工程項目簡介
PROJECT PROFILE

ASB Biodiesel (Hong Kong) Limited

Development of a Biodiesel Plant at Tseung Kwan O Industrial Estate
將軍澳工業邨生物柴油廠發展計劃

Project Profile
工程項目簡介

24th September 2007
二OO七年九月二十四日

Environmental Resources Management
香港環境資源管理顧問有限公司
21/F Lincoln House
Taikoo Place 979 King's Road
Island East Hong Kong
香港英皇道九七九號
太古坊林肯大廈二十一樓
Telephone 電話 2271 3000
Facsimile 傳真 2723 5660

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Environmental Resources Management
21/F Lincoln House
979 King's Road
Taikoo Place
Island East, Hong Kong
Telephone: (852) 2271 3000
Facsimile: (852) 2723 5660
E-mail: post.hk@erm.com
http://www.erm.com

ASB Biodiesel (Hong Kong) Limited

Development of a Biodiesel Plant at Tseung Kwan O Industrial Estate

September 2007

For and on behalf of
ERM-Hong Kong, Limited

Approved by: Andrew Jackson

Signed:

Position: Managing Director

Date: 24th September 2007

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1 BASIC INFORMATION

1.1 PROJECT TITLE

Development of a biodiesel plant at Tseung Kwan O Industrial Estate

1.2 NAME OF PROJECT PROPONENT

ASB Biodiesel (Hong Kong) Limited

1.3 NAME AND TELEPHONE NUMBERS OF CONTACT PERSONS

Mr Sjouke Postma

Managing Director, ASB Biodiesel (Hong Kong) Limited

Tel: 2251 8997

1.4 PURPOSE AND NATURE OF THE PROJECT

The Project Proponent proposes to construct and operate a 100,000 tonnes per annum (tpa) biodiesel plant in Tseung Kwan O Industrial Estate (TKOIE) using a multi-feedstock which consists of waste cooking oil (WCO), oil and grease recovered from grease trap waste (GTW), Palm Fatty Acid Distillate (PFAD) (1) and animal fats. The proposed biodiesel plant not only offers a convenient disposal outlet to the GTW and WCO but also converts the oil and grease recovered from these wastes into useful products. The Project also offers cleaner alternative diesel fuel to the Hong Kong market.

1.5 LOCATION OF PROJECT

The proposed biodiesel plant will be located at the Chun Wang Street within the TKOIE. *Figure 1.5a* shows the location of the proposed biodiesel plant.

1.6 PURPOSE OF THIS PROJECT PROFILE

The proposed biodiesel plant and the associated GTW pre-treatment facility are classified as a Designated Project (DP) under:

- Schedule 2, Part I, Item G.4(b) (ie waste disposal facility or activity for industrial or special waste); and
- Schedule 2, Part I, Item K.6 (Chemical plant with a storage capacity of more than 500 tonnes and in which substances are processed or produced).

(1) PFAD is a fatty acid by-product of a palm oil refinery process. It is a liquid at about 60-80°C.

Under the *Environmental Impact Assessment Ordinance* (EIAO*)*, an Environmental Permit (EP) will be required for the construction and operation of the biodiesel plant (the Project).

This Project Profile is prepared for application for approval to apply directly for an EP for the Project under Section 5(10) of the *EIAO*. It describes the scope of Project, assesses the potential environmental impacts associated with the Project and recommends mitigation measures to minimise the potential environmental impacts. It demonstrates that the potential environmental impacts of the Project and the mitigation measures described in this Project Profile meet the requirements of the *Technical Memorandum on Environmental Impact Assessment Process* (EIAO-TM).

2 *PROJECT INFORMATION*

2.1 *INTRODUCTION*

Biodiesel is a diesel fuel substitute produced from renewable sources such as vegetable oils, animal fats, and recycled oil and grease (ie WCO and oil and grease recovered from GTW (hereafter is referred to as trap grease). Chemically, it is defined as the mono alkyl esters derived from renewable sources. Biodiesel is typically produced through the reaction of a vegetable oil or animal fat (typically made of triglycerides which are esters of fatty acids with glycerine) with methanol or ethanol in the presence of a base-catalyst to produce glycerine and biodiesel (chemically called methyl or ethyl esters). It is a clear liquid at room temperature and its colour depends on the feedstock. Biodiesel can be used alone or mixed in any ratio with petroleum diesel fuel for use in the diesel engines. Biodiesel has similar physical and chemical properties to petroleum diesel with reference to the operation of a diesel motor.

Biodiesel is gaining recognition in many countries as an alternative fuel, which may be utilised without any modifications to the vehicle engine. It is currently produced and used throughout Europe and the USA and has been gaining worldwide popularity as an alternate energy source.

Figure 2.1a ***Transesterification Chemistry***

R-OCOCH$_2$		CH$_3$OH		R-COOCH$_3$	HO-CH$_2$
|					|
R-OCOCH$_2$	+	CH$_3$OH	Catalyst ---------->	R-COOCH$_3$	+ HO-CH$_2$
|					|
R-OCOCH$_2$		CH$_3$OH		R-COOCH$_3$	HO-CH$_2$
Triglyceride from Oils		**3 Methanol**		**3 Methyl Ester (Biodiesel)**	**Glycerine**

A number of advantages have been identified for biodiesel and they are listed below:

- it is non-toxic;
- it is biodegradable;
- it is made of renewable feedstock and therefore considered as a renewable source of energy;
- it contains practically no sulphur and therefore no SO_x will be produced;
- it contains oxygen and can thus provide a good ignition capacity;
- it allows low-pressure storage at ambient temperatures;

- it can be used in most diesel engines without modifications or retrofits [(1)];

- it reduces greenhouse gas emissions;

- it reduces emissions of pollutants, such as carbon dioxide, carbon monoxide, and particulates. Emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle of the engine and testing methods employed; and

- it is safer to transport because its flash point [(2)] of at least 120°C (normally at about 150°C) which is double of that for petroleum diesel (at about 70°C).

When compared with petroleum-based diesel, biodiesel has two significant advantages. It has a high Cetane number (a measure of a fuel's ignition quality) and its emission reduction potential. Therefore, biodiesel is regarded as a fuel that can help to reduce air pollution and related public health risks. Currently all diesel sold in the European Union (EU) must have 5% biodiesel mix (B5) and by 2010 the EU will mandatory require a minimum of 5.75% of all fuel sold to be biofuel (eg biodiesel and ethanol). This requirement will be increased to 8% biodiesel mix (B8) by 2015.

However, biodiesel is generally more expensive than petroleum diesel, which makes it less widely used in many countries. One way to reduce the cost of biodiesel is to use a less expensive form of oil such as WCO from food establishments and oils recovered from GTW. GTW would be a good alternative raw material for biodiesel production as it is virtually free.

2.2 *PROJECT DESCRIPTION*

The proposed 100,000 tpa biodiesel plant will use multi-feedstock (primarily from WCO and trap grease, and supplemented with PFAD and animal fats) to produce biodiesel which complies with the international standards. The biodiesel will be sold to local and international markets.

The proposed biodiesel plant will include a GTW pre-treatment facility (with a designed treatment capacity of 200,000 tpa or about 558 tpd), which will recover oil and grease from GTW and a wastewater treatment plant (with a designed treatment capacity of 170,000 m^3 per annum) for the treatment of wastewaters generated from the GTW pre-treatment facility and the biodiesel production processes.

This section describes the construction and operational activities associated with the proposed biodiesel plant at TKOIE.

(1) Biodiesel can be used as a fuel additive in 20% blends (B20) with petroleum diesel in compression ignition (diesel) engines without modification or retrofit. In some European countries, e.g. Germany, biodiesel is used extensively as pure diesel (B100) by commercial vehicle and bus operators.

(2) Flash point of a fuel is defined as the temperature at which it will ignite when exposed to a spark or flame. A fuel with low flash point a higher potential to cause fire, or even explosions. The higher a fuel's flash point, the safer it is to store and handle. Biodiesel has a flash point of much higher than petroleum diesel.

2.2.1 *Technology to be Used*

The Project Proponent will adopt the BioDiesel international (BDI) technology, a well proven technology in the design of the biodiesel plant in order to achieve a high efficiency (which is able to utilise oil and grease with a high level of free fatty acids (over 20%) and completely transform them into biodiesel and three useable by-products, namely glycerine, fertilizer, and bioheating oil) and safety standard in the biodiesel production operation. Hence, no waste will be generated from the biodiesel production process. The biodiesel produced will meet the specification of European standard CEN EN 14214.

The technology provider, the BDI, has a long history in developing and implementing waste-to-fuel technology. Over 14 plants are currently operating in Europe and USA and 11 new plants are being constructed have adopted BDI technology.

The key design parameters of the proposed biodiesel plant are shown in *Table 2.2a* and the process flow is shown in *Figure 2.2a*

Table 2.2a ***Key Design Parameters of the Biodiesel Production Plant***

Parameters	
Operating mode	Semi-continuous
Operating days per year	330 (guaranteed), 358 (anticipated)
Operating hours per day	24
Capacity per hour (tonnes)	12.6
Capacity per day (tonnes)	303
Capacity per year (tonnes)	100,000

The incoming GTW will be pre-treated to recover the oil and grease (referred as the trap grease). The crude trap grease will then be treated to remove impurities and reduce the residual water content before it can be used the feedstock for the transesterification process. Water will be removed as much as possible because its presence will cause the triglycerides to hydrolyse to form salts of the fatty acids instead of undergoing transesterification to give biodiesel. The wastewater from the GTW pre-treatment plant will be treated at the on-site wastewater treatment plant to comply with the effluent discharge standards for foul sewer leading to the Tseung Kwan O (TKO) Sewage Treatment Works [(1)].

The biodiesel plant will consist of a number of storage and process tanks. *Figures 2.2b* shows the proposed layout plan of the biodiesel plant. The entire biodiesel production process is program-controlled for maintaining high level of safety and uniform quality of the final product. The reception, treatment and the production of biodiesel are described below.

(1) Table 1 of the EPD's *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*.

2.2.2 *Operation of Biodiesel Plant*

The biodiesel plant would include the following major facilities:

- feedstock reception and storage facilities;
- GTW pre-treatment and wastewater treatment works;
- biodiesel production and glycerine purification system; and
- product storage and ancillary facilities.

Feedstock Reception and Handling

The biodiesel plant will be operated and opened to receive GTW and WCO from all specified sources 24 hours a day and 330 days a year.

The GTW and WCO will be delivered to the biodiesel plant by sealed road tankers via Wan Po Road, then through the roads within the TKOIE and enter the site via Chun Wang Street. After weighting at the weighbridge office located at the entrance, the tankers will proceed to the reception area. The GTW will be randomly sampled and tested to check if they comply with the definition of GTW and is not contaminated with chemical waste (eg lubricating oils, engine oils, hydraulic oils etc). GTW contaminated with chemical waste will be rejected. The truck drivers will be advised to dispose the waste at the Chemical Waste Treatment Centre at Tsing Yi.

The GTW and WCO will be unloaded at the designated stations as shown in *Figure 2.2b*. Four unloading bays will be provided. The GTW and WCO will be unloaded via flexible hoses directly to the receiving tanks under a closed system arrangement. The unloading areas will be enclosed and fitted with a ventilation and air scrubbing system (with an odour removal efficiency of 99.5%) and will be maintained with a slight negative pressure as a precautionary measure and a good design practice.

PFAD will be delivered to Site by barge and pumped from the barge to the storage tank. *Table 2.2b* summarises the transportation of feedstock and products to and from the biodiesel plant.

Table 2.2b Estimated Number of Material Delivery to and from Biodiesel Plant

Material	Vehicle / Barge	Estimated Truck Trips Per Day	Estimated Truck Trips Per Hour
Land-based Delivery			
Grease Trap Waste	$10m^3$ Sealed Road Tanker	60	Average: 3 [(a)]; Peak hour: 5
Waste cooking oil	$10m^3$ Sealed Road Tanker	5	1 [(b)]
Animal fat	$10m^3$ Sealed Road Tanker	5	1
Gas Oil	$10m^3$ Sealed Road Tanker	1	1
Glycerine	$10m^3$ Sealed Road Tanker	2	1
Fertilizer	10 tonne truck	1	1
Nitrogen	$10m^3$ Sealed Road Tanker	1 per week	1
Chemicals	10 tonne Truck/Tanker	2 to 3	1
Biodiesel [(c)]	20 m^3 Road Tanker	10	1
Total		***87 to 89***	11 to 13
Marine-based Delivery			
Biodiesel	1,000 tonne barge	2 per week	
PFAD	1,000 tonne barge	1 per week	
Methanol	1,000 tonne barge	1 per week	
Total		***4 per week***	

Notes:

(a) GTW will be delivered to the site on 24-hour basis. Assuming a peak factor of 1.5. With respect to the collection pattern of the GTW collector, it is anticipated that the peak hour will be at night.

(b) WCO will be provided by designated suppliers and will be delivered to the facility during day-time.

(c) Under circumstance when marine transportation is not possible (eg during incremental weather).

The estimated maximum turnaround time for GTW and WCO collection vehicles within the biodiesel plant is about 30 minutes (including weighing, sampling (if selected) and unloading (about 20 minutes)). Four unloading bays will be provided and therefore a total of 8 tankers per hour can be processed in the biodiesel plant. Four unloading bays will be able to handle the forecast vehicle flow and will not cause queuing of tankers outside the site entrance.

Feedstock Pre-treatment

The GTW will be screened to remove food residues and other large objects and then process to recover the oil and grease. The screenings collected will be disposed of at the SENT Landfill or other landfills if SENT Landfill is full.

The oil and grease recovered (trap grease) from the GTW pre-treatment process will be further purified by a multi-step purification system in the oil and fat preparation tank. The oil and water in the mixture will be separated by a decanter and the water content of the oil phase will be reduced to 5 to 10%. The feed will be heated up to about 60 ^{o}C and intensively mixed with saturated steam. The water/oil mixture will then be separated by a decanter so that the purified oil will achieve the required maximum residual water content.

The wastewater generated from the purification processes will be treated at the on-site wastewater treatment plant prior to discharge to the foul sewer leading to TKO Sewage Treatment Works. About 33 tpd of screenings and solid residues (solid impurities) will be produced during the feedstock pre-treatment processes which will be collected and disposed of at SENT Landfill. The purified oils that are suitable for use as the feedstock for the esterification process will be stored in the buffer tanks.

Wastewater Treatment Plant

It is estimated that a total of about 170,000 m^3 per year (or about 515 $m^3 d^{-1}$ or 515 tpd) of wastewater will be generated from feedstock pre-treatment and glycerine dewatering processes. The wastewater collected will contain trace amount of oils and fats (such as triglycerides and free fatty acids) and have a high COD concentration (about 9,400 to 15,000 mg L^{-1}). The on-site wastewater treatment plant will be designed based on these characteristics and to comply with the standards for effluent discharged into foul sewer.

The key components of the wastewater treatment plant will include an oil-water separator, a dissolved air flotation (DAF) system, an Internal Circulation (IC) Reactor (an anaerobic treatment utilises the upflow anaerobic sludge blanket (UASB) technology), an aerobic treatment system and a secondary clarifier. The IC Reactor is an anaerobic treatment technology that can effectively reduce the organic loading of the wastewater especially for wastewater with high organic matter content. The effluent from the IC Reactor will be transferred to the aeration tanks for further treatment. The suspended solids in the treated effluent from the aeration tanks will be settled in the secondary clarifier so that the effluent will meet the standards for effluent discharged into foul sewer leading to the TKO Sewage Treatment Works. The sludge will be dewatered to at least 30% dry solids in order to comply with the landfill acceptance criteria. It is estimated that about 1.3 tpd of dewatered sludge will be generated and stored in enclosed containers prior to landfill disposal. The filtrates from dewatering process will be fed back to the aeration tank for treatment. The dewatered sludge will be delivered to landfill by trucks.

The biogas generated from the IC Reactor (average flow about 80 $m^3 hr^{-1}$) has a high energy value and will be used as an energy source for on-site facilities (eg as fuel for the steam boiler). The biogas will be temporary stored in the biogas buffer tank. It is anticipated that all the biogas will be consumed by the steam boiler. When the steam boiler is under maintenance, the biogas will be combusted by the flare (with a diameter of about 1 m) with a designed capacity of 150 $m^3 hr^{-1}$.

Biodiesel Production

The purified trap grease, WCO, PFAD or other feedstock will be pumped to the transesterification unit. Each batch of transesterification process will use only one type of feedstock (ie either trap grease or WCO or PFAD or animal fats). Here, the oils will be mixed with an alcohol-catalyst (methanol and potassium hydroxide). The system will be operated at about room temperature and under normal pressure.

After the transesterification process, biodiesel (the fatty acid methylester or FAME) and glycerine will be formed. The biodiesel will be purified and excess methanol will be recovered by centrifuge. The methanol recovered will be reused in the transesterification process. The biodiesel will then be fed into the biodiesel distillation tank for polishing in order to improve its quality. The final products from the distillation tank are the biodiesel (up to 303 tpd) and the bioheating oil (about 23 tpd). The biodiesel will be sampled for laboratory testing to ensure that its quality meets the specification requirements. The biodiesel will be stored in the biodiesel storage tanks (2 nos., with a total capacity 3,700 m^3).

The glycerine separated during the transesterification process will also contain unused catalyst (ie potassium hydroxide) which will be neutralised with sulphuric acid to form fertiliser (about 7 tpd). The fertiliser will be sold to the market. The free fatty acids in the glycerine phase will be separated by decanters and fed back to the transesterification process. The glycerine will be purified and dewatered by an evaporation process to remove the trace amount of methanol and water. The methanol will be reused in the transesterification process while the water will be pumped to the wastewater treatment plant for treatment. The purified glycerine (at about 80% purity, up to 7 tpd) will be sold to the local or international market. It is estimated that about 9,600 m^3 per year (or about 30 m^3 d^{-1} or 30 tpd) of wastewater (depending on the characteristics of the feedstock) will be generated in the biodiesel production processes.

No solid waste will be generated from the biodiesel production process.

All vessels/tanks machinery and all other equipment for the biodiesel production plant will be designed to international safety standards and to comply with mechanical, technical and safety standards for chemical plant design and local regulations. The entire production process will be program-controlled. The process visualization allows the monitoring of the process and intervention by the manual mode, if required. The process equipment for the biodiesel production line (such as vessels, machines, pipelines, instruments etc) will be made of stainless steel or other resistant materials fulfilling the respective mechanical, technical and safety standards. The vessels and pipelines will be insulated by aluminium plate. All vessels will be equipped with agitators and with a manhole. All pumps for methanol will be sealed with a magnetic coupling. All other pumps will be equipped with single-acting mechanical seals. All pumps will be monitored by a fully automatic process control system (PCS) to prevent dry running.

The process equipment will be mounted in a steel structure building which is open inside. The building will be covered with metal sheet cladding. The following plant sections will be situated in a separate building:

- Building for process equipment;

- Building for steam boiler, chilling and air compressor;
- Building for chemical storage, workshop, spare parts, control and electrical control room and office;
- Building for trap grease preparation;
- Tank farm (including loading and unloading systems);
- Wastewater treatment plant; and
- Outdoor utility plants (ie air cooling tower).

On-site Storage and Ancillary Facilities

The steam boiler system will make use of the biogas, bioheating oil and biodiesel produced as energy sources for heating. It is estimated that fuel consumption equivalent to about 8.4 tpd of biodiesel will be required for the boiler system. The emissions from the boiler will be discharged to the atmosphere via a 20m stack.

The methanol will be stored in a 500 m^3 steel storage tank. All process tanks and machines will be designed to be gas tight and equipped with a gas displacement system. The methanol in the exhaust gas will be removed in an air scrubber prior to discharge to the atmosphere. A gas warning system measuring the 10% of the lower explosion limit (6% v/v) of methanol (ie alarming level will be set at 0.6% v/v) will be installed to monitor the methanol concentration inside the process room. The plant will shut down automatically and the emergency ventilation system will be activated if the monitoring system detects a methanol concentration of 0.6% v/v inside the room.

The capacities of the storage tanks for various materials are presented in the *Table 2.2b*.

Table2.2c Capacities of Storage Tanks for the Biodiesel Plant

Description of Storage Tank	No.	Capacity (m^3)	Capacity (Days)
Raw GTW Tank	2	1,500 each	5 (total)
Cleaned Trap Grease Tank	1	1,000	3
Raw WCO Tank	2	150 each	1 (total)
Purified WCO Tank	1	1,000	3
PFAD Tank	1	1,500	4.5
Raw Animal Fat Tank	1	500	1.5
Cleaned Animal Fat Tank	1	500	1.5
Methanol Tank	1	500	12
Sulphuric Acid Tank	1	50	21.5
Phosphoric Acid Tank	1	25	49.5
Chemicals Buffer Tank	1	25	-
Additive Storage Tank	1	50	15
Biodiesel Quality Tank	2	500 each	3 (total)
Biodiesel Storage Tank A	1	2,500	7.5
Biodiesel Storage Tank B	1	1,200	3.5
Glycerine (80%) Tank	1	500	18.5
Fertiliser Silo	1	20	3
Bioheating Oil Tank	1	100	10
Gas Oil Tank (as back up fuel)	1	200	13
Nitrogen Tank	1	25	16.5
Switch Tank	1	1,200	-

Transportation of Biodiesel and By-products

The biodiesel will be sold to potential buyers. It will be delivered to the potential buyers by 1,000 tonnes barge. During incremental weather, the biodiesel could be transported by 20 m^3 road tankers similar to that currently used for petroleum diesel in Hong Kong (ie Type D vehicle for conveyance of Category 5 Dangerous Goods). It is estimated that about 2 barge loads per week or 10 truck trips per day will be required to transport biodiesel out of the plant.

The glycerine and fertiliser produced will be sold to buyers, e.g. soap factory, as raw materials in China. They will be transported out of the biodiesel plant by road tankers or trucks.

Plant Personnel

Based on similar biodiesel plant, the staff requirements for the operation of the proposed biodiesel plant are presented in *Table 2.2d*.

Table 2.2d *Operational Staff Requirements*

Designation	Function	No. of Employee
Plant Manager	• Managerial role, supervision of plant operation, maintenance, ensure high safety and environmental standards of the plant	1
Plant Personnel	• Operation of the plant, production control, simple repair/maintenance works	1 to 2 per shift
Logistic Personnel	• Loading/unloading of feedstock and products	2 to 3 during permitted loading/ unloading time
	• Providing of auxiliary and cleaning materials, production control	1 to 2 per shift
Laboratory Personnel	• Laboratory analysis	1 to 2 for entire plant
Wastewater treatment plant technician	• Operation and simple repair/maintenance of the on-site wastewater treatment plant	1 to 2 per shift
Administration and Marketing Personnel	• Providing administrative support and marketing of the products	1 to 2 for entire plant
Total on site at any one time: 8 to 14		

If necessary, external personnel will be hired for maintenance and repair works.

Site Drainage

The stormwater runoff of the site will pass through oil interceptors before discharge into the stormwater drainage system of the TKOIE.

2.2.3 *Construction of the Biodiesel plant*

Metal hoarding will be erected around the site prior to the commencement of the foundation work. As the site has been formed, only minor earthwork will be required. Driven steel H piles with reinforced concrete pile caps will be used for the foundations of the buildings. Reinforced concrete slab and raft foundation will be built for the process area, tank farm area and wastewater treatment plant. The process and tank farm areas will be contained by perimeter bund walls. The pre-fabricated structural steelworks and storage tanks will be assembled on site using hydraulic and tower cranes. The reinforced concrete buildings will be constructed on site using ready-mix concrete and conventional construction method. The pipes, gantries and biogas flare in the wastewater treatment plant will be supported by structural steelwork.

Equipment installation will begin on the completion of civil work. Installation work may be carried out on a 24-hour per day basis and seven days per week.

The jetty for reception of marine vessels during operation phase will be constructed by piled deck (see *Figure 2.2c*). Marine piles will be driven through the existing rubble mound seawall to competent bearing strata by a hydraulic hammer piling barge. Concrete infill to piles will be undetaken prior to placement of trellis beam and pre-cast concrete panels. It is estimated that the construction of the jetty will take about 8 months, including 4 months for pile installation and 4 months for jetty deck construction.

2.2.4 *Project Planning and Implementation*

The Project Proponent has appointed BioDiesel International (BDI) to carry out the design of the biodiesel production plant. Jacobs China Ltd was appointed as the consultant responsible for the overall management of the engineering design of the Project. Paques Environmental Technology Co. Ltd was appointed to undertake the design and construction of the wastewater treatment plant. The contractors for the construction of the Project are yet to be determined through the subsequent tendering process.

The development programme of the biodiesel plant is outlined in *Table 2.2e*:

Table 2.2e ***Project Development Programme***

Activities	Timeline
Engineering design and equipment procurement	May 2007 to March 2008
Commencement of the construction of the Biodiesel plant and installation of equipments	December 2007 to September 2008
Commencement of testing and checkout	October to December 2008
Commencement of the Biodiesel plant	January 2009

3 POSSIBLE IMPACTS ON THE ENVIRONMENT

3.1 INTRODUCTION

Table 3.1a identifies the potential environmental impacts that may arise from the construction and operation of the proposed biodiesel plant. The key potential impacts are air quality, waste management, water quality, and hazard to life associated with the storage of raw materials, biodiesel and biogas.

However, it is not expected that there will be any adverse environmental impacts due to construction and operation of the proposed biodiesel plant provided that the proposed environmental pollution control measures are properly implemented.

Table 3.1a Potential Sources of Environmental Impacts

Potential Impact	Construction	Operation
• Gaseous Emissions	✗	✓
• Dust	✓	✗
• Odour	✗	✓
• Noise	✗	✗
• Night-time Operations	✗	✓
• Traffic (Land & Marine)	✓	✓
• Liquid Effluents, Discharges or Contaminated Runoff	✓	✓
• Generation of Waste or By-products	✓	✓
• Manufacturing, Storage, Use, Handling, Transport, or Disposal of Dangerous Goods, Hazardous Materials or Wastes	✗	✓
• Hazard to Life	✗	✓
• Landfill Gas Hazard	✗	✗
• Disposal of Spoil Material, including potentially Contaminated Materials	✗	✗
• Disruption of Water Movement or Bottom Sediment	✓	✗
• Unsightly Visual Appearance	✗	✗
• Cultural & Heritage	✗	✗
• Terrestrial Ecology	✗	✗
• Marine Ecology	✓	✗
• Cumulative Impacts	✗	✓

Note:
✓ = Possible ✗ = Not Expected

3.2 EXISTING ENVIRONMENTAL CONDITIONS

The proposed biodiesel plant is located at the Chun Wang Street within the TKOIE (see *Figure 3.2a*) which was developed on a reclaimed land and is currently managed by the Hong Kong Science and Technology Park (HKSTP) Corporation. According to *Tseung Kwan O Outline Zoning Plan (OZP) S/TKO/15*, the TKOIE is zoned as "Other Specified Use (Industrial Estate)" which aims to provide land for developing industries which cannot be accommodated in conventional industrial buildings.

The Site can be accessed by barge (via the existing sloping rubble mount seawall, however modification of the existing seawall will be required (see *Figure 1.5a*). The Site has been vacanted since it was formed. The nearest buildings to the Site are the Gammon Skanska and the Trade Development Council Building which are located opposite to the Chun Wang Street. The South East New Territories (SENT) Landfill (about 680 m from the Site) and TKO Area 137 (public fill bank) are located to the south-east of the Site. The nearest existing residential development is Oscar by the Sea which is located at about 2km from the Site. The nearest planned residential development (the Dream City) will be located at TKO Area 86 (on top of the MTRC TKO Line Deport, at about 1km to the north-east of the Site, see *Figure 3.2a*) and is currently under construction.

A stormwater outfall is located at the seawall adjacent to the Site.

The existing environment of the Site and its surroundings were reviewed and sensitive receivers were identified in accordance with the guidelines of the *EIAO-TM*.

3.2.1 Air

There is no EPD's Air Quality Monitoring Station (AQMS) operating in Tseung Kwan O area. The nearest EPD's AQMS is located at Kwun Tong. The means of the annual average air pollutant concentrations recorded at the EPD's Kwun Tong AQMS from 2001 to 2006 are used to establish the background air quality of the Study Area (see *Table 3.2a*).

Table 3.2a Background Air Pollution Concentrations

Air Pollutant	Background Concentration (a)
TSP	81 (b)
RSP	56 (b)
NO_2	66 (b)
CO	751 (c)

Notes:

(a) Reference to Annual Air Quality Statistics 2006 (http://www.epd-asg.gov.hk/english/report/aqr.php)

(b) The data recorded at EPD's Kwun Tong AQMS

(c) Since no CO was recorded at EPD's Kwun Tong AQMS, the CO recorded at the next nearest EPD's AQMS at Tap Mun was used.

Air Sensitive Receivers (ASRs) has been identified in accordance with the criteria stipulated in Annex 12 of the *EIAO-TM*. The locations of representative ASRs are presented in *Figure 3.2b* and listed in *Table 3.2b.*

Table 3.2b Representative Air Sensitive Receivers (ASRs)

ASR	Location	Approximate Distance from nearest Project Site Boundary (m)
A1	Gammon Skanka	30
A2	Proposed Industrial Uses (currently vacant)	30
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	50
A4	HAECO Component Overhaul Building	210
A5	HAELO	470
A6-1	TVB City	510
A6-2	TVB City	560
A6-3	TVB City	570
A7-1	Asia Netcom HK Limited	160
A7-2	Asia Netcom HK Limited	235
A8	Mei Ah Centre	310
A9	Yan Hing Industrial Building	415
A10	Wellcome Co. Ltd	240
A11	Next Media Apple Daily	415
A12	Hitachi Tseung Kwan O Centre	380
A13	Avery Dennison	445
A14	Next Media Co. Ltd	420
A15	Varitronix Limited	500
A16	Hong Kong Oxygen Acetylene Co. Ltd	415

3.2.2 *Noise*

The nearest Noise Sensitive Receiver (NSR) to the biodiesel plant is the residential development at TKO Area 86 (Dream City), which is about 1km away.

3.2.3 *Water Quality*

The marine water adjacent to the biodiesel plant falls within the Junk Bay Water Control Zone (WCZ). The water quality of Junk Bay WCZs has been improved since the implementation of HATS Stage 1 in 2001 and had attained 100% compliance with the key WQOs in 2005. The monitoring data of two EPD marine water monitoring stations in Junk Bay WCZs are shown in *Table 3.2c*.

Table 3.2c Marine Water Quality in Junk Bay (2005)

Parameter	**Junk Bay**	
	JM3	**JM4**
Dissolved Oxygen (mg L^{-1}) Depth-averaged	5.9 (3.7-7.0)	5.8 (4.0-7.2)
Dissolved Oxygen (mg L^{-1}) Bottom	5.7 (3.2-6.9)	5.6 (3.6-7.1)
Dissolved Oxygen (% saturation) Depth-averaged	83 (53-101)	81 (56-95)
Dissolved Oxygen (% saturation) Bottom	79 (45-96)	78 (50-96)
pH	8.2 (7.9-8.5)	8.2 (7.8-8.5)
Suspended Solids (mg L^{-1})	2.7 (1.3-4.3)	3.2 (1.1-8.0)
5-day Biochemical Oxygen Demand (mg L^{-1})	0.7 (0.2-1.5)	0.6 (0.2-1.0)
Unionised Ammonia (mg L^{-1})	0.004 (0.001-0.009)	0.004 (0.001-0.010)
Total Inorganic Nitrogen (mg L^{-1})	0.16 (0.08-0.23)	0.15 (0.08-0.24)
Chlorophyll-a	2.1 (0.6-8.6)	1.8 (0.5-4.9)
E. coli (count/100mL)	67 (15-7,100)	100 (23-550)

Notes:

(a) Data presented in brackets indicate the minimum and maximum data range

(b) Unless otherwise specified, data presented are depth-averaged values calculated by taking the means of three depths: surface, mid-depth, bottom

(c) Data presented are annual arithmetic means of the depth-averaged results except for *E. coli* which are annual geometric means.

There are no major water sensitive receivers (such as mariculture zones, commercial fisheries, seawater intake or recreational beaches) identified in close proximity of the biodiesel plant.

3.2.4 *Ecology*

No ecologically sensitive area is identified within 500m of the Project Site boundary. However, soft corals were found along the natural coastline of Fat Tong Chau at about 700m to the south of the Site.

3.2.5 *Cultural Heritage*

The proposed biodiesel plant will be constructed on reclaimed land within the TKOIE. No cultural heritage resources have been identified within the Project Site. No cultural heritage impacts due to the construction and operation of the biodiesel plant are expected.

3.2.6 *Landscape and Visual*

The Site situated in the TKOIE with an industrial setting and surrounded by factories, warehouses and industrial buildings. The Visual Sensitive Receivers (VSRs) includes offices in TKOIE, visitors of Clear Water Bay Country Park / High Junk Bay Country Trail, planned and existing residential developments in TKO town area, marine users in the Junk Bay area and distance views from Chai Wan and Siu Sai Wan.

3.2.7 *Landfill Gas Hazard*

The proposed biodiesel plant is located outside the landfill consultation zone of the existing SENT Landfill and the restored TKO Stages I and II & III landfills. Therefore the potential hazard associated with landfill gas migration from landfill to the biodiesel plant will be very low.

3.3 *AIR QUALITY*

Construction Phase

The Site has been formed and is currently vacant. Hence, no major earthwork will be required for the site formation works. Minor excavation works will be required for the construction of the foundation works and site utilities. The tank farms and process equipment will be pre-fabricated off-site and assembled on site and hence minimal dust will be generated from this activity. Dust generated from the concreting works for the construction of site buildings will be minimal. With the implementation of dust suppression measures stipulated under the *Air Pollution Control (Construction Dust) Regulation* and adoption of good site practice, no adverse construction dust impact is anticipated.

Operation Phase

Potential air pollution sources from the biodiesel plant during the operation phase include:

- Emissions from fuel combustion of boiler;
- Emissions from the standby biogas flare;
- Odour from unloading and treatment of Grease Trap Waste (GTW);
- Odour from the on-site wastewater treatment; and
- Vehicular emissions from additional traffic associated with the operation of the biodiesel plant.

To assess potential cumulative air quality impacts the emissions from the existing stacks within the Study Area were also considered.

The potential air quality impacts due to the emissions from the boiler stack and the standby flare in the biodiesel plant and the cumulative effect from the emission of Hong Kong Aero Engine Services Company Limited (HAECO) in TKOIE to the ASRs were predicted using the EPD approved air dispersion model ISCST3. The predicted maximum hourly, daily and annual average concentrations of NO_2, CO and VOCs at various heights of all ASRs are well within the respective AQOs. The highest maximum concentrations are predicted at 30m above ground at A2 which is located at the south of the Site. The cumulative impact assessment indicates that there will be no adverse air quality impact to the identified ASRs with the additional emissions from boiler and flare stacks during the operation of the proposed biodiesel plant in TKOIE.

GTW will be delivered to the biodiesel plant by sealed road tankers. GTW will be discharged from the tanker directly to the storage tanks in a closed system (via flexible hose) in order to prevent odour nuisance. As a precautionary measure and a good design measure to prevent odour emission from the site, the unloading stations will be enclosed and fitted with a ventilation and air scrubbing system in order to maintain a slight negative pressure inside the unloading stations. All process tanks, storage tanks and wastewater treatment tanks (including the aeration tanks) will be enclosed and the exhaust air will be scrubbed prior to discharge to atmosphere. The potential odour impacts due to the emission from the wastewater treatment plant were predicted using the ISCST3 model. The predicated odour levels at various heights of all ASRs are well within the 5-second odour criterion. It is therefore anticipated that odour nuisance will be negligible during operation of the biodiesel plant.

Additional traffic associated with the operation of the biodiesel plant (< 100 truck trips per day) only constitutes a very small percentage of the total traffic in the Study Area. Therefore it is anticipated that the potential air quality impact due to additional traffic is negligible.

Detailed of the air quality assessment is presented in *Annex A*.

3.4 NOISE

Construction Phase

The construction of the biodiesel plant (including the jetty) will involve the use of Powered Mechanical Equipment (PME) such as generators, excavators, piling machine, concrete breakers, concrete lorry mixers, and mobile/tower cranes. Given the relative small scale of the Project and the large separation distance between the NSRs and the site of more than 800 m, the construction activities are not expected to cause adverse noise impacts at the identified NSR.

Operation Phase

Noise from fixed sources during the operational phase will be generated from pumps, blowers, and reactors. Most of these noise sources will be installed within buildings. The designed total sound pressure level of the noise generated from all plant and equipment will be limited to 85 dB(A) at the site boundary. Given the large separation distance between the NSR and the site, it is not expected that its operation will cause adverse noise impacts at the identified NSR.

With respect to the small traffic generation (less than 13 trucks in and out per hour) due to the operation of the biodiesel plant, the incremental traffic noise will be negligible when compared with the background traffic noise in the Study Area. It is not expected that the operation of the biodiesel plant will cause adverse traffic noise impacts to the identified NSR.

3.5 *NIGHT TIME OPERATION*

Construction Phase

No piling will be carried out at restricted hours (ie between 21:00 hrs and 07:00 hrs) and public holidays and Sundays. Equipment installation works may be carried out on a 24-hour per day basis and 7 days per week. As these activities will not involve noisy plant and equipment and dusty activities, it is not anticipated that the installation works will cause adverse air and noise impacts at the identified sensitive receivers. Construction work to be carried out within the restricted hours will satisfy the requirements of the *Noise Control Ordinance*.

The installation works at night-time will involve a few vehicles per hour. As the night-time traffic in the Study Area will be low, it is not anticipated that the night-time traffic associated with the installation works will cause adverse traffic impact to the local road network.

Operation Phase

The biodiesel plant will open to receive feedstock and operate 24 hours a day [(1)]. The most significant environmental concern associated with night-time operation will be fixed plant noise. As discussed in *Section 3.5*, the total sound pressure level of all plant and equipment will be limited to 85dB(A) and the nearest NSR is about 800 m away, it is not anticipated that the night-time operation of the biodiesel will cause adverse noise impact at the NSR.

As the night-time traffic of the local road networks will be low, it is not anticipated that the night-time traffic due to delivery of feedstock to the biodiesel plant (a maximum of 5 truck trips per hour) will cause adverse traffic impact to the local road network.

3.6 *TRAFFIC*

The transportation of feedstock, chemicals and products / by-products in and out the biodiesel plant will generate additional traffic in Wan Po Road and the roads within the TKOIE. As indicated in *Table 2.2b*, the anticipated hourly traffic flow associated with the operation of the biodiesel plant will be less than 13 truck trips. This is negligible when compared with the background traffic along Wan Po Road (about 20,000 vehicles per day in 2005). The operation of the facility is not expected to cause adverse traffic impacts to the local road networks.

The reception bays for GTW and WCO could handle at least 8 tankers per hour. It is anticipated that a maximum of 6 road tankers will deliver GTW and WCO to the facility per hour. Queuing of road tankers outside the site entrance will not occur. It should also be noted that the proposed site of the

(1) It should be noted that most of the feedstock will be delivered during day-time. Only GTW will be delivered to site on a 24 hours per day basis.

biodiesel plant is away from the main road (ie Wan Po Road) and hence will not impact on the local traffic.

3.7 *WATER QUALITY IMPACT*

Construction Phase

The construction of jetty and temporary marine access will involve minor marine works (see *Section 2.2*). No dredging of marine sediment will be required.

Marine piling will be conducted for installation of the hollow cylindrical piles. These piles will be driven into position and the soil inside the driven-in piles will not be removed. No soil or sediment excavation would be carried out. It is expected that the marine piling will cause limited disturbance to the sediments and is unlikely to cause unacceptable impacts to the water quality in Junk Bay.

Construction site runoff will be the major source of water quality impacts associated with the land based construction activities. As discussed in *Section 2.2*, the construction of the biodiesel plant will only involve minor earthwork. The construction of the superstructures has low risk of generating contaminated runoff. Portable toilets will be used and the sewage will be collected regularly by specialised contractor for off-site disposal. With the implementation of general good site practice in accordance with the *Practice Note for Professional Persons on Construction Site Drainage (ProPECC PN1/94)*, the land based construction activities will not cause adverse water quality impacts.

Operation Phase

The proposed 60m long and 22.5m width jetty will be in a form of reinforced concrete deck supported on marine piles. A total of about 12 piles, with approximate diameter of 1 m, will stand underneath the deck of the berthing facility. The cross-sectional area of each pile underwater has been estimated to be 0.8 m^2 with the depth underwater will be in a range of 4 m to 7.5 m. It is estimated that the volume of each pile underwater will be in a range of 3.2 to 6 m^3. Although there may be localised effects due to the physical resistance of the piles, the water flow through the piled structure will generally be maintained as at present. In the view of the small cross-sectional area occupied by the piles and the closeness to the shore, it is not expected that the structure will result in any adverse impact to the hydrodynamic system. Therefore no significant impact on the flow regime is anticipated during operation phase.

The draught of the marine vessels (1000 tonnes barges) for the transportation of biodiesel, PFAD and methanol will be about 2m. There will be sufficient water depth for the access of the marine vessels and no dredging will be required during the operation of the biodiesel plant.

The operation of the biodiesel plant has a potential to cause adverse water quality impacts if the site runoff, wastewater and material storage are not properly managed. The first flush of the stormwater runoff from the site will be intercepted and passed through a silt trap and an oil interceptor prior to discharge to existing stormwater drainage system of the TKOIE.

All wastewaters generated from the site (including the wastewater from the GTW pre-treatment, process water from biodiesel production, wash water from the reception area, sewage from site personnel, etc) will be collected and treated at the on-site wastewater treatment plant prior to discharge to foul sewer leading to the TKO Sewage Treatment Works. The effluent quality will comply with the discharge standards stipulated in Table 1 of the *Technical Memorandum on Standards for Effluents Discharged to Drainage and Sewerage Systems, Inland and Coastal Water* published by the EPD. No adverse water quality impact due to operation of the biodiesel plant is anticipated.

There is a potential for spillage of biodiesel, PFAD and methanol during the loading/unloading operations at the jetty area. The operations will be undertaken at the paved loading/unloading station and will be manned by trained staff and closely monitored with flow control equipment. Any spillages will be intercepted by the collection drain and conveyed into the on-site wastewater treatment plant. An emergency response plan will be developed to stipulate the actions to be taken in case spillage occurred and prevent any spillages from discharge into the sea.

3.8 *ECOLOGY*

Construction Phase

No terrestrial ecological impacts are expected, as the proposed biodiesel plant will be constructed on reclaimed land within the TKOIE.

Soft corals (dominated by *Echinomuricea sp*. and *Euplexaura sp*. which are quite common in Hong Kong) were found along the natural coastline of Fat Tong Chau at about 700m to the south of the Site. The marine works associated with the modification of seawall will have minimal disturbance to the seabed and is far away from the soft coral area at Fat Tong Chau. As discussed in *Section 3.7*, it is not expected that the marine works will cause adverse water quality impacts and hence the works will not cause adverse impact to the marine ecology.

Operation Phase

Surface runoff and effluent discharged from the site will be properly controlled during the operation of the biodiesel plant (see *Section 3.7*) and no dredging will be required during the operation phase, potential ecological impacts during the operation of the biodiesel are not expected.

3.9 *LANDSCAPE AND VISUAL*

Landscape Impact

The proposed biodiesel plant will be located at the TKOIE. The proposed site is a reclaimed land with limited vegetation (mainly grasses). The development of the biodiesel plant will therefore have negligible impact on landscape resource.

Visual Impact

Construction Phase: The construction works will last for about 11 months. As the biodiesel plant will be located at the TKOIE and scale of the construction activities is relatively small, it is not expected that it will not cause significant impacts to the Visual Sensitive Receivers (VSRs).

Operation Phase: The biodiesel plant will consist of a number of storage and process tanks. The biodiesel production process will be housed in a process building. *Figure 3.9a* shows the vertical profile of the plant. The heights of the buildings and tanks are comparable to the adjacent buildings within the TKOIE. The biogas flare will be an enclosed flare and no flame will be seen by the VSRs.

Table3.9a Identified Representative VSRs and Their Visual Sensitivity

Visual Sensitive Receivers	Approximate Distance From the Proposed Biodiesel Plant (m)	Visual Sensitivity	Potential Visual Impact
Offices in TKOIE	Immediately adjacent	Low (Industrial)	Slight (VSRs are expected to see other industrial buildings from their offices)
Distance views from users of Clear Water Bay Country Park / High Junk Bay Country Trail	1,500	Low (Transient)	Slight (The biodiesel plant will be seen as one of the industrial facilities within TKOIE. The development of the biodiesel plant will not change the visual quality of the VSR and will not block the view towards existing landscape features.)
Distance views from planned residential development in TKO Area 86 (Dream City)	1,000	High (Residential)	Slight (The character of the biodiesel plant will be compatible with the adjacent industrial facilities. The development of the biodiesel plant will not change the visual quality of the VSR and will not block the view towards existing landscape features.)
Distance views from residential developments in TKO New Town	2,000 to 3,000	High (Residential)	Slight (The biodiesel plant will be seen as one of the industrial facilities within TKOIE. Due to the large separation distance from this VSR, the biodiesel plant will only contribute a small proportion of the viewshed of this VSR. The development of the biodiesel plant will not change the visual quality of the VSR and will not block the view towards existing landscape features.)

Visual Sensitive Receivers	Approximate Distance From the Proposed Biodiesel Plant (m)	Visual Sensitivity	Potential Visual Impact
Distance views from marine user in TKO	500	Low (Transient)	Slight (Gammon Skanska Building and Fat Tong Chau to the south of the biodiesel plant will provide partial screening to the biodiesel plant. The development of the biodiesel plant will not change the visual quality of the VSR and will not block the view towards existing landscape features)
Distance views from Chai Wan and Siu Sai Wan	> 2,500	High (Residential)	Slight (the biodiesel plant will be seen as one of the industrial facilities within TKOIE. Due to the large separation distance from this VSR, the biodiesel plant will only contribute a small proportion of the viewshed of this VSR. The development of the biodiesel plant will not change the visual quality of the VSR and will not block the view towards existing landscape features)

As the biodiesel plant will be developed within the TKOIE, its visual character will be compatible with the adjacent industrial facilities. The out-door structures will include steelwork tanks and buildings. The tallest structure is the IC reactor of the wastewater treatment plant, with a diameter of 4m and a height of 24m. The heights of the main processing building, tank farm and wastewater treatment plant will be lower than the adjacent buildings (eg Gammon Skanaka and TVB City). With respect to the industrial setting of the area, the existing visual quality of the area is low. The development of the biodiesel plant will therefore not change the quality of the viewshed of the VSRs and will not block the view towards existing landscape features. Therefore it is considered that the potential visual impact associated with the proposed biodiesel plant in the TKOIE is acceptable without mitigation measures.

3.10 WASTE

Construction Phase

Construction and Demolition Materials (C&DM): The site is currently covered with limited vegetation (mainly grass). The quantity of site clearance waste to be generated will be minimal (about 20 m^3) and it will be disposed of at the SENT Landfill. C&DM will be generated from site preparation work and construction of biodiesel plant. As the site has been formed, no major earthworks will be required for site formation. All excavated materials generated from the foundation works will be reused on site for site ground levelling.

With respect to the small scale of the new building construction works, it is anticipated that a small amount of C&DM (approximately 1,200 m^3) [(1)] will be generated within 6 months. On average, about 200 m^3 of C&DM will be generated each month. The C&DM will be segregated on-site into public fill and construction waste (including paper, metals, plastics and wood waste from packaging materials and wooden formworks) and stored in separately skips for disposal at public filling facilities at TKO Area 137 and SENT Landfill, respectively. Recyclable, such as paper waste, metal and wood waste will be stored in different skips for recycling as far as practicable. It is expected that the amount of construction waste requiring disposal at SENT Landfill will be small. The disposal of small quantities of public fill (a total of about 960 m^3) and construction waste (a total of about 240 m^3) to public filling facilities and SENT Landfills, respectively, will not cause adverse environmental and operational impacts to these facilities.

Chemical Waste: Chemical wastes will be generated from the construction activities. If not properly stored and disposed of, it waste may pose serious environmental, health and safety hazards. These hazards may include:

- Toxic effect to workers;
- Adverse effect on air, water and land from spills; and
- Fire hazards.

The chemical waste likely to be generated from the construction activities will, for the most part, arise from the maintenance of construction plant and equipment. These may include:

- Scrap batteries or spent acid / alkali from their maintenance;
- Used paint, engine oils, hydraulic fluids and waste fuel;
- Spent mineral oils/ cleaning fluids from mechanical machinery; and
- Spent solvents / solutions, some of which may be halogenated, from equipment cleaning activities.

The quantity of chemical waste to be generated will be small (expected to be less than one hundred litres). These chemical wastes will be readily accepted at the Chemical Waste Treatment Centre (CWTC) at Tsing Yi.

Storage, handling, transport and disposal of chemical waste will be arranged in accordance with the *Code of Practice on the Packaging, Labelling and Storage of Chemical Waste* published by the EPD. Provided that this occurs, the potential environmental impacts arising from the handling, storage and disposal of a small amount of chemical waste generated from the construction activities will be negligible.

(1) Based on "Reduction of Construction Waste Final Report (March 1993)" (Hong Kong Polytechnics), a generation rate of 0.1 m^3 per m^2 of GFA constructed is adopted.

Sewage: Sewage will arise from the construction workforce. It is estimated that a maximum of about 30 workers and site staff 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 4.5 m^3 of sewage will be generated each day. An adequate number of portable toilets will be provided on site to ensure that sewage from site staff is properly collected. The portable toilets will be desludged and maintained regularly by a specialised contractor. No adverse environmental impacts are envisaged.

General Refuse: General refuse will be generated from site operations and personnel. Based on a generation rate of 0.65 kg per worker per day, a total of about 19.5 kg of general refuse per day will require off-site disposal. 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 on-site to avoid 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 is small, no adverse impact on the operation of these waste disposal facilities is anticipated.

Operation

Table 3.10a summarises the types and quantities of waste / by-products that will be generated from the operation of the biodiesel plant.

Table 3.10a ***Solid Waste / By-product To Be Generated During the Operation of the Biodiesel Plant***

Treatment Process	Quantity / Frequency	Reuse / Disposal
Screenings and solid residue from the GTW pre-treatment works	About 30 tpd	Disposed of at landfills by trucks
Wastewater Treatment System	About 1 tpd of dewatered sludge (>30% dry solids contents)	Disposed of at landfills by trucks
Chemical Waste (used lubricant oil, solvents from plant maintenance activities, laboratory waste)	About a few litres per month	Disposed of at CWTC or other licensed facilities
General refuse from site personnel	Less than a tones per month	Disposed of at landfills by trucks
Total: About 31 tpd of solid waste to be disposed of at landfill		

It is not anticipated that the disposal of these wastes at landfills and CWTC will have adverse environmental and operational impacts on landfills and CWTC. The handling and disposal of these wastes will not cause adverse environmental impacts provided good practices (such as storage in appropriate containers to avoid vermin and odour, employ reputable or licensed contractors) are implemented.

The proposed biodiesel plant allows the possibility to reuse the renewable sources such as vegetable oils, animal fats, and recycled oil and grease and hence reduces the amount of solid residues to be disposed of at landfills.

3.11 *LAND CONTAMINATION*

Construction Phase

The site is a reclaimed land and has yet to be developed. There is no land contamination issue associated with the construction of the Project.

Operation Phase

During the operation of the biodiesel plant, potential land contamination may arise when there is any spillage of chemicals. The chemicals to be stored on-site include chemical reagents (sulphuric acid, phosphoric acid, methanol, sodium hydroxide) and products (including biodiesel, glycerine, fertiliser, bioheating oil). Biodiesel is biodegradable. The potential environmental impact due to accidental spillage of biodiesel or leakage from the biodiesel storage tanks will be much lower than that for petroleum diesel.

As all chemical storage tanks will be designed to comply with the relevant statutory requirements (including structural integrity of the tank; construction of a containment bund and concrete floor; and the type of storage tank will be compatible with the chemicals) the chance of chemical or biodiesel seepage into the subsoil will be low. An emergency response plan will be developed to ensure that any spillage of chemicals or biodiesel, and leakage from the storage tanks will be responded immediately and the affected area appropriately cleaned up. With the implementation of the precautionary design measures and an emergency response plan, it is considered that the potential for land contamination due to the operation of the biodiesel plant will be minimal.

GTW and WCO are not a chemical / hazardous waste and therefore any spillage within the site is not expected to cause land contamination as defined by the EPD.

3.12 *HAZARD TO LIFE*

A risk assessment of the proposed biodiesel plant was conducted to assess the hazard to life associated with the operation of the plant. Hazards from storage of the following chemicals were considered:

- Biodiesel;
- Methanol;
- Gas oil;
- Sulphuric acid; and
- Phosphoric acid.

The risk assessment considered releases that may occur as a result of loss of containment from spontaneous failures of outdoor storage tanks. Based on an examination of hazards associated with the proposed biodiesel plant, a checklist of release cases was developed for further assessment.

The frequency of initiating events (such as tank failure, leakage, etc.) was estimated from historical data. Based on this, event tree analysis was conducted to determine the frequencies of various hazardous outcomes (eg pool fires). The effects zones for these hazardous outcomes were determined using various consequence models and the frequency and consequence analyses were integrated using ERM RISKPLOT™ software.

The calculated risk levels were compared with the *Hong Kong Risk Guidelines*. Based on this, the following conclusions were drawn:

- The overall Potential Loss of Life (PLL) value was estimated as 7.1×10^{-6} per year and the Frequency against Number of Fatalities (F-N) curve, which demonstrates the societal risk posed by the facility, was found to be well within the "acceptable" region of the *Hong Kong Risk Guidelines*; and

- The 1.0×10^{-6} per year individual risk contour for the facility does not extend beyond plant boundary. Therefore the individual risk from the plant complies with the Hong Kong individual risk guidelines which state that the individual risk off-site should not exceed 1.0×10^{-5} per year.

Since the estimated individual and societal risks were found to be acceptable when evaluated against the *Hong Kong Risk Guidelines*, no further mitigation measures are deemed to be necessary for further reduction in the risk levels associated with the Project. It should be noted that there are a number of operating biodiesel plants with a similar methanol storage capacity which are operated to high safety standards.

Detailed of the risk assessment is presented in *Annex B*.

3.13 *CUMULATIVE IMPACTS*

Construction Phase

No planned major construction works will be undertaken in the Study Area during the construction of the biodiesel plant. No cumulative environmental impacts are anticipated.

Operation Phase

The traffic and air quality impact assessment have taken account of background traffic and other emission sources during the operation of the biodiesel plant. No adverse impacts have been identified.

3.14 *ENVIRONMENTAL PROTECTION MEASURES*

The following good site management practices and environmental protection measures will be implemented for the Project.

Construction Phase

- All debris and materials will be covered or stored in a sheltered debris collection area. Dust control measures such as water spaying on roads and dusty areas, covering of lorries by impervious sheets and controlling of the falling height of fill materials, will be implemented in accordance with *Air Pollution Control Ordinance*.

- Idling PME will be switched off. Quiet PME will be used as far as practicable. Work sequences to avoid the simultaneous use of noisy PME will be planned ahead of commencement of works.

- Public fill and general refuse will be segregated and stored separately for disposal. Waste will be properly stored at site and windblown litter and dust will be minimised during transportation by either covering trucks or transporting wastes in enclosed containers. Waste will be disposed of at licensed sites. A trip-ticket system will be established in accordance with *ETWBTC No. 31/2004* to monitor the disposal of construction waste at the SENT Landfill and to control fly-tipping.

- The contractor will register as a chemical waste producer with EPD. Chemical waste will be handled in accordance with the *Code of Practice on the Packaging, Handling and Storage of Chemical Waste*.

- Effluent discharge from construction activities shall conform to relevant *ProPECC Note 1/94 Construction Site Drainage* requirements and comply with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* under the *WPCO*.

Operation Phase

Proven technologies and environmental protection measures (for example, reception of GTW and WCO in closed system; enclosure and provision of air scrubbing system for of the GTW reception area and feedstock storage tanks; provision of air scrubbing system for the wastewater storage and treatment tanks; limit the total sound pressure level at the site boundary to 85 dB(A), etc) have been adopted for the design and operation of the proposed biodiesel plant. The environmental assessment shows that the operation of the biodiesel plant will not cause adverse environmental impacts and unacceptable hazard to life. No additional environmental mitigation measures will be required.

3.15 COMMENT ON THE POSSIBLE SEVERITY, DISTRIBUTION AND DURATION OF ENVIRONMENTAL EFFECTS

Based on the findings of the assessment of the Project Profile, the environmental impacts potentially arising from the construction of the Project is considered to be minor and transient. The potential environment impacts during the operation of the biodiesel plant meet the requirements of the *EIAO-TM*. With the implementation of general good construction practice and environmental protection measures to be incorporated in the design of the plant, no adverse residual environmental impacts are anticipated.

With the view that no adverse environmental impacts is expected to arise from the Project and the predicted impacts comply with the requirements of the *EIAO-TM*, the Project Proponent intends to apply for an EP under the provision of Section 5(1) of the *EIAO*.

3.16 REFERENCE TO PREVIOUSLY APPROVED EIA REPORTS

References were made to the *EIA for Fill Bank at Tseung Kwan O Area 147 (EIA-076/2002)* and *EIA for Permanent Aviation Fuel Facility for Hong Kong International Airport (EIA-127/2006)* during the preparation of this Project Profile.

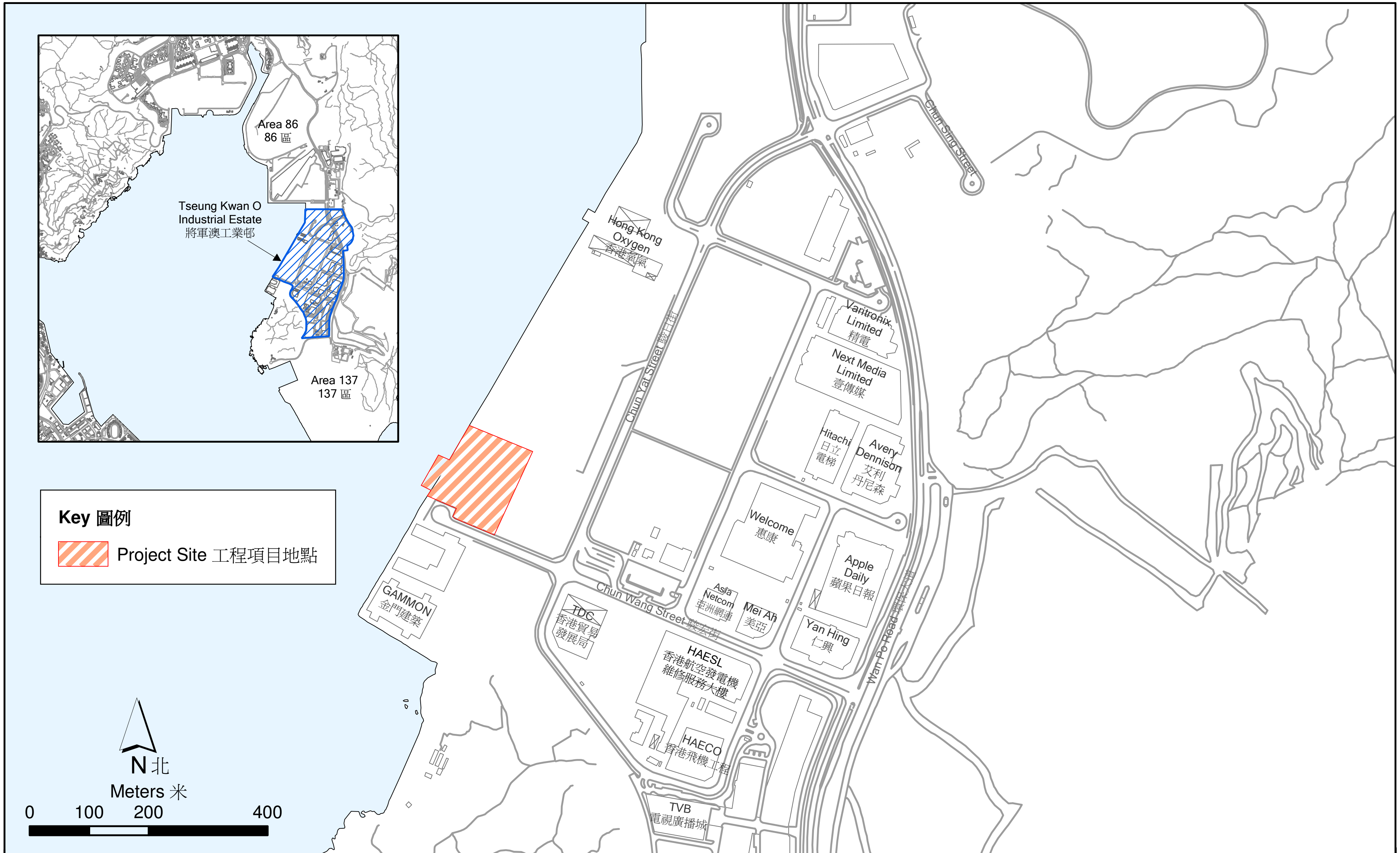

Figure 1.5a
圖 1.5a

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Site Location Plan of the Biodiesel Plant
生物柴油廠位置圖

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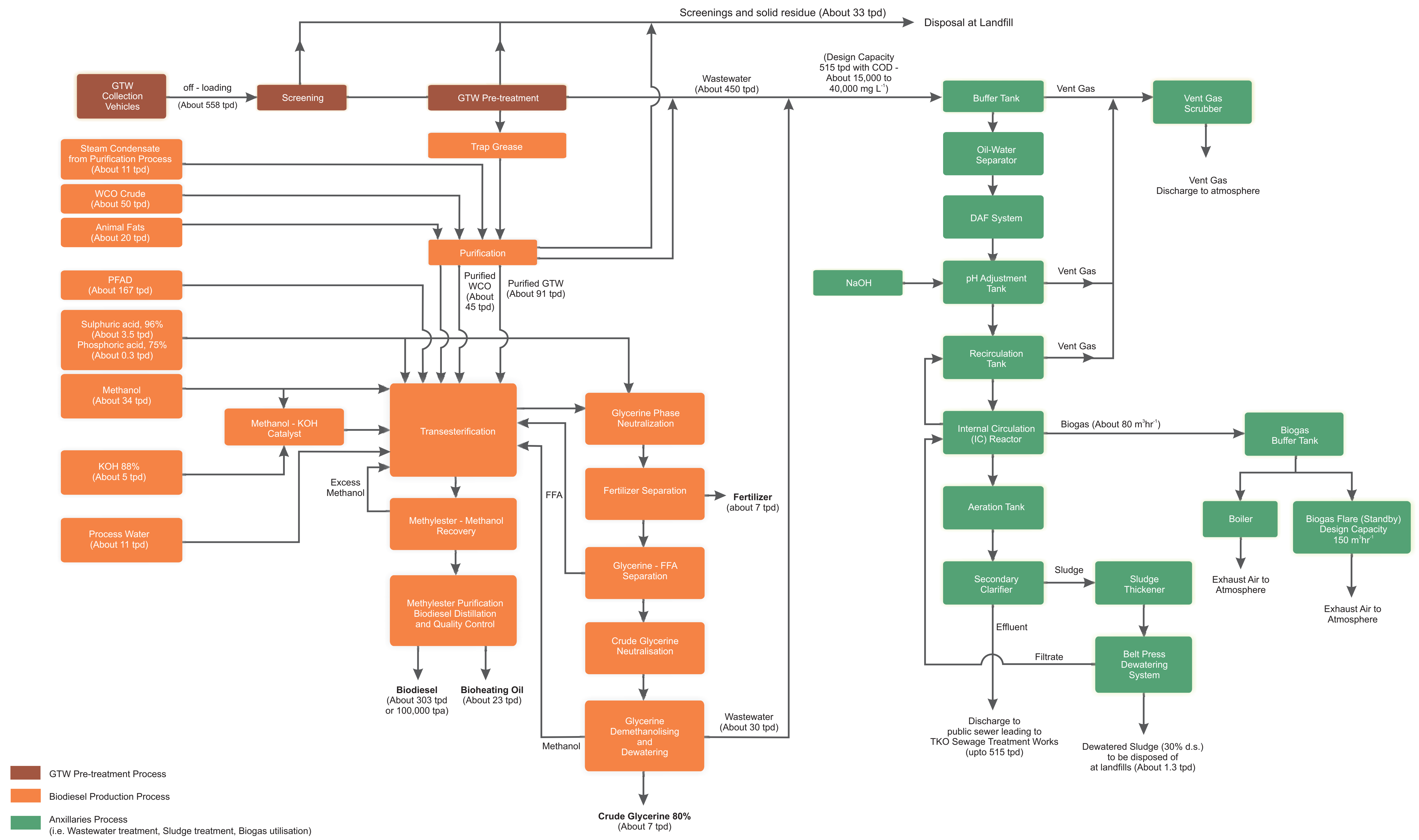

Figure 2.2a

Process Flow Diagram of Proposed Biodiesel Plant

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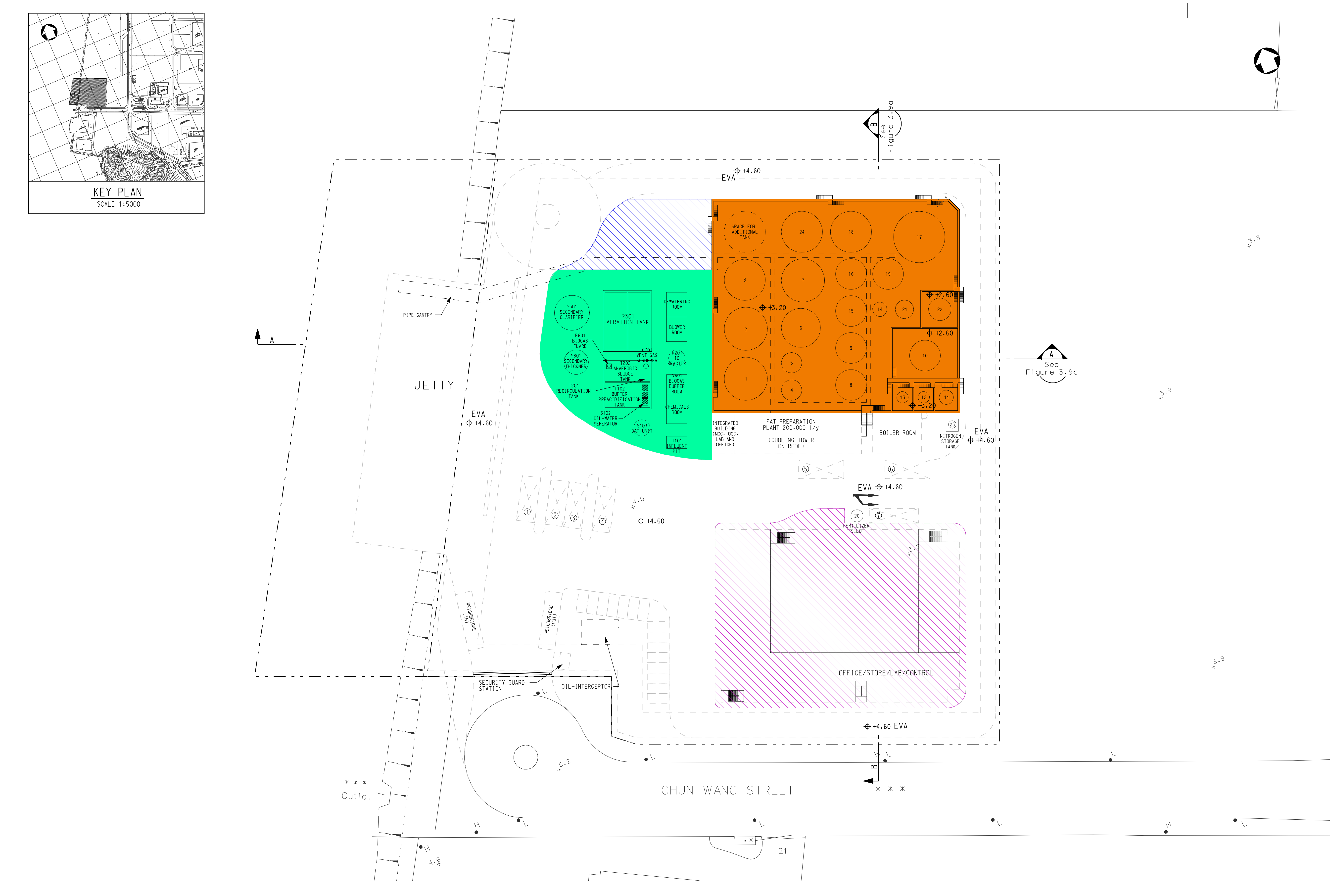

LEGEND :

- Tank Form
- Process Building and Office/Store/Laborating/Control
- Drum Storage Area
- Wastewater Treatment Plant
- +3.90 EXISTING LEVELS
- +4.60 FUTURE FORMATION LEVELS
- SITE BOUNDARY INCLUDING MARINE BOUNDARY
- INGRESS/EGRESS WITH SECURITY GATE

LOADING/UNLOADING BAYS

- *① TRUCK UNLOADING STATION (GTW/WCO)
- *② TRUCK UNLOADING STATION (GTW/WCO)
- *③ TRUCK LOADING STATION (GTW/WCO)
- *④ TRUCK LOADING STATION (GTW/WCO)
- ⑤ TRUCK LOADING STATION (SOLID WASTE)
- ⑥ TRUCK UNLOADING STATION (ACIDS, METHANOL & GAS OIL)
- ⑦ TRUCK LOADING STATION (FERTILIZER)

* REMARK :
TO ACHIEVE FLEXIBILITY, ①, ②, ③ AND ④ CAN BE USED AS BOTH THE TRUCK UNLOADING STATION (GTW/WCO) AND TRUCK LOADING STATION (GLYCERINE/BIODIESEL) IF NECESSARY

	TANK LIST	VOLUME (m 3)	CAPACITY (DAYS)
1	TRAP GREASE, CRUDE STORAGE TANK	1500	2.5
2	TRAP GREASE, CRUDE STORAGE TANK	1500	2.5
3	TRAP GREASE, CLEANED STORAGE TANK	1000	3.0
4	WCO, CRUDE STORAGE TANK	150	0.5
5	WCO, CRUDE STORAGE TANK	150	0.5
6	WCO, CLEANED STORAGE TANK	1000	3.0
7	PFAD STORAGE TANK	1500	4.5
8	ANIMAL FAT, CRUDE STORAGE TANK	500	1.5
9	ANIMAL FAT, CLEANED STORAGE TANK	500	1.5
10	METHANOL STORAGE TANK	500	12.0
11	SULFURIC ACID STORAGE TANK	50	21.5
12	PHOSPHORIC ACID STORAGE TANK	25	49.5
13	CHEMICALS PUFFER TANK	25	-
14	ADDITIVE STORAGE TANK	50	15.0
15	BIODIESEL QUALITY TANK	500	1.5
16	BIODIESEL QUALITY TANK	500	1.5
17	BIODIESEL-EUROPE STORAGE TANK	2500	7.5
18	BIODIESEL HONGKONG STORAGE TANK	1200	3.5
19	GLYCERINE 80% STORAGE TANK	500	18.5
20	FERTILIZER CONTAINER	20	3.0
21	BIOHEATING OIL STORAGE TANK	100	10.0
22	GAS OIL STORAGE TANK	200	13.0
23	NITROGEN STORAGE TANK	25	16.5
24	SWITCH STORAGE TANK	1200	-

0 10 20 M
1:400 SCALE BAR

FIGURE 2.2b

Proposed Layout Plan of the Biodiesel Plant

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DATE: 15/08/2007

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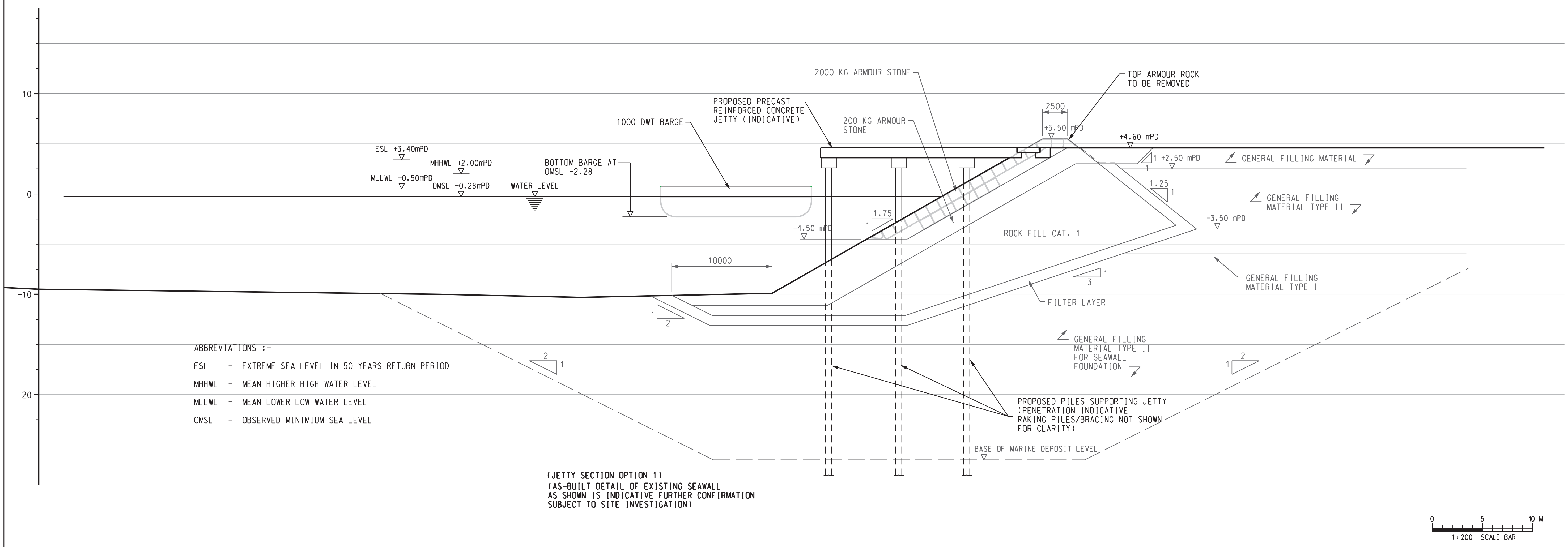

Figure 2.2c

Piled Deck Jetty Construction

FILE: 0062388e
DATE: 15/08/2007

Environmental Resources Management
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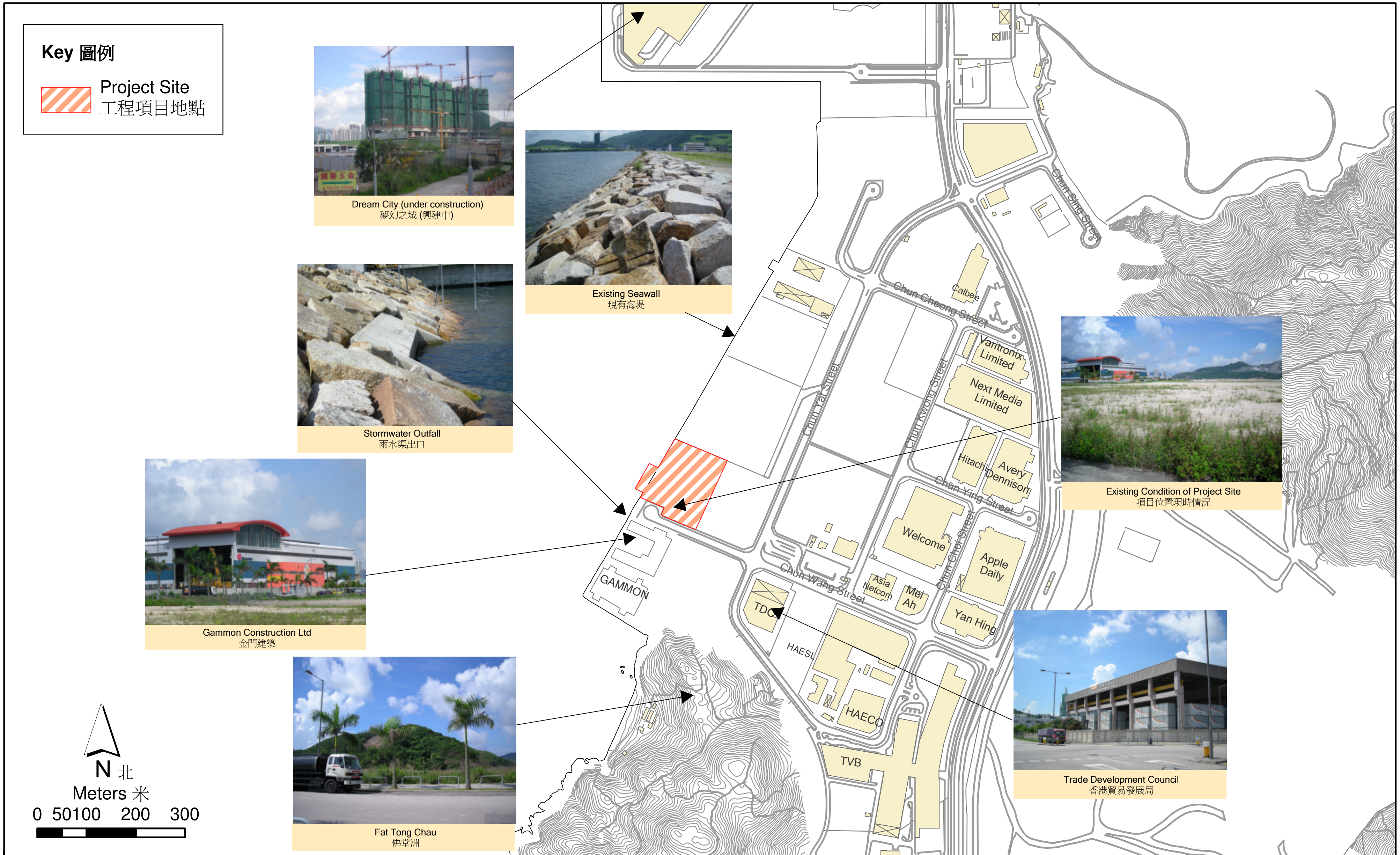

Figure 3.2a
圖 3.2a

Site Surrounding Environment
項目位置鄰近的環境情況

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Date: 02/06/2007

Environmental Resources Management

ERM

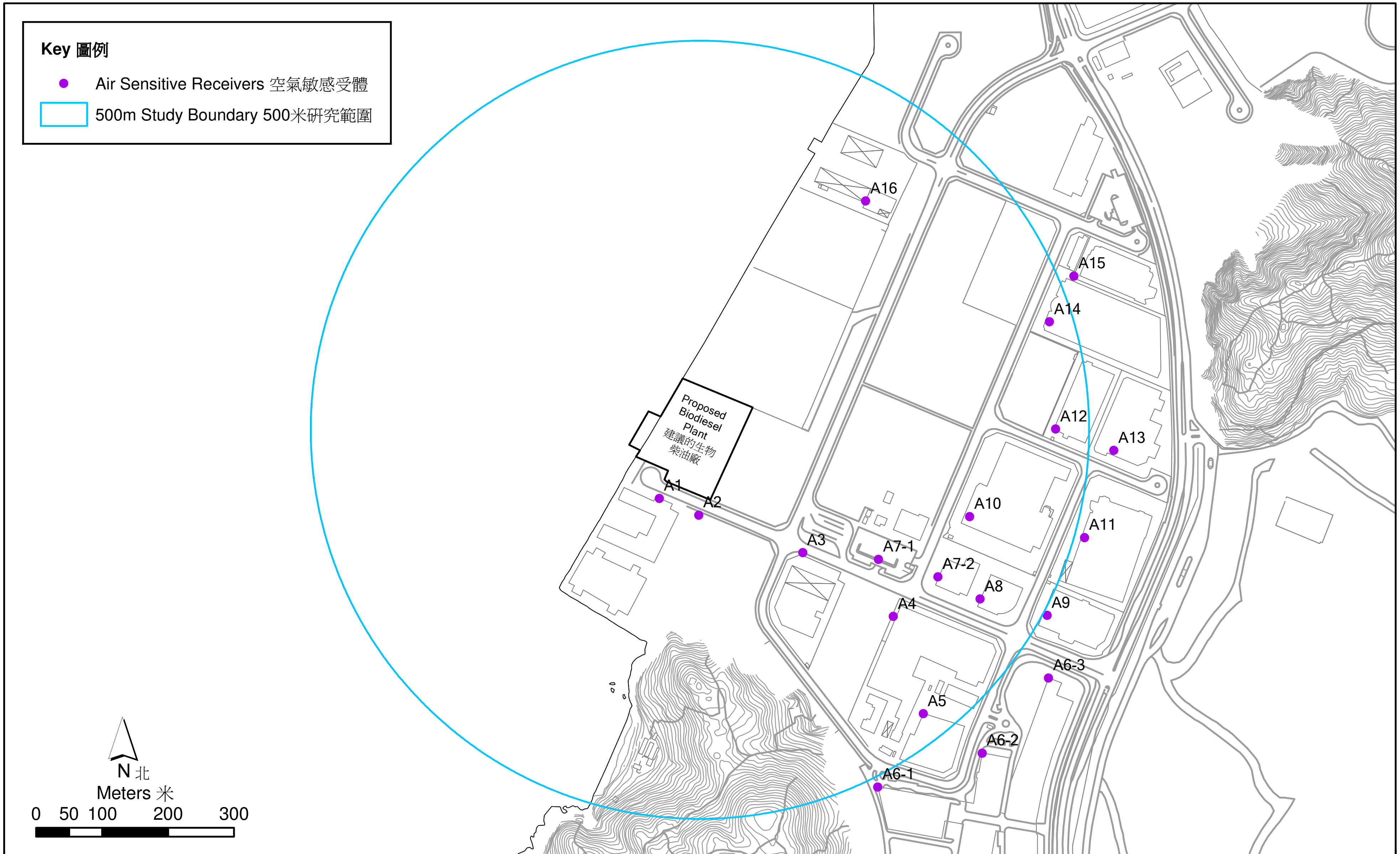

Figure 3.2b
圖 3.2b

Locations of Representative Air Sensitive Receivers
空氣敏感受體位置圖

File: 0062388_8.mxd
Date: 17/08/2007

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ERM

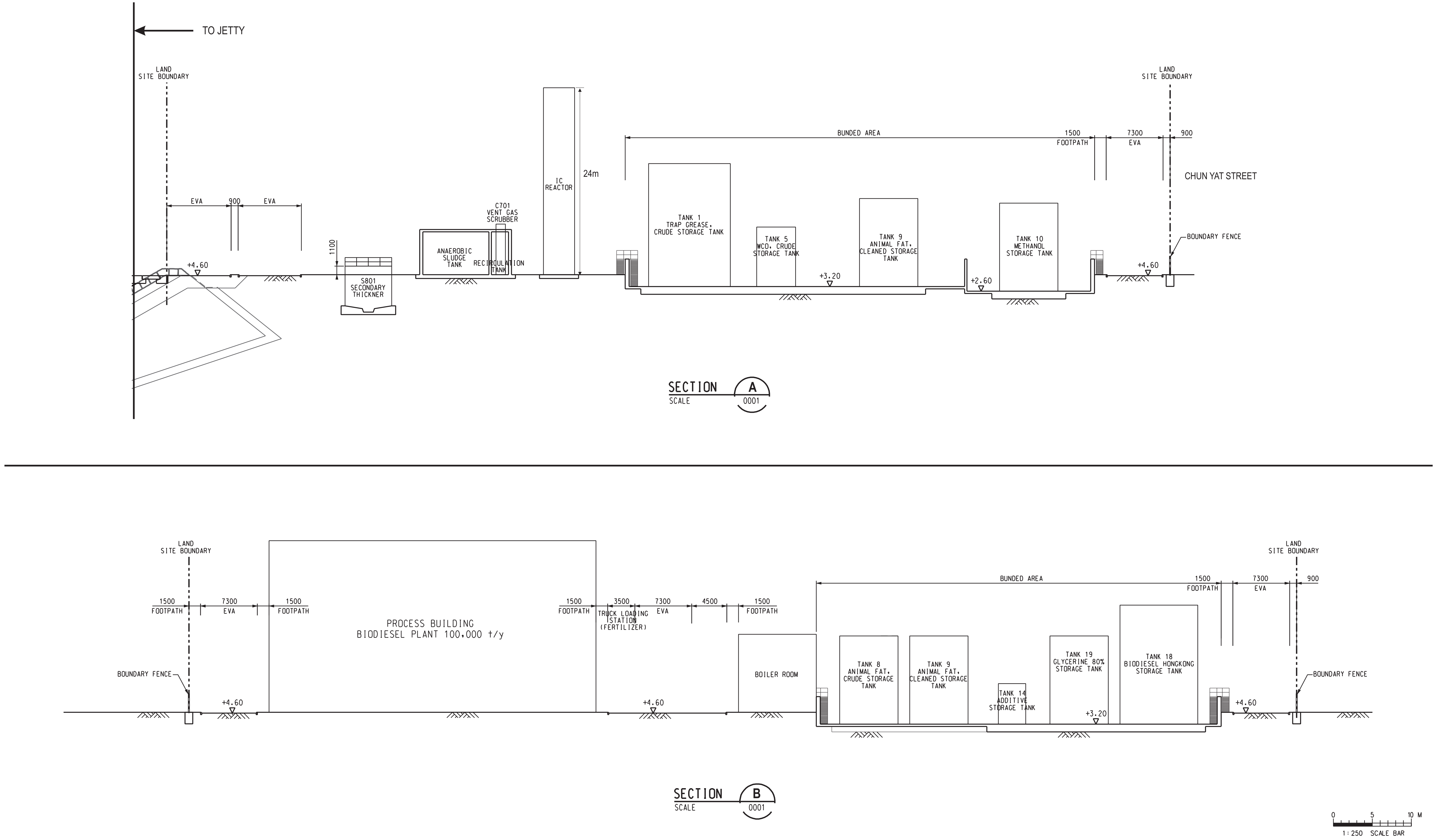

Figure 3.9a

Verticle Profile of Biodiesel Plant

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DATE: 15/08/2007

Environmental Resources Management

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Annex A

Air Quality Impact Assessment

A. AIR QUALITY ASSESSMENT

A.1 INTRODUCTION

This Section presents an assessment of the potential air quality impacts associated with the construction and operation of the proposed Biodiesel Plant in Tseung Kwan O Industrial Estate (TKOIE).

Dust nuisance and stack emissions are the potential air quality impacts during the construction and operation phases, respectively. Air Sensitive Receivers (ASRs) have been identified and potential air quality impacts were evaluated. Where necessary, mitigation measures are recommended to minimize the impacts and ensure compliance with the air quality criteria.

A.2 STATUTORY REQUIREMENTS AND EVALUATION CRITERIA

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 (AQOs), which are presented in *Table A.1,* stipulate the statutory limits for air pollutants and the maximum allowable numbers of exceedences over specific periods.

Table A.1 Hong Kong Air Quality Objectives ($\mu g\ m^{-3}$) [a]

Air Pollutant	**Averaging Time**			
	1 Hour [b]	**24 Hour [c]**	**3 Months [d]**	**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	-	-	-
Photochemical Oxidants (as ozone (O_3)) [f]	240	-	-	-
Lead (Pb)	-	-	1.5	-

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
(f) Photochemical oxidants are determined by measurement of ozone only

In addition, the *Technical Memorandum of Environmental Impact Assessment Ordinance* (EIAO-TM) stipulates an hourly TSP criterion of 500 $\mu g\ m^{-3}$ for construction dust impact and an odour criterion of 5 Odour Unit (OU) in 5-second averaging time for the odour impact assessment.

The measures stipulated in the *Air Pollution Control (Construction Dust) Regulations* should be followed to reduce dust impacts.

A.3 BASELINE CONDITIONS AND IDENTIFICATION OF AIR SENSITIVE RECEIVERS

A.3.1 *Baseline Conditions*

The Site is located at the southwest of the TKOIE on Chun Wang Street. Gammon Skanska is located immediately south of the Site. The west and north of the Site are sea and vacant land, respectively. The SENT Landfill is located at about 680m from the south-east of the Site. The local air quality is dominated by stack emissions of industrial establishments in the TKOIE and vehicle exhaust emissions from Chun Wang Street and Wan Po Road.

There is no EPD's Air Quality Monitoring Station (AQMS) operating in Tseung Kwan O area. The nearest EPD's AQMS is located at Kwun Tong. The means of the annual average air pollutant concentrations recorded at the EPD's Kwun Tong AQMS from 2001 to 2006 are used to establish the background air quality of the Study Area (see *Table A.2*).

Table A.2 Background Air Pollution Concentrations

Air Pollutant	**Background Concentration (a)**
TSP	81 (b)
RSP	56 (b)
NO_2	66 (b)
CO	751 (c)

Notes:

(a) Reference to Annual Air Quality Statistics 2006 (http://www.epd-asg.gov.hk/english/report/aqr.php)

(b) The data recorded at EPD's Kwun Tong AQMS

(c) Since no CO was recorded at EPD's Kwun Tong AQMS, the CO recorded at the next nearest EPD's AQMS at Tap Mun was used.

A.3.2 *Identification of Air Sensitive Receivers*

Within the Study area (ie 500m from the Site boundary), the land uses are all industrial. According to the Outline Zoning Plan (OZP) (No. S/TKO/15), no planned/committed air sensitive uses are proposed in the vicinity of the Site.

Representative Air Sensitive Receivers (ASRs) are presented in *Table A.3* and their locations are shown in *Figure A1*.

Table A.3 Representative Air Sensitive Receivers (ASRs)

ASR	Location	Approximate Distance from nearest Project Site Boundary (m)
A1	Gammon Skanka	30
A2	Proposed Industrial Uses (currently vacant)	30
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	50
A4	HAECO Component Overhaul Building	210
A5	HAELO	470
A6-1	TVB City	510
A6-2	TVB City	560
A6-3	TVB City	570
A7-1	Asia Netcom HK Limited	160
A7-2	Asia Netcom HK Limited	235
A8	Mei Ah Centre	310
A9	Yan Hing Industrial Building	415
A10	Wellcome Co. Ltd	240
A11	Next Media Apple Daily	415
A12	Hitachi Tseung Kwan O Centre	380
A13	Avery Dennison	445
A14	Next Media Co. Ltd	420
A15	Varitronix Limited	500
A16	Hong Kong Oxygen Acetylene Co. Ltd	415

A.4 POTENTIAL SOURCES OF IMPACTS

A.4.1 *Construction Phase*

The Site has been formed and is currently vacant. Hence, no major earthwork will be required for the site formation works. Minor excavation works will be required for the construction of the foundation works and site utilities. The tank farms and process equipment will be pre-fabricated off-site and assembled on site and hence minimal dust will be generated from this activity. Dust generated from the concreting works for the construction of site buildings will be minimal. With the implementation of dust suppression measures stipulated under the *Air Pollution Control (Construction Dust) Regulation* and adoption of good site practice, no adverse construction dust impact is anticipated.

A.4.2 *Operation Phase*

Potential air pollution sources from the biodiesel plant during the operation phase include:

- Emissions from fuel combustion of boiler;
- Emissions from standby biogas flare;

- Odour from unloading and treatment of Grease Trap Waste (GTW); and
- Odour from the on-site wastewater treatment; and
- Vehicular emissions from additional traffic associated with the operation of the biodiesel plant.

To assess potential cumulative air quality impacts the emissions from the existing stacks within the Study Area were also considered.

Emissions from Fuel Combustion of Boiler

The boiler is a dual-fuel fired boiler (biodiesel/bioheating oil or biogas) for production of steam for the biodiesel process. Under normal operation, it will utilise the biogas (a high energy value, 36.44 MJ Nm^{-3}) generated from the IC Reactor of the wastewater treatment plant. Biodiesel or bioheating oil will be used as the supplementary fuel.

It is estimated that an average of about 79 m^3 hr^{-1} of biogas will be produced from the IC Reactor. Based on a steam consumption rate of 6,000 kg hr^{-1}, about 350 kg of biodiesel/bioheating oil will be required per hour (equivalent to a consumption rate of about 346 m^3 hr^{-1} of biogas). In addition to the biogas, about 270 kg of biodiesel/bioheating oil will be required per hour under normal operation of the biodiesel plant.

The major air pollutants from combustion of biogas or biodiesel or bio-heating oil are expected to be volatile organic compounds (VOCs), carbon monoxide (CO) and a limited quantity of nitrogen dioxide (NO_2). The air pollutants will be emitted at a minimum exit velocity of 7 m s^{-1} and temperature of 100°C through a 20m stack with a diameter of 0.5m.

With reference to the emission factor of NO_2, CO and VOCs established for biogas and biodiesel, a comparison of emission rate of NO_2, CO and VOCs from boiler combustion is summarized in *Table A.4*.

Table A.4 Comparison NO_2, CO and VOC Emissions from Combustion of Biogas and Biodiesel at Boiler

Parameter		**Biogas**	**Biodiesel**
Stack Height (m above ground)		20	
Stack Diameter (m)		0.5	
Flue Gas Exit Velocity (m s^{-1})		7 (minimum)	
Flue Gas Exit Temperature (°C)		100 (minimum)	
Flue Gas Exit flow Rate ($m^3 s^{-1}$)		1.4	
Fuel Consumption (kg hr^{-1})		-	350
Volume of Biogas/Biodiesel Consumed ($m^3 hr^{-1}$)		150 (a)	0.39 (b)
Emission Factor for Biogas (mg m^{-3}) (c) (d)	NO_x	100	-
	CO	50	-
	VOCs	10	-
Emission Factor for Biodiesel (kg m^{-3}) (e) (f)	NO_x	-	2.4
	CO	-	0.6
Emission Rate (g s^{-1}) (g)	NO_x	0.004	0.26
	NO_2	0.002	0.05
	CO	0.005	0.06
	VOCs	0.001	-

Notes:

(a) The design capacity of the flare is 150 $m^3 hr^{-1}$ of biogas. Under normal operation, the actual emission will be much less than that based on the design capacity.

(b) The density of biodiesel is 900 kg m^{-3}.

(c) The emission factor of biogas is assumed to be similar to that of landfill gas.

(d) The emission factor of biogas is reference to *UK Guidance on the Management of Landfill Gas*.

(e) The emission factor of biodiesel is assumed to be similar to that of diesel (this is a conservative assumption).

(f) The emission factor for diesel is referenced to the *Compilation of Air Pollutant Emission Factors, AP-42, 5th Edition, USEPA*.

(g) Emission rate of air pollutant from combustion of biogas/biodiesel = emission factor x volume of biogas/biodiesel consumed. For example, NO_x emission rate from combustion of biogas = (100 mg m^{-3}) x (150 $m^3 hr^{-1}$) / (1,000 x 3,600) = 0.004 g s^{-1}

It can be seen from *Table A.4* that the pollutant emission rates for combustion of biodiesel are higher than that of biogas. To assess the worst-case scenario, it is therefore assumed that the boiler will consume only biodiesel.

Emissions from Standby Flare

Under normal operation, all the biogas generated from IC reactor will be used as fuel for boiler. However, when the boiler is under maintenance, all the biogas generated will be flared. The stack of the flare will be installed at about 12.5m above ground. The diameter of stack is about 0.96m and the flue gas flow rate is about 0.39 $m^3 s^{-1}$.

An air scrubber will be installed to remove the hydrogen sulphide (H_2S) in the biogas prior to combustion in the flare or boiler. Nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs) will therefore be the key pollutants from the biogas flare.

Assuming the flare is operating at its maximum capacity (ie 150 $m^3 hr^{-1}$ of biogas), the emission rates of NO_2, CO and VOCs are summarized in *Table A.5*.

Table A.5 Emission of NO_2, CO and VOC from Standby Biogas Flare

		Biogas
Stack Height (m above ground)		10
Stack Diameter (m)		0.96
Exit Flow Rate ($m^3 s^{-1}$)		0.39
Exit Temperature (°C)		900
Volume of Biogas to be flared off ($m^3 hr^{-1}$)		150 (a)
Emission Factor for Biogas ($mg\ m^{-3}$) (b) (c)	NO_x	100
	CO	50
	VOCs	10
Emission Rate ($g\ s^{-1}$)	NO_x	0.004
	NO_2	0.001
	CO	0.0021
	VOCs	$4.2x10^{-4}$

Notes:
(a) The design capacity of the flare is 150 $m^3 hr^{-1}$ of biogas.
(b) The emission factor of biogas is assumed to be similar to that of landfill gas.
(c) The emission factor of biogas is reference to *UK Guidance on the Management of Landfill Gas*.

Odour from Unloading and Treatment of GTW

The unloading and storage of GTW and operation of the wastewater treatment plant have the potential to cause odour nuisance if not properly managed.

GTW will be delivered to the biodiesel plant by sealed road tankers. After weighing, the tankers will be directed to the enclosed reception area. GTW will be discharged from the tanker directly to the storage tanks in a closed system (via flexible hose). Hence, no odour will be emitted from the unloading operation. As a precautionary measure and a good design practice to prevent odour emission from the site, the unloading stations will be enclosed and fitted with a ventilation and air scrubbing system in order to maintain a slight negative pressure inside the unloading stations. All process tanks, including the GTW storage tanks will be enclosed and the exhaust air will be treated by an air scrubbing system (with a design odour removal efficiency of at least 99.5%). The scrubbed exhaust air will be diverted to the aeration tank of the on-site wastewater treatment plant as part of the air intake for the aeration process. Any residual odorous components in the exhaust air will be scrubbed by the wastewater. The vent gas of the aeration tank will be cleaned by an air scrubbing system prior to discharge to the atmosphere (see below).

Odour from On-site Wastewater Treatment Plant

All wastewater storage and treatment tanks will be enclosed. After the anaerobic digestion process in the IC Reactor, the BOD of the wastewater will be significantly reduced (by about 80%) and hence the potential for odour nuisance is significantly reduced. The vent air from the wastewater storage and treatment tanks will be cleaned by an air scrubbing system (with a design odour removal efficiency of at least 99.5%) prior to discharge to the atmosphere. Hydrogen sulphide (H_2S) is the major pollutant in the vent gas which causes odour nuisance. It is estimated that the raw vent gas from the wastewater treatment tanks will contain about 30ppm (or 42.5 mg m^{-3}) of H_2S. After scrubbing, the H_2S concentration in the exhaust air will be reduced to 0.21 mg m^{-3} (1).

The height and diameter of the exhaust vent duct of the air scrubber are 6.5 m above ground and 0.63m, respectively. The exhaust gas flow rate is 0.625 m^3 s^{-1}. The H_2S emission rate will therefore be 1.31 x 10^{-4} g s^{-1}. Since there is no heating process in the air scrubber, the temperature of the exhaust air from the air scrubber is assumed to be the same as the ambient temperature.

Emissions from Existing Stacks within the Study Area

The proposed biodiesel plant will be located at the TKOIE. The total fuel consumption of all industrial facilities within TKOIE is limited to 56.6 m^3 per day. Within the 500m Study area, the only emission source is the Hong Kong Aero Engine Services Company Limited (HAECO) who is allowed to consume up to 4 m^3 of diesel per day. In accordance with the *Table 4.15* of the approved EIA for *Environmental and Traffic Impact Assessment Study for Fill Bank at Tseung Kwan O Area 137 (Agreement No. CE 57/2001)*, the stack information of HAECO is summarized as follows:

• Diesel fuel consumption	4 m^3 per day
• No of stack	1 no.
• Stack height	40m above ground
• Stack diameter	12.5m
• Exit temperature	52°C
• Exit velocity	9 m s^{-1}
• Operating hours	24 hours

Emissions from the HAECO stack have been included to assess the cumulative air quality impacts.

Emissions from Delivery Trucks

Vehicular emissions induced from the Project are expected to be negligible since additional traffic associated with the operation of the biodiesel plant only constitutes a very small percentage of the total traffic in the Study Area. It is therefore considered that the potential air quality impact due to additional traffic is negligible and will not cause adverse air quality impact.

(1) To be conservative, an odour removal efficiency of 99.5% is assumed in the assessment. It should be noted that a number of commercially available air scrubbing systems could achieve a H_2S removal efficiency higher than 99.5%.

A.5 ASSESSMENT METHODOLOGY (OPERATIONAL AIR QUALITY IMPACT)

Stack Emissions from Boiler Stack, Standby Flare and Existing HAECO

The potential air quality impacts due to the emissions from the boiler stack, standby flare and HAECO stack were assessed.

To assess the worst-case scenario, it is assumed the boiler is fuelled with biodiesel and the biogas flare will be operated at its design capacity (ie to flare 150 $m^3 hr^{-1}$ of biogas) and on a 24-hour per day basis. *Table A.6* summarises the emission inventory for the cumulative air quality impact assessment.

Table A.6 Summary of Stack Information and Emission Inventory

Parameter		Boiler Stack	Biogas Flare	HAECO Stack
Operating Hours		24	24	24
No. of Stack		1	1	1
Stack Height (m above ground)		20	12.5	40
Stack Diameter (m)		0.5	0.96	12.5
Flue Gas Exit Temperature (°K)		373	1,173	325
Flue Gas Exit Velocity ($m s^{-1}$)		7	0.54	9
Emission Rates ($g s^{-1}$)	NO_x	0.26	0.004	0.11
	NO_2 (a)	0.05	0.001	0.02
	CO	0.06	0.0021	0.03
	VOCs	-	4.2×10^{-4}	-

Note:
(a) It is assumed that 20% of NO_x emitted from the stacks will be converted to NO_2.

Hourly, daily and annual average NO_2, CO and VOCs concentrations at the identified ASRs were predicted using an EPD approved air dispersion model, Industrial Source Complex Short-Term (ISCST3). The 2006 meteorological data recorded at the TKO Weather Station and "rural" mode were used for the model runs as the Project Site is located at the waterfront.

The hourly, daily and annual average concentrations of the air pollutants were predicted at 1.5m, 10m, 20m and 30m above ground at the identified ASRs as the building height within the TKOIE is restricted to 30m above ground. Background air pollutant concentrations (refer to *Table A.2*) were also included to assess the total air quality impacts.

Critical pollutant will be identified according to the predicted results and isopleths showing the critical pollutant impact in the vicinity are plotted.

Odour from On-site Wastewater Treatment Plant

Table A.7 summarized the H_2S emission inventory of the on-site wastewater treatment plant after treatment by the air scrubbers.

Table A.7 ***Summary of H_2S Emission Inventory***

Parameter	**Air Scrubber Exhaust Stack**
Operating Hours	24
No. of Stack	1
Vent Duct Height (m above ground)	6.5
Vent Duct Diameter (m)	0.63
Exhaust Air Exit Temperature (°K)	Ambient temperature
Exhaust Air Exit Velocity (m s^{-1})	2
H_2S concentration at Exhaust Duct (mg m^{-3})	0.21
H_2S Emission Rate (g s^{-1})	1.31×10^{-4}

An EPD approved air dispersion model, ISCST3 was used to predict an output which is described by the model as a maximum hourly concentration at 1.5m, 10m, 20m and 30m above ground of identified ASRs. Other modeling parameters are similar to that adopted in the stack emission assessment.

In actual fact, the model output corresponds more closely to a maximum 15-minute average concentration. This matter relates to the Pasquill-Gifford vertical dispersion parameter used in the ISCST model which is fully documented in the *Workbook on Atmospheric Dispersion Estimates*.

In order to convert the model outputs to maximum 5-second average concentrations, a two-step conversion process has been defined.

Step 1:

Conversion of the model output to a maximum 3-minute average, using the power law formula proposed by *Duffee et al* (1), which is reproduced below:

$$X_l = X_s \left(\frac{t_s}{t_l} \right)^p$$

Where:
X_l = concentration for the longer averaging time;
X_s = concentration for the shorter averaging time;
t_s = shorter averaging time;
t_l = longer averaging time; and
p = power law exponent, which depends on the Pasquill stability class, and is detailed in *Table A.8*.

Table A.8 ***Power Law Exponents***

Pasquill Stability Class	**p**
A	0.5
B	0.5
C	0.333
D	0.2
E	0.167
F	0.167

(1) RA Duffee, MA O'Brien & N Ostojic, *Odour Modelling - Why and How*, Air & Waste Management Association.

Step 2:

To convert 3-minute average to maximum 5-second average concentration, the approach suggested by the Warren Spring Laboratory (1) 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….."

The resulting factors for converting the model outputs to 5-second averages are presented in *Table A.9*.

Table A.9 ***Factors for Converting Model Outputs to Maximum 5-second Mean H_2S Concentrations***

Pasquill Stability Class	**Conversion 15-minute to 3-minute Average**	**Conversion 3-minute to 5-second Average**	**Overall Conversion Factor**
A	2.23	10	22.3
B	2.23	10	22.3
C	1.70	5	8.50
D	1.38	5	6.90
E	1.31	5	6.55
F	1.31	5	6.55

To convert predicted 5-second H_2S concentrations into odour level, an odour threshold of 1 OU equivalent to 0.66 µg m^{-3} of H_2S concentration was applied to the model results.

Isopleths showing 5-second odour levels are plotted at the different assessment heights of the vicinity.

A.6 *EVALUATION OF IMPACTS*

Stack Emissions from Boiler Stack, Standby Flare and Existing HAECO

The cumulative maximum hourly, daily and annual average concentrations of NO_2, CO and VOCs were predicted at various heights of the identified ASRs and the predicted results, taking account of the background air quality and existing HAECO stack emission, are summarized in *Tables A.10* to *A.12*.

The predicted maximum NO_2, CO and VOCs concentrations under different averaging times at various heights of all ASRs are well within the respective AQOs. The highest maximum NO_2, CO and VOCs concentrations, including the background air quality and existing emission sources in the TKOIE are predicted at 30m above ground at A2 (Proposed Industrial Uses) which is located immediately at the south of the Site.

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

The maximum contribution of hourly NO_2 concentration due to the project is about 60.5% of the total predicted concentration (167 μgm^{-3}). *Figures A2* to *A5* present the isopleths of the cumulative maximum hourly NO_2 concentrations at different heights. The isopleths show that the impacts are localized and complied with the EIAO-TM assessment criterion.

The assessment indicates that the operation of the proposed biodiesel plant (including the boiler and standby flare) in the TKOIE will not cause adverse air quality impacts to the identified ASRs.

Table A.10 Predicted Cumulative Maximum Hourly Air Pollutant Concentrations at ASRs

ASR	Predicted Cumulative Maximum Hourly Air Pollutant Concentrations at Different Elevations ($\mu g\ m^{-3}$ at m above ground)											
	NO_2				CO				VOCs			
	1.5m	10m	20m	30m	1.5m	10m	20m	30m	1.5m	10m	20m	30m
A1	73	78	103	141	759	766	796	841	2.4E-01	2.0E-01	4.1E-01	7.2E-01
A2	77	89	127	167	764	779	825	873	1.7E-01	1.3E-01	2.6E-01	3.8E-01
A3	75	79	86	87	762	766	775	776	1.2E-01	2.3E-01	2.0E-01	1.5E-01
A4	75	78	86	89	762	766	776	779	7.3E-02	1.6E-01	1.4E-01	1.1E-01
A5	72	72	72	72	758	759	759	758	1.0E-01	1.2E-01	1.0E-01	7.8E-02
A6-1	71	71	71	70	757	757	757	756	3.0E-02	8.1E-02	1.0E-01	9.7E-02
A6-2	77	80	85	87	764	767	774	776	1.2E-01	9.8E-02	8.5E-02	6.6E-02
A6-3	68	68	68	68	753	753	753	753	1.5E-01	2.9E-02	2.5E-02	2.0E-02
A7-1	73	76	83	86	759	763	772	775	1.5E-01	1.2E-01	1.0E-01	7.7E-02
A7-2	78	84	95	99	766	773	786	791	1.4E-01	1.4E-01	1.2E-01	9.5E-02
A8	79	84	93	96	767	773	784	788	1.8E-01	1.4E-01	1.2E-01	9.5E-02
A9	75	78	83	84	762	765	771	773	1.1E-01	1.3E-01	1.2E-01	9.0E-02
A10	69	69	72	77	755	755	759	764	1.6E-01	1.7E-01	1.5E-01	1.1E-01
A11	68	68	69	71	753	754	755	757	6.7E-02	1.0E-01	8.9E-02	6.9E-02
A12	70	70	71	72	755	756	758	758	5.5E-02	1.5E-01	1.3E-01	1.0E-01
A13	73	73	84	95	759	760	772	786	1.3E-01	6.4E-02	5.6E-02	4.4E-02
A14	72	73	78	87	759	759	766	777	6.1E-02	5.3E-02	4.7E-02	3.8E-02
A15	71	71	72	73	757	757	758	760	4.0E-05	1.3E-01	1.1E-01	8.5E-02
A16	75	75	87	95	762	762	776	786	5.5E-01	6.6E-02	1.0E-01	1.8E-01
AQO	**300**				**30,000**				**-**			

Note:

(a) Background concentrations (NO_2 of 61 $\mu g\ m^{-3}$, CO of 726 $\mu g\ m^{-3}$) have been included.

Table A.11 Predicted Cumulative Maximum Daily/8-hour Air Pollutant Concentrations at ASRs

ASR	Predicted Cumulative Maximum Daily/8-hour Air Pollutant Concentration at Different Elevations ($\mu g\ m^{-3}$ at m above ground)											
	Daily NO_2				8-hour CO				Daily VOCs			
	1.5m	10m	20m	30m	1.5m	10m	20m	30m	1.5m	10m	20m	30m
A1	67.5	69.8	74.1	75.2	756	759	770	774	2.4E-02	5.0E-02	9.8E-02	2.1E-01
A2	68.7	70.9	77.1	85.2	757	762	777	811	2.1E-02	2.9E-02	7.2E-02	1.3E-01
A3	67.3	67.7	68.4	68.5	754	755	757	757	4.0E-02	3.8E-02	3.3E-02	2.5E-02
A4	66.9	67.6	68.9	69.3	755	757	761	763	2.7E-02	2.6E-02	2.3E-02	1.7E-02
A5	66.0	66.0	66.1	66.2	752	752	752	752	2.0E-02	1.9E-02	1.7E-02	1.3E-02
A6-1	66.8	66.8	66.9	66.8	753	753	753	753	1.6E-02	1.7E-02	1.9E-02	1.7E-02
A6-2	67.4	67.8	68.8	69.1	755	756	758	759	1.7E-02	1.6E-02	1.4E-02	1.1E-02
A6-3	65.8	65.8	65.8	65.8	751	751	751	751	5.3E-03	5.1E-03	4.4E-03	3.5E-03
A7-1	66.6	67.1	68.1	68.5	755	757	761	763	1.9E-02	1.8E-02	1.6E-02	1.2E-02
A7-2	67.4	68.2	69.8	70.4	758	762	768	771	2.1E-02	2.1E-02	1.8E-02	1.4E-02
A8	67.5	68.2	69.5	70.0	759	761	767	769	2.1E-02	2.0E-02	1.8E-02	1.4E-02
A9	66.9	67.3	68.0	68.3	756	758	761	762	2.0E-02	1.9E-02	1.7E-02	1.3E-02
A10	65.8	65.9	66.0	66.2	751	751	752	753	1.5E-02	1.5E-02	1.3E-02	9.8E-03
A11	65.8	65.8	65.9	65.9	751	751	751	752	9.3E-03	8.9E-03	7.7E-03	6.0E-03
A12	66.0	66.0	66.2	66.3	751	752	752	752	1.9E-02	1.8E-02	1.6E-02	1.2E-02
A13	66.0	66.4	67.7	68.9	752	753	754	757	8.3E-03	8.0E-03	7.0E-03	5.5E-03
A14	66.1	66.2	66.7	67.2	752	752	753	755	6.8E-03	6.5E-03	5.9E-03	4.9E-03
A15	65.9	66.0	66.6	67.0	752	752	754	755	1.0E-02	1.0E-02	8.8E-03	7.0E-03
A16	67.4	68.3	70.6	72.2	756	758	765	769	1.3E-02	1.6E-02	3.0E-02	4.5E-02
AQO	**150**				**10,000**				**-**			

Note:

(a) Background concentrations (NO_2 of 61 $\mu g\ m^{-3}$, CO of 726 $\mu g\ m^{-3}$) have been included.

Table A.12 Predicted Maximum Annual Air Pollutant Concentrations at ASRs

ASR	Predicted Maximum Daily Air Pollutant Concentration at Different Elevations (μg m-3 at m above ground)							
	NO_2				VOCs			
	1.5m	10m	20m	30m	1.5m	10m	20m	30m
A1	66.00	66.41	67.34	67.85	3.1E-03	6.4E-03	1.8E-02	3.1E-02
A2	66.00	66.48	68.04	69.33	1.7E-03	3.2E-03	9.0E-03	1.7E-02
A3	65.71	65.75	65.83	65.85	2.8E-03	2.7E-03	2.4E-03	1.8E-03
A4	65.69	65.73	65.80	65.83	1.7E-03	1.6E-03	1.4E-03	1.1E-03
A5	65.64	65.65	65.66	65.66	1.3E-03	1.3E-03	1.1E-03	8.6E-04
A6-1	65.68	65.68	65.70	65.70	1.3E-03	1.5E-03	1.9E-03	1.7E-03
A6-2	65.72	65.74	65.80	65.82	1.1E-03	1.1E-03	9.2E-04	7.2E-04
A6-3	65.61	65.61	65.62	65.62	4.3E-04	4.1E-04	3.6E-04	2.8E-04
A7-1	65.64	65.66	65.70	65.72	1.0E-03	9.9E-04	8.7E-04	6.7E-04
A7-2	65.67	65.70	65.76	65.78	9.1E-04	8.7E-04	7.6E-04	5.9E-04
A8	65.67	65.70	65.75	65.77	8.5E-04	8.1E-04	7.1E-04	5.5E-04
A9	65.65	65.67	65.69	65.70	7.7E-04	7.4E-04	6.5E-04	5.0E-04
A10	65.61	65.61	65.61	65.64	7.4E-04	7.1E-04	6.2E-04	4.8E-04
A11	65.61	65.61	65.61	65.61	4.5E-04	4.3E-04	3.8E-04	3.0E-04
A12	65.61	65.61	65.61	65.62	3.4E-04	3.3E-04	2.9E-04	2.3E-04
A13	65.61	65.62	65.64	65.66	1.8E-04	1.7E-04	1.5E-04	1.2E-04
A14	65.62	65.62	65.65	65.67	3.0E-04	2.8E-04	2.5E-04	2.0E-04
A15	65.62	65.63	65.65	65.67	4.5E-04	4.3E-04	3.8E-04	3.0E-04
A16	65.79	65.86	66.05	66.15	8.9E-04	1.3E-03	2.4E-03	3.6E-03
AQO	**80**				**-**			

Note:

(a) Background concentrations (NO_2 of 61 μg m^{-3}, CO of 726 μg m^{-3}) have been included.

Odour from On-site Wastewater Treatment Plant

The predicted maximum 5-second H_2S concentrations and converted 5-second odour level are summarized in *Table A.13*.

Table A.13 Predicted Maximum 5-second H_2S Concentration and Converted 5-second Odour Level

ASR	Predicted Maximum 5-second H_2S Concentration ($\mu g\ m^{-3}$)				Converted 5-second Odour Level (Odour Unit) [a]			
	1.5m	10m	20m	30m	1.5m	10m	20m	30m
A1	2.1	1.8	1.1	0.5	3.2	2.8	1.7	0.7
A2	1.9	1.7	1.1	0.5	2.9	2.6	1.7	0.7
A3	0.7	0.7	0.6	0.4	1.1	1.0	0.8	0.6
A4	0.4	0.4	0.3	0.2	0.6	0.6	0.5	0.3
A5	0.3	0.3	0.2	0.1	0.4	0.4	0.3	0.2
A6-1	0.2	0.2	0.2	0.1	0.3	0.3	0.2	0.2
A6-2	0.3	0.3	0.2	0.1	0.4	0.4	0.3	0.2
A6-3	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1
A7-1	0.3	0.3	0.3	0.2	0.5	0.4	0.4	0.3
A7-2	0.4	0.3	0.3	0.2	0.6	0.5	0.4	0.2
A8	0.4	0.3	0.3	0.2	0.6	0.5	0.4	0.3
A9	0.4	0.3	0.3	0.2	0.6	0.5	0.4	0.3
A10	0.5	0.4	0.3	0.2	0.7	0.6	0.5	0.3
A11	0.3	0.3	0.2	0.1	0.4	0.4	0.3	0.2
A12	0.4	0.4	0.3	0.2	0.6	0.6	0.4	0.3
A13	0.2	0.2	0.1	0.1	0.3	0.3	0.2	0.2
A14	0.2	0.2	0.1	0.1	0.3	0.2	0.2	0.2
A15	0.3	0.3	0.2	0.1	0.5	0.4	0.3	0.2
A16	0.3	0.3	0.2	0.2	0.4	0.4	0.3	0.3
5-second Odour Criterion					**5**	**5**	**5**	**5**

Note:
(a) 0.66 μgm^{-3} of H_2S concentration equals to 1 Odour Unit (OU).

The predicted 5-second odour levels at various heights of all ASRs are well within the 5 OU in 5-second averaging time criterion. The highest 5-second odour level is predicted at 1.5m above ground at A1 (Gammon Skanka) which is located immediately at the south of the Site.

Figures A6 to A9 present the isopleths of the predicted maximum 5-second odour concentrations at different heights of the identified ASRs. The isopleths show that the odour impacts are localized and complied with the EIAO-TM assessment criterion. Hence, no adverse odour impact is anticipated.

A.7 *MITIGATION MEASURES*

A.7.1 *Construction Phase*

Although the construction dust impact is expected to be minimal, the following dust control measures stipulated in the *Air Pollution Control (Construction Dust) Regulation* are recommended to further reduce the fugitive dust emission as much as possible:

- Dust control measures such as water spaying on roads and dusty areas, covering of lorries by impervious sheets and controlling of the falling height of fill materials should be implemented;

- Effective dust screens, sheeting or netting should be provided to enclose the scaffolding from the ground level of the facility during the building construction;

- All debris and materials should be covered or stored in a sheltered debris collection area;

- Hoarding from ground level should be provided along the entire length of the site boundary except for a site entrance or exit;

- Every stockpile of dusty materials should be covered entirely by impermeable sheeting or placed in an area sheltered on the top and the 3 sides.

A.7.2 Operation Phase

No additional mitigation measures will be required.

A.8 CONCLUSIONS

The Site has been formed and is currently vacant. Hence, no major earthwork will be required for the site formation works. Minor excavation works will be required for the construction of the foundation works and site utilities. The tank farms and process equipment will be pre-fabricated off-site and assembled on site and hence minimal dust will be generated from this activity. Dust generated from the concreting works for the construction of site buildings will be minimal. With the implementation of dust suppression measures stipulated under the *Air Pollution Control (Construction Dust) Regulation* and adoption of good site practice, no adverse construction dust impact is anticipated.

Emissions from the boiler and biogas stacks are the major emission sources associated with the operation of the biodiesel plant. Nitrogen dioxide (NO_2), carbon monoxide (CO) and volatile organic compounds (VOCs) are the potential air pollutants. The assessment indicates that the operation of the proposed biodiesel plant together with the existing air emission sources in TKOIE, will not cause adverse air quality impact to the identified ASRs and the predicted concentrations of pollutants are well below the respective AQO criteria.

The potential odour impact (mainly associated with hydrogen sulphide gas) due to the discharge of exhaust air from the air scrubbing system of the on-site wastewater treatment plant has been evaluated using air dispersion model. After scrubbing, the hydrogen sulphide concentration will be significantly reduced and will not cause adverse odour impact to the identified ASRs.

It is therefore concluded that the construction and operation of the biodiesel plant will not cause adverse air quality impacts and comply with the *EIAO-TM* requirements.

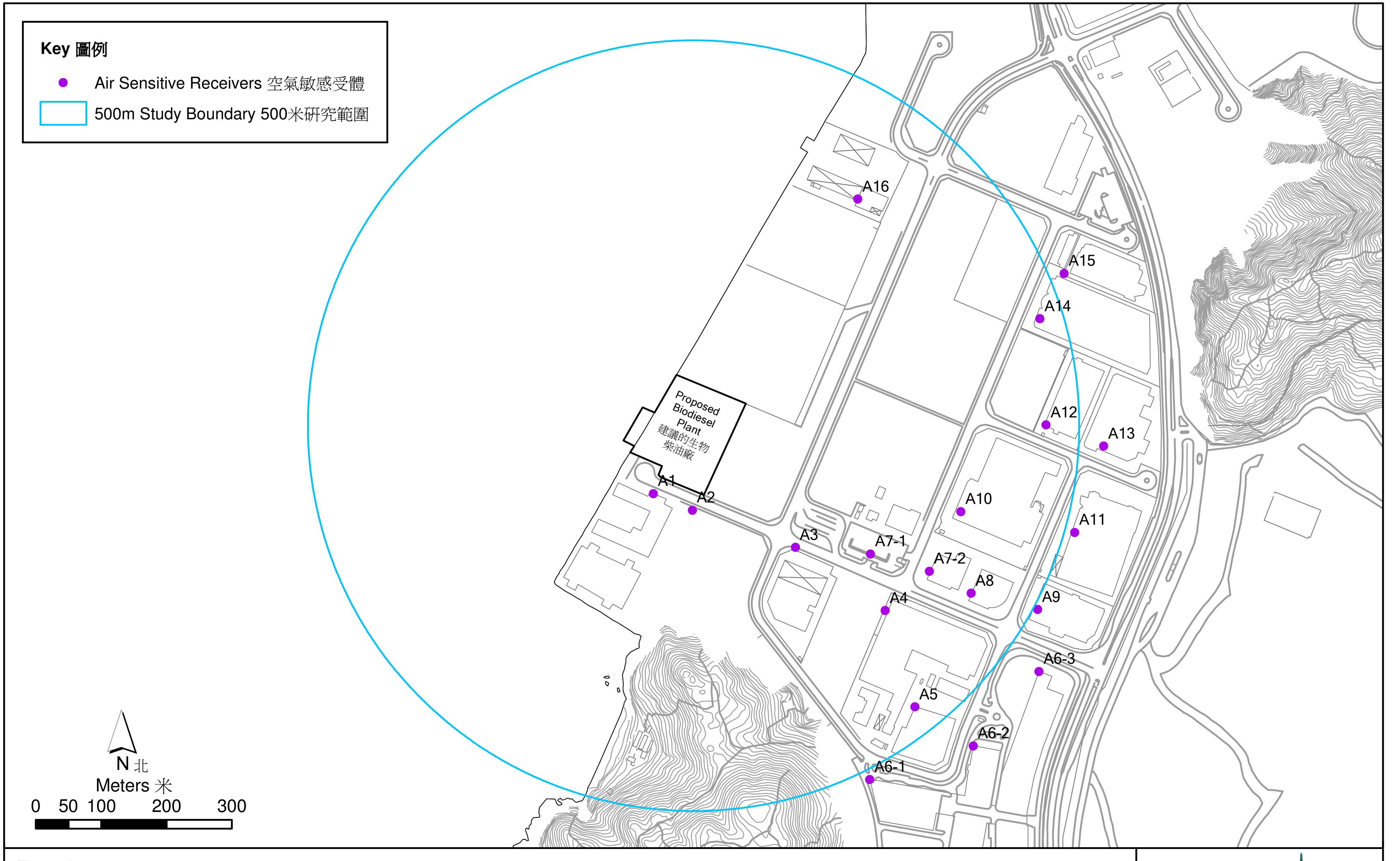

Figure A1
圖 A1

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Locations of Representative Air Sensitive Receivers
空氣敏感受體位置圖

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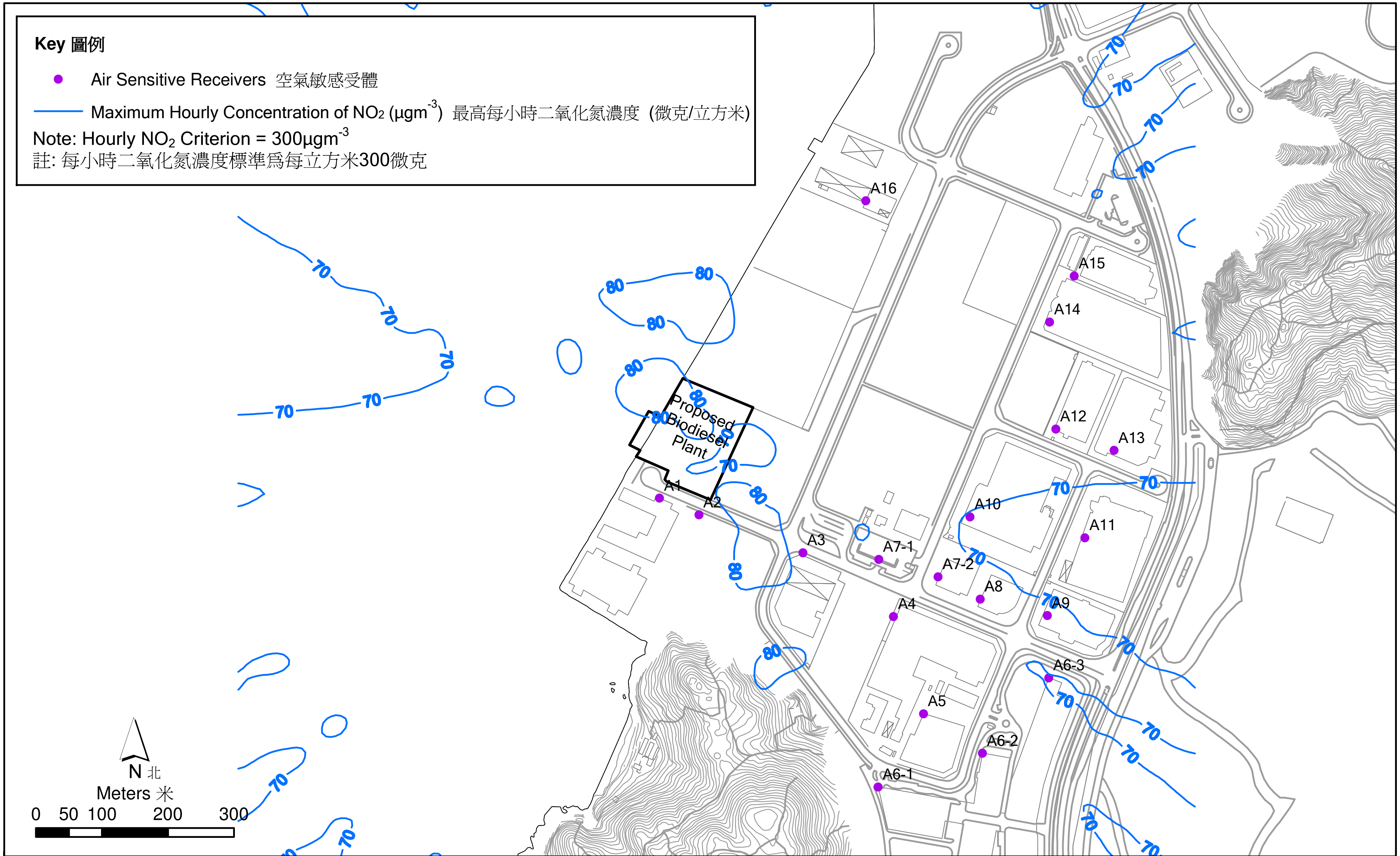

Figure A2
圖 A2

Predicted Cumulative Maximum Hourly NO_2 Concentration at 1.5m above ground
預計累積最高每小時二氧化氮濃度 (離地1.5米)

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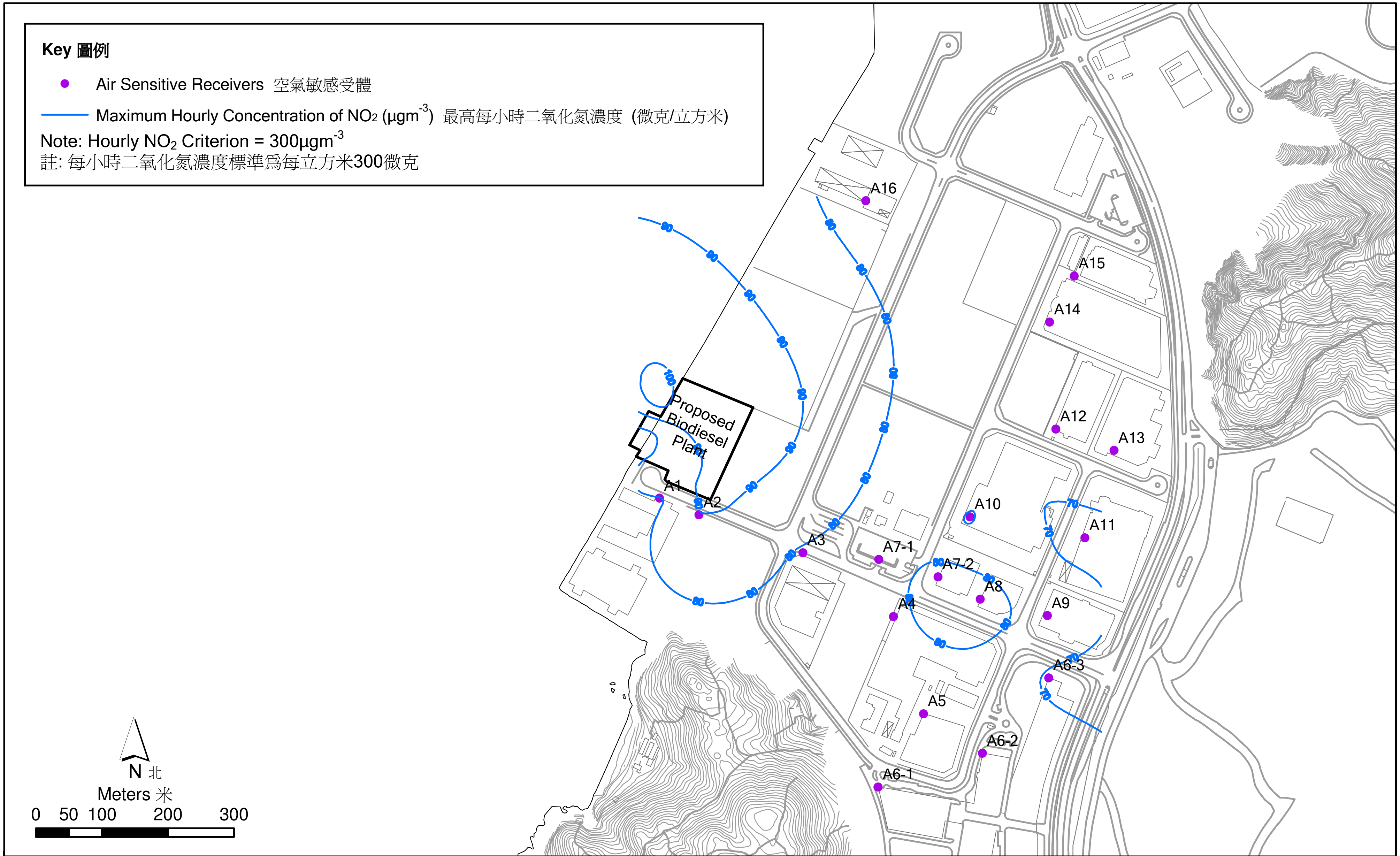

Figure A3
圖 A3

Predicted Cumulative Maximum Hourly NO_2 Concentration at 10m above ground
預計累積最高每小時二氧化氮濃度 (離地10米)

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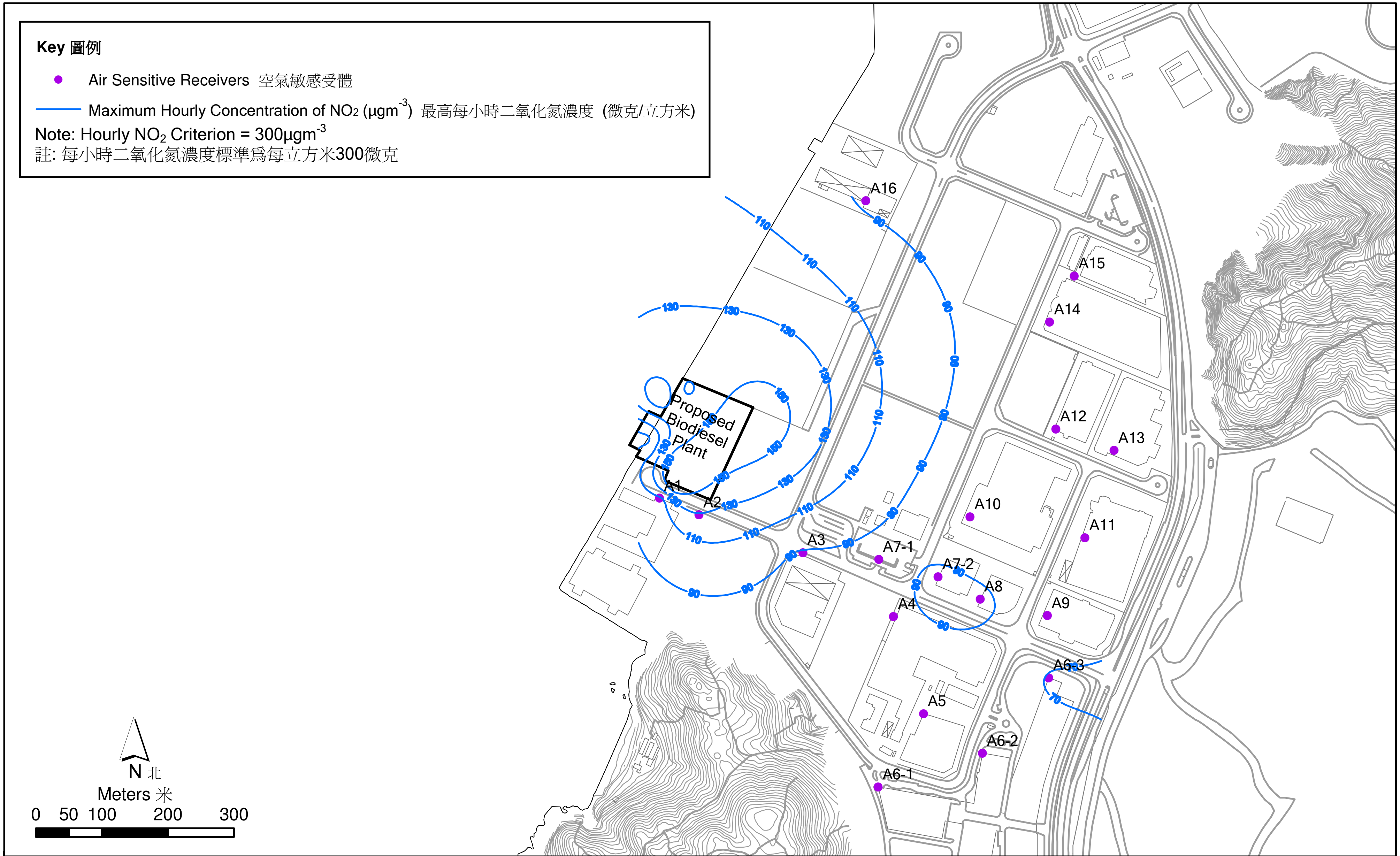

Figure A4
圖 A4

Predicted Cumulative Maximum Hourly NO_2 Concentration at 20m above ground
預計累積最高每小時二氧化氮濃度 (離地20米)

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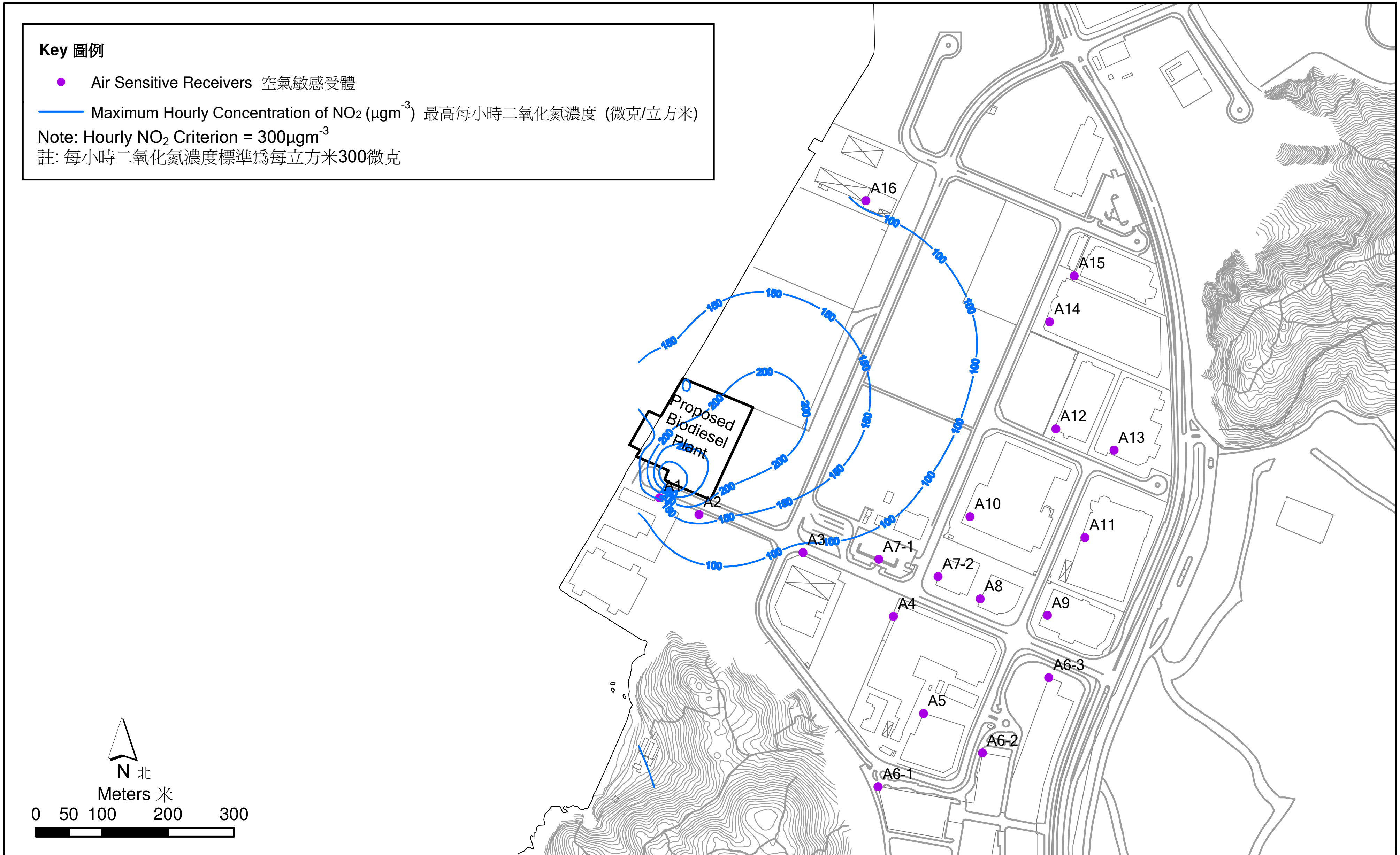

Figure A5
圖 A5

Predicted Cumulative Maximum Hourly NO_2 Concentration at 30m above ground
預計累積最高每小時二氧化氮濃度 (離地30米)

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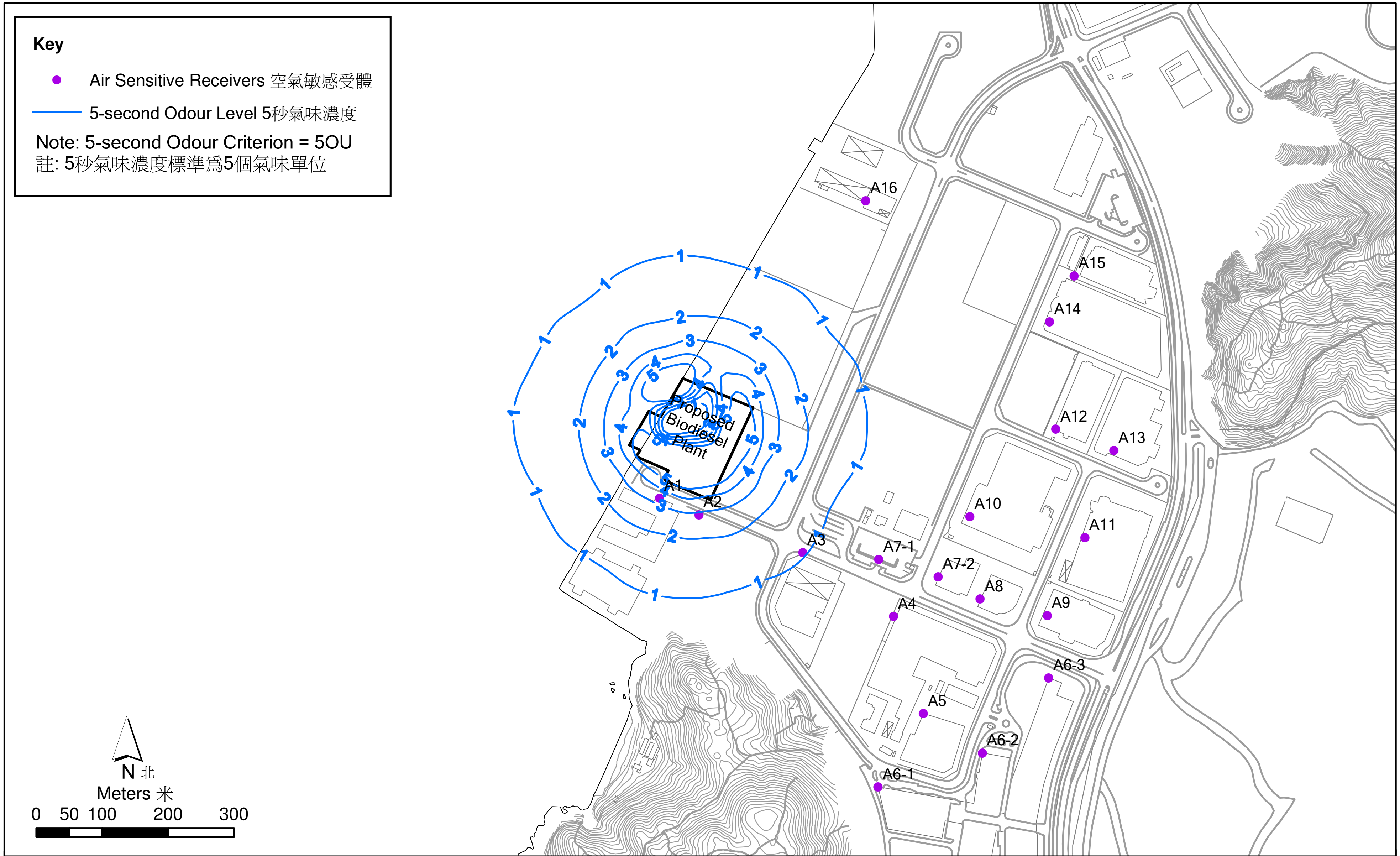

Figure A6
圖 A6

Predicted Maximum 5-second Odour Level at 1.5m above ground
預計累積最高5秒氣味濃度 (離地1.5米)

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Date: 16/08/2007

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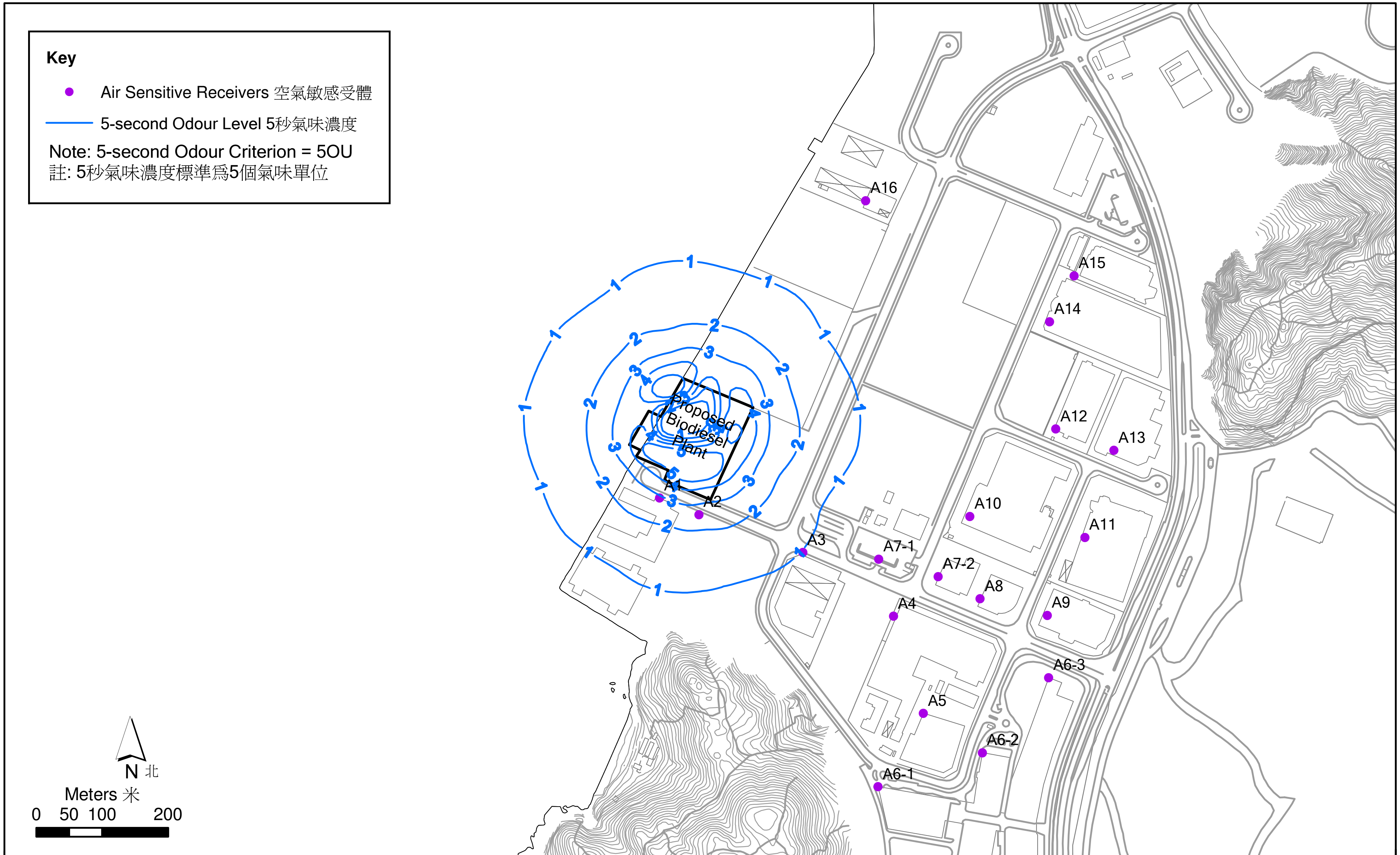

Figure A7
圖 A7

Predicted Maximum 5-second Odour Level at 10m above ground
預計累積最高5秒氣味濃度 (離地10米)

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Date: 16/08/2007

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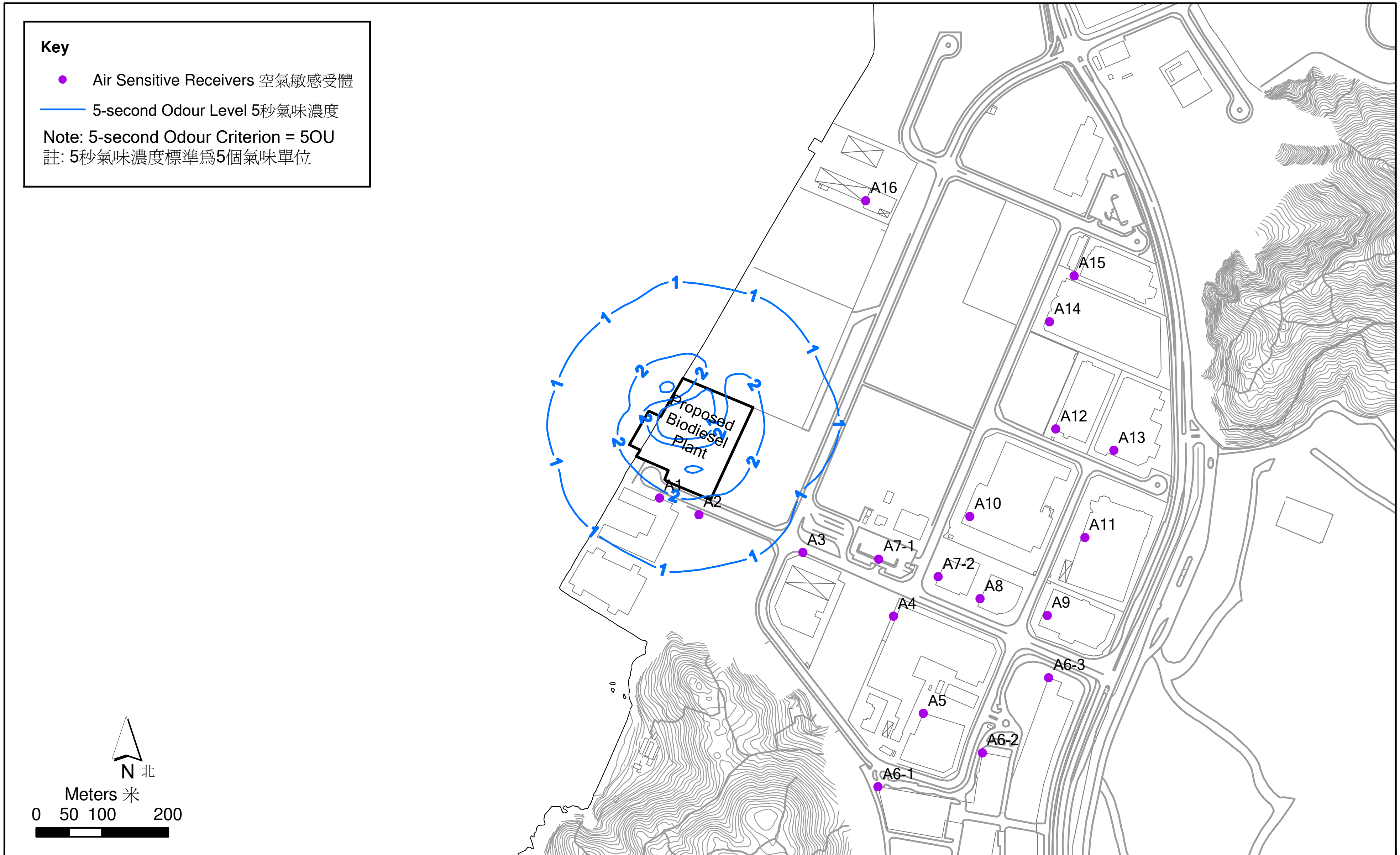

Figure A8

圖 A8

Predicted Maximum 5-second Odour Level at 20m above ground

預計累積最高5秒氣味濃度 (離地20米)

File: 0062388_Odour_20.mxd

Date: 16/08/2007

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ERM

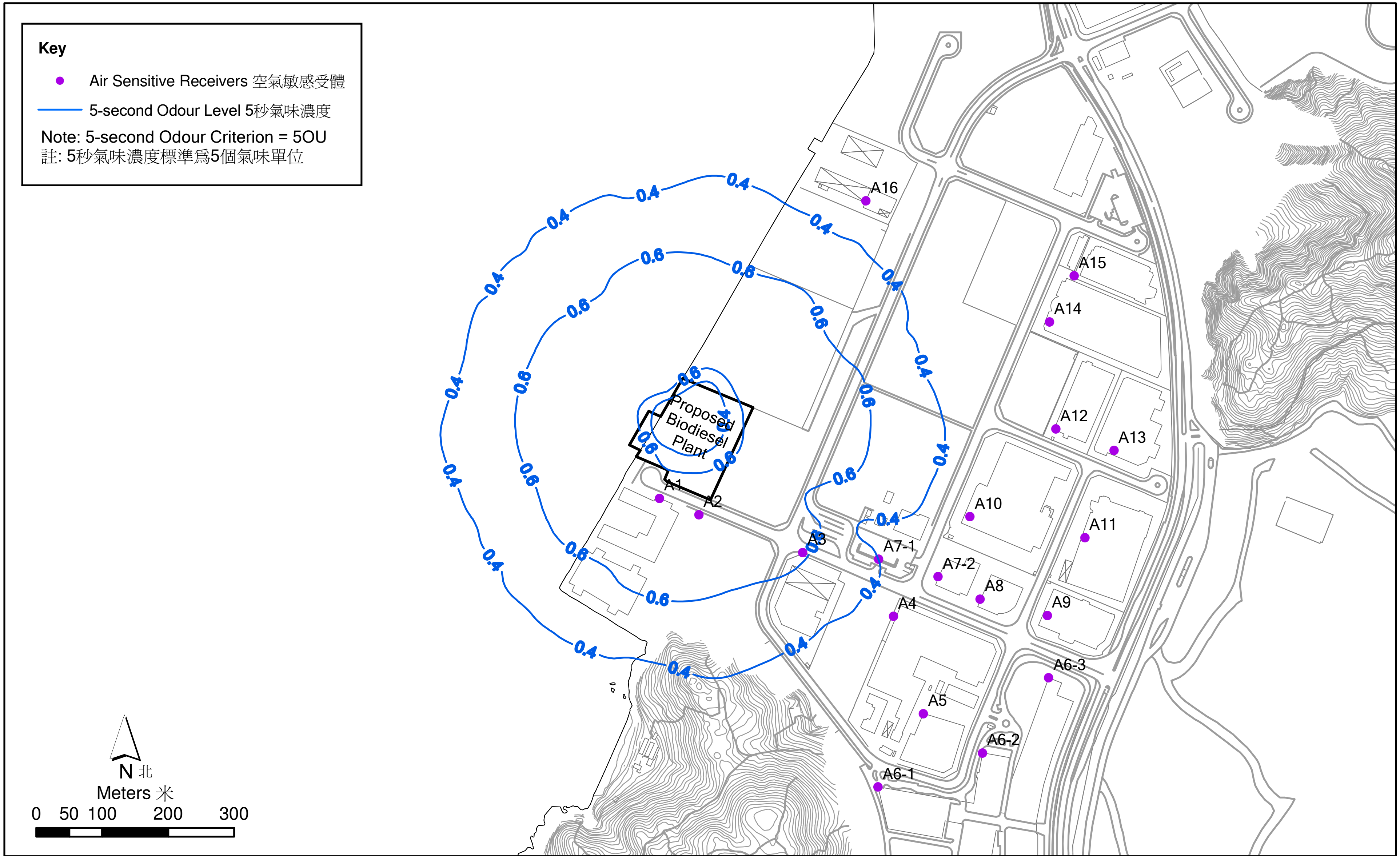

Figure A9
圖 A9

Predicted Maximum 5-second Odour Level at 30m above ground
預計累積最高5秒氣味濃度 (離地30米)

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Date: 16/08/2007

Environmental Resources Management

ERM

Annex B

Risk Assessment

B1 RISK ASSESSMENT

B1.1 INTRODUCTION

B1.1.1 Background

The background of the Study and the description of the Project are provided in *Section 2* of this Project Profile. This *Annex* presents the methodology, findings and recommendations of the risk assessment of the operation of the biodiesel plant.

B1.2 STUDY OBJECTIVES

The objectives of the risk assessment are as follows:

- To assess the hazard to life associated with the operation of the biodiesel plant;
- To ascertain whether the risk is acceptable in accordance with the *Hong Kong Risk Guidelines*; and
- To recommend improvements or remedial measures if the risk is considered too high and quantify the risk reduction achievable by these means.

B1.3 STUDY APPROACH

The methodology adopted for the risk assessment comprises the following elements:

- Data Collection & Review;
- Hazard Identification;
- Consequence Analysis;
- Frequency Estimation;
- Risk Summation and Evaluation; and
- Risk Mitigation (if necessary).

B2 HAZARD IDENTIFICATION

B2.1 HAZARDOUS MATERIALS ON SITE

The hazardous materials to be handled on site may be categorised as follows:

- **Biodiesel:** Biodiesel is a non-toxic chemical. Although it is classified as a Category 5 DG, it presents a low fire hazard as it has a relatively high flash point (over 120°C) and low volatility. Nevertheless it is a flammable chemical and a bund/pool fire may occur if ignited.

- **Methanol:** Methanol is a hazardous chemical that is highly flammable with a flash point of about 12°C and the lower and upper explosive limits are 6% and 36% respectively. It is toxic to humans if ingested or if vapours are inhaled. If a loss of containment event occurs, a bund/pool fire will take place if it is ignited immediately and a flash fire will occur if the dispersed vapour is ignited after some time.

- **Gas oil:** Gas oil is used as supplementary fuel in the biodiesel plant to operate various process equipment such as boilers. It contains medium sized hydrocarbons (C9-C20) and has similar fire properties as biodiesel, but is bunded separately since unlike biodiesel, gas oil is not biodegradable.

- **Sulphuric acid:** Although not flammable, sulphuric acid is extremely corrosive, and highly toxic. Ingestion may be fatal, and skin contact can lead to extensive and severe burns. Chronic exposure may result in lung damage. Nevertheless it has an extremely low volatility and its vapours are diluted immediately.

- **Phosphoric acid:** Phosphoric acid is not as hazardous as sulphuric acid but is harmful if swallowed and in contact with skin. It is also destructive of mucous membranes, respiratory tract, eyes and skin. It has a low volatility and is not flammable.

B2.2 DESIGN SAFETY MEASURES

All vessels/tanks machinery and all other equipment for the biodiesel plant will be designed to meet the applicable safety standards and to comply with mechanical, technical and safety standards for chemical plant design and local regulations. The entire production process will be program-controlled. The process visualisation allows the monitoring of the process and intervention by switching to manual mode, if required. The process equipment for the biodiesel production line (such as vessels, machines, pipelines, instruments etc.) will be made of stainless steel or other resistant materials fulfilling the respective mechanical, technical and safety standards. The vessels and pipelines will be insulated by aluminium plate. All vessels will be equipped with agitators and with a manhole. All other pumps will be equipped with single-acting mechanical seals. All pumps will be monitored by a fully automatic process control system (PCS) to prevent dry running.

Methanol will be stored in carbon steel storage tanks with a double bottom layer and will be maintained at atmospheric pressure. All pumps for methanol will be sealed with a magnetic coupling. All process tanks and machines will be designed to be gas tight and equipped with a gas displacement system. The whole system will be covered by nitrogen under slight overpressure to prevent the entry of oxygen and hence avoiding the formation of explosive gas mixture. The methanol in the exhaust gas will be removed in an air scrubber. A gas warning system will be installed to monitor the methanol concentration inside the process room. The plant will shut down automatically and the emergency ventilation system will be activated, if the monitoring system detects a methanol concentration of 0.6% v/v inside the room.

The outdoor storage tanks will be built in a bunded area where any spilled liquid can be retained. The impacts of fire caused by loss of containment to tanks would therefore be confined to the bunded area and minimise the damage to the surrounding facilities. Bunds for acid storage tanks will be constructed with acid resistant materials.

It should be noted that for acid storage tank bunds, no seepage of acid through ground soil will be allowed to avoid hazardous contamination of acid to the surrounding environment. Also the leaked acid would be properly neutralised before being disposed for further treatment.

B2.3 HAZARDS ASSOCIATED WITH THE FACILITIES

The main hazard associated with the facilities is considered to be spontaneous failure of outdoor storage tanks, where hazardous materials are present in large amounts. This will result in loss of containment events, which are investigated in detail in this report.

Hazards from Biodiesel/Gas Oil Storage Tanks

Hazard events from failure of biodiesel storage tanks will be modelled in the consequence analysis, including pool and bund fires. Hazard events from failure of gas oil storage tanks are modelled similarly except it has an exclusive bund.

Hazards from Methanol Storage Tank

Hazard events from failure of the methanol storage tank will also be investigated in the consequence analysis, including bund/pool fires and flash fires. Although methanol may be explosive when mixed with air, explosion scenarios are not considered since nitrogen blanketing with slight overpressure is provided for the methanol storage tank.

Methanol vapour is also moderately toxic. It has an IDLH of 6,000 ppm and a Lethal Concentration for rats at 64,000 ppm.(1) However, a leakage of methanol at the biodiesel plant is not expected to cause any harm to the surrounding population, as the consequence distances for lethal toxic methanol concentrations are low (< 10m) compared to the vapour dispersion distances which a flash fire may occur.

Hazards from Acid Storage Tanks

Should the sulphuric acid storage tank fail, there can be severe health damage to the personnel on-site within the bunded area. However, due to the extremely low volatility (vapour pressure: 0.001 mmHg) and lack of fire hazard, hazards from the failure of sulphuric acid storage tank will only be on-site. The exclusive, acid-resistant bund for the tank provides further protection for the areas outside the bund.

Consideration for the phosphoric acid storage tank is similar except that the hazardous consequences are less severe.

Hazards from Process and Unloading Areas

Hazards can come from the process area of the biodiesel plant, where biodiesel is produced from raw materials through various process equipment. However, except for the transfer piping, all process equipment are located within the process building. Since the production process is neither pressurised nor cryogenic, it is very unlikely that the process area will generate hazards with large consequences that can affect the public. However to protect working staff in the process building, it is recommended to install gas detectors for methanol which can initiate shutdown of incoming feed.

Hazards may also come from the loading and unloading of materials onto road tankers and sea barges, though the hazards from such loss of containment events are not very frequent. Nevertheless, hose failure from the unloading of methanol from vessels has been considered in this study to investigate the effect of a leakage of this volatile compound, assuming typical unloading rates. In addition, the transfer of dangerous goods must be carried out in accordance with the *Dangerous Goods Ordinance* (CAP 295), using specially designed road tankers and sea barges labelled with the DG category.

B2.4 EXTERNAL HAZARDS

External events that have the potential to result in a release from the biodiesel plant include:

- Earthquake;
- Aircraft crash;

(1) IDLH Documentation, CAS-67651 Methyl Alcohol, National Institute for Occupational Safety & Health.

- Severe environmental event;
- Subsidence;
- Lightning strike;
- Dropped objects; and
- Vehicle impact.

Based on a review of the above, it is considered that external events have been included in the causes of spontaneous equipment failures; external events have therefore not been analysed separately in this study.

B2.5 DERIVATION OF FAILURE CASES

Based on the discussion in *Section B2.2*, seven release events were chosen as the representative events for this risk assessment; they are summarised in *Table B2.1*.

Table B2.1 Representative Release Events Considered

Section ID	Description	Hazardous Material	Physical State	Potential Outcomes
T10	Methanol storage tank	Methanol	Liquid	Bund/pool fire, flash fire
T15	Biodiesel quality tank A	Biodiesel	Liquid	Bund/pool fire
T16	Biodiesel quality tank B	Biodiesel	Liquid	Bund/pool fire
T17	Biodiesel Europe storage tank	Biodiesel	Liquid	Bund/pool fire
T18	Biodiesel Hong Kong storage tank	Biodiesel	Liquid	Bund/pool fire
T22	Gas oil storage tank	Gas oil	Liquid	Bund/pool fire
MUN	Methanol unloading from vessel	Methanol	Liquid	Bund/pool fire, flash fire

B3 FREQUENCY ESTIMATION

B3.1 RELEASE FREQUENCIES

Frequency estimation involves estimating the likelihood of occurrence of each of the representative release events highlighted in the hazard identification exercise.

ERM have collated a large in-house database of internationally recognised failure data for process plant and this was used for the study and adapted as necessary to take account of local factors. The frequency of each identified hazardous release event was estimated using this generic failure data.

Failure frequencies were estimated for:

- Atmospheric storage tanks
  - Catastrophic release (rupture) – 5×10^{-6} per year [(1)]
  - 25 mm release – 1×10^{-4} per year [(2)]

- Unloading arms
  - Full bore release (rupture) – 3×10^{-8} per hour [(3)]
  - 25 mm release – 3×10^{-6} per hour [(4)]

The adopted data were taken from the TNO "Purple Book" for single containment tanks and the COVO Study for unloading arms. Several other references, including Davies et al [(5)], were compared and found that the values were closely comparable.

In this study, it is assumed that methanol unloading from barge is performed once a week, at a rate of 125m^3/hr for 4 hours during each operation. The unloading pressure at the barge is taken as 4 barg.

B3.2 EVENT TREE ANALYSIS

Based on the hazardous release frequencies estimated in the preceding section, the frequencies of the various outcomes associated with each release event (e.g. pool fire, flash fire) was estimated through Event Tree Analysis (ETA). ETA has been used to describe and analyse how an initiating event may lead to a number of different outcomes, depending upon such factors as the

(1) TNO, "Guidelines for Quantitative Risk Assessment (The Purple Book)", Report CPR 18E, The Netherlands Organisation of Applied Scientific Research, Voorburg, 1999.

(2) TNO, "Guidelines for Quantitative Risk Assessment (The Purple Book)", Report CPR 18E, The Netherlands Organisation of Applied Scientific Research, Voorburg, 1999.

(3) Rijnmond Public Authority, "A Risk Analysis of Six Potentially Hazardous Industrial Objects in the Rijnmond Area - A Pilot Study", COVO, D. Reidel Publishing Co., Dordrecht, 1982.

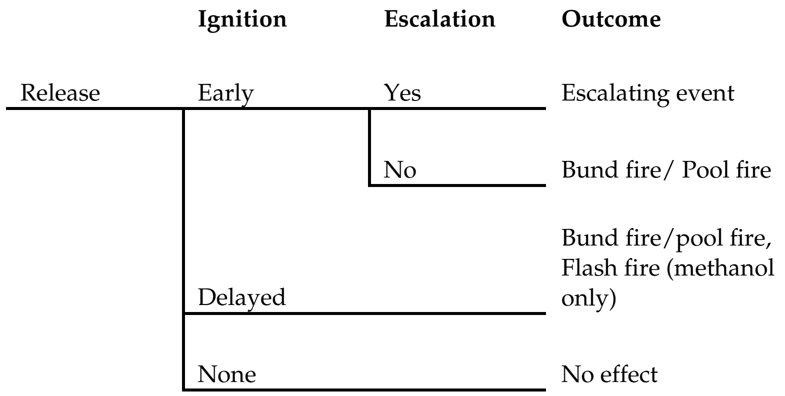
(4) Rijnmond Public Authority, "A Risk Analysis of Six Potentially Hazardous Industrial Objects in the Rijnmond Area - A Pilot Study", COVO, D. Reidel Publishing Co., Dordrecht, 1982.

(5) Davies, T., Harding, A.B., McKay, I.P., Robinson, R.G.J., Wilkinson, A., "Bund Effectiveness in Preventing Escalation of Tank Farm Fires", Trans IChemE, Vol. 74, Part B, May 1996.

successful implementation of the various emergency response activities and the performance of relevant protective safety systems.

An event tree (*Figure B3.1*) is constructed by laying out each identified contributing factor in chronological order and assessing all possible combinations of factors to provide a number of possible hazardous event outcomes. By assigning probabilities to each branch of the event tree, the final frequency of each outcome can then be established. The frequency of occurrence of a particular hazardous outcome is the product of the frequency of occurrence of the initiating event (in this case, the release frequency) and the probabilities that the event develops to the particular hazardous outcome.

Figure B3.1 Generic Event Tree



The contributing factors taken into account in the event trees are discussed in the following sections.

Early Ignition/Delayed Ignition

Early ignition of a hazardous liquid would result in a pool fire. In this study, the size of the fire is limited by the bund, which is approximately 4m high.

If immediate ignition does not occur, a flammable vapour cloud may be formed by evaporation from the liquid pool. If such cloud subsequently ignites, a flash fire will occur. The flash fire may flash back to the source subsequently leading to a pool fire. It is assumed in this study that for the methanol releases the flash fire will have the most damaging effects and those fatalities which may arise from secondary pool fires will be negligible as most people would have been affected by the primary event. On the other hand, due to its low volatility and high flash point, flash fire is an unlikely phenomenon for the biodiesel and gas oil releases. Therefore, for these substances delayed ignition will result in a pool fire confined by the bund. The consequence of delayed ignition of a biodiesel spill is therefore essentially the same as for early ignition.

The overall ignition probabilities used in this study were adapted from Cox, Lees and Ang[(1)] , which are summarised in *Table B3.1*. Since the biodiesel plant contains predominantly heavy hydrocarbons and organics, the ignition probabilities for liquid releases are considered appropriate.

Table B3.1 Ignition Probabilities from Cox, Lees and Ang Model

Leak Size	**Ignition Probability**	
	Gas Release	**Liquid Release**
Minor (< 1 kg s^{-1})	0.01	0.01
Major (1 - 50 kg s^{-1})	0.07	0.03
Massive (> 50 kg s^{-1})	0.30	0.08

The data in *Table B3.1* correspond to the total ignition probabilities. In the current analysis, these are distributed amongst early and delayed ignition, taking into consideration the likely ignition sources.

For this study, in the event of a tank leak or rupture, the cause for the leak or rupture itself may be the source of early ignition. Other probable sources of ignition are the vehicles passing by the biodiesel plant. Hence it is assumed here that the total ignition probability will be equally distributed between early and delayed ignition.

0.08 is taken as the ignition probability for tank rupture scenarios as the release will be massive. For other releases, 0.03 is adopted as the release rate is less than 32kg s^{-1}. The ignition probabilities for biodiesel and gas oil are conservatively taken the same as those for methanol. In reality, biodiesel and gas oil has a lower fire hazard than methanol as they have low volatilities and have to be heated to more than 120°C to allow ignition.

Escalation Effects

If a pool fire impinges on an adjacent tank for a sustained period of time, the target vessel may fail and lead to a more severe event such as a larger pool fire. To estimate the failure frequency of a target vessel due to domino effects, the frequency of fires from neighbouring equipment are summed, taking into account directional probabilities and the size of the event.

In this study, however, the outcome event of an escalating fire is a prolonged bund fire, which has the same consequences as the original event.

If a pool fire occurs within the bund, fire fighting measures such as CO_2 blanketing will be carried out immediately. Meanwhile, the biodiesel or other organics within the bund will be drained away through the plant's drainage

(1) Cox, Lees and Ang, "Classification of Hazardous Locations", IChemE.

system to avoid the presence of fuel for further fire events. Hence it was conservatively assumed that the probability of a bund fire leading to another tank collapse is 0.25, given the limited resistance of the carbon steel storage tanks to prolonged fires.

According to the plant layout, the size of the bund is approximately 2,532m^2. With a height of 4m, the capacity of the bund is therefore 10,128m^3. Overflowing of the bund would require the failure of the 8 largest tanks which have a combined volume of 11,400 m^3.

The likelihood of this occurring may be calculated from:

Probability of pool/ bund fire x 4 x (probability of fire escalation leading to tank collapse)^8

= (1.5E-06 + 2.0E-07) x 4 x (0.25)^8

= 1.04E-10 (per year),

where the factor of 4 arises because the failure of any of the 4 biodiesel tanks may initiate this scenario.

This value is lower than 1.0E-09 per year, which is the minimum frequency for an event to be considered in the risk assessment. A frequency this low will not contribute to the individual risk, or appear on the FN curve. Hence bund overflowing events are not considered in this risk assessment.

B3.3 OUTCOME FREQUENCIES

Combining the initiating event frequency with probabilities for each branch of the event tree (*Figure B3.1*) gives the frequency for each outcome scenario. A complete list of outcome frequencies is provided in *Table B3.2*.

Table B3.2 Outcome Event Frequencies

Section	Description	Release Frequency (per year)	Outcome Frequency (per year)		
			Flash Fire	Bund/ Pool Fire	Unignited Release
T10-CAO	Catastrophic Failure and bund overtopping of Methanol Storage Tank	5.0E-06	2.0E-07	2.0E-07	4.6E-06
T10-25	Partial Failure of Methanol Storage Tank	1.0E-04	1.5E-06	1.5E-06	9.7E-05
T15-CA	Catastrophic Failure of Biodiesel Quality Tank A	5.0E-06	n/a	4.0E-07	4.6E-06
T15-25	Partial Failure of Biodiesel Quality Tank A	1.0E-04	n/a	3.0E-06	9.7E-05
T16-CA	Catastrophic Failure of Biodiesel Quality Tank B	5.0E-06	n/a	4.0E-07	4.6E-06
T16-25	Partial Failure of Biodiesel Quality Tank B	1.0E-04	n/a	3.0E-06	9.7E-05
T17-CA	Catastrophic Failure and bund overtopping of Biodiesel Storage Tank A	5.0E-06	n/a	4.0E-07	4.6E-06
T17-25	Partial Failure of Biodiesel Storage Tank A	1.0E-04	n/a	3.0E-06	9.7E-05
T18-CA	Catastrophic Failure of and bund overtopping Biodiesel Storage Tank B	5.0E-06	n/a	4.0E-07	4.6E-06
T18-25	Partial Failure of Biodiesel Storage Tank B	1.0E-04	n/a	3.0E-06	9.7E-05
T22-CA	Catastrophic Failure of Gas Oil Storage Tank	5.0E-06	n/a	4.0E-07	4.6E-06
T22-25	Partial Failure of Gas Oil Storage Tank	1.0E-04	n/a	3.0E-06	9.7E-05
MUN-FB	Full Bore Failure of Methanol Unloading Piping	6.24E-06	9.36E-08	9.36E-08	6.05E-06
MUN-25	Partial Failure of Methanol Unloading Piping	6.24E-04	9.36E-06	9.36E-06	6.05E-04

B4 CONSEQUENCE ANALYSIS

B4.1 PHYSICAL EFFECTS MODELLING

In this study, the following physical effect models were used to assess the effects zones for the different hazardous outcomes of concern:

- Pool fire; and
- Flash fire.

All were modelled using the PHAST v6.51 suite of models.

B4.1.1 Pool Fires

The effects of pool fire have been modelled for scenarios listed in *Table B2.1*. The pool formed from the release will initially spread due to gravitational and surface tension forces acting on it. As the pool spreads, it will absorb heat from its surroundings and vaporise. The pool will continue to spread until it reaches the walls of the bund, or in the cases modelled without the bund (see below) until it grows to the dimensions where further spread is halted by increased vaporisation.

While the bund capacity is large enough to contain any conceivable multiple-tank spill, the bund may still be overtopped due to the dynamic effects in the case of an instantaneous failure and release of the full contents of one of the tanks. In such a case, if a large and full tank is located close to the bund wall and if the release is at least partially directed towards the wall, a part of its contents due to its initial momentum could spill over the bund wall and cause a pool fire outside the bund. The consequences of such a release would be more severe, since the pool fire would not be contained by the bund.

The bund overtopping cases were considered in this study for the biodiesel tanks T17 and T18 and the methanol tank T10. These are located near the bund wall and therefore overtopping is considered credible. Other tanks are located too far from the bund wall for the bund overtopping to occur.

For the sake of simplicity and to account for the worst case scenarios, all catastrophic failures of T17, T18 and T10 were assumed to overtop the bund. The quantity of liquid overtopping the bund was estimated at 27% of the tank capacity, based on the maximum overtopping obtained for a much larger tank in physical modelling tests conducted during the EIA study (EIA_127/2006) for the HK Permanent Aviation Fuel Facility (1).

(1) http://www.epd.gov.hk/eia/register/report/eiareport/eia_1272006/EIA_Report/pdf/Sect10-HazardtoLifeAssessmentIssue2.pdf

It should be noted that an unconstrained release of 27% of tank content produces greater consequence distances than a 100% release confined to the bund. The hazard distances employed are therefore based on unconstrained releases.

B4.1.2 Flash Fires

For methanol releases, if there is no immediate ignition, the vapour may disperse over a significant distance before subsequently encounter an ignition source. This results in a flash fire that is fatal to anyone caught within the flash fire envelope.

Dispersion modelling is employed by PHAST to calculate the extent of the flammable vapour cloud. This takes into account both the direct vaporisation from the release, and also the vapour formed from evaporating pools. The hazard footprint was obtained by simulating the dispersion to half the lower flammability limit concentration (0.5LFL) conservatively.

B4.2 CONSEQUENCE ANALYSIS RESULTS

The estimation of the fatality/injury caused by a physical effect such as thermal radiation requires the use of probit equations, which describe the probability of fatality as a function of some physical effect. The probit is an alternative way of expressing the fatality probability and is derived from a statistical transformation of the fatality probability.

Detailed results of the consequence analysis conducted for this risk assessment are contained in *Tables B4.1* to *B4.2*, which tabulates the effect zones associated with various fatality probabilities for the hazardous outcomes considered, using the following parameters:

- *d*: maximum downwind distance;
- *c*: maximum crosswind width;
- *s*: offset distance between source and effect zone; and
- *m*: downwind distance at which the maximum width, *c*, occurs.

A graphical representation can be seen in *Figure B4.1*. These dimensions define the footprint area of the hazard and are used in the risk summation process to calculate the area of the hazard and the number of people affected based on the population distribution.

Figure B4.1 Presentation of Consequence Results

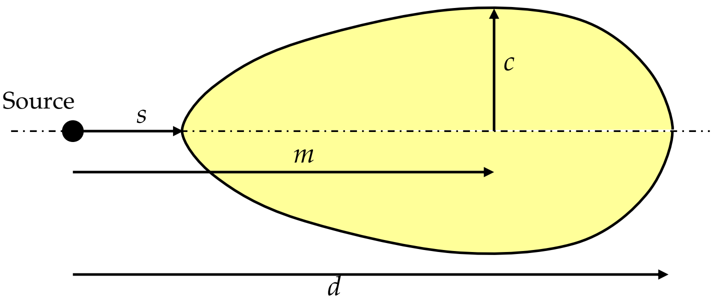


Table B4.1 Consequence Distances for Pool Fires

Event Name(a)	Outdoor Fatality Probability	Indoor Fatality Probability	Incident Radiation (kW/m2)	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
				d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)
T10-CAO-L-PF	90.0%	9.0%	20.9	180	165	-155	10	180	170	-145	20	185	170	-145	20	185	170	-130	30
	50.0%	5.0%	14.4	200	195	-180	10	210	190	-170	20	210	190	-170	20	210	190	-150	30
	1.0%	0.1%	7.3	260	250	-235	10	260	250	-225	20	260	250	-225	20	265	250	-205	30
T10-25-L-PF	90.0%	9.0%	20.9	26	23	-20	3	27	22	-17	5	27	22	-17	5	29	22	-15	7
	50.0%	5.0%	14.4	30	27	-24	3	32	27	-22	5	32	27	-22	5	33	26	-19	7
	1.0%	0.1%	7.3	39	36	-33	3	40	35	-30	5	40	35	-30	5	42	35	-28	7
T15-CA-L-PF	90.0%	9.0%	20.9	29	29	-29	0	29	29	-29	0	29	29	-29	0	30	29	-28	0
	50.0%	5.0%	14.4	30	30	-30	0	31	30	-29	0	31	30	-29	0	32	31	-28	1
	1.0%	0.1%	7.3	45	38	-32	6	51	40	-31	10	51	40	-31	10	58	44	-30	14
T15-25-L-PF	90.0%	9.0%	20.9	16	8	0	8	18	8	1	9	18	8	1	9	19	8	1	10
	50.0%	5.0%	14.4	18	10	-1	9	20	10	0	10	20	10	0	10	21	10	0	11
	1.0%	0.1%	7.3	23	14	-5	9	24	14	-3	10	24	14	-3	10	25	14	-2	11
T16-CA-L-PF	90.0%	9.0%	20.9	29	29	-29	0	29	29	-29	0	29	29	-29	0	30	29	-28	0
	50.0%	5.0%	14.4	30	30	-30	0	31	30	-29	0	31	30	-29	0	32	31	-28	1
	1.0%	0.1%	7.3	45	38	-32	6	51	40	-31	10	51	40	-31	10	58	44	-30	14
T16-25-L-PF	90.0%	9.0%	20.9	16	8	0	8	18	8	1	9	18	8	1	9	19	8	1	10
	50.0%	5.0%	14.4	18	10	-1	9	20	10	0	10	20	10	0	10	21	10	0	11
	1.0%	0.1%	7.3	23	14	-5	9	24	14	-3	10	24	14	-3	10	25	14	-2	11
T17-CAO-L-PF	90.0%	9.0%	20.9	230	230	-230	0	230	230	-230	0	230	230	-230	0	230	230	-230	0
	50.0%	5.0%	14.4	240	235	-230	10	235	235	-230	10	240	235	-225	10	240	230	-220	10
	1.0%	0.1%	7.3	275	255	-230	10	295	255	-235	30	295	255	-235	30	330	270	-225	50
T17-25-L-PF	90.0%	9.0%	20.9	16	8	0	8	18	8	1	9	18	8	1	9	19	8	1	10
	50.0%	5.0%	14.4	18	10	-1	9	20	10	0	10	20	10	0	10	21	10	0	11
	1.0%	0.1%	7.3	23	14	-5	9	24	14	-3	10	24	14	-3	10	25	14	-2	11
T18-CAO-L-PF	90.0%	9.0%	20.9	160	160	-160	0	160	160	-160	0	160	160	-160	0	160	160	-160	0
	50.0%	5.0%	14.4	165	160	-160	5	165	165	-160	0	165	165	-160	0	165	160	-155	5
	1.0%	0.1%	7.3	200	180	-170	10	215	185	-165	15	215	185	-165	15	240	195	-150	40
T18-25-L-PF	90.0%	9.0%	20.9	16	8	0	8	18	8	1	9	18	8	1	9	19	8	1	10
	50.0%	5.0%	14.4	18	10	-1	9	20	10	0	10	20	10	0	10	21	10	0	11
	1.0%	0.1%	7.3	23	14	-5	9	24	14	-3	10	24	14	-3	10	25	14	-2	11

Event Name[(a)]	Outdoor Fatality Probability	Indoor Fatality Probability	Incident Radiation (kW/m²)	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
				d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)
T22-CA-L-PF	90.0%	9.0%	20.9	11	8	-6	2	13	9	-6	3	13	9	-6	3	15	9	-6	5
	50.0%	5.0%	14.4	14	10	-7	3	17	11	-7	5	17	11	-7	5	19	11	-7	6
	1.0%	0.1%	7.3	20	16	-11	4	22	16	-10	6	22	16	-10	6	23	16	-9	7
T22-25-L-PF	90.0%	9.0%	20.9	11	8	-6	2	13	9	-6	3	13	9	-6	3	15	9	-6	5
	50.0%	5.0%	14.4	14	10	-7	3	17	11	-7	5	17	11	-7	5	19	11	-7	6
	1.0%	0.1%	7.3	20	16	-11	4	22	16	-10	6	22	16	-10	6	23	16	-9	7
MUN-FB-L-PF	90.0%	9.0%	20.9	65	54	-43	11	70	54	-38	16	70	54	-38	16	74	53	-32	21
	50.0%	5.0%	14.4	74	63	-52	11	79	63	-47	16	79	63	-47	16	83	62	-41	21
	1.0%	0.1%	7.3	96	85	-74	11	100	84	-68	16	100	84	-68	16	103	82	-61	21
MUN-25-L-PF	90.0%	9.0%	20.9	36	29	-22	7	39	29	-19	10	39	29	-19	10	41	28	-15	13
	50.0%	5.0%	14.4	41	34	-27	7	44	34	-24	10	44	34	-24	10	46	33	-20	13
	1.0%	0.1%	7.3	53	46	-39	7	55	45	-35	10	55	45	-35	10	57	44	-31	13

Note (a): Event Name = aaa-bb-L-PF where aaa is section name (see *Table B2.1*) and bb is release size: CA – catastrophic rupture, CAO – catastrophic rupture with bund overtopping, 25 – 25mm leak and FB – full bore rupture of unloading line

Table B4.2 Consequence Distances for Flash Fires

Event Name[(a)]	Outdoor Fatality Probability	Indoor Fatality Probability	Contour	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
				d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)	d (m)	c (m)	s (m)	m (m)
T10-CA-L-FF	100%	10%	0.5LFL	38	17	-10	12	34	6	-2	15	49	8	-2	20	37	5	0	20
T10-25-L-FF	100%	10%	0.5LFL	16	1	0	12	14	1	0	9	16	1	0	10	10	1	0	5
MUN-FB-L-FF	100%	10%	0.5LFL	82	17	0	55	70	14	0	25	78	14	0	25	62	13	0	30
MUN-25-L-FF	100%	10%	0.5LFL	47	6	0	36	44	5	0	28	45	5	0	28	39	4	0	25

Note (a): Event Name = aaa-bb-L-FF where aaa is section name (see *Table B2.1*) and bb is release size: CA – catastrophic rupture, 25 – 25mm leak and FB – full bore rupture of unloading line

B5 RISK SUMMATION AND EVALUATION

B5.1 OVERVIEW

To rationalise the frequency of hazardous events identified in the risk assessment with the consequences, it is necessary to relate the two. This is known as Risk Summation and was conducted using an in-house software RISKPLOT™. The following two risk measures were derived in the risk assessment:

- **Societal Risk**, which is defined as the risk to a group of people due to all hazards arising from a hazardous installation or activity. The simplest measure of societal risk is the Potential Loss of Life (PLL), which is calculated from the frequency (f) and fatalities (N) associated with each outcome event, as follows:

$$PLL = f_1N_1 + f_2N_2 + f_3N_3 + \ldots + f_nN_n$$

Societal risk is also expressed in the form of an F-N curve, which represents the cumulative frequency (F) of all event outcomes leading to N or more fatalities; and

- **Individual Risk**, which is defined as the frequency of fatality per individual per year due to the realisation of specified hazards. For the purposes of this study, individual risk is reported using iso-risk contours, which express the risk to a single person at a specific location due to all identified hazards.

The risk results are compared with the criteria for acceptability of risks for individual and societal risk, as laid down in the *Hong Kong Planning Standards and Guidelines*, *Chapter 12*. These pertain to risks posed to the general public not deriving any benefit from the hazardous activity. The societal risk criteria are illustrated in *Figure B5.1*.

B5.2 LOCAL METEOROLOGY

The annual average temperature and relative humidity was taken to be 25°C and 70% respectively.

The wind speed, wind stability and direction data used in this study is based on data for Tseung Kwan O in 2000 and is shown in *Table B5.1*.

Figure B5.1 Hong Kong Risk Guidelines

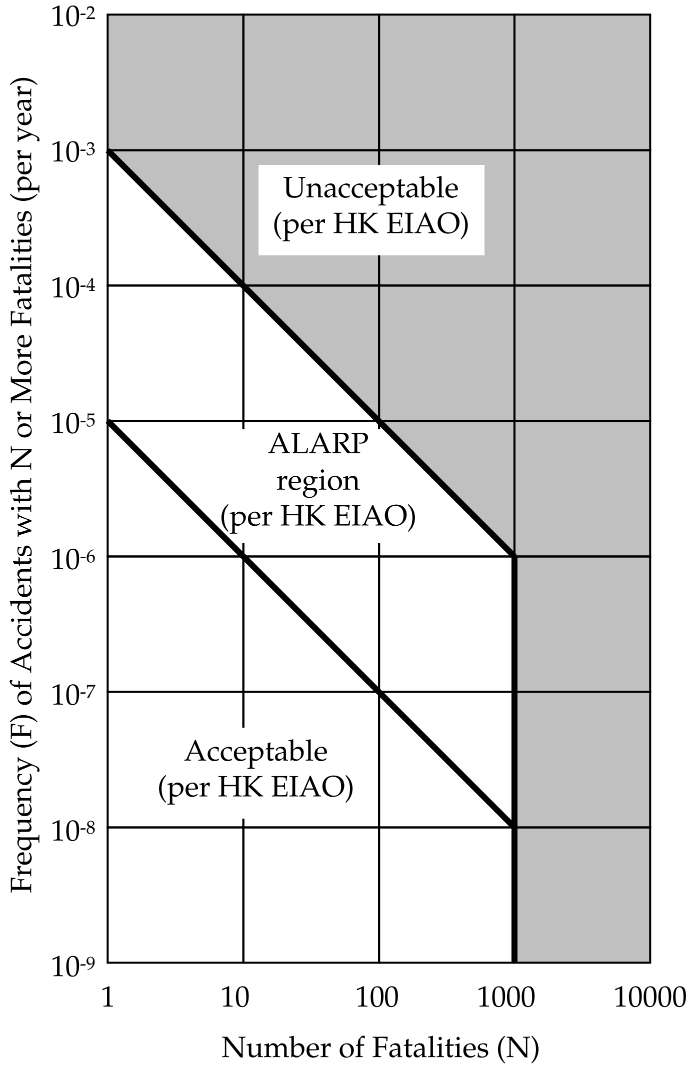


Table B5.1 Overall Weather Class and Wind Direction Probabilities

Direction	Percentage of Occurrence								
	Day				Night				Total
	1.5F	3B	3D	6D	1.5F	3B	3D	6D	
N	1.59	3.56	4.08	2.72	8.80	0.00	2.27	4.97	**27.99**
NE	0.97	5.41	4.66	2.59	3.65	0.00	1.90	3.12	**22.30**
E	1.30	4.05	2.98	1.42	4.12	0.00	1.08	2.64	**17.59**
SE	0.52	0.74	0.65	0.42	2.03	0.00	0.08	0.79	**5.23**
S	0.68	3.95	1.98	0.87	2.38	0.00	0.16	0.95	**10.97**
SW	0.36	0.68	1.39	0.26	4.02	0.00	0.50	1.29	**8.50**
W	0.42	0.23	0.26	0.00	1.22	0.00	0.11	0.16	**2.40**
NW	0.55	0.16	0.42	0.13	3.33	0.00	0.32	0.11	**5.02**
Total	**6.39**	**18.78**	**16.42**	**8.41**	**29.55**	**0.00**	**6.42**	**14.03**	**100.00**

The Pasquill-Gifford atmospheric stability classes used in *Table C5.1* are defined as follows:

- A: Turbulent;
- B: Very unstable;

- C: Unstable;
- D: Neutral;
- E: Stable; and
- F: Very stable.

Wind speed and solar radiation interact to determine the level of atmospheric stability, which in turn suppresses or enhances the vertical element of turbulent motion. The latter is a function of the vertical temperature profile in the atmosphere; the greater the rate of decrease in temperature with height, the greater the level of turbulence. Category D is neutral and neither enhances nor suppresses atmospheric turbulence.

B5.3 POPULATION DATA

A site visit was conducted in March 2007 to investigate the surrounding population of the area. The area surrounding the site is shown in *Figure B5.2*. The vicinity of the biodiesel plant is generally industrial. The estimated population data are presented in *Table B5.2*.

Table B5.2 Surrounding Population of Biodiesel Plant

Site	Day Time Population (People Indoors)	Night Time Population (People Indoors)
Gammon Warehouse North	30 (10)	10 (0)
Gammon Warehouse South	30 (20)	10 (0)
TDC Warehouse	30 (0)	10 (0)
Asia Netcom (1)	20 (0)	10 (0)
Asia Netcom (2)	20 (0)	10 (0)
HAESL	100 (80)	20 (10)
Chun Wang Street	4 (0)	4 (0)

For the road population on Chun Wang Street, the Transport Department 2005 Annual Traffic Census[1] data were adopted. The AADT at Wan Po Road station (number 5514) was found to be 2,440 vehicles per day. Assuming an average speed of 20 km hr^{-1} and 3 persons per car, the population density on Chun Wang Street is:

Road population density

= 2,440 vehicles per day x 3/ 24/ 20 km hr^{-1}

= 15.3 persons/km

(1) The Annual Traffic Census 2005, Transport Department, Hong Kong SAR, June 2006.

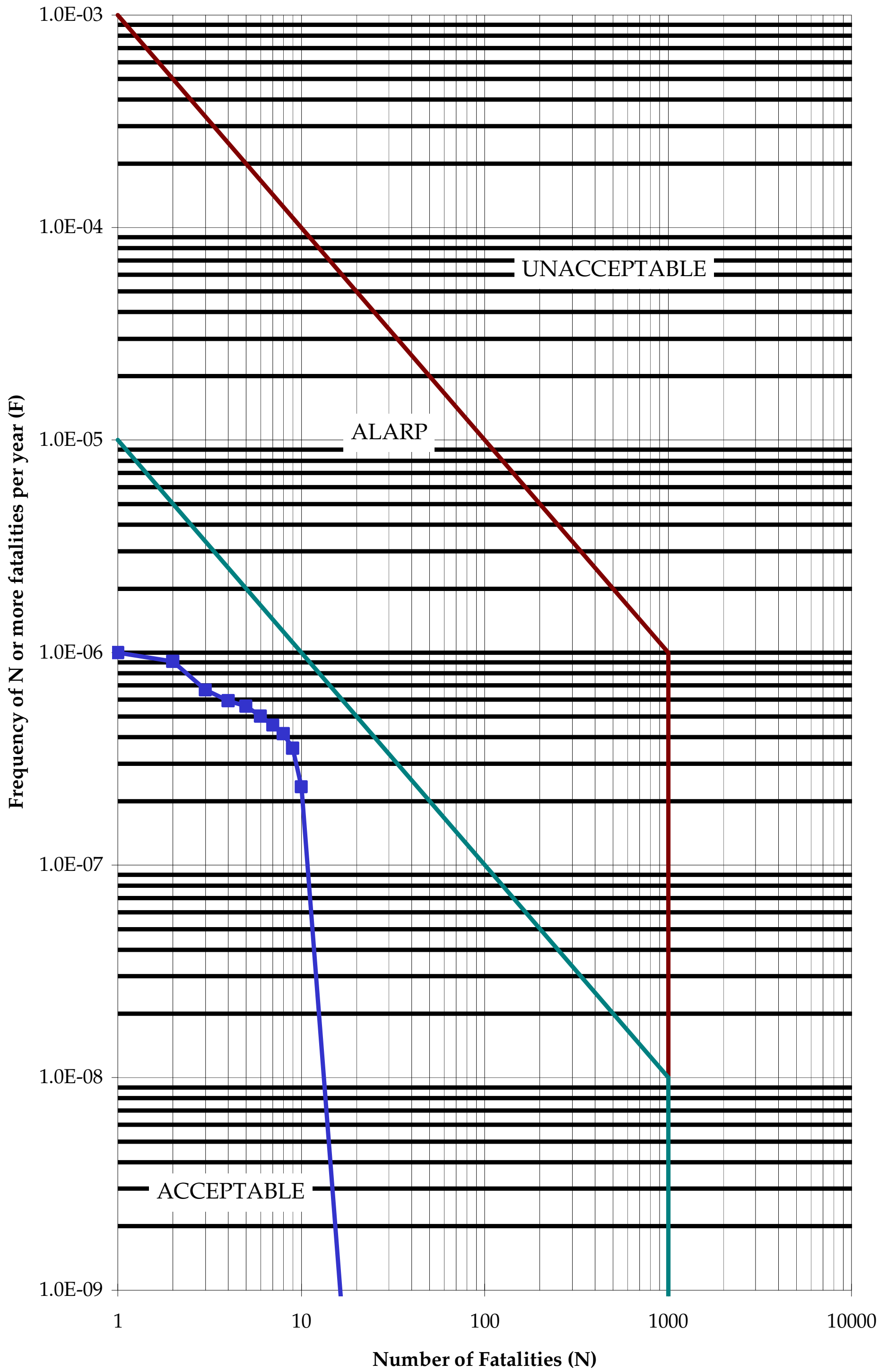
With the road section length at 250m, the road population on Chun Wang Street is assumed to be 4 people during the whole day, all outdoors.

Figure B5.2 *Surrounding Area of Biodiesel Plant*

B5.4 RISK RESULTS

The overall off-site Potential Loss of Life (PLL) value from the biodiesel plant was estimated as 7.1 x 10^{-6} per year, attributed to bund overtopping from a catastrophic rupture of the largest biodiesel tank T17. The corresponding FN curve is presented and compared with the *Hong Kong Risk Guidelines* in *Figure B5.3*.

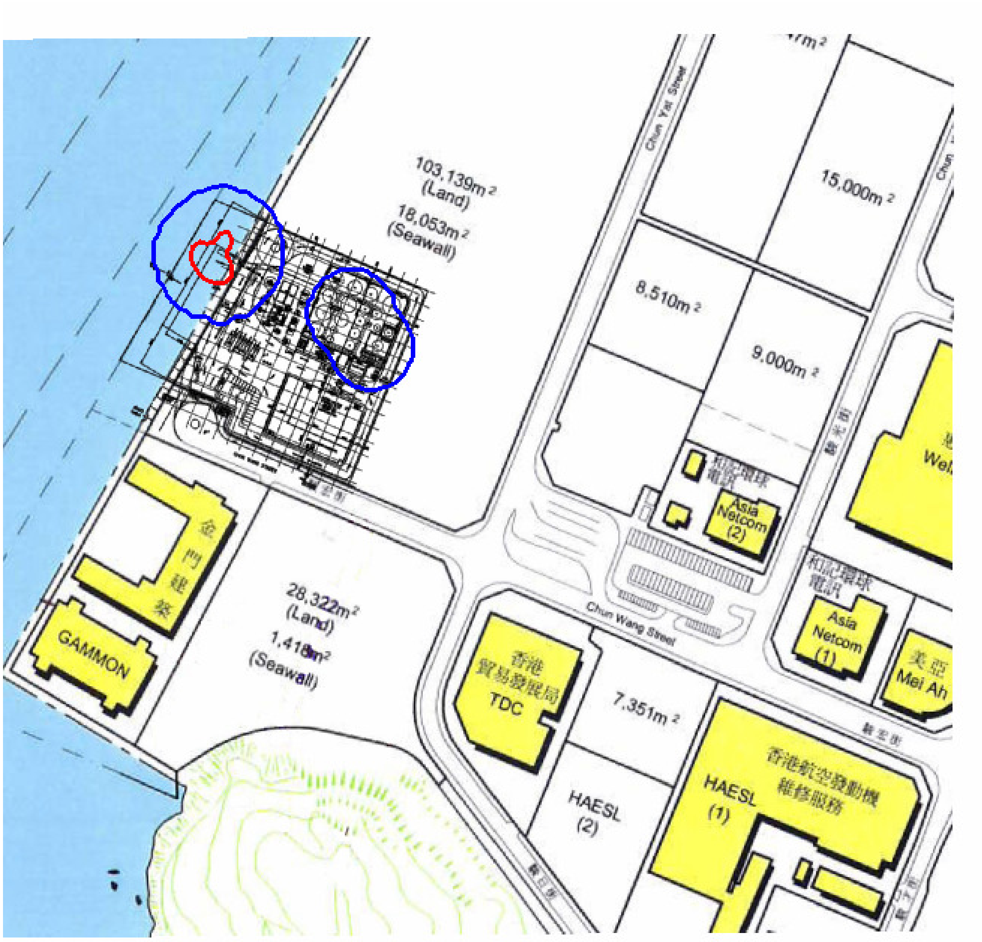
FigureB5.3 FN Curve and its Comparison with the HK Societal Risk Guidelines



As can be seen, all the fatality frequencies are well below the ALARP line and are therefore considered acceptable under the *Hong Kong Risk Guidelines*.

The individual risk contours for the biodiesel plant are shown in *Figure B5.4*; these contours express the risk to a hypothetical individual present outdoors 100% of the time. As seen from the figure, the 1.0×10^{-6} per year individual risk contour for 100% outdoor exposure does not extend beyond plant boundary. Individual risk from the plant is therefore considered satisfactorily low and complies with the Hong Kong individual risk guidelines which state that the individual risk off-site should not exceed 1.0×10^{-5} per year.

Figure B5.4 ***1.0E-5 (Inner, Red) and 1.0E-6 (Outer, Blue) Individual Risk Contours for Biodiesel Plant***



B5.5 CONCLUSIONS

The potential risks from the proposed biodiesel plant were assessed using a standard risk assessment methodology with conservatism (e.g. biodiesel ignition probabilities considered higher than usual). It was found from the study that both the societal and individual risks evaluated for the plant were found to be acceptable when compared against the *Hong Kong Risk Guidelines*.

Therefore, no further mitigation measures are deemed to be necessary for further reduction in the off-site risk levels associated with the Project.

Nevertheless, to minimise risk posed by the facilities to on-site personnel, it is recommended to develop safe handling and loading procedures for methanol, acids and alkalis, such as earthing for transport tankers, emergency plan for handling acid and alkali spills, periodical testing for loading hoses, etc. It is also advised to install methanol gas detectors indoors of process buildings to detect any gas leakage and prevent from further hazards.