tin Ha Shan into Tin Ha Au and thence into the sea on the east or south coast of the Peninsula. Other streams on the west side of the Peninsula have been canalised where they reach the existing SENT Landfill or reclamation and discharge into Junk Bay. Drainage features are described in more detail below.

Vegetation

Vegetation within the Study area includes shrubland, grassland and plantation. On the Area 137 Reclamation, the process of succession has resulted in invasion of scrub and grassland. Vegetation on restored areas of the existing SENT Landfill includes exotic plantation. Other vegetation in the Study area includes roadside and amenity planting along Wan Po Road and TKOIE as well as around the infrastructure area and access road. Vegetation within the Study Area is described in more detail below.

Public Open Spaces

A small part of the Extension Site and that part of the Study Area east of the Site lies within Clear Water Bay Country Park. The Country Park covers the upland areas of the narrow mountainous Clear Water Bay Peninsula. There is little access to the western part of the Country Park other than via the High Junk Peak Trail which follows the summit of the ridge of hills along the Peninsula.

Soil

The soils of the Clear Water Bay Peninsula are generally Krasnosems, or Red Loams, associated with volcanic rocks. They are characterised by a lack of profile development with thin humus deficient upper horizons on a very deep friable clay or clay loam. Areas north, south and west of the Extension Site lie on reclamation, which consists of marine silts and/or general fill.

10.5.2 Specific Landscape Resources

LR1 – Shrubs and topography on Fat Tong Chau Hillside

This landscape resource consists of 3.52 ha of steep natural hillside with shrubs on the former island of Fat Tong Chau (now joined to the Clear Water Bay Peninsula by reclamation). The sensitivity of this landscape resource is "High".

LR2 – Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate

This landscape resource consists of approximately 10 semi-mature ornamental trees such as *Erythrina variegata*, with a typical height of 5m. There are also some ornamental shrubs planted in this area. The sensitivity of this landscape resource is "Low".

LR3 – Shrubs in Hong Kong Aircraft Engineering Building, TKO Industrial Estate

This landscape resource consists of a small area of ornamental shrubs planted in front of one of the units on the Industrial Estate. The sensitivity of this landscape resource is "Low".

LR4 – Trees along Chun Wang Street

This landscape resource consists of about 20 semi-mature roadside trees, comprising mainly *Melaleuca quinquenervia* and *Crateva unilocularis*. They have a typical height of 6m. The sensitivity of this landscape resource is "Low".

LR5 – Trees along Wan Po Road

This landscape resource consists of approximately 100 mature *Ficus microcarpa* trees with an average height of 6m and 200 semi-mature trees, with a typical height of 3m comprising mainly *Lagerstroemia speciosa*, *Ficus altissima*. The sensitivity of this landscape resource is "Low".

LR6 – Drainage channel in TKO Area 137

This landscape resource consists of a man-made concrete-lined channel approximately 0.2m deep, 5m wide and 1,435m long with algae present in the water. The sensitivity of this landscape resource is "Low".

LR7 – Trees in northern part of TKO Area 137

This landscape resource consists of approximately 100 young trees comprising mainly the weedy species, *Leucaena leucocephala* with an average height of 3m. The sensitivity of this landscape resource is "Low".

LR8 – Coastal water east of TKO Area 137

This landscape resource consists of around 1.73 ha of coastal water lying east of Area 137, and forming part of Junk Bay. The sensitivity of this landscape resource is "Medium".

LR9 – Scrub in southern part of TKO Area 137

This landscape resource consists of around 2.71 ha of scattered grass and shrubs on the vacant reclamation of Area 137. The sensitivity of this landscape resource is "Low".

LR10 – Stream on Fat Tong Chau Hillside

This landscape resource consists of an artificial channel (around 100m long) flowing from Fat Tong Chau to TKOIE. The sensitivity of this landscape resource is "Low".

LR11 – Trees and shrubs along lower hillside of Tin Ha Shan

This landscape resource consists of about 40 semi-mature trees lying on what appears to be re-graded lower hillsides. Vegetation comprises mainly *Ficus microcarpa*, *Macaranga tanarius* and *Sapium sebiferum*. They have a typical height of 4m. There is also some shrub in the area. The sensitivity of this landscape resource is "Medium".

LR12 – Infrastructure Area

This landscape resource consists of approximately 20 mature ornamental trees situated around the landfill offices and laboratories. Trees comprise *Ficus microcarpa*, *Hibiscus tiliaceus*, *Ficus virens* and *Melaleuca quinquenervia*. They have a typical height of 6m. Soils in this area are fabricated, and not of great sensitivity. The sensitivity of this landscape resource is "Medium".

LR13 – Plantation and topography in the south of the existing SENT Landfill

This landscape resource consists of about 7.50 ha of semi-mature trees comprising *Acacia confusa, Albizia lebbeck, Ficus fistulosa, Ficus microcarpa* planted as Phases 1-3 of the restoration of the existing SENT Landfill. They have a typical height of 7m. Recreated topography appears slightly artificial, although this effect diminishes as vegetation matures. Soils in this area are fabricated, and not of great sensitivity. The sensitivity of this landscape resource is "Medium".

LR14 – Plantation and topography in the south-east of the existing SENT Landfill

This landscape resource consists of about 5.80 ha of semi-mature trees comprising *Acacia mangium*, *Acacia auriculiformis*, *Casuarina equisetifolia*, *Hibiscus tiliaceus* and *Macaranga tanarius* planted as Phases 1-6 of the restoration of the existing SENT Landfill. They have a typical height of 6m. Recreated topography appears slightly artificial, although this effect diminishes as vegetation matures. Soils in this area are fabricated, and not of great sensitivity. The sensitivity of this landscape resource is "Medium".

LR15 – Plantation and topography in the west of the existing SENT Landfill

This landscape resource consists of about 15.11 ha of young trees comprising *Acacia mangium*, *Acacia auriculiformis*, *Casuarina equisetifolia* planted mainly as Phase 3 of the restoration of the SENT Landfill. They have a typical height of 3m. Recreated topography appears slightly artificial, although this effect diminishes as vegetation matures. Soils in this area are fabricated, and not of great sensitivity. The sensitivity of this landscape resource is "Low".

LR16 – Grassland and topography in the existing SENT Landfill

This landscape resource consists of about 6.89 ha of hydroseeded grassland on recently filled areas in the existing SENT Landfill. Recreated topography appears slightly artificial. Soils in this area are fabricated, and not of great sensitivity. The sensitivity of this landscape resource is "Low".

LR17 – Man-made slope with shrubs and grass in the existing SENT Landfill

This landscape resource consists of about 10.28 ha of steep man-made slopes. Slopes are benched and comprise areas of rock, shotcrete and soil with grass and a few scattered shrubs scattered. Soils in this area are fabricated, and not of great sensitivity. The sensitivity of this landscape resource is "Low".

LR18 – NOT USED

LR19 – Trees, shrubs and topography in Ha Shan Tuk

This landscape resource consists of a group of approximately 40 trees comprising mainly *Acacia confusa*, *Casuarina equisetifolia* with a typical height of 7m which lie on rolling hillsides at Ha Shan Tuk (probably with some natural topsoil cover). There is also some scrub vegetation. The sensitivity of this landscape resource is "High".

LR20 – Shrubs and topography in Tin Ha Shan

This landscape resource consists of an area of 30.45 ha of the natural slopes of the hill of Tin Ha Shan (probably with some natural topsoil cover), which has a covering of common native shrub species. The sensitivity of this landscape resource is "High".

LR21– Streams in Tin Ha Shan

This landscape resource consists of a natural stream approximately 0.5m wide and 327m long flowing from Tin Ha Shan to Clear Water Bay. This stream is seasonal and is without water in dry season. Common riparian vegetation species are present along the natural bank. The sensitivity of this landscape resource is "High".

LR22 – Trees, shrubs and topography in Tin Ha Au

This landscape resource consists of the valley of Tin Ha Au which is densely covered by about 8.30 ha of mature trees comprising typically *Litsea glutinosa*, *Sapium sebiferum*, *Rhus succedanea* and *Zanthoxylum avicennae* (probably with some natural topsoil cover). They have a typical height of 7m. The sensitivity of this landscape resource is "High".

LR23 – Shrubs and Topography in Lower ridge east of TKO Area 137

This landscape resource consists of an area of about 17.1 ha of natural lower hillsides on the south-west tip of the Clearwater Bay Peninsula. Hillsides (probably with some natural topsoil cover) are covered with a scattering of grass and common native shrub species (eg *Rhaphiolepis indica, Rhodomyrtus tomentosa* and *Melastoma candidum*). The sensitivity of this landscape resource is "High".

LR24 – Grass, shrubs and topography on upper ridge east of TKO Area 137

This landscape resource consists of an area of about 19.54 ha of natural upper hillsides on the south-west tip of the Clearwater Bay Peninsula. Hillsides (probably with some natural topsoil cover) are covered predominantly with grass and also with some scattered shrubs of common native spaces. The sensitivity of this landscape resource is "High".

LR25 – Sandy shore south of ridge east of TKO Area 137

This landscape resource consists of a sandy shore / beach approximately 130m long and 5m wide on the south west tip of the Clearwater Bay Peninsula. The shore is backed by rocks. The sensitivity of this landscape resource is "High".

LR26 – Streams in Tin Ha Au

This landscape resource consists of a series of natural stream courses falling down the sides of the valley at Tin Ha Au. They are characterised by common riparian vegetation species along their banks. In total, they are approximately 4,200m long, and are typically around 1m wide and 0.2m deep. The sensitivity of this landscape resource is "High".

LR27 – Sandy shore off Tin Ha Au

This landscape resource consists of a sandy shore / beach approximately 140m long and 10m wide at the mouth of the Tin Ha Au Valley. The shore is backed by rocks. The sensitivity of this landscape resource is "High".

LR28 – Coastal water off Tin Ha Au

This landscape resource consists approximately 18.00ha of coastal waters south/east of Tin Ha Au. The sensitivity of this landscape resource is "Medium".

10.5.3 Landscape and Visual Character Areas

Several landscape and visual character areas (LCAs) have been identified within the Study Area. These areas, and their sensitivity to change, are described below. The locations of the character areas are indicated on *Figure 10.5f*. For ease of reference and co-ordination between text, tables and figures each landscape character area is given an identity number.

LCA1 - Fat Tong O Reclamation

This landscape comprises an area of completed and ongoing reclamation located at the south western tip of the Clear Water Bay Peninsula, between Junk Bay and Joss House Bay (see *Figure 10.5f*). The landscape comprises a large, flat and low-lying area of reclamation on the south west tip of the Clearwater Bay Peninsula, adjoining the Tathong Channel. To the north, it abuts the former island of Fat Tong Chau and to the south it adjoins Tit Cham Chau. The reclaimed shoreline is constructed from a straight alignment of

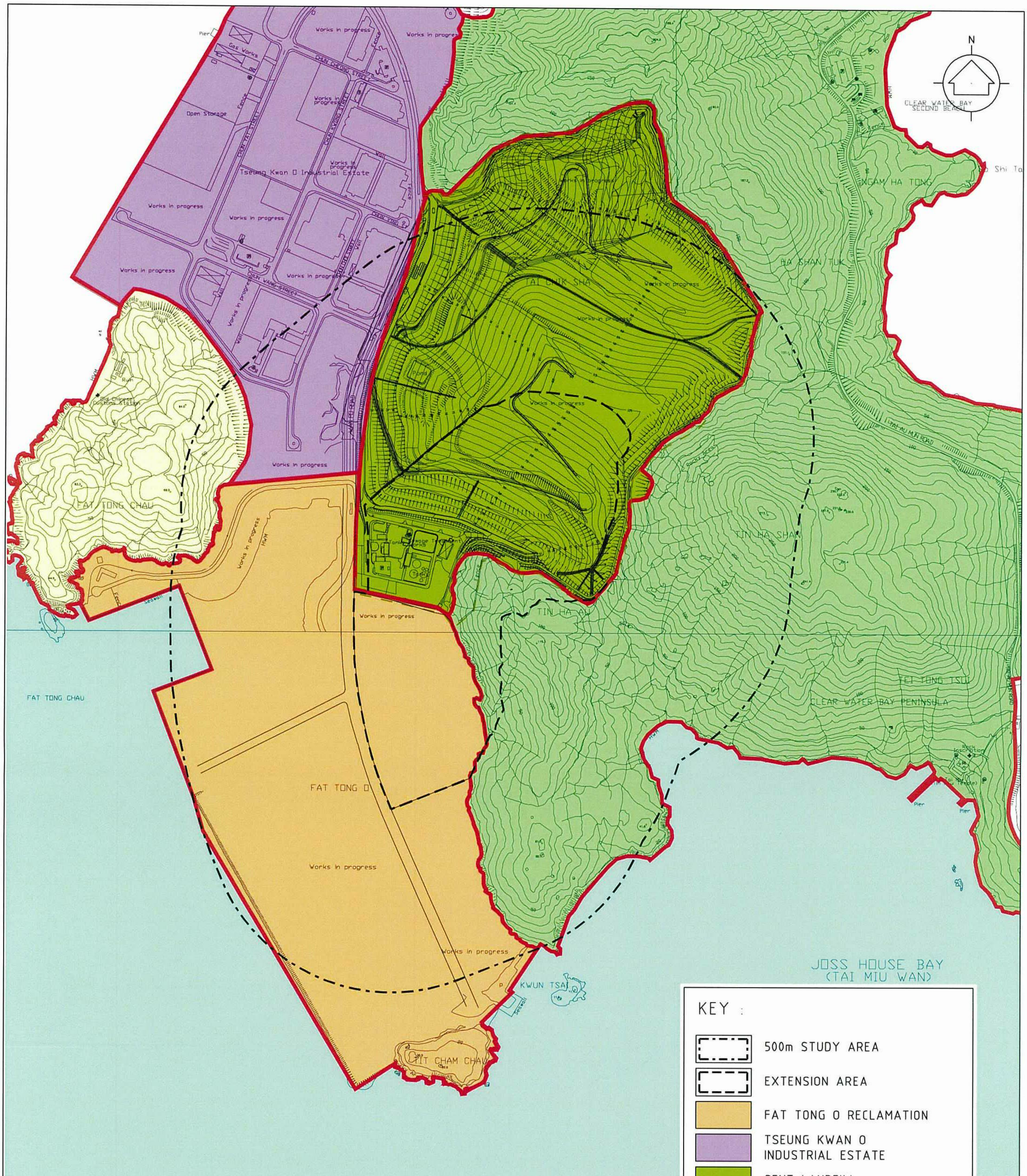

Figure 10.5f

Baseline Landscape Character Areas Plan

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armour stone seawall.   The area is currently reclaimed but undeveloped and there is a constant flow of trucks to the area.   There is little or no vegetation in the landscape, except for occasional patches of scrub.   The result is an almost uniform landscape of huge scale elements which has a character that is expansive and visually incoherent and which has a "Low" sensitivity to change (see *Figure 10.5g*).

LCA2 - Tseung Kwan O Industrial Estate

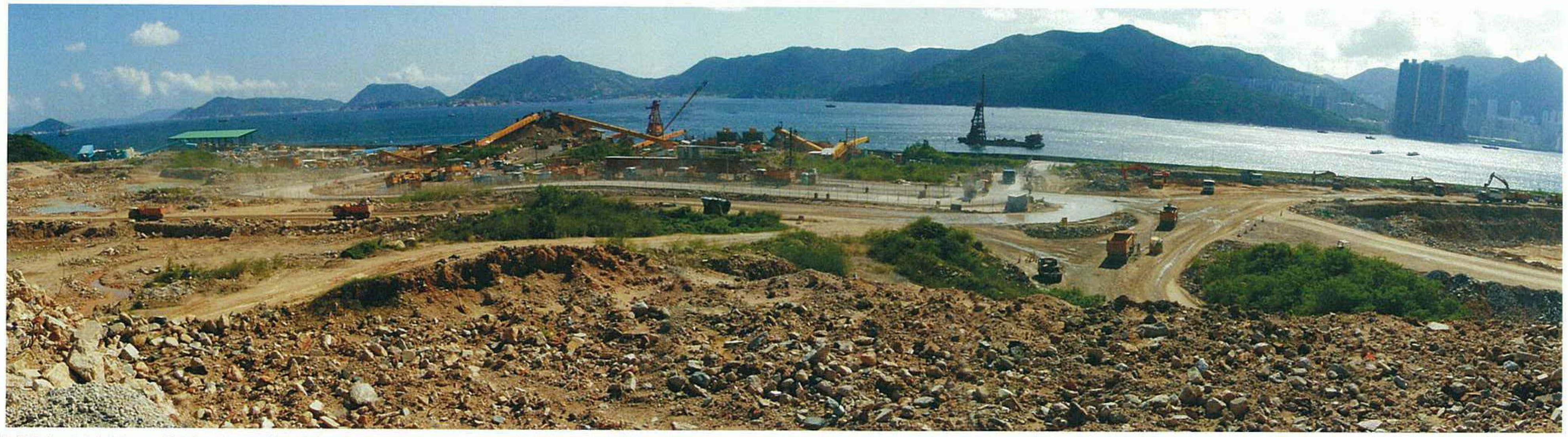
This low-lying landscape lies south of Tseung Kwan O town on the west coast of Clear Water Bay Peninsula, between the MTR depot and Fat Tong Chau (see *Figure 10.5f*).   The landscape comprises an industrial estate and is built on land reclaimed from Junk Bay.   The bay forms the western coastal edge to the landscape at an armour stone seawall.   The landscape is divided into a grid by interior roads and serviced from the north by the Wan Po Road. Despite the presence of established infrastructure, the eastern half of the landscape has been developed for industrial use.   Buildings comprise contemporary modern medium-rise office and factory outlets.   The industrial estate is open and uncluttered and has wide pavements and a spacious layout. Vegetation consists of street tree planting.   The result is a simple landscape of large scale elements which has a character that is enclosed and moderately visually coherent and which has a "Medium" sensitivity to change (see *Figure 10.5g*).

LCA3 – The existing SENT Landfill

This landscape lies on reclaimed land on the west coast of Clear Water Bay Peninsula, between the Clear Water Bay Peninsula central uplands and Tseung Kwan O Industrial Estate (see *Figure 10.5f*).   This rolling landscape comprises the existing SENT Landfill which is enclosed on three sides by the uplands of the Clear Water Bay Peninsula.   Northern parts of the landfill are still active and are characterised by newly tipped waste, areas of waste which are being covered, as well as a constant stream of trucks entering the existing SENT Landfill.   Southern parts of the existing SENT Landfill have been partly restored by soil capping and have been hydroseeded and planted with woodland whips and shrub species.   The topography slopes evenly from approximately 100mPD down to its western boundary with the Wan Po Road. The smooth grassy slopes are criss-crossed by large surface drainage channels and there is an infrastructure area on the southern boundary.   Other features in the landscape include rock cut slopes and a storage pond.   The result is a complex landscape of large scale elements which has a character that is open and visually incoherent and which has a "Low" sensitivity to change (see *Figure 10.5g*).

LCA4 - Fat Tong Chau Headland

This landscape consists of the hilly former island of Fat Tong Chau, which lies off the west coast of Clear Water Bay Peninsula (see *Figure 10.5f*) in the South-east New Territories.   Fat Tong Chau was formerly an island but is now connected to Clear Water Bay Peninsula by reclamation.   It rises steeply to a



LCA1 - Fat Tong O Reclamation

LCA2 - Tseung Kwan O Industrial Estate

LCA3 - SENT Landfill

Figure 10.5g

Photo Views of Landscape Character Areas (Sheet 1 of 2)

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summit at 100mPD. Slopes are natural and rolling and fall to a rocky foreshore on the western coast, which still adjoins Junk Bay. To the north, south and east, the former island is connected to the new reclamation and slope works are evident. Vegetation on the slopes of what is now a headland consists of natural scrub and trees. There are few human features in this landscape except for an historic Fat Tau Chau Old Chinese Custom's Station on the northern shore and an informal footpath. Streams tumble down the lower slopes of the headland to the sea. The result is a simple rural landscape of large scale elements which has a character that is open and tranquil and which has a "High" sensitivity to change (see *Figure 10.5h*).

LCA5 - Clear Water Bay Peninsular Coastal Uplands

This upland landscape forms the spine of the Clear Water Bay Peninsula (see *Figure 10.5f*). The rolling uplands of Clear Water Bay Peninsula comprise a long ridgeline above steep slopes running from Sheung Yeung Shan in the north to Ha Shan Tuk and Tin Ha Shan in the south. The uplands are dominated by High Junk Peak, an extremely steep and jagged peak rising to a height of 344mPD. The uplands fall to Clear Water Bay to the east and include the small rocky headlands at Ngam Ha Tong in the north and Tai Wong Kung in the South. In general, the coast comprises low cliffs and rocky foreshore, but also beaches such as Clear Water Bay Second Beach. East facing slopes tend to be more smooth and even than those to the west. The landscape is largely undeveloped. However, the Clear Water Bay Road runs along the east side of the ridge and there is a footpath along the ridge itself. A small road provides access to traditional fishing village houses and a temple at the southern headland at Tai Wong Kung. Elsewhere, a small sheltered bay lies on the north east coast of the headland at Po Toi O forming a traditional fishing harbour for the village of the same name. The village contains traditional houses, seafood restaurants, a temple and a small pier. There are numerous cut slopes along the Clear Water Bay Road. To the south of the LCA, on the north shore of Joss House Bay, is the Tin Hau Temple at Tai Miu which one of the largest and best known Tin Hau temples in Hong Kong. Vegetation within the uplands comprises grassland and emergent scrub to west facing slopes and scrub woodland to east facing areas. The result is a simple rural landscape of large scale elements which has a character that is open and tranquil and which has a "High" sensitivity to change (see *Figure 10.5h*).

LCA6 - Tathong Channel

This landscape comprises the areas of inshore water between Hong Kong Island and Clearwater Bay Peninsula. The waters extend from Junk Bay and Victoria Harbour in the north to the tip of Cape D'Aguilar (Hong Kong Island) in the south (see *Figure 10.5f*). The landscape is fairly well contained by the steep hills of eastern Hong Kong Island and those of the Clearwater Bay Peninsula. To the south, the waters open out to the open sea. The landscape comprises primarily the waters themselves, as well as Ng Fan Chau, a small, steep rocky island which lies within Island Bay to the immediate south of the Shek O Headland. The island rises evenly from a low

LCA4 - Fat Tong Chau Headland

LCA5 - Clear Water Bay Peninsular Central Coastal Uplands

LCA6 - Tathong Channel

Figure 10.5h

Photo Views of Landscape Character Areas (Sheet 2 of 2)

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rocky coast to a rounded peak of 47mPD and its vegetation comprises mainly scrub. Kau Pei Chau is a small double island at the southern tip of the D'Aguilar Peninsula within Cape D'Aguilar Marine Reserve. The island rises gently from the water to a twin peak 45mPD and is covered by scrub vegetation. Generally, this is an almost uniform landscape of huge scale elements, which has a character that is open and tranquil and which has a "High" sensitivity to change (see *Figure 10.5h*).

10.5.4 *Visual Envelope*

The Visual Envelope will vary during the life of the Extension. The Visual Envelope during the construction phase will reflect the extent of progressive clearance of vegetation and topsoil at the existing SENT Landfill (see *Figure 10.3a*). As the Extension fills during the operational / restoration phase and rises in height, the extent of the Visual Envelope will increase. The Visual Envelope for the aftercare phase (ie the maximum extent of the Visual Envelope) is illustrated in *Figure 10.3b*. Both figures show the extent of the Primary Visual Envelope which is that area within 10km of the Extension from which it can be seen. Although in a small number of cases, there will be a direct line of sight to the Extension from areas beyond this distance, it is considered that the effects of distance will mean that any visual impacts are "Insubstantial".

To the north, the Primary Visual Envelope will extend as far as Fei Ngo Shan (602mPD) and Razor Hill (432mPD) as well as high ground around Tai Sheung Tok, Mau Wu Shan (233mPD), Black Hill (281mPD) and Devils Peak (221mPD). Taller buildings within Po Lam and northern parts of Tseung Kwan O (Metro City) will also fall within the Primary Visual Envelope. Eastern parts of northern Tseung Kwan O (East Point City) will not fall within the Primary Visual Envelope as it will be screened by intervening landforms and restored landfills. The Primary Visual Envelope will include the area designated for the extension of Tseung Kwan O as well as higher ground on the western slopes of the Clear Water Bay Peninsula.

To the east, the Primary Visual Envelope is almost wholly contained by the ridge of hills along the Clear Water Bay Peninsula. However, in one location where the hills dip between High Junk Peak (344mPD) and Tin Ha Shan (273mPD), the Primary Visual Envelope will extend east of the Peninsula including only a small area around Tai Wan Tau. It will also include waters east of Clear Water Bay Peninsula as far as Basalt Island.

To the west, the Primary Visual Envelope is defined by the high ground of Mount Parker (531mPD) and Pottinger Peak (312mPD) on Hong Kong Island and includes taller buildings urban areas of Taikoo, Quarry Bay, Sai Wan Ho, Heng Fa Chuen, and Siu Sai Wan. It also extends to higher ground at Violet Hill (404mPD) and Mount Butler (436mPD). In Kowloon, there is a direct line of sight to the Extension at Hung Hom.

To the south, the Primary Visual Envelope extend to the northern slopes of Tung Lung Chau, to the Tathong Channel (as far as the Po Toi Islands) and to the Dragon's Back, Shek O Peak (284mPD) and Shek O on Hong Kong Island.

Cross-sections showing the derivation of the Visual Envelope (especially with regard to Clear Water Bay Country Park) are presented in *Figure 10.5i*.

10.5.5 Visually Sensitive Receivers (VSRs)

Within the Visual Envelope, a number of key Visually Sensitive Receivers (VSRs) have been identified. These VSRs are mapped in *Figure 10.5j*. They are listed, together with their sensitivity, in *Table 10.7a*. For ease of reference, each VSR is given an identity number, which is used in the text tables and figures.

10.6 LANDSCAPE IMPACT ASSESSMENT

10.6.1 Potential Sources of Impacts

The Extension will involve various sources of landscape and visual impact. The extent of the above works is indicated in *Figure 10.5a*.

The proposed development will create varying levels of impact on the physical landscape resources and landscape character of the surrounding areas at different stages of its lifetime.

During the **Construction Phase**, potential impacts will result from the following:

- Access road construction;
- Temporary slope works;
- Removal of vegetation and re-grading of existing slopes;
- Presence of machinery and plant;
- Relocation and construction of the leachate treatment plant, laboratory and offices;
- Liner installation works; and
- Storage of existing topsoil for reinstatement works.

During the **Operational / Restoration Phase**, potential impacts will result from the following:

- Filling material;
- Presence of machinery and plant;
- Lorry and other vehicle traffic to the Extension;

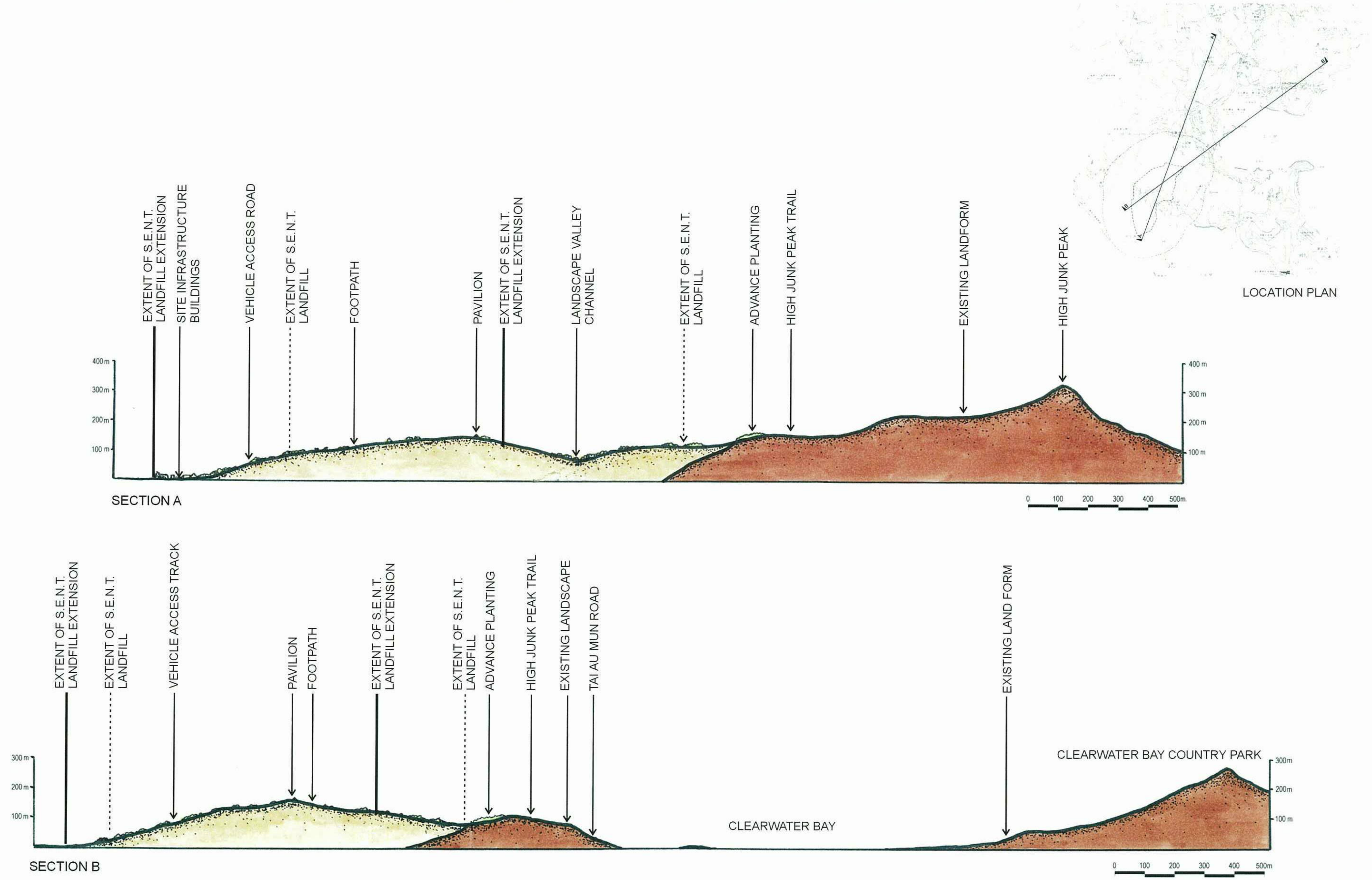

Figure 10.5i

Key Sections Showing Derivation of Visual Envelope

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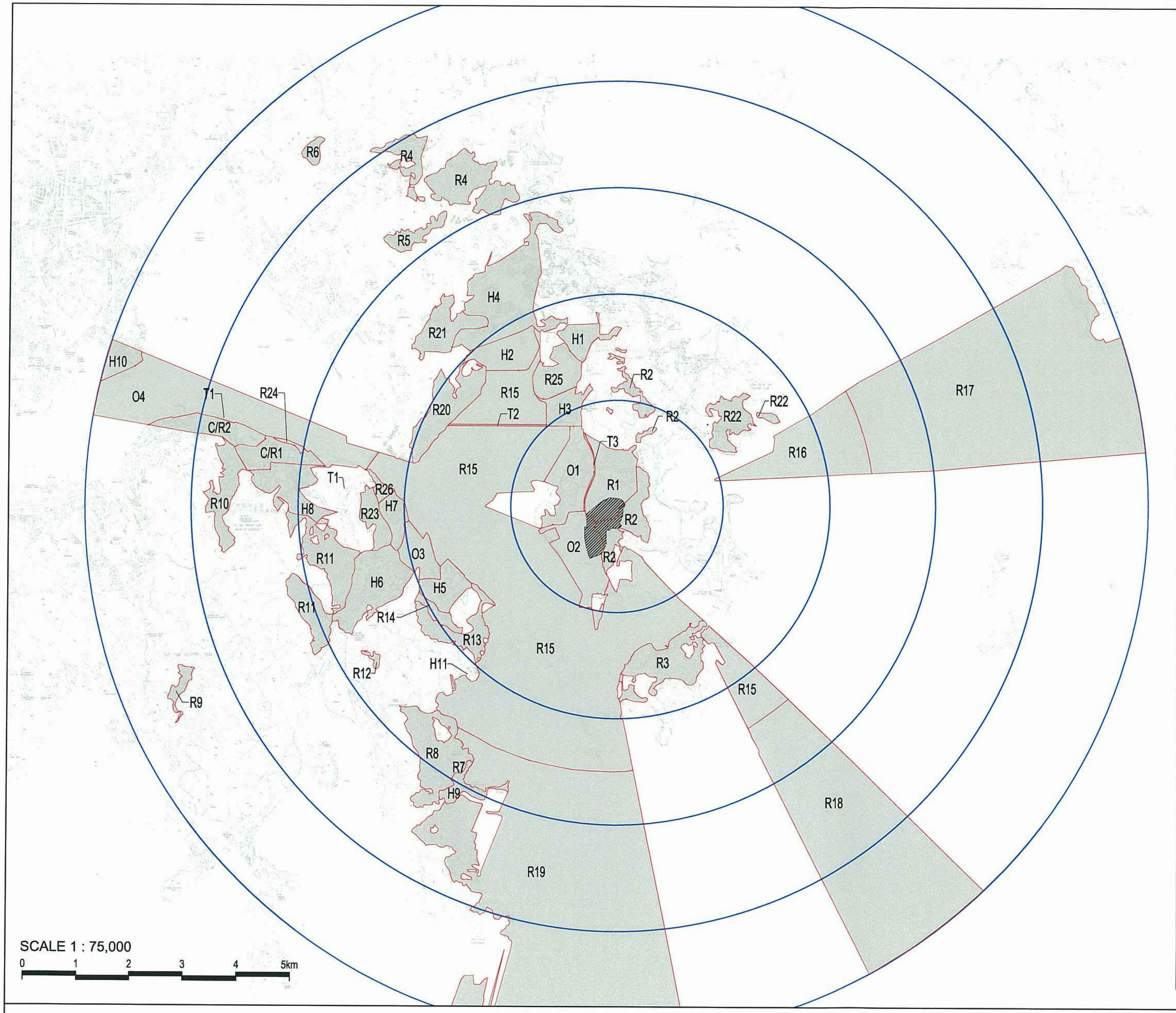

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LEGEND :

EXTENT OF PROPOSED EXTENSION

Recreational VSRS	
R1	Users of Restored SENT Landfill
R2	Hikers on High Junk Peak Trail
R3	Hikers / Campers on Tung Lung Chau
R4	Hikers on Razor Hill
R5	Hikers on Wilson Trail (Tai Sheung Tok)
R6	Hikers on Kowloon Peak (Fei Ngo Shan)
R7	Visitors to Shek O
R8	Hikers on Dragon's Back
R9	Hikers on Violet Hill
R10	Users of Tai Tam Country Park (Quarry Bay Extension)
R11	Hikers on Mount Parker
R12	Hikers on Mount Collinson
R13	Hikers on Pottinger Peak / Cape Collinson
R14	Visitors to Chai Wan Cemetery (East)
R15	Boat Users (and Workers in Vessels) in Tathong Channel & Joss House Bay
R16	Boat Users (and Workers in Vessels) in Waters East of Clear Water Bay
R17	Boat Users (and Workers in Vessels) in Waters South of Bluff Island
R18	Boat Users (and Workers in Vessels) in Waters South-East of Tung Lung Chau
R19	Boat Users (and Workers in Vessels) in Waters East of Cape D'Aguilar
R20	Visitors to TKO Chinese Cemetary and Devil's Peak
R21	Hikers on Black Hill
R22	Users of Clear water Country Park (East)
R23	Users of Lei Yue Mun Park
R24	Users of Quarry Bay Park
R25	Future Recreational Users of TKO Landfill
R26	Visitors to Museum of Coastal Defence
Travelling VSRS	
T1	Travellers on Island Eastern Coridor
T2	Travellers on Future Cross Bay Link
T3	Travellers on Wan Po Road
Residential VSRS	
H1	Future Residents at Pak Shing Kok
H2	Future Residents in TKO Phase 2
H3	Future Residents at TKO Area 86
H4	Residents in TKO
H5	Residents in Siu Sai Wan
H6	Residents in Chai Wan
H7	Residents in Heng Fa Chuen
H8	Residents in Shau Kei Wan (West)
H9	Residents in Shek O
H10	Future Residents Hung Hom (East)
H11	Reisdents in Cape Collison Cotrrectional Institute
Commercial / Residential VSRS	
C/R1	Residents and Workers in Taikoo Shing (North)
C/R2	Residents and Workers in North Point
Occupational VSRS	
O1	Workers in existing (and planned phaes of) TKO Industrial Estate
O2	Future Workers in TKO Area 137
O3	Workers Chai Wan Dock Area
O4	Workers on Vessels in Victoria Harbour

Figure 10.5j

Locations of Visually Sensitive Receivers

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- Temporary cover and final cover earthworks;
- Night lighting;
- Storage of existing topsoil for reinstatement works;
- Presence of landfill gas and leachate treatment plants, laboratory and offices; and
- Restored slope profiles with channels.

During the **Aftercare Phase**, potential impacts will result from the following:

- Restored slope profiles with channels; and
- Presence of the landfill gas and leachate treatment plants, laboratory and offices.

10.6.2 Nature and Magnitude of Landscape Impacts Before Mitigation in Construction Phase

The magnitude of the impacts, before implementation of mitigation measures, on landscape resources and landscape character areas that will occur in the Construction Phase are described below and tabulated in *Table 10.6d*. All impacts are adverse unless otherwise stated.

Landscape Resources

LR7 – Trees in Northern TKO Area 137: The construction of an access road and filling operations will be close to the resource, but are unlikely to significantly affect it. The magnitude of this impact will be "Small".

LR9 - Scrub in southern part of TKO Area 137: Earthworks and vegetation clearance will require the removal of around 0.16 ha of scrub currently self-seeded on the Area 137 reclamation. The magnitude of this impact will be "Small".

LR11 - Trees and shrubs along lower hillside of Tin Ha Shan: Slope works will require the removal of around 40 semi-mature trees (mainly of *Ficus microcarpa*, *Macaranga tanarius* and *Sapium sebiferum)* currently found on what appears to be re-graded topography. The magnitude of these impacts will be "Intermediate".

LR12 – Infrastructure area of the existing SENT Landfill: Earthworks and clearance works will require the removal of around 20 mature ornamental trees situated around the landfill offices and laboratories (typically *Ficus microcarpa*, *Hibiscus tiliaceus*, *Ficus virens*, *Melaleuca quinquenervia*.). The magnitude of these impacts will be "Small".

LR13 - Plantation and topography in the south of the existing SENT Landfill: Earthworks and clearance works for the Extension on the existing SENT Landfill, will require the removal / loss of about 6.03 ha of semi-mature trees comprising (*Acacia confusa*, *Albizia lebbeck, Ficus fistulosa* and *Ficus microcarpa*) planted as Phases 1-3 of the restoration of the existing SENT Landfill, as well as recreated topography. The magnitude of this impact will be "Large".

LR14 – Plantation and topography in the south-east of the existing SENT Landfill: Earthworks and clearance works for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.63 ha of semi-mature trees comprising *Acacia mangium*, *Acacia auriculiformis*, *Casuarina equisetifolia*, *Hibiscus tiliaceus* and *Macaranga tanarius* planted as Phases 1-6 of the restoration of the existing SENT Landfill, as well as recreated topography. The magnitude of this impact will be "Intermediate".

LR15 - Plantation and topography in the west of the existing SENT Landfill: Earthworks and clearance works for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.57 ha of young trees comprising of *Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia* planted mainly as Phase 3 of the restoration of the SENT Landfill, as well as recreated topography. The magnitude of this impact will be "Small".

LR23 - Shrubs and topography in lower ridge east of TKO Area 137: Re-grading of slopes for the Extension will require the loss / removal of about 6.24 ha of natural lower hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered with a scattering of grass and common native shrub species (e.g. *Rhaphiolepis indica, Rhodomyrtus tomentosa, Melastoma candidum*). The magnitude of this impact will be "Large".

LR24 - Grass and topography on upper ridge east of TKO Area 137: Re-grading of slopes for the Extension will require the loss / removal of about 0.05 ha of natural upper hillsides (including topsoils)on the south-west tip of the Clearwater Bay Peninsula, which are covered predominantly with grass and also with some scattered shrubs of common native spaces. The magnitude of this impact will be "Small".

Landscape Character

The Extension will have potential impacts on three Landscape Character Areas during the Construction phase.

LCA1 – Fat Tong O Reclamation: Preparatory works for the Extension on the reclamation will include a small amount of vegetation clearance and the establishment of the office, leachate treatment plant and laboratory. This will last about 3 years. The magnitude of these impacts on this LCA will be "Small", as only the north-east corner of the reclamation will be affected (2.75 ha).

LCA3 – The existing SENT Landfill: Preparatory works for the Extension on the existing SENT Landfill will include vegetation clearance, stabilisation of slopes and demolition of infrastructure area over 3 years. Works will affect approximately one third of the existing SENT Landfill area (29.50 ha) and the magnitude of these impacts on this LCA will be "Intermediate".

LCA5 – Clear Water Bay Peninsula Coastal Uplands: Preparatory works for the Extension on the Clear Water Bay Peninsula Coastal Uplands will include vegetation clearance, topsoil removal and the stabilisation of slopes, over 3 years. Works will affect only a small area (6.29 ha) of the uplands and the magnitude of these impacts on this LCA will be "Small".

10.6.3 Nature and Magnitude of Landscape Impacts Before Mitigation in Operation /Restoration Phase

The magnitude of the impacts, before implementation of mitigation measures, on landscape resources and landscape character areas that will occur in the Operation/Restoration Phase are described below and tabulated in *Table 10.6d*. All impacts are adverse unless stated as being "Positive".

Landscape Resources

LR7 – Trees in Northern TKO Area 137: The construction of an access road and filling operations will be close to the resource, but are unlikely to significantly affect it. The magnitude of this impact will be "Small".

LR9 - Scrub in southern part of TKO Area 137: Filling operations will require the removal of around 0.16 ha of scrub currently self-seeded on the Area 137 reclamation. The magnitude of this impact will be "Small".

LR11 - Trees and shrubs along lower hillside of Tin Ha Shan: Filling operations will require the removal of around 40 semi-mature trees (mainly of *Ficus microcarpa*, *Macaranga tanarius* and *Sapium sebiferum*) currently found on what appears to be re-graded topography. The magnitude of these impacts will be "Intermediate".

LR12 – Infrastructure area of the existing SENT Landfill: Filling works will require the removal of around 20 mature ornamental trees situated around the Infrastructure area (typically *Ficus microcarpa*, *Hibiscus tiliaceus*, *Ficus virens*, *Melaleuca quinquenervia*.). The magnitude of these impacts will be "Small".

LR13 - Plantation and topography in the south of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 6.03 ha of semi-mature trees comprising (*Acacia confusa*, *Albizia lebbeck, Ficus fistulosa* and *Ficus microcarpa*) planted as Phases 1-3 of the restoration of the existing SENT Landfill, as well as recreated topography. The magnitude of this impact will be "Large".

LR14 – Plantation and topography in the south-east of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.63 ha of semi-mature trees comprising *Acacia mangium*, *Acacia auriculiformis*, *Casuarina equisetifolia*, *Hibiscus tiliaceus* and *Macaranga tanarius* planted as Phases 1-6 of the restoration of the existing SENT Landfill, as well as recreated topography. The magnitude of this impact will be "Intermediate".

LR15 - Plantation and topography in the west of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.57 ha of young trees comprising of *Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia* planted mainly as Phase 3 of the restoration of the SENT Landfill, as well as recreated topography. The magnitude of this impact will be "Small".

LR23 - Shrubs and topography in lower ridge east of TKO Area 137: Filling operations for the Extension will require the loss / removal of about 6.24 ha of natural lower hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered with a scattering of grass and common native shrub species (e.g. *Rhaphiolepis indica, Rhodomyrtus tomentosa, Melastoma candidum*) . The magnitude of this impact will be "Large".

LR24 - Grass and topography on upper ridge east of TKO Area 137: Filling operations for the Extension will require the loss / removal of about 0.05 ha of natural upper hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered predominantly with grass and also with some scattered shrubs of common native spaces. The magnitude of this impact will be "Small".

Landscape Character

The Extension will have potential impacts on three LCAs during the Operational/Restoration Phase.

LCA1 – Fat Tong O Reclamation: Landfilling works (with associated lorry movements) of the Extension for 6 years, together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares. The magnitude of these impacts on this LCA will be "Intermediate" (15.64 ha).

LCA3 – The existing SENT Landfill: Landfilling works (with associated lorry movements) of the Extension for 6 years, together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares. Works will affect approximately one third of the existing SENT Landfill area (29.50 ha) and the magnitude of these impacts on this LCA will be "Intermediate".

LCA5 – Clear Water Bay Peninsula Coastal Uplands: Landfilling works of the Extension for 6 years, together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares. Works will affect only a small area (6.29 ha) of the uplands and the magnitude of these impacts on this LCA will be "Small".

10.6.4 *Nature and Magnitude of Landscape Impacts Before Mitigation in Aftercare Phase*

The magnitude of impacts, before implementation of mitigation measures, on the landscape resources and landscape character areas that will occur in the Aftercare Phase are the same as the permanent and irreversible impacts described above for the Operation / Restoration Phase. They are tabulated in *Table 10.6d*. All impacts are adverse unless stated as being "Positive".

10.6.5 *Landscape and Visual Mitigation Measures in Construction, Operation/Restoration and Aftercare Phases*

Alternative Layout Options

Several different layouts / profiles for the Extension were examined during the development of the final layout / profile. The merits of each of the options with regard to landscape and visual issues are provided in *Section 2* of this Report.

Other Mitigation Measures

The proposed landscape and visual mitigation measures for potential impacts generated during the construction, operation / restoration and aftercare phases are described in *Tables 10.6a* to *10.6c* together with the associated funding, implementation, management and maintenance agencies. The mitigation measures, both on-site and off-site are illustrated in *Figures 10.6a* and *10.6b*.

Table 10.6a Proposed Construction Phase Landscape and Visual Mitigation Measures

ID No.	Landscape and Visual Mitigation Measure	Funding Agency	Implementation Agency
CM1	The construction area and area allowed for the contractor's office, leachate treatment plant and laboratory areas will be minimised to a practical minimum, to avoid impacts on adjacent landscape.	EPD	Contractor
CM2	Topsoil, where identified, will be stripped and stored for re-use in the construction of the soft landscape works, where practical. The Contract Specification will include storage and reuse of topsoil as appropriate.	EPD	Contractor
CM3	All existing trees at the edges of the Extension will be carefully protected during construction. Detailed Tree Protection Specification will be provided in the Contract Specification. Under this specification, the Contractor will be required to submit, for approval, a detailed working method statement for the protection of trees prior to undertaking any works adjacent to all retained trees, including trees in contractor's works areas.	EPD	Contractor

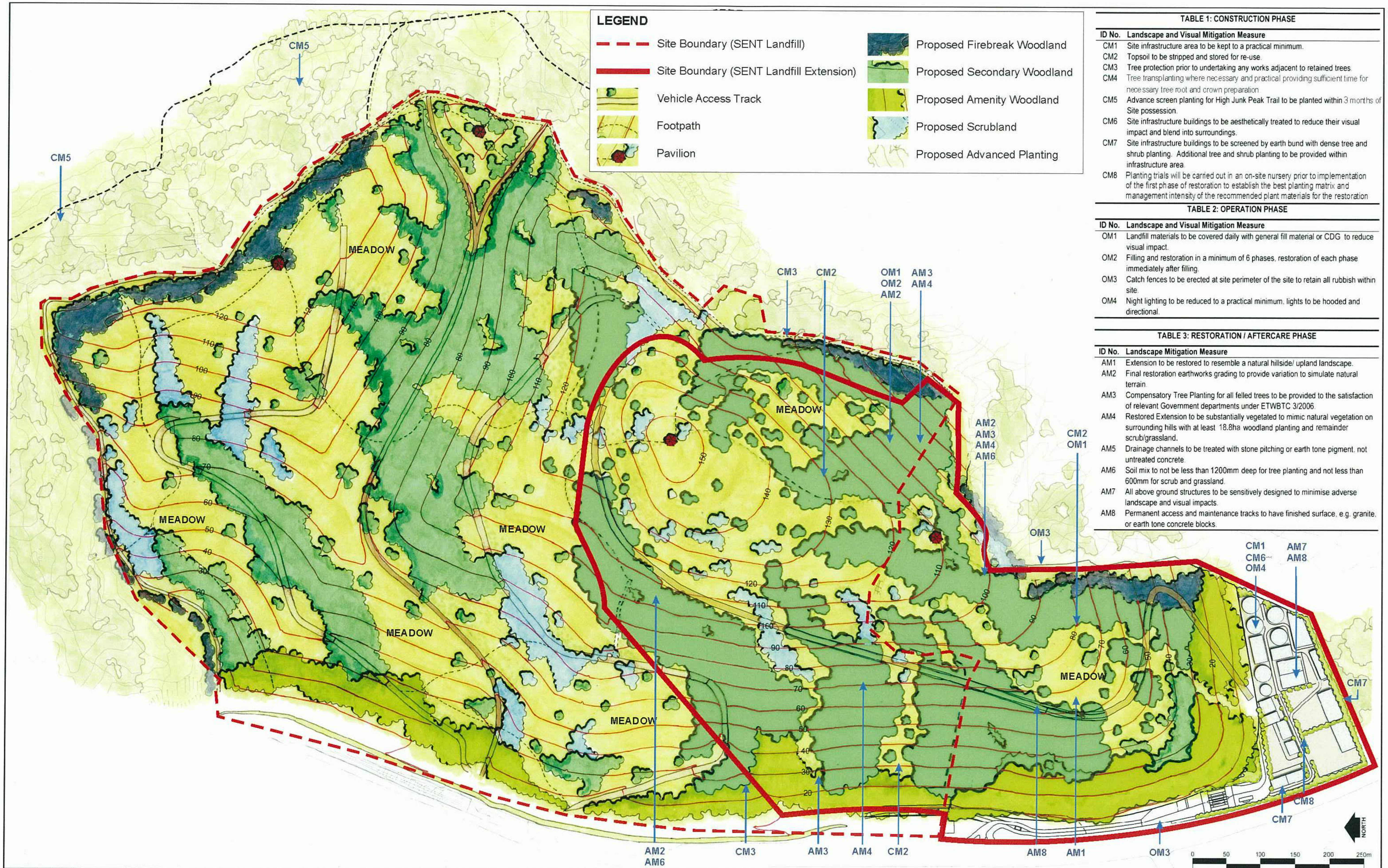

TABLE 1: CONSTRUCTION PHASE

ID No.	Landscape and Visual Mitigation Measure
CM1	Site infrastructure area to be kept to a practical minimum.
CM2	Topsoil to be stripped and stored for re-use.
CM3	Tree protection prior to undertaking any works adjacent to retained trees.
CM4	Tree transplanting where necessary and practical providing sufficient time for necessary tree root and crown preparation.
CM5	Advance screen planting for High Junk Peak Trail to be planted within 3 months of Site possession.
CM6	Site infrastructure buildings to be aesthetically treated to reduce their visual impact and blend into surroundings.
CM7	Site infrastructure buildings to be screened by earth bund with dense tree and shrub planting. Additional tree and shrub planting to be provided within infrastructure area.
CM8	Planting trials will be carried out in an on-site nursery prior to implementation of the first phase of restoration to establish the best planting matrix and management intensity of the recommended plant materials for the restoration

TABLE 2: OPERATION PHASE

ID No.	Landscape and Visual Mitigation Measure
OM1	Landfill materials to be covered daily with general fill material or CDG to reduce visual impact.
OM2	Filling and restoration in a minimum of 6 phases, restoration of each phase immediately after filling.
OM3	Catch fences to be erected at site perimeter of the site to retain all rubbish within site.
OM4	Night lighting to be reduced to a practical minimum, lights to be hooded and directional.

TABLE 3: RESTORATION / AFTERCARE PHASE

ID No.	Landscape Mitigation Measure
AM1	Extension to be restored to resemble a natural hillside/ upland landscape.
AM2	Final restoration earthworks grading to provide variation to simulate natural terrain.
AM3	Compensatory Tree Planting for all felled trees to be provided to the satisfaction of relevant Government departments under ETWBTC 3/2006.
AM4	Restored Extension to be substantially vegetated to mimic natural vegetation on surrounding hills with at least 18.8ha woodland planting and remainder scrub/grassland.
AM5	Drainage channels to be treated with stone pitching or earth tone pigment, not untreated concrete.
AM6	Soil mix to not be less than 1200mm deep for tree planting and not less than 600mm for scrub and grassland.
AM7	All above ground structures to be sensitively designed to minimise adverse landscape and visual impacts.
AM8	Permanent access and maintenance tracks to have finished surface, e.g. granite, or earth tone concrete blocks.

Figure 10.6a

Landscape and Visual Mitigation Measures (on-site)

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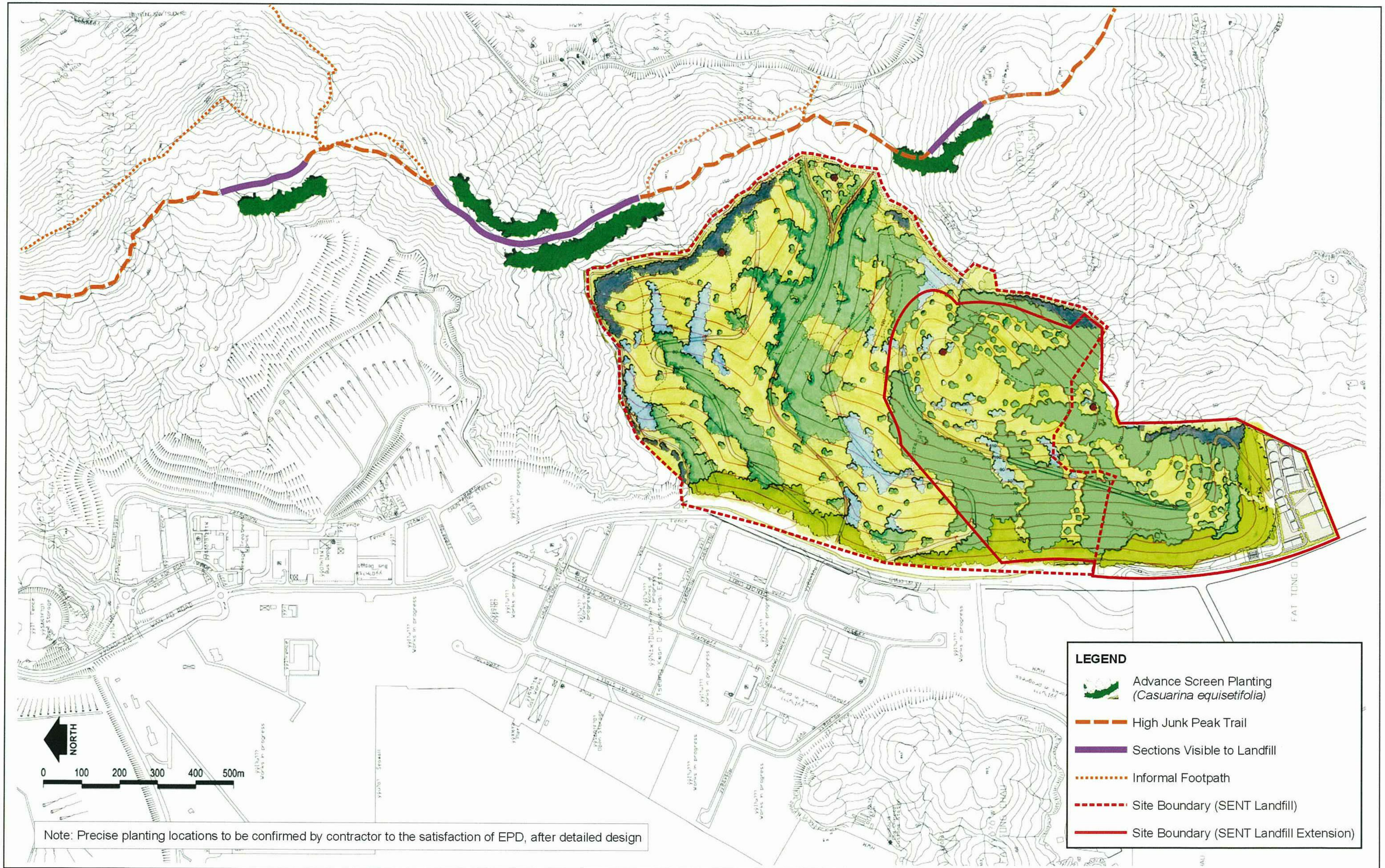

Figure 10.6b

Landscape and Visual Mitigation Measures (off-site)

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ID No.	Landscape and Visual Mitigation Measure	Funding Agency	Implementation Agency
CM4	Trees unavoidably affected by the works will be transplanted where necessary and practical. A detailed Tree Transplanting Specification will be provided in the Contract Specification, if applicable. Sufficient time for necessary tree root and crown preparation periods will be allowed in the project programme.	EPD	Contractor
CM5	Within 3 months of taking possession of the Extension Site, the Contractor will plant advance screen planting of *Casuarina sp* or *Acacia sp* at Light Standard size at 1.5m centres along the High Junk Peak Trail so as to screen views of the Works from the trail. Tree planting locations will be agreed with AFCD. Works will be completed within 9 months of taking possession of the Extension Site.	EPD	Contractor
CM6	The Contractor's office, leachate treatment plant and laboratory will be given an aesthetic treatment in earth tone colours to reduce their visual impact and albedo and blend them into the surrounding landscape.	EPD	Contractor
CM7	The Contractor's office, leachate treatment plant and laboratory will be surrounded by a min 5m wide and 0.75m high earth bund on the west and south sides planted with a dense screen of tree and shrub vegetation. Additional tree planting will be provided in unused spaces with thin infrastructure site, along access roads and in and around car parks. This will be supplemented with shrub planting, where appropriate.	EPD	Contractor
CM8	Planting trials will be carried out in an on-site nursery prior to implementation of the first phase of restoration to establish the best planting matrix and management intensity of the recommended plant materials for the restoration.	EPD	Contractor

Table 10.6b Proposed Operation/Restoration Phase Landscape and Visual Mitigation Measures

ID No.	Landscape and Visual Mitigation Measure	Funding Agency	Implementation Agency
OM1	Landfill materials will be covered with general fill material or CDG on a daily basis to reduce visual impact.	EPD	Contractor
OM2	Filling and restoration will be phased during the course of operations in a minimum of 6 phases, the restoration of each phase to commence immediately on the completion of filling in that phase.	EPD	Contractor
OM3	Catch fences will be erected at the perimeter of the waste boundary, to ensure that all waste stays within the site and is not blown into surrounding areas.	EPD	Contractor
OM4	All night-time lighting will be reduced to a practical minimum both in terms of number of units and lux level and will be hooded and directional.	EPD	Contractor

Table 10.6c Proposed Aftercare Phase Landscape and Visual Mitigation Measures

ID No.	Landscape Mitigation Measure	Funding Agency	Implementation Agency	Management Agency*(a)	Maintenance Agency*(a)
AM1	The Extension will be restored to resemble a natural hillside/ upland landscape as far as possible.	EPD	Contractor	Contractor (for 30 years)	Contractor (for 30 years)
AM2	Final restoration earthworks grading will provide both vertical and horizontal variation to simulate as far as practicable, natural terrain.	EPD	Contractor	Contractor (for 30 years)	Contractor (for 30 years)
AM3	Compensatory Tree Planting for all felled trees will be provided to the satisfaction of relevant Government departments. Required numbers and locations of compensatory trees will be determined and agreed separately with Government during the Tree Felling Application process under ETWB-WBTC 3/2006.	EPD	Contractor	Contractor (for 30 years)	Contractor (for 30 years)

ID No.	Landscape Mitigation Measure	Funding Agency	Implementation Agency	Management Agency*(a)	Maintenance Agency*(a)
AM4	The restored Extension will be substantially vegetated so as to mimic the patterns of natural vegetation on surrounding hills. At least 18.8ha of the area of the Extension Site will be planted with woodland mix planting at no less than 1.2m spacings. 80% of all plants planted will be native species. The remainder of the site will be planted as a grassland / shrub mosaic.	EPD	Contractor	Contractor (for 30 years)	Contractor (for 30 years)
AM5	Drainage channels will be treated with stone pitching or coloured pigment in an earth tone and will not be untreated concrete.	EPD	Contractor	Contractor (for 30 years)	Contractor (for 30 years)
AM6	Soil mix in accordance with the Government's General Specification for Engineering Works will be used in the restoration works. In areas of tree planting soil; mix will not be less than 1.2m deep. In areas of scrub planting and grassland, it will not be less than 600mm deep.	EPD	Contractor	Contractor (for 30 years) then AFCD	Contractor (for 30 years) then AFCD
AM7	All above ground structures, including gas wells and flares will be sensitively designed in a manner that responds to the existing and planned urban context, and minimises potential adverse landscape and visual impacts.	EPD	Contractor	Contractor	Contractor

ID No.	Landscape Mitigation Measure	Funding Agency	Implementation Agency	Management Agency*[a]	Maintenance Agency*[a]
AM8	Permanent access and maintenance tracks will not have an unfinished concrete surface. Acceptable finish materials might include granite, or concrete blocks in an earth tone colour.	EPD	Contractor	Contractor (for 30 years)	Contractor (for 30 years)

Note:
(a) Management and Maintenance Agencies are identified as per WBTC 14/2002.

Programme of Implementation of Landscape and Visual Mitigation Measures

Construction phase mitigation measures above will be carried out before or during the operational/restoration phase of the Extension.

The operation/restoration phase measures listed above will be in place during the operational life of the Extension.

The aftercare phase measures listed above will be adopted during the detailed design, and be built as part of the restoration works and maintained thereafter, so that they are in place at the date of completion of filling of the Extension and during the aftercare period. However, landscape restoration mitigation will be phased during the operational life of the Extension and will be completed in a minimum of 6 restoration phases. It will be noted that the full effect of the soft landscape mitigation measures would not be appreciated for several years.

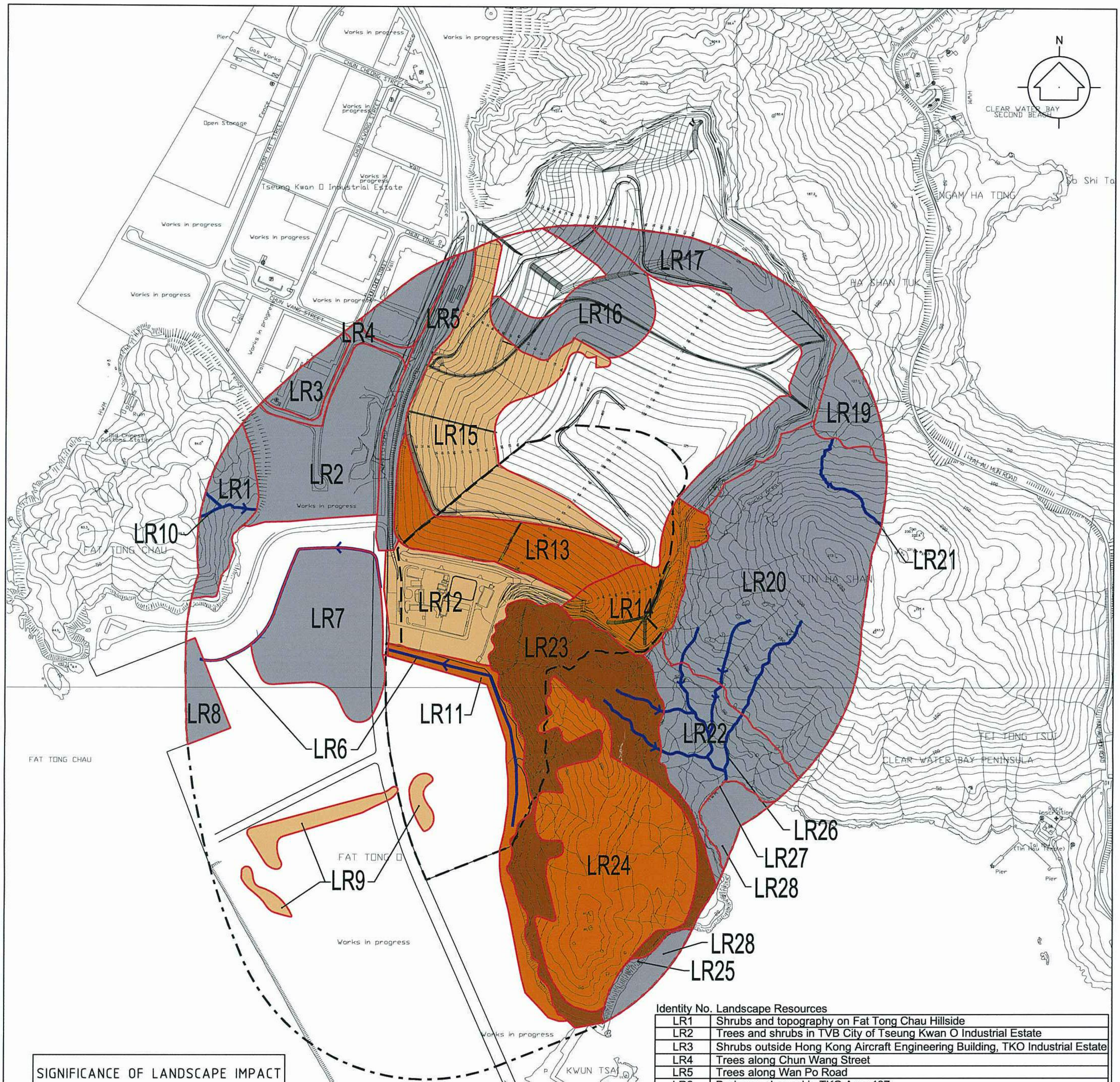
10.6.6 *Prediction of Significance of Landscape Impacts*

The potential significance of the landscape impacts during the construction, operation / restoration and aftercare phases, before and after mitigation, are provided below in *Table 10.6d* and mapped in *Figures 10.6c* to *10.6h*. This assessment follows the methodology outlined above and assumes that the appropriate mitigation measures identified in *Tables 10.6a* and *10.6c* above will be implemented, and that the full effect of the soft landscape mitigation measures will be realised after ten years. Photomontages of the proposed development before and after mitigation are illustrated in *Figures 10.6i* to *10.6p* inclusive.

Construction Phase

In the construction phase, after the implementation of the proposed mitigation measures, there will still be some adverse residual landscape impacts as described below.

Adverse residual landscape impacts of "Substantial" significance will be experienced by the following landscape resources:



SIGNIFICANCE OF LANDSCAPE IMPACT

- INSUBSTANTIAL
- SLIGHT NEGATIVE
- MODERATE NEGATIVE
- SUBSTANTIAL NEGATIVE

KEY :

- 500m STUDY AREA
- EXTENSION AREA
- LR1 LANDSCAPE RESOURCE

Identity No.	Landscape Resources
LR1	Shrubs and topography on Fat Tong Chau Hillside
LR2	Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate
LR3	Shrubs outside Hong Kong Aircraft Engineering Building, TKO Industrial Estate
LR4	Trees along Chun Wang Street
LR5	Trees along Wan Po Road
LR6	Drainage channel in TKO Area 137
LR7	Trees in northern part of TKO Area 137
LR8	Coastal water east of TKO Area 137
LR9	Scrubs in southern part of TKO Area 137
LR10	Stream on Fat Tong Chau Hillside
LR11	Trees and shrubs along lower hillside of Tin Ha Shan
LR12	Site office area of SENT Landfill
LR13	Plantation and topography in South SENT Landfill
LR14	Plantation and topography in South-East SENT Landfill
LR15	Plantation and topography in West SENT Landfill
LR16	Grassland and topography in SENT Landfill
LR17	Man-made slope with shrubs and grass in SENT Landfill
LR18	Not Used
LR19	Trees, shrubs and topography in Ha Shan Tuk
LR20	Shrubs and topography in Tin Ha Shan
LR21	Streams in Tin Ha Shan
LR22	Trees, shrubs and topography in Tin Ha Au
LR23	Shrubs and topography on lower ridge east of TKO Area 137
LR24	Grass, shrubs and topography on upper ridge east of TKO Area 137
LR25	Sandy shore south of ridge east of TKO Area 137
LR26	Streams in Tin Ha Au
LR27	Sandy shore off Tin Ha Au
LR28	Coastal water off Tin Ha Au

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Figure 10.6c (REVISION A)

Residual Landscape Resources Impacts During Construction Phase

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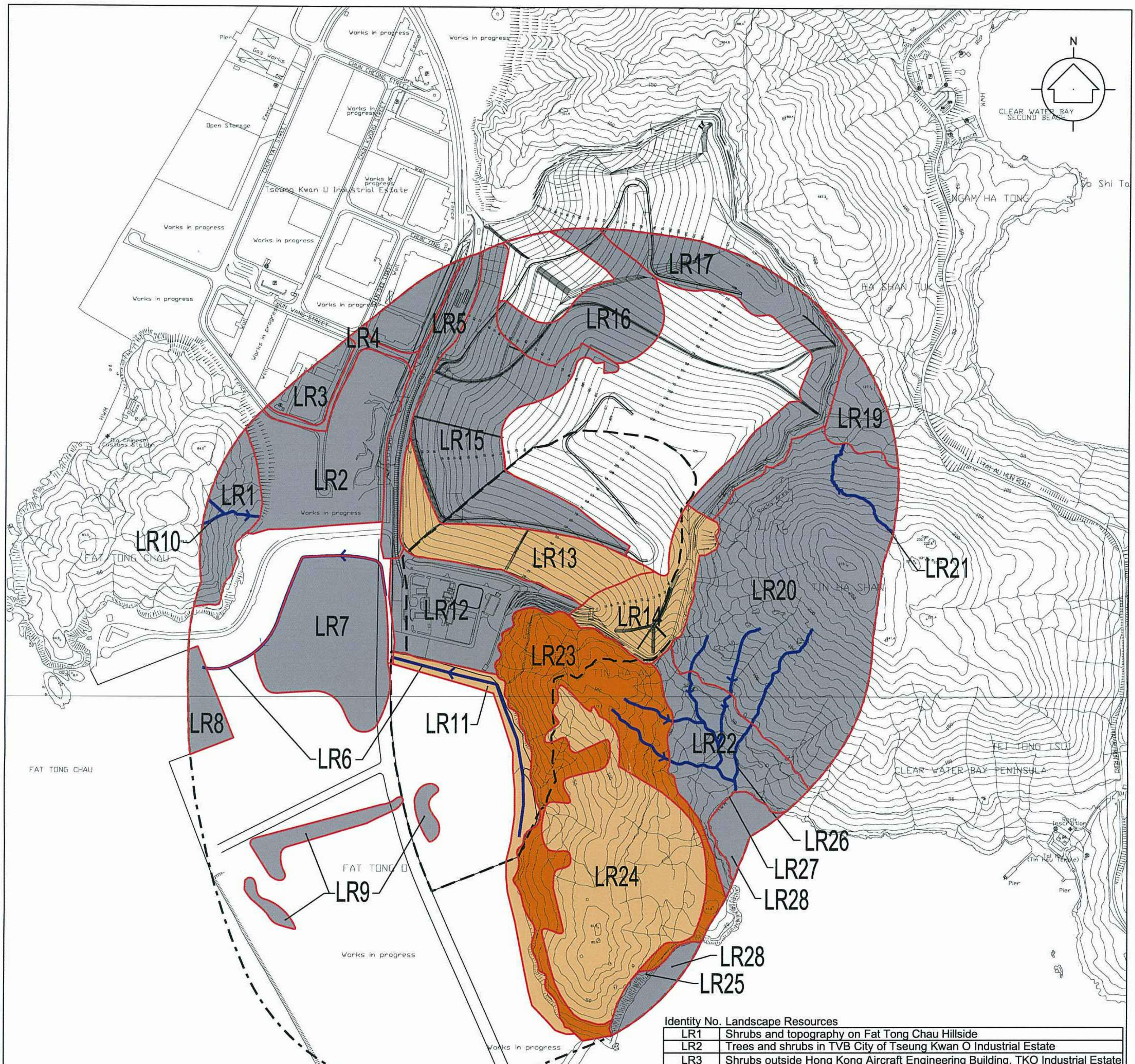

SIGNIFICANCE OF LANDSCAPE IMPACT

- INSUBSTANTIAL
- SLIGHT NEGATIVE
- MODERATE NEGATIVE
- SUBSTANTIAL NEGATIVE

KEY :

- 500m STUDY AREA
- EXTENSION AREA
- LR1 LANDSCAPE RESOURCE

Identity No.	Landscape Resources
LR1	Shrubs and topography on Fat Tong Chau Hillside
LR2	Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate
LR3	Shrubs outside Hong Kong Aircraft Engineering Building, TKO Industrial Estate
LR4	Trees along Chun Wang Street
LR5	Trees along Wan Po Road
LR6	Drainage channel in TKO Area 137
LR7	Trees in northern part of TKO Area 137
LR8	Coastal water east of TKO Area 137
LR9	Scrubs in southern part of TKO Area 137
LR10	Stream on Fat Tong Chau Hillside
LR11	Trees and shrubs along lower hillside of Tin Ha Shan
LR12	Site office area of SENT Landfill
LR13	Plantation and topography in South SENT Landfill
LR14	Plantation and topography in South-East SENT Landfill
LR15	Plantation and topography in West SENT Landfill
LR16	Grassland and topography in SENT Landfill
LR17	Man-made slope with shrubs and grass in SENT Landfill
LR18	Not Used
LR19	Trees, shrubs and topography in Ha Shan Tuk
LR20	Shrubs and topography in Tin Ha Shan
LR21	Streams in Tin Ha Shan
LR22	Trees, shrubs and topography in Tin Ha Au
LR23	Shrubs and topography on lower ridge east of TKO Area 137
LR24	Grass, shrubs and topography on upper ridge east of TKO Area 137
LR25	Sandy shore south of ridge east of TKO Area 137
LR26	Streams in Tin Ha Au
LR27	Sandy shore off Tin Ha Au
LR28	Coastal water off Tin Ha Au

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Figure 10.6d (REVISION A) Residual Landscape Resource impacts During Operation / Restoration phase

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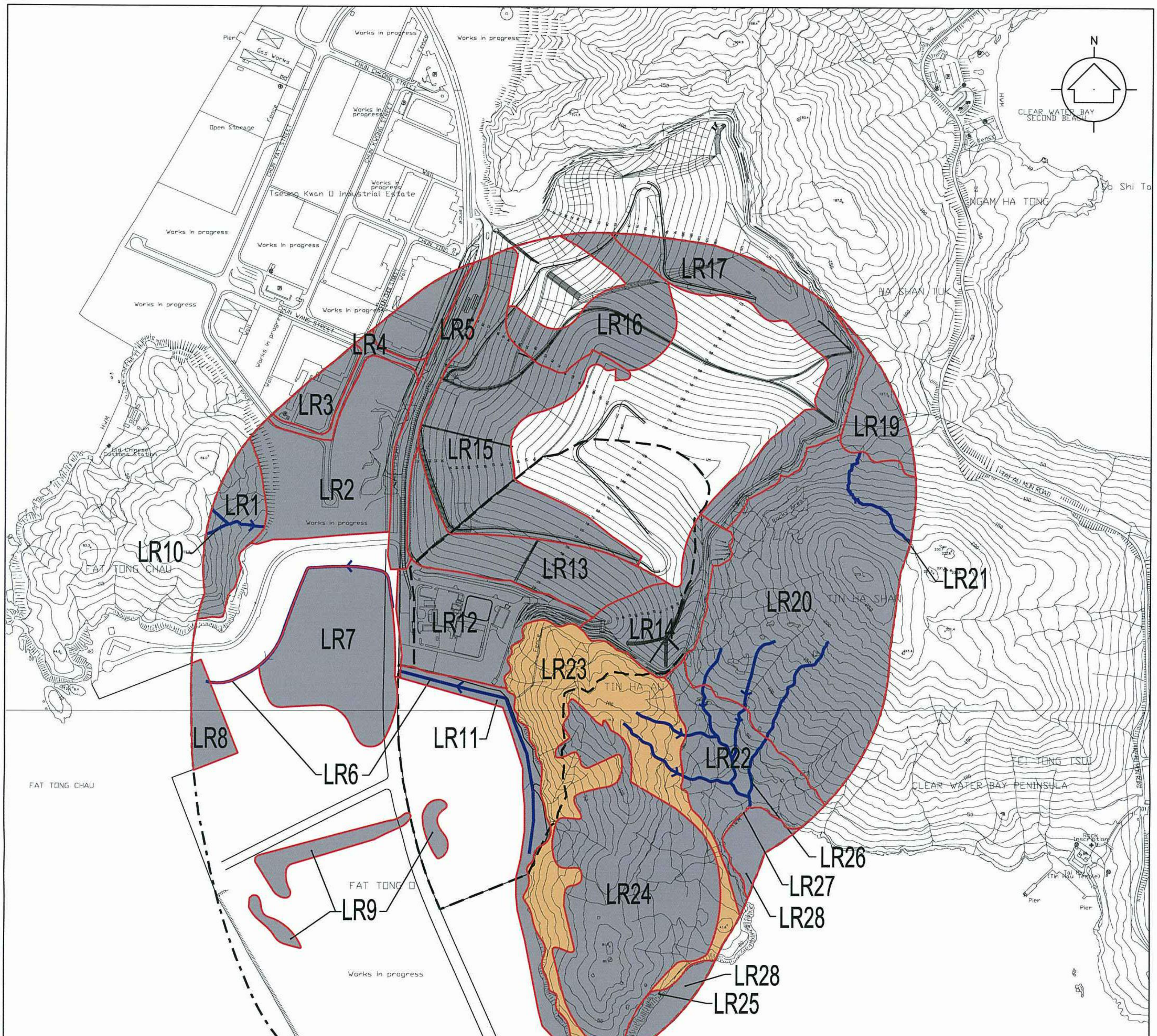

SIGNIFICANCE OF LANDSCAPE IMPACT

- INSUBSTANTIAL
- SLIGHT NEGATIVE
- MODERATE NEGATIVE
- SUBSTANTIAL NEGATIVE

KEY :

- 500m STUDY AREA
- EXTENSION AREA
- LR1 LANDSCAPE RESOURCE

Identity No.	Landscape Resources
LR1	Shrubs and topography on Fat Tong Chau Hillside
LR2	Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate
LR3	Shrubs outside Hong Kong Aircraft Engineering Building, TKO Industrial Estate
LR4	Trees along Chun Wang Street
LR5	Trees along Wan Po Road
LR6	Drainage channel in TKO Area 137
LR7	Trees in northern part of TKO Area 137
LR8	Coastal water east of TKO Area 137
LR9	Scrubs in southern part of TKO Area 137
LR10	Stream on Fat Tong Chau Hillside
LR11	Trees and shrubs along lower hillside of Tin Ha Shan
LR12	Site office area of SENT Landfill
LR13	Plantation and topography in South SENT Landfill
LR14	Plantation and topography in South-East SENT Landfill
LR15	Plantation and topography in West SENT Landfill
LR16	Grassland and topography in SENT Landfill
LR17	Man-made slope with shrubs and grass in SENT Landfill
LR18	Not Used
LR19	Trees, shrubs and topography in Ha Shan Tuk
LR20	Shrubs and topography in Tin Ha Shan
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LR23	Shrubs and topography on lower ridge east of TKO Area 137
LR24	Grass, shrubs and topography on upper ridge east of TKO Area 137
LR25	Sandy shore south of ridge east of TKO Area 137
LR26	Streams in Tin Ha Au
LR27	Sandy shore off Tin Ha Au
LR28	Coastal water off Tin Ha Au

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Figure 10.6e (REVISION A) Residual Landscape Resources Impacts During Aftercare Phase (Year 10)

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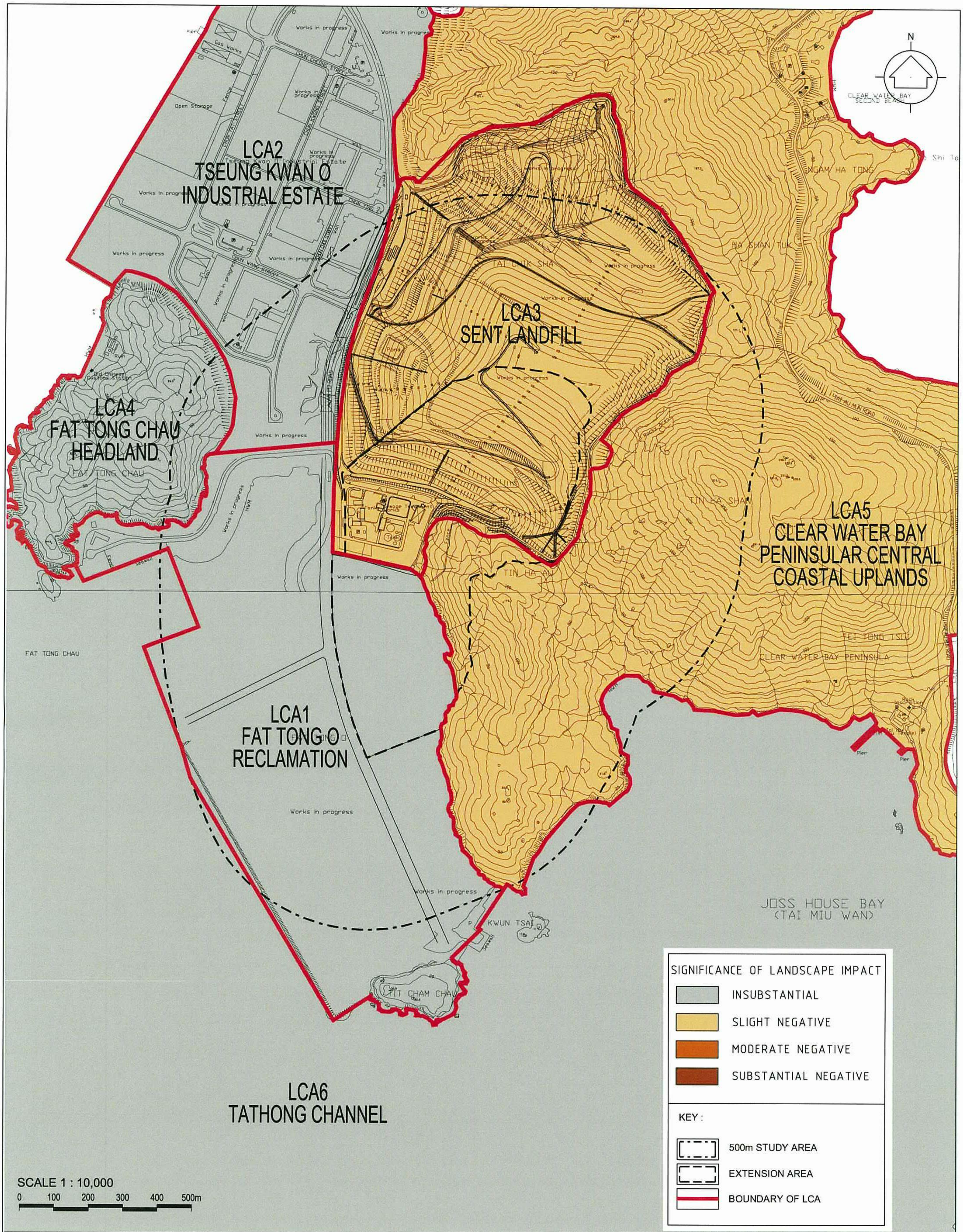

Figure 10.6f Residual Landscape Character Impacts During Construction Phase

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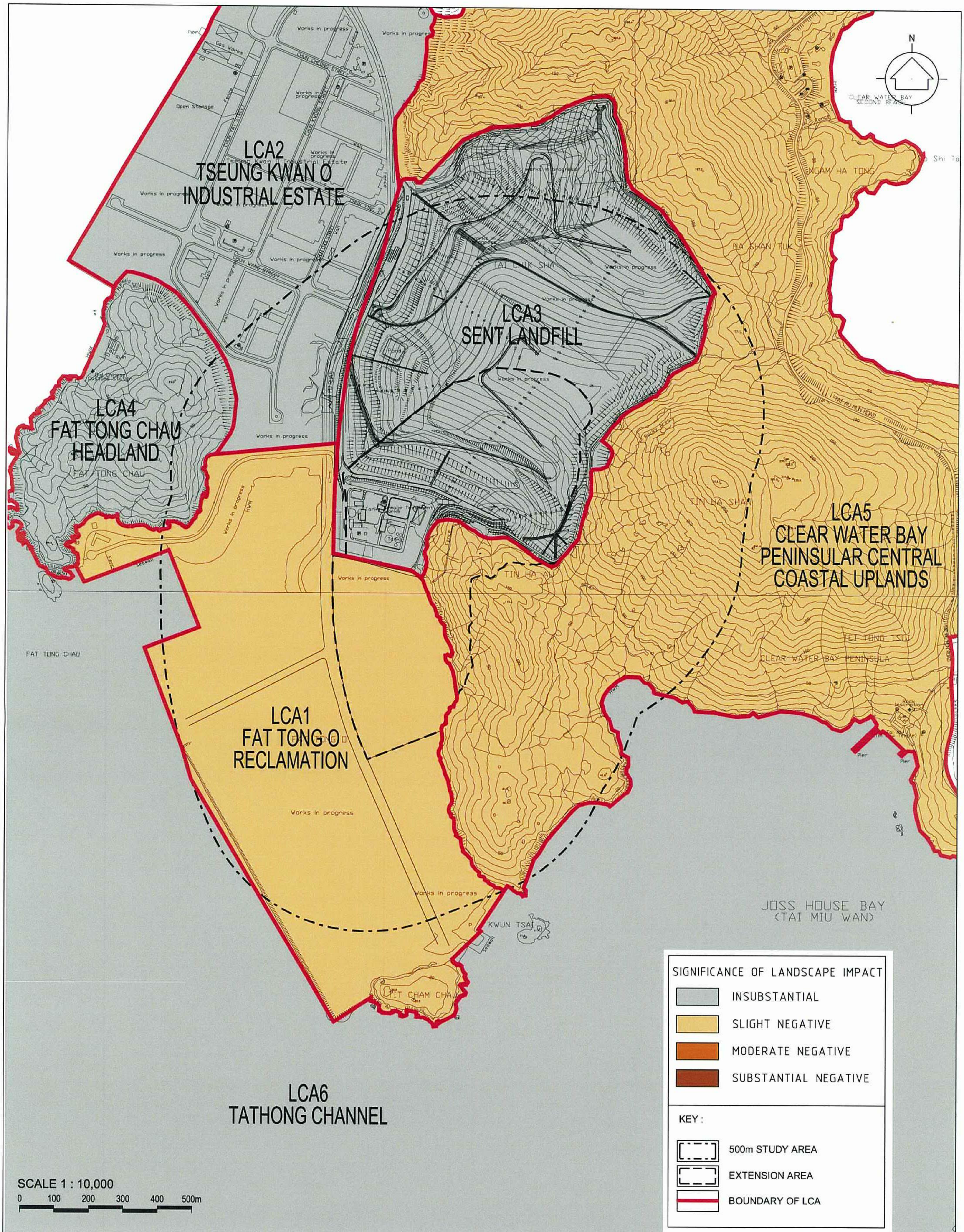

Figure 10.6g Residual Landscape Character Impacts During Operation and Restoration Phases

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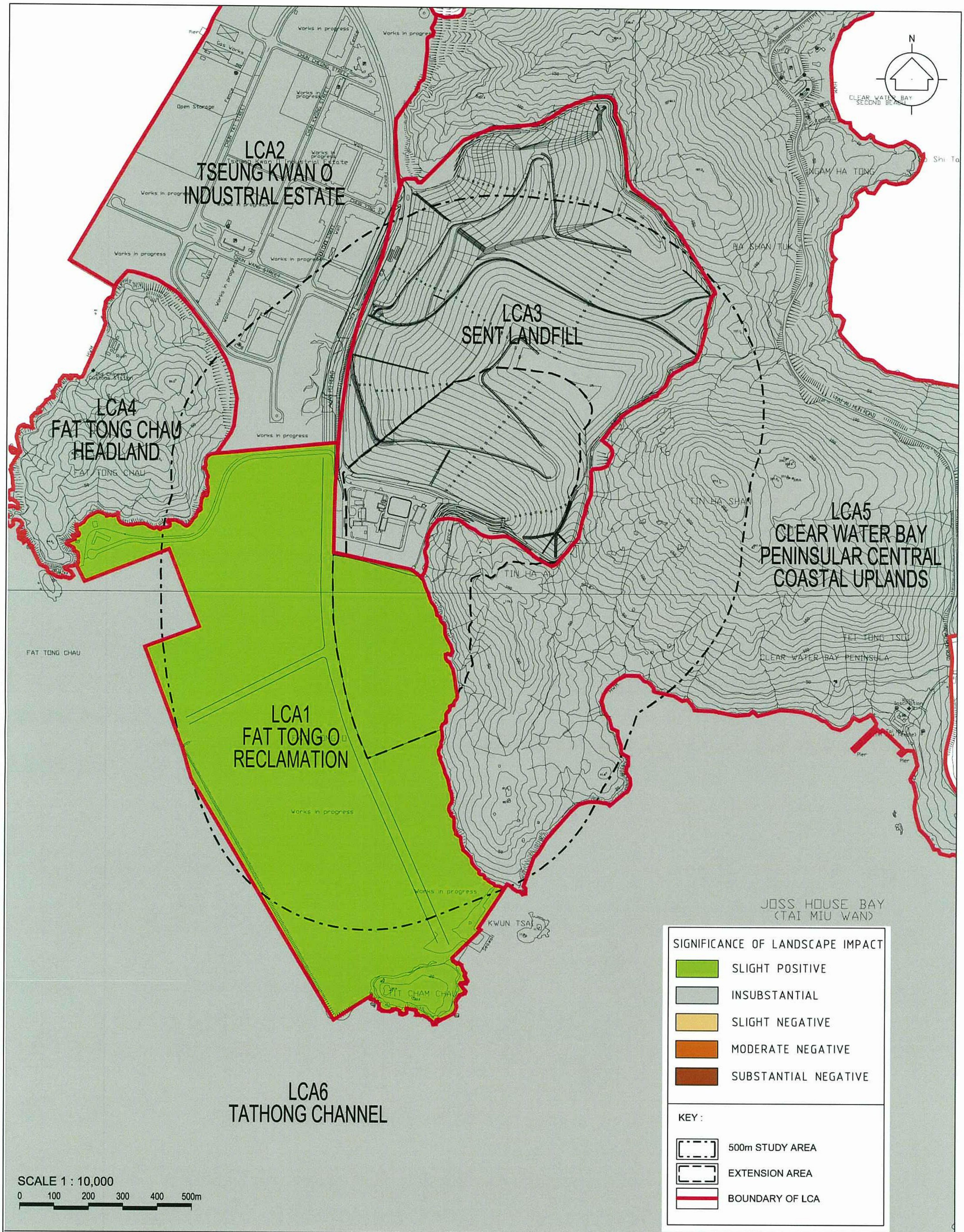

Figure 10.6h Residual Landscape Character Impacts During Aftercare Phase (Year 10)

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LR23 - Shrubs and topography in lower ridge east of TKO Area 137: Re-grading of slopes for the Extension will require the loss / removal of about 6.24 ha of natural lower hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered with a scattering of grass and common native shrub species (eg *Rhaphiolepis indica, Rhodomyrtus tomentosa, Melastoma candidum*). The temporary loss of natural upland topography and native vegetation will constitute a "Substantial" impact during the Construction phase.

Adverse residual landscape impacts of "Moderate" significance will be experienced by the following landscape resources:

LR11 - Trees and shrubs along lower hillside of Tin Ha Shan: Preparation works will require the removal of around 40 semi-mature trees (mainly of *Ficus microcarpa*, *Macaranga tanarius* and *Sapium sebiferum)* currently found on what appears to be re-graded topography. It is unlikely that these trees can be transplanted and resulting temporary impacts during the construction phase will be "Moderate".

LR13 - Plantation and topography in the south of the existing SENT Landfill: Vegetation clearance in preparation for the Extension on the existing SENT Landfill, will require the removal / loss of about 7.50 ha of semi-mature trees comprising (*Acacia confusa, Albizia lebbeck, Ficus fistulosa, Ficus microcarpa*) planted as Phases 1-3 of the restoration of the SENT Landfill. Given the "Large" scale of this impact and the fact that the trees are now semi-mature, temporary impacts during the construction phase before mitigation will be "Substantial". However, as a number of the affected trees will be transplantable, the residual impacts will be reduced to "Moderate" after mitigation.

LR14 – Plantation and topography in the south-east of the existing SENT Landfill: Vegetation clearance in preparation for the Extension on the existing SENT Landfill will require the removal / loss of about 3.63 ha of semi-mature trees comprising *Acacia mangium*, *Acacia auriculiformis*, *Casuarina equisetifolia*, *Hibiscus tiliaceus* and *Macaranga tanarius* planted as Phases 1-6 of the restoration of the SENT Landfill. Given the scale of this impact and the fact that the trees are now semi-mature, temporary impacts during the Construction Phase will be "Moderate".

LR24 - Grass and topography on upper ridge east of TKO Area 137: Re-grading of slopes for the Extension will represent a "Small" change to this resource, involving the loss / removal of about 0.05 ha of natural upper hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered predominantly with grass and also with some scattered shrubs of common native species. Although the sensitivity of this resource is "High", the extent of topography and vegetation affected will be small and resulting temporary impacts during the construction phase after mitigation will therefore be "Moderate".

Adverse residual landscape impacts of "Slight" significance will be experienced by the following landscape resources and character areas:

LR9 - Scrub in southern part of TKO Area 137: Vegetation clearance in preparation for the Extension will require the removal of around 0.56ha of scrub currently self-seeded on the Area 137 reclamation. Given the "Low" sensitivity of this resource and the "Small" magnitude of change, resulting impacts during the construction phase will be "Slight".

LR12 – Infrastructure area of the existing SENT Landfill: Vegetation clearance in preparation for the Extension will require the removal of around 20 mature ornamental trees situated around the landfill offices and laboratories (typically *Ficus microcarpa*, *Hibiscus tiliaceus*, *Ficus virens*, *Melaleuca quinquenervia*.). Given this "Medium" change to this resource of "Medium" sensitivity, temporary impacts during the construction phase before mitigation will therefore be "Moderate". As the number of trees affected will be relatively small and many may be transplantable, resulting temporary impacts after mitigation will be "Slight".

LR15 - Plantation and topography in the west of the existing SENT Landfill: Vegetation clearance in preparation for the Extension, on the existing SENT Landfill, will represent a "Small" change requiring the removal / loss of about 3.57 ha of young trees comprising *Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia* planted mainly as Phase 3 of the restoration of the SENT Landfill, as well as recreated topography. As the vegetation affected will be relatively immature and small in extent, resulting temporary impacts on this resource of "Low" sensitivity during the construction phase will be "Slight".

LCA3 – The existing SENT Landfill: Preparatory works for the Extension of the existing SENT Landfill will include vegetation clearance, stabilisation of slopes and demolition of the infrastructure area. Works will affect approximately one third of the existing SENT Landfill area (29.50 ha) and represent an "Intermediate" change. Given that landfilling works will only just be complete at the existing SENT Landfill (and landscape restoration will not be very mature on some areas of the site at the time of the Extension) additional landfill-related works will not represent a very significant change to this landscape of "Low" sensitivity and resulting temporary impacts during the construction phase will therefore be "Slight".

LCA5 – Clear Water Bay Peninsula Coastal Uplands: Preparatory works for the Extension on the Clear Water Bay Peninsula Coastal Uplands will include vegetation clearance, topsoil removal and the stabilisation of slopes. Works will affect only a small area (6.29 ha) but cleared, engineered slopes will contrast adversely with the muted natural colours, forms and textures of the existing uplands. Resulting temporary impacts on this landscape character of "High" sensitivity will therefore be "Moderate" during the construction phase, but will be reduced to "Slight" after mitigation planting and aesthetic treatment to structures are applied.

Adverse residual landscape impacts of "Insubstantial" significance will be experienced by the following landscape resources and character areas:

LR7 – Trees in Northern TKO Area 137: The construction of an access road and filling operations will be close to the resource, but are unlikely to significantly affect it. The magnitude of this impact will be "Small", resulting in "Slight" impacts before mitigation. Application of protective mitigation measures will reduce residual impacts to "Insubstantial".

LCA1 – Fat Tong O Reclamation: Preparatory works for the Extension on the reclamation will include a small amount of vegetation clearance and the establishment of the office, leachate treatment plant and laboratory. Given the "Low" sensitivity of this landscape, this "Small" magnitude of change would normally result in "Slight" impacts. However, due to ongoing reclamation works in this area and the fact that only the north-east corner of the reclamation will be affected (2.75 ha) the temporary impacts on this landscape during the construction stage will be "Insubstantial".

All other impacts will be of "Insubstantial" significance.

Operation / Restoration Phase

In the operation/restoration phase (which will take place more or less concurrently), after the implementation of the proposed mitigation measures, there will still be some adverse residual landscape impacts as described below.

There will be no adverse residual landscape impacts of "Substantial" significance.

Adverse residual landscape impacts of "Moderate" significance will be experienced by the following landscape resources and character areas:

LR23 - Shrubs and topography in lower ridge east of TKO Area 137: Filling operations for the Extension will require the loss / removal of about 6.24 ha of natural lower hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered with a scattering of grass and common native shrub species (eg *Rhaphiolepis indica, Rhodomyrtus tomentosa, Melastoma candidum*). These works will be accompanied by a phased landscape restoration. The temporary loss of natural upland topography and native vegetation will constitute a "Moderate" impact during the operation/restoration phase.

Adverse residual landscape impacts of "Slight" significance will be experienced by the following landscape resources and character areas:

LR11 - Trees and shrubs along lower hillside of Tin Ha Shan: Filling operations will require the removal of around 40 semi-mature trees (mainly of *Ficus microcarpa*, *Macaranga tanarius* and *Sapium sebiferum)* currently found on what appears to be re-graded topography. These works will be accompanied by a phased landscape restoration. It is unlikely that these trees can be transplanted and resulting temporary impacts during the operation/restoration phase will be "Slight".

LR13 - Plantation and topography in the south of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 7.50 ha of semi-mature trees (comprising *Acacia confusa, Albizia lebbeck, Ficus fistulosa, Ficus microcarpa*) planted as Phases 1-3 of the restoration of the existing SENT Landfill, as well as recreated topography. These works will be accompanied by a phased landscape restoration. Given the "Large" magnitude of this impact on a resource of "Medium" sensitivity and the fact that the trees are now semi-mature, temporary impacts during the operation/restoration phase before mitigation will be "substantial". However, transplanting of trees and other mitigation measures will reduce residual impacts to "Slight".

LR14 – Plantation and topography in the south-east of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.63 ha of semi-mature trees (comprising *Acacia mangium*, *Acacia auriculiformis*, *Casuarina equisetifolia*, *Hibiscus tiliaceus* and *Macaranga tanarius*) planted as Phases 1-6 of the restoration of the existing SENT Landfill, as well as recreated topography. These works will be accompanied by a phased landscape restoration. Given the relatively large scale of this impact and the fact that the trees are now semi-mature, temporary impacts during the operation/restoration phase will be "Slight".

LR24 - Grass and topography on upper ridge east of TKO Area 137: Filling operations for the Extension will require the loss / removal of about 0.05 ha of natural upper hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered predominantly with grass and also with some scattered shrubs of common native species. These works will be accompanied by a phased landscape restoration. Although this is a resource of "High" sensitivity, the change to topography and vegetation will be "Small" and resulting temporary impacts during the operation/restoration phase before mitigation will be "Moderate", reducing to "Slight" after mitigation.

LCA1 – Fat Tong O Reclamation: Works for the Extension on the reclamation will include landfilling (with associated lorry movements) over 6 years, together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares. These works will be accompanied by a phased landscape restoration. As only the north-east corner of the reclamation will be affected (15.64 ha) and given the incoherent landscape character and "Low" sensitivity of the existing reclamation, the Works will represent a "Small decline in character. Resulting temporary impacts during the operation/restoration phase will therefore be "Slight".

LCA5 – Clear Water Bay Peninsula Coastal Uplands: Works for the Extension on the Clear Water Bay Peninsula Coastal Uplands will include landfilling works over 6 years, and final cover grading, together with permanent infrastructure such as drainage channels, gas wells and flares. These works will be accompanied by a phased landscape restoration. Works will affect only a small area (6.29 ha) but the bright colours and artificial textures of waste, construction machinery and engineered slopes will contrast adversely with the muted natural colours and textures of the existing uplands, representing a "Small" change to this landscape. Resulting temporary impacts on landscape character will therefore be "Moderate" before mitigation. However, phased restoration works and aesthetic treatment to structures will reduce residual impacts to "Slight" during the operation/restoration phase.

Adverse residual landscape impacts of "Insubstantial" significance will be experienced by the following landscape resource:

LR7 – Trees in Northern TKO Area 137: The new access road and filling operations will be close to this resource of "Low" sensitivity, but are unlikely to significantly affect it. The magnitude of this impact will therefore be "Small", resulting in "Slight" temporary impacts, reducing to "Insubstantial" after mitigation.

LR9 - Scrub in southern part of TKO Area 137: Filling operations will require the removal of around 0.16 ha of scrub currently self-seeded on the Area 137 reclamation. Given the "Low" sensitivity of this resource and the "Small" magnitude of change, resulting temporary impacts during operation / restoration will be "Slight", reducing to "Insubstantial" after mitigation.

LR12 – Infrastructure area of the existing SENT Landfill: Filling works will require the removal of around 20 mature ornamental trees situated around the Infrastructure area (typically *Ficus microcarpa*, *Hibiscus tiliaceus*, *Ficus virens*, *Melaleuca quinquenervia*). Given this "Small" change to this resource of "Medium" sensitivity, impacts during the operation / restoration phase before mitigation will therefore be "Moderate". As the number of trees affected will be relatively small and many may be transplantable, resulting temporary impacts after mitigation will be "Insubstantial".

LR15 - Plantation and topography in the west of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.57 ha of young trees comprising of *Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia* planted mainly as Phase 3 of the restoration of the SENT Landfill, as well as recreated topography. As the vegetation affected will be relatively immature and small in extent, resulting temporary impacts on this resource of "Low" sensitivity will be "Slight". After mitigation, residual impacts during the operation / restoration phase will be "Insubstantial".

LCA3 – The existing SENT Landfill: Landfilling works (with associated lorry movements) of the Extension for 6 years, together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares. Works will affect approximately one third of the existing SENT Landfill area (29.50 ha) and the magnitude of these impacts on this LCA will be "Intermediate". Given that landfilling works will only just be complete at the existing SENT Landfill (and landscape restoration will not be very mature on some areas of the site at the time of the Extension) additional landfill-related works will not represent a very significant change to this landscape of "Low" sensitivity and resulting temporary impacts during the operation / restoration phase will therefore be "Slight", reducing to "Insubstantial" after mitigation.

All other impacts will be of "Insubstantial" significance.

Aftercare Phase

In the aftercare phase, after the implementation of the proposed mitigation measures, there will still be some adverse residual landscape impacts as described below.

At Day 1 of the aftercare phase, adverse residual landscape impacts of Moderate significance will be experienced by the following landscape resources and character areas:

LR23 - Shrubs and topography in lower ridge east of TKO Area 137: Landscape restoration on former lower hillsides east of the Extension Site, will have the effect of partially compensating for the loss of natural topography, scrub vegetation and topsoils on the south-west tip of the Clearwater Bay Peninsula. At Day 1 of aftercare, these impacts will be "Moderate", but with the maturing of mitigation planting these impacts will be reduced to "Slight" at Year 10 (as the restored landform will be incapable of exactly replicating the former hillside topography).

At Day 1 of aftercare, adverse residual landscape impacts of "Slight" significance will be experienced by the following landscape resources and character areas:

LR11 - Trees and shrubs along lower hillside of Tin Ha Shan: The removal of around 40 semi-mature trees to allow for slope works and filling operation will be mitigated in the final restoration by restored slopes profiles and mitigation planting. The result is that although impacts will be "Slight" at Day 1 of aftercare when vegetation is still young, impacts will be "Insubstantial" at Year 10 when vegetation matures.

LR13 - Plantation and topography in the south of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will represent a "Large" change to this resource, requiring the removal / loss of about 6.03 ha of semi-mature trees as well as recreated topography over a fairly extensive area, thus resulting in "Moderate" impacts before mitigation. The landscape restoration (regrading and replanting) associated with the Extension will mean that at Day 1 of aftercare, landscape impacts will be reduced to "Slight". At Year 10, after this vegetation has a chance to mature, residual impacts will be "Insubstantial".

LR14 – Plantation and topography in the south-east of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.63 ha of semi-mature trees as well as recreated topography over a fairly extensive area. The landscape restoration (re-grading and replanting) associated with the Extension will mean that at Day 1 of aftercare, landscape impacts will be reduced to "Slight". At Year 10, after this vegetation has a chance to mature, residual impacts will be "Insubstantial".

LR24 - Grass and topography on upper ridge east of TKO Area 137: Re-grading of slopes and filling operations for the Extension will require the loss / removal of about 0.05 ha of natural upper hillsides (including topsoils) on the south-west tip of the Clearwater Bay Peninsula, which are covered predominantly with grass and also with some scattered shrubs of common native spaces. The resulting impacts will therefore be "Moderate" before mitigation. However, the extent of topography and vegetation affected will be small and with landscape restoration, landscape impacts at Day 1 of aftercare will be reduced to "Slight". At Year 10, after compensation vegetation has a chance to mature, residual impacts will be "Insubstantial".

LCA5 – Clear Water Bay Peninsula Coastal Uplands: Landfilling operations and landscape restoration will affect only a small area (6.29 ha) of this LCA. Landscape restoration will have the effect of rendering the Extension largely (but not totally) consistent with the surrounding natural upland landscape, interns of colour, form and texture. Impacts on landscape character before mitigation will thus be "Moderate". Immature mitigation planting at Day 1 of aftercare will reduce impacts to "Slight", but the engineered gradients of the restoration will still be visible and will contrast unfavourably with surrounding natural landforms. However, as restoration vegetation matures at Year 10, this will have the effect of obscuring these differences, and given the very limited area of this LCA affected by the Extension, residual impacts on landscape character will be further reduced to "Insubstantial".

There will be "Slight Positive" landscape impacts on the following:

LCA1 – Fat Tong O Reclamation: Given the low sensitivity and ongoing reclamation works in this area, landfilling works together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares will result in "Slight" impacts before mitigation. Final cover grading and landscape restoration works will have the effect of turning what is currently a flat, open, un-vegetated and monotonous reclamation into a more diverse and more natural landscape than at present, with topographic variation and vegetation cover. At Day 1 of aftercare, this effect on landscape character may not be very significant (and resulting impacts on landscape character "Insubstantial") but as vegetation matures at Year 10, there will be "Slight Positive" impacts on existing landscape character.

Adverse residual landscape impacts of "Insubstantial" significance will be experienced by the following landscape resource:

LR7 – Trees in Northern TKO Area 137: The new access road and filling operations will be close to this resource of "Low" sensitivity, but are unlikely to significantly affect it. The magnitude of this impact will therefore be "Small", resulting in "Slight" impacts before mitigation. Landscape restoration and mitigation planting will reduce residual impacts to "Insubstantial" at Day 1 and at Year 10 of aftercare.

LR9 - Scrub in southern part of TKO Area 137: Filling operations will require the removal of around 0.16 ha of scrub currently self-seeded on the Area 137 reclamation. Given the "Low" sensitivity of this resource and the "Small" magnitude of change, resulting impacts during the aftercare phase will be "Slight" before mitigation. Final cover grading and landscape restoration will reduce residual impacts to "Insubstantial" at Day 1 and at Year 10 of aftercare.

LR12 – Infrastructure area of the existing SENT Landfill: Filling works will require the removal of around 20 mature ornamental trees situated around the Infrastructure area (typically *Ficus microcarpa*, *Hibiscus tiliaceus*, *Ficus virens*, *Melaleuca quinquenervia*). Given this "Small" change to this resource of "Medium" sensitivity, impacts during the aftercare phase before mitigation will therefore be "Moderate". As the number of trees affected will be relatively small and many may be transplantable, residual impacts after mitigation will be "Insubstantial" at Day 1 and at Year 10 of aftercare.

LR15 - Plantation and topography in the west of the existing SENT Landfill: Filling operations for the Extension on the existing SENT Landfill, will require the removal / loss of about 3.57 ha of young trees comprising of *Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia* planted mainly as Phase 3 of the restoration of the SENT Landfill, as well as recreated topography. As the vegetation affected will be relatively immature and small in extent, resulting temporary impacts on this resource of "Low" sensitivity will be "Slight". Final cover grading and landscape restoration works will reduce residual impacts during the aftercare phase to "Insubstantial" at Day 1 and at Year 10.

LCA3 – The existing SENT Landfill: Landfilling works (with associated lorry movements) of the Extension for 6 years, together with temporary and final cover grading, and permanent infrastructure such as drainage channels, gas wells and flares. Works will affect approximately one third of the existing SENT Landfill area (29.50 ha) and the magnitude of these impacts on this LCA will be "Intermediate". The new topography will not represent a very significant change to this landscape of "Low" sensitivity and resulting impacts will therefore be "Slight". Final cover grading and landscape restoration works will reduce residual impacts during the aftercare phase to "Insubstantial" at Day 1 and at Year 10.

All other impacts will be of "Insubstantial" significance.

Table 10.6d Significance of Landscape Impacts in Construction, Operation / Restoration and Aftercare Phases (Adverse Impacts unless otherwise stated)

ID No.	Landscape Resource / Landscape Character	Sensitivity to Change (Low, Medium, High)	Magnitude of Change BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
										Construction	Operation / Restoration	Aftercare	
			Construction	Operation / Restoration	Aftercare	Construction	Operation / Restoration	Aftercare				DAY 1	YEAR 10
Part 1 – Physical Landscape Resources (Topography, Vegetation, Soil, Open Space, Special Features, etc)													
LR1	Shrubs and topography on Fat Tong Chau Hillside	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR2	Trees and shrubs in TVB City of Tseung Kwan O Industrial Estate	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR3	Shrubs in Hong Kong Aircraft Engineering building, TKOIE	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR4	Trees along Chun Wang Street	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR5	Trees along Wan Po Road	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR6	Drainage channel in TKO Area 137	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR7	Trees in northern part of TKO Area 137	Low	Small	Small	Small	Slight	Slight	Slight	CM1-CM4; CM8; AM1-4; AM6.	Insubstantial	Insubstantial	Insubstantial	Insubstantial

ID No.	Landscape Resource / Landscape Character	Sensitivity to Change (Low, Medium, High)	Magnitude of Change BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
										Construction	Operation / Restoration	Aftercare	
			Construction	Operation / Restoration	Aftercare	Construction	Operation / Restoration	Aftercare				DAY 1	YEAR 10
LR8	Coastal water east of TKO Area 137	Medium	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR9	Scrub in southern part of TKO Area 137	Low	Small	Small	Small	Slight	Slight	Slight	CM1-CM4; CM8; AM1-4; AM6.	Slight	Insubstantial	Insubstantial	Insubstantial
LR10	Stream at Fat Tong Chau Hillside	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR11	Trees and shrubs along lower hillside of Tin Ha Shan	Medium	Intermediate	Intermediate	Intermediate	Moderate	Moderate	Moderate	CM1-CM4; CM8; AM1-4; AM6.	Moderate	Slight	Slight	Insubstantial
LR12	Site office area of SENT Landfill	Medium	Small	Small	Small	Moderate	Moderate	Moderate	CM1-CM4; CM8; AM1-4; AM6.	Slight	Insubstantial	Insubstantial	Insubstantial
LR13	Plantation and topography in south SENT Landfill	Medium	Large	Large	Large	Substantial	Substantial	Substantial	CM1-CM4; CM8; AM1-4; AM6.	Moderate	Slight	Slight	Insubstantial
LR14	Plantation and topography in south-east SENT Landfill	Medium	Intermediate	Intermediate	Intermediate	Moderate	Moderate	Moderate	CM1-CM4; CM8; AM1-4; AM6.	Moderate	Slight	Slight	Insubstantial
LR15	Plantation and topography in west SENT Landfill	Low	Small	Small	Small	Slight	Slight	Slight	CM1-CM4; CM8; AM1-4; AM6.	Slight	Insubstantial	Insubstantial	Insubstantial

ID No.	Landscape Resource / Landscape Character	Sensitivity to Change (Low, Medium, High)	Magnitude of Change BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
										Construction	Operation / Restoration	Aftercare	
			Construction	Operation / Restoration	Aftercare	Construction	Operation / Restoration	Aftercare				DAY 1	YEAR 10
LR16	Grassland and topography in SENT Landfill	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR17	Man-made slope with shrubs and grass in SENT Landfill	Low	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR18	NOT USED												
LR19	Trees, shrubs and topography in Ha Shan Tuk	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR20	Shrubs and topography in Tin Ha Shan	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR21	Streams in Tin Ha Shan	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR22	Trees, shrubs and topography in Tin Ha Au	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR23	Shrubs and topography in lower ridge east of TKO Area 137	High	Large	Large	Large	Substantial	Substantial	Substantial	CM1-CM4; CM8; AM1-4; AM6.	Substantial	Moderate	Moderate	Slight

ID No.	Landscape Resource / Landscape Character	Sensitivity to Change (Low, Medium, High)	Magnitude of Change BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
										Construction	Operation / Restoration	Aftercare	
			Construction	Operation / Restoration	Aftercare	Construction	Operation / Restoration	Aftercare				DAY 1	YEAR 10
LR24	Grass, shrubs and topography in upper ridge east of TKO Area 137	High	Small	Small	Small	Moderate	Moderate	Moderate	CM1-CM4; CM8; AM1-4; AM6.	Moderate	Slight	Slight	Insubstantial
LR25	Sandy shore south of ridge east of TKO Area 137	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR26	Streams in Tin Ha Au	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR27	Sandy shore off Tin Ha Au	High	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LR28	Coastal water off Tin Ha Au	Medium	None	None	None	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
Part 2 – Landscape Character Areas													
LCA1	Fat Tong O Reclamation	Low	Small	Intermediate	Intermediate	Insubstantial	Slight	Slight	CM1; CM6; CM7; OM1-4; AM1; AM2; AM4; AM7	Insubstantial	Slight	Insubstantial	Slight Positive
LCA2	Tseung Kwan O Industrial Estate	Medium	Negligible	Negligible	Negligible	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial
LCA3	SENT Landfill	Low	Intermediate	Intermediate	Intermediate	Slight	Slight	Slight	CM1; CM6; CM7; OM1-4; AM1; AM2; AM4; AM7	Slight	Insubstantial	Insubstantial	Insubstantial
LCA4	Fat Tong Chau Headland	High	Negligible	Negligible	Negligible	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial

ID No.	Landscape Resource / Landscape Character	Sensitivity to Change (Low, Medium, High)	Magnitude of Change BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
										Construction	Operation / Restoration	Aftercare	
			Construction	Operation / Restoration	Aftercare	Construction	Operation / Restoration	Aftercare				DAY 1	YEAR 10
LCA5	Clear Water Bay Peninsular Coastal Uplands	High	Small	Small	Small	Moderate	Moderate	Moderate	CM1; CM6; CM7; OM1-4; AM1; AM2; AM4; AM7	Slight	Slight	Slight	Insubstantial
LCA6	Tathong Channel	High	Negligible	Negligible	Negligible	Insubstantial	Insubstantial	Insubstantial	None	Insubstantial	Insubstantial	Insubstantial	Insubstantial

10.7 VISUAL IMPACT ASSESSMENT

10.7.1 *Potential Sources of Visual Impacts*

The sources of visual impact will be those identified above.

10.7.2 *Visual Mitigation Measures*

The proposed landscape and visual mitigation measures for impacts caused during the construction, operation / restoration and aftercare phases are described in *Tables 10.6a* to *10.6c,* together with the associated funding, implementation, management and maintenance agencies, and the proposed implementation programme. The mitigation measures are illustrated in *Figures 10.6a* and *10.6b*. Various views experienced by VSRs are illustrated in *Figures 10.7a* to *10.7d* and *Figures 10.6i* to *10.6p*.

10.7.3 *Prediction of Significance of Visual Impacts*

An assessment of the potential significance of the visual impacts during the construction, operation / restoration and aftercare phases, before and after mitigation, is listed in detail in *Table 10.7a*. Residual impacts are described below. This follows the methodology outlined above and assumes that the appropriate mitigation measures identified in *Tables 10.6a* to *10.6c* would be implemented, and that the full effect of the soft landscape mitigation measures would be realised after ten years of Aftercare. Photomontages of the proposed development before and after mitigation are illustrated in *Figures 10.6i* to *10.6p* inclusive.

Construction Phase

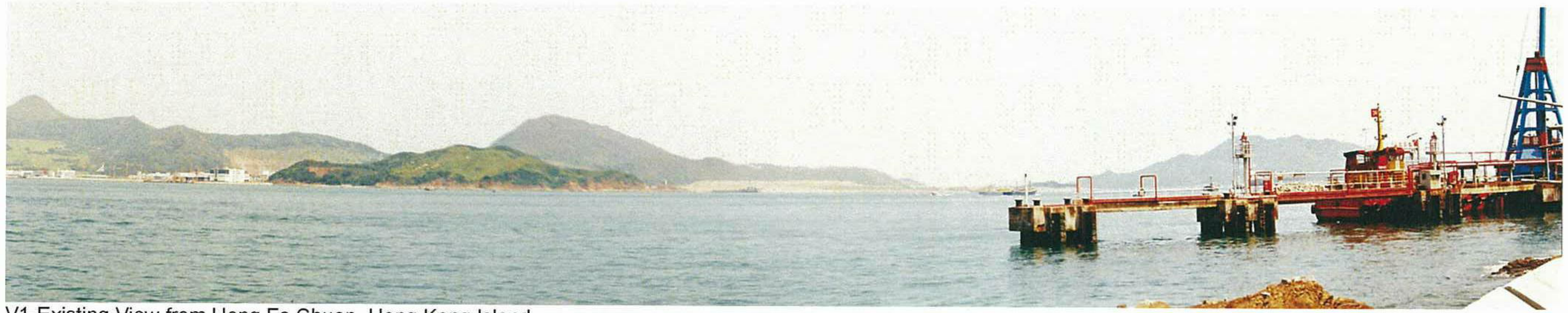
Residual visual impacts in the Construction Phase are mapped in *Figure 10.7e*.

<u>*VSRs North of Extension Site*</u>

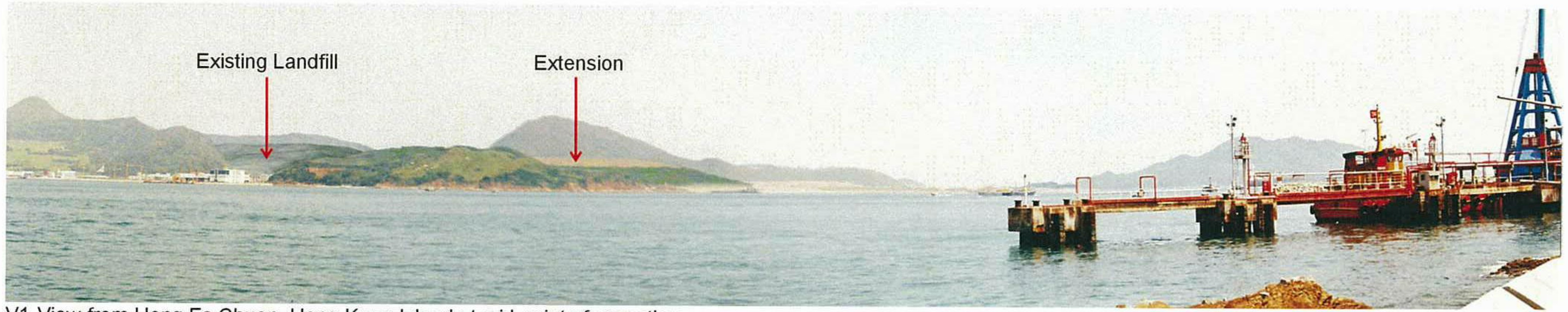
Adverse residual visual impacts of "Slight" significance will be experienced by:

- Hikers on the High Junk Peak Trail (R2) will have close range views (less than 250m) of the Extension, in which earthworks, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape (see *Figure 10.6l*). The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, the industrial character of the landscape of the TKOIE and Area 137, which forms the middle distance of these views, as well as the limited numbers of these VSRs in comparison with other VSR groups. Impacts will also be mitigated to a certain extent by advance screen planting along the trail. This will constitute a "Slight" level of visual impact on these VSRs.

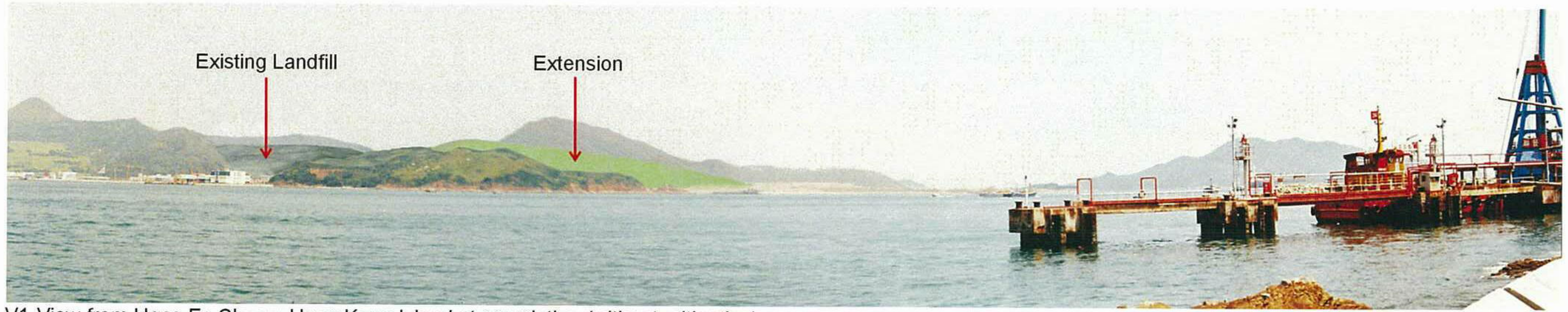
- Residential VSRs in the future Pak Shing Kok development (H1); Future Residents in Phase 2 of TKO new town (H2) and Future Residents in the



V1-Existing View from Heng Fa Chuen, Hong Kong Island



V1-View from Heng Fa Chuen, Hong Kong Island at mid-point of operation



V1-View from Heng Fa Chuen, Hong Kong Island at completion (without mitigation)

V1-View from Heng Fa Chuen, Hong Kong Island at Year 10 after full restoration

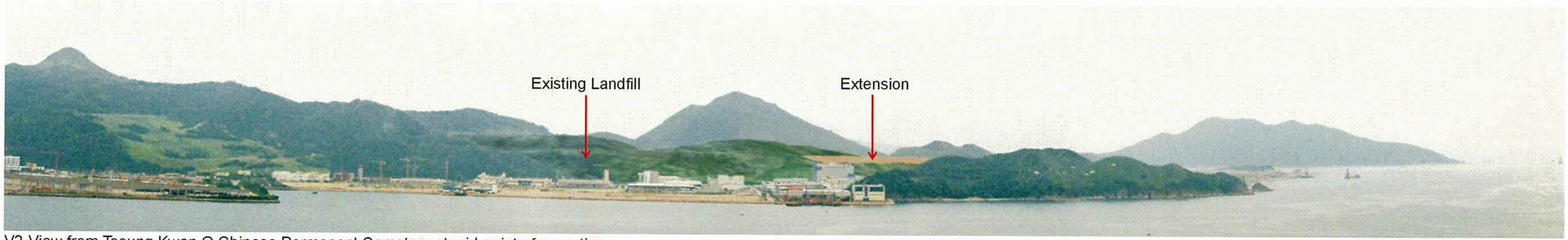
Figure 10.6i

Photomontage View of Extension (Sheet 1 of 8)

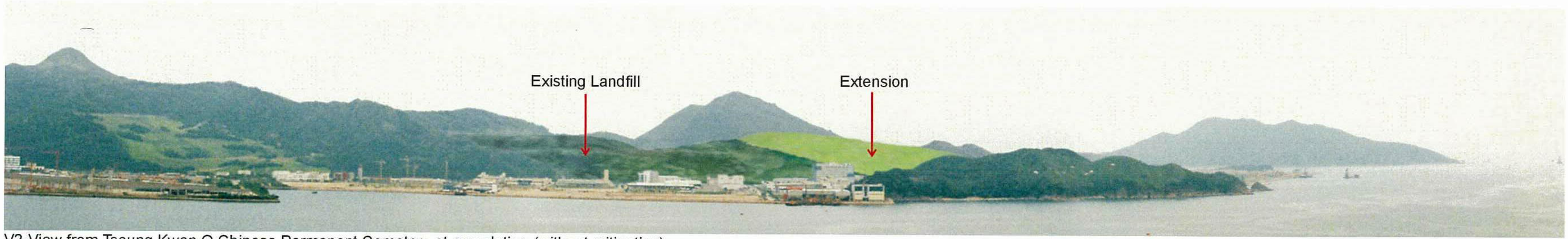
Environmental Resources Management

ERM

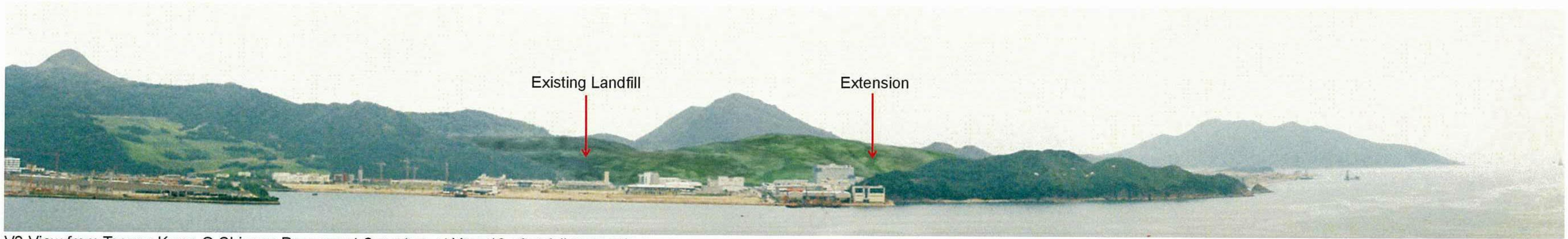
V2-Existing View from Tseung Kwan O Chinese Permanent Cemetery



V2-View from Tseung Kwan O Chinese Permanent Cemetery at mid-point of operation



V2-View from Tseung Kwan O Chinese Permanent Cemetery at completion (without mitigation)



V2-View from Tseung Kwan O Chinese Permanent Cemetery at Year 10 after full restoration

Figure 10.6j

Photomontage View of Extension (Sheet 2 of 8)

Environmental Resources Management

ERM

V3-Existing View from Ocean Shores, Tseung Kwan O

V3-View from Ocean Shores, Tseung Kwan O at mid-point of operation

V3-View from Ocean Shores, Tseung Kwan O at completion (without mitigation)

V3-View from Ocean Shores, Tseung Kwan O at Year 10 after full restoration

Figure 10.6k

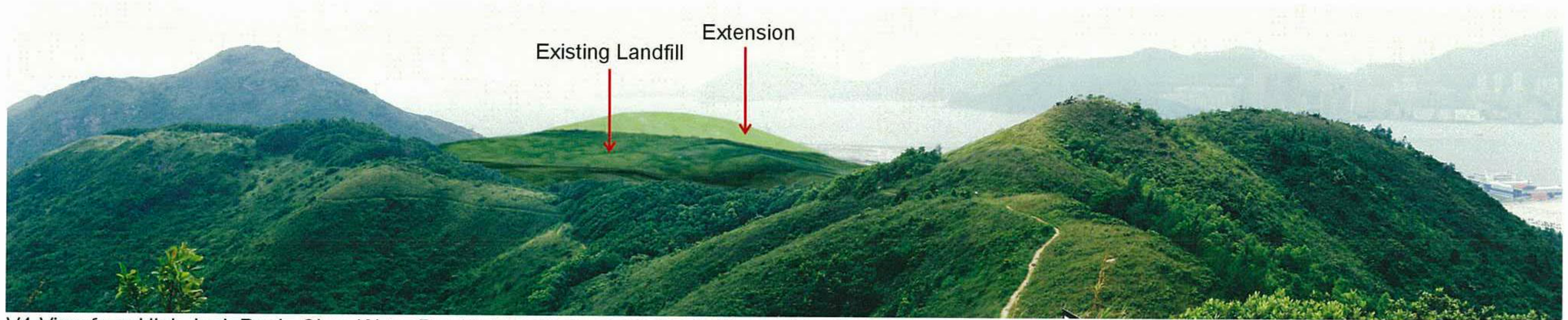
Photomontage View of Extension (Sheet 3 of 8)

Environmental Resources Management

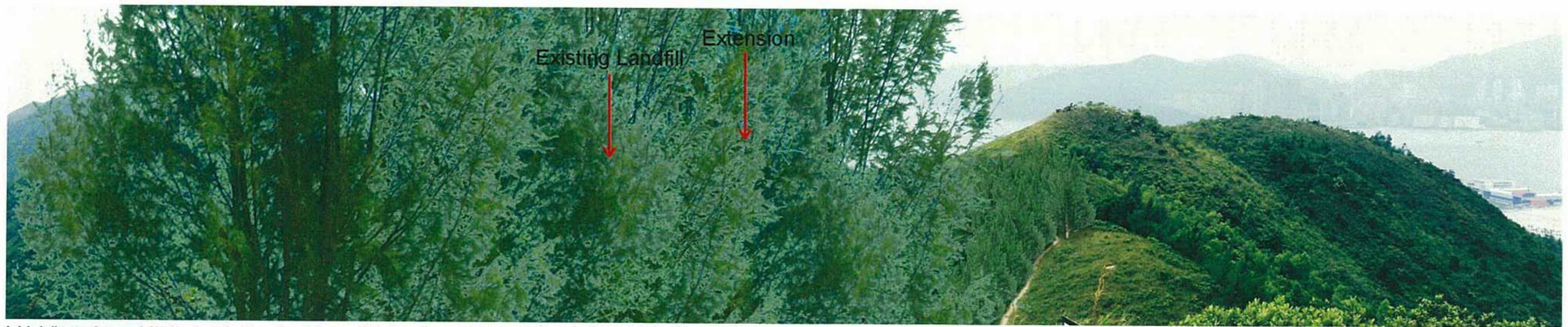
ERM

V4-Existing View from High Junk Peak, Clear Water Bay Peninsula

V4-View from High Junk Peak, Clear Water Bay Peninsula at mid-point of operation



V4-View from High Junk Peak, Clear Water Bay Peninsula at completion (without mitigation)



V4-View from High Junk Peak, Clear Water Bay Peninsula at Year 10 after full restoration

Figure 10.6l

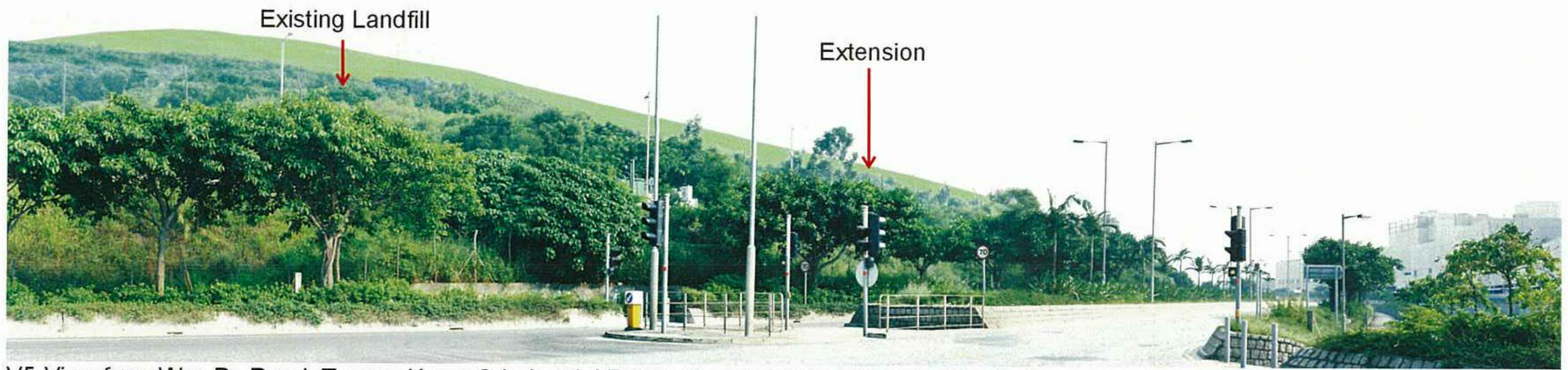
Photomontage View of Extension (Sheet 4 of 8)

Environmental Resources Management

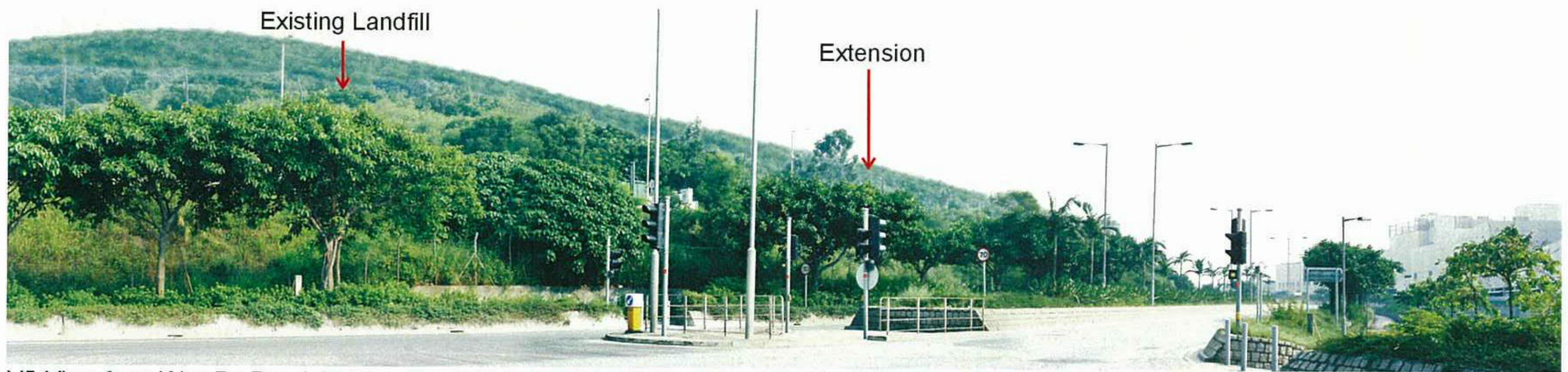
ERM

V5-Existing View from Wan Po Road, Tseung Kwan O Industrial Estate

V5-View from Wan Po Road, Tseung Kwan O Industrial Estate at mid-point of operation



V5-View from Wan Po Road, Tseung Kwan O Industrial Estate at completion (without mitigation)



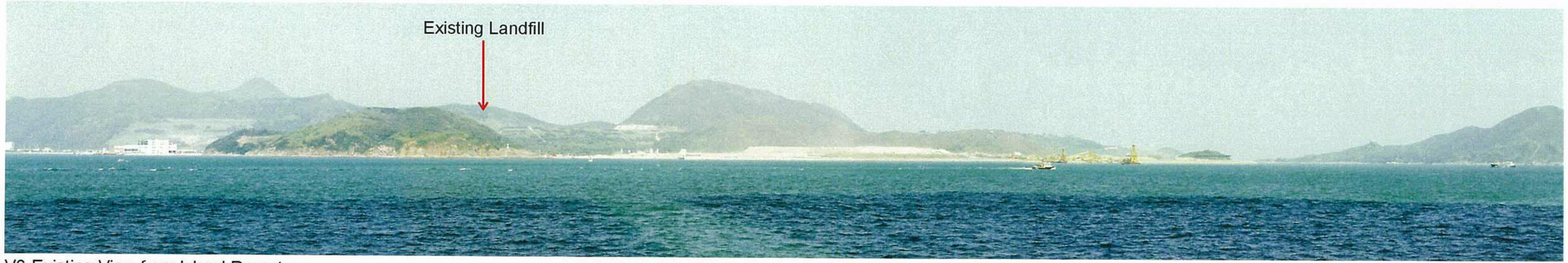
V5-View from Wan Po Road, Tseung Kwan O Industrial Estate at Year 10 after full restoration

Figure 10.6m

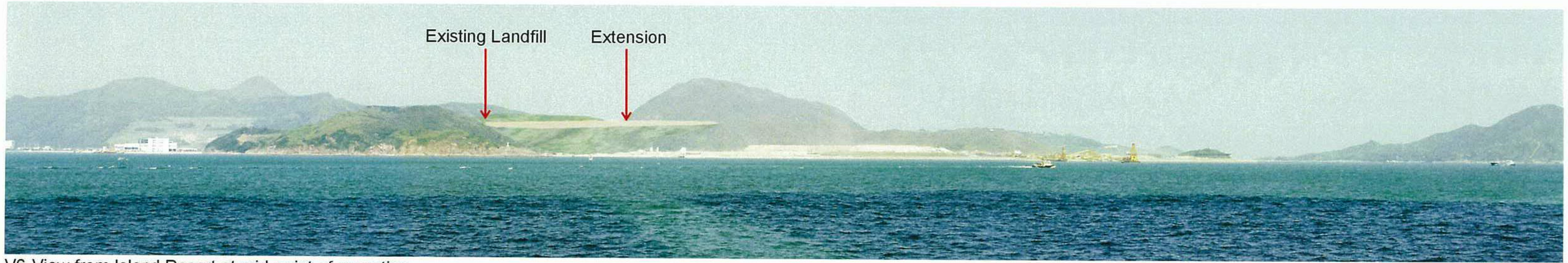
Photomontage View of Extension (Sheet 5 of 8)

Environmental Resources Management

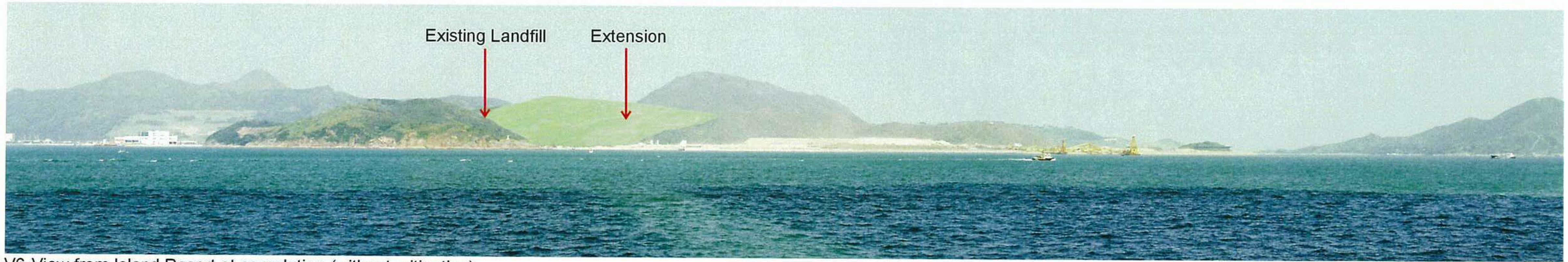
ERM



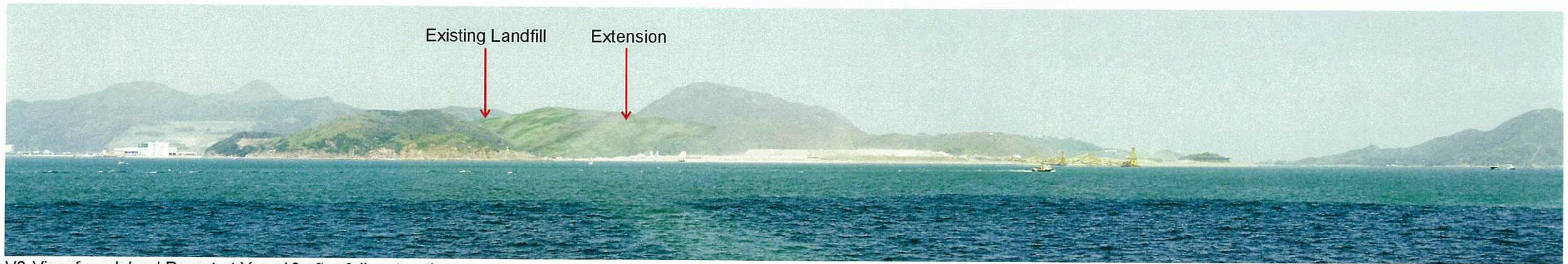
V6-Existing View from Island Resort



V6-View from Island Resort at mid-point of operation



V6-View from Island Resort at completion (without mitigation)



V6-View from Island Resort at Year 10 after full restoration

Figure 10.6n

Photomontage View of Extension (Sheet 6 of 8)

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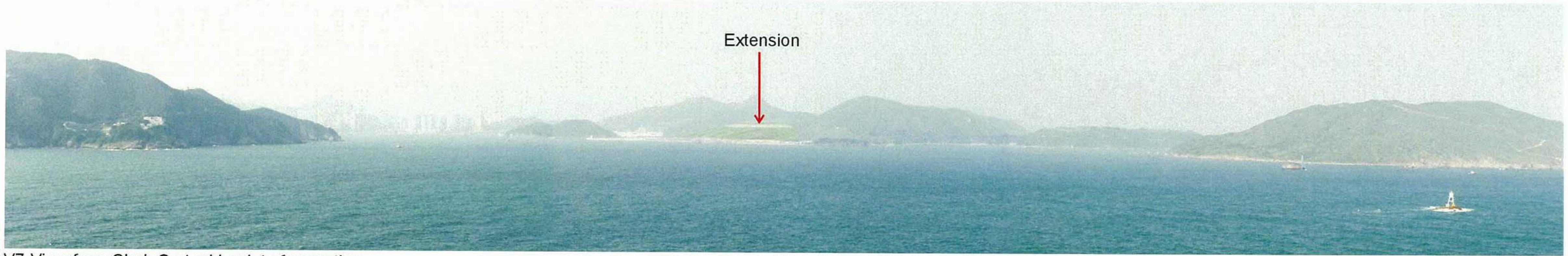
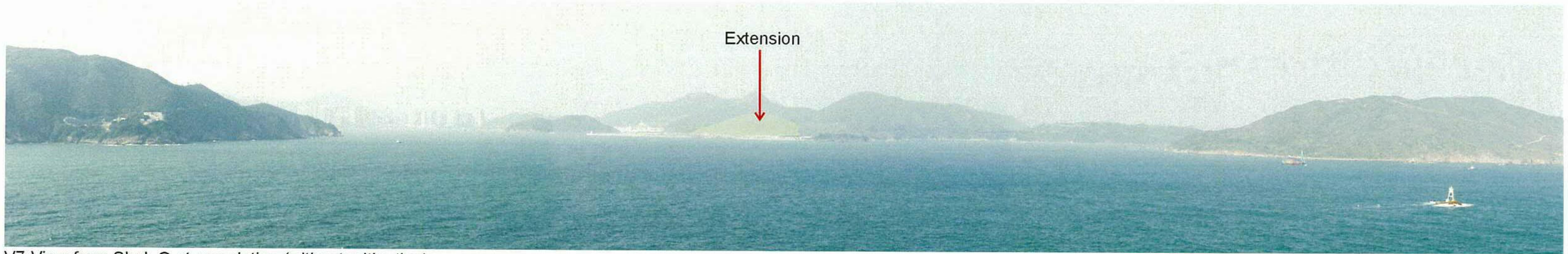
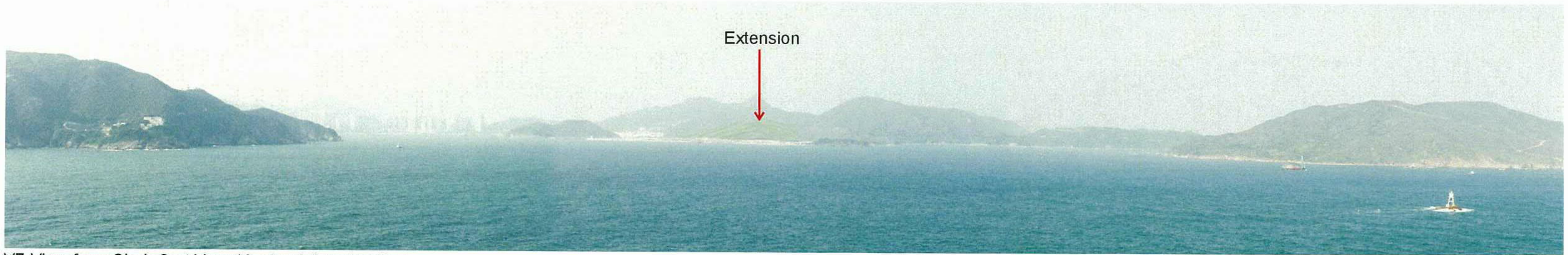
V7-Existing View from Shek O



V7-View from Shek O at mid-point of operation



V7-View from Shek O at completion (without mitigation)



V7-View from Shek O at Year 10 after full restoration

NOTE: EXISTING LANDFILL NOT VISIBLE

Figure 10.6o

Photomontage View of Extension (Sheet 7 of 8)

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V8-Existing View from Tseung Kwan O Area 86

V8-View from Tseung Kwan O Area 86 at mid-point of operation

V8-View from Tseung Kwan O Area 86 at completion (without mitigation)

V8-View from Tseung Kwan O Area 86 at Year 10 after full restoration

Figure 10.6p

Photomontage View of Extension (Sheet 8 of 8)

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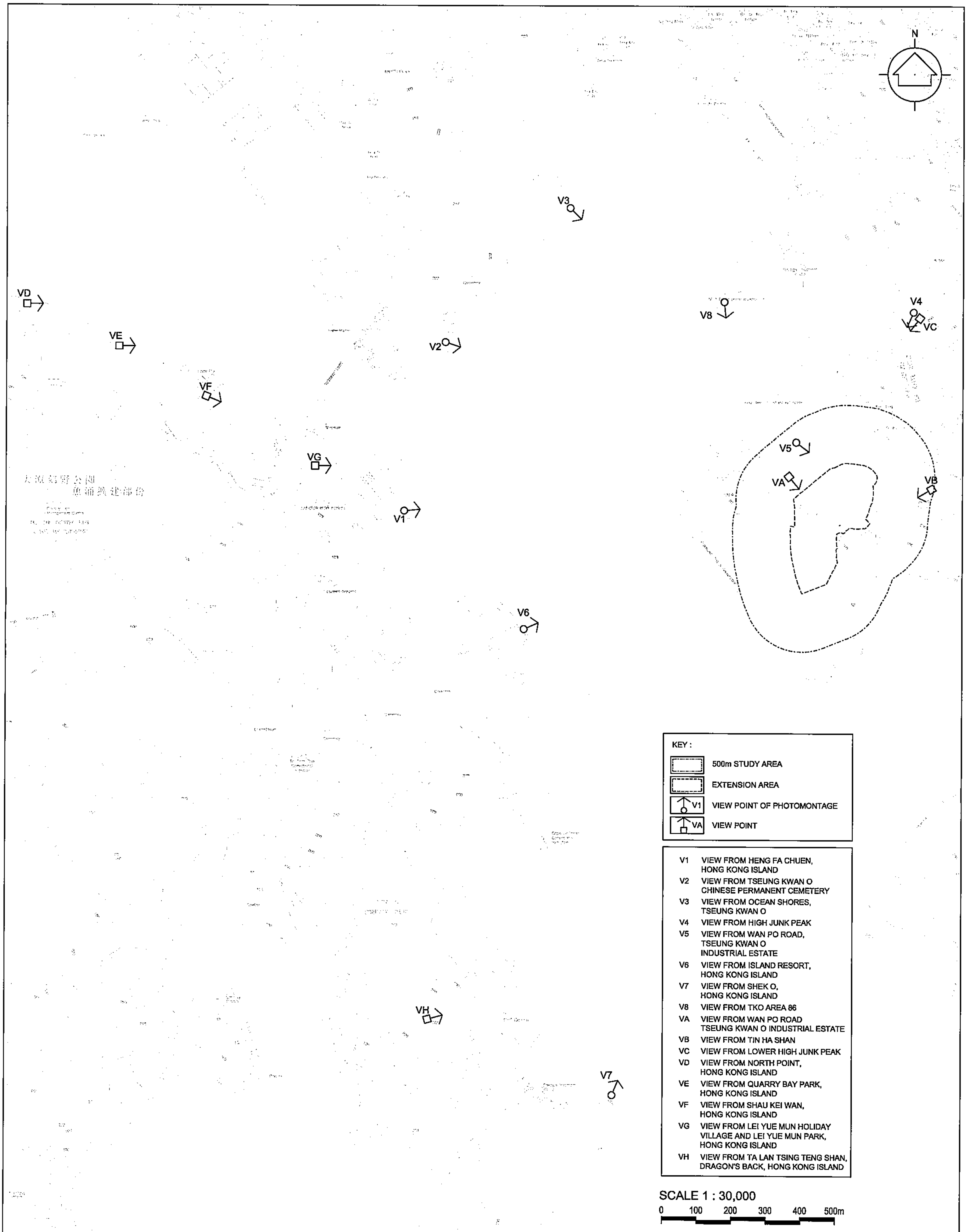

Figure 10.7a

Locations of Key Views and Photomontage Views

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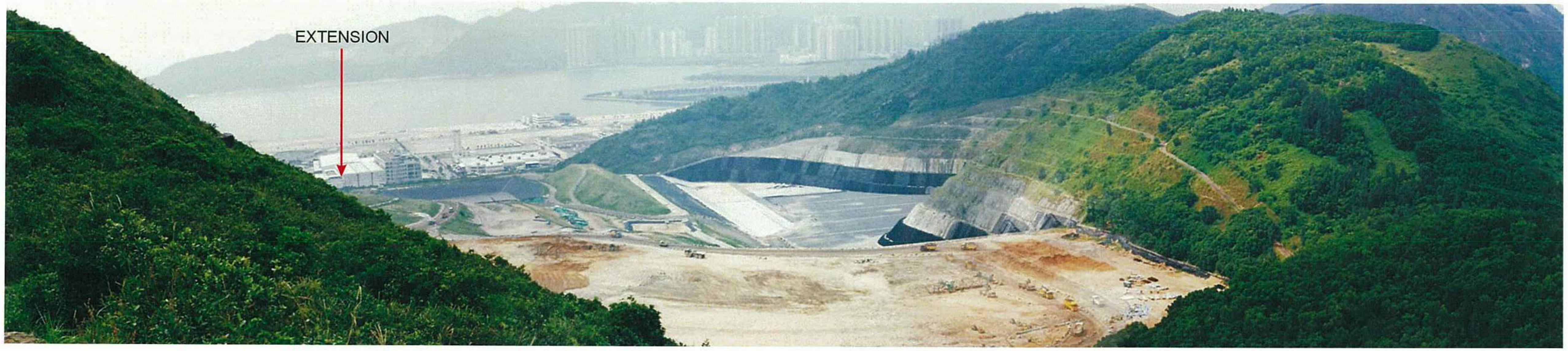
VA-View of Extension from Wan Po Road, Tseung Kwan O Industrial Estate



VB-View of Extension from Tin Ha Shan

VC-View of Extension from lower High Junk Peak

Figure 10.7b

Key Views of Extension (Sheet 1 of 3)

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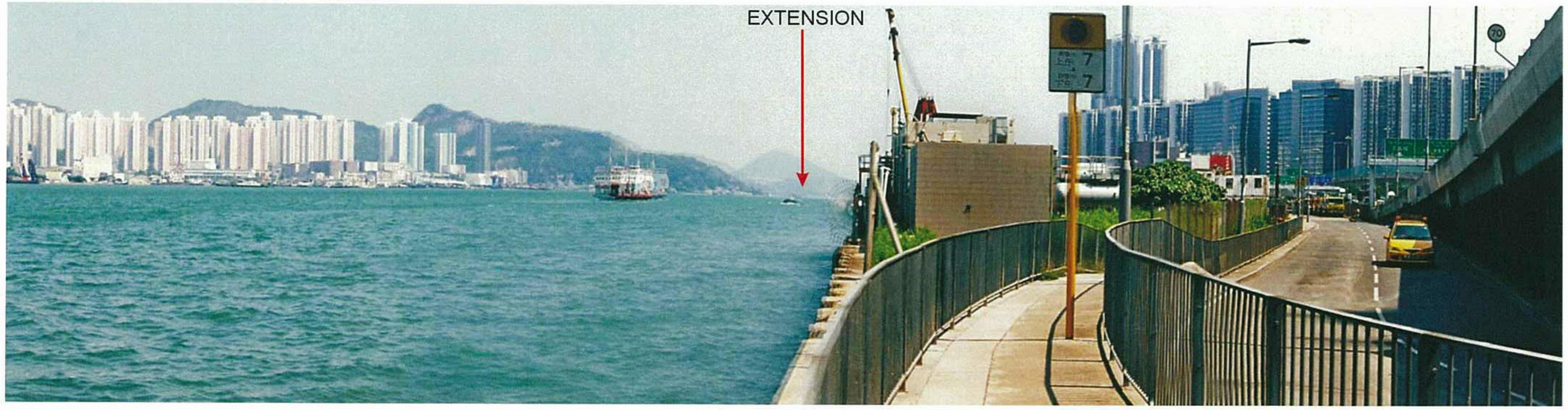
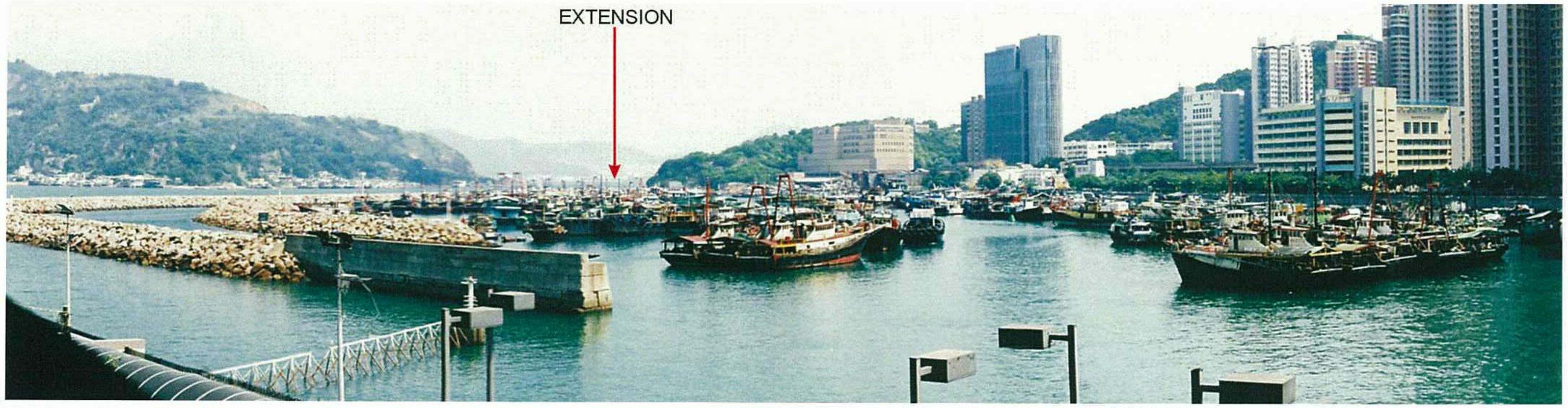


VD-View of Extension from North Point, Hong Kong Island

VE-View of Extension from Quarry Bay Park, Hong Kong Island



VF-View of Extension from Shau Kei Wan, Hong Kong Island

Figure 10.7c

Key Views of Extension (Sheet 2 of 3)

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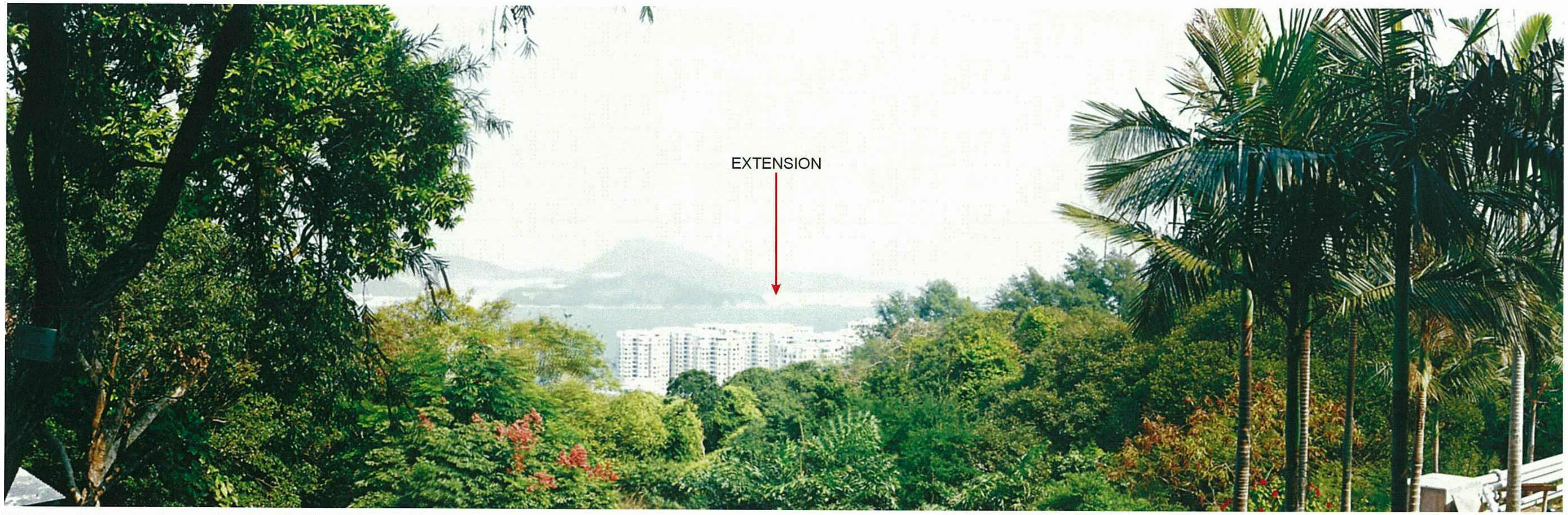
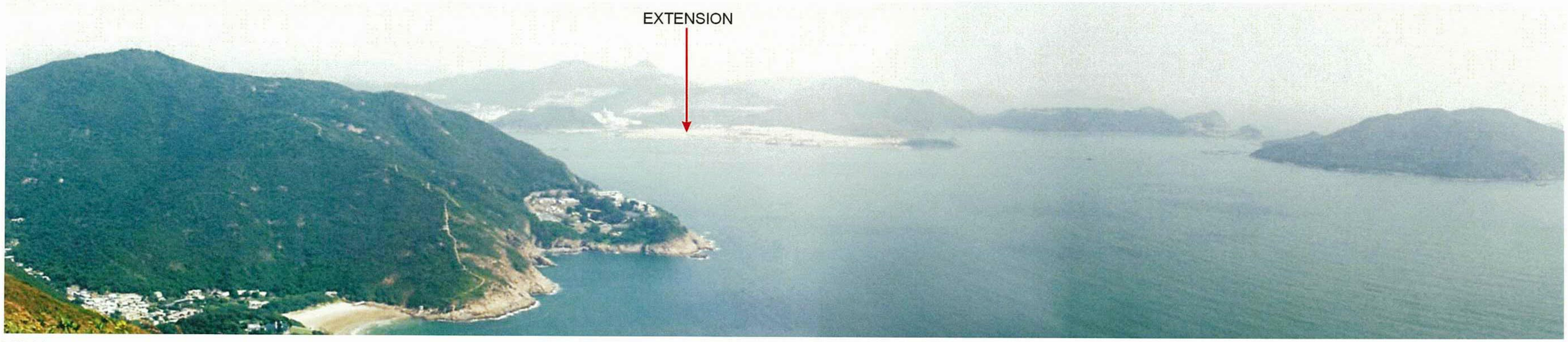


VG-View of Extension from Lei Yue Mun Holiday Village and Lei Yue Mun Park, Hong Kong Island



VH- View of Extension from Ta Lan Tsing Teng Shan, Dragon's Back, Hong Kong Island

Figure 10.7d

Key Views of Extension (Sheet 3 of 3)

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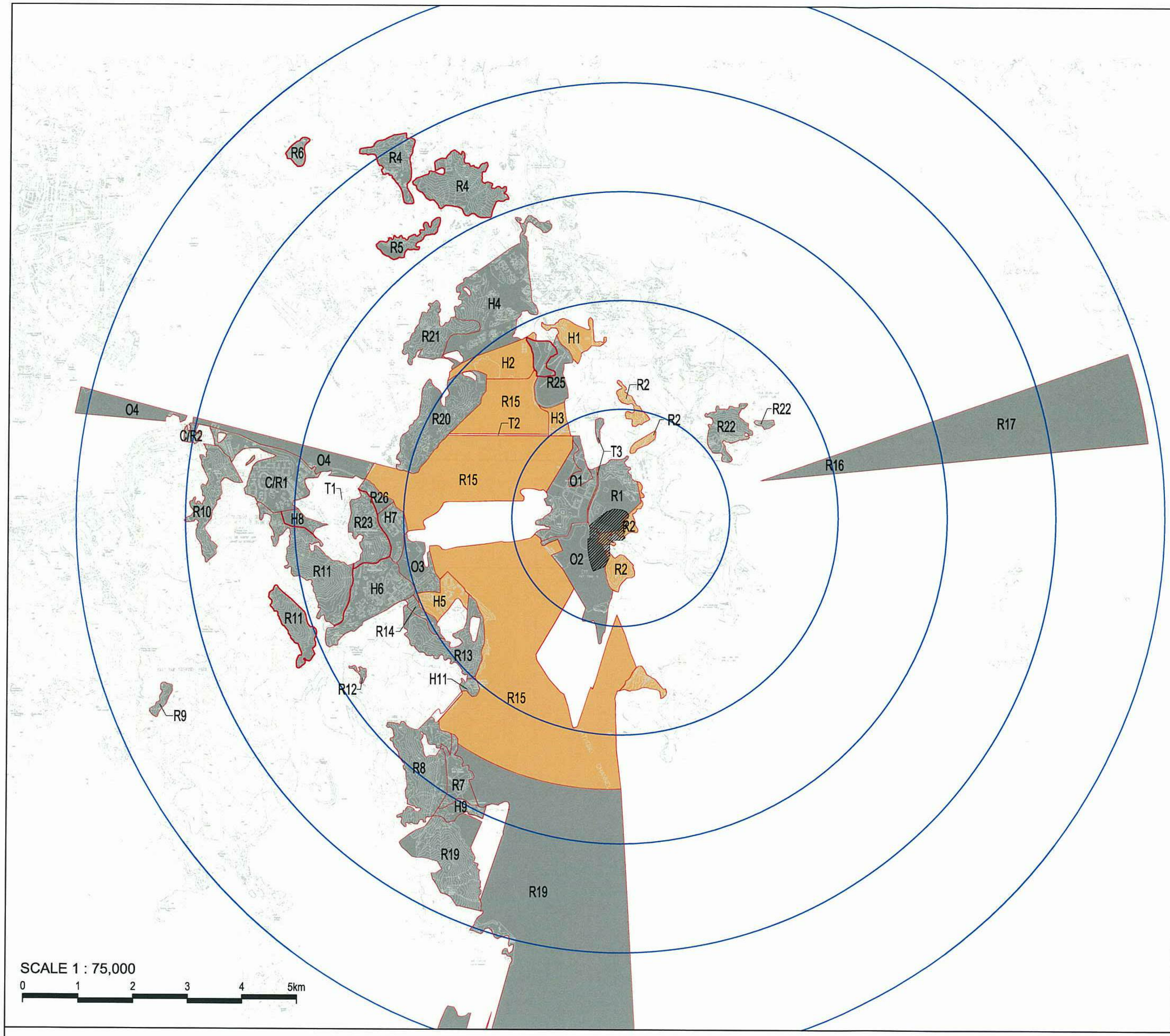

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SIGNIFICANCE OF VISUAL IMPACT

- SUBSTANTIAL POSITIVE
- MODERATE POSITIVE
- SLIGHT POSITIVE
- INSUBSTANTIAL
- SLIGHT NEGATIVE
- MODERATE NEGATIVE
- SUBSTANTIAL NEGATIVE

LEGEND :

- EXTENT OF PROPOSED EXTENSION

Recreational VSRS		
R1	Users of Restored SENT Landfill	Insubstantial
R2	Hikers on High Junk Peak Trail	Slight
R4	Hikers on Razor Hill	Insubstantial
R5	Hikers on Wilson Trail (Tai Sheung Tok)	Insubstantial
R6	Hikers on Kowloon Peak (Fei Ngo Shan)	Insubstantial
R7	Visitors to Shek O	Insubstantial
R8	Hikers on Dragon's Back	Insubstantial
R9	Hikers on Violet Hill	Insubstantial
R10	Users of Tai Tam Country Park (Quarry Bay Extension)	Insubstantial
R11	Hikers on Mount Parker	Insubstantial
R12	Hikers on Mount Collinson	Insubstantial
R13	Hikers on Pottinger Peak / Cape Collinson	Insubstantial
R14	Visitors to Chai Wan Cemetery (East)	Insubstantial
R15	Boat Users (and Workers in Vessels) in Tathong Channel & Joss House Bay	Slight
R16	Boat Users (and Workers in Vessels) in Waters East of Clear Water Bay	Insubstantial
R17	Boat Users (and Workers in Vessels) in Waters South of Bluff Island	Insubstantial
R19	Boat Users (and Workers in Vessels) in Waters East of Cape D'Aguilar	Insubstantial
R20	Visitors to TKO Chinese Cemetary and Devil's Peak	Insubstantial
R21	Hikers on Black Hill	Insubstantial
R22	Users of Clear water Country Park (East)	Insubstantial
R23	Users of Lei Yue Mun Park	Insubstantial
R24	Users of Quarry Bay Park	Insubstantial
R25	Future Recreational Users of TKO Landfill	Insubstantial
R26	Visitors to Museum of Coastal Defence	Insubstantial
Travelling VSRS		
T1	Travellers on Island Eastern Coridor	Insubstantial
T2	Travellers on Future Cross Bay Link	Insubstantial
T3	Travellers on Wan Po Road	Insubstantial
Residential VSRS		
H1	Future Residents at Pak Shing Kok	Slight
H2	Future Residents in TKO Phase 2	Slight
H3	Future Residents at TKO Area 86	Slight
H4	Residents in TKO	Insubstantial
H5	Residents in Siu Sai Wan	Slight
H6	Residents in Chai Wan	Insubstantial
H7	Residents in Heng Fa Chuen	Insubstantial
H8	Residents in Shau Kei Wan (West)	Insubstantial
H9	Residents in Shek O	Insubstantial
H11	Reisdents in Cape Collison Cotrrectional Institute	Insubstantial
Commercial / Residential VSRS		
C/R1	Residents and Workers in Taikoo Shing (North)	Insubstantial
C/R2	Residents and Workers in North Point	Insubstantial
Occupational VSRS		
O1	Workers in existing (and planned phaes of) TKO Industrial Estate	Insubstantial
O2	Future Workers in TKO Area 137	Insubstantial
O3	Workers Chai Wan Dock Area	Insubstantial
O4	Workers on Vessels in Victoria Harbour	Insubstantial

Figure 10.7e

Residual Visual Impacts During Construction Phase

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TKO Area 86 development (H3) will have long distance views (1.6-2.7km) of the Extension (see *Figure 10.6p*). Those affected will be only those residents living on the south side of towers and will be limited predominantly to those on the southern side of these developments. In these views, earthworks and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill and the distance from which they are viewed. This will constitute a "Slight" level of visual impact on these VSRs.

All other VSRs north of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

<u>VSRs East of Extension Site</u>

There are few VSRs east of (or on the east side of) the Clearwater Bay Peninsula who will be able to see the Extension Site. Those who can see the Site, Boat Users and Workers in Vessels in Waters East of Clear Water Bay (R16); Boat Users and Workers in Vessels in Waters South of Bluff Island (R17); and Users of Clear Water Bay Country Park (East) (R22). Visual impacts experienced by these VSRs will be limited to the top few metres of the existing SENT Landfill profile, which will be cleared / stripped, and which will be visible at the ridgeline of the Clear Water Bay Peninsula, in the saddle between Tin ha Shan and High Junk Peak. The saddle is at about 122mPD whereas the summit of the existing SENT Landfill is at about 125mPD. Impacts will offset by the limited numbers of VSRs in these groups and by the distance from which impacts will be visible (no closer than 1.9km). For this reason, visual impacts during the construction phase on these VSRs will be "Insubstantial".

<u>VSRs South of Extension Site</u>

Adverse residual visual impacts of "Slight" significance will be experienced by:

- Boat Users and Workers in Vessels in the Tathong Channel (R15) will have close range views (around 800m) of the construction works on the Extension seen behind TKOIE and TKO Area 137 Works, in which earthworks, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, the industrial character of the landscape of the TKOIE and TKO Area 137, which forms the foreground of these views, as well as the limited numbers of these VSRs in comparison with other VSR groups. This will constitute a "Slight" level of visual impact on these VSRs.

All other VSRs south of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

VSRs West of Extension Site

Adverse residual visual impacts of "Slight" significance will be experienced by:

- Residents in Siu Sai Wan (H5) will have long distance views (2.7km) of the Extension (see *Figure 10.6n*). Those affected will be only those residents living on the north and east side of towers and will be limited predominantly to those on the north and east side of developments. In these views, earthworks and other construction works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill and Area 137 Industrial Facilities and also by the distance from which they are viewed. This will constitute a "Slight" level of visual impact on these VSRs.

All other VSRs west of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

Operation / Restoration Phase

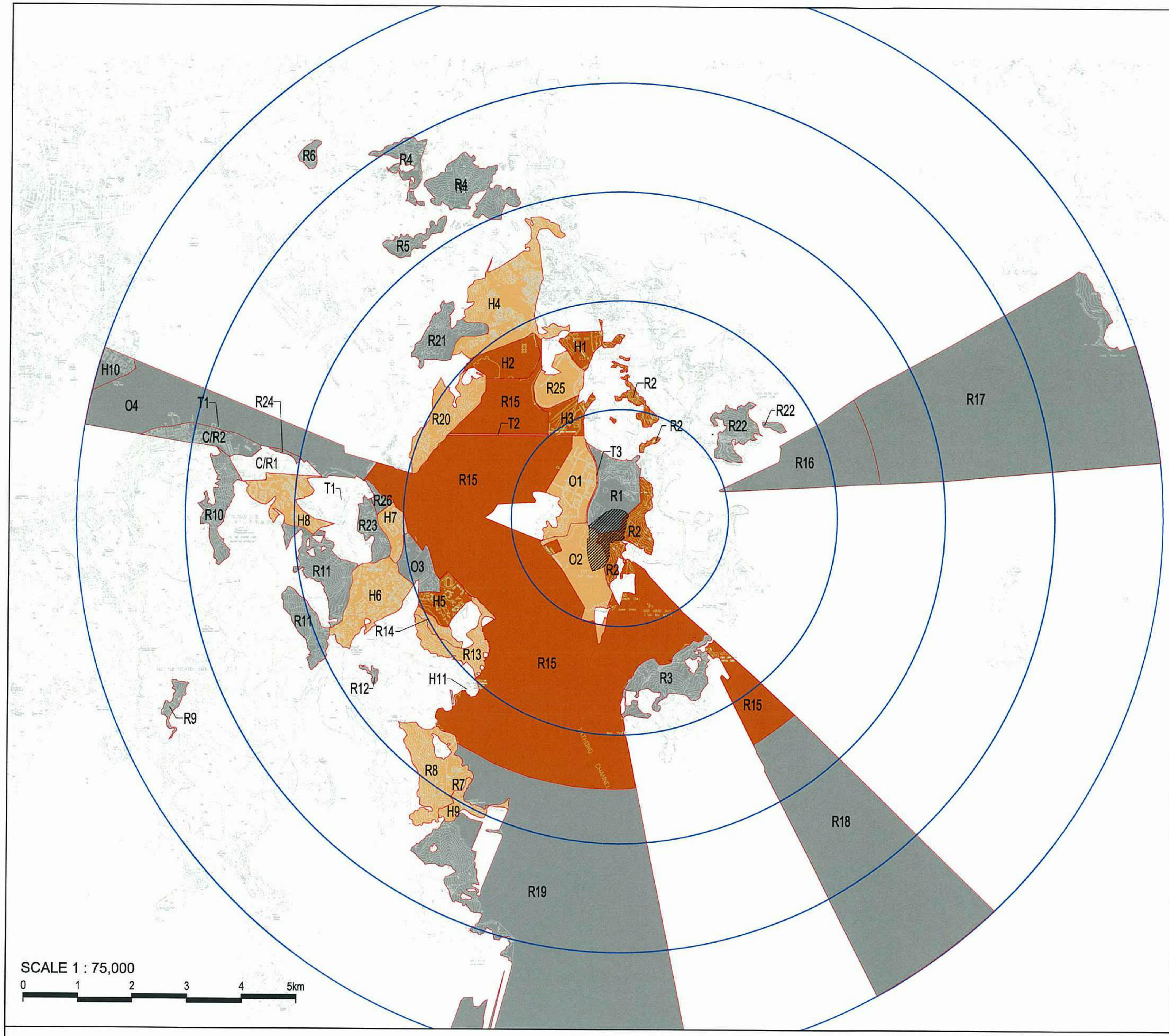
Residual visual impacts in the operation / restoration phase are mapped in *Figure 10.7f*.

VSRs North of Extension Site

Adverse residual visual impacts of "Moderate" significance will be experienced by:

- Hikers on the High Junk Peak Trail (R2) will have close range views (less than 250m) of the Extension, in which earthworks, landfilling works, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape (*Figure 10.6l*). The effect of the impacts will be offset to a certain degree by advance screen planting mitigation measures, the presence of the existing SENT Landfill, the industrial character of the landscape of the TKOIE and TKO Area 137, which forms the middle distance of these views, as well as the limited numbers of these VSRs in comparison with other VSR groups. This will constitute a "Moderate" level of visual impact on these VSRs.

- Residential VSRs in the future Pak Shing Kok development (H1); Future Residents in Phase 2 of TKO new town (H2) and Future Residents in the TKO Area 86 development (H3) will have long distance views (1.6-2.7km) of the SENT Extension (see *Figure 10.6p*). Those affected will be only those residents living on the south side of towers and will be limited predominantly to those on the southern side of these developments. In these views, earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a certain degree by



SIGNIFICANCE OF VISUAL IMPACT

- SUBSTANTIAL POSITIVE
- MODERATE POSITIVE
- SLIGHT POSITIVE
- INSUBSTANTIAL
- SLIGHT NEGATIVE
- MODERATE NEGATIVE
- SUBSTANTIAL NEGATIVE

LEGEND :

- EXTENT OF PROPOSED EXTENSION

Recreational VSRS		
R1	Users of Restored SENT Landfill	Moderate
R2	Hikers on High Junk Peak Trail	Moderate
R3	Hikers / Campers on Tung Lung Chau	Insubstantial
R4	Hikers on Razor Hill	Insubstantial
R5	Hikers on Wilson Trail (Tai Sheung Tok)	Insubstantial
R6	Hikers on Kowloon Peak (Fei Ngo Shan)	Insubstantial
R7	Visitors to Shek O	Slight
R8	Hikers on Dragon's Back	Slight
R9	Hikers on Violet Hill	Insubstantial
R10	Users of Tai Tam Country Park (Quarry Bay Extension)	Insubstantial
R11	Hikers on Mount Parker	Insubstantial
R12	Hikers on Mount Collinson	Insubstantial
R13	Hikers on Pottinger Peak / Cape Collinson	Slight
R14	Visitors to Chai Wan Cemetery (East)	Slight
R15	Boat Users (and Workers in Vessels) in Tathong Channel & Joss House Bay	Moderate
R16	Boat Users (and Workers in Vessels) in Waters East of Clear Water Bay	Insubstantial
R17	Boat Users (and Workers in Vessels) in Waters South of Bluff Island	Insubstantial
R18	Boat Users (and Workers in Vessels) in Waters South-East of Tung Lung Chau	Insubstantial
R19	Boat Users (and Workers in Vessels) in Waters East of Cape D'Aguilar	Insubstantial
R20	Visitors to TKO Chinese Cemetary and Devil's Peak	Slight
R21	Hikers on Black Hill	Insubstantial
R22	Users of Clear water Country Park (East)	Insubstantial
R23	Users of Lei Yue Mun Park	Insubstantial
R24	Users of Quarry Bay Park	Insubstantial
R25	Future Recreational Users of TKO Landfill	Slight
R26	Visitors to Museum of Coastal Defence	Insubstantial
Travelling VSRS		
T1	Travellers on Island Eastern Coridor	Slight
T2	Travellers on Future Cross Bay Link	Slight
T3	Travellers on Wan Po Road	Slight
Residential VSRS		
H1	Future Residents at Pak Shing Kok	Moderate
H2	Future Residents in TKO Phase 2	Moderate
H3	Future Residents at TKO Area 86	Moderate
H4	Residents in TKO	Slight
H5	Residents in Siu Sai Wan	Moderate
H6	Residents in Chai Wan	Slight
H7	Residents in Heng Fa Chuen	Slight
H8	Residents in Shau Kei Wan (West)	Slight
H9	Residents in Shek O	Slight
H10	Future Residents Hung Hom (East)	Slight
H11	Reisdents in Cape Collison Cotrrectional Institute	Slight
Commercial / Residential VSRS		
C/R1	Residents and Workers in Taikoo Shing (North)	Insubstantial
C/R2	Residents and Workers in North Point	Insubstantial
Occupational VSRS		
O1	Workers in existing (and planned phaes of) TKO Industrial Estate	Slight
O2	Future Workers in TKO Area 137	Slight
O3	Workers Chai Wan Dock Area	Insubstantial
O4	Workers on Vessels in Victoria Harbour	Insubstantial

Figure 10.7f

Residual Visual Impacts During Operation and Restoration Phases

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J:\ERL21\DWG-GA\FIGURE-10_07f.dwg, A3, 20-Jun-2007 15:41:19, san the presence of the existing SENT Landfill and the distance from which they are viewed. This will constitute a “Moderate” level of visual impact on these VSRs.

Adverse residual visual impact of “Slight” significance will be experienced by:

- Residential VSRs in the Tseung Kwan O New Town (H4) will have very long distance views (3.6-5km) of the Extension. Those affected will be only those residents living on the south side of towers and will be limited predominantly to those on the southern side of these developments. Views are likely to be obscured or broken by other buildings (including new development in TKO Phase 2). In these views, earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a large extent by the presence of the existing SENT Landfill and the long distance from which they are viewed. This will constitute a “Slight” level of visual impact on these VSRs.

- Recreational VSRs using the restored TKO Landfill site (R25) will have long range views (2.2km) of the Extension, in which earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, the industrial character of the landscape of the TKOIE (which forms the middle distance of these views) and the distance of these views. This will constitute a “Slight” level of visual impact on these VSRs.

- Those using Wan Po Road (T3) (especially those close to the Extension Site) will experience views of the Extension Site – generally glimpsed through roadside vegetation – often from close range (around 20m) in which earthworks, landfilling works, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula (see *Figure 10.6m*). Resulting visual impacts will be “Slight” due to the presence of the existing SENT Landfill and industrial areas.

All other VSRs north of the Extension Site will experience “Insubstantial“ residual visual impacts as noted in *Table 10.7a*.

<u>VSRs East of Extension Site</u>

There are few VSRs east of (or on the east side of) the Clearwater Bay Peninsula who will be able to see the Extension Site. Those who can see the Extension Site include Boat Users and Workers in Vessels in Waters East of Clear Water Bay (R16); Boast Users and Workers in Vessels in Waters South of Bluff Island (R17); and Users of Clear Water Bay Country Park (East) (R22). Visual impacts experienced by these VSRs will be limited to the top 30m of the Extension profile which will be visible at the ridgeline of the Clear Water Bay Peninsula, in the saddle between Tin ha Shan and High Junk Peak. The saddle is at about 122mPD whereas the summit of the Extension will be at about 152mPD. Impacts will offset by the limited duration during which this un-restored profile will be visible (only visible during the final phase of operation), by the limited numbers of VSRs in these groups and by the distance from which impacts will be visible (no closer than 1.9km). For this reason, visual impacts during the operation / restoration phase on these VSRs will be "Insubstantial".

<u>VSRs South of Extension Site</u>

Adverse residual visual impacts of "Moderate" significance will be experienced by:

- Boat Users and Workers in Vessels in the Tathong Channel (R15) will have close range views (around 800m) of the Extension seen behind TKOIE and Area 137 Works, in which the later stages of earthworks, landfilling works, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, the industrial character of the landscape of the TKOIE and TKO Area 137, which forms the foreground of these views, as well as the limited numbers of these VSRs in comparison with other VSR groups. This will constitute a "Moderate" level of visual impact on these VSRs.

Adverse residual visual impact of "Slight" significance will be experienced by:

- Residents in Cape Collison Correctional Institute (H11); Residents in Shek O (H9), Visitors to Shek O (R7) and Hiker's on the Dragon's Back (R8) (see *Figure 10.6o*) will have very distant views (3-4.8km) of the Extension seen behind Area 137 Works, in which the later stages of earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. These views will only be visible to those on the northern side of Shek O. The effect of the impacts will be offset by the distance of these views and presence of the existing SENT Landfill, the industrial character of the landscape of Area 137, which forms the foreground of these views. Resulting visual impacts will be "Slight".

- Workers in TKO Area 137 (O2) will experience close range views of the Extension often from close range (around 30m) in which earthworks, landfilling works, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula and Fat Tong Chau. However, these impacts will be offset by the presence of the existing SENT Landfill and the Area 137 industrial areas in these views, as well as the Low sensitivity of these receivers. Resulting visual impacts will be "Slight".

All other VSRs south of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

VSRs West of Extension Site

Adverse residual visual impacts of "Moderate" significance will be experienced by:

- Residents in Siu Sai Wan (H5) will have long distance views (2.7km) of the Extension (see *Figure 10.6n*). Those affected will be only those residents living on the north and east side of towers and will be limited predominantly to those on the north and east side of developments. In these views, earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill and Area 137 Industrial Facilities and also by the distance from which they are viewed. This will constitute a "Moderate" level of visual impact on these VSRs.

Adverse residual visual impacts of "Slight" significance will be experienced by:

- Visitors to Chai Wan Cemetery (East) (R14); Hikers on Pottinger Peak / Cape Collison (R13) and Visitors to TKO Cemetery and Devil's Peak (R20) will have long distance views of the Extension (2.5-3.1 km). In these views, earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, TKOIE and Area 137 Industrial Facilities, by the distance from which they are viewed and by the limited number of these receivers. This will constitute a "Slight" level of visual impact on these VSRs.

- Residents in Chai Wan (H6); Residents in Heng Fa Chuen (H7); and Residents in Sha Kei Wan (West) (H8) will have long distance views (3.7-4.7km) of the Extension. Those affected will be only those residents living on the east side of towers and will be limited predominantly to those on the east side of developments. In these views, earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, TKOIE and TKO Area 137 Industrial Facilities and also by the long distance from which they are viewed. This will constitute a "Slight" level of visual impact on these VSRs.

- Travellers at the eastern end of the Island Eastern Corridor (T1) and Travellers on the Future Cross Bay Link (T2) will have distant views of the Extension (2.0-3.5 km). In these views, earthworks and landfilling works will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape, which form the background. Though the Island eastern Corridor is very distant, impacts will be increased by virtue of the large numbers of people in this VSR group. Conversely, users of the future Cross Bay Link make up a smaller receiver group which is closer to the Extension. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, TKOIE and TKO Area 137 Industrial Facilities. This will constitute a "Slight" level of visual impact on both of these VSRs.

- Workers in Existing (and Planned) Phases of TKOIE (O1) will experience close range views of the Extension often from close range (around 100m) in which earthworks, landfilling works, lorry movements and the presence of construction plant will contrast unfavourably with the natural forms and muted colours of the hills of the Clearwater Bay Peninsula and Fat Tong Chau. However, these impacts will be offset by the presence of the existing SENT Landfill and the Area 137 industrial areas in these views, as well as the Low sensitivity of these receivers. Resulting visual impacts will be "Slight".

All other VSRs west of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

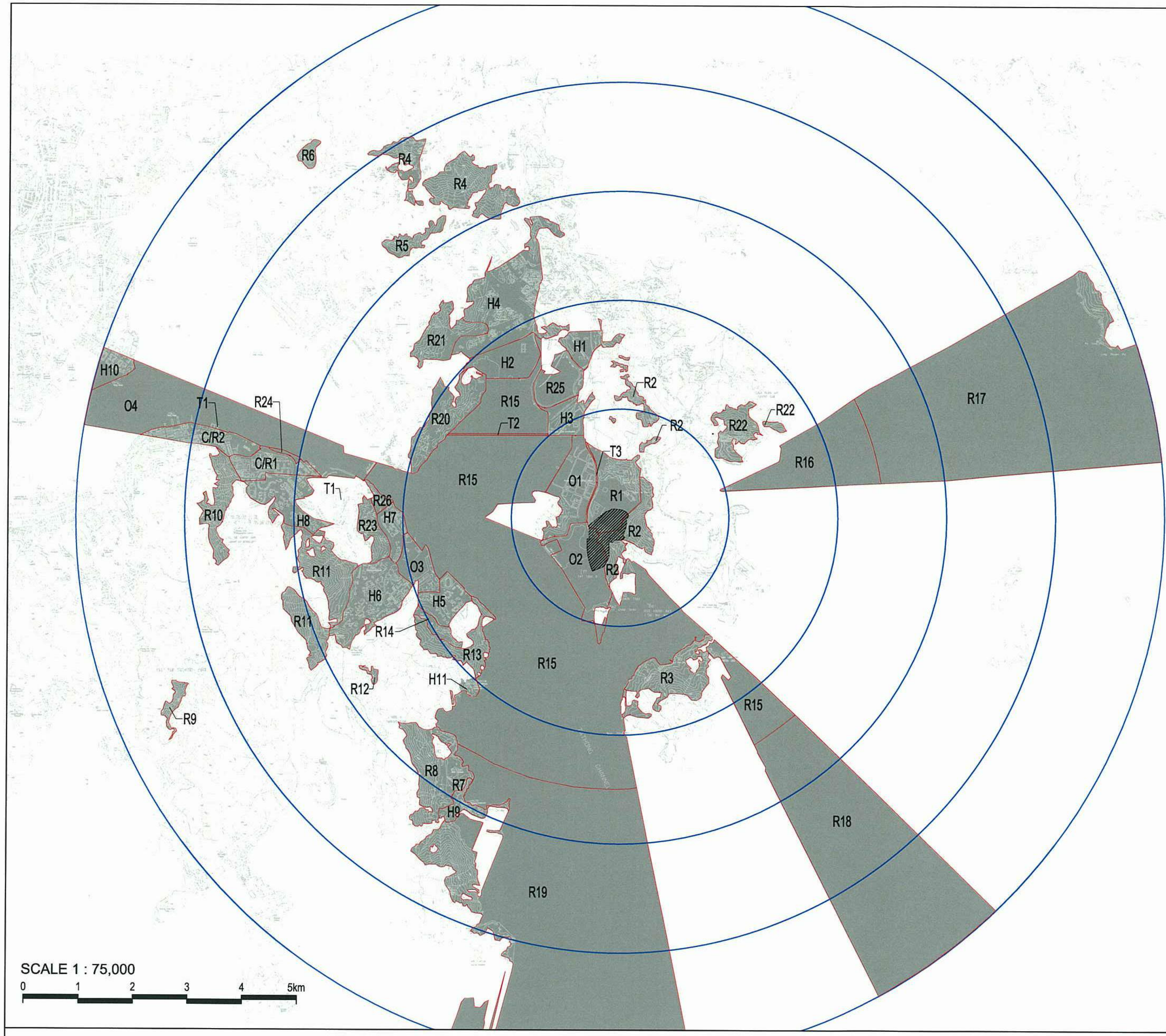
Aftercare Phase

Residual visual impacts in the Aftercare Phase are mapped in *Figure 10.7g*.

<u>VSRs North of Extension Site</u>

At Day 1 of the aftercare phase, adverse residual visual impacts of "Slight" significance will be experienced by:

- Recreational VSRs using the restored SENT Landfill site (R1) and Hikers on the High Junk Peak Trail (R2) (see *Figure 10.6l*) will have close range views (less than 250m) of the restored Extension, in which newly restored and vegetated slopes (as well as slopes restored some years before in early phases of the restoration) will be visible. Newly restored slopes and vegetation will contrast slightly with the natural land forms, vegetation patterns and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of mitigation advance screen planting, the existing SENT Landfill, the industrial character of the landscape of the TKOIE and TKO Area 137 (which forms the middle distance of these views) as well as the limited numbers of these VSRs in comparison with other VSR groups. This will constitute a "Slight" level of visual impact on these VSRs. At Year 10, as vegetation matures and increasingly hides landforms, visual impacts will be reduced to "Insubstantial".



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SIGNIFICANCE OF VISUAL IMPACT

- SUBSTANTIAL POSITIVE
- MODERATE POSITIVE
- SLIGHT POSITIVE
- INSUBSTANTIAL
- SLIGHT NEGATIVE
- MODERATE NEGATIVE
- SUBSTANTIAL NEGATIVE

LEGEND :

- EXTENT OF PROPOSED EXTENSION

Recreational VSRS		
R1	Users of Restored SENT Landfill	Insubstantial
R2	Hikers on High Junk Peak Trail	Insubstantial
R3	Hikers / Campers on Tung Lung Chau	Insubstantial
R4	Hikers on Razor Hill	Insubstantial
R5	Hikers on Wilson Trail (Tai Sheung Tok)	Insubstantial
R6	Hikers on Kowloon Peak (Fei Ngo Shan)	Insubstantial
R7	Visitors to Shek O	Insubstantial
R8	Hikers on Dragon's Back	Insubstantial
R9	Hikers on Violet Hill	Insubstantial
R10	Users of Tai Tam Country Park (Quarry Bay Extension)	Insubstantial
R11	Hikers on Mount Parker	Insubstantial
R12	Hikers on Mount Collinson	Insubstantial
R13	Hikers on Pottinger Peak / Cape Collinson	Insubstantial
R14	Visitors to Chai Wan Cemetery (East)	Insubstantial
R15	Boat Users (and Workers in Vessels) in Tathong Channel & Joss House Bay	Insubstantial
R16	Boat Users (and Workers in Vessels) in Waters East of Clear Water Bay	Insubstantial
R17	Boat Users (and Workers in Vessels) in Waters South of Bluff Island	Insubstantial
R18	Boat Users (and Workers in Vessels) in Waters South-East of Tung Lung Chau	Insubstantial
R19	Boat Users (and Workers in Vessels) in Waters East of Cape D'Aguilar	Insubstantial
R20	Visitors to TKO Chinese Cemetary and Devil's Peak	Insubstantial
R21	Hikers on Black Hill	Insubstantial
R22	Users of Clear water Country Park (East)	Insubstantial
R23	Users of Lei Yue Mun Park	Insubstantial
R24	Users of Quarry Bay Park	Insubstantial
R25	Future Recreational Users of TKO Landfill	Insubstantial
R26	Visitors to Museum of Coastal Defence	Insubstantial
Travelling VSRS		
T1	Travellers on Island Eastern Coridor	Insubstantial
T2	Travellers on Future Cross Bay Link	Insubstantial
T3	Travellers on Wan Po Road	Insubstantial
Residential VSRS		
H1	Future Residents at Pak Shing Kok	Insubstantial
H2	Future Residents in TKO Phase 2	Insubstantial
H3	Future Residents at TKO Area 86	Insubstantial
H4	Residents in TKO	Insubstantial
H5	Residents in Siu Sai Wan	Insubstantial
H6	Residents in Chai Wan	Insubstantial
H7	Residents in Heng Fa Chuen	Insubstantial
H8	Residents in Shau Kei Wan (West)	Insubstantial
H9	Residents in Shek O	Insubstantial
H10	Future Residents Hung Hom (East)	Insubstantial
H11	Reisdents in Cape Collison Cotrrectional Institute	Insubstantial
Commercial / Residential VSRS		
C/R1	Residents and Workers in Taikoo Shing (North)	Insubstantial
C/R2	Residents and Workers in North Point	Insubstantial
Occupational VSRS		
O1	Workers in existing (and planned phaes of) TKO Industrial Estate	Insubstantial
O2	Future Workers in TKO Area 137	Insubstantial
O3	Workers Chai Wan Dock Area	Insubstantial
O4	Workers on Vessels in Victoria Harbour	

Figure 10.7g

Residual Visual Impacts During Aftercare Phase (Year 10)

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Environmental Resources Management

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- Residential VSRs in the future Pak Shing Kok development (H1); Future Residents in Phase 2 of TKO new town (H2) and Future Residents in the TKO Area 86 development (H3) will have long distance views (1.6-2.7km) of the restored Extension (see *Figure 10.6p*). Those affected will be only those residents living on the south side of towers and will be limited predominantly to those on the southern side of these developments. In these views, newly restored slopes and vegetation will contrast slightly with the natural land forms, vegetation patterns and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill, TKOIE and the distance from which they are viewed. This will constitute a "Slight" level of visual impact on these VSRs. At Year 10, as vegetation matures and increasingly hides landforms, visual impacts will be reduced to "Insubstantial".

All other VSRs north of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

<u>VSRs East of Extension Site</u>

There are few VSRs east of (or on the east side of) the Clearwater Bay Peninsula who will be able to see the Extension Site. Those who can see the Site, Boat Users and Workers in Vessels in Waters East of Clear Water Bay (R16); Boast Users and Workers in Vessels in Waters South of Bluff Island (R17); and users of Clear Water Bay Country Park (East) (R22). Visual impacts experienced by these VSRs will be limited to the top 30m of the SENT Extension profile which will be visible able the ridgeline of the Clear Water Bay Peninsula, in the saddle between Tin ha Shan and High Junk Peak. The saddle is at about 122mPD whereas the summit of the Extension will be at about 152mPD. After restoration, the Extension will represent an insignificant change in the view to a very small number of VSRs, from some distance and for this reason, visual impacts at Day 1 and Year 10 of the aftercare phase will be "Insubstantial".

<u>VSRs South of Extension Site</u>

Adverse residual visual impacts of Slight significance will be experienced by:

- Boat Users and Workers in Vessels in the Tathong Channel (R15) will have close range views (around 800m) of the restored Extension seen behind TKOIE and TKO Area 137 Works. In these views, newly restored slopes and vegetation will contrast slightly with the natural land forms, vegetation patterns and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill and industrial developments at TKOIE and TKO Area 137. This will constitute a "Slight" level of visual impact on these VSRs. At Year 10, as vegetation matures and increasingly hides landforms, visual impacts will be reduced to "Insubstantial".

All other VSRs south of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

VSRs West of Extension Site

Adverse residual visual impacts of "Slight" significance will be experienced by:

- Residents in Siu Sai Wan (H5) will have long distance views (2.7km) of the SENT Extension (see *Figure 10.6n*). Those affected will be only those residents living on the north and east side of towers and will be limited predominantly to those on the north and east side of developments. In these views, newly restored slopes and vegetation will contrast slightly with the natural land forms, vegetation patterns and muted colours of the hills of the Clearwater Bay Peninsula, Fat Tong Chau and the surrounding seascape. The effect of the impacts will be offset to a certain degree by the presence of the existing SENT Landfill and Area 137 Industrial Facilities and also by the distance from which they are viewed. This will constitute a Slight level of visual impact on these VSRs. At Year 10, as vegetation matures and increasingly hides landforms, visual impacts will be reduced to "Insubstantial".

All other VSRs west of the Extension Site will experience "Insubstantial" residual visual impacts as noted in *Table 10.7a*.

Table 10.7a Significance of Visual Impacts in the Construction, Operation / Restoration and Aftercare Phases (Note: All impacts adverse unless otherwise noted)

VSR Type & ID.	Key Visually Sensitive Receiver (VSR)	Degree of Visibility of Source(s) of Visual Impact (Full, Partial, Glimpse) & Distance Between VSR & Nearest Source(s) of Impact	Magnitude of Impact BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Receptor Sensitivity & Number		Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
												Construction	Operation / Restoration	Aftercare	
		Operation	Construction	Operation / Restoration	Aftercare	Sensitivity (Low, Medium, High)	Number (Very Few, Few, Many, Very Many)	Construction	Operation / Restoration	Aftercare		(Substantial, Moderate, Slight Insubstantial)	(Substantial, Moderate, Slight, Insubstantial	DAY 1	YEAR 10
R1	Users of Restored SENT Landfill	Full, 10	N/A	N/A	Large	High	Very Few	N/A	N/A	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	N/A	N/A	Slight	Insubstantial
R2	Hikers on High Junk Peak Trail	Partial, 260	Intermediate	Large	Large	High	Very Few	Moderate	Substantial	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Slight	Moderate	Slight	Insubstantial
R3	Hikers / Campers on Tung Lung Chau	Partial, 2100	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R4	Hikers on Razor Hill	Partial, 5700	Negligible	Negligible	Negligible	High	Very Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R5	Hikers on Wilson Trail (Tai Sheung Tok)	Partial, 6000	Negligible	Negligible	Negligible	High	Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R6	Hikers on Kowloon Peak (Fei Ngo Shan)	Partial, 8300	Negligible	Negligible	Negligible	High	Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R7	Visitors to Shek O	Full, 5100	Negligible	Small	Small	High	Many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
R8	Hikers on Dragon's Back	Full, 4600	Negligible	Small	Small	High	Few	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
R9	Hikers on Violet Hill	Partial, 8000	Negligible	Negligible	Negligible	High	Very Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R10	Users of Tai Tam Country Park (Quarry Bay Extension)	Full, 6500	Negligible	Negligible	Negligible	High	Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R11	Hikers on Mount Parker	Full, 4300	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R12	Hikers on Mount Collinson	Full, 4500	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R13	Hikers on Pottinger Peak / Cape Collinson	Full, 2500	Small	Intermediate	Intermediate	High	Very Few	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
R14	Visitors to Chai Wan Cemetery (East)	Full, 3000	Small	Intermediate	Intermediate	High	Few	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
R15	Boat Users (and Workers in Vessels) in Tathong Channel & Joss House Bay	Full, 800	Intermediate	Large	Large	High	Few	Moderate	Substantial	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Slight	Moderate	Slight	Insubstantial
R16	Boat Users (and Workers in Vessels) in Waters east of Clear Water Bay	Partial, 1600	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R17	Boat Users (and Workers in Vessels) in Waters south of Bluff Island	Partial, 4500	Negligible	Negligible	Negligible	High	Very Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R18	Boat Users (and Workers in Vessels) in waters south-east of Tung Lung Chau	Partial, 4500	Negligible	Negligible	Negligible	High	Very Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R19	Boat Users (and	Full, 4500	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4;	Insubstantial	Insubstantial	Insubstantial	Insubstantial

VSR Type & ID.	Key Visually Sensitive Receiver (VSR)	Degree of Visibility of Source(s) of Visual Impact (Full, Partial, Glimpse) & Distance Between VSR & Nearest Source(s) of Impact	Magnitude of Impact BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Receptor Sensitivity & Number		Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
												Construction	Operation / Restoration	Aftercare	
		Operation	Construction	Operation / Restoration	Aftercare	Sensitivity (Low, Medium, High)	Number (Very Few, Few, Many, Very Many)	Construction	Operation / Restoration	Aftercare		(Substantial, Moderate, Slight Insubstantial)	(Substantial, Moderate, Slight, Insubstantial	DAY 1	YEAR 10
	Workers in Vessels) in Waters east of Cape D'Aguilar										AM1-2; AM4-5; AM7-8				
R20	Visitors to TKO Chinese Cemetery and Devil's Peak	Full, 3100	Negligible	Small	Small	High	Many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
R21	Hikers on Black Hill	Full, 4200	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R22	Users of Clear water Country Park (East)	Partial, 1900	Negligible	Small	Small	High	Very Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R23	Users of Lei Yue Mun Park	Partial, 3900	Negligible	Small	Small	High	Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R24	Users of Quarry Bay Park	Partial, 6000	Negligible	Negligible	Negligible	High	Many	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
R25	Future Recreational Users of TKO Landfill	Full, 2200	Small	Intermediate	Intermediate	High	Few	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
R26	Visitors to Museum of Coastal Defence	Partial, 3500	Negligible	Small	Small	High	Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
T1	Travellers on Island Eastern Corridor	Partial, 3500-7000	Negligible	Small	Small	Medium	Very many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
T2	Travellers on Future Cross Bay Link	Partial, 2000	Small	Intermediate	Intermediate	Medium	Many	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
T3	Travellers on Wan Po Road	Glimpse, 20-3000	Intermediate	Large	Large	Medium	Few	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
H1	Future Residents at Pak Shing Kok	Partial, 2700	Small	Intermediate	Intermediate	High	Many	Moderate	Substantial	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Slight	Moderate	Slight	Insubstantial
H2	Future Residents in TKO Phase 2	Full, 3000	Small	Intermediate	Intermediate	High	Very many	Moderate	Substantial	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Slight	Moderate	Slight	Insubstantial
H3	Future Residents at TKO Area 86	Full, 1600	Small	Intermediate	Intermediate	High	Many	Moderate	Substantial	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Slight	Moderate	Slight	Insubstantial
H4	Residents in TKO	Partial, 3600-5000	Negligible	Small	Small	High	Very many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
H5	Residents in Siu Sai Wan	Full, 2400	Small	Intermediate	Intermediate	High	Very many	Moderate	Substantial	Substantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Slight	Moderate	Slight	Insubstantial
H6	Residents in Chai Wan	Full, 3700	Negligible	Small	Small	High	Very many	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
H7	Residents in Heng Fa Chuen	Partial, 3800	Negligible	Small	Small	High	Very many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
H8	Residents in Shau Kei Wan (West)	Partial, 4700	Negligible	Small	Small	High	Very many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
H9	Residents in Shek O	Full, 4800	Negligible	Small	Small	High	Many	Insubstantial	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
H10	Future Residents Hung Hom (East)	Partial, 9100	Negligible	Negligible	Negligible	High	Many	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
H11	Residents in Cape Collison Correctional Institute	Full, 3000	Small	Intermediate	Intermediate	High	Few	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
C/R1	Residents and Workers in Taikoo Shing (North)	Partial, 5100	Negligible	Negligible	Negligible	Medium	Very many	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial

VSR Type & ID.	Key Visually Sensitive Receiver (VSR)	Degree of Visibility of Source(s) of Visual Impact (Full, Partial, Glimpse) & Distance Between VSR & Nearest Source(s) of Impact	Magnitude of Impact BEFORE Mitigation (Negligible, Small, Intermediate, Large)			Receptor Sensitivity & Number		Impact Significance BEFORE Mitigation (Insubstantial, Slight, Moderate, Substantial)			Recommended Mitigation Measures	Residual Impact Significance Threshold AFTER Mitigation (Insubstantial, Slight, Moderate, Substantial)			
												Construction	Operation / Restoration	Aftercare	
		Operation	Construction	Operation / Restoration	Aftercare	Sensitivity (Low, Medium, High)	Number (Very Few, Few, Many, Very Many)	Construction	Operation / Restoration	Aftercare		(Substantial, Moderate, Slight Insubstantial)	(Substantial, Moderate, Slight, Insubstantial	DAY 1	YEAR 10
C/R2	Residents and Workers in North Point	Partial, 6200	Negligible	Negligible	Negligible	Medium	Very many	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
O1	Workers in existing (and planned phases of) TKOIE	Full, 100	Intermediate	Large	Large	Low	Many	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
O2	Future Workers in TKO Area 137	Full, 30	Intermediate	Large	Large	Low	Many	Slight	Moderate	Moderate	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Slight	Insubstantial	Insubstantial
O3	Workers Chai Wan Dock Area	Partial, 3000	Small	Intermediate	Intermediate	Low	Few	Insubstantial	Slight	Slight	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial
O4	Workers on Vessels in Victoria Harbour	Partial, 4000	Negligible	Small	Small	Low	Few	Insubstantial	Insubstantial	Insubstantial	CM5-7; OM1-OM4; AM1-2; AM4-5; AM7-8	Insubstantial	Insubstantial	Insubstantial	Insubstantial

* O = Occupational; C/R = Mixed Commercial/Residential; H = Residential; R = Recreational; T = Travelling.

10.8 *ENVIRONMENTAL MONITORING AND AUDIT*

It is recommended that EM&A for landscape and visual resources is undertaken during the design, construction, operation and restoration / aftercare phases of the Extension. The design, implementation and maintenance of landscape mitigation measures is a key aspect of this should be checked to ensure that they are fully realised and that potential conflicts between the proposed landscape measures and any other Extension works and operational requirements are resolved at the earliest possible date and without compromise to the intention of the mitigation measures. In addition, implementation of the mitigation measures recommended by the EIA will be monitored through the site audit programme throughout construction, operation, restoration and aftercare phases.

10.9 *CONCLUSIONS*

10.9.1 *Summary of Landscape and Visual Mitigation Measures*

Construction phase mitigation measures will comprise the following (described in detail in *Table 10.6a*):

- CM1 - The construction area and area allowed for the contractor's office, leachate treatment plant and laboratory areas will be minimised to a practical minimum, to avoid impacts on adjacent landscape.

- CM2 - Topsoil, where identified, will be stripped and stored for re-use in the construction of the soft landscape works, where practical. The Contract Specification will include storage and reuse of topsoil as appropriate.

- CM3 - All existing trees at the edges of the landfill will be carefully protected during construction. Detailed Tree Protection Specification will be provided in the Contract Specification. Under this Specification, the Contractor will be required to submit, for approval, a detailed working method statement for the protection of trees prior to undertaking any works adjacent to all retained trees, including trees in Contractor's works areas.

- CM4 - Trees unavoidably affected by the works will be transplanted, where necessary and practical. A detailed Tree Transplanting Specification will be provided in the Contract Specification, if applicable. Sufficient time for necessary tree root and crown preparation periods will be allowed in the project programme.

- CM5 - Within 3 months of taking possession of the Extension Site, the Contractor will plant advance screen planting of *Casuarina sp* or *Acacia sp* at Light Standard size at 1.5m centres along the High Junk Peak Trail so as to screen views of the Works from the trail. Tree planting locations will be agreed with AFCD. Works should be completed within 9 months of taking possession of the Extension Site.

- CM6 - The Contractor's office, leachate treatment plant and laboratory will be given an aesthetic treatment in earth tones to reduce their visual impact and albedo and blend them into the surrounding landscape.

- CM7 - The Contractor's office, leachate treatment plant and laboratory will be surrounded by a minimum of 5m wide and 0.75m high earth bund on the west and south sides planted with a dense screen of tree and shrub vegetation. Additional tree planting will be provided in unused spaces with thin infrastructure site, along access roads and in and around car parks. This will be supplemented with shrub planting, where appropriate.

- CM8 - Planting trials will be carried out in an on-site nursery prior to implementation of the first phase of restoration to establish the best palette of plant materials for the restoration.

Operation/restoration phase mitigation measures will comprise the following (described in detail in *Table 10.6b*):

- OM1 - Landfill materials will be covered with general fill material or CDG on a daily basis to reduce visual impact.

- OM2 - Filling and restoration will be phased during the course of operations in a minimum of 6 phases, the restoration of each phase to commence immediately on the completion of filling in that phase.

- OM3 - Catch fences will be erected at the perimeter of the waste boundary, to ensure that all waste stays within the site and is not blown into surrounding areas.

- OM4 - All night-time lighting will be reduced to a practical minimum both in terms of number of units and lux level and will be hooded and directional.

Aftercare phase mitigation measures will comprise the following (described in detail in *Table 10.6c*):

- AM1 - The Extension will be restored to resemble a natural hillside/ upland landscape as far as possible.

- AM2 - Final restoration earthworks grading will provide both vertical and horizontal variation to simulate as far as practicable, natural terrain.

- AM3 - Compensatory Tree Planting for all felled trees will be provided to the satisfaction of relevant Government departments. Required numbers and locations of compensatory trees will be determined and agreed separately with Government during the Tree Felling Application process under ETWB-WBTC 3/2006.

- AM4 - The restored Extension will be substantially vegetated so as to mimic the patterns of natural vegetation on surrounding hills. At least

18.8ha of the area of the Extension will be planted with woodland mix planting at no less than 1.2m spacings. 80% of all plants planted will be native species. The remainder of the site will be planted as a grassland / shrub mosaic.

- AM5 - Drainage channels will be treated with stone pitching or coloured pigment in an earth tone and should not be untreated concrete.

- AM6 - Soil mix in accordance with the Government's General Specification for Engineering Works will be used in the restoration works. In areas of tree planting, soil mix will not be less than 1.2m deep. In areas of scrub planting and grassland, it will not be less than 600mm deep.

- AM7 - All above ground structures, including gas wells and flares will be sensitively designed in a manner that responds to the existing and planned urban context, and minimises potential adverse landscape and visual impacts.

- AM8 - Permanent access and maintenance tracks will not have an unfinished concrete surface. Acceptable finish materials might include granite, or concrete blocks in an earth tone colour.

10.9.2 Nature and Significance of Landscape and Visual Impacts Generally

Generally, construction phase and operation / restoration phase, landscape resource impacts are similar (as the magnitude of impacts on landscape resources does not really increase in phases after the construction phase). Construction phase visual impacts are limited due to the relatively small scale of the construction and preparation works. Generally these impacts are relatively insignificant due to the fact that the Extension Site is currently either a landfill or a recent reclamation, meaning that it has few sensitive landscape resources.

The most significant visual impacts and impacts on landscape character occur during the operation / restoration phase. But even during this phase and subsequently, visual impacts are in many cases not very significant, due to the fact that most sensitive residential receivers are relatively distant and because the numbers of sensitive recreational receivers are relatively small. Screen planting and the rather incoherent visual context of the Extension Site will limit visual impacts on users of the High Junk Peak Trail. Visual impacts are also offset to a certain extent by the indifferent visual amenity associated with views of the Extension Site, including the presence of the unrestored parts of the SENT Landfill, the existing TKOIE and the future industrial area at TKO Area 137, in views of the Extension Site.

10.9.3 *Summary of Predicted Landscape and Visual Impacts in the Construction Phase*

Residual landscape impacts in the construction phase are listed in *Table 10.6d* and mapped in *Figures 10.6c* and *10.6f*. Residual visual impacts in the construction phase are listed in *Table 10.7a* and mapped in *Figure 10.7e*.

The potentially most significant impacts after mitigation during the construction phase will be "Substantial" landscape impacts on LR23 - Shrubs and topography in lower ridge east of TKO Area 137 (6.24 ha).

There will be "Moderate" landscape impacts during the construction phase on LR11 - Trees and shrubs along lower hillside of Tin Ha Shan (2.81 ha); LR13 - Plantation and topography in south SENT Landfill (6.03 ha); LR14 – Plantation and topography in south-east SENT Landfill (3.63 ha) and LR24 - Grass and topography on upper ridge east of TKO Area 137 (0.05 ha).

There will be "Slight" landscape Impacts during the construction phase on LR9 - Scrub in southern part of TKO Area 137 (0.56 ha); LR12 - Site office area of SENT Landfill (around 20 mature trees); LR15 - Plantation and topography in west SENT Landfill (3.57 ha); LCA3 – SENT Landfill (29.50ha) and on LCA5 – Clear Water Bay Peninsula Coastal Uplands (6.29ha).

There will be "Slight" visual Impacts during the construction phase on Hikers on the High Junk Peak Trail (R2); Residential VSRs in the future Pak Shing Kok development (H1); Future Residents in Phase 2 of TKO new town (H2) and Future Residents in the TKO Area 86 development (H3); Boat Users and Workers in Vessels in the Tathong Channel (R15) and Residents in Siu Sai Wan (H5).

10.9.4 *Summary of Predicted Landscape and Visual Impacts in the Operation/ Restoration Phase*

Residual landscape impacts after mitigation in the operation / restoration phase are listed in *Table 10.6d* and mapped in *Figures 10.6d* and *10.6g*. Residual visual impacts in the operation / restoration phase are listed in *Table 10.7a* and mapped in *Figure 10.7f*.

There will be no "Substantial" landscape impacts during the operation / restoration phase.

The potentially most significant impacts during the operation / restoration phase will be "Moderate" landscape impacts on LR23 - Shrubs and topography in lower ridge east of TKO Area 137 (6.24 ha).

There will be "Slight" landscape impacts during the operation / restoration phase on LR11 - Trees and shrubs along lower hillside of Tin Ha Shan (2.81 ha); LR13 - Plantation and topography in the south of the existing SENT Landfill (6.03 ha); LR14 – Plantation and topography in the south-east of the existing SENT Landfill (3.63 ha) and LR24 - Grass and topography on upper ridge east of TKO Area 137 (0.05 ha);on LCA1 – Fat Tong Reclamation

(15.64ha); and on LCA5 – Clear Water Bay Peninsula Coastal Uplands (6.29 ha).

There will be "Moderate" visual Impacts during the operation / restoration phase on Hikers on the High Junk Peak Trail (R2); Residential VSRs in the future Pak Shing Kok development (H1); Future Residents in Phase 2 of TKO new town (H2) and Future Residents in the TKO Area 86 development (H3); Boat Users and Workers in Vessels in the Tathong Channel (R15) and Residents in Siu Sai Wan (H5).

There will be "Slight" visual Impacts during the operation / restoration phase on Residential VSRs in the Tseung Kwan O New Town (H4); Recreational VSRs using the restored TKO Landfill site (R25) and Travellers on Wan Po Road (T3); Residents in Shek O (H9), Visitors to Shek O (R7), Residents in Cape Collison Correctional Institute (H11), and Hiker's on the Dragon's Back (R8); Workers in TKO Area 137 (O2); Visitors to Chai Wan Cemetery (East) (R14); Hikers on Pottinger Peak / Cape Collison (R13) and Visitors to TKO Cemetery and Devil's Peak (R20); Residents in Chai Wan (H6); Residents in Heng Fa Chuen (H7); Residents in Sha Kei Wan (West) (H8); Travellers at the eastern end of the Island Eastern Corridor (T1) and Travellers on the Future Cross Bay Link (T2) and Workers in Existing (and Planned) Phases of TKOIE (O1).

10.9.5 *Summary of Predicted Landscape and Visual Impacts in the Aftercare Phase*

Residual landscape impacts in the aftercare phase are listed in *Table 10.6d* and mapped in *Figures 10.6e* and *10.6h*. Residual visual impacts in the Aftercare Phase are listed in *Table 10.7a* and mapped in *Figure 10.7g*.

The potentially most significant impacts during the aftercare phase will be "Moderate" landscape impacts on LR23 - Shrubs and topography in lower ridge east of TKO Area 137 (6.24 ha) at day 1, reducing to "Slight" impacts at Year 10.

There will be "Slight" landscape impacts at Day 1 of the aftercare phase on LR11 - Trees and shrubs along lower hillside of Tin Ha Shan (2.81 ha); LR13 - Plantation and topography in south SENT Landfill (6.03 ha); LR14 – Plantation and topography in south-east SENT Landfill (3.63 ha); LR24 - Grass and topography on upper ridge east of TKO Area 137 (0.05 ha) and on LCA5 – Clear Water Bay Peninsula Coastal Uplands (6.29 ha).

There will be "Slight Positive" landscape impacts on LCA1 – Fat Tong Reclamation.

At Day1 of aftercare, all other Landscape Impacts will be "Insubstantial".

At Year 10 of aftercare, all Landscape Impacts will be reduced to "Insubstantial" (except for LCA1 – Fat Tong Reclamation, which will be "Slight Positive").

There will be "Slight" visual impact at Day 1 of the aftercare phase on Recreational VSRs using the restored SENT Landfill site (R1) and Hikers on the High Junk Peak Trail (R2); Residential VSRs in the future Pak Shing Kok development (H1); Future Residents in Phase 2 of TKO new town (H2) and Future Residents in the TKO Area 86 development (H3); Boat Users and Workers in Vessels in the Tathong Channel (R15); and residents in Siu Sai Wan (H5). At Year 10, Visual Impacts will be reduced in all cases to "Insubstantial".

10.9.6 Overall Conclusion

Overall, it is considered that, in the terms of *Annex 10* of the *EIAO-TM*, the landscape and visual impacts are <u>acceptable with mitigation measures.</u>

11 *ENVIRONMENTAL MONITORING AND AUDIT REQUIREMENTS*

11.1 *INTRODUCTION*

This *Section* describes the requirements for environmental monitoring and audit (EM&A) during the construction, operation, restoration and aftercare of the Extension. The objectives of carrying out EM&A include the following:

- to provide a database against which any short or long term environmental impacts of the Project can be determined;
- to provide an early indication should any of the environmental control measures or practices fail to achieve the acceptable standards;
- to monitor the performance of the Project and the effectiveness of mitigation measures;
- to verify the environmental impacts predicted in the EIA Study;
- to determine Project compliance with regulatory requirements, standards and government policies;
- to take remedial action if unexpected problems or unacceptable impacts arise; and
- to provide data to enable an environmental audit.

The implementation schedule, containing the recommended mitigation measures, monitoring and audit requirements, and implementation agent of the mitigation measures for the Project, is presented in *Annex E*. Details of the EM&A requirements are provided in a stand-alone *EM&A Manual*.

11.2 *ORGANISATION AND PERSONNEL OF THE EM&A*

The proposed organisation of all personnel involved in the EM&A process is illustrated in *Figure 11.2a*. The roles and responsibilities of the various parties involved in the EM&A process are detailed in the EM&A Manual, and summarised below:

- **Project Proponent**: Waste Facilities Group, Environmental Infrastructure Division, EPD.
- **Project Design, Construct and Operate**: Extension Contractor employed by the Project Proponent to carry out design, construction and operate the Extension.
- **Environmental Team (ET)**: The ET will be responsible for implementing all environmental measures and EM&A requirements recommended in

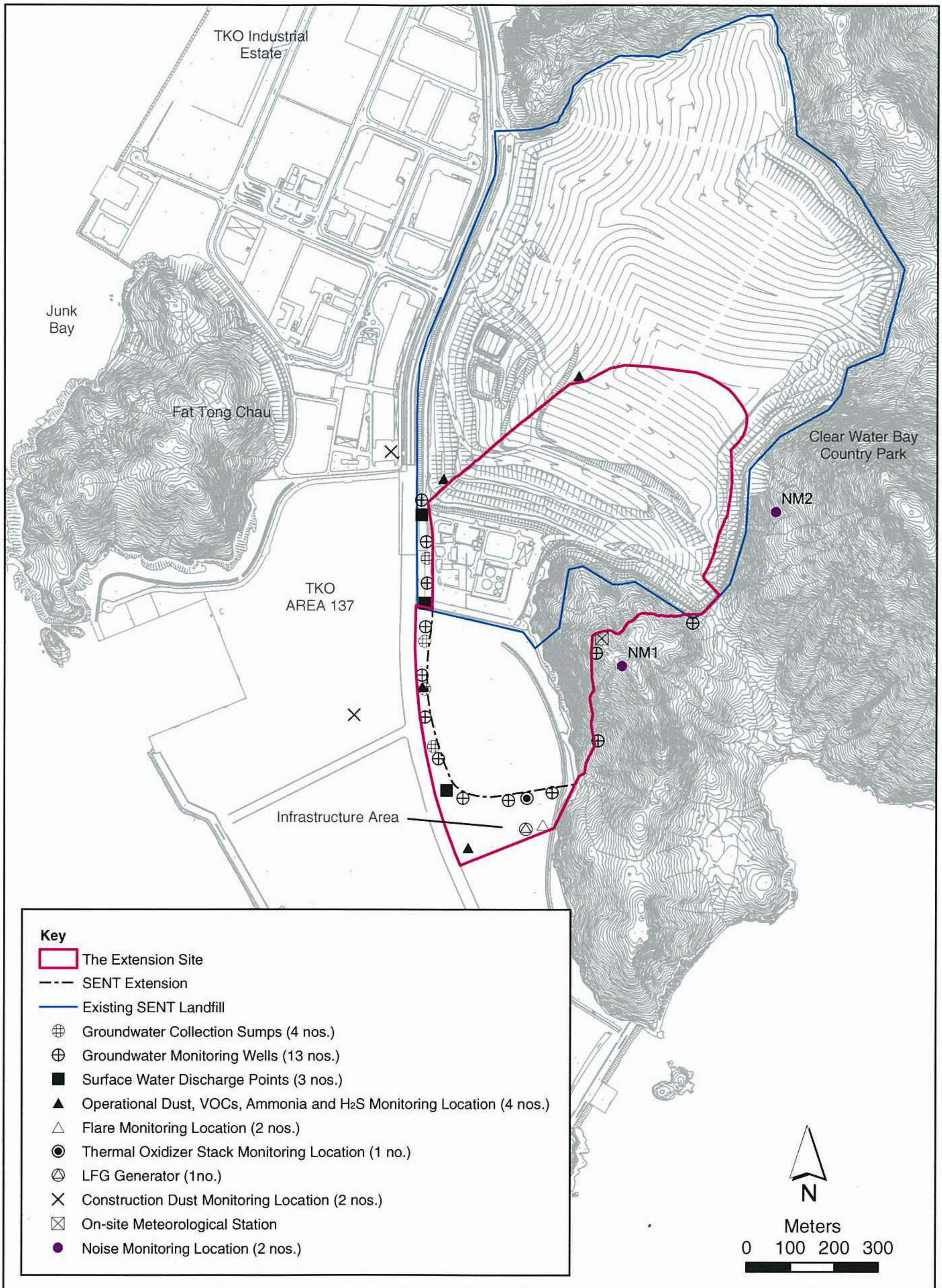


FIGURE 11.3a

Monitoring Location

File: 0036286_Monitoring_Location1.mxd
Date: 15/02/2007

Environmental Resources Management

ERM

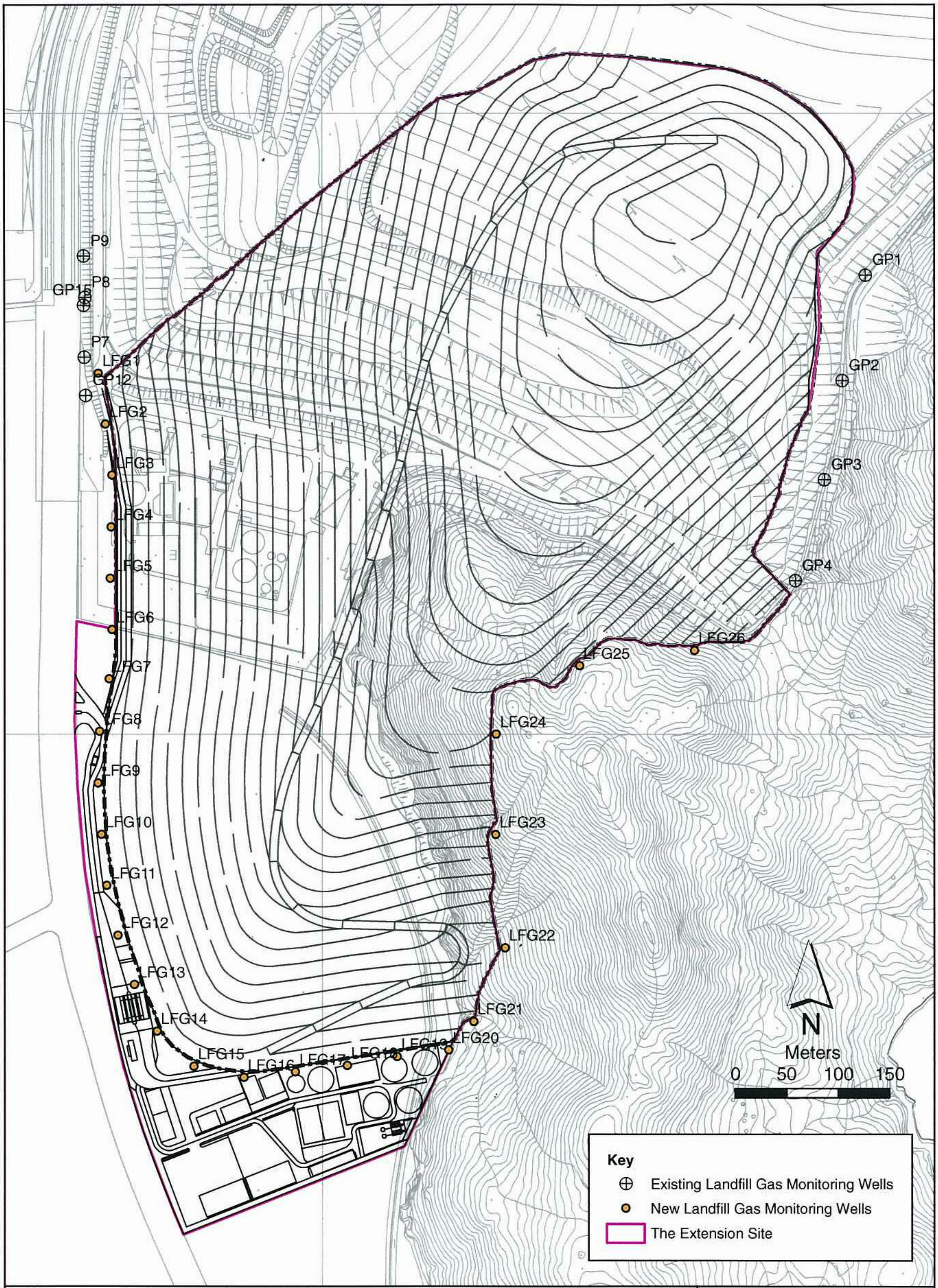


FIGURE 11.3b

Location of Landfill Gas Monitoring Wells

File: 0036286_Landfill_Gas_Monitoring_Wells.mxd
Date: 25/06/2007

Environmental Resources Management
ERM

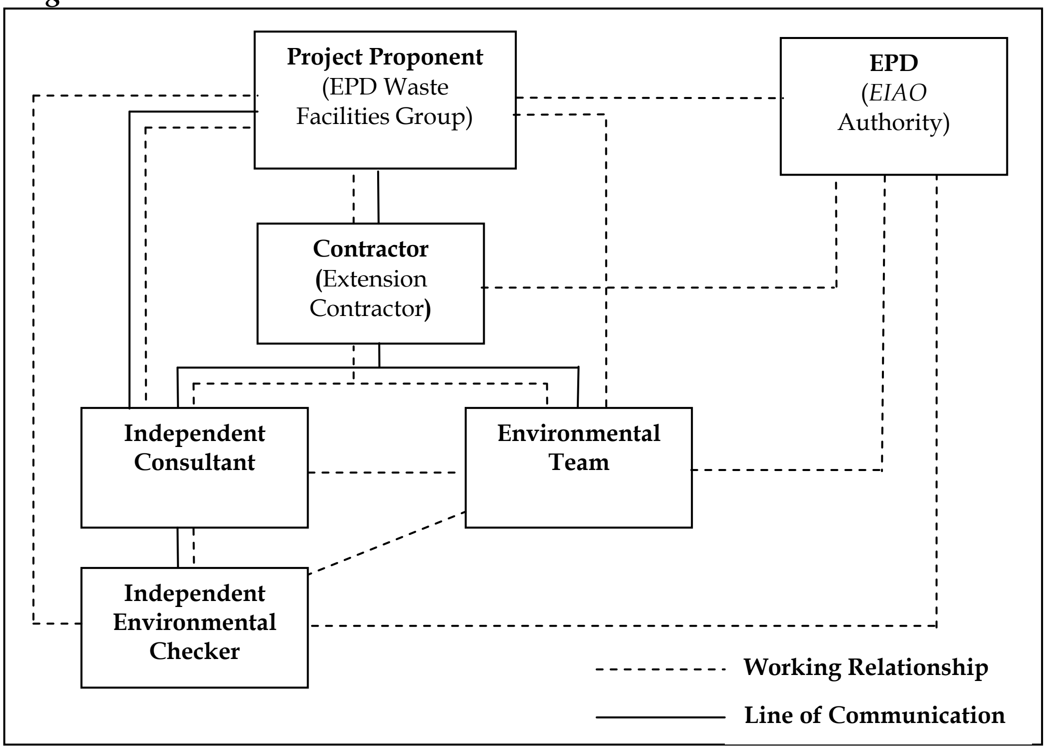
this *EIA Report* throughout the construction, operation, restoration and aftercare of the Extension, and report to the Extension Contractor on all environmental aspects of the Project. The ET can be a separate consultants employed by the Extension Contractor or the Contractor's in house environmental specialists.

- **Independent Consultant (IC)**: The IC will be appointed by the Project Proponent to provide an independent review and certification of the design, construction, operation, restoration and aftercare of the Extension.

- **Independent Environmental Checker (IEC)**: The IEC will be appointed by the Project Proponent as part of the IC to provide independent monitoring and audit to verify the overall environmental performance of the Project and to assess the effectiveness of the ET in their duties. An IEC will be responsible to certify all environmental submissions to the EPD.

- **EPD**: the *EIAO* Authority. The EPD will be the authority to approve all submissions under the *EIAO*.

Figure 11.2a Organisation Chart



11.3 MONITORING REQUIREMENTS

11.3.1 Construction Phase

Monitoring of dust, noise and surface water is required during the construction phase. Landfill gas, groundwater and organic emissions will also be monitored prior to the commencement of waste filling to establish the baseline conditions for these parameters. The details of the monitoring requirements are summarized in *Table 11.3a* and the monitoring locations are shown in *Figures 11.3a* and *11.3b*.

11.3.2 *Operation/Restoration Phase*

During the operation/restoration phase, leachate levels within the landfill, effluent discharged from the LTP, surface water discharged from the Extension Site, groundwater, dust, odour, noise, landfill gas, and organic emissions will be monitored at the designated monitoring locations. The details of the monitoring requirements are summarized in *Table 11.3a* and the monitoring locations are shown in *Figures 11.3a* and *11.3b*.

11.3.3 *Aftercare Phase*

Most of the monitoring requirements implemented during the operation/restoration phase should be continued. However, the number of monitoring locations and frequency of some monitoring aspects could be relaxed. The details of the monitoring requirements are summarized in *Table 11.3a* and the monitoring locations are shown in *Figures 11.3a* and *11.3b*.

Table 11.3a Summary of Monitoring Requirements

Environmental Aspect	Construction Phase			Operation/Restoration Phase			Aftercare Phase		
	Location	**Frequency**	**Parameters [a]**	**Location**	**Frequency**	**Parameters [a]**	**Location**	**Frequency**	**Parameters [a]**
Leachate	-	-	-	Leachate levels above the basal liner	Continuous	Leachate level	Leachate level above the basal liner	Continuous	Leachate level
				Effluent discharged from LTP	Each batch of discharge	volume, temperature, pH, COD, BOD, TOC, NH_4-N, nitrate-N, nitrite-N, total nitrogen, chloride, alkalinity, magnesium, calcium, potassium, iron, zinc, suspended solids, oil & grease, sulphate, copper, chromium, nickel, cadmium, phosphate and boron.	Effluent discharge from LTP	Each batch of discharge	volume, temperature, pH, COD, BOD, TOC, NH_4-N, nitrate-N, nitrite-N, total nitrogen, chloride, alkalinity, magnesium, calcium, potassium, iron, zinc, suspended solids, oil & grease, sulphate, copper, chromium, nickel, cadmium, phosphate and boron.
				Stack of Thermal Oxidizer	Monthly for the first 12 months and thereafter at quarterly intervals	NO_2, CO, SO_2, benzene and vinyl chloride and NMOC	-	-	-
				Stack of Thermal Oxidizer	During commissioning of the thermal oxidizer	Ammonia	-	-	-

Environmental Aspect	Construction Phase			Operation/Restoration Phase			Aftercare Phase		
	Location	**Frequency**	**Parameters [(a)]**	**Location**	**Frequency**	**Parameters [(a)]**	**Location**	**Frequency**	**Parameters [(a)]**
				Stack of Thermal Oxidizer	Continuously	Gas combustion temperature, exhaust gas temperature and exhaust gas velocity	-	-	-
Landfill Gas	All perimeter landfill gas monitoring wells	Monthly, for a period 12 months prior to waste filling (act as baseline monitoring)	Methane, carbon dioxide, oxygen (%v/v)	All perimeter landfill gas monitoring wells	Weekly for monitoring wells in the areas where there is development within 250m of the Extension Site boundary. Monthly for other monitoring wells.	Methane, carbon dioxide, oxygen (%v/v), atmospheric pressure	All perimeter landfill gas monitoring wells	Weekly for monitoring wells in the areas where there is development within 250m of the Extension Site boundary. Monthly for other monitoring wells.	Methane, carbon dioxide, oxygen (%v/v), atmospheric pressure
				At least 2 perimeter landfill gas monitoring wells	Quarterly	Laboratory analysis for methane, oxygen, nitrogen, carbon dioxide, carbon monoxide and other flammable gases using gas chromatography	At least 2 perimeter landfill gas monitoring wells	Quarterly	Laboratory analysis for methane, oxygen, nitrogen, carbon dioxide, carbon monoxide and other flammable gases using gas chromatography
				Permanent gas monitoring system in all occupied on-site buildings	Continuous	Methane (or flammable gas), (%v/v)	Permanent gas monitoring system in all occupied on-site buildings	Continuous	Methane (or flammable gas), (%v/v)

Environmental Aspect	Construction Phase			Operation/Restoration Phase			Aftercare Phase		
	Location	**Frequency**	**Parameters [a]**	**Location**	**Frequency**	**Parameters [a]**	**Location**	**Frequency**	**Parameters [a]**
				Areas between the Extension Site boundary and the waste boundary (surface emission) and location of vegetation stress	Quarterly	Flammable gas	Areas between the Extension Site boundary and the waste boundary (surface emission)	Quarterly	Flammable gas
				Service voids, utilities pits and manholes along the Site boundary and within the Extension Site	Monthly	Oxygen, methane and carbon dioxide	Service voids, utilities pits and manholes along the Site boundary and within the Extension Site	Monthly	Oxygen, methane and carbon dioxide
				Landfill gas flare(s)	Monthly for the first 12 months and thereafter at quarterly interval	NO_2, CO, SO_2, benzene, vinyl chloride and NMOC	Landfill gas flare(s)	Quarterly	NO_2, CO, SO_2, benzene, vinyl chloride and NMOC
				Landfill gas flare(s)	Continuously	Gas combustion temperature, exhaust gas temperature and exhaust gas velocity	Landfill gas flare(s)	Continuously	Gas combustion temperature, exhaust gas temperature and exhaust gas velocity
				LFG Generator Stack	Monthly, for a period of 12 months of operation and thereafter at quarterly	NO_2, CO, SO_2	LFG Generator Stack	Quarterly, throughout aftercare phase	NO_2, CO, SO_2

Environmental Aspect	Construction Phase			Operation/Restoration Phase			Aftercare Phase		
	Location	Frequency	Parameters [(a)]	Location	Frequency	Parameters [(a)]	Location	Frequency	Parameters [(a)]
					intervals				
Surface Water	All surface water discharge points	Weekly, throughout construction phase	pH, SS, DO	All surface water discharge points	Monthly	pH, SS, COD, NH_4-N EC, DO, BOD, TOC, carbonate, bicarbonate, nitrate-N, nitrite-N, total nitrogen, oil & grease, sulphate, sulphide, phosphate, chloride, sodium, potassium, calcium, magnesium, nickel, manganese, chromium, cadmium, copper, lead, iron, zinc, mercury and boron.	All surface water discharge points	Monthly	pH, SS, COD, NH_4-N EC, DO, BOD, TOC, carbonate, bicarbonate, nitrate-N, nitrite-N, total nitrogen, oil & grease, sulphate, sulphide, phosphate, chloride, sodium, potassium, calcium, magnesium, nickel, manganese, chromium, cadmium, copper, lead, iron, zinc, mercury and boron.
Groundwater	All groundwater monitoring wells	Monthly, for a period 12 months prior to waste filling (act as baseline monitoring)	Water level, pH, EC, COD, BOD, TOC, carbonate, bicarbonate, NH_4-N, nitrate-N, nitrite-N, TKN, total nitrogen, sulphate, sulphide, chloride, sodium, potassium,	All groundwater monitoring wells	Monthly	Water level, pH, EC, COD, BOD, TOC, carbonate, bicarbonate, NH_4-N, nitrate-N, nitrite-N, TKN, total nitrogen, sulphate, sulphide, chloride, sodium, potassium,	All groundwater monitoring wells	Monthly	Water level, pH, EC, COD, BOD, TOC, carbonate, bicarbonate, NH_4-N, nitrate-N, nitrite-N, TKN, total nitrogen, sulphate, sulphide, chloride, sodium, potassium,

Environmental Aspect	Construction Phase			Operation/Restoration Phase			Aftercare Phase		
	Location	Frequency	Parameters (a)	Location	Frequency	Parameters (a)	Location	Frequency	Parameters (a)
			calcium, magnesium chromium, cadmium, zinc, copper, lead, nickel, manganese, iron, mercury and boron.			calcium, magnesium chromium, cadmium, zinc, copper, lead, nickel, manganese, iron, mercury and boron.			calcium, magnesium chromium, cadmium, zinc, copper, lead, nickel, manganese, iron, mercury and boron.
	-	-	-	Groundwater collection sumps	Monthly	pH, EC, COD, BOD, TOC, carbonate, bicarbonate, NH_4-N, nitrate-N, nitrite-N, TKN, total nitrogen, sulphate, sulphide, chloride, sodium, potassium, calcium, magnesium chromium, cadmium, zinc, copper, lead, nickel, manganese, iron, mercury and boron	Groundwater collection sumps	Monthly	pH, EC, COD, BOD, TOC, carbonate, bicarbonate, NH_4-N, nitrate-N, nitrite-N, TKN, total nitrogen, sulphate, sulphide, chloride, sodium, potassium, calcium, magnesium chromium, cadmium, zinc, copper, lead, nickel, manganese, iron, mercury and boron
Dust	At two air sensitive receiver (ASRs)	Once every 6 days, throughout construction phase	24-hr TSP	Along Extension Site boundary	Once every 6 days, throughout operation/ restoration phase	24-hr TSP	Along Extension Site boundary	Once every 6 days when there are major maintenance works	24-hr TSP

Environmental Aspect	Construction Phase			Operation/Restoration Phase			Aftercare Phase		
	Location	**Frequency**	**Parameters [a]**	**Location**	**Frequency**	**Parameters [a]**	**Location**	**Frequency**	**Parameters [a]**
Noise	At two monitoring location near the Extension Site boundary	Weekly	$L_{Aeq\ 30\ min}$	At two monitoring location near the Extension Site boundary	Weekly	$L_{Aeq\ 30\ min}$	At two monitoring location near the Extension Site boundary	Weekly when there are major maintenance works	$L_{Aeq\ 30\ min}$
Ambient VOCs, Ammonia and Hydrogen Sulphide	Along Extension Site boundary	Quarterly, for a period 12 months prior to waste filling (act as baseline monitoring)	A suite of VOCs, ammonia and hydrogen sulphide	Along Extension Site boundary	Quarterly, throughout operation/ restoration phase	A suite of VOCs, ammonia and hydrogen sulphide	Along Extension Site boundary	Quarterly, throughout aftercare phase	A suite of VOCs, ammonia and hydrogen sulphide
Odour	-	-	-	Patrol along Extension Site boundary	Daily, three times a day by ET and IEC Three times per week on different days conducted by an independent third party together with the ET and the IEC	Odour intensity	Patrol along Extension Site boundary	Weekly when there are maintenance works required excavation of waste	Odour intensity
Meteorological Condition				Meteorological Station	Continuously	Wind speed, wind direction, air temperature, rainfall and relative humidity	Meteorological Station	Continuously	Wind speed, wind direction, air temperature, rainfall and relative humidity

Note:
(a) Chemical abbreviations: BOD = biological oxygen demand; CO = carbon monoxide; COD = chemical oxygen demand; DO = dissolved oxygen; EC = electrical conductivity; NH_4-N = ammoniacal-nitrogen; nitrate-N = nitrate nitrogen; nitrite-N = nitrite-nitrogen; NMOC = non-methane organic compound; NO_2 = nitrogen dioxide; RSP = respirable suspended particulates; SS = suspended solids; TKN = Total Kjeldahl nitrogen; TOC = total organic carbon; TSP = total suspended particulates; VOCs = volatile organic compounds.

11.4 AUDIT REQUIREMENTS

11.4.1 *Construction Phase*

Weekly site audits will be undertaken jointly by the Extension Contractor, the IEC and the site representative of the Project Proponent during the construction phase to ensure that the proposed mitigation measures and good site practices are implemented.

During the preparation of the detailed landscape design plan, the design submission will be audited against the recommendation proposed in this *EIA Report* by the landscape architect from the IEC.

11.4.2 *Operation/Restoration Phase*

Weekly site audits will be undertaken to ensure the proposed environmental mitigation measures are implemented. The audit will cover the aspects on the management of dust, odour, noise, surface water and effluent discharge from the LTP, waste management and landfill gas. The audits will be undertaken jointly by the Extension Contractor and the IEC.

The condition of the restoration plantation will be audited at monthly intervals by a Registered Landscape Architect from the IEC.

11.4.3 *Aftercare Phase*

The restoration plantation will be audited quarterly by the Registered Landscape Architect from the IEC.

12 CONCLUSIONS AND SUMMARY OF ENVIRONMENTAL OUTCOMES

12.1 INTRODUCTION

This *Section* summarises the environmental outcomes associated with the construction, operation, restoration and aftercare of the Extension.

12.2 AIR QUALITY

12.2.1 Construction Phase

Potential dust nuisance from construction activities and gaseous emissions from construction plant have been evaluated. With the implementation of the recommended standard dust control measures and good construction site practices, it is not anticipated that the construction of the Extension will cause adverse dust or air quality impacts.

12.2.2 Operation/Restoration Phase

The following potential air quality impacts have been evaluated:

- Gaseous emissions from the LFG flares, LTP and LFG generator;
- Odour and dust from the landfill operation;
- Volatile organic compounds (VOCs) from landfill gas emissions from the landfill's surface.

Landfill Gas Treatment Facility, Leachate Treatment Plant and LFG Generator

The principal pollutants of concern that could be emitted from the operation of the landfill gas treatment facility, leachate treatment plant and generator are nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), benzene and vinyl chloride. The concentrations of these pollutants predicted due to emissions from these two plants and generator are within the relevant assessment criteria at air sensitive receivers (ASRs).

Landfill Operations

The design of the Extension has incorporated a stringent odour control management system. Good site practices and housekeeping measures will be stipulated in the operation contract.

With the exception of those ASRs in the immediate vicinity of the boundary of the Extension, no exceedances of the odour criterion were predicted with the implementation of the odour management and control system. Residual impacts were predicted in a small area zoned for industrial development covering part of TKO Area 137 and TVB City adjacent to the Extension boundary.

The frequency of the exceedances at TVB City will be reduced through the rephasing of waste tipping activity (1). Over the six year operation period, the number of exceedances at TVB City is expected to diminish to zero as the separation distances and heights between the active tipping face and the ASRs increase. It should be noted that the odour emission rate adopted in the assessment are considered to be conservative. For example, no sludge from sewage treatment works will be received in the Extension and the emission rate used for the special waste trench allowed for the presence of sludge. It is anticipated that the actual odour level and number of exceedances will be much less than that predicted in this assessment. The residual impacts are considered acceptable taking account of (i) the nature of the developments affected, (ii) the small number of people impacted, and (iii) the transient nature, low frequency and magnitude of the exceedances.

VOCs from Landfill Gas

The VOC emissions from the Extension are not envisaged to cause adverse air quality impact at ASRs. Monitoring data from the existing SENT Landfill indicate that the ambient VOC concentrations are low at the site boundary and that levels are within the trigger values specified in the Contract. Similar types of waste will be received at the Extension and the operation of the Extension will be similar to the existing SENT Landfill. However, the Extension Site will also use an impermeable liner to cover waste and areas not in use and will have a more comprehensive landfill gas collection system. VOC emissions are therefore likely to be lower at the Extension Site. It is therefore not envisaged that the operation of the Extension will cause adverse air quality impacts to the identified ASRs with respect to potential VOC emissions.

12.2.3 Aftercare Phase

During the aftercare phase, air emission sources are primarily associated with the LFG flares and the generator. The Extension will be sealed with a capping system (including an impermeable liner) and LFG will be extracted to be flared or utilised. The vent gas produced in the enclosed tanks will be either diverted to the flares or to an air scrubber prior to discharge to the atmosphere. Odour sources will be limited to the SBR tanks of the LTP. As the emission strength and scale of the Extension operation during this phase are significantly reduced when compared to the operation/restoration phase, no adverse odour impact is anticipated.

12.2.4 EM&A Requirements

It is recommended that dust should be monitored during the construction phase. For the operation/restoration phase, dust, ambient VOCs, ammonia and H_2S, stack emissions from the flares, thermal oxidizer and LFG generator, and meteorological condition will be monitored. In addition, regular odour patrols along the Extension Site boundary will be required. During the

(1) No waste tipping activity at the northern sector of the Extension between July and November.

aftercare phase, the most of the monitoring requirements for the operation/restoration phase will be continued, except for the monitoring of the emission from the thermal oxidiser. Dust and odour patrols, which will only be required if there are major maintenance works at the Extension.

It is recommended that weekly site audits be carried out during the construction and operation/restoration phases to determine if the site activities are being managed in accordance with the recommended good site practices and mitigation measures.

12.3 NOISE

12.3.1 Construction/Restoration Phases

The predicted construction noise levels at the identified noise sensitive receivers (NSRs) range from 37 dB(A) to 59 dB(A). These levels are well below the noise criterion of 75 dB(A) for domestic premises. Hence, NSRs will not be adversely affected by the construction/restoration of the Extension. However, it is recommended that good construction site practices should be implemented by the Contractor to further minimise the noise impact.

12.3.2 Operation Phase

Sources of noise during operations include:

- Landfilling operations (eg operation of compactor vehicles and bulldozers);
- Fixed plant (eg the LTP and LFG treatment facility); and
- Off-site traffic for the delivery of waste.

On-Site Operations

The levels of noise generated by the operation of landfilling and fixed plant items are predicted to be between 41 dB(A) and 53 dB(A) during daytime and 33 dB(A) and 47 dB(A) during night-time at the NSRs. These levels are well below the day-time criterion of 60 dB(A) and night-time criterion of 50 dB(A) as set out in the *Technical Memorandum on Noise From Places Other Than Domestic Premises, Public Places or Construction Sites*.

Traffic Noise

The levels of façade traffic noise along Wan Po Road, Chiu Shun Road and the future Cross Bay Link have been predicted. The contribution to noise levels due to the traffic associated with the Extension is predicted to be less than 0.4 dB(A) in 2018. In view of the fact that the noise contribution due to the Extension is less than 1.0 dB(A), the noise impact from the Extension traffic is considered insignificant.

While no adverse noise impacts are expected during the operational phase of the Extension, it is recommended that good site practices be implemented to further minimise any impact.

12.3.3 *Aftercare Phase*

The aftercare of the restored Extension will involve limited construction works and is expected to have an insignificant noise impact compared with the construction, operation and restoration of the Extension, for which noise levels were already predicted to be within relevant criteria. The LTP and LFG treatment plant will continue to operate during the aftercare period and the predicted noise levels at the NSRs due to the operation of these plants are well within the criteria set out in the *Technical Memorandum on Noise From Places Other Than Domestic Premises, Public Places or Construction Sites.* Noise impact during the aftercare phase is anticipated to be negligible.

12.3.4 *EM&A Requirements*

It is recommended that weekly site audits be carried out during the construction and operation/restoration phases to determine if the site activities are being managed in accordance with the recommended good site practices and mitigation measures.

12.4 *WATER QUALITY*

12.4.1 *Construction Phase*

Potential sources of impacts to water quality during the construction phase are construction runoff and sewage generated by the workforce. With the implementation of the mitigation measures set out in the EIA and good construction site practices, there will be no adverse impacts to the receiving water bodies.

12.4.2 *Operation/Restoration Phase*

Potential sources of impact on water quality during the operation/restoration phase include uncontrolled discharge of leachate from the active tipping area into the surface water drainage system, sub-surface off-site migration of leachate into groundwater and marine water through any defects in the landfill liner and discharge of improperly treated effluent from the LTP.

The hydrogeological assessment concludes that, while the landfill cap remains intact and leachate control is maintained, there will be no adverse impacts on groundwater quality. Even in the very long term (on a timescale of several hundred years), when the landfill cap degrades and the active leachate control system can no longer performs its full function, the potential impacts on groundwater quality are predicted to be slight. Under such conditions, the quality of groundwater discharges to Junk Bay would still be expected to comply with the effluent discharge standards set out in the *Water Pollution Control Ordinance*.

A temporary surface water drainage system will be constructed around the active tipping area to prevent stormwater from entering the landfill, and to prevent contaminated rainwater from discharging off-site. Contaminated runoff will be collected by this system and treated with the leachate. A comprehensive leachate containment system will be installed to contain leachate generated from the landfill. Construction quality control / quality assurance procedures will be implemented to ensure that joints are properly sealed and to avoid damage to the impermeable liner during construction of this system.

Leachate and sewage collected from the Extension will be treated at the on-site leachate treatment plant. Treated effluent will be discharged to the public sewer and conveyed to the Government treatment works for further treatment. Treated effluent entering the sewer will comply with the effluent discharge standards set out in the *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Inshore Waters*. There will be no adverse water quality impact.

12.4.3 Aftercare Phase

Potential sources of impacts to water quality during the aftercare phase are:

- Sub-surface migration of leachate off site and into groundwater and marine water; and
- Discharge of improperly treated effluent from the leachate treatment works.

In the very long term, the potential impacts on groundwater quality are predicted to be slight from both these sources.

Leachate collected from the restored landfill will be treated to comply with effluent discharge standards as set out in the *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Inshore Waters* for discharge to foul sewer leading to a sewage treatment works. No adverse water quality impact is anticipated.

12.4.4 EM&A Requirements

It is recommended that weekly site audits be carried out during the construction and operation/restoration phases to determine if the site activities are being managed in accordance with the recommended good site practices and mitigation measures. Monitoring of surface water and groundwater quality and effluent discharged from the LTP has been recommended.

12.5 WASTE MANAGEMENT

12.5.1 *Construction Phase*

The key potential impacts during the construction phase are related to wastes generated from site clearance, site formation, demolition of the existing SENT Landfill infrastructure and construction of new infrastructure for the Extension.

It is estimated that approximately 1.1 Mm^3 of excavated materials (eg soil and rock) will be generated by the construction works, mainly from the slope formation works. Some of these excavated materials will be reused on-site for the site formation work and the landfill operation itself. The remaining excavated materials (approximately 517,000 m^3) will be disposed off site. The construction of the Extension will require fill material to be imported onto the site. These materials could be obtained from local construction industries, Construction and Demolition Material Handling Facilities and the quarry, subject to review and the prevailing operational condition at these facilities.

It is estimated that approximately 2,800 m^3 of inert construction and demolition material will be generated from the construction and demolition of the existing infrastructure. These materials will be reused on-site as fill material and in miscellaneous engineering works.

Approximately 1,500 tonnes of construction waste will be generated from site clearance works and about 700 m^3 of construction waste will be generated from the construction and demolition of infrastructure. Construction waste will be disposed of at the existing SENT Landfill. A small amount of chemical waste (less than a hundred litres per month), sewage (about 25.5 m^3 per day) and general refuse (about 110.5 kg per day) will be generated during the construction phase.

With the implementation of standard good construction site practices, the construction of the Extension will not cause adverse waste management or environmental impacts.

12.5.2 *Operation/Restoration Phase*

It is estimated that dewatered sludge (maximum of about 4.9 m^3 per day at 30% dry solids), chemical waste (less than a hundred litres per month), sewage (22.5 m^3 per day) and general refuse (97.5 kg per day) will be generated during the operation/restoration phase. With good site practices, the storage, handling, collection, transport and disposal of waste arising from the operation and restoration of the Extension will meet the requirements set out in the *EIAO-TM.* No adverse waste management impacts are anticipated.

12.5.3 *Aftercare Phase*

A small quantity of dewatered sludge (about 0.33 m^3 per day), sewage (3 m^3 per day) and general refuse (13 kg per day) will be generated during the aftercare of the Extension. While the sewage will be treated in the leachate treatment plant, the sludge and general refuse will require off-site disposal at other waste disposal facilities.

With good site practices, the potential environmental impacts associated with the storage, handling, collection, transport and disposal of the small quantity of waste arising from the aftercare of the Extension will be within acceptable limits set out in the *EIAO-TM*. No adverse waste management impacts are anticipated.

12.5.4 *EM&A Requirements*

It is recommended that weekly audits of the waste management practices be carried out during the construction and operation/restoration phases to determine if wastes are being managed in accordance with the recommended good site practices. Audits of waste management practices during the aftercare phase are not considered necessary given that the amount of waste to be handled is small.

12.6 *LANDFILL GAS HAZARD*

The potential hazards associated with sub-surface migration of landfill gas from the existing SENT Landfill to the Extension and from the Extension to the adjacent existing and future developments have been assessed. Both the existing SENT Landfill and the Extension are considered as a "medium" source due to the comprehensive and proven landfill gas control measures installed or to be installed. The source-pathway-target analysis shows that landfill gas risk posed by the SENT Landfill and the Extension is medium to high during both the construction and operation phases within the Extension. The risk posed by the Extension to the adjacent developments ranges from very low to low, depending on the nature and location of the these developments.

In general, underground rooms or voids should be avoided as far as practicable in the design of the Extension infrastructure area. Other precautionary and protection measures during construction, design and operation/restoration phases of the Extension have been recommended. It is expected that with the proposed precautionary measures in place, the potential risk of landfill gas migration to the respective targets will be minimal. Regular monitoring of landfill gas in the perimeter landfill gas monitoring wells and service voids within the Extension Site and the along the Site boundary will be undertaken to ensure that no unacceptable off-site migration of landfill occurs.

12.6.1 *EM&A Requirements*

The Extension Contractor will be required to undertake regular monitoring of landfill gas along the Extension boundary as required by the Contract Specification.

12.7 ECOLOGY

The terrestrial and aquatic ecological resources recorded within the Study Area (including the Extension Site and the 500m buffer area) include plantation, shrubland, grassland, developed area, seasonal stream and subtidal habitats, as well as associated wildlife. Of these habitats, shrubland has a moderate ecological value, whilst other habitats are of low or low to moderate ecological value. The ecological value of the developed area is negligible.

The majority of the proposed Extension will be located in habitats which are already disturbed/developed, including the existing SENT Landfill and the fill bank in TKO Area 137. The proposed Extension will encroach into a small strip (approximately 5 ha) of the CWBCP, comprising shrubland and grassland habitats of low to moderate ecological value. The potential impacts on these habitats within the CWBCP are considered to be low to moderate. With the implementation of the recommended mitigation measures, no adverse residual impact is expected. There are no marine works involved and no marine habitats and species will be affected.

A survey recorded 11 wildlife species of conservation interest (including birds, butterflies, bat and reptile) at the Extension Site. As these species are highly mobile and as there is a large extent of similar habitat in the vicinity of the Extension, the impacts on wildlife are considered to be minimal.

The EIA sets out mitigation measures to reduce ecological impacts. These include the adoption of surface water, groundwater, leachate and landfill gas management systems, good construction practices and provision of compensatory planting. These measures will reduce potential disturbance to the surrounding environment and will also help provide a habitat of higher ecological value than that of the existing site once the restoration works are complete.

12.7.1 EM&A Requirements

It is recommended that weekly site audits be carried out during the construction and operation/restoration phases to determine if the site activities are being managed in accordance with the recommended good site practices and mitigation measures.

12.8 LANDSCAPE AND VISUAL IMPACT

With mitigation measures in place, the landscape impacts would range from "insubstantial" to "substantial" at landscape resources during the construction phase. The landscape impacts will be reduced to "insubstantial to moderate" during the operation/restoration phase and further reduced to "insubstantial to slight" at year 10 of the aftercare phase when the restored landscape is fully mature. There will be "Slight positive" landscape impacts on the reclaimed TKO Area 137.

Most of the sensitive residential receivers are relatively distant from the Extension (ie greater than 1.6 km). With mitigation measures in place, the visual impacts to the sensitive residential receivers would range from "Insubstantial" to "slight" during the construction phase and slightly worsen to "Insubstantial to moderate" during the operation/restoration phase as the volume and height of the landfill gradually increase. During the aftercare phase, the impact will be reduced to "Insubstantial to slight" on day 1 of the aftercare phase, when landfilling operations have ceased; and further reduced to "Insubstantial" as the landscape restoration gradually matures.

12.8.1 EM&A Requirement

It is recommended that EM&A for landscape and visual resources is undertaken during the design, construction, operation and restoration/ aftercare phases of the Extension. The design, implementation and maintenance of landscape mitigation measures should be checked to ensure that they are fully realised and that potential conflicts between the proposed landscape measures and any other Extension works and operational requirements are resolved at the earliest possible date and without compromise to the intention of the mitigation measures. In addition, implementation of the recommended mitigation measures should be monitored through the site audit programme.

12.9 OVERALL CONCLUSION

The environmental impact assessment has concluded that no unacceptable environmental impacts are envisaged as a result of the construction, operation, restoration and aftercare of the Extension, provided that the recommended mitigation measures are implemented. It is predicted that there will be a residual odour impact on air sensitive receivers in the immediate vicinity of the Extension Site boundary. Taking account of the nature of the developments affected, the number of people impacted, the transient nature, low frequency and magnitude of the exceedances, the residual impacts are considered acceptable.

12.10 KEY ENVIRONMENTAL OUTCOMES

12.10.1 Population and Environmentally Sensitive Areas Protected

The EIA has concluded that residual impacts are only related to odour while other environmental impacts are found to be acceptable.

With the implementation of good odour management practices and control measures at the Extension, the population in the TKO Town are effectively protected from landfill odour.

12.10.2 *Environmentally Friendly Design and Benefits*

Environmentally Friendly Design

The environmental friendly design features of the Extension include:

- Double-liner system at the base of the landfill to ensure full containment of leachate and LFG and to prevent off-site migration.
- Comprehensive leachate and LFG management systems to contain, collect and treat leachate and LFG in a safe manner without polluting the environment.
- A comprehensive surface water management system to prevent contaminated runoff entering the surrounding environment while preventing clean surface water from the surrounding environment entering the landfill site.

Environmental Benefits

As each of the three strategic landfills plays an important integral part of the waste management strategy in Hong Kong, it is important to extend the life of SENT Landfill for as long as possible. When the SENT Landfill is closed, refuse collection vehicles from the SENT Landfill catchment will be required to travel to the NENT and WENT Landfills located in more remote areas in the New Territories for waste disposal, resulting in additional traffic and related environmental impacts. The Extension will thus be important to maintain efficiency of the current disposal pattern and to avoid causing additional environmental impacts. Its development will provide the Government with more time to plan, develop and assess the environmental impacts of a new waste management facility to replace the SENT Landfill.

The Extension Site is currently occupied by developed land and a hillslope in the CWBCP, neither are easily accessible nor used by the public. When the Extension is restored, it can provide around 50 ha of space for the development of beneficial afteruse(s), eg recreational uses, linkage to the CWBCP and providing access from the TKO area to the High Junk Peak Hiking Trail etc. This could enhance the opportunity for the public to enjoy the environmental resources in the vicinity.

12.10.3 *Key Environmental Problem Avoided*

The design and operation of the landfill has incorporated stringent odour management and control system to avoid odour impact to residential populations. The design described in *Section 12.10.2* will avoid leachate, LFG and contaminated water from migrating off-site affecting the nearby environment.

12.10.4 Environmental Protection Measures and Precautionary Measures

Mitigation measures and good site practices have been recommended through the impact assessment to minimise the potential impacts to the environment. The Extension will unavoidably impact a small area of natural habitat comprising shrubland and grassland of low to moderate ecological value. Compensation of woodland plantation with native species on the restored Extension has been recommended to provide a habitat of higher ecological value.