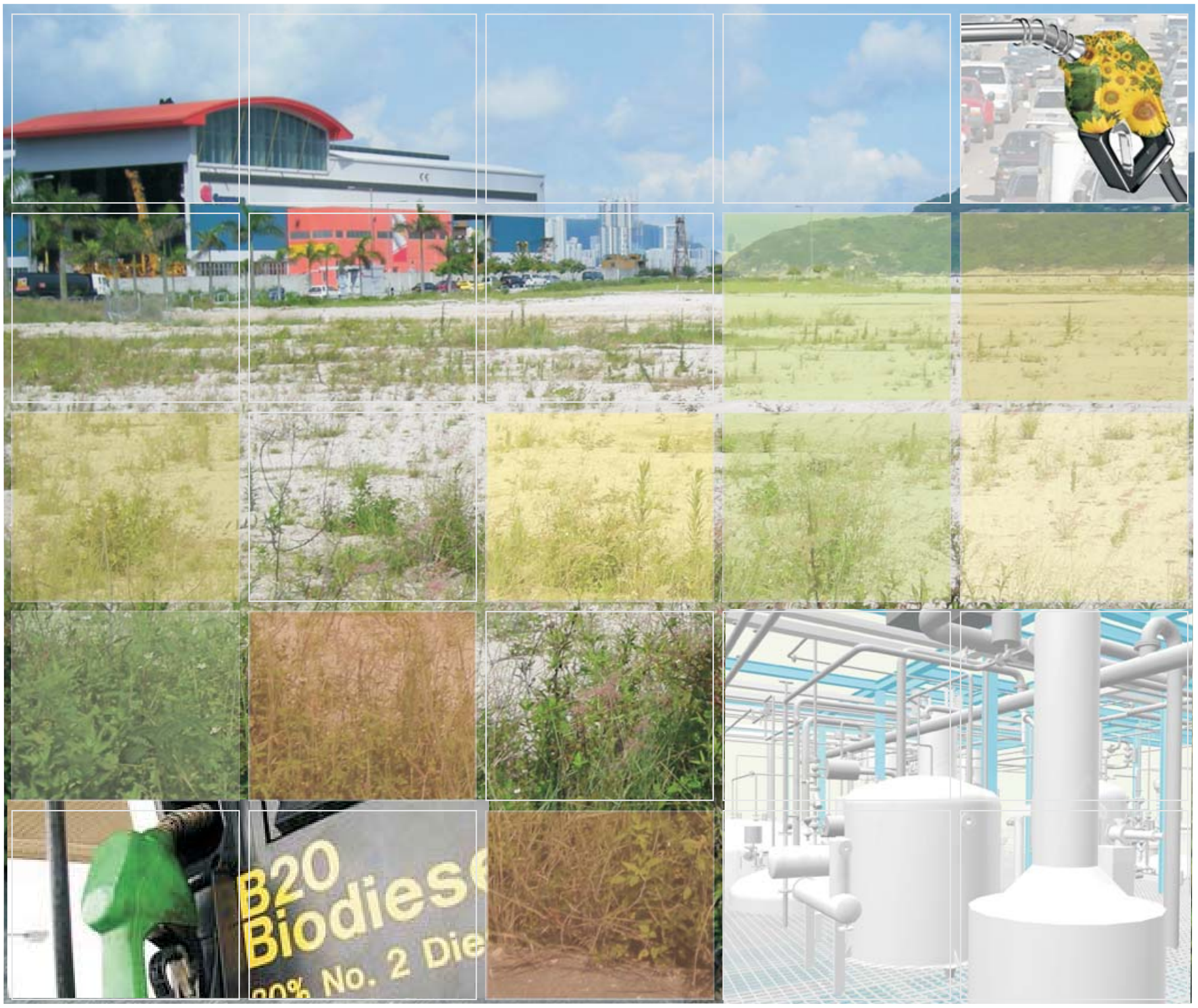
EIA REPORT



ASB Biodiesel (Hong Kong) Limited

Development of a Biodiesel Plant at Tseung Kwan O Industrial Estate

Environmental Impact Assessment Report

6th October 2008

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ASB Biodiesel (Hong Kong) Limited

Development of a Biodiesel Plant at Tseung Kwan O Industrial Estate: *Environmental Impact Assessment Report*

October 2008

For and on behalf of
ERM-Hong Kong, Limited

Approved by: Andrew Jackson

Signed:

Position: Managing Director

Date: 6th October 2008

CONTENTS

ANNEXES

1 INTRODUCTION

1.1 BACKGROUND

ASB Biodiesel (Hong Kong) Ltd (the Project Proponent) proposes to construct and operate a 100,000 tonnes per annum (tpa) biodiesel plant (the Project) in Tseung Kwan O Industrial Estate (TKOIE). The plant will use 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 recycling outlet for GTW and WCO but also converts the oil and grease recovered from these wastes into useful products. The Project also offers a cleaner alternative to diesel fuel to the Hong Kong market.

ERM-Hong Kong, Ltd (ERM) has been commissioned by the Project Proponent to undertake an Environmental Impact Assessment (EIA) Study in accordance with the EIA Study Brief (No. ESB-178/2007) issued under the *Environmental Impact Assessment Ordinance* (*EIAO*) and the guideline on assessment methodology provided in the *Technical Memorandum on Environmental Impact Assessment Process* (EIAO-TM).

This *EIA Report* addresses the nature and extent of the potential environmental impacts associated with the construction and operation of the proposed biodiesel plant. The assessments in this EIA Study are conducted using well-proven and internationally accepted methods based on reasonable worst-case conditions.

1.2 OBJECTIVES

The Project is classified as a Designated Project under the *Schedule 2 Part I* of the *EIAO* and therefore the construction and operation of the Project will require an Environmental Permit (EP). The overall objectives of the EIA Study are to provide information on the nature and extent of potential environmental impacts arising from the Project; to recommend appropriate mitigation measures to control the potential environmental impacts so that it complies with the requirements of the EIAO-TM, and to confirm the environmental acceptability of the Project.

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

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

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

(ii) to identify and describe elements of community and environment likely to be affected by the Project and/or likely to cause adverse impacts to the Project, including both the natural and man-made environment, and associated environmental constraints;

(iii) to consider alternative options with a view to avoiding and minimizing the potential environmental impacts to sensitive receivers;

(iv) to evaluate the potential risk of off-site population due to the Project operation as shown in the Project Profile (including but not limited to biodiesel production process, storage and pipeline transfer of raw materials, immediate products and final products and Dangerous Goods involved);

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

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

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

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

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

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

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

1.3 ORGANIZATION OF THE REPORT

The remainder of this report is organised as follows.

- *Section 2* discusses various construction and operation arrangements considered in the design in order to avoid or minimise adverse environmental impacts;

- *Section 3* describes the proposed construction and operation activities;
- *Section 4* presents the air quality assessment;
- *Section 5* presents the noise assessment;
- *Section 6* presents the water quality assessment;
- *Section 7* presents the marine ecological assessment;
- *Section 8* presents the hazard to life assessment;
- *Section 9* presents the environmental monitoring and auditing requirements; and
- *Section 10* presents the conclusions and summary of the environmental outcomes.

2 *CONSIDERATION OF ALTERNATIVES*

2.1 *INTRODUCTION*

In response to clause 3.3 of the EIA Study Brief, the Project Proponent has explored different construction methods and operation arrangements for the Projects in a view to avoid or minimize adverse environmental impacts. This section summarizes the alternatives that have been considered during the planning and design stages and the rational for choosing the preferred options.

2.2 *OPTIONS FOR CONSTRUCTION*

2.2.1 *Jetty Construction*

The proposed biodiesel plant will be located at the Chun Wang Street within the TKOIE (the Site) (see *Figure 2.2a*). The Site is located adjacent to the existing rubble mount sloping seawall of the TKOIE. Transportation of biodiesel, PFAD and methanol will be by marine-going vessels. It is therefore necessary to develop a jetty for the reception of PFAD and methanol from the barges and loading of biodiesel to the barge. A jetty of 50m long and 26m wide is proposed.

During the project planning and design stage, two construction methods for the jetty were considered. The first option (Option 1) (see *Figure 2.2b*) is to construct a vertical seawall with concrete blocks. Standard concrete seawall blocks will be placed by crane on compacted rockfill foundation and the space between the concrete block seawall and the land will be filled with compacted granular fill. The area reclaimed will be paved with concrete or bitumen macadam. In this option, the reclamation will obstruct the water flow in the area and thus may affect the flow regimes during the operational phase. The habitat and marine organisms on the existing seawall will be directly impacted as a result of the construction of the jetty.

Another option considered is construction of a piled deck jetty (Option 2) (see *Figure 2.2c*). The jetty will be in form of a reinforced concrete deck supported by marine piles (about 1m diameter each). The piles will be installed using drilling rig and hence will have minimal impact on the existing seawalls. No dredging works or reclamation will be required. Although there may be localised effects due to physical resistance of the piles, the water flows through the piled structure and the bathymetry will generally be maintained. It is not expected that the piles will cause adverse impacts to the water flow regime at the jetty during operation phase. Unlike Option 1, this option will only affect the areas where the piles will be placed and hence the potential impacts to marine ecology will be very much reduced and minimal. The piles will also serve as artificial habitat for the settlement and re-colonisation of marine

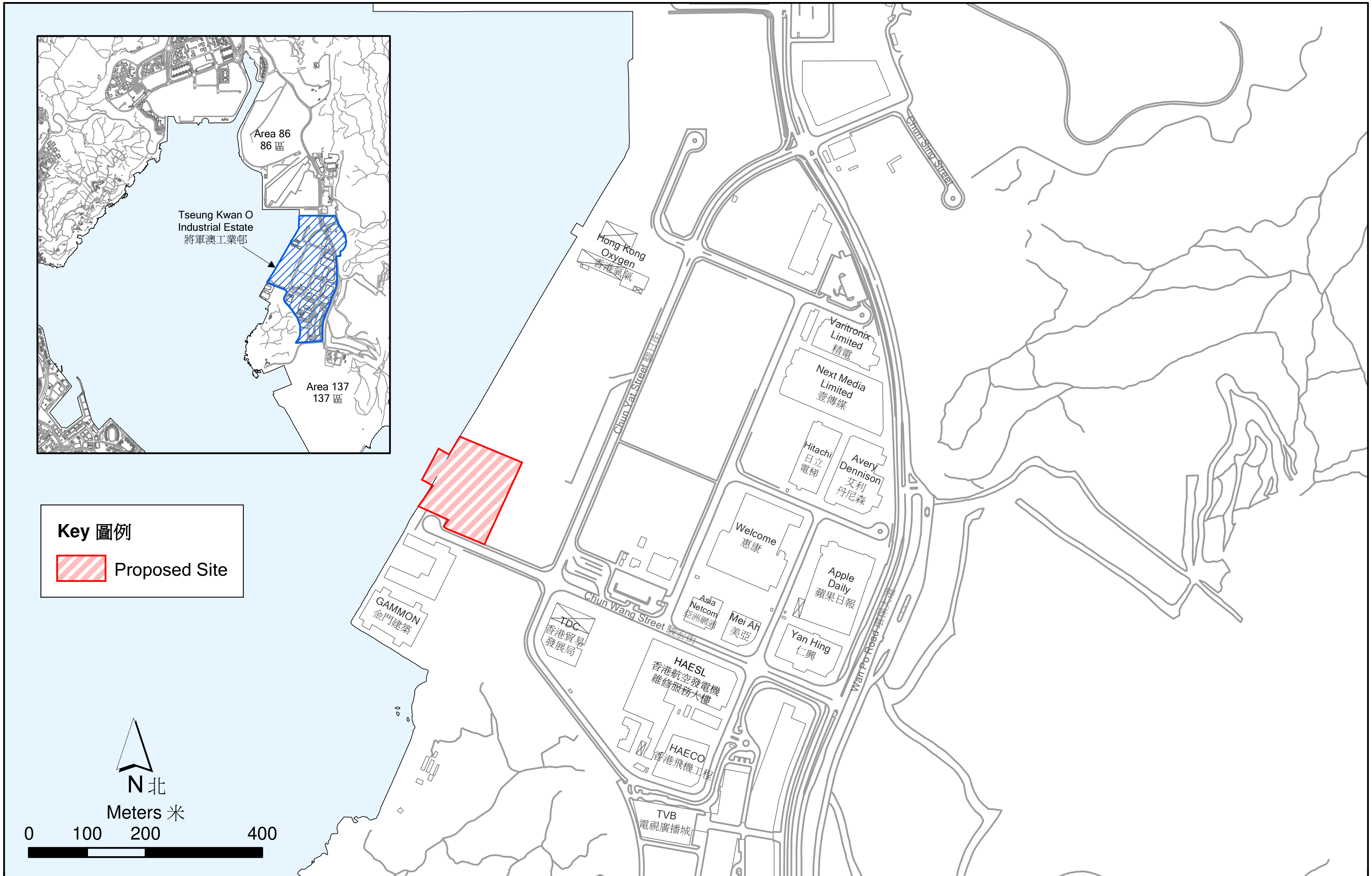

Figure 2.2a

Site Location Plan of the Biodiesel Plant

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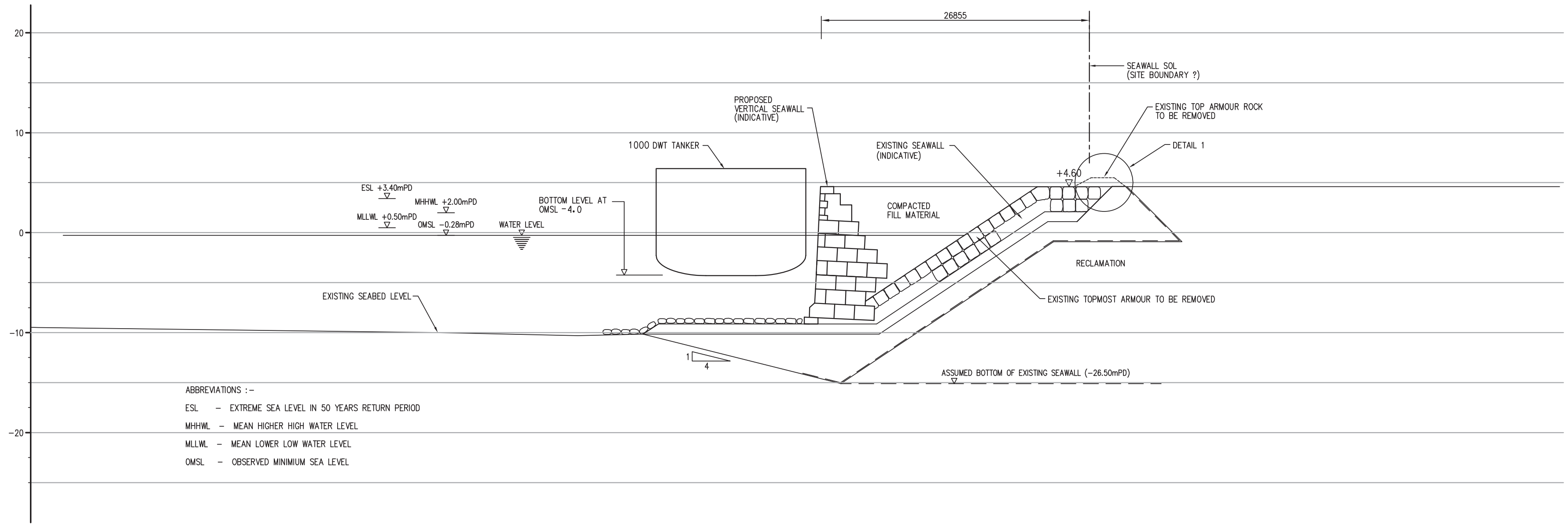

Figure 2.2b

Jetty with Vertical Seawall
(Option 1)

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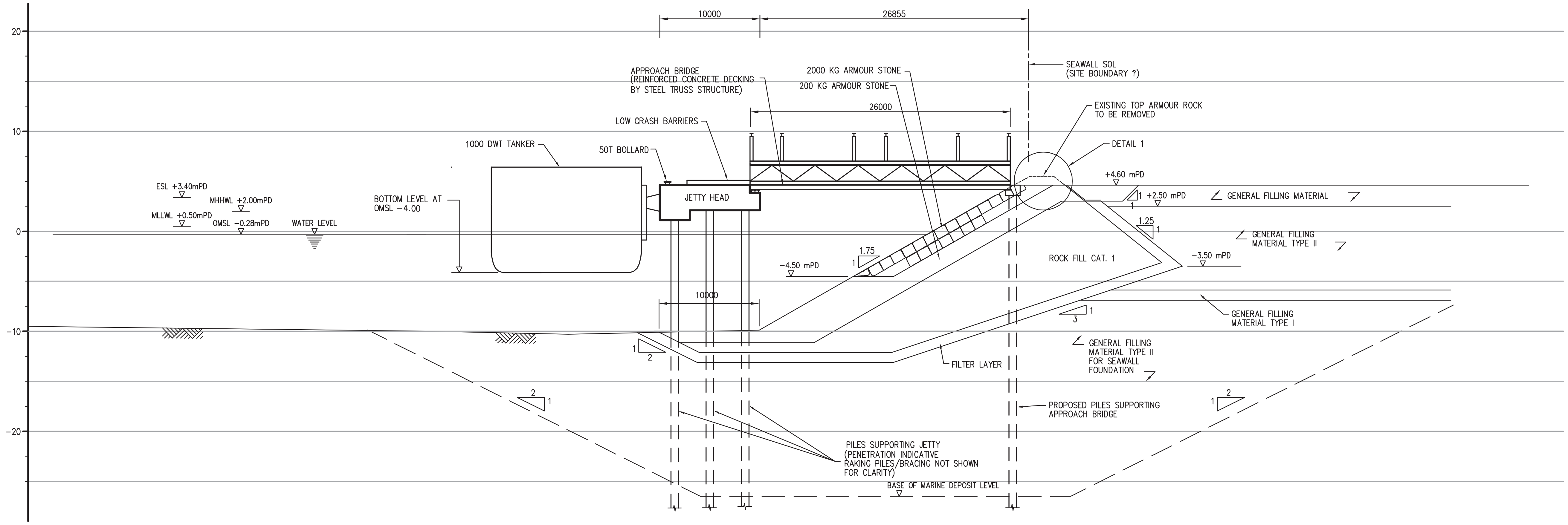

Figure 2.2c

Piled Deck Jetty Construction
(Option 2, the Preferred Option)

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assemblages. Therefore, Option 2 (ie a piled deck jetty) is selected for detailed engineering design and adopted for EIA Study.

2.2.2 *Construction of Tank Farm*

A tank farm will be constructed within the biodiesel plant for storage of feedstock and products. With respect to the nature of the materials to be stored, concrete tanks are more susceptible for cracks and hence have a higher change of leakage. For storage of similar materials, steel tanks are commonly used. Steel tank offers better mechanical, technical and safety standards. In addition, the concrete tanks will have to be constructed on-site and will generate more construction waste and have a higher potential to cause dust and noise impacts. The storage tanks will therefore be constructed with structural steel.

The tanks will be prefabricated off-site and delivered to the site for installation. To ensure the integrity of the tanks, the tanks will be installed on a reinforced concrete platform which will be supported by a thick layer of granular fill to allow for settlement during full load. This will minimize the potential leakage from the tanks. The tank farm area will be bunded (at least 110% of the volume of the largest tank) to contain ay spillage or leakage from the tanks.

2.2.3 *Pipelines*

Most of the pipelines for conveying raw materials, semi-products and end-products within the Site are overhead pipelines installed on the pipe bridges. Overhead pipelines are preferred to underground pipelines as any leakage of the pipelines can be easily detected by visual inspection. The potential for land contamination can be minimized if leakage occurred. All pipelines on the pipe bridges are welded and the connections (such as flanges and values) will be placed within or above a bunded area to minimize the environmental impacts if leakage occurred at the joints.

The minimum height of all pipe bridges is 4.5m above ground level to prevent them from collision by vehicles. Height check and control will be implemented at the site entrance to ensure no vehicle taller than 4.5m will enter to the pipe bridges areas. The columns of the pipe bridges will be protected by a concrete wall.

2.3 OPTIONS FOR OPERATION

2.3.1 *Materials for Biodiesel Processes*

The biodiesel manufacturing process adopted for the plant has taken accounted of the best available technology (BAT) for the multiple feedstock processes. Material recycling and waste minimization have been carefully considered in the design of the production processes which allow better material utilization and minimize the generation of solid waste and wastewater. The adopted technology has the following characteristics:

- **Generate saleable by-product:** All by-products are saleable. The main by-products are glycerine and potassium sulphate which can be sold for chemical, pharmaceutical and other industrial applications. This will avoid the need to dispose the by-products generated from the processes.

- **Offer a high material-to-product conversion:** During the processes, sub-standard products will be recycled back into the system at various stages. This will minimise the generation of chemical waste and wastewater from the plant.

- **Minimize energy use**: The main biodiesel production line is a semi-continuous process which is operated at atmospheric pressure and room temperature. This minimizes the energy consumption of the plant. In addition, the bioheating oil (which is a lower grade biodiesel) and biogas generated from the biodiesel production process and wastewater treatment plant, respectively will be reused on-site as a fuel for the boilers. This minimizes the use of petroleum based fuel (eg diesel or Town Gas).

- **Choose the most suitable raw materials:** The raw materials used for the manufacturing processes are chosen to minimize the potential environmental, health and safety impacts. *Table 2.3a* summarizes the rationales for choosing raw materials to be used for the biodiesel production processes.

Table 2.3a *Raw Materials to be used for the Biodiesel Production Processes*

Function in the Production Line	Raw Materials Chosen	Other Potential Materials	Rationale
Strong acid to be added to carboxylic acids in the fat to minimize reaction time	Sulphuric Acid	Other strong acids	A saleable by-product potassium sulphate (a raw material for agricultural fertilisers) will be produced and thus minimized waste generation
Simple alcohol to replace glycerol in the feedstock during the transesterification process	Methanol	Other simple alcohol (eg ethanol)	To produce a saleable product, fatty acid methyl ester. Methanol has been attributed a harmfulness ranking of "low" and has a lower photochemical ozone creation potential (POCP) of 21 comparing with that of ethanol (45)
Acid to be used in the washing steps	Phosphoric Acid	Other acids (eg sulphuric acid)	To reduce the input of sulphur-based materials and hence minimise the risk of sulphur being added to the biodiesel. Phosphoric acid is more effective than other acids in removal of impurities.
Alkaline catalyst for various stages of process	Potassium Hydroxide	Other alkaline catalyst (eg sodium hydroxide)	To produce a saleable product, potassium sulphate (a solid which is easy to handle). The use of sodium hydroxide will produce sodium sulphate which is highly soluble. It will be discharged into liquid waste stream and cannot be reused

2.3.2 *Air Abatement Technology*

Volatile Organic Carbons (VOC)

Various VOC recovery and abatement technologies listed in the European Commission's Integrated Pollution Prevention and Control (IPPC) have been reviewed. Wherever possible, the VOCs recovered will be re-used within process. The VOC recovery technologies considered during the design stage are listed in *Table 2.3b*.

Table 2.3b VOC Recovery Technologies

Technique		**Recycling Potential**
Condensation	To condense the VOCs by increasing the pressure or reduce temperature	Condensate can be reused in the system
Absorption	Remove VOCs from a gas stream by mass transfer into a scrubbing liquor	Resulting a mixture which can recycled
Adsorption	Remove VOCs from a gas stream by passing the gas through a solid medium	Typically for final polishing of the exhaust gas. The VOCs cannot be recovered for recycling
Thermal Oxidation	Complete thermal breakdown of VOCs will lead to the formation of carbon and water. This can be combined with existing combustion units such as boilers or biogas flares	Do not enable recycling

Condensation is chosen to recycle the majority of the spent methanol. Methanol from the process exhaust emissions will be recovered for reuse using condensers and a wet scrubber which will use water as the scrubbing medium. The spent scrubber water will be recycled and the methanol will be separated in the demethanolisation/ dewatering column. The methanol will be reused in the production processes. Although the VOCs arising from feedstock pre-treatment and storage tanks are expected to be low (1), the exhaust air or vent gas from the pre-treatment and storage tanks which will be removed by a two-bed carbon filter adsorption system. The potential VOC emission from the plant will therefore be negligible. During the loading of the methanol tank, the vent gas will be recovered/ recycled back to the tanker so that the vent gas will not be discharge to the atmosphere.

Odour Emissions

In order to minimize potential odour nuisance, all the GTW and WCO will be unloaded at the designated stations via flexible hoses or pipelines in a closed system arrangement. The GTW screening room and screenings storage room

(1) The oil and grease will be recovered from the GTW in the feedstock pre-treatment tanks. As GTW containing diluted oily water from food establishments, it is anticipated that the vent gas will contain low level of VOCs. Other raw materials include PFAD, WCO, animal fat, sulphuric acid and phosphoric acid will generate minimal VOCs or are inorganic compounds.

will be provided with ventilation at all time (except during maintenance period) to maintain a slight negative pressure to prevent odour emissions to the atmosphere. The exhaust air will be scrubbed. Instead of discharging to the atmosphere, the scrubbed air will be used as part of the ventilation air for the enclosed wastewater treatment tanks and air supply for the aeration tanks. This will further minimise the discharge of odorous air to the atmosphere (please refer to *Section 3.2.2* for further details).

All processing vessels and tanks in the biodiesel plant, including wastewater treatment tanks, will be enclosed to prevent odour emissions [(1)]. The vent gas will be scrubbed prior to discharge to the atmosphere (please refer to *Section 3.2.2* for further details).

The surplus sludge from the sludge thickener will be dewatered to at least 30% dry solids (about 1.3 tpd) using a belt press in the Sludge Dewatering Room. The dewatered sludge will be stored in container inside the Sludge Room. The roller door of the Sludge Room will be closed except for removal of the sludge container for disposal. The Sludge Dewatering Room and Sludge Room will be provided with a ventilation system and the exhaust air will be scrubbed (by the final scrubber, see *Figure 4.4a*) prior to discharge to the atmosphere. A slight negative pressure will be maintained at all times when the sludge dewatering process is carrying out and sludge is being stored in the Sludge Room. The sludge container will be properly covered with metal flip doors or tarpaulin before the roller door of the Sludge Room is opened.

2.3.3 Wastewater Management

Source reduction and segregation are adopted in the design of the wastewater management system to minimize the needs for treatment. Source reduction measures include recycling of the biodiesel wash water through the process and careful control of the process and utilities. In addition, containment bund will be provided for the material storage tanks and good housekeeping will avoid/ minimize the potential for land contamination and surface water contamination.

Drainage System

The Site will be provided with separate surface water and foul water drainage systems to prevent untreated sewage/ potentially contaminated stormwater runoff from discharge into the sea (see *Figure 3.2h*). The proposed drainage system consists of three separate sub-systems:

- Wastewater from the process, utilities and high-risk yard areas (ie tank farm and GTW reception area);
- Surface water runoff from low risk areas (ie non process area); and
- Surface water runoff from roofs.

(1) Except for the storage tanks of acids (sulphuric acid and phosphoric acid) and base as these materials are not cause odour nuisance.

The wastewater collected from the process and high-risk yard areas will be collected and treated at the on-site wastewater treatment plant to meet the statutory requirements for discharge to foul sewer. In order to prevent contaminated surface runoff from discharge off-site, surface runoff of the bunded area will pass through an oil interceptor before discharge to the stormwater drainage system of the TKOIE.

Wastewater Treatment Plant

Wastewater generated from feedstock pre-treatment and glycerine dewatering processes will contain trace amount of oils and fats and have a high COD concentration. The wastewater will be treated at the on-site wastewater treatment plant prior to discharge to the foul sewer leading to the TKO Sewage Treatment Plant. Different treatment methods have been considered in the planning and design stages and they are described below.

Pre-treatment options including grit separation, sedimentation (including coagulation and flocculation), air flotation, filtration and membrane filtration have been considered. Three pre-treatment techniques, including the dissolved air flotation (DAF), settlement after chemical treatment and membrane filtration, can achieve more than 80% fat/oil removal efficiency and therefore they are further studied. *Table 2.3c* compares these technologies. Oil-water separator and DAF with prior equalisation and pH adjustment are selected for the design of the on-site wastewater treatment plant.

Table 2.3c A Comparison of Potential Wastewater Pre-Treatment Technologies

Technique	**Advantages / Disadvantages**
Dissolved Air Flotation (DAF)	• Ideally suited to treat wastewaters containing high concentrations of fats and oils • Can reduce COD/BOD concentrations by more than 80%
Settlement / Sedimentation	• Much larger footprint than DAF or membrane filtration • The process is not induced / controlled by a physical separation process • Settlement tank requires a large open area and also have a higher potential for odour emissions
Membrane Filtration	• Fats have a high potential to block the membrane which will lead to a rapid tail off of removal efficiency

After pre-treatment (ie DAF process), the wastewater will be conveyed to the biological treatment processes to further reduce the organic loading. An anaerobic treatment process, Internal Circulation (IC) reactor (utilising the upflow anaerobic sludge blanket (UASB) technology), will be used to further reduce the organic loading of the wastewater. The wastewater will then be treated by an activated sludge treatment process to reduce the remaining COD from the anaerobic digestion. These treatment technologies were chosen because of their high removal efficiency for organic matters in the wastewater. A combination of the IC reactor and an activated sludge treatment process has been widely used to treat wastewater with high COD/BOD (such as fermentation, paper and pulp, brewery and food etc).

2.3.4 *Materials Transfer*

PFAD and methanol will be received from barges via the on-site jetty. Biodiesel will be pumped from the storage tanks to the barge. Different transfer methods, such as drums and ISO tankers, hose pipe, etc were considered for the transfer of materials from the jetty to the tank farm to minimize the risk of spillage and hence water pollution and land contamination. Dry coupling will be used to connect the loading/unloading pipes to prevent leakage of the material at the joints. This technology has been used in a number of existing biodiesel plants in Europe and proved to be very effective and reliable in preventing spillage.

Barge with well insulated compartments will be used to minimise energy required to heat up the PFAD and maintains the material in liquid during transfer. The PFAD will be pumped to the storage tank through a coiled heat pipeline. ISO Tanker barge can also be used as the heating coils can be put into the tanker if heating is required. ISO tanker barge has been used for transfer of oil at the Shell Oil Terminal in Tsing Yi. The bulk transfer of feedstock (PFAD and methanol) by barge will also minimise the traffic associated with delivery of the materials by road.

Other precautionary measures such as loading/unloading of materials at a bunded area and on-site drainage system will also minimise the risk of water pollution (see *Section 6*).

2.3.5 *On-site Storage of Raw Materials and Products*

The tank farm is the main area for on-site storage of raw materials and products. All tanks and pumps are designed to fulfil both local and international standards for mechanical, technical and safety requirements. The layout of the tanks has been designed to comply with local fire protection requirements. The methanol storage tank will be placed in a separate bunded area. It will be located more than 15m from other dangerous goods tanks (such as the biodiesel storage tanks) and away from the site boundary in order to minimise the potential risk to off-site population. The other storage tanks for the dangerous goods are located at least 10m from site boundary so that there will be sufficient buffer zone to minimize potential risk to off-site population.

2.4 *CHOOSING THE BEST AVAILABLE OPTIONS*

The Project Proponent has explored various construction methods and operation arrangements for the Project in a view to avoid or minimise adverse environmental impacts. Practicable means to prevent marine pollution and hazardous incidents arising from transfer of PFAD and methanol from the jetty to storage tanks and biodiesel from the storage tank to the jetty have been considered in the design. The design and operation of the biodiesel plant have taken account of the best available technology to minimise potential environmental pollution and risk to the public.

3 PROJECT DESCRIPTION

3.1 INTRODUCTION

Biodiesel is the commercial name for fatty acid methyl esters which is a diesel fuel substitute produced from renewable sources (such as vegetable oils, animal fats, and recycled oil and grease (eg WCO and oil and grease recovered from GTW (hereafter is referred to as trap grease)). It is typically produced through the transesterification 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. 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-based diesel for use in the diesel engines. Biodiesel has similar physical properties and combustion and energy value to petroleum-based 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.

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

(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.

testing methods employed; and

- it is safer to transport because its flash point [(1)] 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% and 10% biodiesel mix by 2015 and 2010, respectively.

However, biodiesel is generally more expensive than petroleum-based 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.

Based on the nature of the feedstock and the availability of the technology, biodiesel production can be classified into three generations (see *Table 3.1a)*. There are discussions over the world about the adverse impacts of production of first generation of biodiesel on the world's food supply and prices which cause major criticism and objection to biodiesel. The second generation of biodiesel production uses waste materials (such as animal fats, and recycled oil and grease) as feedstock which will not impact on food supply. However, it requires a higher investment cost for the production plant. There are also suggestions on producing biodiesel from non-food crops but the technology is still in its infant stage and not available for commercial scale production. In the view of the availability of feedstock and the proven track records, the second generation of biodiesel production technology is considered to be the best available option for commercial scale production of biodiesel in Hong Kong.

(1) 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.

Table 3.1a Different Generations of Biodiesel

Biodiesel Production Technology	Feedstock	Potential Impacts	Technology Availability
1st Generation	Common feedstock includes virgin vegetable oil (mainly rape seed in Europe and soybean oil in the USA) and palm oil	• May cause increase in food prices • May impact on natural resources and habitats	• Well-proved technology is available for commercial scale production
2nd Generation	Waste materials (eg waste cooking oil or grease trap waste)	• No impacts on world food supply and prices	• Well-proved technology is available for commercial scale production
3rd Generation	Feedstock not in competition with food chain (eg oil from poisonous bush Jatropha which has no value as food) Feedstock can growth in poor conditioned areas which is not suitable for normal agriculture (eg algae grow in deserts)	• No impacts on world food supply and prices	• Technology is not proven and not available for commercial scale production

3.2 BIODIESEL PLANT AT TKOIE

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. The Site has been vacated since it was formed. 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 proposed 100,000 tpa biodiesel plant will make use of the 2nd generation of biodiesel production technology and make 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 606 tpd [(1)]), 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.

(1) Based on 330 operating days per year.

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

3.2.1 *Technology to be Used*

The Project Proponent will adopt the 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 bio heating 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 which is also the government's mandates for biodiesel to be used in Hong Kong.

The technology provider, the BDI, has a long history in developing and implementing waste-to-fuel technology. Over 28 biodiesel plants are currently operating in Europe and USA have adopted BDI technology.

The key design parameters of the proposed biodiesel plant are shown in *Table 3.2a* and the process flow is shown in *Figure 3.2b.*

Table 3.2a ***Key Design Parameters of the Biodiesel Production Plant***

Parameters	
Operating mode	Semi-continuous
Process operating days per year	330 (guaranteed), 358 (anticipated)
Feedstock reception days per year	365 days
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 3.2c, 3.2d* and *3.2e* show the proposed layout plan and vertical profile of the biodiesel plant. The entire biodiesel production process is program-controlled for maintaining high level of safety and uniform quality of

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

Figure 3.2a

Site Surrounding Environment

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Date: 02/06/2007

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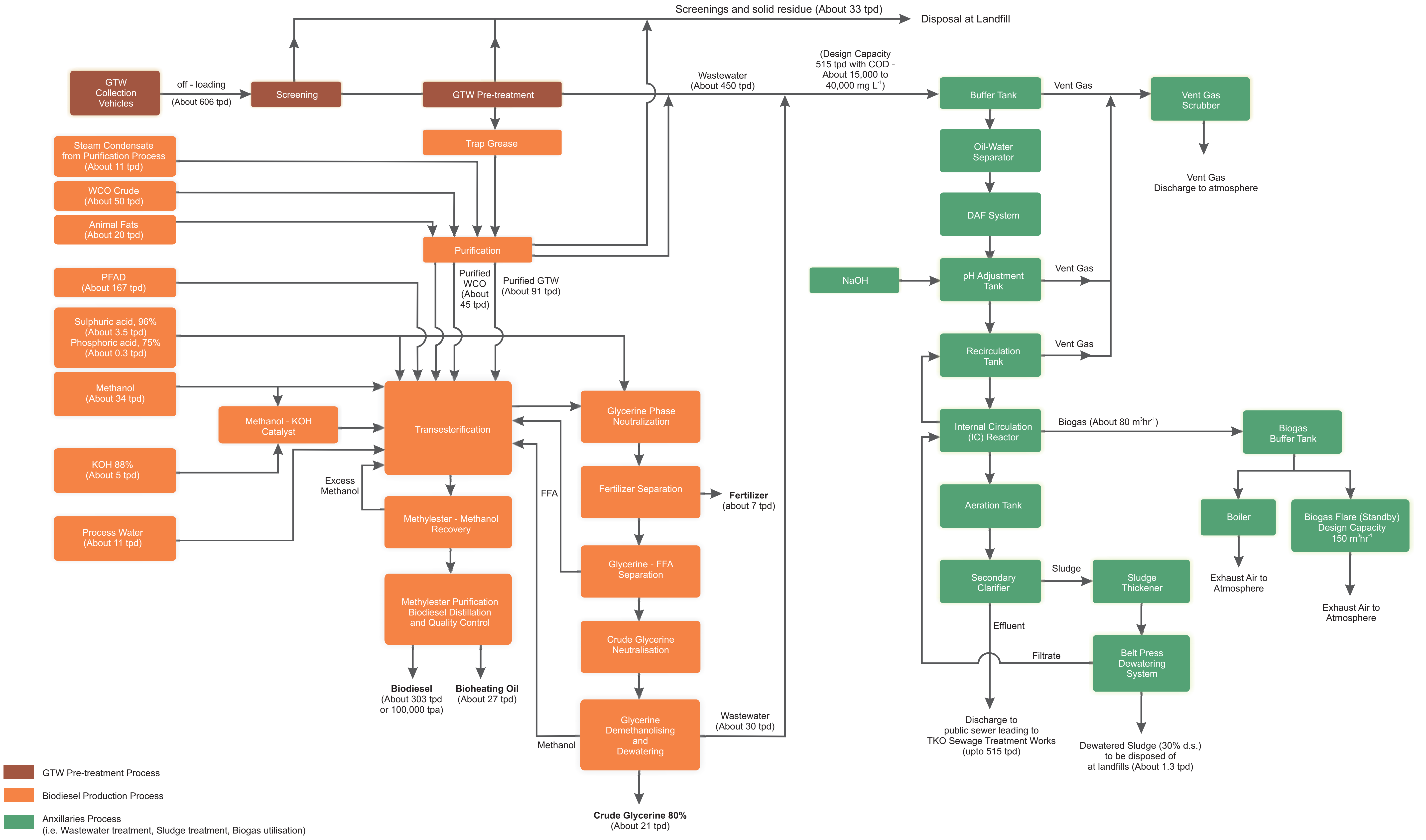

Figure 3.2b

Process Flow Diagram of Proposed Biodiesel Plant

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DATE: 05/08/2008

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	TANK LIST	VOLUME [m³]
1	TRAP GREASE, CRUDE STORAGE TANK	1500
2	TRAP GREASE, CRUDE STORAGE TANK	1500
3	TRAP GREASE, CLEANED STORAGE TANK	1000
4	DEWATERED GREASE TRAPPED WASTE (LIPOFIT)	150
5	DEWATERED GREASE TRAPPED WASTE (LIPOFIT)	150
6	WASTE COOKING OIL, CLEANED STORAGE TANK	1000
7	PFAD STORAGE TANK	1500
8	ANIMAL FAT, CRUDE STORAGE TANK	500
9	ANIMAL FAT, CLEANED STORAGE TANK	500
10	METHANOL STORAGE TANK	500
11	SULFURIC ACID STORAGE TANK	50
12	PHOSPHORIC ACID STORAGE TANK	25
14	ADDITIVE STORAGE TANK	50
15	BIODIESEL QUALITY TANK	500
16	BIODIESEL QUALITY TANK	500
17	BIODIESEL-EUROPE STORAGE TANK	2500
18	BIODIESEL HONGKONG STORAGE TANK	1200
19	GLYCERINE 80% STORAGE TANK	500
20	FERTILIZER CONTAINER	20
21	BIOHEATING OIL STORAGE TANK	200
22	GAS OIL STORAGE TANK	100
23	NITROGEN STORAGE TANK	25
24	WASTE COOKING OIL, CRUDE STORAGE TANK	1200

Legend

Zone 1 - Processiong Building
- 1A - Administration Building
- 1B - Process Building

Zone 2 - Tank Farms

Zone 3 - Waste Water Treatment Plant

Zone 4 - Loading & Unloading Facilities

0 10 20 M

Figure 3.2c

Proposed Layout Plan of the Biodiesel Plant

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DATE: 04/08/2008

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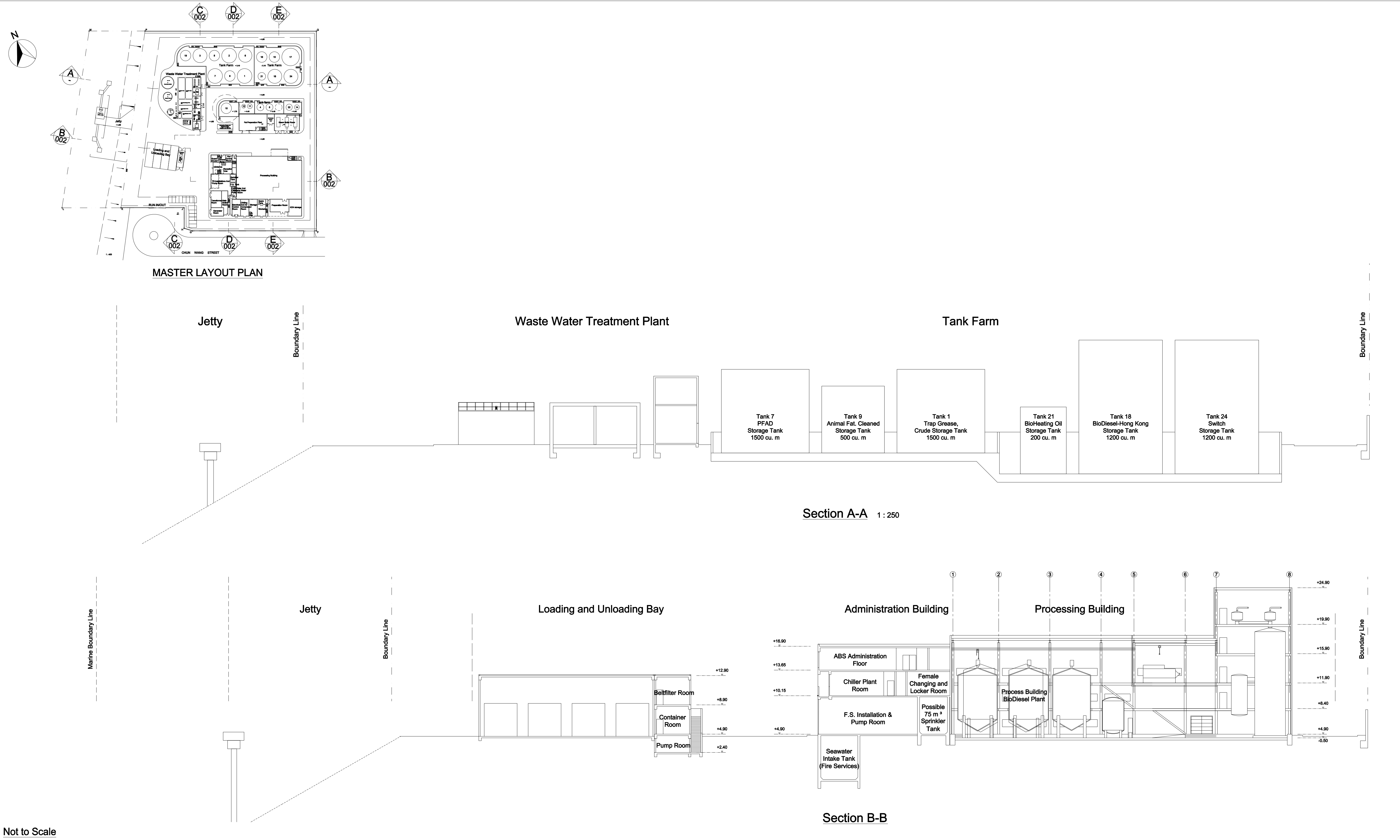

FIGURE 3.2d

Verticle Profile of Biodiesel Plant (Page 1 of 2)

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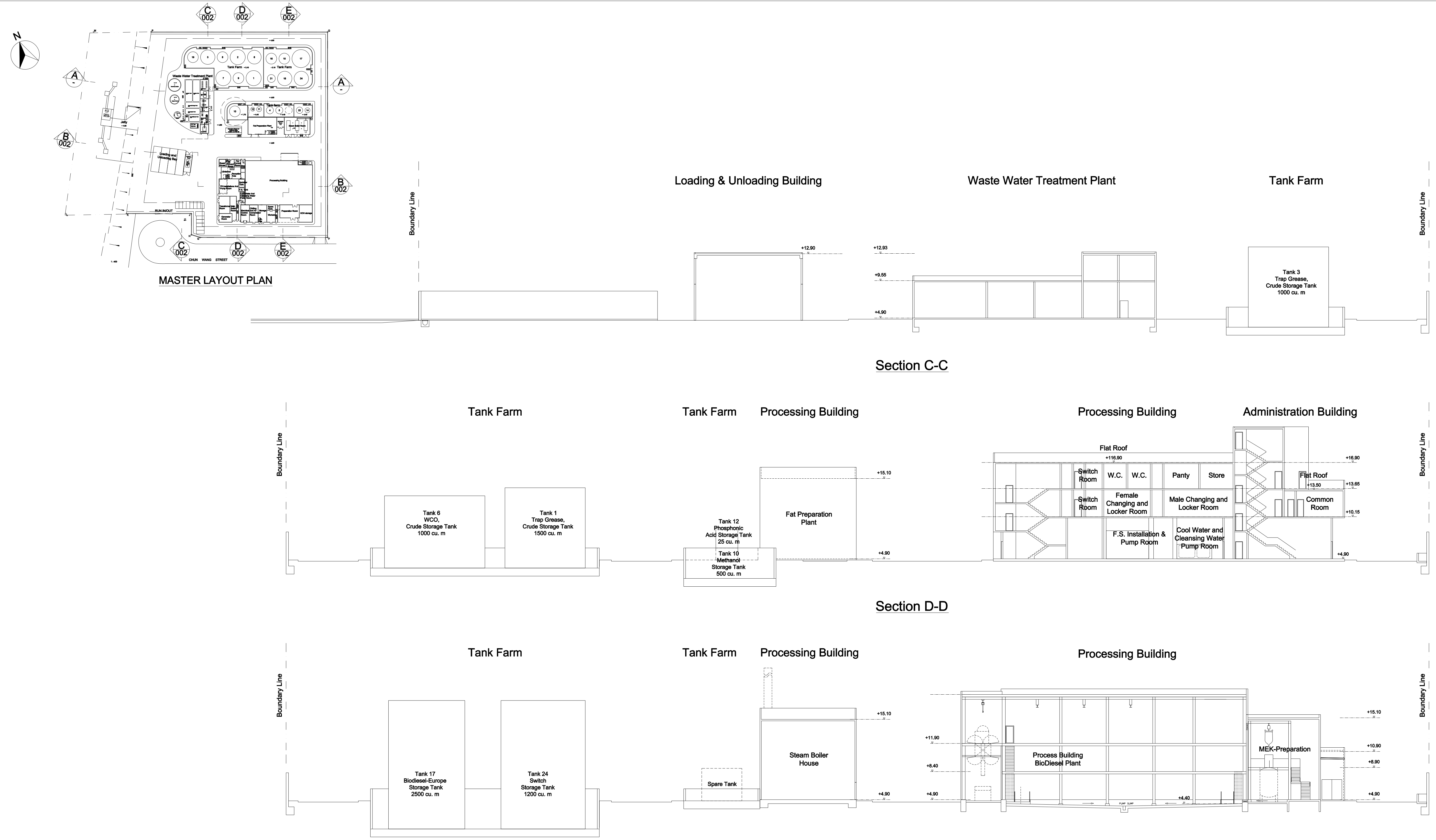

Not to Scale

FIGURE 3.2e

Verticle Profile of Biodiesel Plant (Page 2 of 2)

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DATE: 04/08/2008

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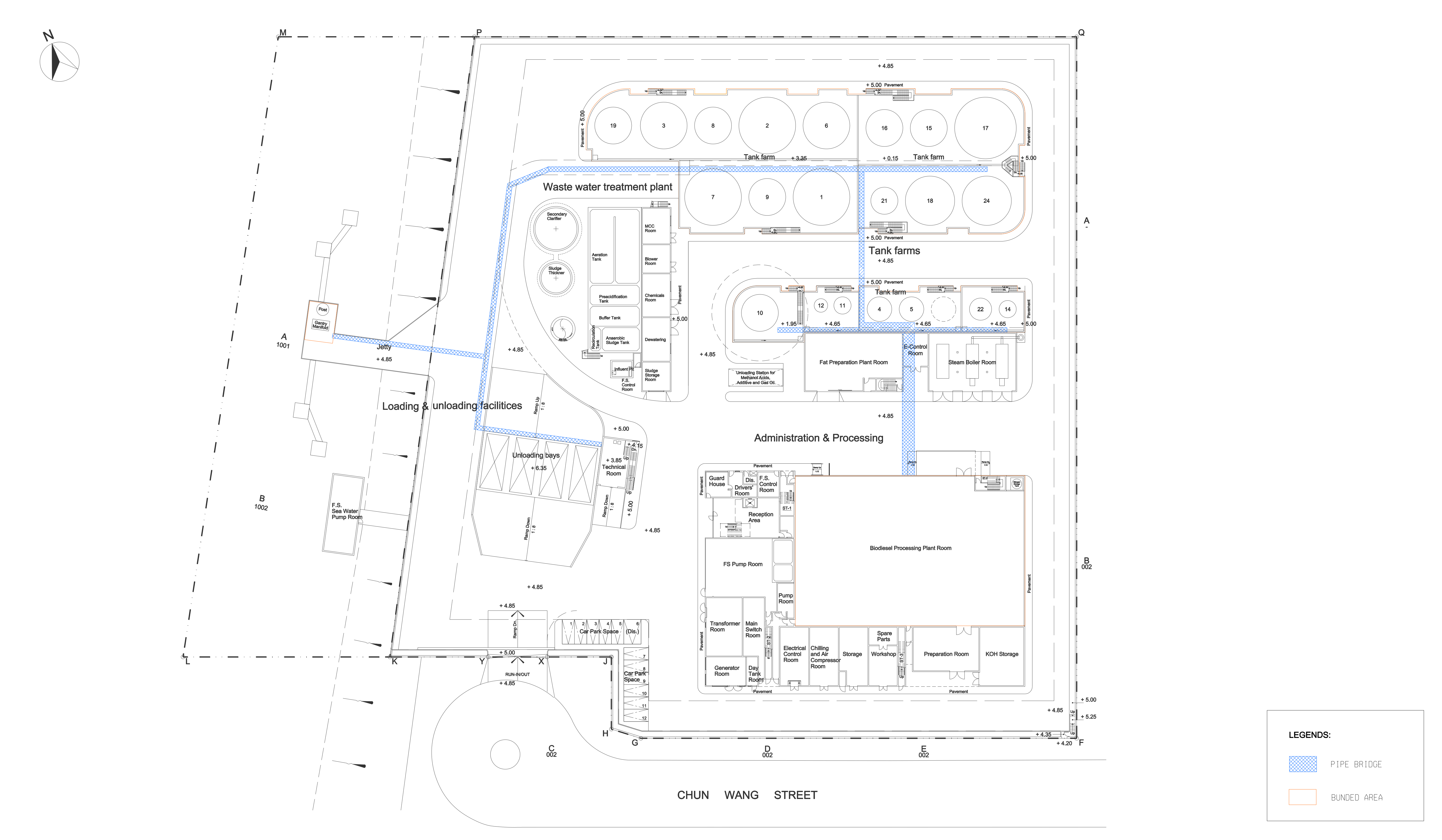

Figure 3.2f

Layout of Pipe Bridge and Bunded Area

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DATE: 05/11/2008

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the final product. The reception, treatment and the production of biodiesel are described below.

3.2.2 *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 on 24 hours basis. GTW will be delivered to site by road tankers on 24 hours basis. WCO will be delivered by road tankers during day-time. Delivery of methanol and PFAD to the site and export of biodiesel by marine vessels will be carried out on a 24 hour basis.

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 weighing at the weighbridge office located at the entrance, the tankers will proceed to the reception area. All GTW arrived will be 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 bays as shown in *Figure 3.2c*. Four unloading bays will be provided. The estimated maximum turnaround time for GTW and WCO collection vehicles within the biodiesel plant is about 30 minutes (including weighing, sampling and unloading (about 20 minutes)). Four unloading bays will be adequate to handle the forecast vehicle flow and no queuing of tankers outside the site entrance will occur. The GTW and WCO will be unloaded by gravity via flexible hoses directly to the underground receiving tanks under a closed system arrangement. Similar unloading system has been used at the Grease Trap Waste Treatment Facility at the West Kowloon Transfer Station and it demonstrates that it is effective to prevent odour and spillage during unloading operation. Separate drainage system will be provided for the unloading bay area to collect wash water (1) which will be discharged to the on-site treatment plant for treatment.

(1) The quantity of wastewater to be generated from the washing of the GTW Reception Area (including the unloading area and the Technic Room) is estimated as follows: (a) low water consumption, high pressure water jet machine will be used for the washing (water consumption rate of about 80 litres/min); (b) the GTW unloading area and the Technic Room will be washed once a day for about 15 minutes; (c) wastewater generation = 80 litres/min x 30 minutes sec/minute = 2.4 m^3 per day. This wastewater will be negligible comparing to the volume of the wastewater to be generated from the GTW pre-treatment process. As the anticipated GTW volume received at the site is conservative, the wastewater engineer has confirmed that the design capacity of the wastewater treatment plant will be able to accommodate this small flow of wastewater.

PFAD and methanol will be delivered to Site by barge and pumped from the barge to the storage tanks using dedicated pipelines. Flexible hose will be used to connect storage tanks of the barge to the pipelines at the jetty. Dry coupling will be used to ensure a secured connection and prevent potential leakage of the materials (1). The pipelines (the PFAD pipeline will be heated insulated) from the jetty to the storage tanks will be placed on overhead gantry. This will enable easy inspection and maintenance of the pipeline and early detection of any leakage of material and hence minimise the potential of land contamination. Other chemicals (alkaline, acids, liquid nitrogen, etc) will be delivered to Site by trucks or tankers and unloading at the designated unloading bay. *Table 3.2b* summarises the transportation of feedstock and products to and from the biodiesel plant.

Table 3.2b 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	Trucks with 20ft containers	5	1 [(b)]
Animal fat	$10m^3$ Sealed Road Tanker	4	1
Gas Oil	$10m^3$ Sealed Road Tanker	2	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
Other supplies and deliveries	10 tonne Truck/Tanker	3	1
Biodiesel [(c)]	20 m^3 Road Tanker	10	1
Screenings and dewatered sludge	10 m^3 skip	5	1
Total		***93***	12 to 14
Marine-based Delivery			
Biodiesel	1,000 tonne barge [(d)]	2 per week	
PFAD	1,000 tonne barge [(d)]	1 per 10 days	
Methanol	1,000 tonne barge [(d)] or ISO tanker 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 inclement weather).

(d) Single hulled, self propelled vessels. Dimension: length (56.5m), width (12.8m), and height (4.3m). Draft when loaded ranges from 3.5 to 4m.

(1) Dry coupling connection has been used in a number of biodiesel plant design by BDI and it has a good track record of preventing leakage due to unsecured joints.

Feedstock Pre-treatment

The GTW received will be screened in the Belt Filter Room adjacent to the unloading bays to remove food residues and other large objects. The screenings will be stored in containers inside the Technic Room. The Belt Filter Room and the Technic Room will be enclosed and provided with a ventilation system which will maintain a slight negative pressure to prevent odour emissions to the atmosphere. The exhaust air from these rooms will be treated by an air scrubbing system (with a removal efficiency of>99.5%). The scrubbed air will be diverted to the on-site wastewater treatment plant as the air supply for the aeration tanks. When the container is full, the container will be enclosed with metal flip doors. The opening between the Belt Filter Room and the Technic Room will be closed. The roller door of the Technic Room will then be opened. The loaded container will be removed and an empty container will be put in place. The Roller door of the Technic Room will be closed and the screening process resumed. The screenings will be transported in the enclosed container and disposed of at the existing SENT Landfill or other landfills if SENT Landfill is full.

The screened GTW from the reception area will be pumped to the GTW storage tanks and then to the oil and fat preparation tank for further purification. 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 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 Floatation (DAF) system, an IC Reactor, 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 (1) 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 boilers). The biogas will be temporary stored in the biogas buffer tank (with a capacity of 30 m^3 and the gas will be stored at low pressure). It is anticipated that all the biogas will be consumed by the steam boiler. When the steam boilers are 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}.

To minimise odour emissions from the site, all the treatment and storage tanks of the wastewater treatment plant will be enclosed. After the anaerobic digestion process in the IC Reactor, the biochemical oxygen demand 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 scrubber prior to discharge to the atmosphere.

The surplus sludge from the sludge thickener will be dewatered to at least 30% dry solids using a belt press in the Sludge Dewatering Room. The dewatered sludge will be stored in container inside the Sludge Room. The roller door of the Sludge Room will be closed except for removal of the sludge container for disposal. The Sludge Dewatering Room and Sludge Room will be provided with a ventilation system and the exhaust air will be scrubbed by the final air scrubber prior to discharge to the atmosphere. A slight negative pressure will be maintained at all times when the sludge dewatering process is carrying out and sludge is being stored in the Sludge Room. The sludge container will be properly covered with metal flip doors or tarpaulin before the roller door of the Sludge Room is opened.

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 a mix of available feedstock according to pre-programmed recipes. Here, the oils will be mixed with an alcohol-catalyst (methanol and potassium hydroxide).

(1) As the proposed SENT Landfill Extension will not accept dewatered sludge, the dewatered sludge arising from the operation of the wastewater treatment plant of the biodiesel plant will be disposed of at other strategic landfills.

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 27 tpd) (1). 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 local and international markets. 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 21 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.

To minimise potential odour emissions from the biodiesel process, the material storage and processing tanks will be enclosed and the vent gas will be cleaned by an air scrubber (except for the storage tanks of acid and base which will not cause potential odour nuisance) and then diverted to the wastewater treatment plant for use as the ventilation air for the enclosed treatment tanks or the air intake for the aeration tanks.

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 biodiesel 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

(1) Bioheating oil is a low grade biodiesel. This is the residue generated from the biodiesel distillation process. The characteristics of bioheating oil are similar to those of biodiesel. Bioheating oil contains a higher sulphur content (ranges from about 58 to 2,000 mg/kg sulphur) than that of the biodiesel (less than 10 mg/kg). A comparison of the characteristics of biodiesel and bioheating oil is given in *Annex E*. The bioheating oil will be used as a fuel for the boiler. Due to its high sulphur content, it will be blended with gas oil (at a ratio of about 80 : 20 for gas oil : bioheating oil) in order to comply with the fuel/emission requirements under the amended *Air Pollution Control (Fuel Restriction) Regulation* (2008).

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 materials 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 generated from the IC Reactor and bioheating oil and biodiesel produced from the biodiesel production process as energy sources for heating. If necessary, it will be supplemented with gas oil and town gas. The Project Proponent is committed to use an appropriate fuel or a mixture of fuels which will comply with the new emission limits stipulated in the *Air Pollution Control (Fuel Restriction) (Amendment) Regulation* taking effect on 1 October 2008. It is estimated that fuel consumption equivalent to about 21.5 tpd of biodiesel will be required for the boiler system. The emissions from the boilers (2 nos.) will be discharged to the atmosphere via a single stack of 31 m high.

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 and recovery system and hence avoid discharging 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 3.2c*.

Table3.2c Capacities of Storage Tanks for the Biodiesel Plant

Tank Number	Description of Storage Tank	No.	Capacity (m^3)	Capacity (Days)
1 & 2	Raw GTW Tank	2	1,500 each	4.6 (total)
3	Cleaned Trap Grease Tank	1	1,000	10.3
4 & 5	Dewatered GTW (Lipofit)	2	150 each	3.4 (total)
6	Cleaned WCO Tank	1	1,000	11.3
7	PFAD Tank	1	1,500	16.1
8	Raw Animal Fat Tank	1	500	11.2
9	Cleaned Animal Fat Tank	1	500	11.2
10	Methanol Tank	1	500	14.3
11	Sulphuric Acid Tank	1	50	12.5
12	Phosphoric Acid Tank	1	25	83.3
14	Additive Storage Tank	1	50	15
15 & 16	Biodiesel Quality Tank	2	500 each	3.2 (total)
17	Biodiesel Storage Tank A	1	2,500	14.2
18	Biodiesel Storage Tank B	1	1,200	9.2
19	Glycerine (80%) Tank	1	500	30.2
20	Fertiliser Container	1	20	2.6
21	Bioheating Oil Tank	1	200	7.5
22	Gas Oil Tank (as back up fuel)	1	100	8.3
23	Nitrogen Tank	1	25	16.5
24	Crude WCO 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 (Potassium Sulphate) produced will be sold to buyers, eg soap and fertiliser production factories, as raw materials in China. They will be transported out of the biodiesel plant by road tankers or trucks.

Plant Personnel

Based on the operation experience of similar biodiesel plants, the staff requirements for the operation of the proposed biodiesel plant will be 20 in day-time and at least 8 at any time. If necessary, external personnel will be hired for maintenance and repair works.

Site Drainage

The stormwater runoff of the bunded area (see *Figures 3.2f* and *3.2g*) will pass through an oil interceptor before discharge into the stormwater drainage system of the TKOIE. The preliminary drainage plan of the Project Site is shown in *Figure 3.2h*. The design of the oil interceptor and silt traps is presented in *Figure 3.2i*.

The bunded area will be inspected regularly to ensure there is no leakage of materials. Leakage detected system will be installed to monitor any leakage of tanks. Any spillage of materials within the bunded area will be cleaned up immediately in accordance with the procedures described in *Sections 6.6.4* and *6.7.2*.

The treated effluent will be discharged to the existing public sewer at Chun Wang Street via a terminal manhole. The location of the terminal manhole is shown in the preliminary drainage layout plan (see *Figure 3.2h*). The quality of the treated effluent will comply with the effluent discharge standards for foul sewer leading to Government sewage treatment works.

3.2.3 Construction of the Biodiesel Plant

As the site has been formed, no major earthworks will be required for site formation. All excavated materials generated from foundations works and site levelling works will be reused on site.

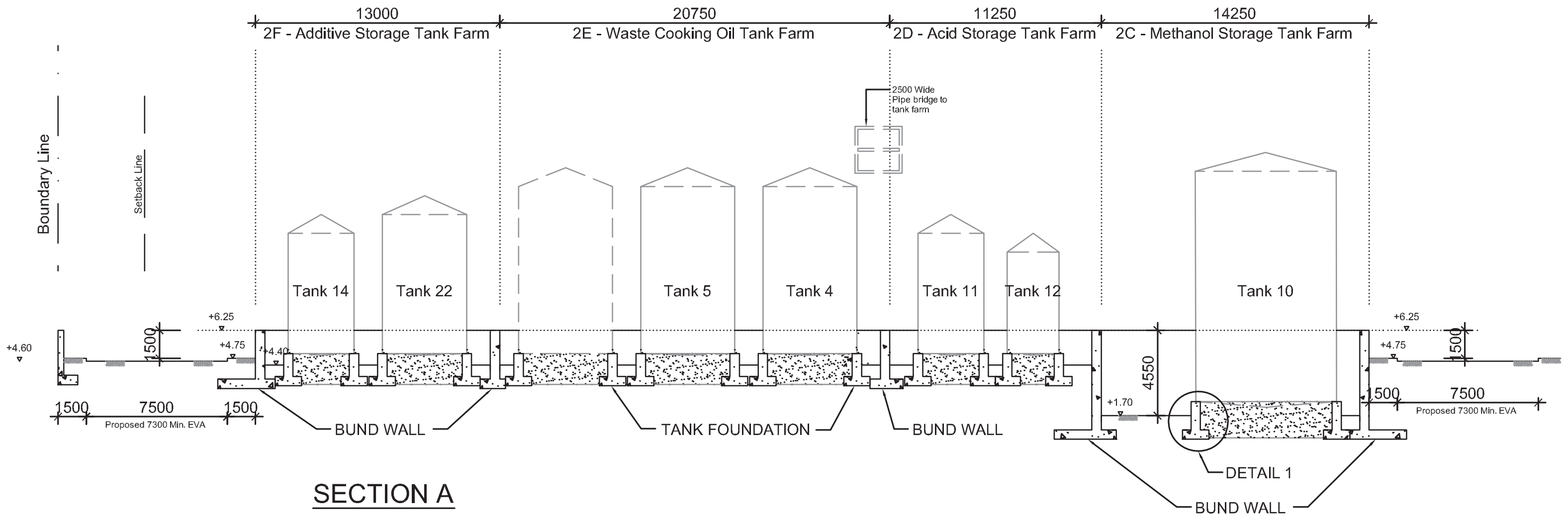
Metal hoarding will be erected around the site prior to the commencement of the foundation work. Driven steel H piles with reinforced concrete pile caps will be used for the foundations of the buildings. Piling will be carried out during day-time. Reinforced concrete slab and raft foundation will be 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.

The jetty for reception of marine vessels during the operation phase will be constructed by piled deck (see *Figure 2.2b*) and no dredging of marine sediment will be required. Marine piles will be drilled through the existing rubble mound seawall to competent bearing strata by a piling rig mounted barge. Concrete infill to piles will be undertaken 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 3 months for pile installation and 5 months for jetty deck construction.

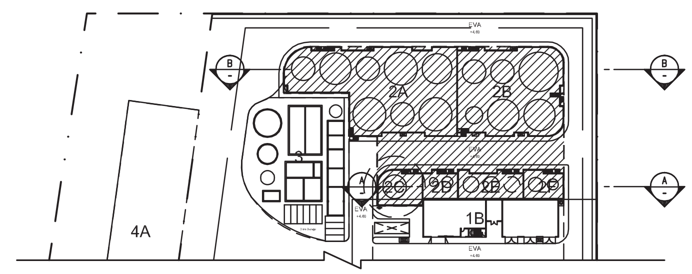
Figure 3.2j presents the construction programme of the Project.

3.2.4 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

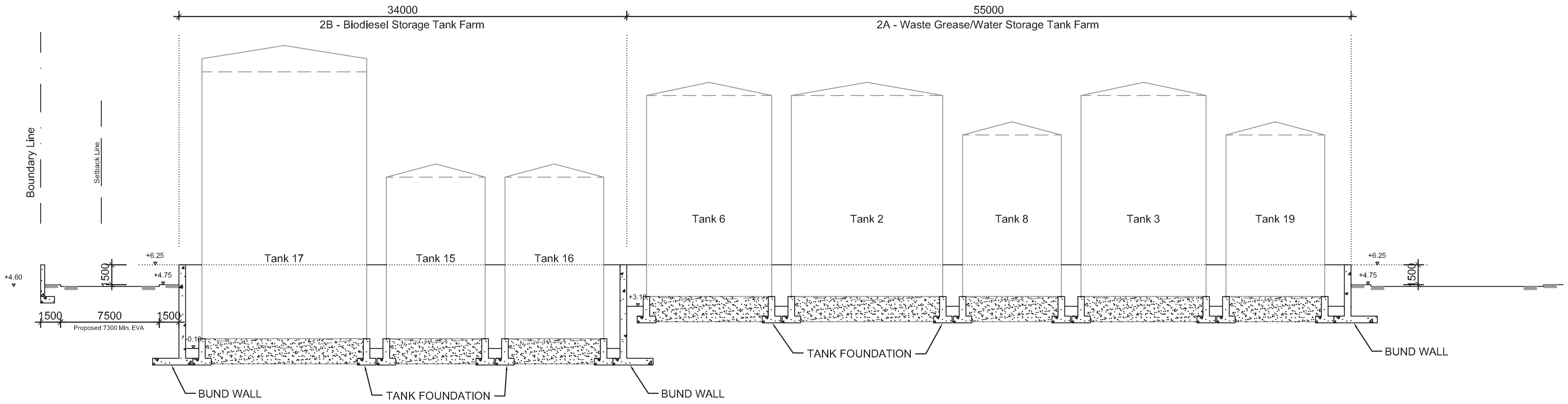


SECTION A



KEY PLAN

N.T.S.



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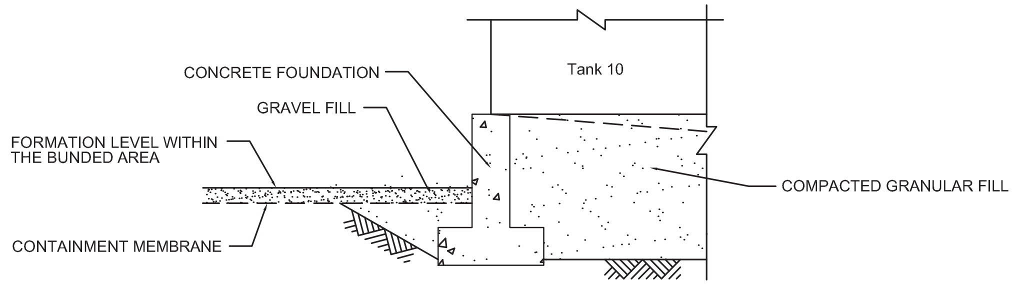

DETAIL 1

BUNDED AREA	FORMATION LEVEL WITHIN THE BUNDED AREA
2A	+3.10
2B	-0.10
2C	+1.70
2D	+4.40
2E	+4.40
2F	+4.40

Figure 3.2g

Bund Wall & Tank Foundation General Arrangement

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DATE: 05/11/2008

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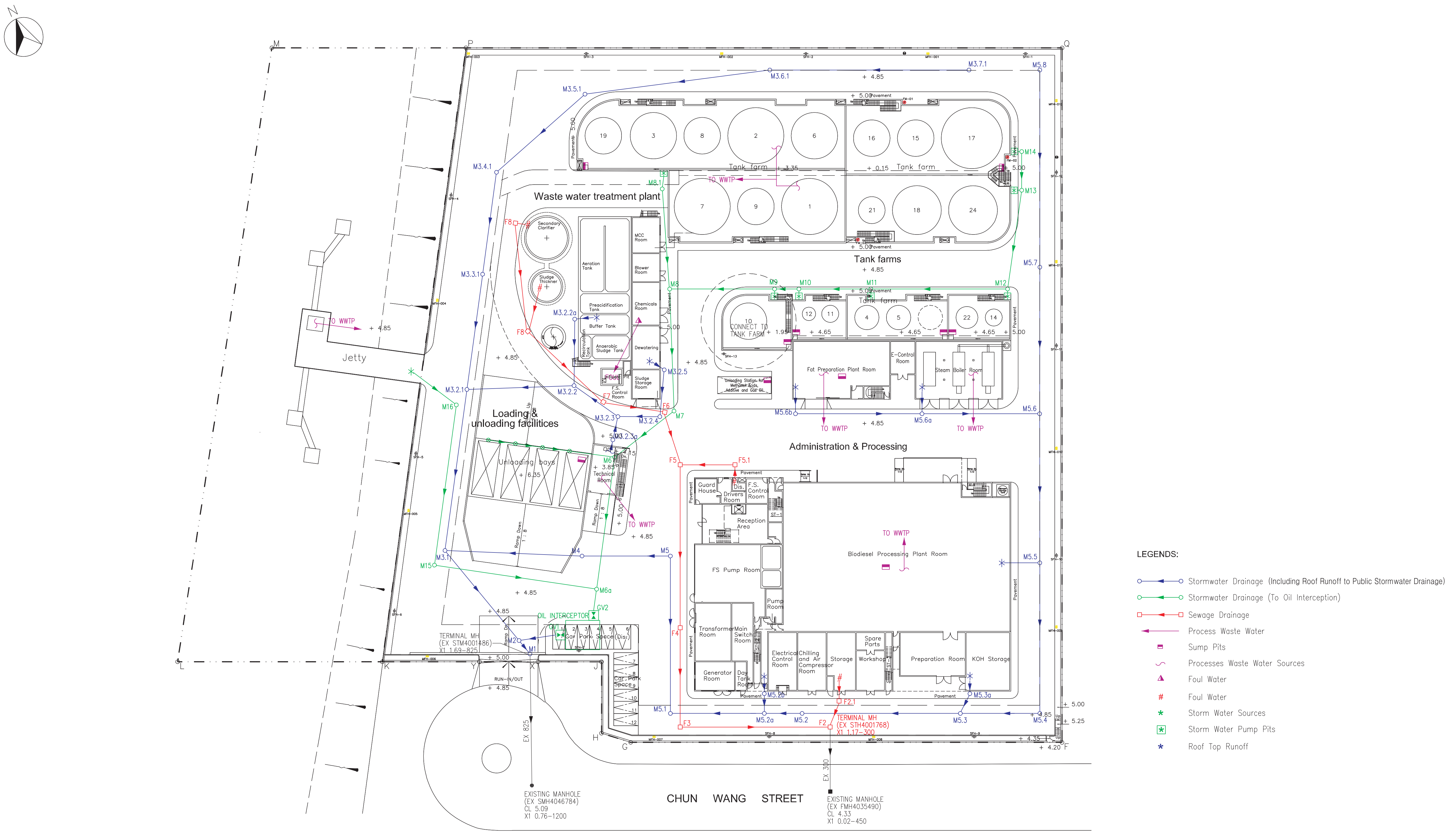

Figure 3.2h

Preliminary Drainage Plan

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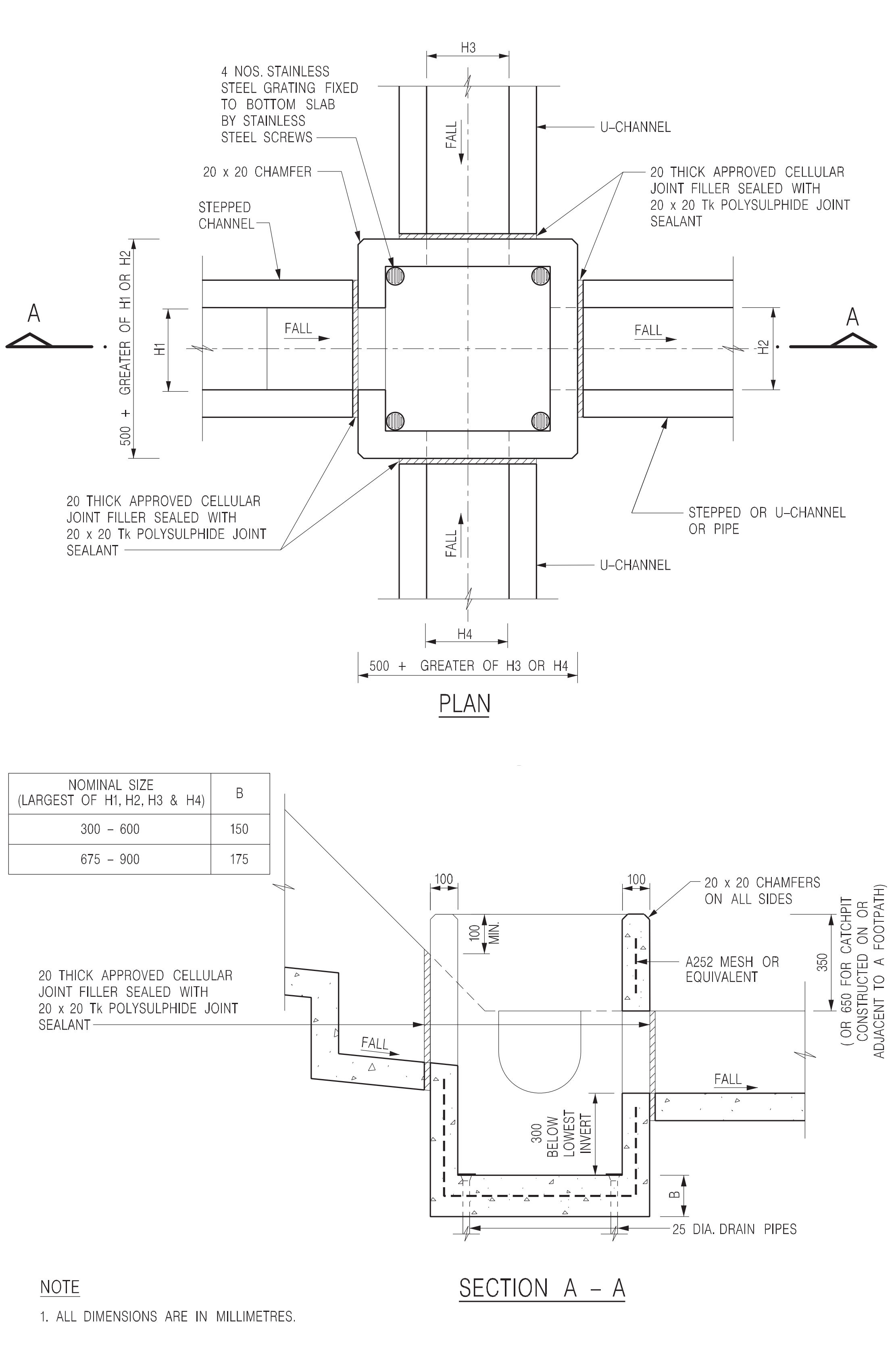
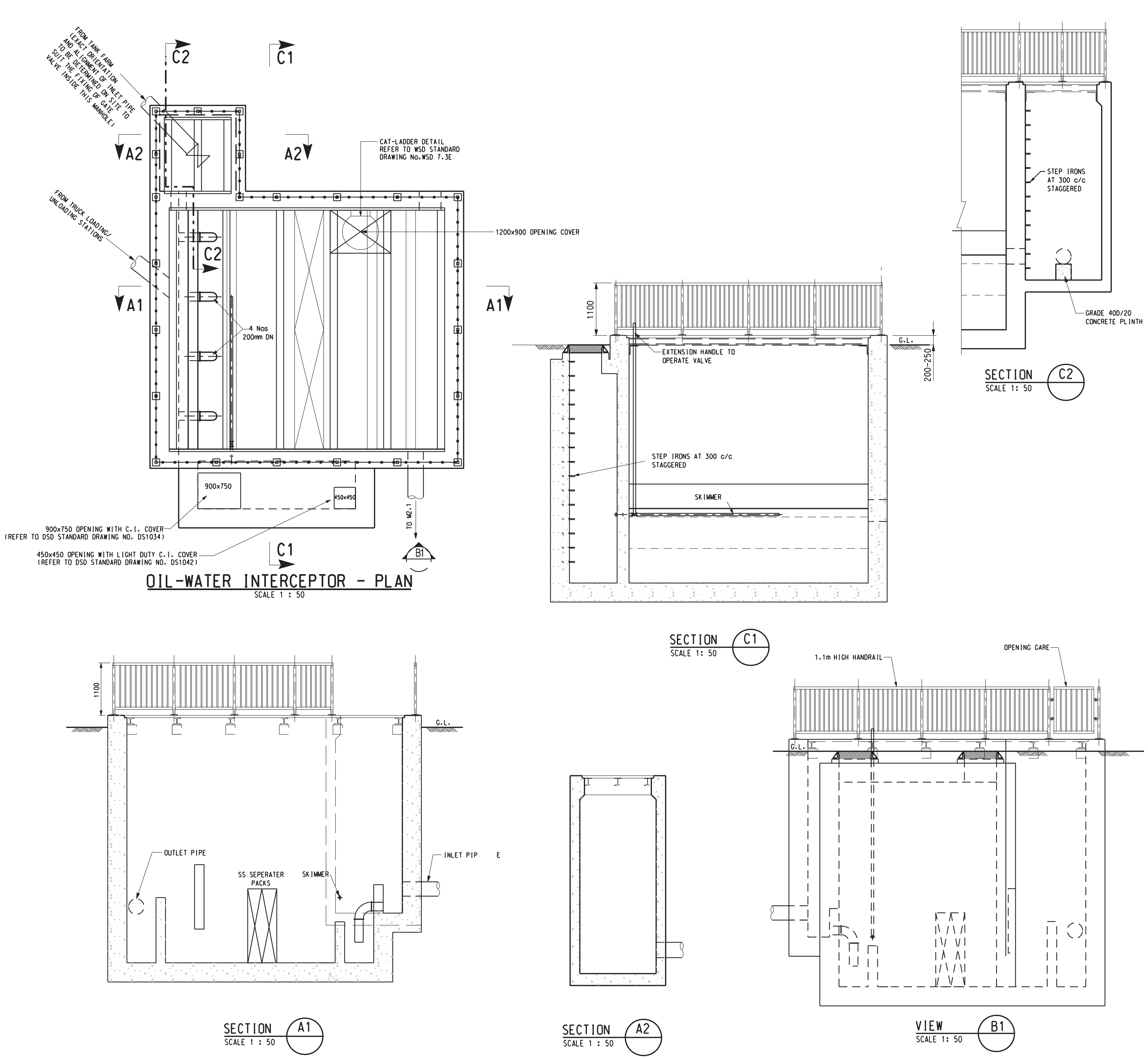
Environmental Resources Management



NOMINAL SIZE (LARGEST OF H1, H2, H3 & H4)	B
300 – 600	150
675 – 900	175

Silt Trap



Oil Interceptor

Figure 3.2i

Typical Design of Oil Interceptor and Silt Trap

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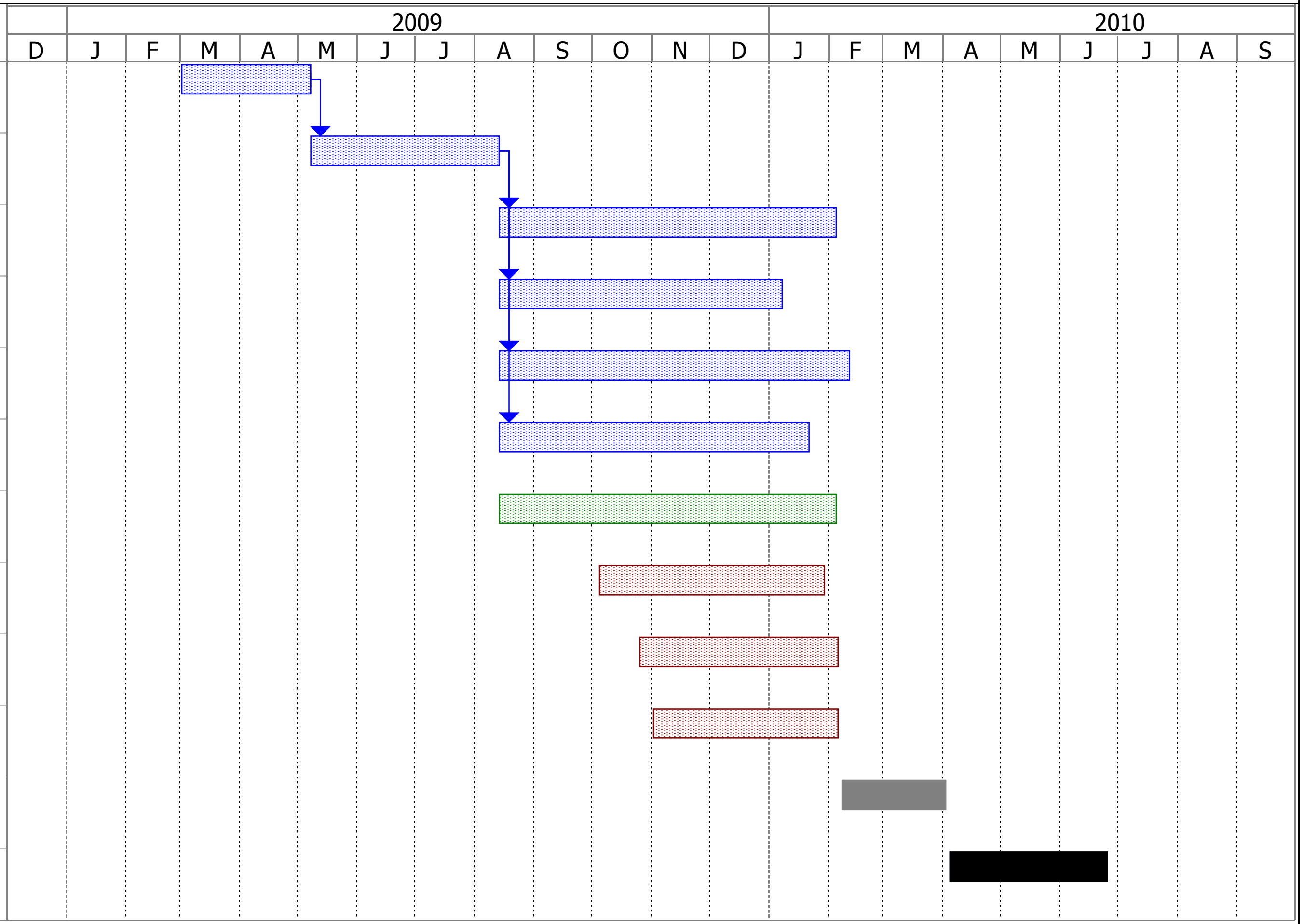
Figure 3.2j Hong Kong Biodiesel Plant at Tseung Kwan O Industrial Estate - Construction Programme

Task Name	Duration
1. Hoarding & Site Office	10 wks
2. Piling and Foundations	14 wks
3. Building Works	25 wks
4. Tanks Works	21 wks
5. Civil Works	26 wks
6. Marine Works	23 wks
7. Waste Water Treatment Works	25 wks
8. Fire Services Installation	17 wks
9. Pipeline Works	15 wks
10. E & M Works	14 wks
11. Statutory Inspection	8 wks
12. Testing & Commissioning	12 wks



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Civil Works
Waste Water Treatment Works
Fire Services and E&M Works
Statutory Inspection
Testing & Commissioning

treatment plant. CNCCC will undertake the detailed design of the plant and equipment based on BDI's requirements and construct the facility. The development programme of the biodiesel plant is outlined in *Table 3.2e.*

Table 3.2e ***Tentative Project Development Programme***

Activities	**Timeline**
Engineering design and equipment procurement	April 2008 to March 2009
Commencement of the construction of the Biodiesel plant and installation of equipments	March 2009 to February 2010
Statutory Inspection	February 2010 to April 2010
Commencement of testing and checkout	April to June 2010
Commencement of the Biodiesel plant	June 2010

3.3 CONCURRENT PROJECTS AT TKO

Several existing and planned projects have been identified in the Tseung Kwan O area (see *Table 3.3a*). These are mainly roads and infrastructure works and therefore it is anticipated that the potential cumulative environmental impacts may arise only during the construction phase of these projects. Based on the tentative project development programme, the construction of the proposed biodiesel plant will be completed by early 2010. The concurrent projects during the construction of the biodiesel plant are the TKO Further Development project which is located more than 2,000 m away from the biodiesel plant, and the SENT Landfill and the TKO Area 137 Fill Bank which are located more than 700m from the biodiesel plant. Given a large separation distance between the TKO Further Development site and the biodiesel plant, it is not anticipated that these concurrent projects will cause adverse cumulative environmental impacts. The potential cumulative dust impacts with the operation of the SENT Landfill and TKO Area 137 Fill Bank and the construction of the TKO Further Development project are discussed in *Section 4.4.3*.

Table 3.3a ***Planned Projects in TKO***

Planned Projects	**Distance from Biodiesel Plant (m)**	**Planned Construction Date**
Cross Bay Link	> 600	2013 – 2016
TKO - Lam Tin Tunnel	> 1,800	2012 – 2016
TKO Further Development – infrastructure works at Town Centre South and Tiu Ken Leng	> 2,000	Mid 2009 – 2011
SENT Landfill Operation	700m	Till end of 2012
SENT Landfill Extension	> 1,000	2011 - 2018
TKO Area 137 Fill Bank	>1,000	Till 2013

Other major air emissions sources within 500m of the site boundary in TKOIE have been considered in the air quality assessment. Details can be referred to *Section 4*.

4 AIR QUALITY ASSESSMENT

4.1 INTRODUCTION

This *Section* presents an assessment of the potential air quality impacts associated with the construction and operation of the proposed biodiesel plant at 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.

4.2 LEGISLATION REQUIREMENTS AND EVALUATION CRITERIA

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

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

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

Air Pollutant	Averaging Time			
	1 Hour [b]	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 assessment 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.

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

Should the total quantity of organic liquid to be stored in tanks exceed 100 tonnes per annum, a licence must be obtained under the *Air Pollution Control (Specified Process) Regulation* and the control measures set out in the *Guidance Note on the Best Practicable Means for Organic Chemical Works (Bulk Storage of Organic Liquids) (BPM 25/2)* should be followed.

4.2.2 *Air Pollutants Not Covered by HKAQOs*

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

- WHO;
- US EPA; and
- CARB.

Cancer Health Risk Assessment

Of the non-criteria substances emitted during the operation, acetaldehyde is considered carcinogenic. *Table 4.2b* shows the Unit Risk Factors (URFs) for the carcinogenic substances considered in this assessment.

Table 4.2b ***Guideline Unit Risk Factor for Carcinogenic Substance***

Substance	**Unit Risk Factor ($\mu g\ m^{-3})^{-1}$**
Acetaldehyde	$2.7x10^{-6}$ (a)

Note:

(a) The unit risk factor (URF) of acetaldehyde [i.e. $(1.5\text{-}9 \times 10^{-7})\ (\mu gm^{-3})^{-1}$] is available in Guidelines for Air Quality, WHO, Geneva, 1999 (*http://aix.meng.auth.gr/AIR-EIA/METHODS/AQGuide/aqguide3.pdf*). With reference to the *USEPA-IRIS - online data as in Sept 2008* (*http://www.epa.gov/iriswebp/iris/subst/0290.htm*) and *California Environmental Protection Agency, Air Resources Board (ARB)/Office of Environmental Health Hazard Assessment (OEHHA) – On-line data as in Sept 2008* (*http://www.oehha.org/air/hot_spots/pdf/TSDlookup2002.pdf*), the URFs of acetyldehyde are $2.2x10^{-6}/\mu gm^{-3}$ and $2.7x10^{-6}/\mu gm^{-3}$, respectively. The highest URF, ie, $2.7x10^{-6}/\mu gm^{-3}$ is adopted in the assessment as a conservative approach.

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

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

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

Non-Cancer Health Risk Assessment

Acetaldehyde has the potential to cause chronic impacts from long term exposure whereas methanol has the potential to cause both acute and chronic impacts to humans from short term and long term exposures. The chronic reference concentration of acetaldehyde and the acute and chronic reference concentrations of methanol are summarised in *Table 4.2d.*

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

Substance	**Chronic Reference Concentration (RC_c) (Annual Average in µg m^{-3})**	**Acute Reference Concentration (RC_A) (Hourly in µg m^{-3})**
Acetaldehyde	9 (a)	- (b)
Methanol	4,000 (c)	$2.8x10^4$ (d)

Notes:

(a) The RC_cs for acetaldehyde are both 9 µgm^{-3} with reference to the *USEPA-IRIS - online data as in Sept 2008 (http://www.epa.gov/iriswebp/iris/subst/0290.htm)* and *California Environmental Protection Agency, Air Resources Board (ARB)/Office of Environmental Health Hazard Assessment (OEHHA) – On-line data as in Sept 2008 (http://www.oehha.org/air/hot_spots/pdf/TSDlookup2002.pdf)*. RC_c for acetaldehyde (ie, 50 µg m^{-3}) is available in Guidelines for Air Quality, WHO, Geneva, 1999 (http://aix.meng.auth.gr/AIR-EIA/METHODS/AQGuide/aqguide3.pdf). More stringent RC_c for acetaldehyde of 9 µgm^{-3} is adopted in the assessment as a conservative approach..

(b) No acute reference concentrations of acetyldehyde are available in WHO, CARB/OEHHA or USEPA-IRIS database.

(c) The RC_c for methanol is 4,000 µgm^{-3} with reference to *California Environmental Protection Agency, Air Resources Board (ARB)/Office of Environmental Health Hazard Assessment (OEHHA) – On-line data as in Sept 2008 (http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html)*. No RC_c for methanol is available in USEPA-IRIS database and WHO guidelines.

(d) The RC_A for methanol is $2.8x10^4$ µgm^{-3} with reference to *California Environmental Protection Agency, Air Resources Board (ARB)/Office of Environmental Health Hazard Assessment (OEHHA) – On-line data as in Sept 2008 (http://www.oehha.ca.gov/air/acute_rels/allAcRELs.html)*. No RC_A for methanol is available in USEPA-IRIS database and WHO guidelines.

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

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

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

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

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

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

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

4.3 BASELINE CONDITIONS AND IDENTIFICATION OF AIR SENSITIVE RECEIVERS

4.3.1 *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. To 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 emissions from facilities in the TKOIE, vehicle exhaust emissions from Chun Wang Street and Wan Po Road and background air quality in the Pearl River Delta.

There is no EPD Air Quality Monitoring Station (AQMS) operating the 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 Kwun Tong AQMS from 2003 to 2007 are adopted to establish the background air quality of the Study Area (see *Table 4.3a*).

Table 4.3a *Background Air Pollution Concentrations*

Air Pollutant	Background Concentration
TSP	79 (a)
RSP	56 (a)
NO_2	63 (a)
SO_2	19 (a)
CO	1,181 (b)

Notes:

(a) Annual average data on air pollutant concentrations measured at the EPD Kwun Tong AQMS from 2003 – 2007 (http://www.epd-asg.gov.hk/english/report/aqr.php).

(b) Since no CO data is recorded at EPD Kwun Tong AQMS, therefore, the annual average CO data recorded at Mongkok AQMS from 2003-2007 is used.

4.3.2 *Identification of Air Sensitive Receivers*

Within the Study Area (ie 500m from the Site boundary), the land uses are all industrial. No residential dwellings have been identified within 500m of the site boundary. The nearest residential use (LOHAS Park), which is under construction, is located at about 0.8 km from the site boundary. Representative ASRs were identified in line with the requirements set out in the *EIA Study Brief* (*ESB-199/2004)* and Annex 12 of the *EIAO-TM* and they are summarised in *Table 4.3b* and illustrated in *Figure 4.3a.* The list includes existing and planned buildings within TKOIE, Areas 85 and 86. Planned developments were identified with reference to the latest Outline Zoning Plans (No. S/TKO/16 gazetted in June 2008).

Table 4.3b *Representative Air Sensitive Receivers (ASRs)*

ASR	Location	Type of Uses (a)	Approx. Distance from the nearest Project Site Boundary (m)	Approx. Max. Height of Building (m above ground)
A1	Gammon Skanka	I	30	30
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)	I	25	30
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	C	140	30
A4	Hong Kong Aero Engine Services Ltd	I	310	30
A5	HAECO	I	440	30
A6-1	Asia Netcom HK Limited	I	255	30
A6-2	Asia Netcom HK Limited	I	345	30
A7	Mei Ah Centre	I	420	30
A8	Wellcome Co. Ltd (Storage)	I	345	30
A9	Hitachi Tseung Kwan O Centre	I	450	30
A10	Next Media Apple Daily	I	450	30
A11	Hong Kong Oxygen Acetylene Co. Ltd	I	355	30

ASR	Location	Type of Uses (a)	Approx. Distance from the nearest Project Site Boundary (m)	Approx. Max. Height of Building (m above ground)
A12-1	TVB City	I	510	30
A12-2	TVB City	I	550	30
A12-3	TVB City	I	560	30
A13	Yan Hing Industrial Building	I	515	30
A14	Next Media Apple Daily	I	530	30
A15	Avery Dennison	I	540	30
A16	Varitronix Limited	I	530	30
A17	Committed HSBC Office	C	700	30
A18	Eastern Pacific Electronics	I	780	30
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School	G/IC	820	30
A20-1	LOHAS Park - 1	CDA	800	200
A20-2	LOHAS Park - 2	CDA	820	200
A20-3	LOHAS Park - 3	CDA	930	200
A21	Chiaphua-Shinko Centre	I	1,300	30

Note:
(a) I = Industrial premises, C = Commercial premises, G/IC = Government/Institution/Community and CDA = Comprehensive Development Area

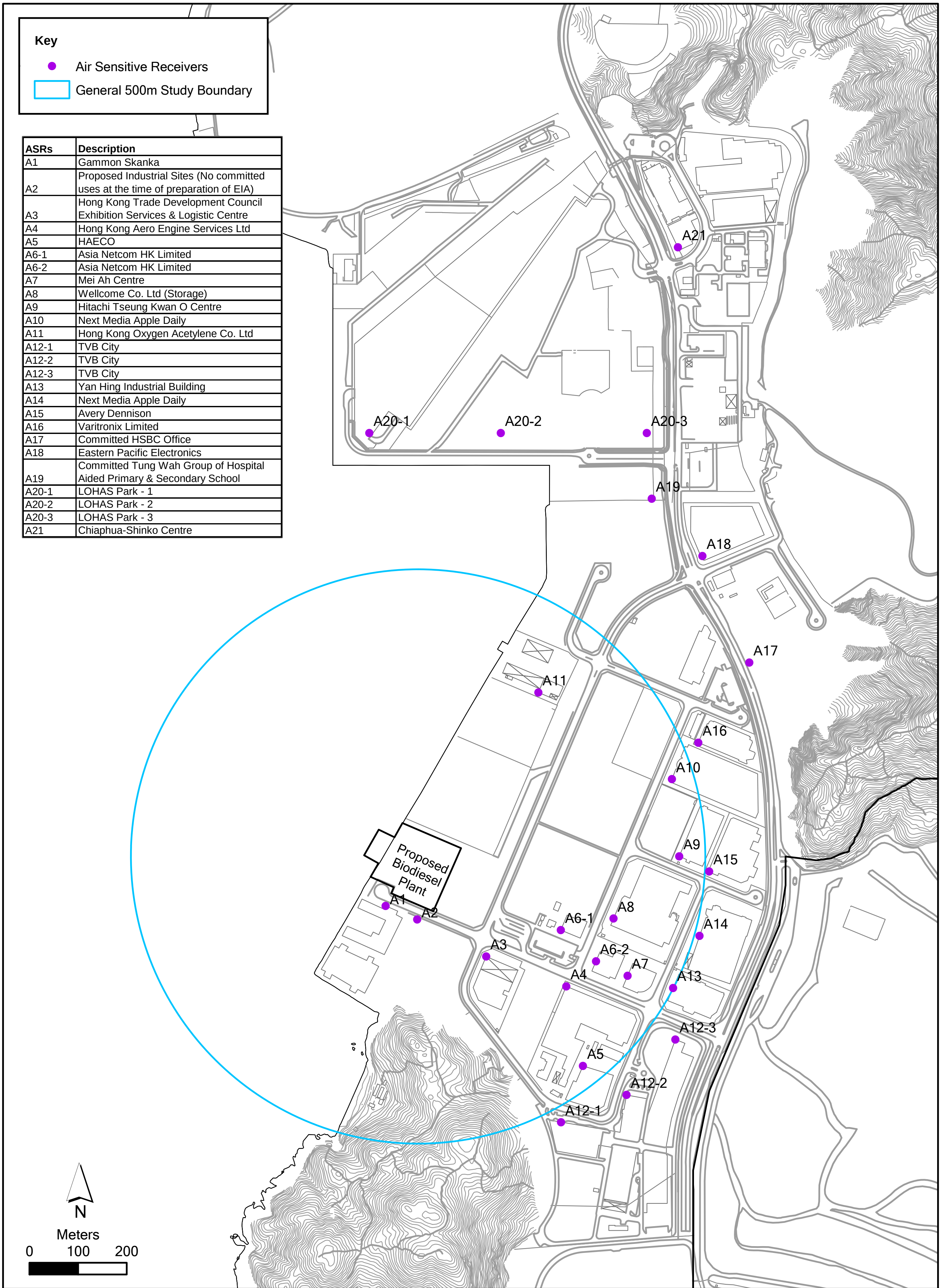
4.4 *POTENTIAL SOURCES OF IMPACTS*

4.4.1 *Construction Phase*

The Project Site is currently a vacant lot which has been formed by reclamation as part of the TKOIE development. The construction works will last for about 13 months from March 2009, tentatively. Foundation works will last for about 3 months. A detailed construction programme is presented in *Figure 3.2f*.

The total site area is about 18,000 m^2. Since the site has been formed, no major earthworks will be required for site formation. Minor excavation works will be required for the construction of foundation works and site utilities. Driven steel H piles with reinforced concrete pile caps will be used for the foundations of the buildings. All excavated materials generated from foundation works and site levelling works will be reused on site. The storage tanks and process equipment will be pre-fabricated off-site and assembled on-site using hydraulic and tower cranes and hence minimal dust will be generated from this activity. About 4 to 5 trucks will be operating on site at the same time during the foundation works, and building and civil works. According to the construction programme, there is no overlapping of the foundation works, and building and civil works.

Dust generated from the excavation works and gaseous emissions from diesel-driven construction equipment are the major concerns during the construction phase. As only minor excavation works will be required, the potential dust



ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.3a

Locations of Representative Air Sensitive Receivers

Environmental Resources Management

ERM

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emissions will be minimal with the implementation of the dust control measures stipulated in the *Air Pollution Control (Construction Dust) Regulation*. The reinforced concrete buildings will be constructed on site using ready-mix concrete and conventional construction methods. Limited dust will be emitted from the concreting works and assembling of the pre-fabricated units of the storage tanks and processing system.

Due to the small site area, the number of diesel-driven construction plant and equipment operating simultaneously on-site will be limited. The potential gaseous emissions from these plant and equipment are expected to be minimal and unlikely to cause adverse air quality impacts.

The jetty for the reception of marine vessels during the operation phase will be constructed by piled deck (see *Figure 2.2b*) and no dredging of marine sediment will be required. Marine piles will be drilled through the existing rubble mound seawall to competent bearing strata by a piling rig mounted barge. The bored piles will be filled with concrete prior to placement of trellis beam and pre-cast concrete panels. The dust and air emissions generated from the marine works will be minimal.

With the implementation of dust suppression measures stipulated under the *Air Pollution Control (Construction Dust) Regulation* and the adoption of good site practices, the potential dust impacts will be controlled to within the relevant standards as stipulated in Section 1 of Annex 4 of the *EIAO-TM*. No adverse impacts are anticipated.

4.4.2 Operation Phase

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

- Emissions from fuel combustion in the boilers;
- Emissions from the standby biogas flare (if in operation);
- Organic emissions from the Process Building;
- Odour from final air scrubber which will scrub all the pre-treated exhaust gas from the unloading and treatment of Grease Trap Waste (GTW) and the on-site wastewater treatment plant; and
- Vehicular emissions due to additional traffic associated with the operation of the biodiesel plant.

To assess potential cumulative air quality impacts, the emissions from the adjacent major stacks within the TKOIE were also considered.

Emissions from Fuel Combustion

The boilers are a dual-fuel fired boiler (which could utilise gas (eg biogas) or fuel oil (eg gas oil, or a mixture of gas oil and bio-heating oil (hereafter called oil mixture) [1]) for production of steam for the biodiesel process and thermal oil system. The Project Proponent is committed to use an appropriate fuel or a mixture of fuels which will comply with the new emission limits stipulated in the *Air Pollution Control (Fuel Restriction) (Amendment) Regulation* taking effect on 1 October 2008. About 21.5 tonnes of the oil mixture will be required per day (which is equivalent to about 920 m^3 of biogas per hour). Under normal operation, biogas (a high energy value, 36.44 MJ Nm^{-3}) generated from the IC Reactor of the wastewater treatment plant (an average of about 80 m^3 hr^{-1} of biogas generated) will be used as the priority fuel which will be supplemented by oil mixture or gas oil.

The major air pollutants from the combustion of biogas and oil mixture (or gas oil) are expected to be carbon monoxide (CO), nitrogen dioxide (NO_2) and a limited quantity of non-methane organic compounds (NMOCs) (if biogas is combusted) and sulphur dioxide (SO_2). The air pollutants will be emitted at a minimum exit velocity of 7 m s^{-1} and temperature of 100°C through a 31m stack with a diameter of 0.75m.

With reference to the emission factors for NO_2, CO, SO_2 and NMOCs established for biogas and oil mixture, a comparison of the emission rates from the boiler is summarised in *Table 4.4a.*

(1) Bio-heating oil is a lower grade biodiesel. The physical properties of bio-heating oil could be referred to *Annex E*. To meet the SO_2 emission limit stated in the amendment of the *Air Pollution Control (Fuel Restriction) Regulation*, which was in place in June 2008, a mixture of gas oil (light diesel oil) (80%) and bioheating oil (20%) will be used as fuel for the boiler operation.

Table 4.4a ***Comparison of NO_2, CO, SO_2 and NMOCs Emissions from Combustion of Biogas and Oil Mixture at Boiler***

Parameter		**Boiler**	
		Biogas	**Oil Mixture (Mixture of Gas Oil (80%) and Bioheating Oil (20%))**
Stack Height (m above ground)		31	
Stack Diameter (m)		0.75	
Exhaust Velocity (m s^{-1})		7 (minimum)	
Exhaust Temperature (°C)		100 (minimum)	
Exhaust Flow Rate (m^3hr^{-1})		11,133	
Fuel Consumption (tonnes day^{-1})		-	21.5
Maximum Volume of Biogas (equivalent) & Oil Mixture Consumed (m^3 hr^{-1})		920.7 (a)	0.995 (b)
Emission Factor for Biogas at Exhaust Temperature (mg m^{-3}) (c) (d)	NO_x	109.8	-
	CO	36.6	-
	H_2S	10 (i)	-
	NMOCs	3.7	-
Emission Factor for Oil Mixture (kg m^{-3}) (f)	NO_x	-	2.4
	CO	-	0.6 (e)
	SO_2	-	0.864
Emission Rate (g s^{-1}) (g) (h)	NO_x	0.34	0.66
	NO_2	0.07	0.13
	CO	0.11	0.17
	SO_2	0.01(j)	0.24
	NMOCs	0.01	-

Notes:

(a) Equivalent to oil mixture consumed. Under normal operation, the actual biogas consumption is only about 80 m^3 hr^{-1} produced from the IC Reactor based on the design capacity.

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

(c) Due to the nature of biogas, the emission factor of biogas is assumed to be similar to that of landfill gas.

(d) The emission factors of biogas were converted to that under exhaust gas condition. The original emission factors of biogas used are reference to *UK Guidance on the Management of Landfill Gas (http://www.environment-agency.gov.uk/commondata/acrobat/lftgn05_flares_936497.pdf)* and are adjusted by the exhaust temperature. Please also refer to *Annex A1*.

(e) Reference to USEPA AP-42, Section 1.3, Table 1.3-1 (*http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s03.pdf*).

(f) Reference to *Amendment of Air Pollution Control (Fuel Restriction) Regulation* in June 2008.

(g) The emission rate of air pollutants from combustion of oil mixture were calculated based on the volume of oil consumed. The emission rate of air pollutants from combustion of biogas were calculated based on the exhaust flow rate. Emission rate of air pollutant from combustion of oil mixture = emission factor (oil mixture) x volume of oil mixture consumed. For example, NO_x emission rate from combustion of oil mixture = ($2.4x10^6$ mg m^{-3}) x (0.995 m^3 hr^{-1}) / (1,000 x 3,600) = 0.66 g s^{-1}. Emission rate of air pollutant from combustion of biogas = emission factor (biogas) x exhaust flow rate. For example, NO_x emission rate from combustion of biogas = (109.8 mg m^{-3}) x (11,133 m^3 hr^{-1}) / (1,000 x 3,600) = 0.34 g s^{-1}

(h) Refer to *Annex A1* for detailed emission rate calculation.

(i) The emission factor of H_2S (in ppm) in biogas is measured at 30°C and given by the plant design engineer.

(j) The emission rate of SO_2 from is calculated based on the equivalent biogas consumption rate of about 920.7 m^3 hr^{-1}.

It should be noted that there have been a number of research studies determine the NO_x emissions from biodiesel compared with petroleum based diesel oil. There is no commonly-agreed NO_x emission factor for the combustion of biodiesel.

Testing emissions from the combustion of biodiesel in a similar boiler was conducted by BDI. A summary of the testing results is presented in *Annex A2*. The testing results show that the NO_x emissions range from 0.83 kg hr^{-1} to 1.01 kg hr^{-1} (ie, 0.23 g s^{-1} to 0.28 g s^{-1}). Compared to the emission factors given in *Table 4.4a* (which are based on the emission rates of petroleum based diesel oil), the NO_x emissions analysed from the emission test are much lower. Therefore, the assessment is considered conservative.

Comparing the pollutant emission rates of biogas and oil mixture (see *Table 4.4a*), it is evident that the emission rates for the combustion of oil mixture are higher. As a conservation assumption, it is assumed that the boilers will consume only oil mixture.

Emissions from Standby Biogas Flare

Under normal operation, all the biogas generated from the IC reactor will be used as fuel for the boilers. However, when the boilers are under maintenance, all the biogas generated will be flared. The stack of the flare will be installed at about 12.5m above ground and located at to the on-site wastewater treatment plant. The diameter of stack is about 0.96m and the flue gas flow rate is 1,407 m^3 hr^{-1}.

An air scrubber will be installed to remove the majority of the hydrogen sulphide (H_2S) in the biogas (down to a maximum of 10 ppm) prior to combustion in the flare or boilers. NO_2, CO, SO_2 (from destruction of H_2S at high temperature) and NMOCs will be the key air pollutants from the emissions from the biogas flare.

As a conservative assumption, it was assumed that the flare will be operating at its maximum capacity (ie 150 m^3 hr^{-1} of biogas), the emission rates of NO_2, CO, SO_2 and NMOCs are summarised in *Table 4.4b*.

Table 4.4b ***Emission of NO_2, CO, SO_2 and NMOCs from Standby Biogas Flare***

Parameters		**Standby Biogas Flare**
Stack Height (m above ground)		12.5
Stack Diameter (m)		0.96
Exhaust Flow Rate ($m^3 hr^{-1}$)		1,407
Exhaust Temperature (°C)		815
Volume of Biogas to be flared off (Designed flare capacity) ($m^3 hr^{-1}$)		150 [(a)]
Emission Factor of Biogas at Exhaust Temperature ($mg\ m^{-3}$) [(b)]	NO_x	37.6
	CO	12.5
	H_2S	10 ppm [(c)]
	NMOCs	1.3
Emission Rate ($g\ s^{-1}$) [(b)]	NO_x	0.015
	NO_2	0.003
	CO	0.005
	SO_2	1.07×10^{-3} [(d)]
	NMOCs	4.9×10^{-4}

Notes:

(a) The design capacity of the flare is 150 $m^3 hr^{-1}$ of biogas.

(b) Reference to *Annex A1* for detailed calculation.

(c) The emission factor of H_2S in biogas is measured at 30°C and given by the plant design engineer.

(d) SO_2 is estimated from the H_2S concentration in the biogas. Reference to *Annex A1* for detailed calculation.

Organic Emissions from Process Building

The biodiesel production is carried out inside the Process Building (refer to *Section 3* for details of the production process). A ventilation system is provided and about 50 m^3 of process gas will be emitted per hour. The exhaust gas consists mainly of nitrogen, and water, with a trace amount of methanol (a maximum concentration of 2,000 mg m^{-3} at 35 to 45 °C) and other trace organics (consisting of dimethyl ether, methyl butyrate and some impurities of methanol such as acetone and acetyldehyde [(1)]).

Among of these organics, only acetyldehyde is classified as carcinogenic and has the potential to lead to chronic heath effects. Methanol has also the potential to cause both chronic and acute health effects.

The emission inventory and exhaust vent pipe design parameters are summarized in *Table 4.4c*.

(1) The maximum total concentration of all the organics is 2,000 mg m^{-3}.

Table 4.4c Emission of Acetyldehyde and Methanol from Process Building

Parameters	Exhaust Pipe of Process Building	
	Acetyldehyde	Methanol
Stack Height (m above ground)	22.8	
Stack Diameter (m)	0.15	
Exhaust Flow Rate ($m^3 hr^{-1}$)	50	
Exhaust Temperature (°C)	35	
Maximum Concentration at Stack ($mg\ m^{-3}$)	2,000 [(a)]	2,000
Emission Rate ($g\ s^{-1}$) [(b)]	0.028	0.028

Notes:

(a) Since the percentage of acetyldehyde in the impurities of methanol is not known, it is assumed that all the impurities of methanol are acetyldehyde for the worst case assessment.

(b) Refer to *Annex A1* for detailed emission rate calculation.

Odour from Unloading and Treatment of GTW and On-site Wastewater Treatment Plant

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

Unloading and Treatment of GTW

GTW will be delivered to the biodiesel plant by sealed road tankers. After weighing, the tankers will be directed to the unloading bays. GTW will be discharged from the tanker directly to the underground storage tanks in a closed system (via a flexible hose). The GTW received will be screened in the Belt Filter Room adjacent to the unloading bays to remove food residues and other large objects. The screenings will be stored in containers inside the Technic Room. The Belt Filter Room and the Technic Room will be enclosed and provided with a ventilation system which will maintain a slight negative pressure to prevent odour emissions. The exhaust air from these rooms will be treated by an air scrubbing system (with a removal efficiency of >99.5% [(1)]). The scrubbed air will be diverted to the on-site wastewater treatment plant as the ventilation air for the enclosed wastewater treatment tanks.

All biodiesel process tanks [(2)], including the GTW storage tanks will be enclosed and the exhaust air will be treated by an air scrubbing system (with a removal efficiency of >99.5%). The scrubbed exhaust air will be diverted to the on-site wastewater treatment plant as part of the air intake for the aeration process and ventilation air for the enclosed wastewater treatment tanks. 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 the final air scrubber (with a removal efficiency of >99.5%) prior to discharge to the atmosphere.

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

(2) Except for the storage tanks of acids (sulphuric acid and phosphoric acid), base and methanol as these materials are not cause odour nuisance.

On-site Wastewater Treatment Plant

All wastewater storage and treatment tanks will be enclosed. After the anaerobic digestion process in the IC Reactor, the Biochemical Oxygen Demand (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 the final air scrubber prior to discharge to the atmosphere.

Summary

Figure 4.4a shows the flow rates of the scrubbed exhaust air from the GTW unloading and pre-treatment facilities and on-site wastewater treatment plant.

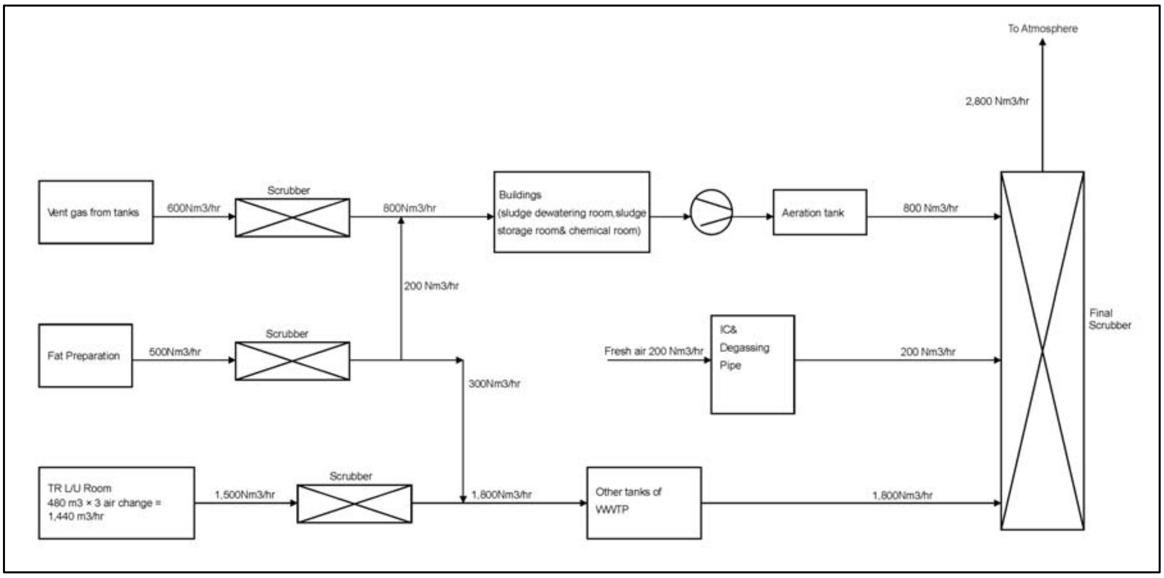

***Figure 4.4a* Exhaust Air Flow Chart**

There is only one emission point for the air scrubbers (which is the final air scrubber of the wastewater treatment plant). The odour concentration after treatment at the final air scrubber will be controlled at a limit of 257.6 OUm^{-3}. The exhaust air from the final air scrubber will be dispersed at ambient temperature with a flow rate of 2,800 m^3 hr^{-1}. The details of the stack and odour emission rate are summarised in *Table 4.4d*.

Table 4.4d Odour Emission from Final Scrubber

Parameters	Final Scrubber
Stack Height (m above ground)	13.8
Stack Diameter (m)	1.2
Exit Flow Rate ($m^3 hr^{-1}$)	2,800
Exit Temperature (°C)	ambient
Maximum Odour Concentration at Exhaust Point (OU m^{-3}) [(a)]	257.6
Odour Emission Rate (OU s^{-1}) [(b)]	200.3

Notes:

(a) Monitoring will be performed to ensure the odour concentration emitted from the exhaust point will not exceed the maximum odour concentration. This will be included in the Contract Specification.

(b) Refer to *Annex A1* for detailed odour emission rate calculation.

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 (0.47%) of the total background traffic on Wan Po Road (ie 93 trucks per day compared to AADT of 19,860 in 2006, refer to *Section 5.4.2*). It is therefore considered that the potential air quality impact due to additional traffic is negligible and will not cause an adverse air quality impact.

Emissions from Marine Vessels during Berthing

According to *Section 3.2.2* and *Table 3.2b*, PFAD, biodiesel and methanol will be delivered by barge. It is estimated that about 4 barges will be berthed per week and it takes less than 15 minutes for the marine vessel to travel fro 500m from the approach channel to the jetty and berth. Therefore, the potential air quality impact during maneuvering of the marine vessel will be transient and negligible. PFAD and methanol delivered to the Site by barge will be pumped to the storage tanks using dedicated pipelines. Flexible hoses will be used to connect storage the tanks of the barge to the pipelines at the jetty. During berthing, the main engine and the auxiliary engine of the vessels will be switched off to minimize the emissions. The power supply to the marine vessels will be provided by an on-site power supply. Therefore, no emission is anticipated from the marine vessels during berthing.

4.4.3 Cumulative Impacts

Construction Phase

The operation of TKO Area 137 Fill Bank and existing SENT Landfill and the construction of the TKO Further Development works are identified as concurrent projects during the construction of the biodiesel plant (see *Section 3.3*).

TKO Area 137 Fill Bank and existing SENT Landfill are located at south and east of the biodiesel plant, respectively and the nearest distance from the existing SENT Landfill to the Project Site is about 700m. The TKO Area 137 Fill Bank is further away. Given the large separation distances and different worst case wind directions, it is not anticipated that these concurrent projects will cause adverse cumulative dust impacts.

The TKO Further Development – Infrastructure works site is located at more than 2 km from the biodiesel plant. It is therefore, not anticipated that it will cause cumulative dust impact to the identified ASRs.

Operation Phase

A chimney survey within the TKOIE was conducted in January 2008 and the major emissions sources within 500m from the Project Site boundary are HAESL and TVB City. The survey team has approached the operators of the TKOIE to obtain stack emission data. Only TVB City and HAESL are willing to provide information about their stacks. In addition, the Consultant has consulted the Hong Kong Science and Technology Parks Corporation (HKSTPC, who manages the TKOIE) regarding the fuel consumption of the premises within the TKOIE. They confirmed that most of the tenants in the TKOIE are using electricity for their plant operation.

Interviews with TVB City and HAESL were also conducted to validate the stack operation and its emission inventory.

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

With reference to the EIA Report of *HAECO/HAESL Aircraft Engine Test Cell Facility at TKO*, NO_2, CO and SO_2 are the key air pollutants to be emitted during engine testing. These emission rates and stack characteristics are summarized in *Table 4.4e*.

Table 4.4e Stack and Emission Characteristics of HAESL *(a)*

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

Notes:

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

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

These data have been confirmed by HAESL. The emissions of NO_2, CO and SO_2 from HAESL are included to assess the cumulative air quality impact during the operation phase.

To assess the potential cumulative air quality impact due to other minor emission sources in TKOIE, the Consultant has made reference to the emission sources and data adopted in the approved EIA Report of Fill Bank at TKO Area 137. The estimation of the emissions from these sources has taken account of the total fuel consumption of the whole TKOIE which includes potential future emission sources. The assessment is therefore considered conservative. The facilities were assumed to operate for 10 hours a day on an annual basis, as detailed in the reference report. Emission rates of NO_2 from the potential sources were similar to those in the TKO 137 Fill Bank EIA, while emission rates of CO and SO_2 were calculated with reference to the USEPA *Compilation of Air Pollutants Emission Factors, 5th Edition (AP42) (1995)* and the SO_2 emission limit stipulated in the *Air Pollution Control (Fuel Restriction) Regulation* Amendment 2008, respectively. Calculation details of respective emission rates are presented in *Annex A1*.

No similar odour source is identified within 500m of the Project site boundary and hence, no cumulative odour impact is expected.

4.5 ASSESSMENT METHODOLOGY (OPERATIONAL AIR QUALITY IMPACT)

Stack Emissions from Boiler Stack, Biogas Flare, Process Building and Existing HAESL

An emission inventory for the boiler stack, Process Building, HAESL stack and other emission sources in TKOIE during normal operation of the biodiesel plant is summarised in *Table 4.5a*. It should be noted that the biogas flare will only be operated when the boiler is shut down for maintenance. Under such a situation, the emission from the biogas flare will be lower than that from the boilers. However, as the gas exhaust temperature, characteristics and location of biogas flare are different from boiler, the emissions from the biogas flare will also be considered as a separate scenario in the detailed assessment. The emission inventory for the biogas flare during emergency operation is also summarised in *Table 4.5a*. *Figure 4.5a* illustrates the location of the emission points.

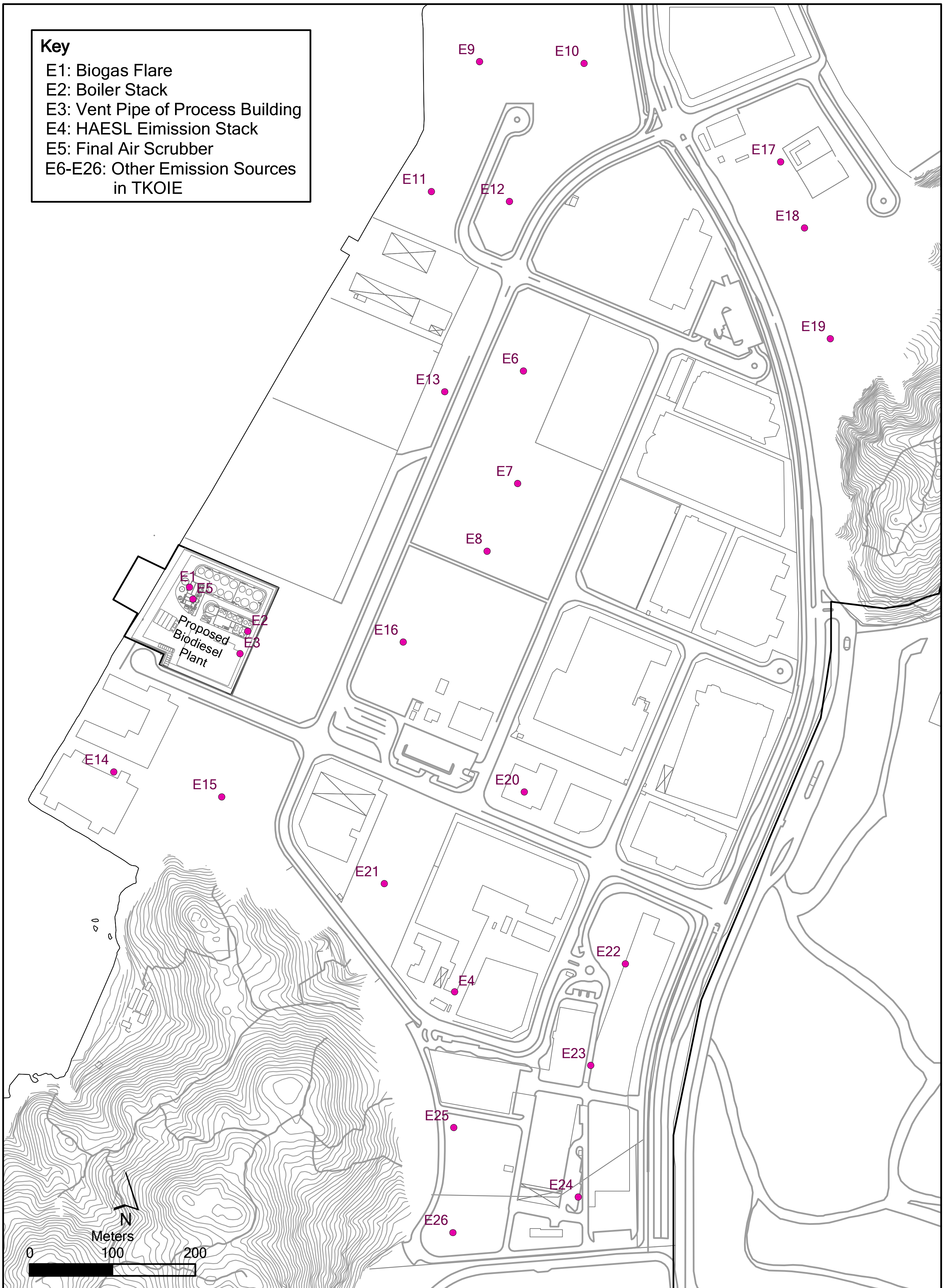

Figure 4.5a

Locations of Emission Sources

Environmental Resources Management

ERM

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Date: 10/11/2008

Table 4.5a Summary of Stack Information and Emission Inventory

Parameter		Boiler Stack	Biogas Flare	Process Building	HAESL Stack	TKOIE Stacks[f]
Operating Hours		24	24	24	24	10
No. of Stack		1	1	1	1	21
Stack Height (m above ground)		31	12.5	22.8	40	10
Stack Diameter (m)		0.75	0.96	0.15	14.7	1.2
Flue Gas Exit Temperature (°K)		373	1,088	308	325	463.15
Flue Gas Exit Velocity (m s^{-1})		7	0.54	0.79	16.4 (NO_2 & SO_2); 12 (CO)	9.00
Emission Rates (g s^{-1}) [a]	NO_x	0.66	0.015	-	106	
	NO_2 [b]	0.13	0.003	-	21.2	0.043 [c]
	CO	0.17	0.005	-	23.9	0.042[d]
	SO_2	0.24	1.07×10^{-3}	-	1.9	0.06[e]
	Acetyldehyde	-		0.028	-	
	Methanol	-		0.028	-	

Notes:

(a) As shown in *Table 4.4a*, burning of mixture of gas oil/bioheating oil generates higher emission rates of air pollutants than burning of biogas.

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

(c) Reference has been made to NO_2 emission rates in the Fill Bank at TKO Area 137 EIA Report (EIA – 076/2002)

(d) CO emission rate is calculated with reference to the USEPA *Compilation of Air Pollutants Emission Factors, 5th Edition (AP42) (1995)*

(e) SO_2 emission rate is calculated with reference to the SO_2 limit stipulated in the *Air Pollution Control (Fuel Restriction) Regulation Amendment 2008*

(f) With reference to approach adopted in the approved TKO Area 137 Fill Bank EIA Report

Hourly, daily and annual average NO_2, CO and SO_2 concentrations, hourly methanol concentration and annual average acetyldehyde and methanol concentrations at different elevations (1.5m to 120m) of the identified ASRs were predicted using an EPD approved air dispersion model, Industrial Source Complex Short-Term (ISCST3). The meteorological data recorded at the TKO Weather Station in 2003 (1) and "rural" mode were used for the model runs as the Project Site is located along the waterfront.

Two scenarios were established for the model run:

Scenario 1 : Under Normal Operation (Emission from Boiler Stack)
Scenario 2 : Under Emergency Operation (Emission from Biogas Flare)

In each scenario, emissions from HAESL and other emission sources in TKOIE are also included in the model to assess the cumulative impact. Background air pollutant concentrations (refer to *Table 4.3a*) were added to the modelled cumulative results to assess the total air quality impacts at the ASRs.

(1) More than 90% raw meteorological data obtained from the HKO are valid.

Odour Emission from Final Air Scrubber

Table 4.5b summarises the odour emission inventory of the exhaust air after treatment by the final scrubber.

Table 4.5b ***Odour Emission Inventory***

Parameter	Final Scrubber Exhaust Stack
Operating Hours	24
No. of Stacks	1
Vent Duct Height (m above ground)	13.8
Vent Duct Diameter (m)	1.2
Exhaust Air Exit Temperature (°K)	Ambient temperature
Exhaust Air Exit Velocity ($m\ s^{-1}$)	0.7
Odour Concentration at Exhaust Duct ($OU\ m^{-3}$)	257.6
Odour Emission Rate ($OU\ s^{-1}$)	200.3

An EPD approved air dispersion model, ISCST3, was used to predict the odour concentration at different elevations of the identified ASRs. Other modeling parameters are similar to those adopted in the stack emission assessment.

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 4.5c*.

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

Table 4.5c ***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

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 4.5d*.

Table 4.5d ***Factors for Converting Model Outputs to Maximum 5-second Mean Odour Concentration***

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

The overall conversion factors under different stability classes are applied to the model so that the predicted outputs are in 5-second averages.

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

4.6 EVALUATION OF IMPACTS

Stack Emissions from Boiler Stack, Standby Flare, Process Building and HAESL

NO_2, CO and SO_2

The maximum hourly, daily and annual average concentrations of NO_2 and SO_2 and maximum hourly and 8-hour average CO concentrations were predicted at various heights at the identified ASRs. The highest cumulative

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

maximum hourly, daily and annual average concentrations of NO_2 and SO_2 and maximum hourly and 8-hour average CO concentrations, taking account of the background air quality, are summarised in *Table 4.6a* for both scenarios. The predicted concentrations of these air pollutants at different ASR elevations are summarized in *Annex A4*.

Table 4.6a Predicted Highest Cumulative Air Pollutant Concentrations at ASRs

ASR	Highest Hourly Concentration (μg m^{-3})			Highest 8-hour Concentration (μg m^{-3})	Highest Daily Average Concentration (μg m^{-3})		Annual Average Concentration (μg m^{-3})	
	NO_2	CO	SO_2	CO	NO_2	SO_2	NO_2	SO_2
Scenario 1 : Normal Operation (Emission from Boiler Stack)								
A1	96.5	1,224	79.5	1,200	72.3	35.7	65.5	23.24
A2	99.0	1,227	84.5	1,205	74.0	39.1	65.2	22.75
A3	77.2	1,200	45.2	1,186	65.3	23.1	63.6	19.76
A4	84.1	1,202	48.4	1,191	66.6	24.0	64.1	20.45
A5	71.2	1,189	30.4	1,184	64.7	20.7	63.6	19.57
A6-1	80.3	1,198	43.1	1,186	65.0	21.7	63.5	19.62
A6-2	209.9	1,324	224.0	1,253	94.2	62.5	65.4	22.24
A7	97.8	1,216	68.4	1,191	66.9	23.7	63.4	19.52
A8	89.0	1,207	54.6	1,191	66.9	23.8	63.6	19.80
A9	69.3	1,189	30.5	1,184	64.4	21.1	63.4	19.42
A10	71.7	1,192	35.1	1,186	65.1	21.5	63.4	19.52
A11	77.0	1,195	39.3	1,190	66.2	24.4	63.9	20.24
A12-1	79.9	1,197	42.5	1,190	66.4	23.8	63.9	19.92
A12-2	84.7	1,202	49.3	1,191	67.2	24.9	64.0	20.39
A12-3	110.3	1,227	85.0	1,208	74.6	35.2	64.2	20.61
A13	74.7	1,192	35.4	1,185	64.9	21.3	63.4	19.47
A14	68.3	1,188	28.8	1,185	64.6	21.0	63.3	19.37
A15	72.0	1,193	35.6	1,184	64.6	21.3	63.3	19.39
A16	73.5	1,194	37.2	1,185	65.0	22.0	63.5	19.65
A17	103.9	1,221	76.0	1,195	68.7	27.0	64.4	20.89
A18	79.3	1,201	47.2	1,188	67.0	25.4	63.6	19.89
A19	91.1	1,209	58.3	1,201	72.3	32.2	64.0	20.39
A20-1	104.1	1,249	92.1	1,196	69.0	26.5	63.4	19.54
A20-2	90.8	1,225	51.0	1,196	68.7	24.1	63.5	19.61
A20-3	128.4	1,291	86.2	1,216	72.7	29.1	63.9	20.08
A21	75.4	1,198	39.4	1,189	66.1	23.8	63.4	19.56
Scenario 2 : Emergency Operation (Emission from Biogas Flare)								
A1	80.8	1,198	43.8	1,189	66.5	23.9	63.8	19.97
A2	70.0	1,188	28.8	1,184	64.6	20.6	63.7	19.82
A3	74.0	1,192	34.3	1,185	65.0	21.7	63.5	19.62
A4	84.1	1,202	48.4	1,191	66.6	24.0	64.1	20.42
A5	71.2	1,189	30.4	1,184	64.7	20.4	63.6	19.52
A6-1	80.3	1,198	43.1	1,186	65.0	21.7	63.5	19.57
A6-2	209.9	1,324	224.0	1,253	94.2	62.5	65.4	22.18
A7	95.7	1,213	64.6	1,191	66.7	23.5	63.4	19.46

ASR	Highest Hourly Concentration (µg m^{-3})			Highest 8-hour Concentration (µg m^{-3})	Highest Daily Average Concentration (µg m^{-3})		Annual Average Concentration (µg m^{-3})	
	NO_2	CO	SO_2	CO	NO_2	SO_2	NO_2	SO_2
A8	89.0	1,207	54.6	1,191	66.9	23.8	63.6	19.77
A9	67.6	1,188	24.1	1,184	64.4	20.4	63.3	19.39
A10	69.0	1,190	25.6	1,185	64.5	20.3	63.4	19.47
A11	77.0	1,195	38.5	1,187	65.8	22.9	63.6	19.81
A12-1	79.9	1,197	42.5	1,190	66.4	23.8	63.9	19.84
A12-2	84.7	1,202	49.3	1,191	67.2	24.9	64.0	20.29
A12-3	110.3	1,227	85.0	1,208	74.6	35.2	64.2	20.58
A13	74.7	1,192	35.4	1,185	64.9	21.3	63.4	19.43
A14	67.5	1,185	25.2	1,185	64.6	21.0	63.3	19.35
A15	67.1	1,187	24.7	1,184	64.4	20.5	63.3	19.34
A16	70.3	1,192	27.1	1,185	64.5	20.3	63.4	19.52
A17	103.9	1,221	76.0	1,195	68.7	27.0	64.4	20.84
A18	76.1	1,196	36.6	1,188	65.6	21.0	63.4	19.40
A19	90.9	1,208	57.9	1,201	71.4	30.5	63.9	20.11
A20-1	104.1	1,249	45.4	1,196	68.8	21.7	63.3	19.31
A20-2	90.8	1,225	51.0	1,196	68.3	22.1	63.4	19.39
A20-3	128.4	1,291	86.2	1,216	72.6	28.4	63.9	19.93
A21	75.3	1,198	34.6	1,188	65.0	21.5	63.3	19.35
AQO	**300**	**30,000**	**800**	**10,000**	**150**	**350**	**80**	**80**

Notes:

(a) Background concentrations (NO_2 of 63 µg m^{-3}, CO of 1,181 µg m^{-3} and SO_2 of 19 µg m^{-3}) have been included.

(b) The predicted concentrations of these air pollutants at different ASR elevations are summarized in *Annex A4.*

The predicted cumulative maximum NO_2, CO and SO_2 concentrations under different averaging times at various heights at ASRs A1 – A19 and A21 are well within the respective AQOs. The worst affected height is at 30m above ground. The highest cumulative maximum NO_2, CO and SO_2 concentrations, including the background air quality, are predicted at 30m above ground; the ASR that is affected the most varies depending on the averaging period.

The maximum contribution of hourly NO_2 concentration at the identified ASRs from the operation of the biodiesel plant alone is at ASR A2, which is located immediately at the south of the Project Site. It is about 34%of the total predicted concentration at A2 (34 µgm^{-3} contributed from the biodiesel plant operation during normal condition).

The predicted cumulative maximum NO_2, CO and SO_2 concentrations under different averaging times at various heights at LOHAS Park (A20) are also well within the respective AQOs.

Referring the predicted results presented in *Table A4-1* of *Annex A4*, the maximum hourly NO_2 concentration at LOHAS Park due to the operation of the biodiesel plant, (ie 39.6 µg m^{-3}, which is about 13.2% of the hourly AQO criterion for NO_2), is predicted at 60m above ground. The predicted hourly

NO_2 concentrations at this ASR due to the operation of the biodiesel plant reduce with increasing height and at 120m above ground the hourly NO_2 concentration reduced to 2.8 µg m^{-3}, which is about 0.9% of the hourly AQO criterion for NO_2. This suggests that at level higher than 120m, the Project contribution to the total hourly NO_2 concentrations at LOHAS Park will be negligible and there will be no cumulative impact.

The highest predicted cumulative maximum hourly NO_2 concentrations (including background) at LOHAS Park at 60m and 120m above ground are 114 µg m^{-3} and 128 µg m^{-3} respectively, which are well below the AQO criterion.

Figures 4.6a to *4.6e* and *4.6h* to *4.6j* present the isopleths of the cumulative maximum average hourly NO_2 concentrations at 1.5m to 30m above ground and 60m, 90m and 120m at LOHAS Park. *Figures 4.6f* and *4.6g* present the isopleths of the cumulative maximum daily and annual average NO_2 concentrations at 30m above ground (the worst affected height) within 500m of Study Area, respectively. The isopleths show that the impacts comply with the *EIAO-TM* assessment criterion.

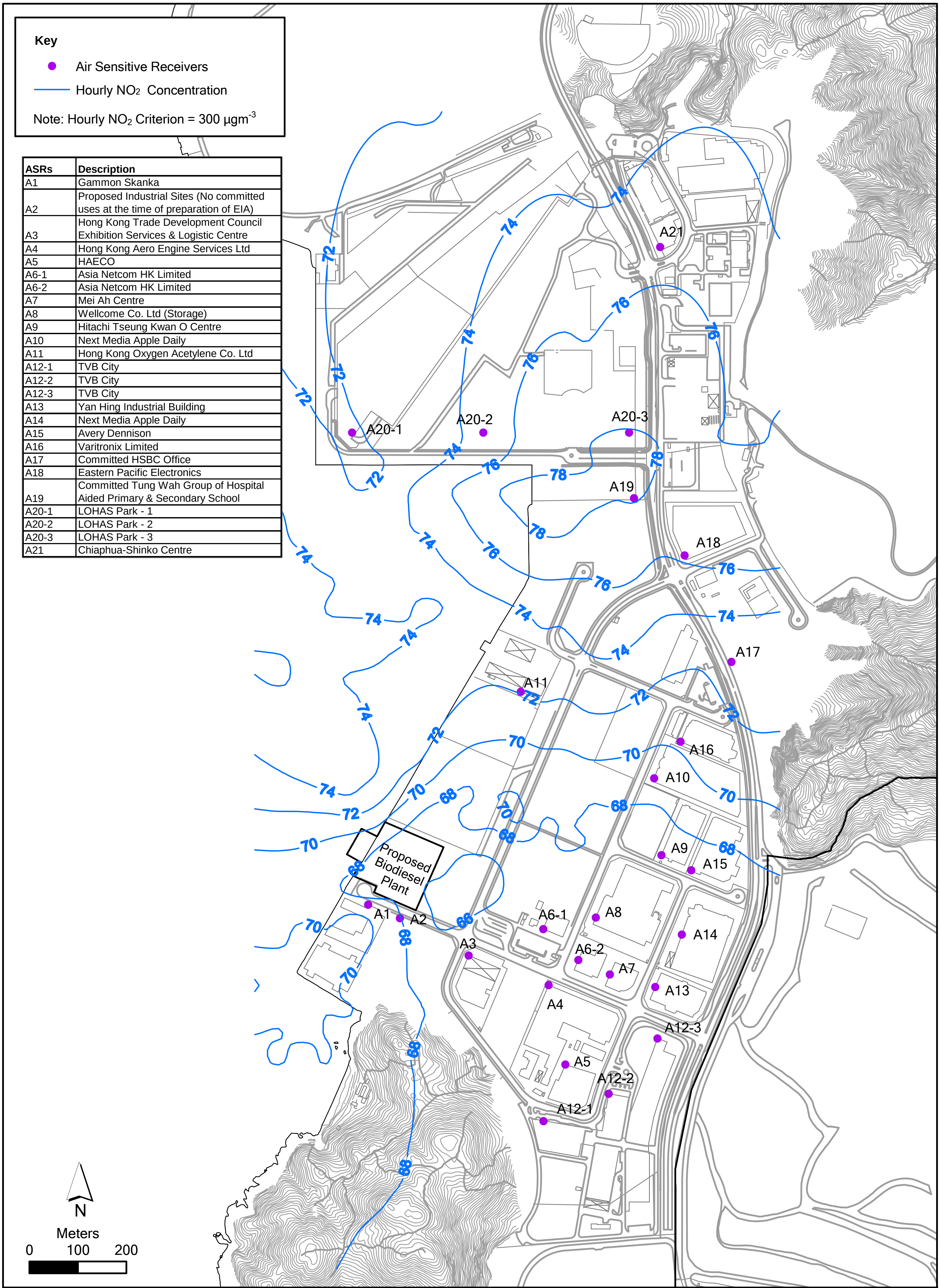
The assessment indicates that the operation of the proposed biodiesel plant in the TKOIE will not cause adverse air quality impacts to the identified ASRs at TKOIE, Areas 85 and 86.

Acetyldehyde and Methanol

Non-cancer Health Risk Assessment: The predicted hourly methanol concentration and annual average acetyldehyde and methanol concentrations at different ASR elevations are presented in *Annex A4* and the highest predicted results are summarized in *Table 4.6b.*

Table 4.6b ***Predicted Highest Hourly Concentration of Methanol and Annual Average Concentrations of Acetyldehyde and Methanol***

ASR	Predicted Highest Hourly Concentrations (µg m^{-3})	Predicted Highest Annual Average Concentrations (µg m^{-3})	
	Methanol	Methanol	Acetyldehyde
A1	15.5	1.27	1.27
A2	58.9	2.90	2.90
A3	10.6	0.32	0.32
A4	5.2	0.10	0.10
A5	6.8	0.10	0.10
A6-1	7.1	0.08	0.08
A6-2	6.3	0.08	0.08
A7	5.4	0.06	0.06
A8	7.0	0.05	0.05
A9	6.2	0.04	0.04
A10	3.0	0.04	0.04
A11	7.7	0.16	0.16
A12-1	6.4	0.16	0.16



ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6a

Isopleths showing Maximum Hourly NO_2 Concentrations at 1.5m above ground

File: 11nov\0077089_4.6a.mxd
Date: 12/11/2008

Environmental Resources Management

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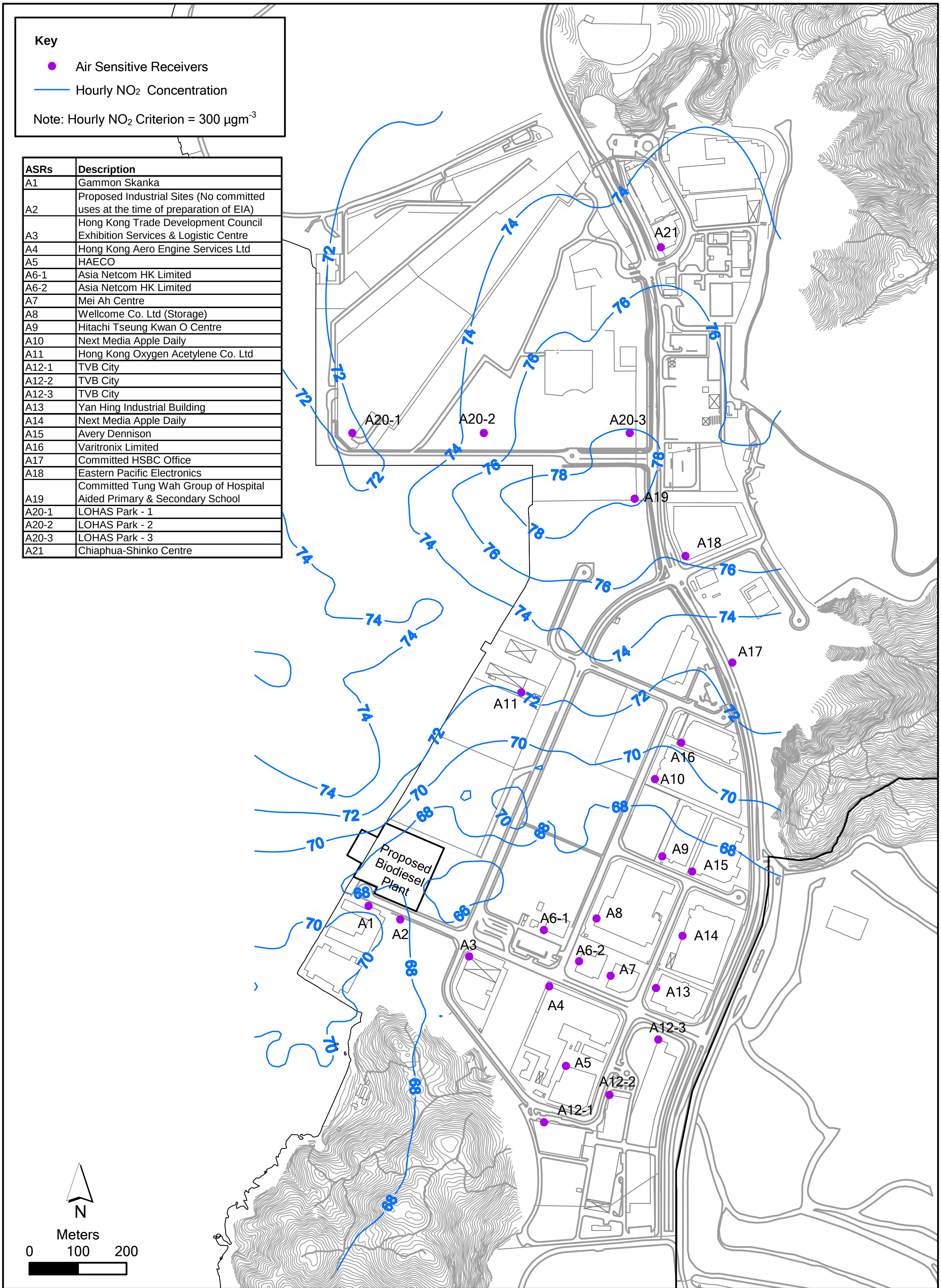

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6b

Isopleths showing Maximum Hourly NO_2 Concentrations at 5m above ground

File: 11nov\0077089_4.6b.mxd
Date: 12/11/2008

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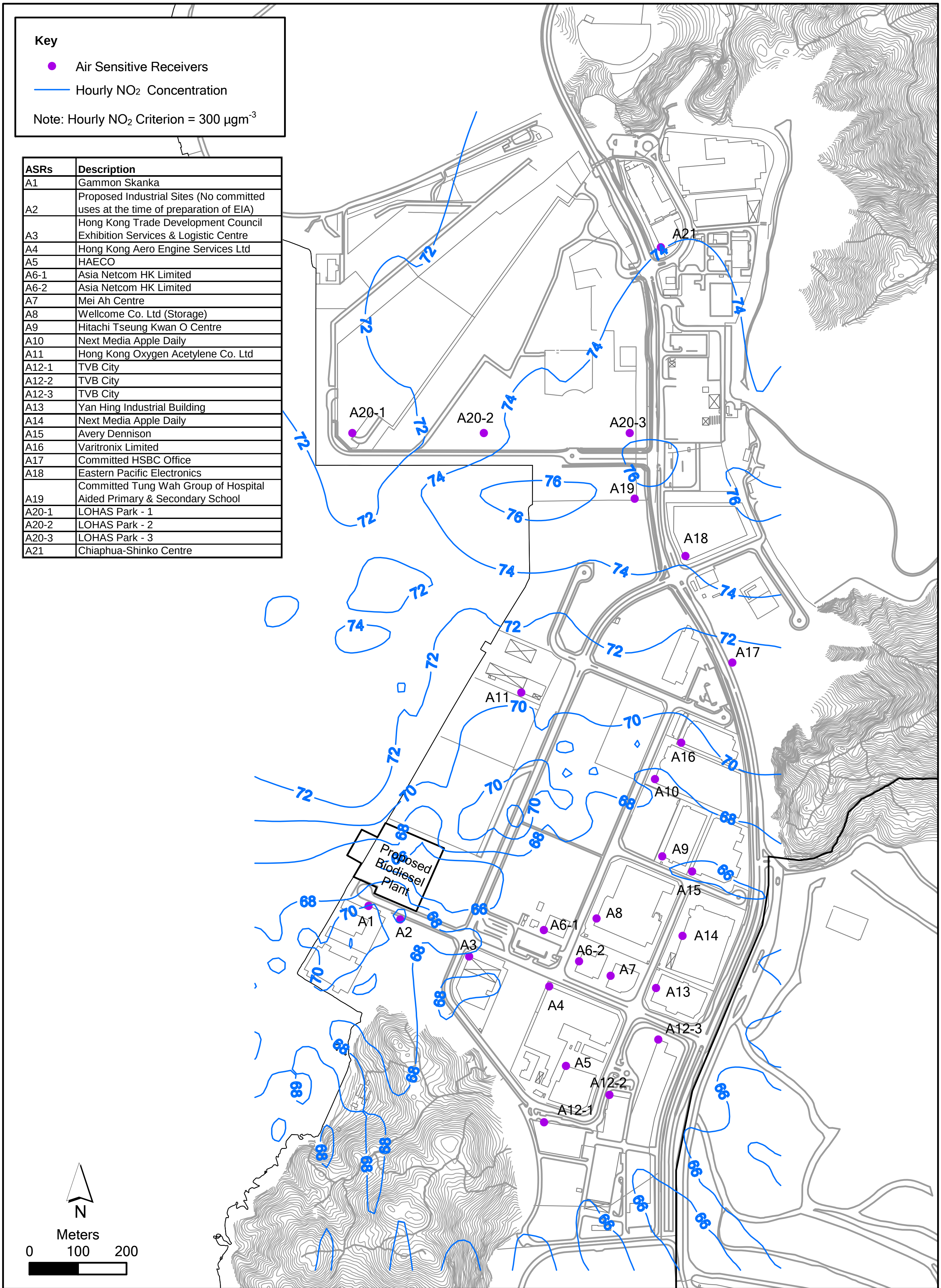
ERM



ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6c

Isopleths showing Maximum Hourly NO_2 Concentrations at 10m above ground

Environmental Resources Management

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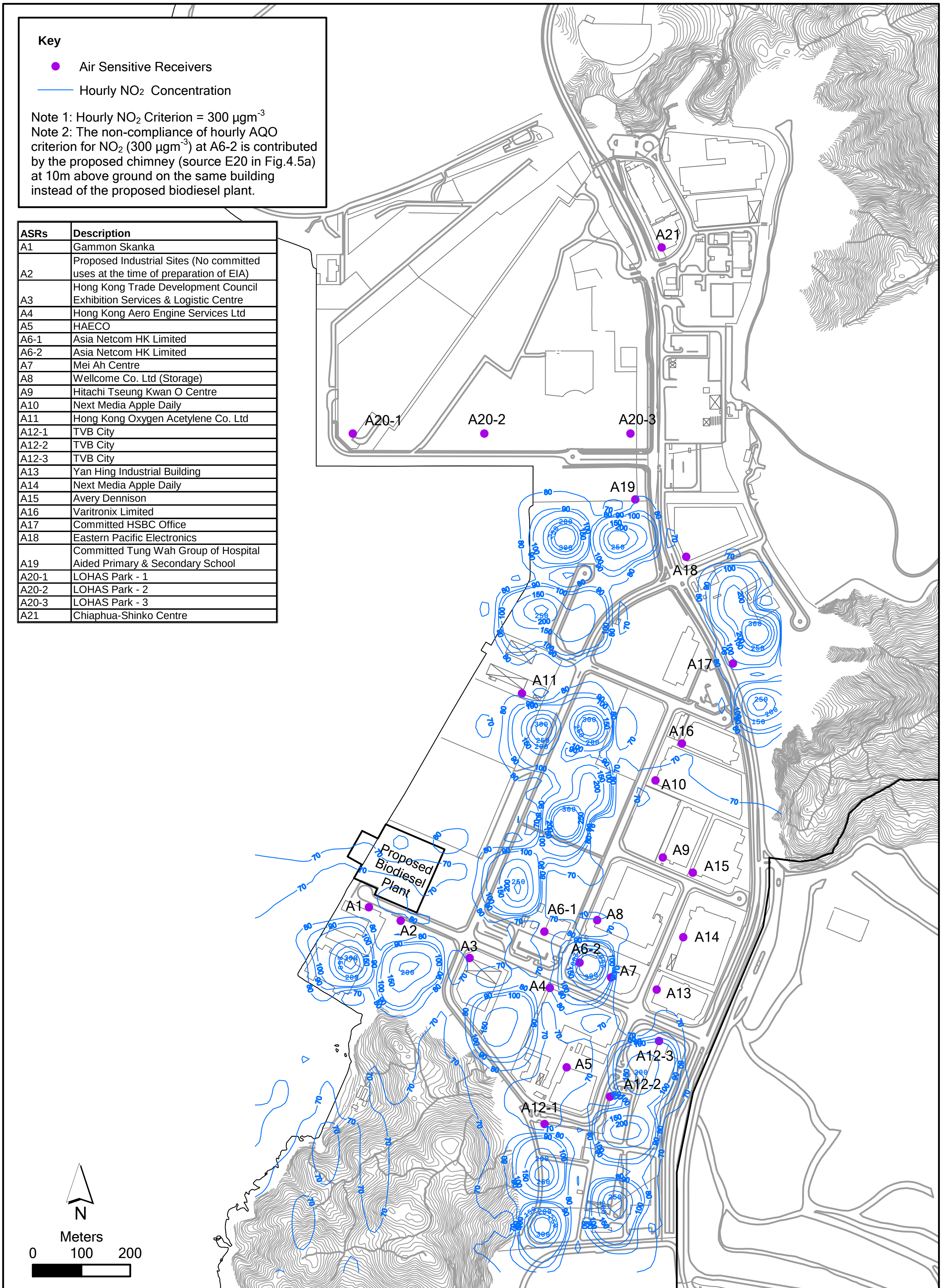
Date: 12/11/2008



Key

● Air Sensitive Receivers

— Hourly NO_2 Concentration

Note 1: Hourly NO_2 Criterion = 300 μgm^{-3}
Note 2: The non-compliance of hourly AQO criterion for NO_2 (300 μgm^{-3}) at A6-2 is contributed by the proposed chimney (source E20 in Fig.4.5a) at 10m above ground on the same building instead of the proposed biodiesel plant.

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6d

Isopleths showing Maximum Hourly NO_2 Concentrations at 20m above ground

File: 11nov\0077089_4.6d.mxd
Date: 12/11/2008

Environmental Resources Management

ERM

Key

- Air Sensitive Receivers
- Hourly NO_2 Concentration

Note: Hourly NO_2 Criterion = 300 μgm^{-3}

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

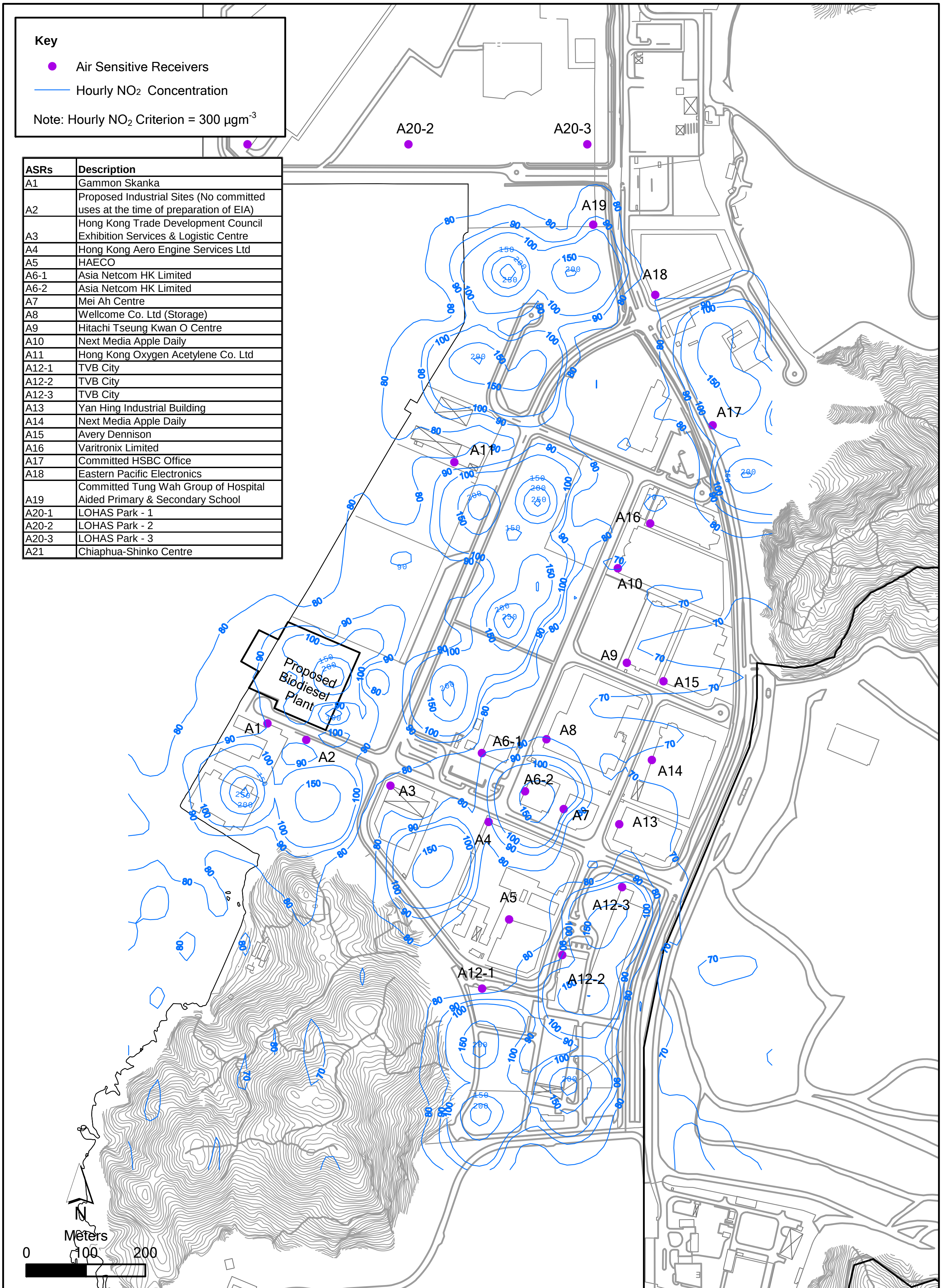


Figure 4.6e

Isopleths showing Maximum Hourly NO_2 Concentrations at 30m above ground

Environmental Resources Management

ERM

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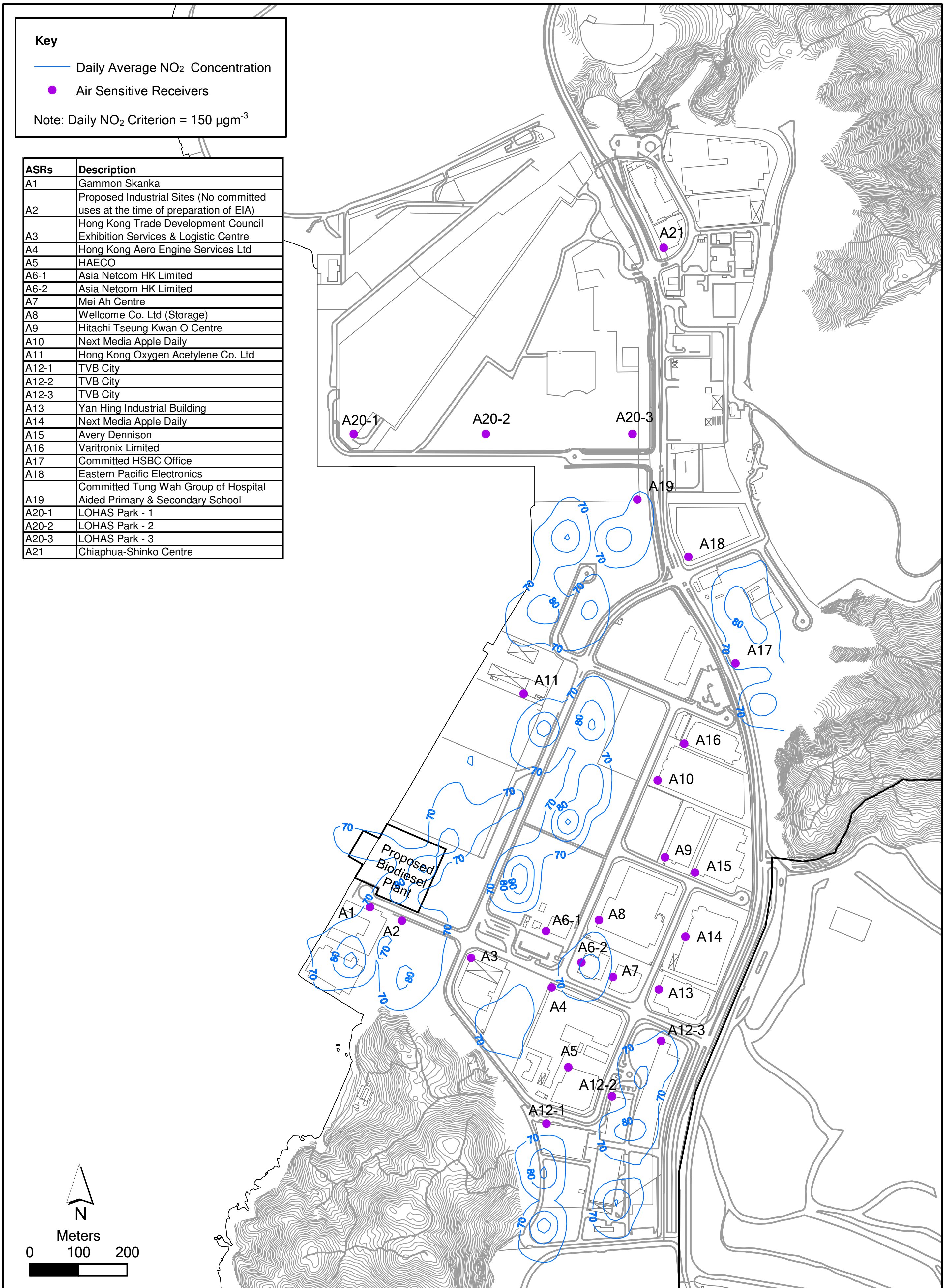
Date: 12/11/2008



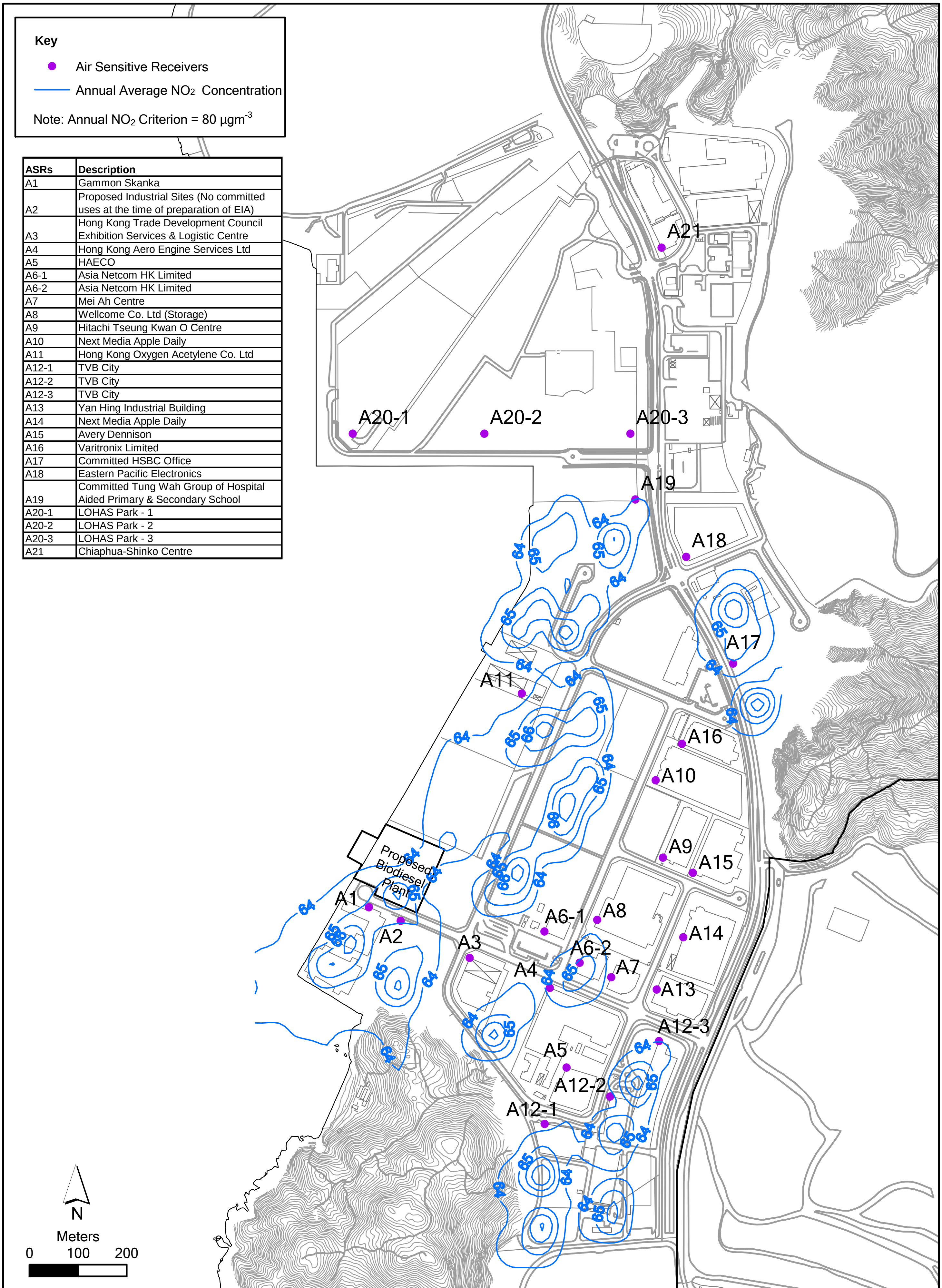
ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6f

Isopleths showing Daily Average NO_2 Concentrations at 30m above ground

File: 11nov\0077089_4.6f.mxd
Date: 12/11/2008

Environmental Resources Management
ERM



Key

- Air Sensitive Receivers
- Annual Average NO_2 Concentration

Note: Annual NO_2 Criterion = 80 μgm^{-3}

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6g

Isopleths showing Annual Average NO_2 Concentrations at 30m above ground

Environmental Resources Management

ERM

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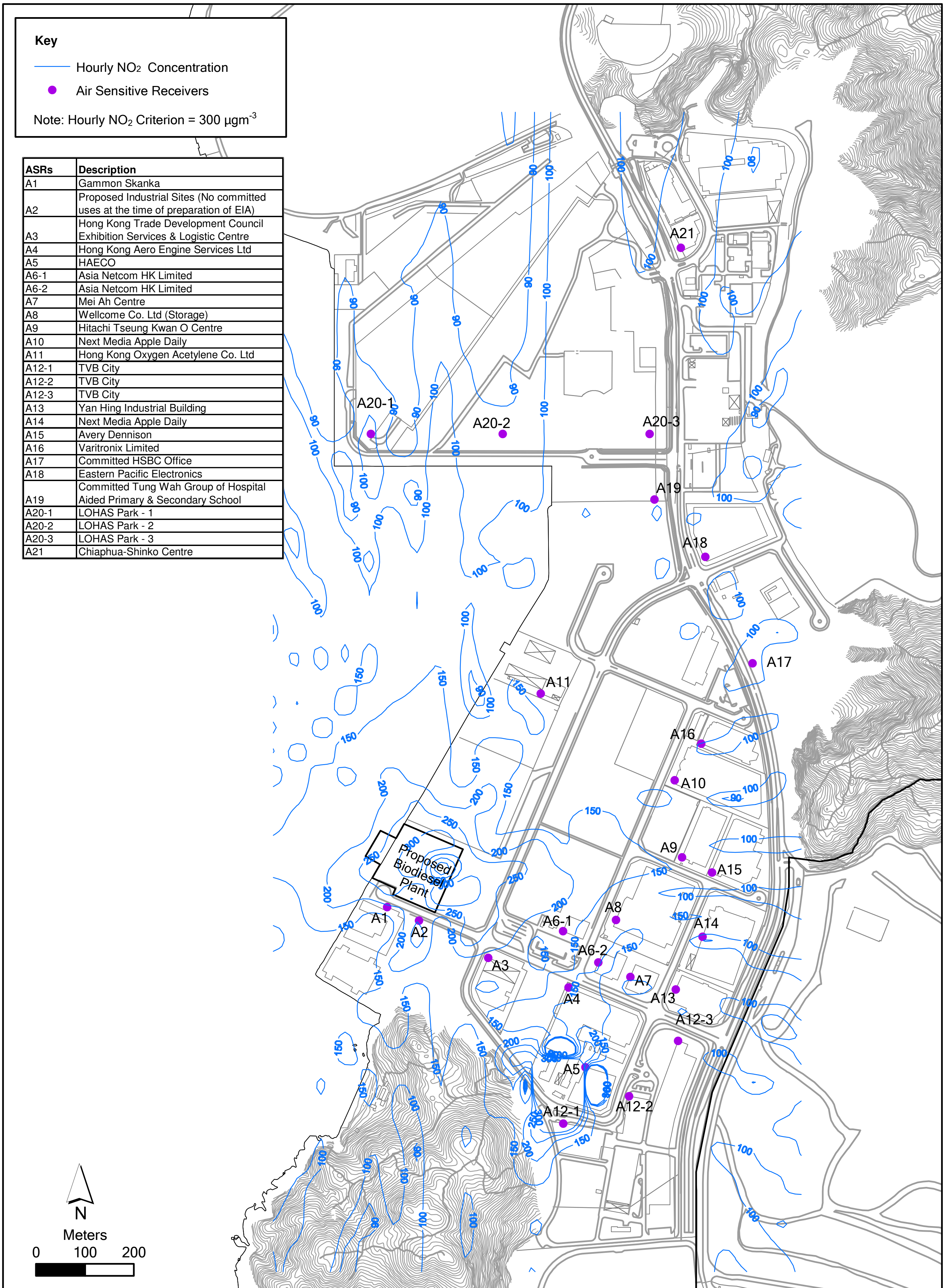
Date: 12/11/2008



ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6h

Isopleths showing Maximum Hourly NO_2 Concentrations at 60m above ground

File: 11nov\0077089_4.6h.mxd
Date: 12/11/2008

Environmental Resources Management

ERM

Key

- Air Sensitive Receivers
- Hourly NO_2 Concentration

Note: Hourly NO_2 Criterion = 300 μgm^{-3}

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

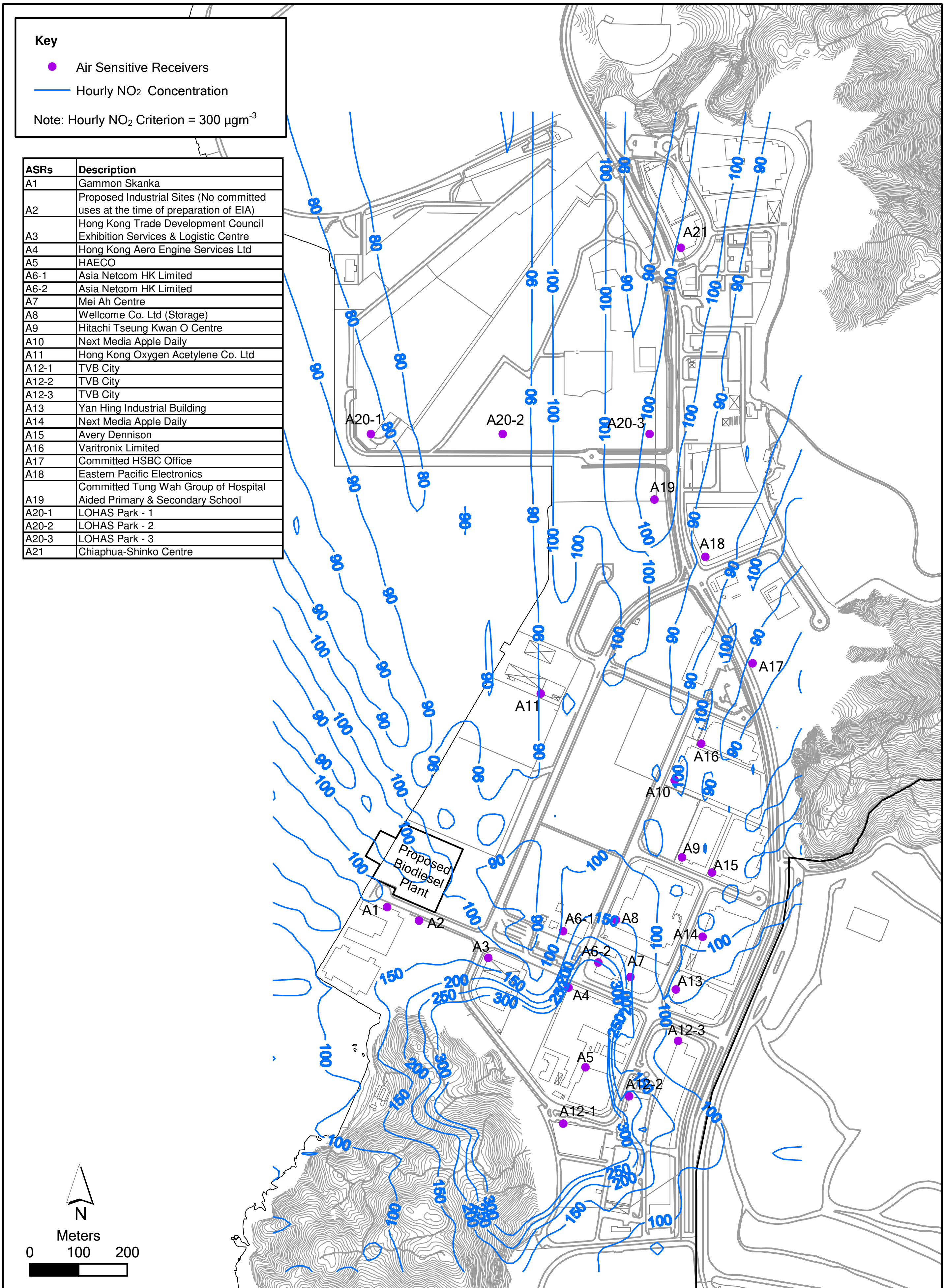


Figure 4.6i

Isopleths showing Maximum Hourly NO_2 Concentrations at 90m above ground

Environmental Resources Management

ERM

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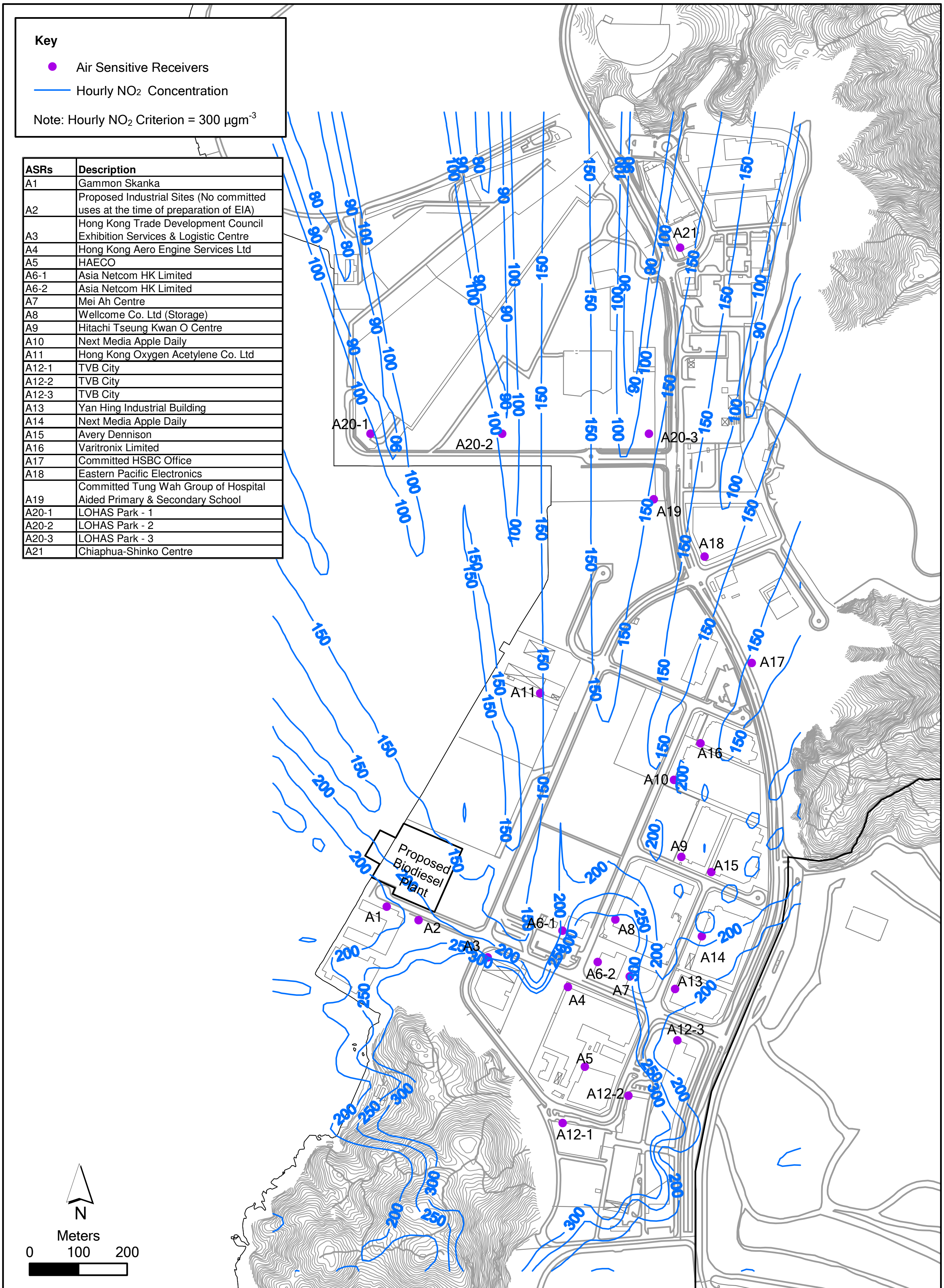

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6j

Isopleths showing Maximum Hourly NO_2 Concentrations at 120m above ground

Environmental Resources Management

ERM

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Date: 12/11/2008

ASR	Predicted Highest Hourly Concentrations (μg m^{-3})	Predicted Highest Annual Average Concentrations (μg m^{-3})	
	Methanol	Methanol	Acetyldehyde
A12-2	4.0	0.07	0.07
A12-3	5.8	0.07	0.07
A13	5.8	0.05	0.05
A14	6.2	0.04	0.04
A15	3.3	0.03	0.03
A16	6.5	0.06	0.06
A17	2.2	0.05	0.05
A18	5.1	0.11	0.11
A19	5.7	0.10	0.10
A20-1	3.9	0.02	0.02
A20-2	4.6	0.05	0.05
A20-3	1.3	0.03	0.03
A21	4.7	0.06	0.06
Reference Concentration :	**2.8×10^4**	**4,000**	**9**

The results indicate that the predicted hourly concentration of methanol and annual average concentrations of acetyldehyde and methanol at the identified ASRs are well below the respective reference chronic and acute concentrations. Hence, the chronic and acute health impacts of acetyldehyde and methanol are considered to be insignificant.

Cancer Health Risk Assessment: The calculated individual cancer health risk levels of acetyldehyde at different elevations of the identified ASRs are presented in *Annex A4* and the highest individual risk level of ASRs are summarized in *Table 4.6c*.

Table 4.6c Individual Cancer Risk of Acetyldehyde

ASR	Predicted Highest Individual Cancer Risk of Acetyldehyde [(a)]
A1	3.43E-06
A2	7.82E-06
A3	8.61E-07
A4	2.78E-07
A5	2.83E-07
A6-1	2.28E-07
A6-2	2.05E-07
A7	1.67E-07
A8	1.37E-07
A9	9.65E-08
A10	1.10E-07
A11	4.31E-07
A12-1	4.19E-07
A12-2	1.86E-07
A12-3	1.76E-07
A13	1.30E-07
A14	9.77E-08
A15	7.00E-08
A16	1.52E-07
A17	1.44E-07
A18	3.00E-07
A19	2.61E-07
A20-1	5.27E-08
A20-2	1.32E-07
A20-3	7.48E-08
A21	1.63E-07

Note:

(a) Unit risk factor of acetyldehyde (as presented in *Table 4.2b*) was used for the calculation. The individual risk level is calculated by the predicted annual average concentration of acetyldehyde multiplying the unit risk factor.

The calculated individual cancer risk levels of acetyldehyde at different elevations at the identified ASRs are lower than 10^{-6} except at A1 and A2. For A1 and A2, the risk should be reduced to As Low As Reasonably Practicable (ALARP). It should be noted that the assessment conservatively assumed that all the impurities of methanol are acetyldehyde (see *Section 4.4.2*) and it is expected that the actual risk will be lower than predicted in this assessment.

Odour Emission from Final Scrubber

The predicted maximum 5-second odour levels at different elevations of ASRs are presented in *Annex A4* and the highest predicted odour levels at ASRs are summarized in *Table 4.6d*.

The predicted 5-second average odour levels at various heights at the identified ASRs are well within the odour criterion (ie 5 OU in 5-second averaging time).

Figures 4.6k to *4.6o* present the isopleths of the predicted maximum 5-second odour levels at different heights of the identified ASRs. The isopleths show that the odour impacts are localized and comply with the *EIAO-TM* assessment criterion. Hence, no adverse odour impact is anticipated.

Table 4.6d ***Highest Predicted Maximum 5-second Odour Levels***

ASR	Predicted Maximum 5-second Odour Level (Odour Unit)
A1	2.7
A2	2.2
A3	1.0
A4	1.2
A5	0.9
A6-1	0.6
A6-2	1.1
A7	0.9
A8	0.6
A9	0.5
A10	0.3
A11	0.5
A12-1	0.7
A12-2	0.5
A12-3	0.2
A13	0.3
A14	0.2
A15	0.3
A16	0.4
A17	0.4
A18	0.1
A19	0.1
A20-1	0.1
A20-2	0.3
A20-3	0.3
A21	0.1
5-second Odour Criterion :	**5**

4.7 *MITIGATION MEASURES*

4.7.1 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* will be implemented 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 will be implemented;

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

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

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

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

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

4.7.2 Operation Phase

No mitigation measures will be required.

4.8 RESIDUAL IMPACTS

4.8.1 Construction Phase

No adverse residual impact is anticipated after the implementation of the recommended mitigation measures described in *Section 4.7.1*.

4.8.2 Operation Phase

No adverse residual impact is anticipated.

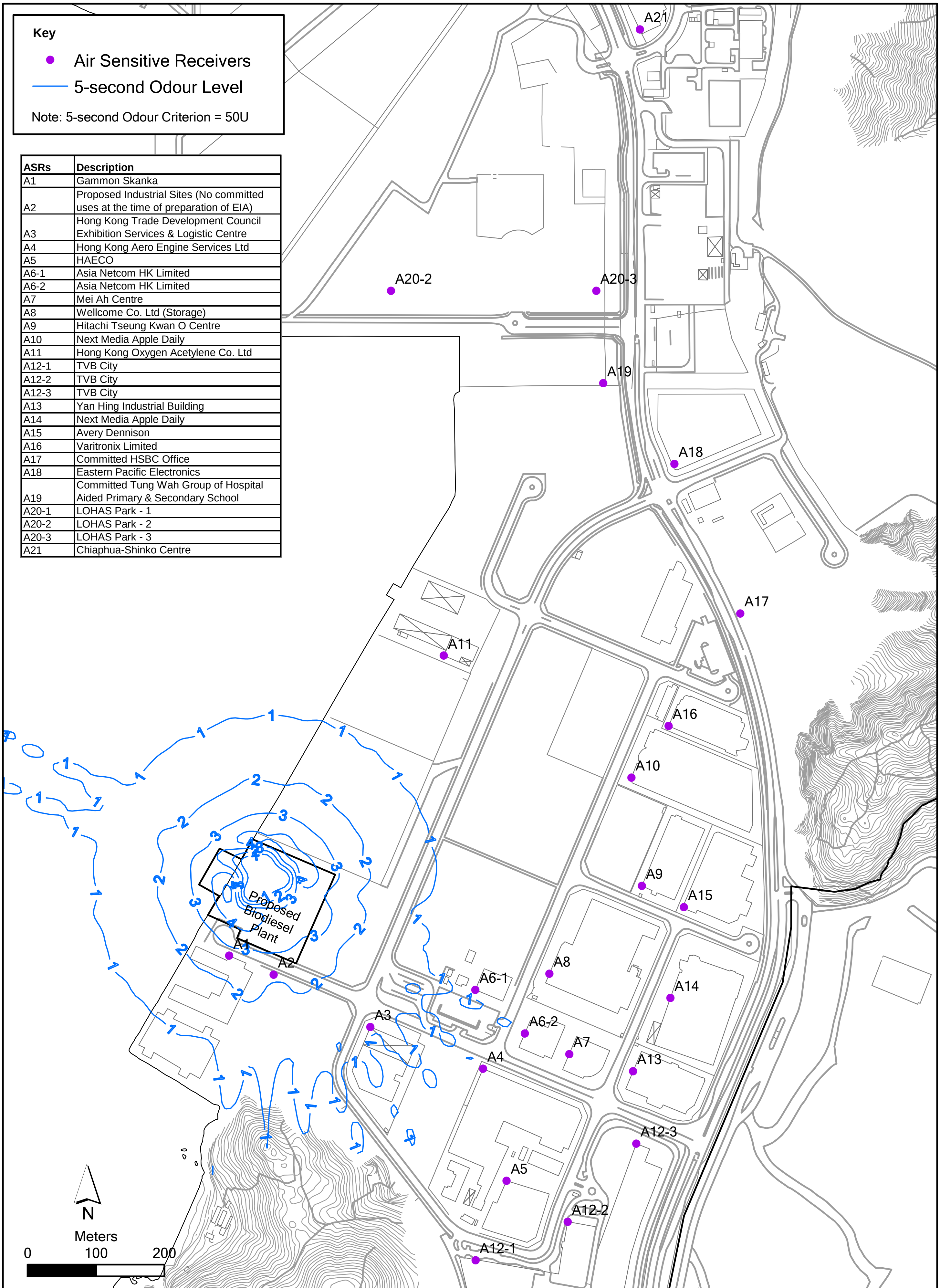
4.9 ENVIRONMENTAL MONITORING AND AUDIT

4.9.1 Construction Phase

As the scale of construction works is small, no dust monitoring (in terms of TSP) is required. However, regular site audit (ie monthly) will be performed to ensure the implementation of suitable dust control measures and good site practices recommended in *Section 4.7.1*.

4.9.2 Operation Phase

NO_x, CO, SO_2 and NMOC concentrations in the flue gas of the stacks of the boilers and biogas flare (if in operation), methanol and acetyldehyde concentrations in the vent gas of process building will be monitored on



ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6k

Isopleths showing 5-second Odour Levels at 1.5m above ground

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Date: 03/10/2008

Environmental Resources Management
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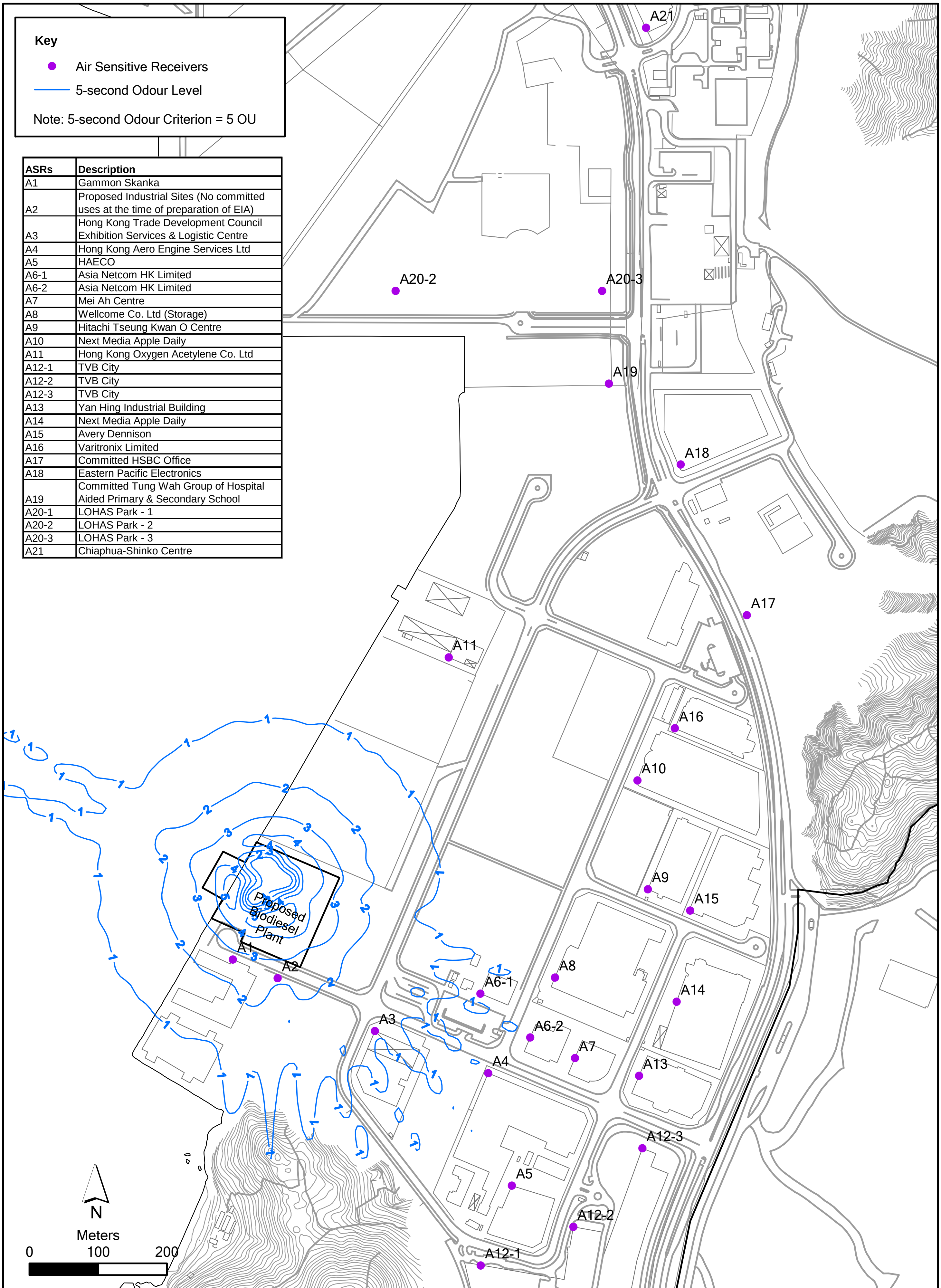


ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

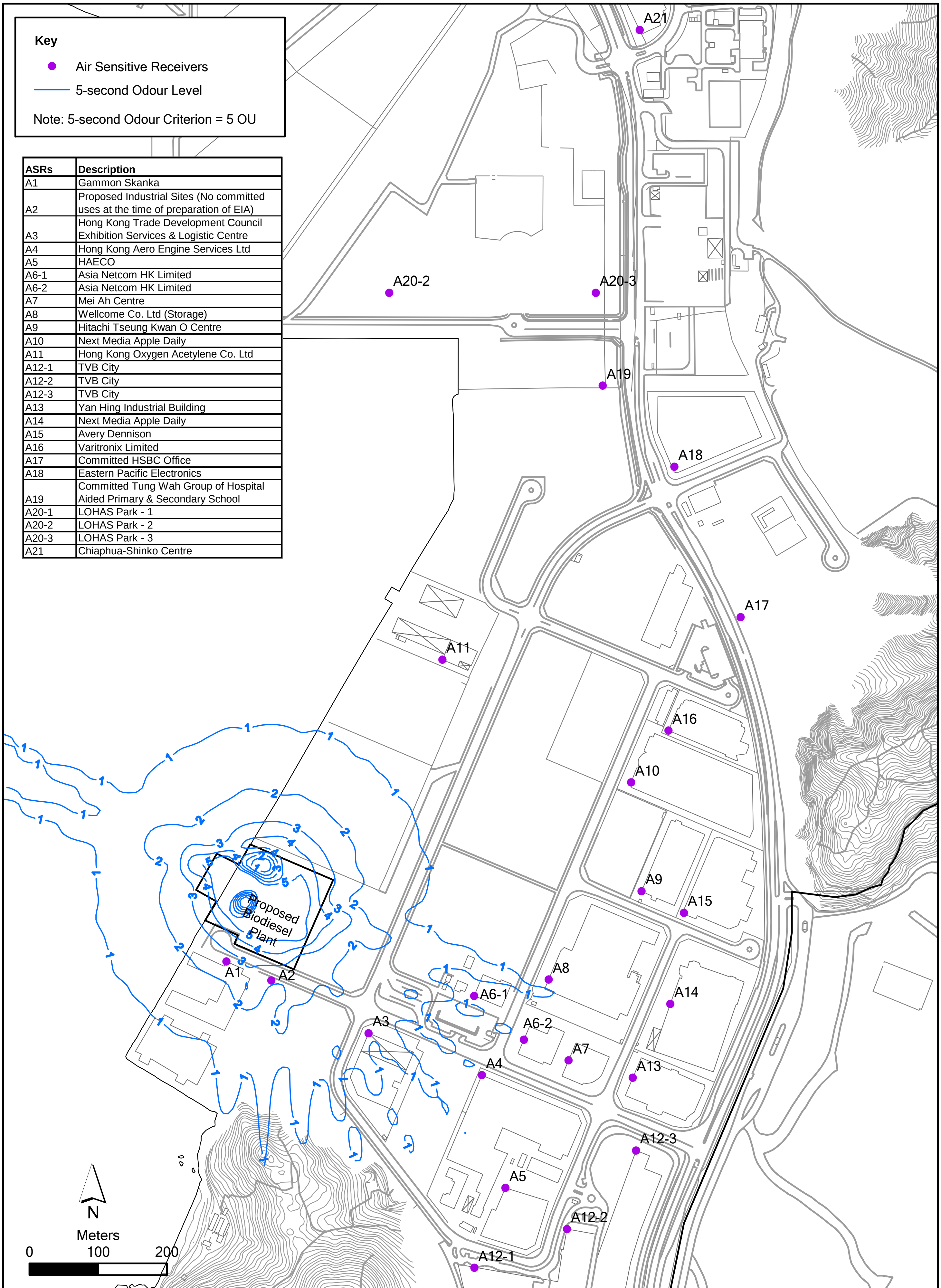
Figure 4.6l

Isopleths showing 5-second Odour Levels at 5m above ground

Environmental Resources Management

ERM

File: 10nov\0077089_4.6l.mxd
Date: 10/11/2008



Key

- Air Sensitive Receivers
- 5-second Odour Level

Note: 5-second Odour Criterion = 5 OU

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6m

Isopleths showing 5-second Odour Levels at 10m above ground

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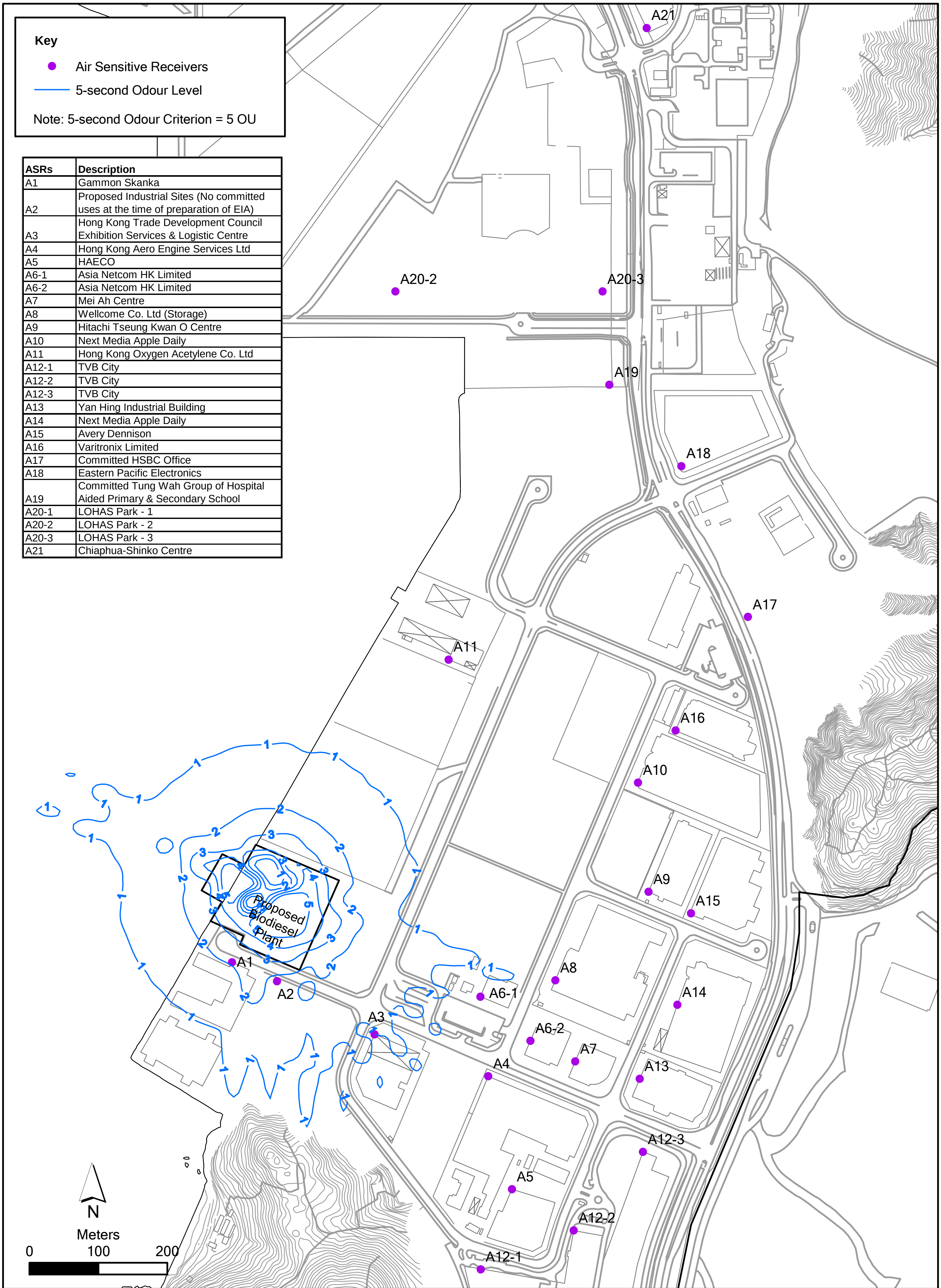

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
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A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
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A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6n

Isopleths showing 5-second Odour Levels at 20m above ground

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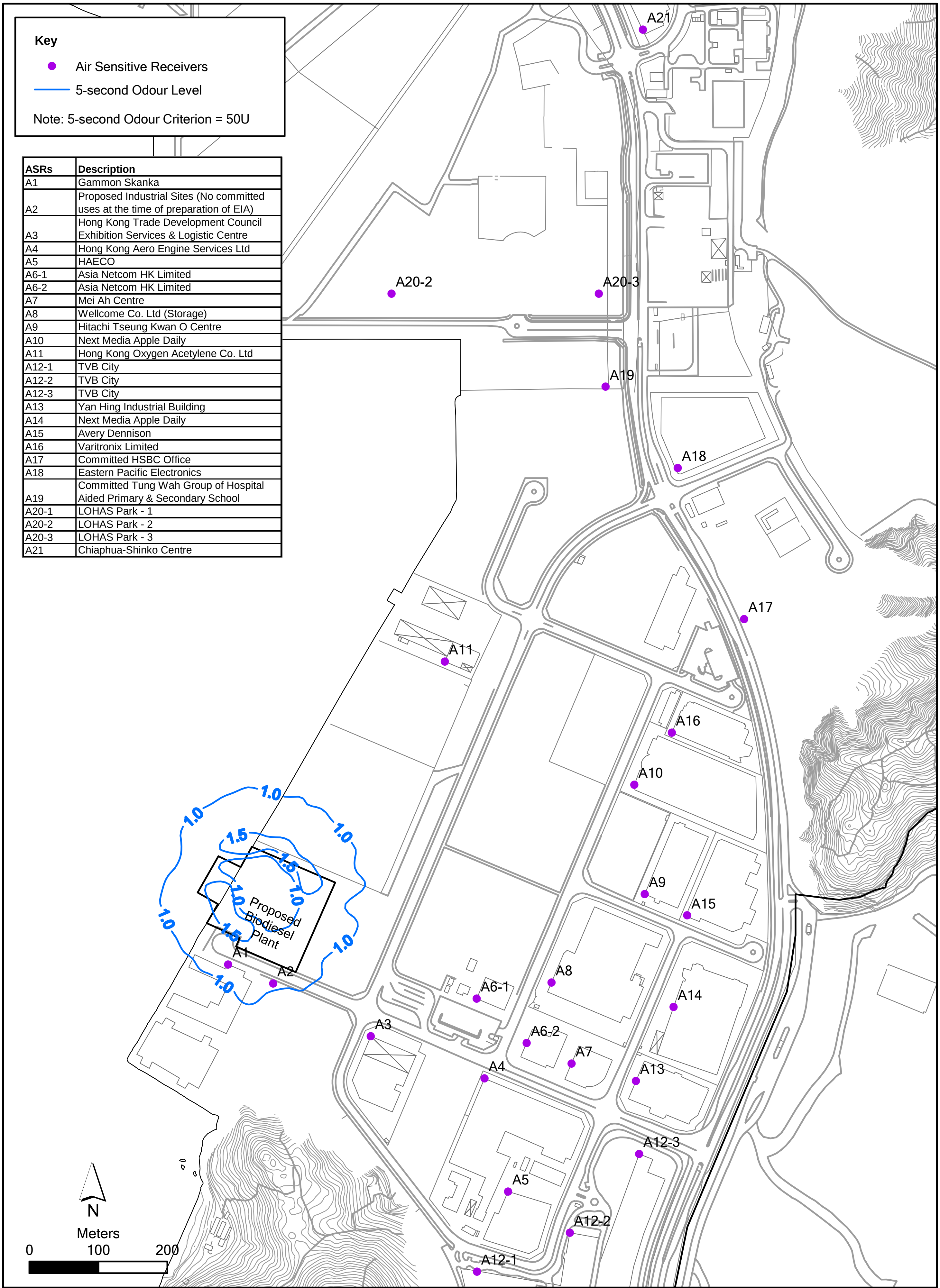

ASRs	Description
A1	Gammon Skanka
A2	Proposed Industrial Sites (No committed uses at the time of preparation of EIA)
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre
A4	Hong Kong Aero Engine Services Ltd
A5	HAECO
A6-1	Asia Netcom HK Limited
A6-2	Asia Netcom HK Limited
A7	Mei Ah Centre
A8	Wellcome Co. Ltd (Storage)
A9	Hitachi Tseung Kwan O Centre
A10	Next Media Apple Daily
A11	Hong Kong Oxygen Acetylene Co. Ltd
A12-1	TVB City
A12-2	TVB City
A12-3	TVB City
A13	Yan Hing Industrial Building
A14	Next Media Apple Daily
A15	Avery Dennison
A16	Varitronix Limited
A17	Committed HSBC Office
A18	Eastern Pacific Electronics
A19	Committed Tung Wah Group of Hospital Aided Primary & Secondary School
A20-1	LOHAS Park - 1
A20-2	LOHAS Park - 2
A20-3	LOHAS Park - 3
A21	Chiaphua-Shinko Centre

Figure 4.6o

Isopleths showing 5-second Odour Levels at 30m above ground

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monthly basis for the first year of the operation. If the results of the first year monitoring meet the limit levels, the monitoring will be reduced to half-year intervals for the operational stage. Exhaust gas temperature and exhaust gas velocity will also be monitored at the same frequency.

Odour concentration at the stack of the final air scrubber will be monitored on monthly basis for the first two years of the operation. Exhaust gas temperature and exhaust gas velocity of the final scrubber will also be monitored at the same frequency.

Odour patrol will be carried out along the Project Site boundary on monthly basis during the first year of the operation of the biodiesel plant. If there is no exceedance of action limit or there is no substantiated odour compliant during the first year of operation, the monitoring frequency will be reduced to quarterly intervals in the second year of the operation. During the second year of operation, if the action level is triggered, the frequency will be resumed to monthly until compliance with the action level for three consecutive months is obtained and the frequency will be reduced to quarterly interval thereafter. If the action level is not triggered for four consecutive quarterly monitoring, the monitoring can be terminated

Detailed monitoring programme and requirements are presented in *Section 9.2*.

4.10 CONCLUSIONS

4.10.1 Construction Phase

The Site has been formed and is currently vacant. No major earthworks will be required for the site formation works and only minor excavation works will be required for the construction of the foundation works and site utilities. The storage tanks and process equipment will be pre-fabricated off-site and assembled on site using hydraulic and tower cranes and hence minimal dust will be generated from this activity. Dust generated from the minor excavation works and concreting works for the construction of site buildings will be minimal. The dust and air emissions generated from the marine works will be minimal.

The jetty will be constructed by piled deck and no dredging of marine sediment will be required. Marine piles will be drilled through the existing rubble mound seawall to competent bearing strata by a piling rig mounted barge. The bored piles will be filled with concrete prior to placement of trellis beam and pre-cast concrete panels. The dust and air emissions generated from the marine works will be minimal.

With the implementation of dust suppression measures stipulated under the *Air Pollution Control (Construction Dust) Regulation* and the adoption of good site practices, no adverse construction dust impact is anticipated. Dust monitoring during the construction phase is therefore considered not necessary.

Monthly site audits will be conducted to ensure the implementation of suitable dust control measures and good site practices during the construction phase.

4.10.2 Operational Phase

The stacks of the boiler and biogas flare (if in operation), and the exhaust of the Process Building are the major emission sources associated with the operation of the biodiesel plant. Nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), non-methane organic compounds (NMOC) are the principal emission of concerns of the boiler and biogas flare stacks, and methanol and acetyldehyde (as one of the impurities of methanol) are the principal emissions of concerns for the exhaust of the Process Building. The assessment indicates that the operation of the proposed biodiesel plant together with the existing air emission sources in the TKOIE, will not cause adverse air quality impacts at the identified ASRs. The predicted concentrations of pollutants are well below the respective criteria.

The potential odour impact due to the discharge of exhaust air from the final air scrubber of the on-site wastewater treatment plant has been evaluated. After scrubbing, the odour concentration will be significantly reduced and will not cause adverse odour impacts to the identified ASRs.

The concentrations of NO_x, CO, SO_2 and NMOC in the flue gas of the stacks of the boiler and biogas flare (if in operation) and the concentrations of methanol and acetyldehyde from the exhaust pipe of process building will be monitored for during the operation of the biodiesel plant.

Odour concentration at the stack of the final air scrubber will be monitored for the first two years of operation of the biodiesel plant and odour patrols along the Project Site boundary will also be carried out to confirm that the operation of biodiesel plant will not cause adverse odour impacts.

With the implementation of proper design, the recommended mitigation measures and monitoring programme, it is concluded that the construction and operation of the biodiesel plant will not cause adverse air quality impacts and will comply with the *EIAO-TM* requirements.

5 NOISE

5.1 INTRODUCTION

This *Section* assesses the potential noise impacts associated with the construction and operation of the proposed biodiesel plant at Tseung Kwan O Industrial Estate (the Project).

5.2 RELEVANT LEGISLATION AND GUIDELINES

5.2.1 Construction Noise

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

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

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

General Construction Works

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

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

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

Notes:
(1) The above standards apply to building uses which rely on opened windows for ventilation.
(2) The above standards shall be viewed as the maximum permissible noise levels assessed at 1m from the external façade.

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

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

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

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

The relevant ANLs for each area sensitivity rating are shown in *Table 5.2c*.

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

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

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

Percussive Piling

Percussive piling is prohibited between 19:00 and 07:00 hrs on any weekday not being a general holiday and at any time on Sunday or general holiday. A CNP is required for carrying out percussive piling between 07:00 and 19:00 hrs on any day not being a general holiday. The *Technical Memorandum on Noise from Percussive Piling* (*PP-TM*) issued under the *NCO* sets out the requirements for working and determination of the permitted hours of operations. The ANLs for percussive piling for different type of NSRs are shown in *Table 5.2d*.

Table 5.2d ***Acceptable Noise Levels for Percussive Piling***

NSR Window Type or Means of Ventilation	Acceptable Noise Levels (dB(A))
NSR (or part of NSR) with no windows or other openings	100
NSR with central air conditioning system	90
NSR with windows or other openings but without central air conditioning system	85

Note:
(a) A 10 dB(A) should be subtracted from the ANLs shown above for NSRs which are hospitals, medical clinics, educational institutes, courts of law or other NSRs which are considered by the Authority to be particularly sensitive to noise.

The CNP may contain permitted hours of operation as a condition with reference to the predicted noise levels at the NSRs.

5.2.2 *Operational Noise*

Fixed Plant Noise

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

Table 5.2e ***ANLs to be used as Fixed Plant Noise Criteria***

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

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

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

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

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

In any event, the ASR assumed in this *EIA Report* is for indicative assessment only. It should be noted that fixed noise sources are controlled under Section 13 of the *NCO*. At the time of investigation, the Noise Control Authority shall determine noise impact from concerned fixed noise sources on the basis of prevailing legislation and practices being in force, and taking account of contemporary conditions / situations of adjoining land uses. Nothing in this *EIA Report* shall bind the Noise Control Authority in the context of law enforcement against any fixed noise source being assessed.

5.3 BASELINE ENVIRONMENTAL CONDITIONS AND NOISE SENSITIVE RECEIVERS

5.3.1 Baseline Environmental Conditions

The Project Site is located in the western part of the Tseung Kwan O Industrial Estate. The nearest existing high-rise residential developments are located at more than 2.6km and 2.4km away in the Eastern District of Hong Kong Island and Tseung Kwan O (TKO), respectively. Background noise levels are typical of a general rural environment and there are limited numbers of vehicles or industrial plant items operating during evening and night-time periods. The major existing noise sources were identified as the general noise from the Tseung Kwan O Industrial Estate and the traffic noise in the vicinity.

5.3.2 Noise Sensitive Receivers

In accordance with the requirements given in Section 3.4.3.2 of the EIA Study Brief, the Study Area for the noise impact assessment covered a distance of 300m from the boundary of the Project Site. The Study Area was extended to include NSRs at distances over 300m from the Project as the proposed biodiesel plant will be operated during night-time period. The area considered in the assessment is shown in *Figure 5.3a*.

Existing NSRs that would potentially affected by the Project are identified as the Island Resort at Siu Sai Wan which is located at more than 2.5km to the south-west of the Project Site boundary, and Oscar By the Sea in Tseung Kwan O which is located at more than 2.2km to the north of the Project Site. Other

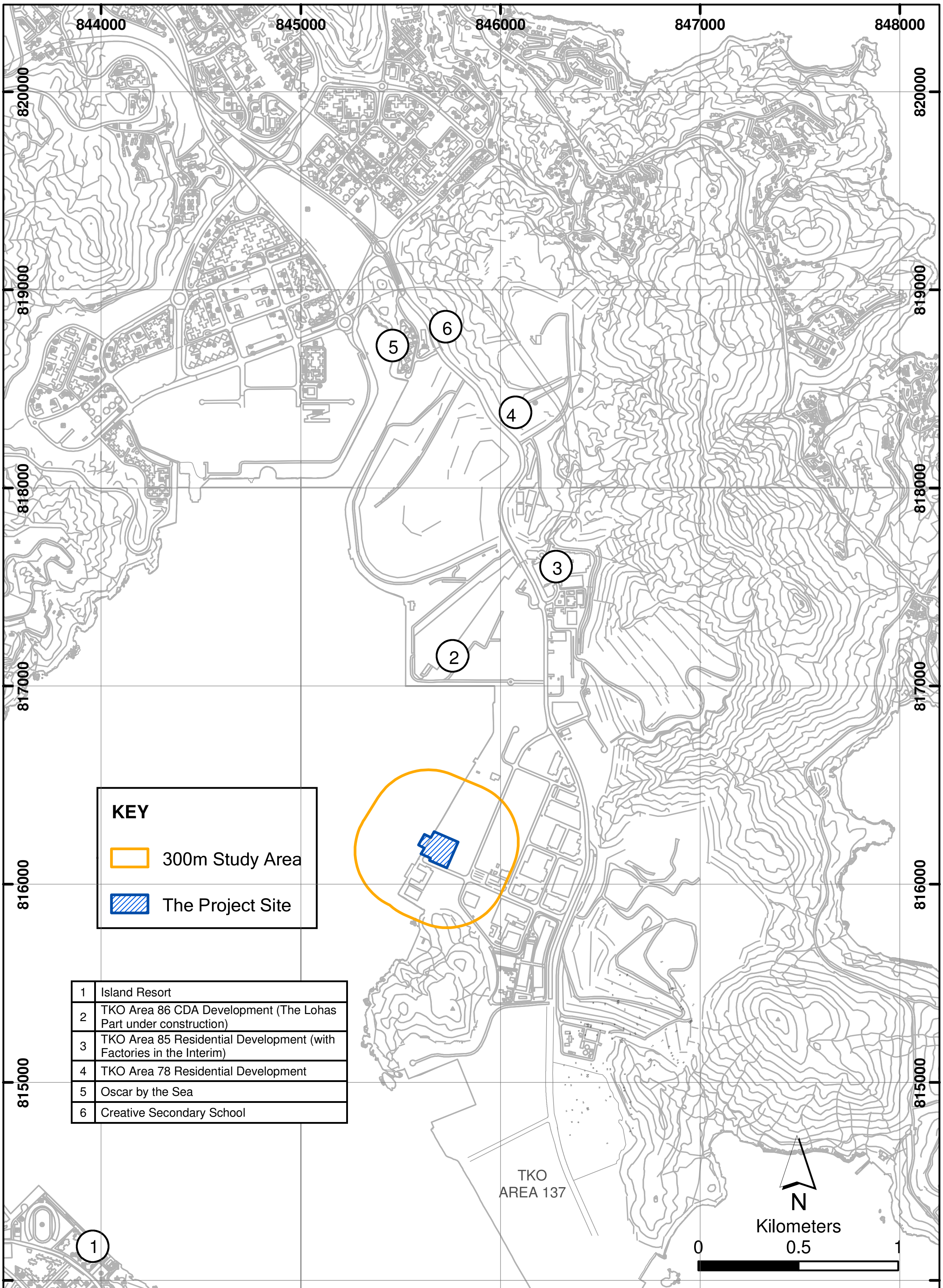

FIGURE 5.3a

The 300m Study Area for Noise Impact Assessment and Representative Noise Sensitive Receivers

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existing NSRs, including residential developments and schools, are located at a further distance away to the north. Planned residential developments and schools in TKO Area 85 and Area 86 are located at more than 800m to the north of the Project Site boundary. The locations of the identified representative NSRs and photographs showing the existing representative NSRs are presented in *Figures 5.3b* and *5.3c*. The locations of the identified representative planned NSRs for assessment are presented in *Figure 5.3d*.

As the NSRs are located in an isolated high-rise development area and are indirectly affected by Wan Po Road or the Tseung Kwan O Industrial Estate, an ASR of "B" was assigned. In consideration of the similar surrounding environment of the South East New Territories (SENT) Landfill and the Project Site in terms of their locations and the potential Influencing Factors, reference was made to a recently approved EIA Report for SENT Landfill Extension [1] on the measured prevailing noise levels, which were 60 dB(A) $L_{eq, 30min}$ and 55 dB(A) $L_{eq, 30min}$ during day-time and night-time, respectively. Therefore, the (ANL – 5) criteria of 60 dB(A) $L_{eq, 30min}$ and 50 dB(A) $L_{eq, 30min}$ for day-time and night-time periods, respectively were considered as the stipulated noise limits for the assessment of operational noise impact from the proposed biodiesel plant.

The identified representative NSRs selected for assessment and the separation distances between the representative NSRs and the Project Site are listed in *Table 5.3a*.

Table 5.3a Representative Noise Sensitive Receivers Selected for Assessment

NSR	Location	Use	No. of Floors	Distance to the Project Site (km) (Approx.)
IR1	Island Resort	Residential	50 - 51	2.5
A86R1 [a]	Planned Residential Development in Area 86 (The Lohas Park)	Residential	40 – 50	0.8
A86S1 [b]	Planned School in Area 86	Institution	7 - 8	0.9
CSS1 [c]	Creative Secondary School	Institution	4 - 6	2.3

Notes:

(a) The first phase of the Lohas Park, Captial, is near completion and is expected to have population intake from June 2009.

(b) Planned NSR A86S1 was selected for operational noise impact assessment only as it is expected that the operation of the school will not be prior to the completion of the construction of the proposed biodiesel plant.

(c) Existing NSR CSS1 was selected for construction noise impact assessment only as the assessment point for NSR A86S1 is located closer to the proposed biodiesel plant than CSS1 for the operational noise impact assessment.

(1) Final EIA Report "South East New Territories (SENT) Landfill Extension" (Register No. EIA-143/2007).

5.4 POTENTIAL SOURCES OF IMPACT

5.4.1 Construction Phase

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

- *Foundation work for Jetty and Buildings* – piling, excavation, transportation of materials and the use of generators and cranes; and
- *Building and civil works* – the use of excavators, cranes, concrete lorry mixers, rollers, lorries and generators.

The construction noise assessment was undertaken based on the proposed construction works programme (see *Figure 3.2f*) and plant inventory presented in *Annex B1*. The plant inventory was reviewed by the Design Engineer and was confirmed to be suitable for completing the proposed biodiesel plant within the scheduled timeframe.

The construction of the building foundation will require percussive piling. However, it will be controlled under the *NCO* and therefore is not included in this assessment.

The normal working hours of the Contractor will be between 07:00 and 19:00 hrs from Monday to Saturday (except public holidays). A CNP will be applied if percussive piling to be conducted between 07:00 and 19:00 hrs on any day other than public holidays. Construction activities during restricted hours are not expected. Should evening and night works between 19:00 and 07:00 hrs of the next day or on public holidays (including Sundays) be required, the Contractor will submit a CNP application which will be assessed by the Noise Control Authority. No percussive piling will be conducted during the restricted hours and on public holidays.

5.4.2 Operational Phase

Fixed Plant Operation

Noise associated with the operational phase of the proposed biodiesel plant will arise from the tank farm, fat preparation plant, steam boiler room, process building, wastewater treatment plant, jetty and the loading/unloading area. The layout plan of the proposed biodiesel plant is shown in *Figure 3.2c*. The dominant noise sources are mainly from the machinery including the following equipment:

- Various kinds of pumps and agitators;
- Cooling tower at roof top of the fat preparation plant;
- Steam boiler plant and thermal fluid heater;
- Compressor, dewatering plant and blower;

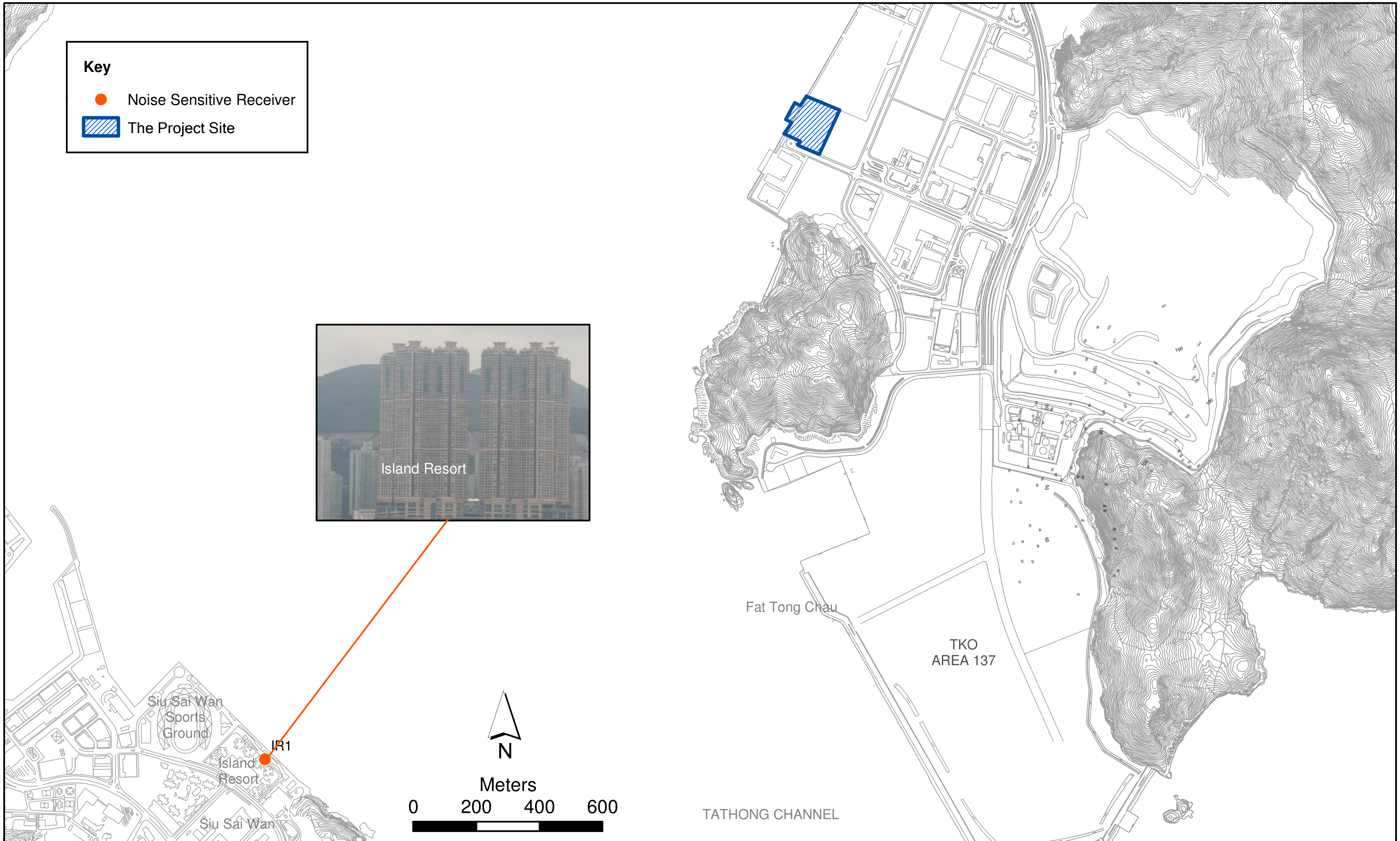

Figure 5.3b

Locations of Existing Noise Sensitive Receivers for Assessment (Page 1 of 2)

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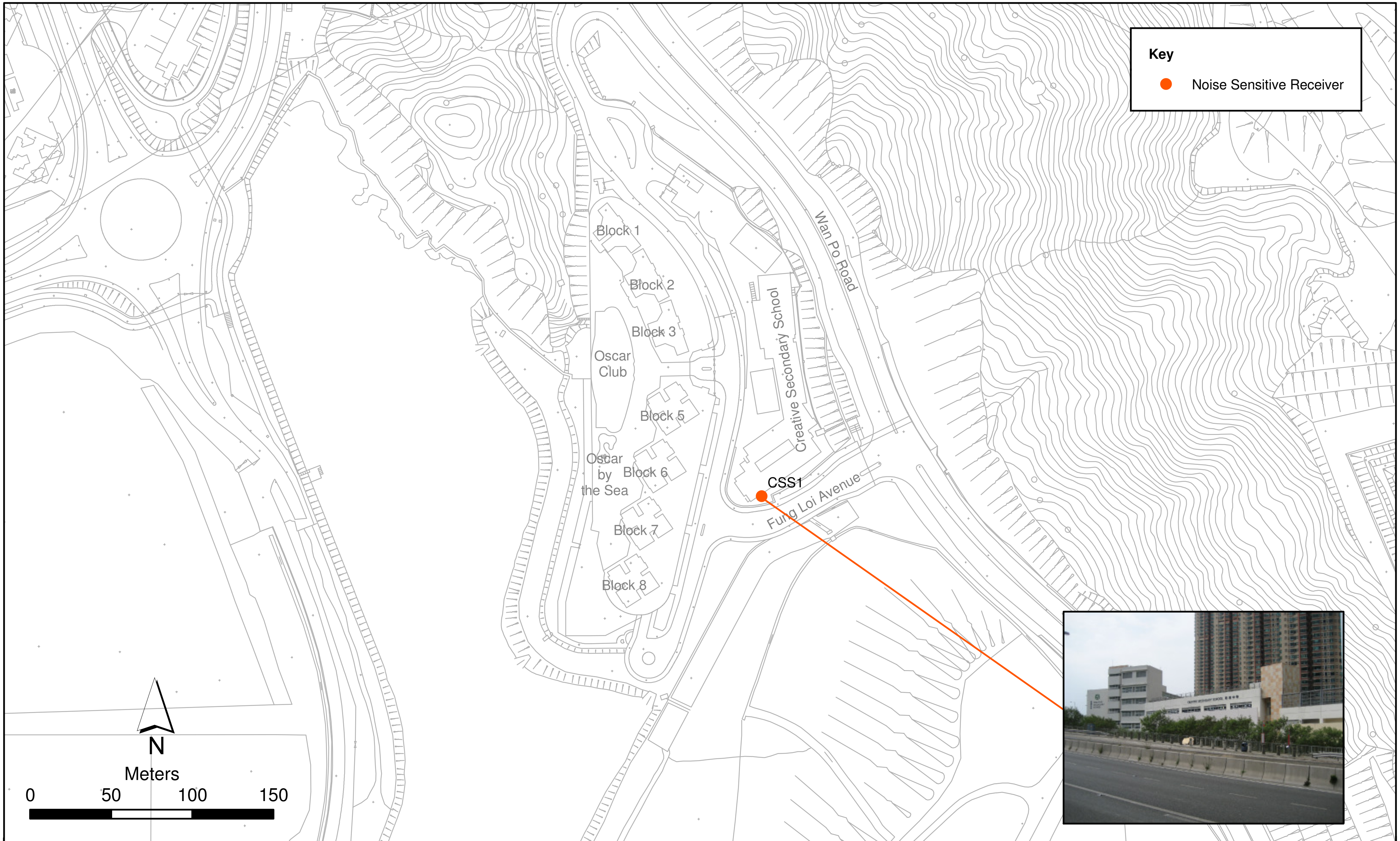

Figure 5.3c

Locations of Existing Noise Sensitive Receivers for Assessment (Page 2 of 2)

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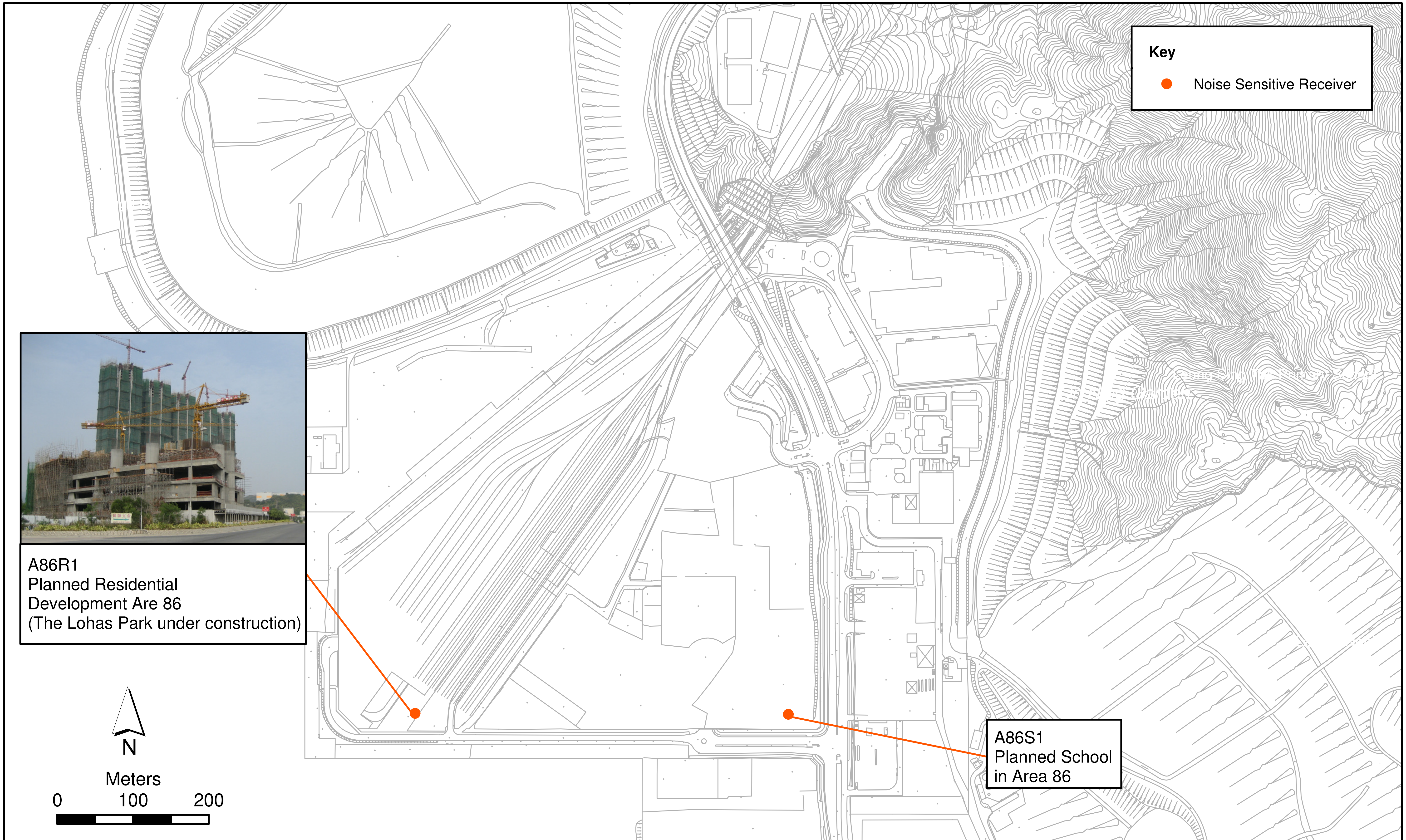

Figure 5.3d

Locations of Planned Noise Sensitive Receivers for Assessment

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- Gantry and barge at the jetty; and
- Loading/unloading of feedstock and products to and from the road tankers.

Appropriate sound power levels (SWL) of the compressor, barge and gantry were made reference to *GW-TM*. The Project Proponent and Design Engineer have confirmed that water cooling tower and air-cooled chiller will be used for the Fat Preparation Plant and site office, respectively. The water cooling tower to be used will have motor power of 30kW, ie equivalent to 40 horsepower (hp). Reference was made to the *Good Practices on Ventilation System Noise Control* to determine the SWL of water cooling tower with 40 hp. The noise levels for other equipment have made reference to the specifications provided by the suppliers and the results of field measurement conducted at overseas biodiesel plants. To minimise the noise impact to the environment, most of the noise sources will be housed within individual enclosures. All outdoor pumps will be provided with complete noise enclosures with no opening facing the LOHAS parks or located within plant rooms. Taking a conservative approach, it is assumed that all equipment will be operated 24-hour per day, except for the air-cooled chiller of the site office which will only be operated during the day-time period.

The specification of the Project will require that all the pumps in the Project and other equipment in the tank farm, steam boiler room, process building and wastewater treatment plant will have a maximum allowable measured free-field SPL of 85 dB(A) at 1 m from each noise source, with no tonality, impulsiveness and intermittency characteristics, and the water cooling tower and air-cooled chiller will have a maximum allowable SWL of 102 dB(A). Pumps, water cooling tower and air-cooled chiller with such specifications are widely available in the market and have been widely adopted in other biodiesel plants over the world (see *Annex B2*). The Project Proponent and Design Engineer have confirmed that the fixed plants and equipment stated in the *EIA Report* will have sufficient capacity and output power for carrying out the intended operation.

The suppliers of pumps should guarantee the specified SPL (ie 85 dB(A)) and the equipment should be free of the characteristics of tonality, impulsiveness and intermittency, by providing a certificate of measurement and verify the SPL during testing and commissioning in accordance with international standard procedures. With such guarantee included in procurement contract, the noise emission from the equipment should comply with the tender specification. If necessary, the suppliers should apply attenuation measures to achieve the guaranteed noise levels determined during the detailed design stage. The process engineers have also confirmed that the proposed equipment is available in the market.

The operation of the proposed biodiesel plant will result in a small increase in traffic to the existing TKO Industrial Estate. As per *Table 3.2b*, the truck trips that will be generated by the Project will be about 186 truck trips per day (including both the number of trucks going in and out of the plant). This truck trip generation is considered insignificant compared with the background traffic on Wan Po Road (Annual Average Daily Traffic (AADT) of 19,860 in 2006 as per the *Annual Traffic Census 2006* prepared by the Transport Department), the operation of the biodiesel plant will contribute an additional 0.9% to background traffic on Wan Po Road. No adverse noise impact due to project-induced traffic during operational phase is therefore expected.

5.5 *ASSESSMENT METHODOLOGY*

5.5.1 *Construction Phase*

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

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

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

5.5.2 *Operational Phase*

Fixed Plant Operation

Noise impact assessment due to on-site operation of the Project was undertaken based on standard acoustic principles as per the requirements of the *EIAO-TM.* The methodology for the fixed plant noise assessment is presented below:

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

- Identify types of equipment and the number of equipment;
- Make reference to the *GW-TM* and *Good Practices on Ventilation System Noise Control* for the SWL of equipment, if available, or employ maximum SPL for the major noise sources that will be specified in the tender specification;
- Identify representative NSRs as defined by the *EIAO-TM* based on existing and committed landuses in the Study Area that may be affected by the Project;
- Calculate the distance attenuation to the NSRs from the noise sources; and
- Present the results in terms of $L_{eq\ (30min)}$ dB(A).

The noise impact due to the operation of the proposed biodiesel plant was assessed and compared with the noise criteria as outlined in *Section 5.2.2*.

5.6 EVALUATION OF IMPACTS

5.6.1 *Construction Phase*

With the large separation distance between the representative NSRs and the Project Site, the predicted construction noise levels at the identified representative NSRs are well within the stipulated construction noise criteria. The representative NSRs will not be adversely affected by the construction of the Project. A summary of the predicted construction noise levels is presented in *Table 5.6a*. Details of the noise calculations are presented in *Annex B3*.

Table 5.6a Predicted Construction Noise Levels at Representative NSRs

NSR	Description	Approx. Horizontal Distance to Notional Source Position(a) (km)	Predicted Construction Noise Levels(b), $L_{eq,\ 30\ min}$ dB(A)
A86R1	Planned Residential Development in Area 86 (The Lohas Park)	0.82	58 - 64
CSS1	Creative Secondary School	2.38	48 – 55
IR1	Island Resort	2.60	48 – 54

Notes:
(a) According to the GW-TM, notional source position refers to the position mid-way between the approximate geographical centre of the construction site and its boundary nearest to the NSR.
(b) All predicted noise levels were corrected with 3dB(A) for façade reflection.
(c) Assessment criteria for construction noise impact are 75 dB(A) for domestic premises, 70dB(A) for educational institution and 65dB(A) during examination periods).

5.6.2 *Operational Phase*

Fixed Plant Operation

The noise levels due to the operation of the proposed biodiesel plant at the representative NSRs were predicted and are summarised in *Table 5.6b*. The predicted noise levels are well within the stipulated day-time and night-time (ANL-5) noise criteria. Details of the noise calculations are presented in *Annex B4*.

Table 5.6b Predicted Operational Noise Levels at Representative NSRs

NSR	Description	Predicted Facade Noise Level[a], $L_{eq, 30 min}$ dB(A)	
		Day-time (07:00 – 23:00hrs)	Night-time (23:00 – 07:00hrs)
A86R1	Planned Residential Development in Area 86 (The Lohas Park)	49	47
A86S1	Planned School in Area 86	48	46
IR1	Island Resort	40	38

Notes:
(a) All predicted noise levels were corrected with 3dB(A) for façade reflection.
(b) According to *EIAO-TM*, day-time and night-time (ANL-5) noise criteria are 60 dB(A) and 50 dB(A), respectively.

Except for the water cooling tower and air-cooled chiller located on roof top, barge and gantry at the jetty and the tankers at the loading/unloading area, all other noisy equipment in the fat preparation plant, wastewater treatment plant, steam boiler room and process building will be located within completely enclosed buildings or provided with complete noise enclosures. The complete noise enclosures will be internally lined with minimum 50mm thick sound absorbing material and will be provided with silencers at outlet and inlet of the enclosure. A noise reduction of 20dB(A) with the provision of complete noise enclosure was included in the noise assessment as per the *Good Practices on Pumping System Noise Control* prepared by EPD.

The water cooling tower and air cooled chiller will be located outdoor on roof top of the fat preparation plant and site office buildings. A 3 dB(A) correction was included in the noise assessment to account for the potential reflection from any nearby hard surface as detailed building layout is not available at this stage. The assessment is therefore conservative.

The Design Engineer confirmed that the operation time for the barge, gantry and the tankers will be about 50% during any 30 minutes [1]. This assumption was included in the noise assessment to present the real operational practice.

(1) After the barge is moored at the jetty, the engine of the barge will be switched off. The materials will be pumped to and from the barge by the on-shore pumps. When the road tanker is parked at the unloading bay, its engine will be switched off and GTW will be discharged from the tanker to the underground tank by gravity.

The noise assessment for fixed plant operation did not take account of the atmospheric absorption. Therefore, the noise levels at the NSRs in real situation will be less than the predicted noise levels presented in *Table 5.6b*.

5.7 MITIGATION MEASURES

5.7.1 Construction Phase

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

- Only well-maintained plant will be operated on-site and plant will be serviced regularly during the construction program;
- Silencers or mufflers on construction equipment will be utilized and will be properly maintained during the construction phase;
- Mobile plant, if any, will be sited as far from NSRs as possible;
- Machines and plant (such as trucks) that may be in intermittent use will be shut down between work periods or will be throttled down to a minimum;
- Plant known to emit noise strongly in one direction will, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and
- Material stockpiles and other structures will be effectively utilised, wherever practicable, in screening noise from on-site construction activities.

5.7.2 Operational Phase

Although no adverse noise impact is expected during the operational phase of the Project, the following measures will be implemented as far as practicable:

- Choose quieter equipment;
- Include noise levels specification when ordering new plant items;
- Locate fixed plant items or noise emission points away from the NSRs as far as practicable;
- Provide complete noise enclosures for all outdoor pumps with no opening facing the LOHAS parks;
- Locate noisy machines in enclosed plant rooms or buildings; and
- Develop and implement a regularly scheduled plant maintenance

programme so that plant items are properly operated and serviced. The programme will be implemented by properly trained personnel.

5.8 *CUMULATIVE IMPACTS*

There will be no other construction activity in the vicinity of the site during the construction of the Project and hence it is expected that no cumulative noise impacts will be resulted.

5.9 *ENVIRONMENTAL MONITORING AND AUDIT*

Given the large separation distance between the identified representative NSRs and the Project Site, and the predicted noise levels at the NSRs during the construction and operational phases are well below the stipulated noise criteria, noise monitoring is not required during construction and operational phases.

5.10 *CONCLUSIONS*

No adverse noise impacts are anticipated at the representative NSRs during the construction and operation of the Project as a result of the implementation of noise control measures in the design of the facility and the large horizontal separation between the identified NSRs and the Project Site. To further minimise the noise impacts, good site practices and noise reduction measures are recommended during the construction and operational phases of the Project. No noise monitoring and audit programme is required.

6 WATER QUALITY ASSESSMENT

6.1 INTRODUCTION

The construction and operation of the Project has the potential to cause adverse water quality impact to the receiving water bodies if not properly managed. This section examines the potential impacts on the nearby water resources due to construction activities (particularly piling works for the jetty), effluent discharge from the on-site wastewater treatment works, surface water runoff and potential spillage of raw materials and biodiesel products. Consideration is given to identify practicable means and/or mitigation measures to avoid marine pollution incidents arising from loading and unloading of materials at the jetty and on-site storage of raw materials and biodiesel products.

6.2 LEGISLATION AND STANDARDS

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

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

6.2.1 Water Pollution Control Ordinance (WPCO)

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

The assessment area (thereafter referred to as the Study Area) is located inside the Junk Bay WCZ and is in close proximity to the Eastern Buffer WCZ (see

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

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

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

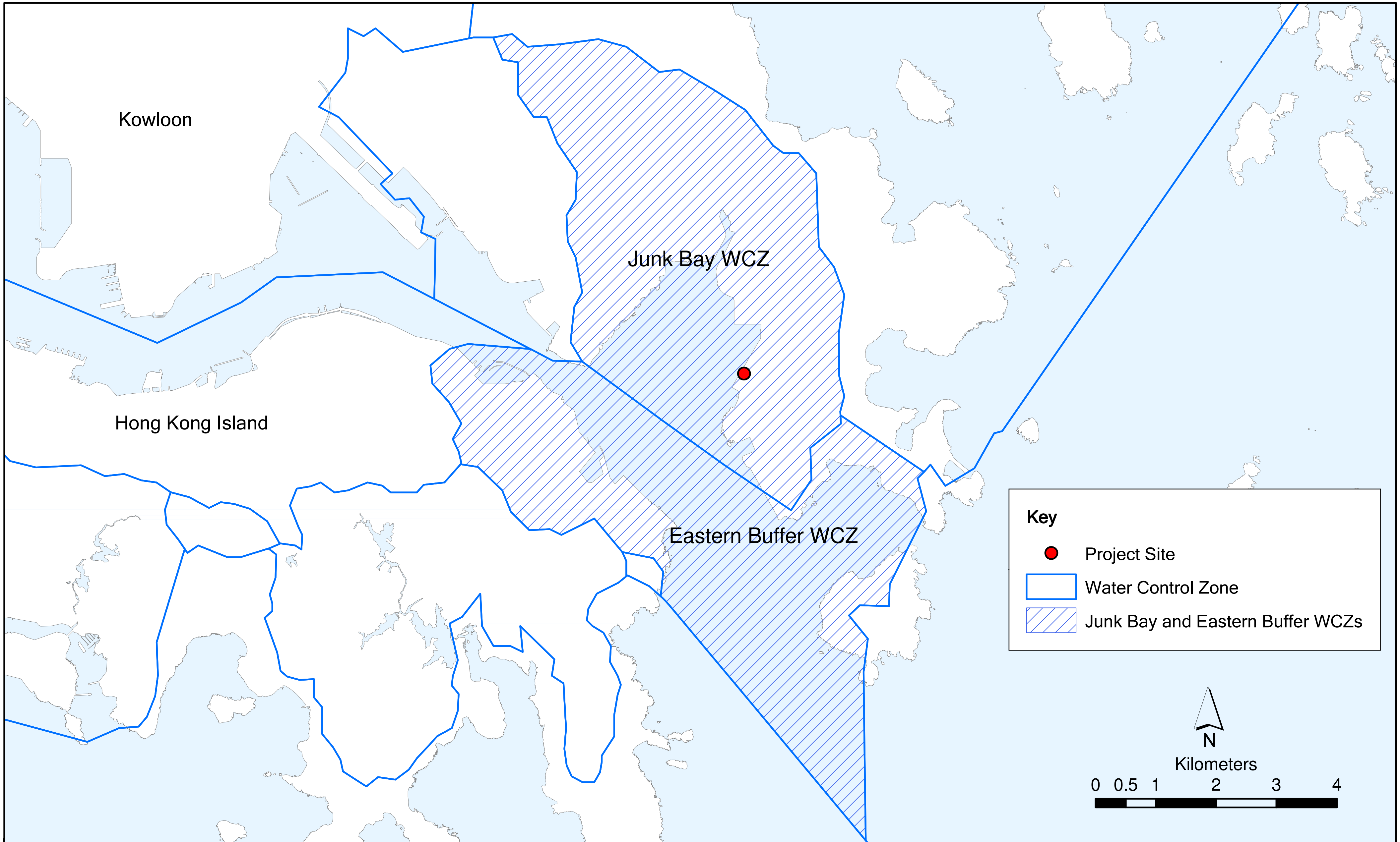

Figure 6.2a

Junk Bay and Eastern Buffer Water Control Zones

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Environmental Resources Management

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6.3 *ASSESSMENT METHODOLOGY*

The Study Area was defined as the area within 500 m of the Project Site boundary.

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

The construction sequence, duration and activities, and the operation activities were reviewed to identify activities with the potential to impact on the identified WSRs and other water courses.

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

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

6.4 WATER QUALITY SENSITIVE RECEIVERS AND BASELINE CONDITIONS

6.4.1 *Existing Conditions*

The Project Site is located at the seafront of the TKOIE which is situated in the southeast of the Tseung Kwan O New Town, Sai Kung District in Hong Kong (see *Figure 6.4a*). The TKOIE was mainly built on reclaimed land.

There are no natural streams and rivers either passing through the Project Site or within the catchment of the Project Site. A few seasonal streams were recorded within Study Area in another catchment near Fat Tong Chau which is located to the south of the Project Site. They are classified as seasonal streams because they were found to have limited water flows during the wet season and no water flows during the dry season. In addition, the Project Site is not situated with the secondary contact recreation area, in accordance with the *WPCO*.

The ecological impact assessment was detailed in *Section 7*. Ecological surveys were conducted along the seawall of the TKOIE and the natural shoreline at Fat Chau Tong. Based on the surveys results, the assessment concluded that there were no species of high ecological value within the Study Area.

6.4.2 *Water Sensitive Receivers (WSRs)*

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

The WSRs identified in the Study Area include:

- Inshore waters in Junk Bay; and
- Surface water including seasonal streams.

6.5 EVALUATION OF IMPACTS DURING CONSTRUCTION PHASE

6.5.1 *Piling Works for the Jetty*

The jetty in a form of piled deck will be constructed (see *Figure 2.2b*) for berthing of marine vessels. No dredging of marine sediment will be required for the construction of the jetty. Marine piles will be driven through the existing rubble mound seawall (see *Figure 2.2c*) to competent bearing strata by

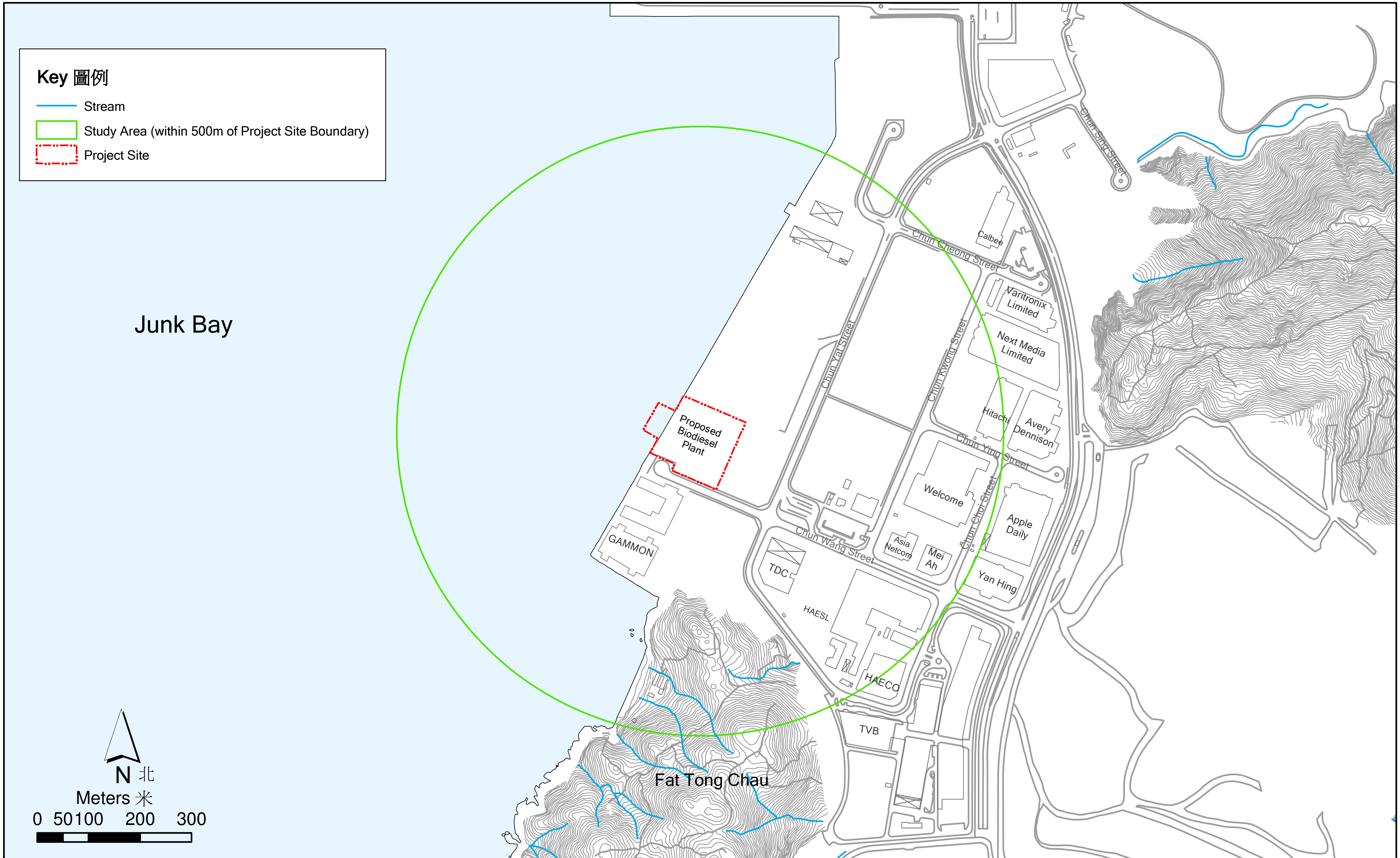

Figure 6.4a

Surrounding Environment within 500m of the Project Site

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Environmental Resources Management

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a hydraulic hammer piling barge. During the construction of the existing rubble mound seawall, the sediments below the seawall have been removed and backfilled with marine sand. The materials to be excavated from the bore pile will consist of rock and sand. No sediment will be excavated.

A temporary working platform will be constructed by placing steel piles on the seawall and then welding steel planks on top. The casing of the pile will be drilled through the existing seawall to the rock head. The rock fill will be removed and the marine sand will be airlifted under pressure through the top of the casing and channelled to a sedimentation tank located on land. The top of the casing will be covered with canvas to prevent spillage of material during removal of the sand fill. After settling the sands, the effluent will be discharged to stormwater drain. A disposal license will be applied under the *Water Pollution Control Ordinance* (WPCO) for the discharge and the licence conditions will be complied with prior to discharge. The settled sand will be reused on-site.

Silt curtain will be installed around the marine piling area to contain any suspended mud and sediments generated during the piling works. It is expected that the marine piling will cause limited disturbance to the existing seawall and is unlikely to cause unacceptable impacts to the water quality in Junk Bay. It should be noted that once the pile is driven into the seawall, the removal of rock/sand will be confined within the pile and this operation will not cause adverse water quality impact.

Concrete infill to piles will be undertaken prior to placement of trellis beam and pre-cast concrete panels. It is estimated that the construction of the jetty will take about 6 months, including 2 months for pile installation and 4 months for jetty deck construction.

6.5.2 Sewage and General Refuse generated by Workforce

Sewage and general refuse will be generated from construction workforces. 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. Recyclable materials (ie paper, plastic bottles and aluminium cans) will be separated for recycling as far as possible, in order to reduce the amount of general refuse to be disposed of at landfill. An adequate number of enclosed waste containers will be provided on-site to ensure waste is fully contained. No adverse water quality impacts associated with the handling and disposal of sewage and general refuse generated by the construction workforce are envisaged.

6.5.3 Surface Runoff and Drainage

Construction site runoff will be the major source of water quality impacts associated with the land based construction activities. As discussed in *Section 3.3.2*, the construction of the biodiesel plant will only involve minor earthworks.

The construction of the superstructure has a low risk of generating contaminated runoff since drainage systems will be well established before the commencement of construction works and as portable toilets will be used and will be serviced regularly by a 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.

6.6 EVALUATION OF IMPACTS DURING OPERATION PHASE

6.6.1 *Presence of Jetty*

The proposed jetty (50 m long and 26 m wide) will have a reinforced concrete deck and will be supported by marine piles. A total of about 60 piles, of approximate diameter of 1m, will stand underneath the deck of the berthing facility. The cross-sectional area of each pile underwater has been estimated at 0.8 m^2 and the depth underwater will be in the range 10 m to 12 m. It is estimated that the volume of each pile underwater will be in the range 8 m^3 to 9.6 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. In view of the small cross-sectional area occupied by the piles, the closeness to the shore, and an average and maximum current speeds at the study area of about 0.07 m s^{-1} and 0.37 m s^{-1} respectively (1), the marine piles will not have adverse impact to the hydrodynamic system or marine water flow regime at the jetty during the operational phase. The layout of the marine piles and the jetty is designed to minimise influence to the seawater flow around the jetty.

The maximum draft of the loaded barges (1,000 tonne barges) for the transportation of biodiesel, PFAD and methanol is about 4m. The water depth at the jetty is about 10m (see *Figure 2.2c*) and therefore there will be sufficient water depth for the access of the barges without the need to dredging during operation.

6.6.2 *Wastewater Generated From the Operation of the Facility*

With reference to other biodiesel plants of similar scale, the number of personnel for the operation of the proposed biodiesel plant will be approximately 20 during the day and 8 at night. If necessary, additional personnel will be hired for maintenance and repair works. The small amount of sewage generated by the site staff (a maximum of about 1.5 m^3 per day (2)) will be collected and discharged to the foul sewer of the TKOIE which leads to the TKO Sewage Treatment Works.

(1) Hong Kong Tidal Stream Atlas 2006.

(2) Based on 55 litres per worker per day.

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 the glycerine dewatering processes. As advised by the Hong Kong Science and Technology Parks Corporation [(1)], the capacity of the sewerage system of the TKOIE is in excess of 20,000 m^3 d^{-1} and hence will have sufficient capacity to handle the anticipated flow of the effluent discharged from the plant (ie daily discharge of 515 m^3 d^{-1} from the Project which is about 2.6% of the existing capacity). It should be noted that a number of land lots at the TKOIE have not been occupied. In addition, the discharge of the treated effluent could be carried out on a continuous basis so that the flow will be minimal (about 6 litres/sec). The effluent discharge from biodiesel plant will not have an adverse impact on the downstream sewers. A review by the Design Engineer shows that the foul sewers downstream of the biodiesel plant will have sufficient capacity to handle the hourly flow of the effluent discharge from the wastewater treatment plant.

The wastewater generation from the biodiesel pre-treatment and production processes will contain trace amounts of oils and fats (such as triglycerides and free fatty acids) and will have a high COD concentration (about 9,400 mg L^{-1} 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 that 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.

(1) Hong Kong Science and Technology Parks Corporation confirmed on 27 May 2008.

All wastewaters generated from the site (including the wastewater from the GTW pre-treatment, process water from biodiesel production and wash water from the GTW reception area [1], 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 resulting from the operation of the biodiesel plant is anticipated.

6.6.3 *Surface Runoff and Drainage*

The operation of the biodiesel plant has the potential to cause adverse water quality impacts if site runoff, wastewater and material storage are not properly managed. The following control measures have been incorporated in the design of the plant.

Control of Leakages from the Tank Farm /Process Building

Bund wall will be provided at the tank farm (including the storage tank of the raw materials/products) and the process tanks within the Process Building to contain any spillage of materials (the wall is designed to hold 110% of the largest tank) within the bunded area. The floor of the bunded area will also be paved with concrete and coated with waterproofing material. It will effective prevent any spill from seeping into the soil. The bunded area will be provided with a sump pit(s) with a manually controlled valve/penstock which is normally close. All surface water discharged from the bunded area will pass through an oil interceptor. No surface water will be automatically drained from the bunded area.

Stormwater runoff of the bunded area (see *Figure 3.2f*) will pass through an oil interceptor (see *Figure 3.2i*) before discharge into the stormwater drainage system of the TKOIE (see *Figure 3.2h*).

During rainstorm, the valve of the sump pit of the bunded area of the tank farm will be manually open to allow an appropriate flow to pass through the oil interceptor. The water discharged from the oil interceptor will be checked to ensure that the effluent comply with the discharge standards prior discharge to the stormwater system.

The sump pit will also be equipped with a level switch instrument to detect the water level. The sensor will be connected to an alarm of the PCS-system. Spill/leak within the bunded area will be cleaned up immediately. If a large

(1) The quantity of wastewater to be generated from the washing of the GTW Reception Area (including the unloading area and the Technic Room) is estimated as follows: (a) low water consumption, high pressure water jet machine will be used for the washing (water consumption rate of about 80 litres/min); (b) the GTW unloading area and the Technic Room will be washed once a day for about 15 minutes; (c) wastewater generation = 80 litres/min x 30 minutes sec/minute = 2.4 m^3 per day. This wastewater will be negligible comparing to the volume of the wastewater to be generated from the GTW pre-treatment process. As the anticipated GTW volume received at the site is conservative, the wastewater engineer has confirmed that the design capacity of the wastewater treatment plant will be able to accommodate this small flow of wastewater.

spill/leak is detected, the materials will be pumped out and reuse, where appropriate. Otherwise the material will be disposed of as a chemical waste to the Chemical Waste Treatment Centre. If the leak is from the GTW and WCO storage tanks, the materials will be pumped to other GTW storage tank or to the wastewater treatment plant for treatment.

All storage tanks will be hydro-tested with water (according the designed test pressure) before used. The tanks will be provided with leak detection system. The integrity of the tanks will be inspected regularly in accordance with relevant building regulations.

Control of Leakages from the Pipe Bridge

After installation, the pipelines will be tested (pressure test with water). There will be no connection (eg flanges and valves) on the pipe bridge as the pipes on the pipe bridge will be welded. Flanges and valves will only be located within/above a bunded area (eg Process Building, tank farm, Technic Room). The pipeline will be visual inspected on a regularly basis.

To prevent the pipe bride against any traffic collisions, the bottom line of the bridge will be at least 4.5m above ground level. At the site entrance, a "height check/control" will be installed to ensure that vehicles taller than 3m will not been allowed to enter the site unless it is escorted by senior site operator. The columns of the pipe bridge at the street level will be protected by barriers and sufficient clearance from the road.

Control of Pollution during Loading/Unloading Operations at the GTW Unloading Area and Jetty

At the GTW loading and unloading stations, the following control measures will be implemented:

- Dry couplings will be used to connect the pipes with the truck or barge;
- The GTW unloading area will be paved with concrete and the drainage will be separated from the stormwater drainage system. The drainage will be connected to the wastewater treatment plant. For the unloading area at the jetty area, gate valve of the sump pit of the bunded area of the dry coupling will be closed to ensure any spillage will be contained and collected. This avoids direct discharge of any spill to the stormwater drainage system.
- Emergency stops of loading and unloading will be installed at all stations.
- The loading and unloading operation is carried out by trained staff personnel.

With the implementation of the proposed pollution control measures and site drainage, no adverse water quality impacts arising from site runoff, wastewater and material storage are expected.

6.6.4 *Spillage of Raw Materials and Biodiesel Plants*

There is potential for spillage of biodiesel, PFAD and methanol during the loading/unloading operations at the jetty area. Dry coupling will be used to connect two loading/unloading pipes or a flexible hose to a transfer pipe in order to avoid any leakage of the materials at the joint. The loading/unloading area will be bunded to contain any potential spillage of materials. In addition, 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 contained and the spill be absorbed by appropriate absorbents. The area will be properly washed and the wastewater will be conveyed to the on-site wastewater treatment plant for treatment.

For accidental spills that could occur during transportation of biodiesel from the site, retainer booms will be used to create a warp around the barge and the contaminated areas to prevent the spillage spreading. Unlike other petroleum products, the raw materials and biodiesel products are biodegradable and potential impacts arising from a small amount of uncaptured spilled materials to the marine environment will be minimal.

An outline emergency response plan related to prevention of pollution is presented in *Annex F*. A detailed emergency response plan will be developed prior to the commencement of the operation of the biodiesel plant. In case of accidental spills, the emergency response plan will be implemented to confine the area affected and clean up the spillage immediately, hence minimising potential impacts on the marine environment.

6.7 *MITIGATION MEASURES*

Proposed mitigation measures for containing and minimising water quality impacts are summarised below.

6.7.1 *Construction Phase*

Piling Activities

Silt curtain will be installed around the marine piling area to contain any suspended mud and sediments generated during the piling works. Silt removal facilities such as silt traps or sedimentation facilities will be provided to remove silt particles from groundwater (if pumping is required) (1) to meet the requirements of the *TM* standard under the *WPCO*. The design of silt removal facilities will be based on the guidelines provided in *ProPECC PN 1/94*. All drainage facilities and erosion and sediment control structures will be inspected monthly and maintained to ensure proper and efficient operation at all times and particularly during rainstorms.

(1) H-piles will be used for the construction of the building foundations, it is therefore not anticipated that pumping of groundwater will be required for the construction works.

Construction Site Run-off and Drainage

Good site practices outlined in *ProPECC PN 1/94* "*Construction Site Drainage*" will be followed as far as practicable in order to minimise surface runoff and the chance of erosion, and also to retain and reduce any suspended solids prior to discharge. These practices include the follows:

- Silt removal facilities such as silt traps or sedimentation facilities will be provided to remove silt particles from runoff to meet the requirements of the *TM* standard under the *WPCO*. The design of silt removal facilities will be based on the guidelines provided in *ProPECC PN 1/94*. All drainage facilities and erosion and sediment control structures will be inspected monthly and maintained to ensure proper and efficient operation at all times and particularly during rainstorms.

- Careful programming of the works to minimise surface excavations for the construction works during the wet season. If excavation of soil cannot be avoided during the wet season, exposed slope surfaces will be covered by a tarpaulin or other means. Other measures that need to be implemented before, during, and after rainstorms are summarised in *ProPECC PN 1/94*.

- Exposed soil surfaces will be protected by paving or fill material as soon as possible to reduce the potential of soil erosion.

- Open stockpiles of construction materials or construction wastes on-site of more than $50m^3$ will be covered with tarpaulin or similar fabric during rainstorms. These materials will not be placed in the seawall area.

General Construction Activities

- Debris and refuse generated on-site will be collected, handled and disposed of properly to avoid entering the nearby WSRs. Stockpiles of cement and other construction materials will be kept covered when not being used.

- Oils and fuels will only be used and stored in designated areas which have pollution prevention facilities. All fuel tanks and storage areas will be provided with locks and be sited on sealed areas, within bunds of a capacity equal to 110% of the storage capacity of the largest tank. The bund will be drained of rainwater after a rain event.

Sewage generated from On-site Workforce

- Temporary sanitary facilities, such as portable chemical toilets, will be provided on-site. A specialised contractor will be responsible for regular collection and appropriate disposal of the sewage and maintenance of these facilities.

6.7.2 *Operational Phase*

Accidental Spillage of Raw Materials and Biodiesel Products

Should a spill arise, the following actions will be taken:

- *Within the loading/unloading area*: The bunded loading and unloading area will be paved with an impermeable surface and spills will be contained by appropriate absorbent materials. The spill area will be properly washed. The contaminated wastewater will be transferred to the on-site wastewater treatment plant for treatment.

- *Spillage on site:* The spill will be contained and removed by using appropriate absorbent or dispersant. The spillage area will be cleaned up immediately. The wastewater will be collected and treated at the on-site wastewater treatment plant.

- *During transportation*: Retainer booms will be used to create a wrap around the barge and the contaminated areas to prevent the spillage spreading. Absorbents will be used to absorb the waste in the confined area.

An outline emergency response plan is presented in *Annex F* which forms the based for a detailed plan which will be developed prior to the commencement of the operation of the biodiesel plant. The detailed plan will stipulate the detailed actions to be taken in case accidental spills occurred and prevent any spillages from discharge into the sea.

The training for the staff will include all possible risks, which can be occurred when handling different materials (eg methanol, acids and bases, biodiesel, etc) and the necessary clean up procedures. Training will make reference to the MSDS (Material safety data sheets) so that the staff will be fully conversant with the potential risks and environmental implications associated with spillage of materials.

6.8 *CUMULATIVE IMPACTS*

There will be no other construction activity in the vicinity of the site during the construction of the Project and hence it is expected that there will be no cumulative impacts on the surrounding water bodies.

The capacity of the sewerage system in the TKOIE is in excess of 20,000 $m^3 d^{-1}$ and can therefore accommodate the daily discharge of 515 $m^3 d^{-1}$ of treated effluent from the Site (1) during operation. The Project is hence unlikely to contribute to cumulative water quality impacts with other plants operating during this period.

(1) Hong Kong Science and Technology Parks Corporation confirmed on 27 May 2008.

6.9 RESIDUAL IMPACTS

With the full implementation of the recommended mitigation measures for the construction and operational phases of the Project, no unacceptable residual impacts on water quality are expected. It is recommended that regular site audits of the implementation of the recommended mitigation measures be undertaken during the construction phase.

6.10 ENVIRONMENTAL MONITORING AND AUDIT

The impact assessment indicates that there will be no adverse water quality impacts on the WSRs within the Study Area. Environmental monitoring of water quality during the construction phase is therefore not required. Monthly site inspections will be carried out during construction to ensure that the mitigation measures listed above are properly implemented. The site audit frequency will be increased to weekly intervals during the piling works.

During the operation phase, the quality of the stormwater/effluent will be monitored at the terminal manholes of the stormwater and foul water drainage systems on a monthly basis. Parameters to be monitored will include:

- Stormwater discharge from the site: oil and grease and suspended solids; and

- Treated effluent from the wastewater treatment plant: Parameters listed in Table 1 of the Technical Memorandum on Standards for Effluents Discharged to Drainage and Sewerage Systems, Inland and Coastal Water or those specified in the *WPCO* licence.

6.11 CONCLUSIONS

6.11.1 Construction Phase

The construction works for the Project will mainly be land-based and the construction for the jetty will involve piling activities. Water quality impacts will be minimal during the construction phase of the Project provided that good practices are implemented. No water quality monitoring is thus considered necessary during the construction phase. Nevertheless, monthly site inspections will be undertaken to ensure that the recommended mitigation measures are properly implemented.

6.11.2 Operational Phase

During the operation of the biodiesel plant, a surface water drainage system will be provided to collect the road runoff and to facilitate drainage of runoff during rainstorms. The stormwater runoff from the bunded area will be intercepted and passed through an oil interceptor prior to discharge off-site. Sewage generated by the site workforce will be collected and discharge to the foul sewer. Wastewater generated from the GTW pre-treatment works and biodiesel process will be collected and treated at the on-site wastewater treatment plant prior to discharge to the foul sewer leading to the TKO Sewage Treatment Works. A detailed emergency response plan will be developed to set out the actions to be taken in case a spillage occurs and prevent any spillages from discharging into the sea. Based on the above and with the provision of appropriate mitigation measures, no adverse water quality impacts are anticipated. To ensure compliance with the effluent discharge standards, the quality of the stormwater/effluent will be monitored at the terminal manholes of the stormwater and foul water drainage systems on a monthly basis.

7 MARINE ECOLOGICAL ASSESSMENT

7.1 INTRODUCTION

This section presents the baseline condition of ecological resources within the Study Area [1], and findings of the marine ecological impact assessment associated with the construction and operation of the Project. Measures required to mitigate any identified adverse impacts are recommended, where appropriate.

7.2 RELEVANT LEGISLATION AND GUIDELINES

The criteria for evaluating marine ecological impacts are laid out in the *EIAO-TM* as well as the EIA Study Brief (No. ESB-126/2005). *Annex 16* of the *EIAO-TM* sets out the general approach and methodology for the assessment of marine ecological impacts arising from a project or proposal. This assessment allows a complete and objective identification, prediction and evaluation of the potential marine ecological impacts. *Annex 8* of the *EIAO-TM* recommends the criteria that can be used for evaluating marine ecological impacts.

Legislative requirements and evaluation criteria relevant to the study for the protection of species and habitats of marine ecological importance are:

- *Marine Parks Ordinance (Cap 476);*
- *Wild Animals Protection Ordinance (Cap 170);*
- *Protection of Endangered Species of Animals and Plants Ordinance (Cap 586);*
- *Town Planning Ordinance (Cap 131);*
- *Hong Kong Planning Standards and Guidelines Chapter 10 (HKPSG);*
- *The Technical Memorandum on Environmental Impact Assessment Process under the Environmental Impact Assessment Ordinance (EIAO-TM);*
- *United Nations Convention on Biodiversity (1992);*
- *Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention);* and
- *PRC Regulations and Guidelines.*

Details on each of the above are presented below.

(1) Area includes 500m from the Project Site boundary.

7.2.1 *Marine Parks Ordinance (Cap 476)*

The *Marine Parks Ordinance* provides for the designation, control and management of marine parks and marine reserves. It also stipulates the Director of Agriculture, Fisheries and Conservation as the Country and Marine Parks Authority which is advised by the Country and Marine Parks Board. The *Marine Parks and Marine Reserves Regulation* was enacted in July 1996 to provide for the prohibition and control certain activities in marine parks or marine reserves.

7.2.2 *Wild Animals Protection Ordinance (Cap 170)*

Under the *Wild Animals Protection Ordinance* (Cap 170), designated wild animals are protected from being hunted, whilst their nests and eggs are protected from destruction and removal. All birds and most mammals including all cetaceans are protected under this Ordinance, as well as certain reptiles (including all sea turtles), amphibians and invertebrates. The Second Schedule of the Ordinance that lists all the animals protected was last revised in June 1997.

7.2.3 *Protection of Endangered Species of Animals and Plants Ordinance (Cap 586)*

The *Protection of Endangered Species of Animals and Plants Ordinance* (Cap 586) was enacted to align Hong Kong's control regime with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). With effect from 1 July 2006, it replaces the *Animals and Plants (Protection of Endangered Species) Ordinance* (Cap 187). The purpose of the *Protection of Endangered Species of Animals and Plants Ordinance* is to restrict the import and export of species listed in CITES Appendices so as to protect wildlife from overexploitation or extinction. The Ordinance is primarily related to controlling trade in threatened and endangered species and restricting the local possession of them. Certain types of corals are CITES listed, including Blue coral (*Heliopora coerulea*), Organ pipe corals (family Tubiporidae), Black corals (order Antipatharia), Stony coral (order Scleractinia), Fire corals (family Milleporidae) and Lace corals (family Stylasteridae). The import, export and possession of listed species, no matter dead or living, is restricted.

7.2.4 *Town Planning Ordinance (Cap 131)*

The recently amended *Town Planning Ordinance* (Cap 131) provides for the designation of areas such as "Coastal Protection Areas", "Sites of Special Scientific Interest (SSSIs)", "Green Belt" and "Conservation Area" to promote conservation or protection or protect significant habitat.

7.2.5 *Hong Kong Planning Standards and Guidelines Chapter 10 (HKPSG)*

Chapter 10 of the *HKPSG* covers planning considerations relevant to conservation. This chapter details the principles of conservation, the conservation of natural landscape and habitats, historic buildings, archaeological sites and other antiquities. It also addresses the issue of enforcement. The appendices list the legislation and administrative controls for conservation, other conservation related measures in Hong Kong, and Government departments involved in conservation.

7.2.6 *Technical Memorandum on Environmental Impact Assessment Process under the Environmental Impact Assessment Ordinance*

Annex 16 of the *EIAO-TM* sets out the general approach and methodology for assessment of ecological impacts arising from a project or proposal, to allow a complete and objective identification, prediction and evaluation of the potential ecological impacts. *Annex 8* recommends the criteria that can be used for evaluating ecological impacts.

7.2.7 *Other Relevant Legislation*

The Peoples' Republic of China (PRC) is a Contracting Party to the *United Nations Convention on Biological Diversity* of 1992. The Convention requires signatories to make active efforts to protect and manage their biodiversity resources. The Government of the Hong Kong Special Administrative Region (HKSAR) has stated that it will be "committed to meeting the environmental objectives" of the Convention (PELB 1996).

The *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (the Ramsar Convention) applies in the HKSAR. The Convention requires parties to conserve and make wise use of wetland areas, particularly those supporting waterfowl populations. Article 1 of the Convention defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." The Mai Po/Inner Deep Bay wetland was declared a Wetland of International Importance ("Ramsar site") under the Convention in 1995.

The PRC in 1988 ratified the *Wild Animal Protection Law* of the PRC, which lays down basic principles for protecting wild animals. The Law prohibits killing of protected animals, controls hunting, and protects the habitats of wild animals, both protected and non-protected. The Law also provides for the creation of lists of animals protected at the state level, under Class I and Class II. There are 96 animal species in Class I and 156 in Class II. Class I provides a higher level of protection for animals considered to be more threatened.

7.3 *STUDY AREA FOR THE MARINE ECOLOGICAL IMPACT ASSESSMENT*

With reference to the footprint of the proposed biodiesel plant and the results of water quality assessment (see *Section 6*), any potential direct or indirect impacts to marine ecological sensitive receivers that may be caused by construction and operation of the Project are likely to occur within 500 m from the Project Site boundary. Therefore, the Study Area of the *Marine Ecological Impact Assessment* is defined as the area within a 500 m radius of the Project site boundary to ensure adequate coverage for the purpose of assessment

(*Figures 7.6a* and *7.6b*). The Study Area consisted of both artificial shoreline of the TKOIE and natural shoreline of Fat Tong Chau. Information on marine ecological resources within the Study Area is extracted from relevant literature and past marine ecological surveys within Tseung Kwan O, which are subsequently used for the *Marine Ecological Impact Assessment*.

7.4 LITERATURE REVIEW OF MARINE ECOLOGICAL CHARACTERISTICS OF STUDY AREA

7.4.1 Methodology

A literature review was conducted to determine the existing marine ecological conditions within the Study Area to identify habitat resources and species of potential importance. The local literature reviewed included:

- EIA Report for SENT Landfill Extension Feasibility Study [1] ;
- *Porcupine!* (Newsletter of Department of Ecology & Biodiversity, University of Hong Kong) [2];
- Ecological Study for SENT Landfill Extension - Final Report [3];
- Further Development of Tseung Kwan O Feasibility Study [4];
- SENT Landfill Study - Final Report [5]; and
- Field Guide to Hard Corals of Hong Kong [6].

7.4.2 Results

Subtidal Habitats

Based on the literature review, existing information on subtidal marine ecological resources within the Study Area is limited. Data on subtidal marine ecological resources are only available for Fat Tong Chau. The underwater dive surveys conducted in 1999 and 2003, with findings presented in the Area 131 Further Ecological Study Report and the HATS Dive Survey Report respectively [7], indicated that Fat Tong Chau harboured very few hard corals (i.e. *Porites* sp. and *Cyphastrea* sp.). Nevertheless, soft corals and gorgonians including *Echinomuricea* sp., *Euplexaura* sp., *Anthogorgia* sp., *Dendronephthya* sp., *Menella* sp. and *Echinogorgia* sp., were encountered frequently and occurred in moderate abundance.

(1) ERM (2007). *South East New Territories (SENT) Landfill Extension - Feasibility Study: Environmental Impact Assessment Report.*

(2) *Newsletter of Department of Ecology & Biodiversity*, University of Hong Kong Issues 1 to 33.

(3) Hong Kong Baptist University (2005). *Ecological Study for SENT Landfill Extension - Final Report.* For EPD.

(4) Maunsell Consultant Asia Ltd (2005). *Further Development of Tseung Kwan O Feasibility Study-EIA.* For CEDD.

(5) Scott Wilson Kirkpatrick (1991). *SENT Landfill Study-Final Report.* For EPD.

(6) Alan Chan, Choyce Choi, Denise McCorry, Khaki Chan, M W Lee and Ang Put Jr. (2005). *Field Guide to Hard Coral of Hong Kong*. Friends of the Country Parks.

(7) Details presented in the *Further Development of Tseung Kwan O Feasibility Study-EIA Report*.

A more recent dive survey was carried out by ERM at Fat Tong Chau in 2005[1] with the collection of semi-quantitative data on subtidal hard bottom assemblages using Rapid Ecological Assessment (REA). Results of the REA survey indicated the presence of isolated hard coral colonies at subtidal habitats of Fat Tong Chau. Both the abundance and diversity of the hard coral community were reported as low, with only nine hard coral species from four hermatypic coral families (ie *Faviidae, Merulinidae, Poritidae* and *Siderastreidae*) and one ahermatypic genus – *Tubastrea* sp. recorded. All hard coral species recorded are commonly found in Hong Kong. The coverage of hard coral was in the range of 1 to 10 %. For soft corals, a total of four genera including *Cladiella* sp., *Dendronephtha* sp., *Echinomuricea* sp. and *Euplexaura* sp. were recorded. A high abundance of *Echinomuricea* sp. and *Euplexaura* sp. was recorded and the widespread distribution and common occurrence of these particular genera in Hong Kong waters noted.

Information on the subtidal soft bottom assemblages in the vicinity of the Project area is available from the *Consultancy Study on Marine Benthic Communities in Hong Kong* [2]. One sampling station (Station 85) is close to the proposed works area and data extracted from the station can be considered to be representative of the assemblages within the proposed Project area.

According to the findings of the *Consultancy Study*, the substratum of the sampling station is covered by very fine sand and/or silt. Their benthic assemblages are typical of Hong Kong waters and similar to benthic assemblages in majority of other subtidal habitats in Hong Kong. No species of conservation interest was recorded at the sampling station. In summer, the average number of species is medium (23.00 species per 0.5 m^2) and average wet weight (1.64 g per m^2), while the average number of individuals (114 individuals per m^2) are low when compared with average values of Hong Kong (33 species per 0.5 m^2, 540 individuals per m^2 and 71.2 g per m^2). In winter, the average number of species (23 species per 0.5 m^2) is medium, while the average number of individuals (158 individuals per m^2) and average wet weight (2.34 g per m^2) are low in comparison with average values of benthic assemblages in Hong Kong (34 species per 0.5 m^2, 450 individuals per m^2 and 28 g per m^2).

Intertidal Habitats

From the literature review, it is found that no existing information was available on the intertidal habitats within the Study Area.

7.5 IDENTIFICATION OF INFORMATION GAPS

As revealed by the literature review, information on the marine ecological resources within the Study Area is limited to data from several studies [3] [1] on

(1) ERM (2007). *Op. cit.*

(2) CityU Professional Services Limited (2002). Consultancy Study on Marine Benthic Communities in Hong Kong (Agreement No. CE 69/2000). Final Report submitted to AFCD.

(3) ERM (2007). *Op. cit.*

the coral communities at Fat Tong Chau. No existing information is available on the subtidal and intertidal habitats along the artificial shoreline within the Study Area. To fill these information gaps for the baseline marine ecological conditions, marine ecological baseline surveys were carried out within the Study Area in April 2008.

7.6 *ASSESSMENT METHODOLOGY*

7.6.1 *Marine Ecological Baseline Surveys*

Marine ecological baseline surveys were carried out to characterise the existing marine ecological conditions of the Study Area. The surveys were designed to provide an update of the physical and ecological attributes of the Study Area and address the data gaps identified in literature review. The intertidal and dive surveys focused on the remaining natural shoreline habitat and those areas which will be directly impacted by the proposed Project.

The following marine ecological baseline surveys were undertaken:

- Subtidal (dive) survey; and
- Intertidal survey

Subtidal Survey

A series of Rapid Ecological Assessment (REA) surveys were conducted to investigate the subtidal sessile benthos of the natural shoreline and artificial seawall within the Study Area (see *Figure 7.6a*). An initial qualitative reconnaissance survey was conducted along the natural shoreline and artificial seawall within the Study Area. During the survey, the position and number of transects (T1 – T8) were decided upon, on site.

The standardised semi-quantitative Rapid Ecological Assessment (REA) – survey technique was used to assess the benthic communities of the study location. This technique is now one of the standard practices for EIA marine baseline surveys in Hong Kong and has been modified from the standardised REA survey technique established for the assessment of coral communities on the Great Barrier Reef (2) for marine environment of Hong Kong (3).

The REA methodology encompasses an assessment of the benthic cover (Tier I) and taxon abundance (Tier II) undertaken in a swathe ~ 4 m wide, 2 m either side of each transect. The belt transect width is dependent on underwater visibility experienced and for Hong Kong generally consists of a swathe ~2 m wide, 1 m either side of the each transect. An explanation of the two assessment categories (Tiers) used in the survey is presented below.

(1) Details presented in the *Further Development of Tseung Kwan O Feasibility Study-EIA Report*.

(2) DeVantier, L.M., G. De'Ath, T.J. Done and E. Turak 1998. *Ecological assessment of a complex natural system: A case study from the Great Barrier Reef*. Ecological Applications 8: 480-496.

(3) Fabricius, K.E. and D. McCorry. 2006. *Changes in octcoral communities and benthic cover along a water quality gradient in reefs of Hong Kong*. Marine Pollution Bulletin 52: 22-33.

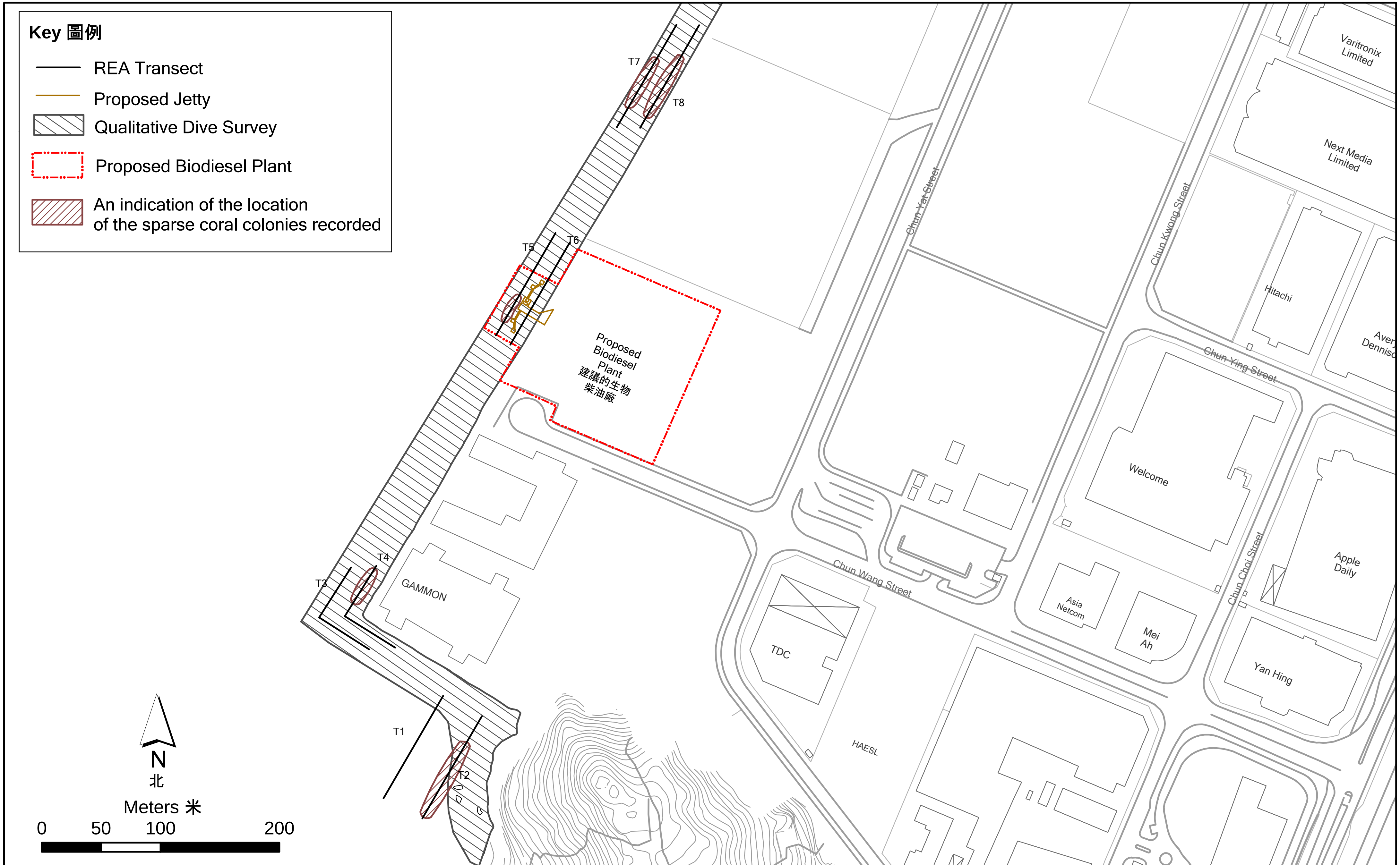

Figure 7.6a

Location of Rapid Ecological Assessment Transects

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Date: 05/11/2008

Environmental
Resources
Management

ERM

Tier I - Categorisation of Benthic Cover

Upon the completion of each survey transect, five ecological and seven substratum attributes were assigned to one of seven standard ranked (ordinal) categories (see *Tables 7.6a* and *7.6b*).

Table 7.6a Categories to be used in the Surveys - Benthic Attributes

Ecological	**Substratum**
Hard coral	Hard substrate
Dead standing coral	Continuous pavement
Soft coral	Bedrock
Black coral	Rubble
Macroalgae	Sand
Turf algae	Silt
	Large boulders (>50 cm)
	Small boulders (<50 cm)

Table 7.6b Categories to be used in the Surveys - Ordinal Ranks of Percentage Cover

Rank	**Percentage Cover (%)**
0	None recorded
1	1-5
2	6-10
3	11-30
4	31-50
5	51-75
6	76-100

Tier II - Taxonomic Inventories to Define Types of Benthic Communities

An inventory of benthic taxa was also compiled for each transect. Taxa were identified *in situ* to the following levels:

- Scleractinian (hard) corals to species wherever possible.
- Soft corals, anemones and conspicuous macroalgae recorded according to morphological features and to genus level where possible.
- Other benthos (including sponges, zoanthids, ascidians and bryozoans) recorded to genus level wherever possible or phylum plus growth form.

Following the completion of the survey at each transect, each taxon in the inventory was ranked in terms of abundance in the community (see *Table 7.6c*). These broad categories rank taxa in terms of relative abundance of individuals, rather than the contribution to benthic cover along each transect. The ranks are subjective assessments of abundance, rather than quantitative counts of each taxon.

Table 7.6c *Ordinal Ranks of Taxon Abundance*

Rank	Abundance
0	Absent
1	Rare (a)
2	Uncommon
3	Common
4	Abundant
5	Dominant

Note:
(a) The classification of "rare" abundance refers to low abundance (small quantity) on the transect, rather than in terms of distribution in Hong Kong waters.

A set of environmental site descriptors were also recorded for each REA transect as follows:

(A) The coral communities were classified into one of three categories based on the amount of three dimensional coral accretion:

(a) extremely sparse corals (<1 % cover) not forming a community, developed as subsidiary components among other sessile benthos (eg *Perna* sp., oysters, bryozoans);

(b) coral communities with no biogenic carbonate accretion developed on rock, sand or rubble; and

(c) coral communities with substantial biogenic accretion - three dimensional structure - but no reef flats (incipient reefs).

(B) The degree of exposure to prevailing wave energy was ranked from 1 - 4, where:

1 = sheltered (highly protected by topographic features from prevailing waves);

2 = semi-sheltered (moderately protected);

3 = semi-exposed (only partly protected); and

4 = exposed (experiences the full force of prevailing wave energy).

(C) Sediment deposition on the reef substratum (particle sizes ranging from very fine to moderately coarse) rated on a four point scale, from 0 – 3, where:

0 = no sediment;

1 = minor (thin layer) sediment deposition;

2 = moderate sediment deposition (thick layer), but substrate can be cleaned by fanning off the sediment; and

3 = major sediment deposition (thick, deep layer), and substrate cannot be cleaned by fanning.

During the REA survey, the field data were recorded by an observer experienced in the underwater identification of sessile benthic taxa (coral specialist), swimming along identified sections of coastline on SCUBA from haphazardly-chosen starting points. Due to the REA observers' experience and familiarisation with the sublittoral benthic communities of Hong Kong's nearshore no qualitative reconnaissance surveys were undertaken. REA surveys were conducted within two depth ranges of: 2 to -4 mCD and -4 to -6 mCD as this is the typical depth range of hard corals (if present) in turbid, low light conditions. Poor visibility and the known lack of hard corals in deeper waters was confirmed by occasional spots dives and in general, dive conditions encountered did not permit REA surveys deeper than 8 to 10 m. REA surveys were carried out using 50 m long transects with the transect tapes laid out within a single ecological zone - habitat - depth range. This coincided with the surveys being conducted approximately parallel with the shoreline and a standardised swathe of seabed (2 to 4 m wide) was surveyed at all sites.

All field data were checked upon completion of each REA transect and a dive survey proforma sheet completed at the end of the fieldwork day. Upon completion of the fieldwork photographs were compiled for each transect. Photographs for each REA transect were then reviewed and REA data verified.

Once the transect photographs were reviewed and REA data checked all data were input and stored in Excel spreadsheets. Two spreadsheets were used and data were separated into:

- site (transect) information (Tier I and II data), depth and environmental descriptors; and
- species abundance data for each transect.

Species lists, species richness and mean values for ecological and substratum types were compiled for the two depth ranges surveyed within each of the two locations (natural and artificial shorelines). The rank abundance values were converted to a mid-value percentage cover.

Intertidal Survey

Quantitative transect surveys were conducted on the artificial seawalls next to the Project Site and the natural rocky shore at Fat Tong Chau on 8 April 2008. The survey locations are presented in *Figure 7.6b*.

A quantitative belt transect method was used for the intertidal survey. Three horizontal (belt) transects along the shoreline were surveyed at each of the three shore heights: 2 m, 1.5 m and 1 m above Chart Datum. On each transect, 10 quadrats (50 cm x 50 cm) were placed randomly to assess the abundance and distribution of flora and fauna. All organisms found in each quadrat were identified and recorded to species level so that density per quadrat could be determined. Sessile animals such as algae, barnacles and oysters in each quadrat were not counted but estimated as percentage cover on the rock surface. All species of algae (encrusting, foliose and filamentous) were also identified and recorded by estimating the percentage of cover of the rock surface.

7.7 *MARINE ECOLOGICAL BASELINE CONDITIONS*

7.7.1 *Sub-tidal Habitat*

Seabed Condition

All REA surveys were conducted on 8 April 2008. Weather conditions were fine with the dive locations sheltered from a moderate north-easterly wind, the sky was overcast with sunny spells and the sea conditions calm with little current. The underwater dive conditions were typical for the nearshore waters of this region of Hong Kong with waters highly turbid and of low light creating extremely low underwater visibility conditions for all survey transects (lowest visibility recorded was ~25 cm). The seabed of the artificial seawall was composed of artificial boulders with very low coral coverage (<1%) and only a few small colonies of *Oulastrea crispata* and *Psammocora superficialis* recorded. The seabed of the natural shoreline of Fat Tong Chau was composed of mainly small to large sized boulders and soft sediment (silt), and only a few small hard coral colonies were observed (eg *Montipora venosa, Psammocora superficialis, Turbinaria peltata, Cyphastrea serailia,* and *Goniopora stutchburyi*). The natural shoreline also had an extremely low coral cover (<1%).

A total of eight REA transects were completed during the survey (T1 to T8). Four transects were located at depths between -2 and -4 mCD while the remaining four were laid at depths of -4 to -6 mCD. The transects covered the natural shoreline to the south of the proposed biodiesel plant (ie Fat Tong Chau) and the artificial seawall at or adjacent to the proposed plant site (see *Figure 7.6a*)

The physical/abiotic composition of the seabed substrata recorded for each transect is represented in *Tables C1* and *C2* of *Annex C*. The natural shoreline of Fat Tong Chau between -2 and -4 mCD was composed of small to large sized boulders overlying bedrock in the intertidal zone. A narrow boulder slope existed at around 4 m depth and extended deeper. Horizontal boulder surfaces at the lower depth range were heavily silted. The artificial seawall was composed of large introduced boulders/rocks and vertical and horizontal surfaces were covered in a layer of silt.

At depths between -4 to -6 mCD, the seabed along the natural shoreline of Fat Tong Chau was mainly composed of silt and mud with scattered small patches of shell fragments. At the same depth range along the artificial seawall of TKOIE, large boulders/rocks predominated and similar to the shallow depths were covered in silt.

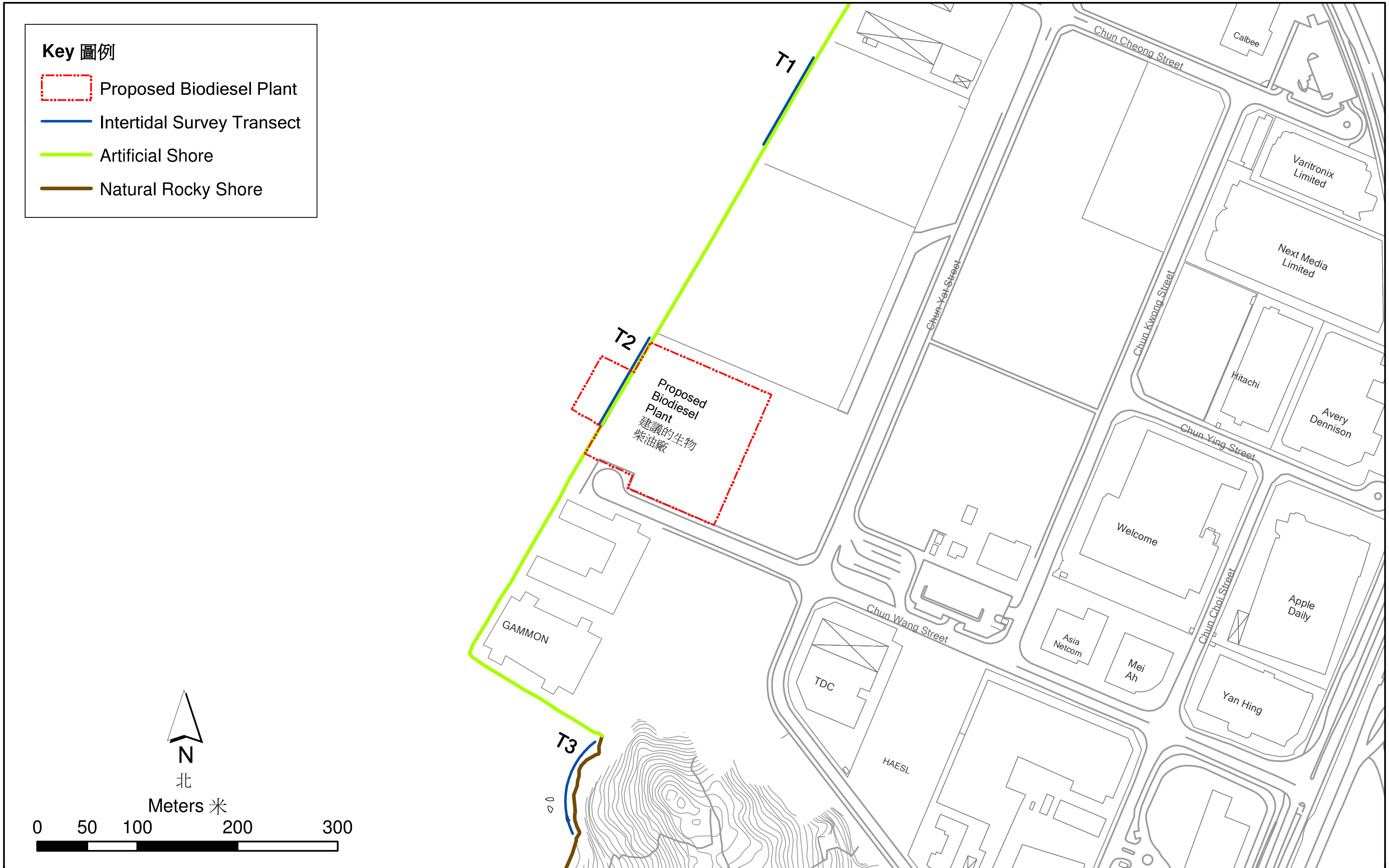

Figure 7.6b

Location of Intertidal Survey Transects

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Subtidal Marine benthic communities

A total of six species of hard corals and two species of gorgonians were recorded along the REA transects (see *Tables* C3 and *C4* of *Annex C*) conducted in the two depth ranges. Live coral cover was less than 1% with isolated and scattered small, coral colonies recorded for the shallow depths along the natural shoreline and at both depth ranges of the artificial seawall. A total of two hard coral species were recorded for both depths (ie -2 to -4 m and -4 to -6 mCD) along the artificial seawall of TKOIE. *Oulastrea crispata* was recorded for both depths while *Psammocora superficialis* was only recorded on deeper transects. All these hard coral species recorded on the artificial seawall are common and have a widespread distribution throughout Hong Kong's nearshore waters (see *Table C5*). In comparison, hard corals were restricted to between -2 to -4 mCD along the natural shoreline of Fat Tong Chau and five of the six hard coral species recorded are listed as common for Hong Kong (see *Table C5*). The abundance and diversity of hard corals was, therefore, considered low within the entire Study Area. It was also noted that two species of gorgonians were recorded within the deeper, soft sediment transects of the natural shoreline of Fat Tong Chau. Similar to the hard corals abundance, diversity and percentage cover were all considered extremely low (< 1% live coral cover).

A total of 14 hard coral colonies were recorded along the transects. All corals encountered were not movable as they were attached to either the natural nearshore or artificial seawall rock. Most of these immovable corals are small in size (<10cm in diameter) and were found to be the common species that have been recorded throughout the coastal areas in the eastern waters of Hong Kong with the exception of one species – *Montipora venosa* which is categorised as uncommon (see *Table C6).* Only one coral colony *Psammocora superficialis* (<10cm in diameter) was recorded within the proposed jetty area.

In addition to the corals recorded the benthic communities of the natural shoreline and artificial seawall comprised a common suite of fouling organisms including (see *Tables* C3 and *C4* in *Annex C*):

- rock oysters *Saccostrea cucullata*;
- barnacles;
- fan worms,
- common sea cucumber *Holothuria leucospilota;*
- bryozoans *Schizoporella errata*;
- bubble anemone *Entacmaea quadricolor* (natural shoreline only);
- variety of gastropods; and
- sea urchins with the long-spined sea urchin *Diadema setosum* abundant for both habitat types.

All fouling invertebrate species recorded are common and widespread in Hong Kong.

Representative photos of the subtidal marine fauna observed within the Study Area are shown in *Figures 7.7a* to *7.7b* and *Figure C1 in Annex C*.

General observations of fishes associated with the natural and artificial seawall of the Study Area were noted during the REA surveys and a list of species observed is presented in *Table C7* of *Annex C*. A total of six fish species was recorded and the abundance of fish was low. A suite of common and widespread fish species were noted (for Hong Kong waters) [(1)], such as damselfishes, goby and pufferfishes. One individual frogfish (*Antennarius nummifer*) was observed along the seawall. This species is widespread in the Indo-Pacific region [(2)] and is not included on the *IUCN Red List of Threatened Species*. In Hong Kong, this frogfish species is noted as rare [(3)], however, it is considered cryptic and possibly remains under detected in nearshore waters.

Overall, the ecological value of the subtidal habitat within the Study Area is considered low.

7.7.2 *Intertidal Habitat*

The artificial seawall exhibited a low diversity of species. Animals recorded were mainly the rock oyster *Saccostrea cucullata*, periwinkles *Echinolittorina radiata* and *E. trochoides*, and limpets *Nipponacmea concinna* and *Patelloida pygmaea* (see *Table C8* of *Annex C*). The topshell *Monodonta labio* and chiton *Acanthopleura japonica* were also recorded in low abundance. A few mobile juvenile crustaceans were also observed at the mid intertidal zone during the survey on the artificial seawall, though its identification remains unknown. Representative photos of the intertidal habitats within the Study Area are shown in *Figure 7.7c*.

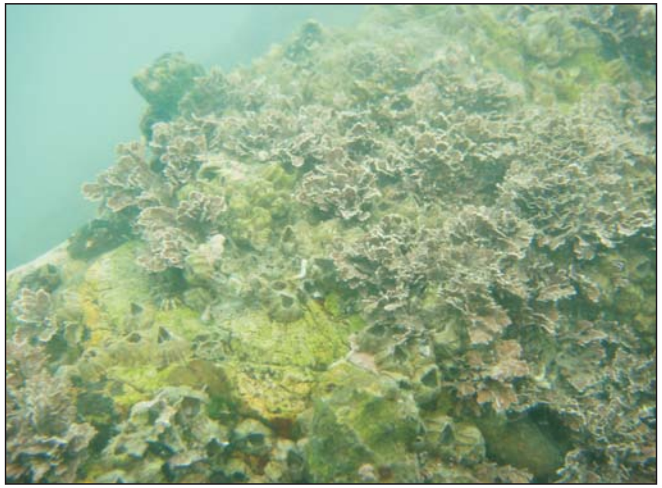
Dominant species of the natural intertidal shoreline included the rock oyster *Saccostrea cucullata*, periwinkles *Echinolittorina radiata* and *E. trochoides*, limpets *Nipponacmea concinna* and topshell *Monodonta labio*. Species found only in the natural shore during the survey include snails *Planaxis sulcatus*, *Chorostoma argyrostoma*, *Lunella coronata*, sea anemone and numerous algal species. These species are all common species on natural rocky shores of Hong Kong. The natural rocky shore exhibited higher species diversity and abundance than those of artificial shore.

Overall, results of the survey show that all species were common and widespread, and no species of note were recorded. Assemblage pattern appears to be slightly different between the artificial seawalls and the natural shore. Diversity of intertidal biota at the Study Area was similar to those recorded from other shores in Hong Kong.

(1) Sadovy Y. and Cornish A. S. (2000). *Reef Fishes of Hong Kong*. Published by Hong Kong University Press.

(2) FishBase: www.fishbase.com

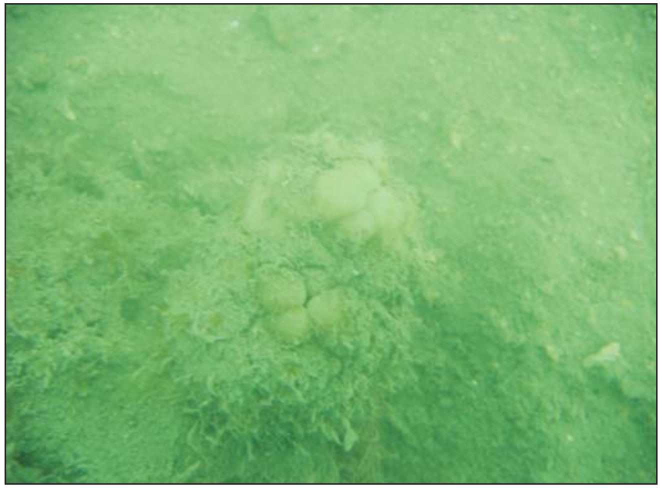
(3) Sadovy Y. and Cornish A. S. (2000). *Op. cit.*



Coralline algae and barnacles

Fouling organism covered with thick layer of silt

Fouling organisms on rock (barnacles and bivalves)



Sea squirt

Figure 7.7a

Benthic communities of the natural shoreline habitat

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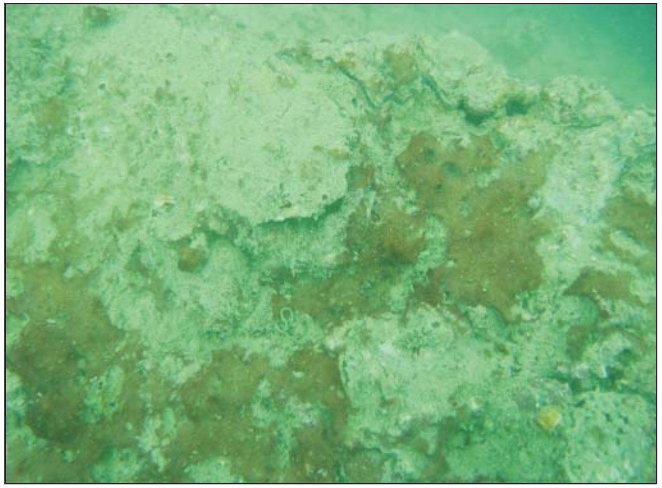
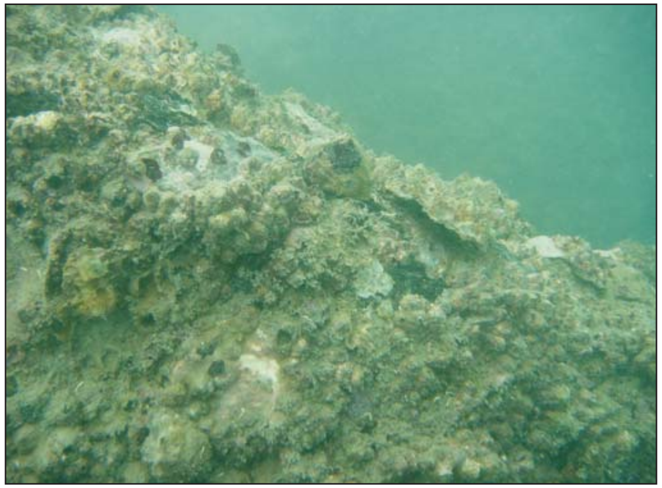
Big rocks found in the shallow



Bryozoan

Coralline algae and gastropods



Fouling organisms on rock

Figure 7.7b

Benthic communities of the shallow artificial seawall

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Artificial seawall

Natural shoreline

A mosaic of rock oysters and seasonal foliose algae on the rock surface of the natural shoreline

Rock oysters on the artificial seawall

Figure 7.7c

Representative photos of intertidal habitats observed within the Study area

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7.8 ECOLOGICAL EVALUATION

In this section, the ecological importance of marine habitats identified within the Study Area is evaluated in accordance with the criteria stipulated in *Annex 8* of the *EIAO-TM*. The evaluation is based upon the information presented in *Section 7.7*. The ecological importance of the subtidal and intertidal habitat types within the Study Area are presented in *Tables 7.8a* and *7.8b*.

Table 7.8a Ecological Importance of the Subtidal Habitats within the Study area

Criteria	**Natural Shoreline**	**Artificial Shoreline**
Naturalness	Natural bedrock and boulder substrate	Introduced rock/boulder seawall
Size	Short section of Fat Tong Chau (~0.1 km)	Long stretch of artificial seawall (>1 km)
Diversity	Low for hard and soft corals. A total of five hard coral species recorded	Extremely low for hard and soft corals. Two hard coral species recorded
Rarity	Low – majority of hard and soft coral species commonly recorded throughout Hong Kong's waters with the exception of one uncommon coral (*Montipora venosa*).	Low- all hard and soft coral species commonly recorded throughout Hong Kong's waters. One species of Frogfish recorded.
Re-creatability	Hard bottom substrata may be re-colonised by subtidal organisms including corals	Hard bottom substrata may be re-colonised by subtidal organisms including corals
Fragmentation	Low – typical fouling community existing in turbid shallow waters of nearshore Hong Kong.	Low – introduced substrate and not representative of natural benthic assemblages.
Ecological Linkage	Small section of natural shoreline not functionally linked to any high value habitat in a significant way.	Artificial shoreline not functionally linked to any high value habitat in a significant way
Potential Value	Low. Marginal representation of hard and soft corals with the habitat supporting sparse coral cover. Highly turbid and high sedimentation rates indicate that the area does not and will merit conservation measures.	Low. Marginal representation of hard and soft corals with the habitat supporting sparse coral cover though it is noted that hard corals have settled on the introduced substrate. Highly turbid and high sedimentation rates indicate that the area does not and will merit conservation measures.
Nursery/Breeding Ground	No significant records identified during the literature review or field surveys.	No significant records identified during the literature review or field surveys
Age	Individual coral colonies were typically <10 cm indicative of settlement within the last five years or less. Individual colonies are scattered and no large hard coral colonies or substantial biogenic accretion.	Individual coral colonies were typically <10 cm indicative of settlement within the last five years or less. Individual colonies are scattered and no large hard coral colonies or substantial biogenic accretion.
Abundance/Richness of Wildlife	Extremely low with only a few coral colonies collected.	Extremely low with only a few coral colonies collected.
Overall Ecological Value	**Low**	**Low**

Table 7.8b Ecological Importance of the Intertidal Habitats within the Study Area

Criteria	**Natural Shore**	**Artificial Seawall**
Naturalness	Natural habitat (sheltered to semi-exposed rocky shores).	Man-made habitat (slope artificial seawall).
Size	Approximately 0.1 km of natural rocky shores was recorded within the Study Area. No natural rocky shores were found within the Project Site.	Approximately 1.1 km of artificial shoreline was recorded within the Study Area.
Diversity	Medium for intertidal marine flora and fauna.	Low for intertidal marine flora and fauna.
Rarity	Nil.	Nil.
Re-creatability	The habitat cannot be recreated.	The habitat can be recreated.
Fragmentation	No.	Not applicable.
Ecological Linkage	Not functionally linked to any highly valued habitat in close proximity.	Not functionally linked to any highly valued habitat in close proximity.
Potential Value	Medium	Low
Nursery/Breeding Ground	Unknown.	Unknown.
Age	Unknown	Not applicable.
Abundance/Richness of Wildlife	Medium	Low
Overall Ecological Value	**Medium**	**Low**

7.9 POTENTIAL IMPACTS AND IMPACT ASSESSMENT ON MARINE ECOLOGICAL RESOURCES

Potential impacts due to the construction and operation of the Biodiesel Plant were assessed (following the guidelines stipulated in *Annex 16* of the *EIAO-TM*) and the impacts evaluated (based on the criteria in *EIAO-TM Annex 8*).

7.9.1 *Construction Phase*

Potential impacts to marine ecological resources arising from the construction works will be associated mainly with the construction of the jetty by piling. These impacts may be divided into those due to:

- Direct disturbances to the habitat, ie habitat loss; and
- Perturbations to key water quality parameters, ie changes in water quality.

Each of the above impacts is discussed in detail below.

Habitat Loss

The jetty in the form of a piled deck will be constructed for marine vessel berthing. Bore piles will be driven through the existing rubble mound seawall. Direct loss of a small stretch of intertidal and subtidal hard-substrata habitats associated with the artificial seawall is, therefore, anticipated.

A total of about 60 piles, each with approximate diameter of 1 m and a cross-sectional area of 0.8 m^2, will be installed at the artificial seawall of the Project Site (see *Figures 3.2c* and *7.6a*). Piling works for jetty construction at the Project Site will thus result in the loss of approximately 48 m^2 of marine habitats within a 60 m stretch of low ecological value intertidal and subtidal artificial seawall area. Based on the dive surveys, only one small coral colony *Psammocora superficialis* (<10cm in diameter) was recorded within the Project Site boundary. Intertidal and subtidal assemblages (ie rock oyster *Saccostrea cucullata* and bryozoans *Schizoporella errata*), as well as the small coral colony, within this area may be lost through physical damage to organisms existing there. These assemblages are regarded as widespread and common in other similar artificial intertidal and nearshore areas of Hong Kong. Although these impacts may be an unavoidable consequence of the Project, they will be very minor and would only affect a small stretch of the seawall, occurring at the footprint of the piles. Once available, the location of the piles will be reviewed to determine the possibility of preventing direct loss of hard coral colony and other marine organisms caused by the piling footprint. No unacceptable ecological impact due to the construction of the jetty is anticipated.

Changes in Water Quality

No dredging of marine sediment will be required for the construction of the jetty. As discussed in *Section 6.5.1 (Water Quality Impact Assessment)*, it is expected that marine piling will only result in limited disturbance to the sediments and is unlikely to cause unacceptable impacts to the water quality (eg elevated suspended solids level) in Junk Bay. Consequently, adverse impacts on intertidal and subtidal assemblages are not expected.

Likewise, land-based construction activities at the proposed facility are not expected to generate significant amount of contaminated construction site runoff and with the implementation of good construction site practice as recommended in *ProPECC PN 1/94* it is unlikely to result in adverse water quality impacts. Subsequent adverse impacts on marine ecological resources are thus not expected.

7.9.2 Operational Phase

Potential impacts to marine ecological resources arising from the operation of the proposed facility may include:

- Changes to hydrodynamic regime;
- Presence of artificial habitats provided by marine piles;
- Changes in water quality; and

- Spillage of Raw Materials and Biodiesel Plants.

Each of the above is discussed in detail below.

Changes to Hydrodynamic Regime

As discussed in *Section 6.6.1*, the presence of the jetty and the associated piling structure is not expected to result in any adverse impact to the hydrodynamic system and flow regime. No significant adverse impact on marine ecological resources is, therefore, anticipated during the operation phase.

Presence of Artificial Habitats

Direct, permanent loss of a small stretch of artificial seawall is anticipated for the construction of the jetty by piling. Although low ecological value intertidal and subtidal hard-substrata habitats and the associated marine assemblages at this stretch of shoreline will be lost (see *Section 7.9.1*), since the piles will be installed at a depth of 4 m to 7.5 m, the presence of piles will provide approximately 750 to 1,400 m^2 of artificial habitat for intertidal and subtidal organisms to colonise. The marine organisms recorded on the artificial seawall have colonised this artificial substrate after the completion of the seawall construction for the Tseung Kwan O Industrial Estate. Moreover, assemblages of marine organisms have been recorded on artificial habitats such as wharf piles (1). It is therefore expected that similar assemblages will settle on and recolonise the piles as environmental conditions of that area would be similar to the existing conditions that have allowed the settlement and growth of the marine organisms recorded.

Changes in Water Quality

All sewage and wastewater generated during operational activities of the proposed facility will be collected and treated at the on-site wastewater treatment plant prior to off-site disposal via discharge to a foul sewer leading to the Tseung Kwan O Sewage Treatment Works. The effluent quality will comply with the relevant discharge standards. Surface runoff and site drainage will pass through on-site silt trap and oil interceptors before discharge into the stormwater drainage system of the Tseng Kwan O Industrial Estate. Overall, no adverse water quality impact due to effluent discharge is anticipated, and subsequent adverse impacts on marine ecological resources are thus not expected.

Spillage of Raw Materials and Biodiesel Plants

Accidental spillage of biodiesel, PFAD and methanol may potentially occur during loading/unloading operations at the jetty area. With the implementation of loading and unloading control measures, the possibility of accidental spillage will be low and volume of the material released is anticipated to be small. Both biodiesel and PFAD have low volatility and have density lower than seawater. Upon spillage, biodiesel will form a thin

(1) Morton B and Morton J (1983). The Sea Shore Ecology of Hong Kong. Hong Kong University Press.

slick on the water surface while PFAD will float on water in solid form so that it is unlikely to disperse and should be relatively easy to clean up. In addition, both biodiesel and PFAD are non-toxic and biodegradable, therefore adverse impacts on marine ecological resources are expected to be minimal upon spillage.

Methanol, however, is highly volatile and is completely miscible with seawater. It has a relatively short half-life in aqueous environments (< 7 days) and is biodegradable; therefore it is unlikely to accumulate or persist in the marine environment upon spillage (1). Research has also shown that methanol is essentially non-toxic to marine organisms (2). As methanol would rapidly dissipate into the environment, and within fairly short distances from the spill it would reach levels where biodegradation would rapidly occur, it is reasonable to expect that the dilution and dispersion capacity of the surrounding coastal waters is sufficient to buffer the adverse effects, if any, of the spill. No significant impacts on marine ecological resources are thus expected.

7.9.3 Evaluation of the Impacts to Marine Ecological Resources

Based upon the information presented above, the significance of the marine ecological impacts associated with the construction and operation of the proposed facility have been evaluated in accordance with *Table 1* of *Annex 8* of the *EIAO-TM*, and are summarised in *Table 7.9a*.

Table 7.9a Overall Impact Evaluation for Intertidal and Subtidal Artificial Hard Substrata Habitat

Evaluation Criteria	**Intertidal and Subtidal Artificial Hard Substrata Habitat**
Habitat quality	Low
Species	The potential exists for direct and indirect impacts to the marine faunal species, particular sessile species. One coral colony *Psammocora superficialis* (<10cm in diameter) was recorded within the proposed jetty area during the dive survey.
Size/Abundance	Permanent area loss is approximately 48 m^2.
Duration	The impact will persist during the construction and operation phases.
Reversibility	Impacts to assemblages inhabiting the seawall within the direct footprint of the proposed jetty and piling work area are expected to be permanent. Recolonisation on piles is expected to occur.
Magnitude	The scale of the habitat loss is small in the context of the surrounding similar habitats.
Overall Impact Conclusion	**Low**

(1) Malcolm Pirnie Inc (1999) *Evaluation of the Fate and Transport of Methanol in the Environment*. Prepared for The American Methanol Institute

(2) Malcolm Pirnie Inc (1999) *Evaluation of the Fate and Transport of Methanol in the Environment*. Prepared for The American Methanol Institute

Overall, the impact assessment indicates that no unacceptable adverse impacts to marine ecology are expected to occur. Loss of intertidal and subtidal assemblages as a result of piling is expected to be compensated through the provision of artificial habitats from piles that provide adequate surfaces for colonisation.

7.10 *CUMULATIVE IMPACTS*

Several existing and planned projects have been identified in the Tseung Kwan O area which are mainly roads and infrastructure works (see *Table 7.10a*). Based on the tentative project development programme, the construction of the biodiesel plant will be completed by early 2010. The concurrent projects during the construction of the biodiesel plant are the TKO Further Development project, the SENT Landfill Operation and TKO Area 137 Fill Bank. The latter two projects are land-based and will be located at least 700 m away from the biodiesel plant and so no cumulative impacts are expected. For the TKO Further Development project, given the large separation distance (>2,000 m) from the biodiesel plant (which is small in scale), it is also expected that no cumulative impacts on the nearshore marine ecological resources will occur.

Table 7.10a Planned Projects in TKO

Planned Projects	Distance from Biodiesel Plant (m)	Planned Construction Date
Cross Bay Link	> 600	2013 – 2016
TKO - Lam Tin Tunnel	> 1,800	2012 – 2016
TKO Further Development – infrastructure works at Town Centre South and Tiu Ken Leng	> 2,000	Mid 2009 – 2011
SENT Landfill Operation	700m	Till end of 2012
SENT Landfill Extension	> 1,000	2011 - 2018
TKO Area 137 Fill Bank	>1,000	Till 2013

7.11 *MITIGATION MEASURES*

In accordance with the guidelines in the *EIAO-TM* on marine ecology impact assessment, the general policy for mitigating impacts to marine ecological resources, in order of priority, are:

- *Avoidance:* Potential impacts should be avoided to the maximum extent practicable by adopting suitable alternatives;
- *Minimisation:* Unavoidable impacts should be minimised by taking appropriate and practicable measures such as constraints on the intensity of works operations or timing of works operations; and
- *Compensation:* The loss of important species and habitats may be provided for elsewhere as compensation. Enhancement and other conservation measures should always be considered whenever possible.

Proposed mitigation measures for minimising impacts to marine ecological resources are summarised below.

7.11.1 *Direct Loss of Hard Coral Colony*

Once available, the location of the piles will be reviewed to determine the possibility of preventing direct loss of hard coral colony and other marine organisms caused by the piling footprint. Therefore, no unacceptable environmental impact is anticipated.

7.11.2 *Changes in Water Quality*

Mitigation measures for minimising water quality impacts are presented in detail in *Section 6.7.1*. These measures will be properly implemented and good construction practices will be adopted to minimise potential adverse impacts to marine ecological resources.

7.11.3 *Spillage of Raw Materials and Biodiesel Plants*

Any spillages will be intercepted by the collection drain and conveyed into the on-site wastewater treatment plant, and an Emergency Response Plan will be in place and implemented should spillages occur to minimise potential impacts on the marine environment.

Specific measures for spill containment are presented in *Section 6.7.2*.

7.12 RESIDUAL IMPACTS

There will be a permanent loss of approximately 48 m^2 of intertidal and subtidal habitats at the artificial seawall due to marine piling for jetty construction. Given the fact that these habitats are of low ecological value and recolonisation of marine organisms on the piles is expected, the residual impacts are considered to be low.

With effective implementation of the proposed mitigation measures for the construction and operational phases of the biodiesel plant, no further adverse residual impact on marine ecological resources is expected.

7.13 ENVIRONMENTAL MONITORING AND AUDIT

The Impact Assessment has evaluated that there would be no unacceptable marine ecological impacts within the Study Area. As a result, it is considered that environmental monitoring is not required. Nevertheless, regular site inspection is recommended during construction to ensure that the recommended mitigation measures on water quality are properly implemented such that secondary adverse impacts on marine ecological resources can be avoided and minimised.

7.14 *CONCLUSIONS*

Findings of this Impact Assessment suggest that the marine habitats within the Study Area are of low to medium ecological value, and potential adverse impacts are only anticipated at the low ecological value intertidal and subtidal habitats and associated assemblages at the seawall in the immediate vicinity of the Project Site.

Permanent loss of a small stretch of marine habitats at the artificial seawall is expected due to marine piling for jetty construction. Pile surfaces can, however, serve as artificial habitats for settlement and recolonisation of marine assemblages. Residual impacts are expected to be low.

Other potential impacts to marine ecological resources, which may be caused by changes in water quality and hydrodynamic regime, and accidental spillage of raw materials and biodiesel during the construction and operation phases of the proposed facility, are likely to be negligible and minimal provided that the recommended mitigation measures and good site practices are implemented.

No environmental monitoring is thus considered necessary during the construction and operation phases of the Project. Regular site inspections are recommended during construction.

8 *RISK ASSESSMENT*

8.1 INTRODUCTION

8.1.1 *Background*

The background to the EIA Study and the description of the Project are provided in *Sections 1* to *3* of this report. This section presents the methodology, findings and recommendations of the Hazard to Life assessment with regard to the operation of the biodiesel plant.

8.1.2 *Legislation Requirement and Evaluation Criteria*

The requirement for a Quantitative Risk Assessment (QRA), for projects where risk to life is a key issue with respect to Hong Kong Government Risk Guidelines (HKRG), is specified in Section 12 of the *Technical Memorandum on Environmental Impact Assessment Process* (EIAO-TM). *Annex 4* of the EIAO-TM specifies the Individual Risk and Societal Risk Guidelines.

Individual Risk

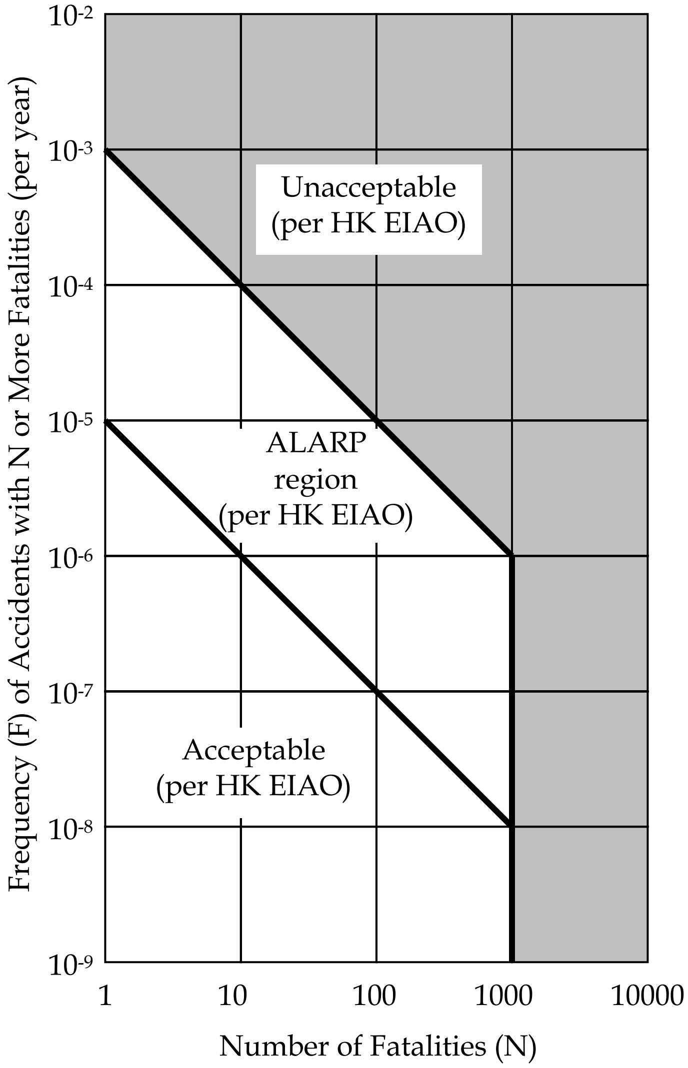
Individual risk is the predicted increase in the chance of fatality per year to a hypothetical individual who remains 100% of the time at a given stationary point.

The individual risk guidelines require that the maximum level of off-site individual risk associated with a hazardous installation should not exceed 1×10^{-5} per year.

Societal Risk

Societal risk expresses the risks to the whole population. The HKRG is presented graphically in *Figure 8.1a.* It is expressed in terms of lines plotting the frequency (*F*) of *N* or more deaths in the population from incidents at the installation. Two FN risk lines are used in the HKRG to demark "acceptable" and "unacceptable" societal risks. The intermediate region indicates the acceptability of societal risk is borderline and should be reduced to a level which is "as low as reasonably practicable" (ALARP). It seeks to ensure that all practicable and cost-effective measures which can reduce risks will be considered.

Figure 8.1a Hong Kong Government Risk Guidelines



8.1.3 *Study Objectives*

The objective of this risk study is to assess the risk to life of the general public, including the workers of nearby plants, from the proposed facility during its operational phase. The results of the QRA are compared with the HKRG.

The detailed requirements of the study (see *Section 3.4.1.1* of the EIA study brief) are as follows:

- To identify hazardous scenarios associated with the Project operation and then determine a set of relevant scenarios to be included in a Quantitative Risk Assessment (QRA);
- To execute a QRA of the set of hazardous scenarios identified, expressing population risks in both individual and societal terms;
- To compare the individual and societal risks with the criteria for evaluating hazard to life stipulated in *Annex 4* of the EIAO-TM; and
- To identify and assess practicable and cost-effective risk mitigation measures.

As required in the EIA Study Brief, the methodology used in this study is consistent with previous studies having similar issues, in particular the PAFF EIA (1).

8.2 *PROCESS DESCRIPTION*

This section summarises those aspects of the process that are relevant to the risk assessment.

8.2.1 *Plant Layout*

The layout of the site is shown in *Figure 8.2a*. The process and administration buildings are labelled as items 1A/1B/1C and are located in the centre and towards the south of the site. The tank farm is labelled as items 2A-2F and is situated on the north side. Storage tanks are provided with impoundment bunds to contain any leaks from the tanks. The waste water treatment plant (item 3) is situated on the west side of the site, as is the jetty (item 4A) for loading/unloading of barges. The whole site will be surrounded by a perimeter wall about 2m in height. Access to the site will be through an entrance on Chun Wang Street.

The process operations are carried out inside a building, about 13m in height and 46m by 30m in area which is constructed of concrete walls on two sides and steel structures with panels on the other two sides. The building is provided with continuous ventilation as well as emergency ventilation to prevent flammable atmosphere. All equipment and piping inside the building are sealed and there are no continuous emissions inside the building. The processing equipment is located inside a building to enable to control the ambient temperature as well as for limiting the separation distances imposed by the electrical area classification requirements.

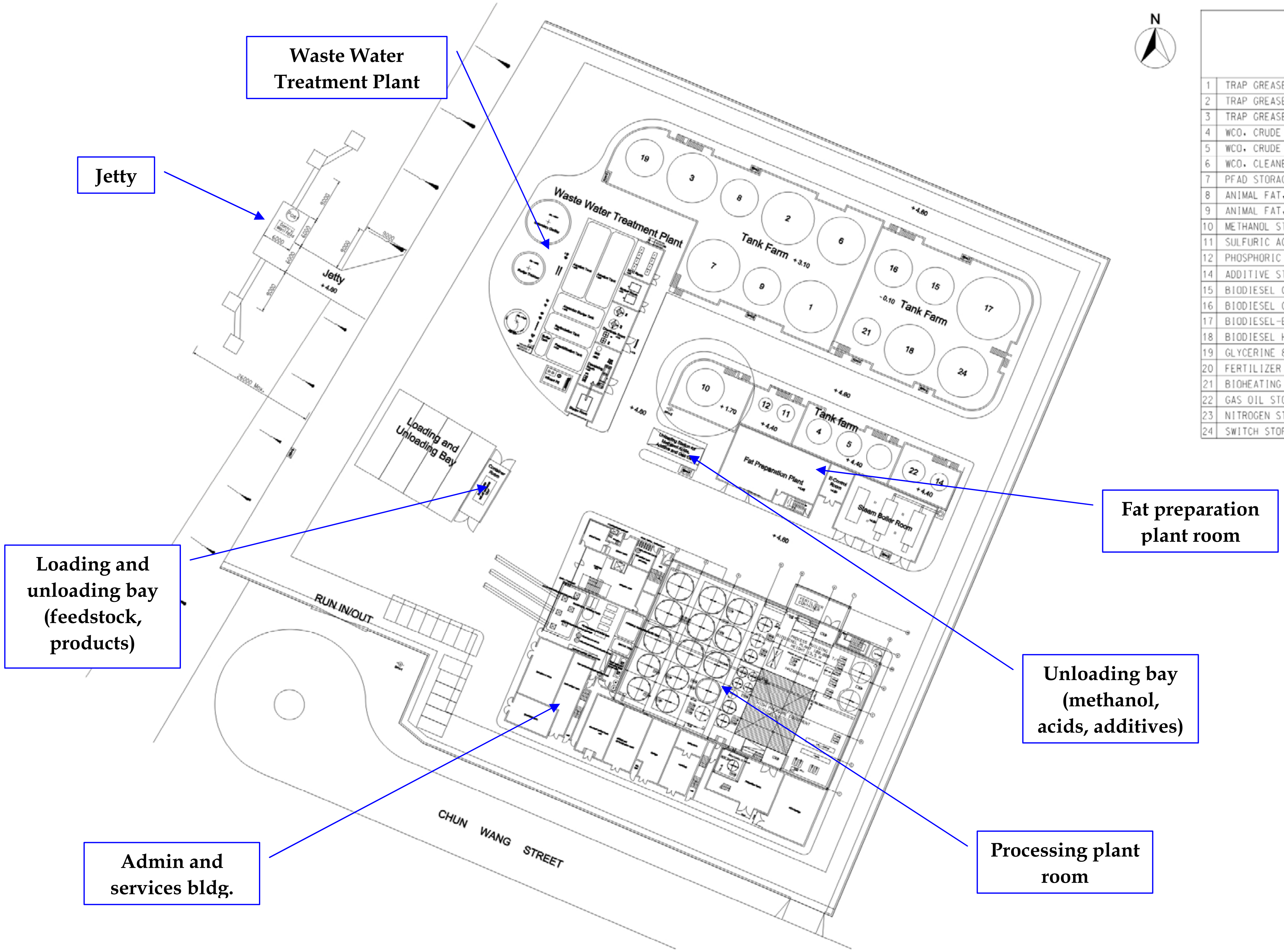
According to the Hong Kong Code of Practice for Oil Storage Installations,[2] minimum separations are recommended between adjacent tanks in a tank farm, and between tanks and buildings. In this Code, combustible liquids are classified according to their flash point. Separation requirements depend on the classification of the tank contents. In the proposed plant, most tank contents would fall into Class 3 (lowest risk), for which no separation requirements are specified. Only one tank, the methanol storage tank T10, falls into Class 1 (highest risk), and this tank complies with the layout requirements. It may be noted that although this Code applies to petroleum products, reference to this Code was made based on the flash point and boiling point of materials being handled in this project to determine the adequacy of inter tank separation distances and bund capacities.

(1) Engineering Safety and Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility, Environmental Impact Assessment Report, Feb 2007.

(2) Code of Practice for Oil Storage Installations 1992, Building Authority, Hong Kong.

A process flow diagram and flow chart are shown in *Figure 8.2b* and *Figure 8.2c*. A summary of the process will be described below.

Figure 8.2a   Site Layout



	TANK LIST	VOLUME (m 3)
1	TRAP GREASE, CRUDE STORAGE TANK	1500
2	TRAP GREASE, CRUDE STORAGE TANK	1500
3	TRAP GREASE, CLEANED STORAGE TANK	1000
4	WCO, CRUDE STORAGE TANK	150
5	WCO, CRUDE STORAGE TANK	150
6	WCO, CLEANED STORAGE TANK	1000
7	PFAD STORAGE TANK	1500
8	ANIMAL FAT, CRUDE STORAGE TANK	500
9	ANIMAL FAT, CLEANED STORAGE TANK	500
10	METHANOL STORAGE TANK	500
11	SULFURIC ACID STORAGE TANK	50
12	PHOSPHORIC ACID STORAGE TANK	25
14	ADDITIVE STORAGE TANK	50
15	BIODIESEL QUALITY TANK	500
16	BIODIESEL QUALITY TANK	500
17	BIODIESEL-EUROPE STORAGE TANK	2500
18	BIODIESEL HONGKONG STORAGE TANK	1200
19	GLYCERINE 80% STORAGE TANK	500
20	FERTILIZER CONTAINER	20
21	BIOHEATING OIL STORAGE TANK	200
22	GAS OIL STORAGE TANK	100
23	NITROGEN STORAGE TANK	25
24	SWITCH STORAGE TANK	1200

0 10 20 M

Figure 8.2b Process Flow Diagram

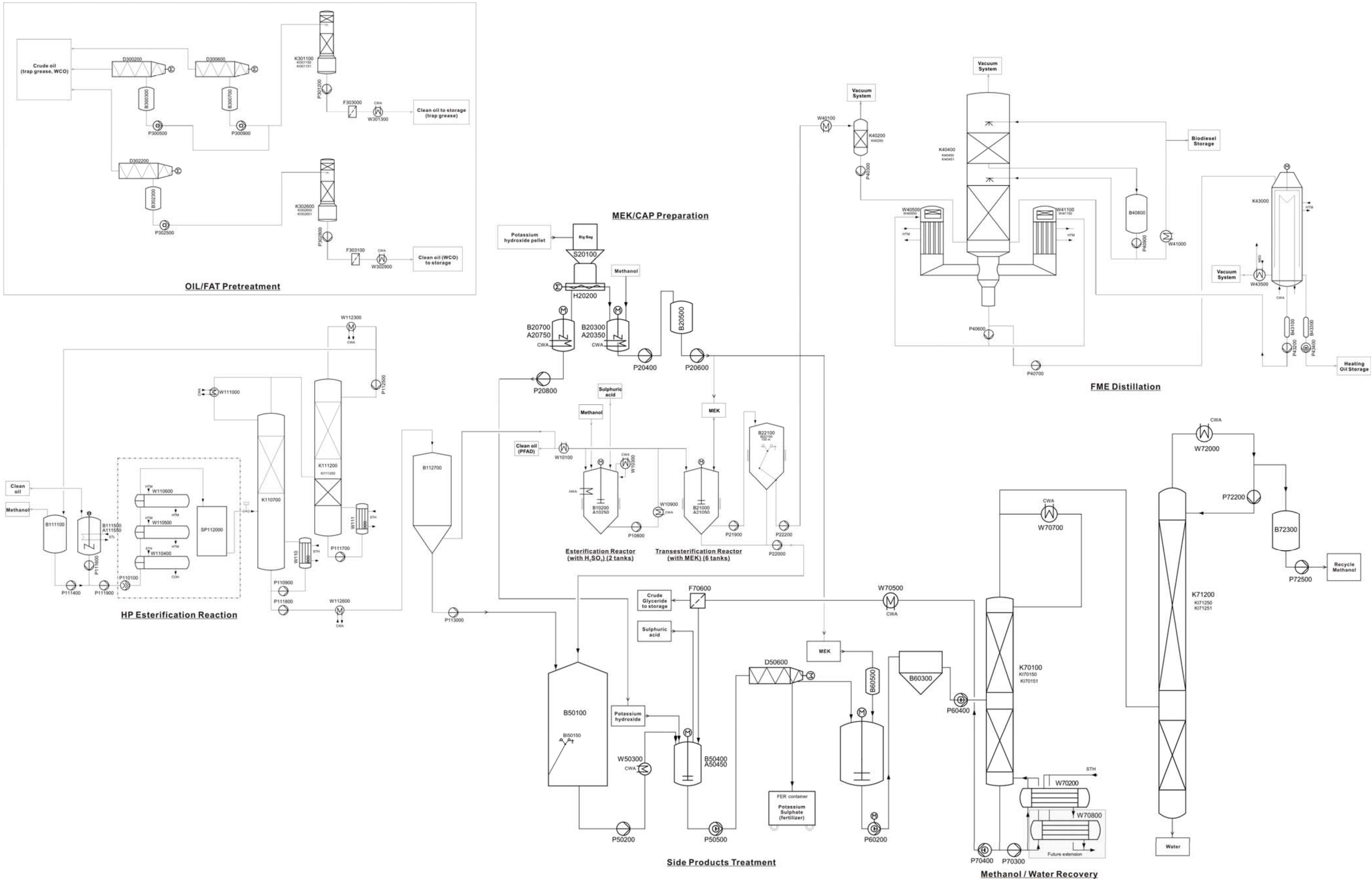
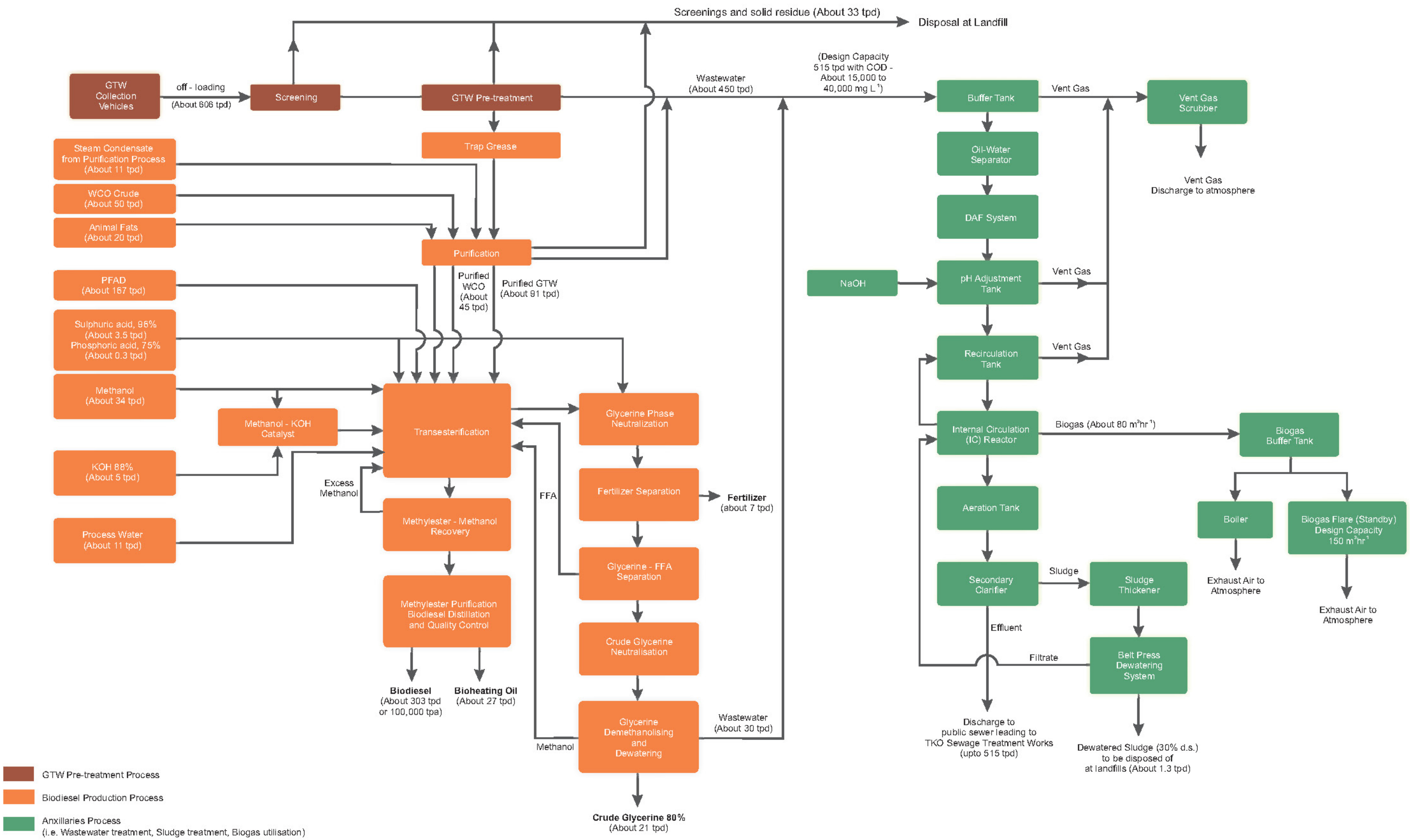


Figure 8.2c Process Flow Chart



8.2.2 *Transport Activities*

Feedstock Reception and Handling

Grease trap waste (GTW), waste cooking oil (WCO), gas oil, glycerine and other feedstock will be delivered by sealed 10 m^3 road tankers or 10 tonne trucks.

Materials will be unloaded at the designated stations as shown in *Figure 8.2a*. 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.

Typical fire safety measures including spill containment, drainage of spills to a safe location, fire sprinkler systems, fire detection systems, provision of means of firefighting including hydrants and extinguishers, and adequate access for emergency services will be provided. All tanker loading and unloading operations will be supervised by trained personnel.

Jetty Operations

Palm Fatty Acid Distillate (PFAD) will be delivered to site by barge and pumped from the barge to the storage tank. Similar procedures will apply to the delivery of methanol and shipping out of biodiesel. 1,000 tonne barges will be used for all marine-based transport. It is estimated that about 2 barges per week will be required to transport biodiesel out of the plant.

When marine transport is not possible, e.g. due to adverse weather conditions, biodiesel will be shipped out in 20 m^3 road tankers (type D vehicles for conveyance of Category 5 Dangerous Goods similar to those used for transport of petroleum diesel). 10 trucks per day will be required to transport biodiesel out of the plant.

The transportation of feedstock and products to and from the biodiesel plant was tabulated in *Table 3.2b* and is repeated here in *Table 8.2a* for convenience.

Table 8.2a Estimated Number of Material Delivery to and from Biodiesel Plant

Material	Vehicle / Barge	Frequency
Land-based Delivery		
Grease Trap Waste	$10m^3$ Sealed Road Tanker	60[(a)] per day
Waste cooking oil	Trucks with 20ft containers	5 per day
Animal fat	$10m^3$ Sealed Road Tanker	4 per day
Gas Oil	$10m^3$ Sealed Road Tanker	1 per day
Glycerine	$10m^3$ Sealed Road Tanker	2 per day
Fertilizer	10 tonne truck	1 per day
Nitrogen	$10m^3$ Sealed Road Tanker	1 per week
Other supplies and deliveries	10 tonne Truck/Tanker	2 to 3 per day
Biodiesel [(b)]	20 m^3 Road Tanker	10 per day
Methanol[(b)]	$10m^3$ Sealed Road Tanker	2 per day
Total		***76 to 89***
Marine-based Delivery		
Biodiesel	1,000 tonne barge	2 per week
Palm oil fatty acid distillate	1,000 tonne barge	1 per 10 days
Methanol	1,000 tonne barge or ISO-tanker barge	1 per week
Total		***4 per week***

Notes:
(a) GTW will be delivered to the site on 24-hour basis.
(b) Only when marine transportation is not possible (eg during inclement weather).

8.2.3 Oil/Fat Preparation

Crude oil/fat (grease trap waste, waste cooking oil, animal fats or palm oil fatty acid distillate) which is part of the feedstock is cleaned from impurities in a washing step by adding heated water and steam. The separation step is performed by a series of decanters. Solids are collected in waste containers and the aqueous phase is sent to the waste water treatment plant. The clean oil can either be sent to oil drying columns for further treatment or pumped to the storage tank in the tank farm area directly.

8.2.4 Esterification (with catalyst)

The esterification is a one step batch reaction under atmosphere pressure. This reaction is used to convert free fatty acids (FFA) to methyl ester, which is the main ingredient of biodiesel. In this process, FFA is esterified with methanol to methyl ester and water under acidic conditions. The reaction is catalysed by sulphuric acid and is operated at methanol's boiling point with reflux condensation. The esterification reactor is first filled with oil, then methanol and sulphuric acid are added according to the recipe. The reactor is heated by an internal heating coil. After the batch is completed, the agitator is stopped and the water phase is allowed to settle before sending to the waste water treatment. The oil phase is then cooled and pumped to the transesterification reactor.

8.2.5 *High Pressure Esterification (without catalyst)*

Feedstock with a high concentration of Free Fatty Acids (FFA) is esterified with methanol under high pressure and temperature rather than using the catalyst process. This high pressure esterification reaction is a continuous process in a tubular reactor jacketed by steam. The operating pressure of the reactor is 100 barg and the temperature is between 180°C and 240°C. The reaction mixture consists mainly of Fatty Acid Methyl Ester (FME), Glycerine, Methanol, Water, Mono-/Di-/Triglyceride and FFA. Unused methanol and water are separated from the oil phase in a demethanolisation dewatering column. Methanol and water are further separated in a methanol water column and the methanol recovered for reuse.

8.2.6 *MEK Preparation*

MEK is a mixture of methanol and potassium hydroxide and acts as a catalyst for the transesterification reaction. Methanol and potassium hydroxide combine to form potassium methanolate (CH_3OK).

8.2.7 *Transesterification, FME-Purification*

The transesterification reaction is used to convert triglycerides to methyl ester and glycerine. The reaction is done in a two stage catalytic reaction with MEK. Oil from esterification reactors (both with catalyst and without catalyst) is pumped to the transesterification reactor. Fresh methanol, recycle methanol and MEK (catalyst) are then added according to the recipe. The reaction mixture is agitated for some time before the heavy glycerine phase (GLP) is allowed to be settled at the bottom. The GLP is discharged to a buffer vessel for further processing. Additional fresh methanol and MEK are added to the remaining mixture and the second stage of the transesterification takes place. After draining the GLP, the remaining content goes through a 3 stage washing sequence.

Water is added during the first washing step which helps separate the soap and glycerine from the methyl ester. The aqueous phase is steeled and drained to the GLP collection tank. Phosphoric acid is added to the transesterification tank during step 2 of the washing sequence. This is mainly to convert potassium soap back to FFA. The heavier phase is then partially discharged to the GLP collection tank. At the third washing step, water is dosed to the vessel again to further remove any remaining acid in the oil phase and improve the separation between the lighter oil phase and the heavier phase. Finally the purified oil phase (Methyl ester; Biodiesel) is discharged to the FME buffer tank.

8.2.8 *FME Distillation (including Vacuum System)*

The purified FME after the 3 washing steps still contains small amounts of methanol and water. The FME is first heated to 200°C and then flashed to remove most of the remaining methanol and water. The flash drum operates under vacuum condition. The FME then enters 2 distillation columns which are both under vacuum condition to allow moderate distillation temperatures (the two columns operate at 230°C and 250°C). The final FEM contains 96.5% or higher methyl ester. The distillate which contains other reaction by-products is used as heating oil to fuel the column reboilers. The FEM is sent to the quality tank where samples are taken to ascertain product quality. Provision is made to route any off-spec product back to the feed for reprocessing.

8.2.9 Acidulation, Phase-Separation

The glycerine phase from the transesterification reactor is collected in the GLP collection tank. A continuous stream from the collection tank is pumped to the acidulation tank where it is mixed with the acidic water from the esterification reactor, which contains sulphuric acid. Inside the acidulation tank, potassium soap will react with acid and form potassium sulphate (solid phase) and FFA. The reaction also produces 2 liquid phases (GLP and FFA). Decanting is used to separate the 3 phases. The solid phase is discharged to containers and sold as fertilizer, FFA is collected and recycled while the GLP phase will be sent to the neutralization tank for further processing.

8.2.10 Neutralization

The acidic glycerine phase (GLP) is collected in the neutralization tank where the pH is adjusted to 7 by dosing with MEK. The solution is then filtered and enters the demethanolization column.

8.2.11 Methanol and Water Recovery

The solution from the neutralization process, which contains glycerine, methanol and water, is sent to the demethanolization column. Glycerine with small amounts of water exit from the column bottom and are sent to the GLP storage tank. Methanol and water from the top of the column are further separated in the MET recovery column. Liquid methanol from the top of the MET recovery column is collected in the recycle methanol tank and water from the bottom of the column is sent to recycle water buffer tank. Both streams are reused in the process.

8.2.12 Wastewater Treatment Plant

Used process water from the Oil/Fat preparation unit and the process areas are sent to the wastewater treatment plant for treatment before routing to the public 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 utilising up flow 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 biogas generated from the IC Reactor has a high energy value and will be used as an energy source for on-site facilities, namely as fuel for the steam boiler. The biogas will be temporarily stored in a biogas buffer tank of 30 m^3 capacity, under a pressure of up to 5.5 kPa (0.055 barg). Under normal conditions, all biogas will be consumed by the steam boiler. When the steam boiler is under maintenance, the biogas will be sent to flare.

8.2.13 On-site Storage and Ancillary Facilities

The steam boiler system will make use of towngas, biogas, bioheating oil and biodiesel 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.

24 storage tanks are planned for the storage of feedstock and products. The capacities of the tanks for various materials are presented in *Table 8.2b*.

Table 8.2b Capacities of Storage Tanks for the Biodiesel Plant

Tank Number	Description of Storage Tank	No.	Capacity (m^3)	Capacity (Days)
1 & 2	Raw GTW Tank	2	1,500 each	4.6 (total)
3	Cleaned Trap Grease Tank	1	1,000	10.3
4 & 5	Dewatered GTW (Lipofit)	2	150 each	3.4 (total)
6	Cleaned WCO Tank	1	1,000	11.3
7	PFAD Tank	1	1,500	16.1
8	Raw Animal Fat Tank	1	500	11.2
9	Cleaned Animal Fat Tank	1	500	11.2
10	Methanol Tank	1	500	14.3
11	Sulphuric Acid Tank	1	50	12.5
12	Phosphoric Acid Tank	1	25	83.3
14	Additive Storage Tank	1	50	15
15 & 16	Biodiesel Quality Tank	2	500 each	3.2 (total)
17	Biodiesel Storage Tank A	1	2,500	14.2
18	Biodiesel Storage Tank B	1	1,200	9.2
19	Glycerine (80%) Tank	1	500	30.2
20	Fertiliser Container	1	20	2.6
21	Bioheating Oil Tank	1	200	7.5
22	Gas Oil Tank (as back up fuel)	1	100	8.3
23	Nitrogen Tank	1	25	16.5
24	Crude WCO Tank	1	1,200	-

8.2.14 Safety Features

All vessels/tanks and 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 monitoring of the process and intervention 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 a manhole. Pumps for methanol will be equipped with magnetic coupling to eliminate the problems of leaking seals. All pumps will be monitored by a fully automatic process control system (PCS) to prevent dry running.

Methanol will be stored in a carbon steel storage tank with a double bottom layer and will be maintained at atmospheric pressure. All process tanks and machines will be designed to be gas tight and equipped with a gas displacement system. The whole system will have nitrogen blanketing under positive pressure to prevent air ingress that may otherwise lead to the formation of explosive gas mixtures. 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 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 spills can be contained. In most cases (some unlikely exceptions are discussed in *Section 8.3.2*) the impacts of fire caused by loss of containment to tanks would therefore be confined to the bund area and minimise the damage to the surrounding facilities. Bunds for acid storage tanks will be constructed with acid resistant materials.

Explosion Protection

The entire plant is accomplished with equipment according to the required explosion proof class. Open flames and smoking are not permitted. For maintenance and repair works, non-sparking tools will be used.

Each component in which the concentration of methanol is high enough to form an explosive vapour is connected to an inertisation system (ventilation system). Nitrogen is fed to this system to reduce the oxygen content to an amount that no explosive vapour mixtures are formed. Excessive vapour from this system is sent first to a cooling trap in which the methanol is condensed, and then to an exhaust gas washing column. The purified gas is ventilated through a vent above the roof of the process plant.

Furthermore, rotating equipment in which methanol vapour can be present is purged with nitrogen to avoid explosions due to sparks in case of a possible malfunction of the equipment internals.

Within the plant and near all possible methanol emission sources (unloading station, methanol storage, etc.) gas detection instruments will be installed. If gas is detected in the process room, the emergency ventilation is activated automatically and an alarm is displayed in the process control room. Each item of equipment is grounded by proper connections to prevent electrostatic discharges.

Alarms & Shutdown

Every deviation from normal operation condition is reported by the PCS by an alarm. In case of an emergency the process can be stopped by one of the following shut down procedures.

- Loss of utilities - In case of a loss of electrical supply, all electric equipment stops. As the PCS is equipped with an uninterruptible power system, final adjustments for safe shut down and preparation for easy recovery can be made.

  There are two redundant cooling pumps installed to maintain cooling. If deviations in temperature occur, the units are shut down automatically by the PCS. In case of complete loss of cooling water, the process is shut down. The cooling capacity in the system allows a controlled shutdown without major evaporation of methanol.

  Loss of instrument air or nitrogen automatically activates the protective shutdown procedure.

- Safety pressure relief – Vessels and equipment are fitted with safety pressure relief valves or rupture discs to protect against possible over pressurisation.

- Other measures - The plant will be protected by elaborate fire protection and fire fighting systems.

8.2.15 Plant Personnel

Based on similar existing biodiesel plants, the staffing requirements for the operation of the proposed biodiesel plant will be about 20 in daytime and at least 8 at night time. If necessary, external personnel will be hired for maintenance and repair works.

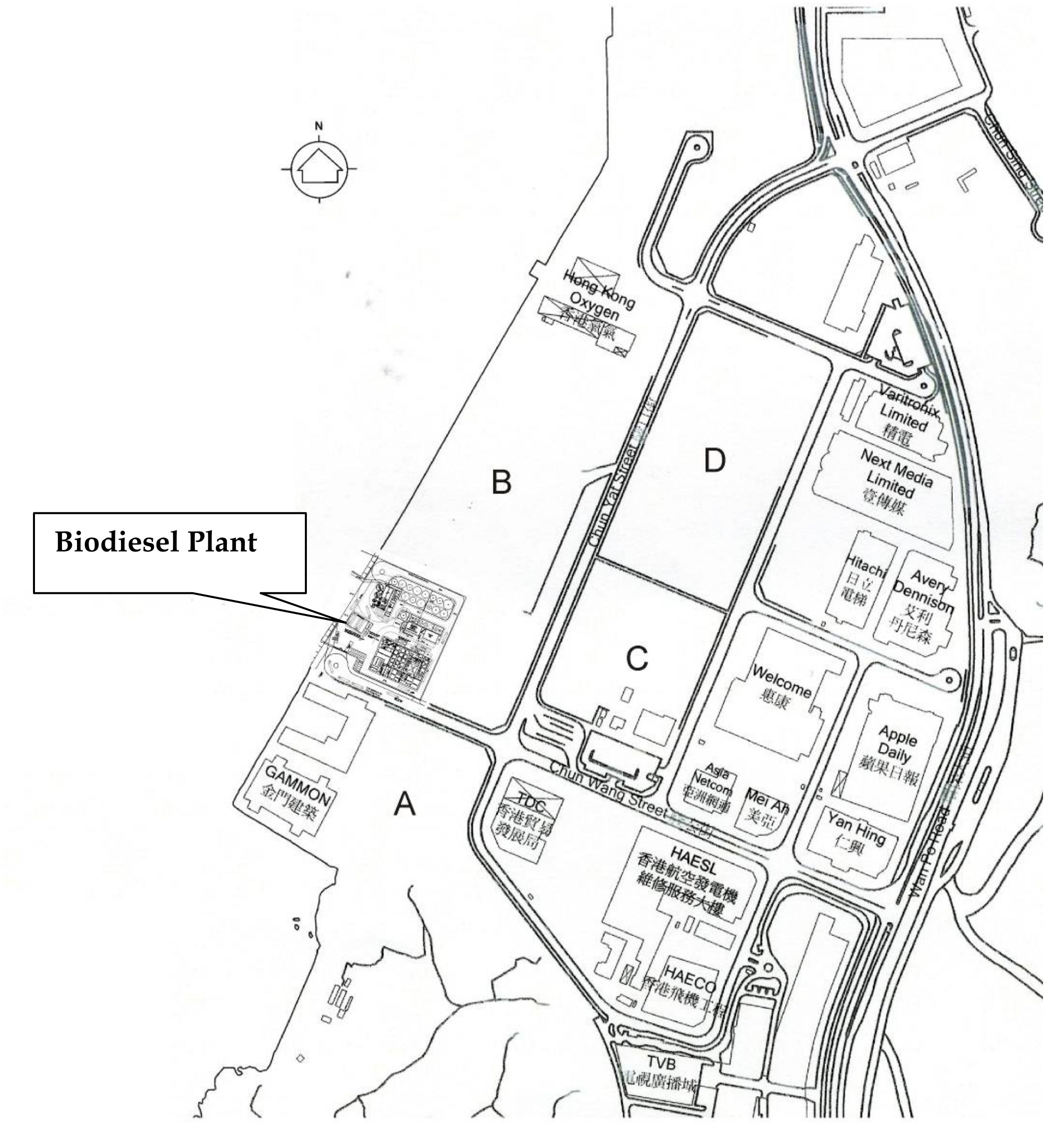
8.2.16 Plant Documentation

Since the planning of the plant is at a relatively early stage, some plant documents such as safety management system, emergency plan and maintenance system have not yet been finalized. In this assessment, it is assumed that they will be developed later in line with chemical process industry best practices.

8.3 SITE DESCRIPTION

The proposed biodiesel plant will be situated in the industrial estate of Tseung Kwan O, along the coast of Junk Bay (see *Figure 8.3a*).

Figure 8.3a Project Site and its Surroundings



8.3.1 Population Data

The vicinity of the biodiesel plant is generally industrial, with the daytime population significantly exceeding the night time occupancy. A Gammon warehouse and technology park lie to the south, Hong Kong Oxygen about 400m to the north, and the Trade Development Council to the east. Sites labelled as A, B, C and D are currently undeveloped. The nearest high-rise residential buildings are those of the Dream City development, about 800m to the north.

The population within the vicinity of the site was estimated based on a combination of site visits, data provided by the Hong Kong Science and Technology Parks and company websites. The maximum consequence distance from accidents at the facility was calculated at about 300m and so all population within about 500m was considered in the survey. A summary of the estimated population is given in *Table 8.3a*.

Table 8.3a Current Population in the Vicinity of the Project Site

Site	Day Time Population		Night Time Population	
	Outdoor	Indoor	Outdoor	Indoor
Building Population				
Gammon Warehouse (North) [(a)]	5	45	1	9
Gammon Technology Park (South) [(a)]	20	180	4	36
Hong Kong Oxygen [(b)]	23	207	5	41
TDC Warehouse [(a)]	30	270	6	54
Asia Netcom Landing Site 1 [(a)]	2	18	1	3
Asia Netcom Landing Site 2 [(a)]	2	18	1	3
HAESL [(c)]	65	585	13	117
Wellcome Warehouse [(a)]	25	225	5	45
Mei Ah [(d)]	21	189	4	38
HAECO [(e)]	37	333	7	67
Sub Total	**230**	**2070**	**47**	**413**
Road Population				
Chun Wang Street (550m) [(f)]	1.5	0	0.3	0
Chun Yat Street (900m) [(f)]	23	0	4.7	0
Chun Kwong Street (370m) [(g)]	1	0	0.2	0
Bus Terminal	10	0	2	0
Sub Total	**35.5**	**0**	**7.2**	**0**
Marine Population				
Water Edge [(f)]	4	0	0.8	0
Junk Bay [(f)]	4	0	0.8	0
Sub Total	**8**	**0**	**1.6**	**0**
Total	**274**	**2070**	**56**	**413**

Notes:

(a) Populations are estimated based on a total population of 2300 people within 500m of the biodiesel plant. The judgement is based on a site visit and functionality of the building.

(b) Hoovers, http://www.hoovers.com/Hong+Kong+Oxygen+&+Acetylene+Company+Limited/--HD__jxjfstyxx,src__global--/free-co-dnb_factsheet.xhtml

(c) Hong Kong Aero Engine Services Ltd, http://www.haesl.com/en_frame_facilites.html

(d) Hoovers, http://www.hoovers.com/Mei-Ah-Laser-Disc-Co-Ltd/--HD__jjyrcyxky,src__global--/free-co-dnb_factsheet.xhtml, http://www.hoovers.com/Mei-Ah-Video-Production-Company-Limited/--HD__jxjshyxht,src__global--/free-co-dnb_factsheet.xhtml

(e) Hong Kong Aircraft Engineering Company Limited Environmental Report 2005, http://www.haeco.com/company_update/HX%20Env%20report%202005.pdf

Site	Day Time Population		Night Time Population	
	Outdoor	Indoor	Outdoor	Indoor
(f) Estimated based on site visit carried out in September 2008. Eight barges were observed anchored within Junk Bay, but no activity was observed on any of the barges. As a conservative assumption, each barge was assumed to have a population of 5 persons indoors giving a total population of 40. Given that the vessels will offer some protection to their occupants, an exposure factor of 0.1 was used in the analysis to give an effective outdoor population of 4.				
(g) The traffic density for Chun Kwong Street is assumed to be the same as Chun Wang Street which is 2.75 person/km				

The night time worker population has been assumed to be 20% of the daytime population. It is also assumed that 90% of the workers would reside indoors, with the remaining 10% being outdoors. A distinction between populations indoors and outdoors is made because the buildings may offer some protection to their occupants from accident scenarios such as fires. Population in vehicles are assumed to be all outdoors.

A distinction is also made between the daytime and night time populations, since significant differences are to be expected. Daytime is defined as 8am to 6pm for 6 days a week and night time from 6pm to 8am. Night time population is also assumed on Sunday. The quoted population estimates represent the average over these time periods.

For marine population, the population of 4 people is distributed evenly over the Junk Bay area of $4km^2$ to derive a population density of 1 person/km^2. The water edge population of 4 is distributed evenly along the coast of the industrial estate to give a line population.

The traffic populations on the Chun Yat Street and Chun Wang Street were measured during a site visit. One hour of data was collected in the morning between 9am and 10am, and an hour of data was collected in the afternoon between 2pm and 3pm. The daytime traffic population was then calculated by assuming 2 hours of morning traffic and 10 hours of afternoon traffic. Population estimates were obtained by counting the number of vehicles of various types travelling in each direction (*Table 8.3b*) and multiplying by average occupancy estimates obtained from the Transport Department Annual Traffic Census 2007[(1)]. These vehicle occupancy estimates are based on cross harbour tunnel traffic and are likely to be conservative for vehicles within the industrial estate.

Assuming an average speed of 20 km hr^{-1}, the population density on the roads may be calculated from:

Chun Yat Street daytime population =

$$\frac{513\ persons/hr \times 2\ hours + 518\ persons/hr \times 10\ hours}{12\ hours \times 20\ km/hr} = 26 \text{ persons/km}$$

(1) The Annual Traffic Census 2007, Transport Department, Hong Kong SAR.

Similar calculations were performed for Chun Wang Street to give the road population figures presented in *Table 8.3b*. The site visit indicated that the bus terminal is quiet with few people and so a population of 10 people present continuously was conservatively assumed.

Night time road population is assumed to be 20% of the day time population.

The current population within 500m from the biodiesel plant was estimated by the Hong Kong Science and Technology Parks at 2300. The population data summarised in *Table 8.3c* was determined so as to be in agreement with this estimate. The Tseung Kwan O Industrial Estate is expected to undergo intensive development in the coming years. Once fully developed, the ultimate worker population within 500m from the project site is estimated by the Hong Kong Science and Technology Parks at 5300. For the purpose of this assessment, these additional 3000 people are assumed to be evenly spread (on a per unit area basis) in the empty lots labelled as A, B, C and D in *Figure 8.3a*. The road and bus terminal population are also increased proportionally. The future population resulting from this analysis is summarised in *Table 8.3c*.

Following the above discussion, this QRA study considers two population cases, corresponding to the current and future population estimates. Results are presented for both cases in *Section 8.8*.

Table 8.3b Traffic Counts near the Project Site

Type of Vehicle	Average Occupancy	Morning		Afternoon	
		Vehicles	Population	Vehicles	Population
Chun Yat Street					
Motor Cycle	1.1	4	4.4	8	8.8
Private Car	1.4	93	130.2	75	105
Taxi	2.2	24	52.8	17	37.4
Private Light Bus	3.1	1	3.1	3	9.3
Public Light Bus	14.2	0	0	0	0
Light Goods Vehicles	1.7	22	37.4	22	37.4
Heavy Goods Vehicles	1.5	22	33	24	36
Non-Franchised Bus	20.6	0	0	4	82.4
Franchised Bus (Double Deck)	50.4	5	252	4	201.6
Total		**171**	**513**	**157**	**518**
Chun Wang Street					
Motor Cycle	1.1	1	1.1	0	0
Private Car	1.4	18	25.2	6	8.4
Taxi	2.2	5	11	2	4.4
Private Light Bus	3.1	0	0	1	3.1
Public Light Bus	14.2	0	0	0	0
Light Goods Vehicles	1.7	3	5.1	4	6.8
Heavy Goods Vehicles	1.5	22	33	19	28.5
Non-Franchised Bus	20.6	0	0	0	0
Franchised Bus (Double Deck)	50.4	0	0	0	0
Total		**49**	**75**	**32**	**51**

Table 8.3c ***Future Population Estimates in the Vicinity of the Project Site***

Site	**Day Time Population**		**Night Time Population**	
	Outdoor	**Indoor**	**Outdoor**	**Indoor**
Building Population				
Gammon Warehouse (North)	5	45	1	9
Gammon Technology Park (South)	20	180	4	36
Hong Kong Oxygen	23	207	5	41
TDC Warehouse	30	270	6	54
Asia Netcom Landing Site 1	2	18	1	3
Asia Netcom Landing Site 2	2	18	1	3
HAESL	65	585	13	117
Wellcome Warehouse	25	225	5	45
Mei Ah	21	189	4	38
HAECO	37	333	7	67
A	41	369	8	74
B	106	954	21	191
C	53	477	11	985
D	100	900	20	180
Sub Total	**530**	**4770**	**107**	**1843**
Road Population				
Chun Wang Street (550m)	3.5	0	0.7	0
Chun Yat Street (900m)	53	0	10.6	0
Chun Kwong Street (370m)	2.3	0	0.5	0
Bus Terminal	23	0	4.6	0
Sub Total	**82**	**0**	**16**	**0**
Marine Population				
Water Edge	4	0	0.8	0
Junk Bay	4	0	0.8	0
Sub Total	**8**	**0**	**1.6**	**0**
Total	**620**	**4770**	**125**	**1843**

8.3.2 *Meteorological Conditions*

The consequences of accident scenarios, such as the dispersion of flammable gases, depend on meteorological conditions of wind speed, wind direction and atmospheric stability class. Hourly data were obtained from the Tseung Kwan O weather station for the most recent 5 years from 2003 to 2007. These weather data were then rationalised into different combinations of wind direction, speed and atmospheric stability class and the probability of occurrence for each combination determined (see *Table 8.3d*).

Table 8.3d Tseung Kwan O Meteorological Data (2003-2007)

Direction	Percentage of Occurrence of each Wind Speed (m/s)/Stability Category								
	Daytime (9am to 6pm)				Night time (6pm to 9am)				Total
	1.5F	3B	3D	6D	1.5F	3B	3D	6D	
N	0.61	2.3	1.78	0.29	12.13	0	3.79	0.8	**21.69**
NE	0.61	6.11	3.24	0.62	7.02	0	4.29	0.94	**22.84**
E	0.66	6.01	2.24	0.32	6.47	0	2.9	0.49	**19.1**
SE	0.23	1.5	0.51	0.08	3.48	0	0.96	0.19	**6.95**
S	0.19	5.63	0.96	0.12	2.68	0	1.29	0.2	**11.06**
SW	0.24	1.34	0.55	0.06	5.57	0	1.51	0.13	**9.41**
W	0.13	0.39	0.11	0.01	2.23	0	0.34	0.03	**3.23**
NW	0.15	0.32	0.19	0	4.64	0	0.41	0.01	**5.73**
Total	**2.81**	**23.61**	**9.58**	**1.5**	**44.23**	**0**	**15.48**	**2.8**	**100**

Note:

(a) Weather condition 1.5F denotes wind speed of 1.5 m/s and atmospheric stability class F. Similar notation applies to 3B, 3D and 6D.

Note on Atmospheric Stability Class

The Pasquill-Gifford atmospheric stability classes are defined as follows:

A: Turbulent;
B: Very unstable;
C: Unstable;
D: Neutral;
E: Stable; and
F: Very stable.

Atmospheric turbulence 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. The vertical temperature profile generally depends on conditions of wind speed and cloud cover.

Category A typically occurs in conditions of light wind with strong solar insulation. This leads to rising air pockets, strong vertical mixing and good dispersion characteristics. Stable atmospheric conditions generally occur during light wind conditions, at night time with clear skies. Radiative cooling of the ground leads to a reduced rate of decrease of temperature with height, or even a temperature inversion. This creates a stable atmosphere which inhibits vertical mixing and leads to poor dispersion characteristics.

Category D is neutral and neither enhances nor suppresses atmospheric turbulence. Conditions near class D usually occur during stronger winds and/or overcast conditions.

To represent the range of meteorological conditions possible at the Tseung Kwan O site, 4 weather conditions are considered in the current study: 1.5F, 3B, 3D and 6D.

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

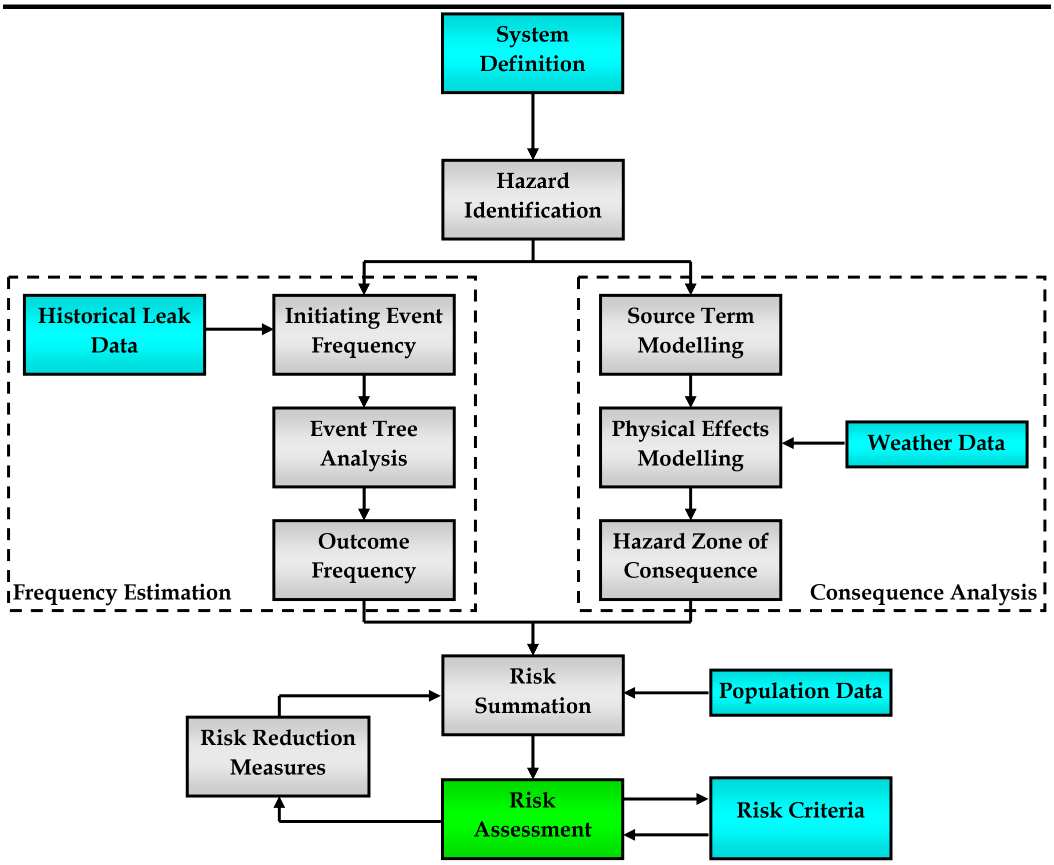
8.4 *QRA STUDY APPROACH*

The methodology adopted for the risk assessment comprises the following major elements which are discussed in detail in the following sections:

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

The elements of a QRA are shown schematically in *Figure 8.4a*. The study focuses on those hazardous scenarios that have a potential to affect the off-site population.

Figure 8.4a ***Schematic Diagram of QRA Process***



8.5 *HAZARD IDENTIFICATION*

8.5.1 *Materials Handled on Site*

Material Safety Data Sheets (MSDS) were reviewed for all materials handled on site, including feedstock, intermediate products, products and by-products, so as to understand the potential hazards arising from these substances. A summary of the relevant properties of these substances is provided in *Table 8.5a*.

Methanol

Methanol is used as a reactant throughout the biodiesel process. Methanol (CH_3OH) is a highly flammable liquid which burns with an invisible flame. Release can cause an immediate risk of fire and explosion. Methanol is a volatile, clear, colourless liquid at ambient conditions with weak alcohol odour.

Loss of containment of methanol may lead to a bund/pool fire if ignited, or a flash fire if the dispersing vapour cloud encounters an ignition source. If methanol vapour accumulates in a congested/confined area, a vapour cloud explosion (VCE) may also occur. Nevertheless, unlike most petroleum fires, methanol fires can be extinguished with water.

Methanol is also mildly toxic. Acute exposure by inhalation to high concentrations of methanol vapour can cause irritation to mucous membranes, headaches, confusion, loss of consciousness and even death.

Main Hazard: Highly flammable. Considered extremely flammable when stored at elevated temperature above its boiling point of 64.5 °C.

Crude Oil

Crude oil is the main feedstock for producing biodiesel. The main types of oil used are waste cooking oil (WCO), grease trap waste (GTW), palm oil fatty acid distillate (PFAD) and animal fats. The compositions of these oils are highly variable but consist mainly of triglycerides and free fatty acids. They are viscous liquids or even solids at ambient conditions. They have low vapour pressures, high flash points and high boiling points. This means they are difficult to ignite although they are combustible.

Main Hazard: Combustible

Sulphuric Acid

Sulphuric Acid (H_2SO_4) is a strong mineral acid and is highly corrosive. Pure sulphuric acid is an odourless, clear, colourless, oily liquid. Sulphuric acid reacts violently with water and the reaction is highly exothermic.

Sulphuric acid is not considered toxic. Main occupational risks are skin contact leading to burns and the inhalation of aerosols. Exposure to aerosols at high concentration leads to immediate and severe irritation of the eyes, respiratory tract and mucous membranes and may be fatal.

The reported lethal concentration LC_{50} for sulphuric acid through inhalation is 510mg/m^3 for 2 hours exposure in rats. LC_{50} for humans is estimated to be 625mg/m^3 for 10 min exposure using Lee's method [(1)]. The vapour pressure of sulphuric acid at room temperature (25°C) is less than 0.13 Pa which is equivalent to a saturated concentration of 5mg/m^3. This is much lower than the LC_{50}. This suggests that a leak from the sulphuric acid storage tank or other equipment near ambient temperature will not pose any risk to personnel due to inhalation of vapours.

Process equipment containing sulphuric acid at the highest operating temperature is the transesterification vessel at 72 °C. However, the acid is diluted to about 12% in this vessel and so the vapour pressure will be correspondingly lower. For comparison, the vapour pressure of pure acid at 50 °C is 0.4 Pa, corresponding to a concentration of 15 mg/m^3, still significantly lower than the LC_{50}. In conclusion, the vapour pressure of sulphuric acid is insufficient to cause dangerous concentrations of vapours and hence sulphuric acid is not considered hazardous to offsite population.

Main Hazard: No significant hazard offsite

Phosphoric Acid

Phosphoric Acid (H_3PO_4) is a strong mineral acid and is a white powder under normal conditions. Phosphoric acid solution is corrosive and may cause severe respiration tract, digestive tract, eye and skin irritation with possible burns. Phosphoric acid is non-toxic and non-combustible.

Phosphoric acid has similar properties as sulphuric acid. The reported lethal limit LC_{50} through inhalation is 850mg/m^3 for 1 hour exposure in rats. LC_{50} for humans is estimated to be 520mg/m^3 for 10 min using Lee's method. The vapour pressure of phosphoric acid is 0.044 Pa at 25 °C, rising to 1.3 Pa at 80 °C. The maximum vapour concentration at process temperatures of 72°C was estimated at 26 mg/m^3, much lower than the LC_{50}. In conclusion, the vapour concentration in air is too low to present any hazards to people offsite.

Main Hazard: No significant hazard offsite

Sodium Hydroxide

Sodium hydroxide (NaOH) is a white solid and forms a strong alkaline solution when dissolved in water with liberation of heat. Sodium hydroxide is corrosive and can cause eye and skin burns. Potential severe respiratory tract, digestive tract irritation with possible burns and damage to mucous

(1) Lees, F. P., Loss Prevention in the Process Industries, Second Edition, 1996.

membranes. Irritation may lead to chemical pneumonitis and pulmonary edema. Sodium hydroxide is non-toxic and non-combustible.

Although sodium hydroxide has a lethal limit LC_{50} of 2300 mg/m^3/2H (rats), sodium hydroxide is extremely non-volatile. The vapour pressure of sodium hydroxide is 1 mmHg (132 Pa) at 739 °C at which is still well below the lethal limit.

Main Hazard: No significant hazard offsite

Potassium Hydroxide

Potassium hydroxide (KOH) is a white solid and forms a strong alkaline solution when dissolved in water with liberation of heat. It has similar properties as sodium hydroxide. Potassium hydroxide is corrosive and can cause eye and skin burns. Potential severe respiratory tract, digestive tract irritation with possible burns and damage to mucous membranes. Irritation may lead to chemical pneumonitis and pulmonary edema. Potassium hydroxide is non-toxic and non-combustible.

Main Hazard: No significant hazard offsite

Additive (Infineum R408)

Infineum R408 is being added to the biodiesel to enhance its combustion properties. Infineum includes the following hazardous ingredients: solvent naphtha, distillates (hydrotreated light), kerosene, alkylhydroxybenzoate formaldehyde condensate, vinyl acetate, mesitylene, 1,2,4-trimethylbenzene, naphthalene. Inhalation of vapours from the heated product can cause irritation of the respiratory tract and the eyes. It has a flash point of 62°C.

Main Hazard: Flammable

Monoglycerides and Diglycerides

Monoglycerides and diglycerides are the side products generated during the esterification and transesterification process. They have similar properties as biodiesel and are combustible under normal conditions. They pose a minor health hazard including skin/eye/respiratory tract irritation on contract.

Main Hazard: Combustible

Triglyceride

Triglyceride (more properly know as triacylglycerol, TAG or triacylglyceride) is a glyceride in which the glycerol is esterified with three fatty acids. It is common in both vegetable oil and animal fats. The melting point of triglyceride is heavily depending on the length of the fatty acid molecule. Triglyceride with a carbon chain longer than 10 carbons atoms would most likely be a solid at room temperature.

Main Hazard: Combustible

Glycerine

Glycerine is generated during the transesterification reaction. It is a colourless, clear liquid without odour. Glycerine poses a minor health hazard including skin/eye/respiratory tract irritation on contract. It has a rather high flash point, giving it a classification of 'combustible'.

Main Hazard: Combustible

Potassium Phosphate Monobasic

Potassium phosphate monobasic is an intermediate product. Pure potassium phosphate monobasic is a white crystalline solid. Inhalation or ingestion may cause respiratory and digestive tract irritation.

In the biodiesel production process, this material only appears in a few streams with a maximum concentration of 5%wt. No significant hazards have been identified.

Main Hazard: No significant hazard offsite

Biodiesel

Biodiesel is a non-toxic chemical. The main composition of the biodiesel is methyl ester (over 96%). Biodiesel has a very high flash point of over 125 °C and is not volatile. It is therefore considered as combustible rather than flammable. Biodiesel poses a minor health hazard including skin/eye/respiratory tract irritation on contract.

Main Hazard: Combustible

Biogas

Biogas is generated from the IC reactor in the water treatment plant. Biogas is temporarily stored in the biogas buffer tank of 30 m^3. Biogas consists mostly of methane and its properties are very similar to Natural Gas (NG). While it is non-toxic, in high concentrations it could lead to asphyxiation. A loss of containment can lead to jet fire (if stored/transferred under sufficient pressure) or to an explosion if the gas accumulates in a confined space.

Main Hazard: Extremely Flammable

Potassium Sulphate (fertiliser)

Potassium Sulphate is a by-product from neutralizing sulphuric acid with potassium hydroxide during the side product treatment step. No specific hazards are identified for potassium sulphate. It is non-toxic, non-flammable, and non-combustible [1].

Main Hazard: None

Gas oil and Bioheating oil

Gas oil and bioheating oil are 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 to biodiesel. Gas oil is, however, bunded separately since unlike biodiesel, gas oil is not biodegradable.

Main Hazard: Combustible

Other Chemicals

Other chemicals involved in the biodiesel process includes Sodium Sulphate and Nitrogen and are considered to pose negligible risk to the offsite population and only a minimal risk to the on-site work-force.

Based on the list of materials on site, potentially hazardous materials identified include Methanol, Crude oil, Infineum R408 (additive), Mono-/di-/tri- Glycerides, Glycerine, Biodiesel, Gas oil/Bioheating oil and Biogas. These are considered further in the analysis.

(1) Note that no ammonium- or other nitrogen-containing byproducts will be produced. There is no fire or explosion risk from this part of the process.

Table 8.5a Key Properties of Chemicals

Chemical	CAS #	Normal State	Molecular Formula	MW	Vapour Pressure (kPa)	Vapour Density (Air =1)	Melting Point (°C)	Boiling Point (°C)	Flash point (°C)	Auto-ignition Temperature (°C)	Flammability Limit (%) UFL	LFL	LC 50	Main Hazard
Feedstock														
Methanol	67-56-1	Liquid	CH_3OH	32.04	12.8	1.11	-98	64.5	11	455	36.5	5.5	64000ppm /4 hrs (rat)	Highly Flammable[1]
Crude Palm Oil Fatty Acid (PFAD)	-	Liquid	-	-	<1	-	-	> 200	> 200	> 250	-	-	-	Combustible
Free Fatty Acid	67254-79-9	Liquid	-	-	-	-	-	> 200	315	400	-	-	-	Combustible
Animal Fat (mainly triglycerides)	-	Solid	-	-	-	-	35	-	274	-	-	-	-	Combustible
Sulphuric Acid (solution)	7664-93-9	Liquid	H_2SO_4	98.08	0.00013	3.4	-15	310	-	-	-	-	510 mg/m³ /2 hrs (rat)	None
Phosphoric Acid (solution)	7664-38-2	Liquid	H_3PO_4	98	0.0038	-	-20	158	-	-	-	-	850 mg/m³ /1 hr (rat)	None
Sodium Hydroxide	1310-73-2	Solid	NaOH	40	-	-	318	1390	-	-	-	-	2300 mg/m³ /2 hr (rat)	None
Potassium Hydroxide	1310-58-3	Solid	KOH	56.1	-	-	380	1384	-	-	-	-	-	None
Infineum R408 (additive)	-	Liquid	~20% Naphtha, ~5% Petroleum Distillates, ~5% Kerosene, ~5% Alkylhydroxybenzoate, formaldehyde condensate	-	-	-	-	-	62	-	-	-	-	Flammable
Intermediate Products														
Mono/Di Glycerides (Glyceryl Mono – Dicaprylate)	26402-26-6	Solid	-	-	<0.27	-	34	155	180	-	-	-	-	Combustible

Chemical	CAS #	Normal State	Molecular Formula	MW	Vapour Pressure (kPa)	Vapour Density (Air =1)	Melting Point (°C)	Boiling Point (°C)	Flash point (°C)	Auto-ignition Temperature (°C)	Flammability Limit (%) UFL	LFL	LC 50	Main Hazard
Monoglyceride (distilled)	97593-29-8	Solid	-	-	-	-	-	250	100	-	-	-	-	Combustible
Triglycerides	85665-33-4	Solid	-	-	-	-	34	-	200	-	-	-	-	Combustible
Glycerine	56-81-5	Liquid	$CH_2CHOHCH_2OH$	92.1	< 0.01	3.1	-	171	199	370	-	-	-	Combustible
Potassium Phosphate Monobasic	7778-77-0	Solid	KH_2PO_4	136.08	-	-	252.6	-	-	-	-	-	-	None
Products/By-products														
Methyl Ester (Biodiesel) [2]	67784-80-9 73891-99-3 61788-71-2	Liquid	-	-	<0.27	> 1	-	> 200	130	-	-	-	-	Combustible
Biogas [3]	8006-14-2	Gas	CH_4	-	-	0.59 to 0.72	-182.5	-161.4	-188	580	5	15	-	Extremely Flammable
Potassium Sulphate (fertilizer)	7778-80-5	Solid	K_2SO_4	14.26	-	-	1067	1689	-	-	-	-	-	None

Notes:

All data are measured at standard state of 20°C and 101kPa.

Flammability classification is according to COMAH guideline (1999 No. 743); Combustible classification is according to OSHA guideline:

- Flammable: Any substance having a flash point higher than 20 °C and lower than 55°C
- Highly Flammable: Substances having a flash point lower than 21°C which are not extremely flammable, or substances which have a flash point lower than 55°C and which remain liquid under pressure, where particular processing conditions such as high pressure or high temperature may create major accident hazards.
- Extremely Flammable: Any substance having a flash point lower than 0°C and boiling point less than 35 °C or flammable substance maintained above their boiling point or gaseous substances that are flammable at ambient temperature and pressure.
- Combustible: Any substance having a flash point above 100°C.

[1] Methanol is highly flammable for storage at ambient temperature. For handling at elevated temperatures in the process areas, it will be classed as extremely flammable if the temperature exceeds the boiling point.

[2] Methyl ester is a group of similar chemicals. Depending on the raw material, different methyl ester will be produced. The three CAS numbers given are associated with the typical biodiesel produced from a combination of animal fats and vegetable oil.

[3] The properties of biogas are very similar to those of Natural Gas (NG), therefore the data for NG is presented.

8.5.2 *Review of Previous Incidents*

To investigate further the possible hazards from the biodiesel plant, a review of past incidents at similar facilities worldwide was conducted. This involved the review of accident databases such as MHIDAS and the IChemE Accident Database, as well as internet searches.

Incidents at Same Technology Plants

The proposed biodiesel plant in Tseung Kwan O uses the Biodiesel International (BDI) Technology. There are currently 28 biodiesel plants in Europe using the same technology with a combined plant experience of about 280 plant-years. To date, no noteworthy incidents have occurred at any of the plants, demonstrating an excellent safety record. However, the sample size is not large enough to derive a statistically significant incident frequency for comparison with the EIAO-TM risk guidelines.

Incidents at Other Biodiesel Plants

A review of incidents at other biodiesel plants is provided in *Table 8.5b*. It can be seen that most incidents are related to ignition of methanol vapours although some fires also occurred involving biodiesel and vegetable oil. Further fire incidents relating to methanol are listed in *Table 8.5c*. A detailed consideration of previous incidents and their relevance to this study is given below, in later paragraphs.

Biodiesel production in both Europe and the US is growing rapidly. In Europe, for example, one estimate[1] puts the number of plants in operation in 2006 at 65, while another report[2] shows European output growing at more than 50% per year. The European biodiesel industry has an excellent safety record, with no major incidents reported in recent years.

We have also considered the US biodiesel industry, which has experienced a number of plant incidents, unlike in Europe, as shown in the following table. According to some estimates,[3] there could be as many as 200 biodiesel plants in the USA at present, although many of these are likely to be small scale and/or idling (as discussed later in this report). Based on this, we could assume approximately 600 plant years of experience in the US.

As shown in the incident reports below, there have been 3 incidents leading to fatalities onsite in the USA in recent years (although no offsite fatalities). Once again, the sample size is not large enough to determine a statistically significant accident frequency but the data may be used to derive an upper bound. There is evidence to suggest a significant difference in the operating

(1) http://www.ethanolmarketplace.com/plant/list/3

(2) http://www.biodieselmagazine.com/article.jsp?article_id=1779&q=number%20plants&category_id=29

(3) http://biodieselmagazine.com/plantmap/

philosophy of biodiesel plants in Europe and the US. Whereas in Europe, plants are managed by professionals experienced in chemical processing, US plants often grow organically from 'backyard' or entrepreneur start-up operations. This results in substantial differences in the way the plants are operated and managed. To reflect this, we have investigated the recent incidents in more detail, with the aim of examining their relevance to the proposed plant. This has enabled us to obtain a rough quantitative estimate of the incident frequency in the proposed plant, for comparison with the QRA results, as described in the following section.

Diesel Tanker Related Incidents

A search for incidents relating to diesel road tankers produced the results shown in *Table 8.5d*. Although several incidents resulted in fuel release, in none of the case was the fuel ignited. This demonstrates that the probability of ignition of diesel fuel is rather low due to its high flash point. The properties of biodiesel are similar to petroleum diesel.

Following this review of past incidents, the main hazard is associated with explosions and fires from methanol due to its low flash point. This QRA study therefore looks at possible methanol incidents in detail, and also the possibility of fires from other flammable/combustible materials.

Tank Failures

Table 8.5e provides a list of storage tank failures. The causes are mostly mechanical failure and corrosion. One case was caused by earthquake. It is interesting to note that in at least 2 cases, the bund failed to contain the whole inventory.

Tank failure and the possibility of bund overtopping is considered in the current assessment.

Table 8.5b Previous Incidents Involving Biodiesel Plants and Related Materials

Date of incident	Location of incident	Material Name	Incident Type	Injuries/ Fatalities	Description	Reference
15/08/2008	DECATURVILLE, TENNESSEE, USA		Fire; Explosion	0 Injured 0 Killed	An explosion took place in a standby biodiesel plant awaiting conversion to glycerine production. The explosion and fire destroyed all the existing stocks of biodiesel, sodium hydroxide, methanol and glycerine. No injury is reported	1
18/05/2008	PRINCESS ANNE, MD, USA	METHANOL/ Biodiesel	Fire; Explosion	1 Injured 1 Killed	2 worker were installing a new methane line at the facility when a massive explosion occurred which blew the walls of the building out and bubbled the roof out. One worker died and the other one injured	2
15/04/2008	CALGARY, CANADA	METHANOL VAPOR	Fire; Explosion	0 Injured 1 Killed	A worker died in an explosion at a biodiesel plant while carrying out welding operation on top of a 30-ft biodiesel settling tank. Fumes and methanol accumulated inside the tank ignited by the welding operation caused the explosion. Fire continued to burn in the tank for several hours until all the biodiesel is consumed	3
04/01/2008	DEFIANCE, OHIO, USA	METHANOL VAPOR	Fire; Explosion	3 Injured 0 Killed	Operator in the biodiesel plant left a manhole cover open on a storage tank holding glycerin, and a spark from an electric motor ignited the methanol vapors that escaped. Three workers inside the biodiesel plant were hurt.	4
07/07/2006	NEW PLYMOUTH, IDAHO, USA	METHANOL VAPOR/ BIODIESEL VAPOR	Explosion	2 Injured 1 Killed	Two explosions happened while one worker was working on top of a tank used to store soy oil. One worker was killed, one suffered 2nd degree burn and another suffered from smoke inhalation. Nearby highway was shut down for 4 hours.	5
17/02/2006	BAKERSFIELD, CA, USA	METHANOL	Fire	0 Injured 0 Killed	The accident happened outside of the plant building when, during a transfer of methanol, a small spill occurred that ignited (ignition source unknown, probable cause static electricity). The plant was in full production mode when the outside fire spread into the building. The operators followed their training and safety procedures and quickly shut down operations. Then, when they could not contain the fire with on-site extinguishers, they left the premises and quickly notified the Fire Department and Hondo personnel in the other buildings located on the property. No other buildings were affected because they were not in close proximity. Unfortunately, ABF	6

Date of incident	Location of incident	Material Name	Incident Type	Injuries/ Fatalities	Description	Reference
					suffered a total loss of the building and equipment. The plant burned violently for several hours and the non-hazardous plumes of smoke could be seen for miles. As a result, although the entire plant was destroyed: five biodiesel tanks (containing approx. 30,000 gallons) and 6,000 gallons of methanol were saved; and, approx. 90,000 gallons of corn oil stored in railroad cars were moved back safely with only some minor fire damage to the exterior of the cars.	
03/11/1997	ISRAEL	DIESEL	Fire; Explosion	0 Injured 1 Killed	A fire occurred in a diesel storage tank following explosion and caused a fatality. Worker had gone for a test sample when the explosion occurred	IChemE
11/01/1995	USA; TENNESSEE; CHATTANOOGA	VEGETABLE OIL	Fire	Not reported	Derailment of twenty cars of freight train. Box car containing half gallon containers of vegetable oil was first to catch fire.	MHIDAS
03/06/1988	Izmir, TURKEY	VEGETABLE OIL	Ship to shore impact	0 Injured 0 Killed	A marine transportation incident. A marine tanker hit berth at a terminal while manoeuvring in to discharge vegetable oil. Bow heavily damaged. Jetty destroyed.	IChemE
10/11/1979	NORWAY; SKREIA	VEG OIL + SODA	Runaway-reaction	0 Injured 0 Killed	Chemical reaction between vegetable oil and soda. Violent explosion destroyed 2-Storey building of area 25,000m^2.	MHIDAS
10/02/1970	FRANCE; MARSEILLES	VEGETABLE OIL	Fire; Explosion	12 Injured 2 Killed	Explosion in vegetable oil refinery of a soap factory. Refinery gutted by fire.	MHIDAS

1: http://www.biofuels-news.com/news/tennessee_explosion.html
2: http://wjz.com/local/bio.diesel.plant.2.726871.html
3: http://www.cbc.ca/canada/calgary/story/2008/04/15/biodiesel-explode.html
4: http://www.indianasnewscenter.com/news/local/13062367.html
5: http://www.idahobusiness.net/archive.htm/2006/07/17/What-Now-Explosion-at-New-Plymouth-biodiesel-plant-raises-questions-for-highlytouted-market
6: http://www.greaseworks.org/modules.php?op=modload&name=News&file=article&sid=274&mode=thread&order=0&thold=0

Table 8.5c Previous Incident Involving Methanol

Date of incident	Location of incident	Material Name	Incident Type	Injuries/ Fatalities	Description	Reference
20/02/2001	USA; ALASKA; PRUDHOE BAY	METHANOL	Continuous-release	0 Injured 0 Killed	Water frozen in oil pipeline creating an ice plug. Pipeline flushed with warm crude oil and methanol, and pressure raised to help melt the ice. The oil and methanal leaked from a crack on the top of the pipeline. Size of spill unclear.	MHIDAS
06/12/2000	USA; NEW MEXICO; JAL	METHANOL	Fire	Not reported	A natural gas pipeline ruptured and exploded underneath two storage tanks containing methanol and glycol. The tanks burned out and the plant was forced to close.	MHIDAS
05/11/2000	USA; TEXAS; SONORA	METHANOL	Fire	0 Injured 0 Killed	Lightning struck a transformer, igniting a chemical warehouse. All residents within half a mile were evacuated. Fire was extinguished within three hours. Warehouse contained methanol, cleaning solvents and other hazardous chemicals.	MHIDAS
04/09/2000	UK; ESSEX; PURFLEET	METHANOL	Continuous-release	0 Injured 0 Killed	19,000 kg of methanol spilled out onto the dock side after a container loaded with the solvent toppled over. The area was cordoned off by police to allow specialists to remove the chemical. The wharf was cleared of all shipping as a precaution.	MHIDAS
14/03/2000	UK; NORFOLK; NORWICH	METHANOL	Release	0 Injured 0 Killed	Workers were evacuation after a single container of chemical leaked in a warehouse. It is unclear whether the chemical was sulphuric acid or methanol. Fire fighters cleaned up and made safe the leaking container.	MHIDAS
19/08/1999	UK; WEST MIDLANDS; WEST BROMWICH	METHANOL	Gas-cloud	0 Injured 2 Killed	2 night watch men found dead when day shift arrived. They were overcome by fumes believed to be form mixture of methanol, potassium powder & hydrochloric acid, used to strip wheels. High levels of methylene chloride traced in building.	MHIDAS
30/03/1998	UK; CHESHIRE; ELLESMERE PORT	METHANOL	Fireball	Not reported	Tanker carrying 20 tonnes methanol overturned on a roundabout and caught fire. Methanol burns invisibly and fireball was recorded on a thermal imaging camera in a police aircraft which helped direct evacuation and firefighting. Motorway closed for 6 hours.	MHIDAS

Table 8.5d Previous Incident Involving Diesel Tankers

Date of incident	Location of incident	Material Name	Incident Type	Injuries/ Fatalities	Description	Reference
29/10/1998	UK; MID GLAMORGAN; PENCOED	DIESEL FUEL	Continuous-release; Liquid pool formed	0 Injured 0 Killed	A Diesel tanker and a gas tanker collided on the M4 spilling hundreds of gallons of diesel. The motorway was blocked for more than 6 hours. Fire fighters undertook a huge mopping up operation. Both drivers were uninjured.	MHIDAS
09/07/1998	UK; DEVON; CULLOMPTON	DIESEL FUEL	Continuous-release	0 Injured 0 Killed	A Diesel tanker and a BMW collided on the M5 between junctions 28 and 29. No one was injured but the collision and fire crews were called in to deal with the spill. Sand was used to soak up fuel.	MHIDAS
19/02/1996	UK; CLEVELAND; THORNABY	DIESEL	Continuous-release	3 Injured 0 Killed	Tanker with nitrobenzene crossed central reservation & crashed head on with a diesel tanker. The diesel tanker overturned & one compartment of the nitrobenzene tanker ruptured allowing chemical to spill to roadside drain & subsequently to river tees.	MHIDAS
08/09/1995	UK; LINCOLNSHIRE; NORTH THORESBY	GAS OIL	Continuous-release	Not reported	Lorry and diesel tanker collided head on when one of the vehicles skidded in wet and locked brakes. Collision forces part of articulation of tanker back into tank, which then buckled. 400L gas oil from fully laden tanker leaked onto road.	MHIDAS
12/10/1990	UK; ESSEX; BISHOPS STORTFORD	DIESEL	Continuous-release	Not reported	Diesel tanker toppled onto oncoming car spilling 3000galls	MHIDAS

Table 8.5e Catastrophic Tank Failure (100% Instantaneous Rupture) of Petroleum Product Tanks Since 1970

Date of incident	Location of incident	Material Name	Failure Cause	Spill Contained by Bund	Reference
29/07/1993	El Segundo, CA, USA	Fuel oil	Not known	No - about 2% lost	MHIDAS
11/05/1993	Fawley, UK	Bunker oil	Mechanical	Unknown if bund used	MHIDAS
10/1989	Richmond, CA, USA	Gasoline	Earthquake	Yes	MHIDAS
6/02/1989	New Haven, CT, USA	Heating oil	Mechanical	Yes	MHIDAS
11/07/1988	Brisbane, Australia	Gasoline	Corrosion	Not known	MHIDAS
2/01/1988	Floreffe, PA, USA	Diesel oil	Mechanical	No - 40 to 71% lost	MHIDAS
28/12/1980	El Dorado, KS, USA	Solvents	Mechanical	Not known	MHIDAS

Relevance of Serious Incidents at Other Biodiesel Plants

15/08/2008 – Decaturville, Tennessee, USA. This incident relates to an explosion within a biodiesel plant building which was idled. The cause of this incident appears to be unknown, however based on the incident reports, the following may be deduced. The plant covered an area less than 800 m^2 and producing 35,000 T/year, corresponding to a backyard facility typical to entrepreneur start-up plants in US. In such plants, safety is most likely to be compromised as entrepreneurs are trying to get into the industry at minimal costs often compromising on safety (1). Analysing accident reports further, it is noted that an explosion occurred, followed by the building fire. An explosion would only have been possible following a loss of containment of flammable substances. The substance that caused the explosion is not known. It could have been methanol or any other flammable substance stored at the facility. Since the plant had been shut down for several months, the initiating event was likely caused by inadequate procedures for operation (inventory not empty/ inappropriate purging, etc) and maintenance of the facility (e.g. no check for leaks, etc) which would not occur if the facility is under regular checks and monitoring. The safety features are not specified in accident records, but based on typical design of such facilities, if fire mitigation systems were in place and inert gas blanketing was applied the explosion would not have occurred. Therefore, if the operator followed standard operation and maintenance procedures for this facility this accident would not have occurred.

18/05/2008 – Princess Anne, Maryland, USA. This incident relates to an explosion within a biodiesel plant building which was idled. The explosion was triggered by welding work being undertaken by external contractors. In addition, plant modification was carried out without positive isolation. The incident does not, therefore, relate to normal plant operation, and can only arise from lapses in proper maintenance procedures and permit-to-work controls. Therefore, if the operator followed standard operation and maintenance procedures for this facility this accident would not have occurred. Safety management systems will be in place in the proposed plant to minimize the risks of any similar incidents.

15/04/2008 – Calgary, Canada. This incident relates to tank failure outside the process building. This, again, was triggered by welding by contractors. See comments on Princess Anne incident.

04/01/2008 – Defiance, Ohio, USA. This incident relates to an explosion within a biodiesel plant building. This incident appears to have been related to accumulation of methanol vapours inside a glycerine tank, and their subsequent release through an open manhole. The vapour was believed to have ignited by operation of a motorized door. The injured persons were

(1) See, for example, www.biodieselmagazine.com/article.jsp?article_id=1127, where a consultant design engineer, Rocky Costello, comments: that safety is most likely to be compromised in smaller, startup plants in which entrepreneurs are trying to get into the industry at minimal costs.

reported to have been located in a plant office. Such an incident is less likely in the proposed plant because:

- methanol is distilled from the crude glycerine before it is sent for storage and in addition any accumulated methanol vapour in the building would be vented;
- the glycerine tank is in the open air, not inside a building, reducing the likelihood of vapour accumulation; and
- All electric motors in chemical-handling areas are designed to be flameproof (Ex-rated).

07/07/2006 – New Plymouth, Idaho, USA. This incident relates to tank failure outside the process building. The plant was under conversion from a non-chemical warehouse to a biodiesel facility. Again, this incident was related to hot work on a tank that had not been properly drained or purged. The tank contained a mixture of methanol and glycerine.[1]

It may be noted that four of the five incidents above occurred during shutdown periods and related to hazards common to any type of facility handling flammable chemicals. Only one fatality (the Defiance, Ohio incident) is known to have arisen from a cause specific to biodiesel plants. Also, it is found that no fatality has been reported beyond the site boundary as the result of any incident at a biodiesel plant.

17/02/2006 – Bakersfield, California, USA. This incident relates to methanol spill during transfer outside the process building. The fire arose from a methanol spill during transfer from a movable bulk container. In the proposed plant, such a spill is unlikely because all methanol transfers (apart from transfer from delivery vehicles) will use fixed piping only, not hoses. Although leaks can occur from flanges, these are rare, especially in low pressure, clean service systems. Leaks can also occur from bleeders if left open and uncapped, but this is poor operational practice and should be controlled by a permit-to-work system.

It was reported that the spill was 'small' and yet the fire spread from outside the process building to inside. This suggests that the spill was actually quite substantial, and there may have been no physical barrier between outside and inside (cf. the concrete containment wall around the process building for the proposed plant).

Other Incidents

22/11/2006 – Danvers, Massachusetts, USA. A serious incident occurred in a paint and ink manufacturing facility which, although not directly related to biodiesel, is considered here because the causes and findings are highly relevant. In this incident, a major vapour cloud explosion occurred overnight

[1] http://www.ktvb.com/news/localnews/stories/ktvbn-jul1406-explosion_cause.113ae8b1.html

inside a process building. Although the exact cause has not been established, it appears due be due to leakage of heptane and alcohol vapours from a vessel left heating unattended. The vapours were released due to overheating, and built up because the building ventilation had been turned off at night to prevent noise complaints. The entire plant was destroyed and several neighbouring buildings severely damaged.

The official investigation (1) found that the underlying causes were:

- inadequate ventilation in the process area
- absence of automated safeguards, controls or alarms
- no proper management or procedures in place for handling hazardous substances

Each of these issues is addressed in the proposed plant. Adequate full-time ventilation will be provided, with automatic emergency ventilation in the event of a buildup of flammable vapours; automated safeguards, controls and alarms will be provided to control process-related risks; and adequate procedures and management controls will be instituted for all hazardous operations onsite.

28/08/92 – Castle Peak Power Plant, Hong Kong. This was one of the most significant incidents to occur in Hong Kong. An explosion occurred inside a high pressure hydrogen receiver, resulting in damage to the power plant, roof, storeroom and concrete blast walls. Two people were killed and 19 injured. There was however, no injury or fatality involving the public. The incident arose from inadvertent injection of air over a period of 20 hours prior to changeover from a temporary receiver to the permanent one following maintenance.

A design error in the plant allowed the injection of air into the receiver at high pressure. To eliminate such a possibility at the proposed biodiesel plant, a full HAZOP study will be carried out on the proposed plant during the detail design in order to confirm the adequacy of design safety measures.

This incident again highlights the importance of proper maintenance, start-up and shutdown procedures, since a large fraction of incidents occur during these times (see discussion below).

Buncefield, UK, 10 December 2005

One of the tanks at this storage tank farm containing petrol overflowed while being filled from a pipeline. The liquid overflow led to a rapid formation of a vapour cloud which extended offsite. Upon ignition, this resulted in an explosion that led to a fire engulfing over 20 tanks. There were no offsite

(1) U.S. Chemical Safety and Hazard Investigation Board, "Confined Vapor Cloud Explosion", Report No. 2007-03-I-MA, p. 68 (2008).

fatalities since the event occurred in the early morning hours. The explosion caused severe damage to adjoining buildings.

This accident is relevant to some extent to this study since methanol has a low flash point and hence there is potential for a vapour cloud formation upon spillage which can potentially lead to an explosion upon ignition. However, the amount of methanol stored in this plant is less than 500m^3 which is very low in comparison with large petroleum storage tank farms.

Relevance of the Six Biodiesel Incidents

In order to estimate the frequency of explosions and fire at the proposed plant based on historical incident data, the relevance of previous incidents at biodiesel plants has been assessed, in terms of the scope for any incident of this type at the proposed plant compared with the affected plants in the USA. These are assigned on the basis that a physical safety system (e.g. inerting), proper maintenance and safety management procedures, and intrinsically safe design (e.g. hard-piping for flammable liquid) will each reduce the likelihood by an order of magnitude. Draining of tanks prior to maintenance is assigned a lower reduction factor of 0.2 instead of 0.1 for other cases because, under exceptional circumstances, it may not be possible. It is also to be noted that these incidents did not cause any offsite fatality and hence the likelihood of an incident that could lead to an offsite fatality may be assumed as 10%. This additional factor has, however, not been considered since the reduction factors assumed for better systems and practices have already accounted for the lower potential for a serious incident.

Table 8.5f ***Relevance factors for related incidents***

Incident	Probable cause and underlying factors	Relationship to proposed plant at TKO	Relevance factor assigned
Incidents relating to explosion within the process building			
Decaturville	No emptying of vessels not in operation and inadequate purging Inadequate maintenance of equipment not in operation	Standard operating procedure to empty and purge vessels on shutdown. Safety systems such as gas leak detectors and maintenance checks/rounds.	0.01
Princess Anne*	Damage to gas pipe during hot work No positive isolation before maintenance	Hot work strictly controlled by management system. Positive isolation required in hazardous areas	0.02
Defiance	Accumulation of methanol vapours indoors. Failure to close manway on tank. Non-flameproof electrical equipment in process area	Gas detection and automatic emergency ventilation provided. Flameproof electrical equipment. No storage tanks in indoor areas.	0.001
TOTAL			*0.031*
Incidents relating to loss of containment events outside process building			

Incident	Probable cause and underlying factors	Relationship to proposed plant at TKO	Relevance factor assigned
Calgary*	Failure to inert, purge and/or empty tank for hot work during shutdown	Hot work strictly controlled by management system. Draining and purging of tank required	0.02
New Plymouth*	Failure to inert, purge and/or empty tank for hot work during shutdown	Hot work strictly controlled by management system. Draining and purging of tank required	0.02
Bakersfield	Fire following methanol spill	Any methanol transfer is a supervised/attended operation with emergency fire fighting systems ready to operate. Methanol container will be iso-container and not subject to catastrophic failure	0.01
TOTAL			*0.05*

Incidents resulting in an onsite fatality are marked *

Estimating average Potential Loss of Life due to Biodiesel Related Incidents

From the evaluation above, we may estimate the frequency of an incident at the proposed plant as follows. There have been 3 fatalities in the US biodiesel industry (all onsite) in around 600 plant years, with a total relevance factor of 0.06, giving an average PLL (for onsite population) of 1 x 10^{-4} per biodiesel plant per year. Based on the review of historical accidents, even if those incidents did not cause any offsite fatalities, it is judged that only one reported vapour cloud explosion incident (Princess Anne incident with relevance factor of 0.02) within the process building may have the potential to cause offsite fatalities, which would lead to a PLL (for offsite population) of 3.3 x 10^{-5} per biodiesel plant per year.

Estimating Frequency of Explosions from Related Incidents

Based on the vapour cloud explosion incidents within the process buildings, only one (Princess Anne) was reported to damage the process building directly. Although the building was damaged, the damage was not comparable to explosions which would cause fatalities offsite. Additionally, this facility may not have been provided with emergency ventilation system (typical configuration in US is without emergency ventilation).

It should be noted that there have been no reported serious incidents at biodiesel plants in Europe. The proposed plant will use technology licensed from a European company, already successfully implemented in around 20 other plants across Europe, and will be operated to European safety standards. Thus, the fatality frequency estimated from American incidents can be regarded as a conservative upper limit.

Conservatively accounting that all of the three of the historical biodiesel accidents would be relevant, a total relevance factor of 0.031 may be derived (referring to *Table 8.5f*). The overall frequency of explosions is therefore estimated at 0.031 x 1/600y, ie 5.2×10^{-5} per year. This frequency can therefore be considered to represent the overall explosion frequency including minor and major explosions (although no major explosion was reported with offsite fatalities). This may be compared with the derived frequency for explosion in this plant, which is described in later sections.

Hazards during Maintenance and Shutdown

The discussion above indicates that maintenance activities, especially during shutdown periods, have contributed to a substantial proportion of serious previous incidents in biodiesel plants. This is in line with data from the chemical industry generally: for example, a typical refinery operation is shut down for only 2% of the time, but 20% of accidents occur during this period (1). In the case of the biodiesel industry, there are indications that, in the USA, a substantial fraction of plants are idle at any given time (2). This would explain the preponderance of downtime-related incidents.

In a review of around 500 previous incidents in the oil and chemical industries, Duguid (3) notes that about half of the incidents occurred during shutdown (15%), start-up (14%), maintenance (11%) and abnormal operations (13%). Abnormal operations include mainly actions to avoid shutdowns due to faulty equipment.

Also, he reports that around 22% of incidents are related to tank usage. He comments that "one can get the impression that because storage is an ancillary service it may not get the same attention in safety matters as process plant." This is certainly reflected in the pattern of previous incidents reviewed above, and emphasizes the importance of proper attention to safety management with regard to tank farms.

The scenario of a similar maintenance-related incident occurring at the proposed plant, is discussed in a later section.

8.5.3 Hazards Associated with Marine Transport

Hazards associated with the final approach and manoeuvring of barges within 100m of the jetty are included in this assessment. These hazards include leaks and fires arising from collisions and groundings.

Since methanol is completely miscible with water, this rules out the possibility of a pool fire occurring on the sea surface due to a methanol leak. Small to

(1) *Hazards of Oil Refining Distillation Units*, BP Process Safety Series, Institution of Chemical Engineers, 2008, p.4.

(2) http://www.biodieselmagazine.com/plantmap/

(3) Duguid, I. M. "Analysis of past incidents in the oil, chemical and petrochemical industries," *Loss Prevention Bulletin (IChemE)*, issue 142 (1998), p.3-6.

medium leaks would have little effect since the methanol would simply pour into the sea and disperse. If a large rupture were to ignite, the remaining contents within the tank may ignite leading to a tank fire. This scenario was included in the assessment.

Pool fires on the sea surface for other flammable/combustible materials are included in the analysis.

8.5.4 *Hazards Associated with the Tank Farm*

Brittle Failure and Material/Weld Defects

The main hazard associated with a storage tank is a loss of containment leading to release of a hazardous substance.

There are a number of old recorded incidents involving a tank suddenly splitting from top to bottom releasing the whole inventory, also known as unzipping. These cases involved a crack propagated suddenly from an initial defect when the tank material was brittle at the prevailing temperature.

Design standards and knowledge of materials have improved since these early recorded incidents. One of the improvements includes welding the plates together in a staggered array such that a single crack cannot propagate vertically over an extended length. Cracks propagating horizontally are less likely since the stresses in this direction are lower.

Brittle failure involves very low ambient temperature, which is not applicable to the proposed biodiesel plant in Hong Kong. All storage tanks will store materials at or near ambient temperature, hence the steel of the tank will behave in a ductile way, in which cracks will arrest or propagate slowly (1).

Defects in welds or materials can also lead to tank failures.

Tank failure scenarios are considered in this study, modelled using generic failure frequencies (*Section 8.6*). It is assumed that the biodiesel storage tanks will be designed and constructed to the appropriate standards so that generic failure frequencies are appropriate.

Internal Explosion

A number of past incidents have occurred involving an explosion in the vapour space of a storage tank. This can result in the failure of the shell to floor seam and instantaneous release of the tank inventory.

Modern tanks are constructed with a weak shell to roof connection which is designed to fail first during an internal overpressure scenario. In this case, the content of the tank will be retained and the worst consequence would be a fire

(1) Engineering Safety & Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility – Environmental Impact Assessment Report, Feb 2007, section 10.6.2.5

on top of the tank.

Internal explosion is possible only if the vapour generated is able to form a flammable mixture. In the tank farm of the proposed biodiesel plant, all materials handled have insufficient vapour pressure at ambient conditions to form a flammable vapour cloud. The exception is the methanol storage tank. Internal explosion of the methanol tank leading to tank fire was therefore considered further but the consequence modelling demonstrated that the radiation effects at ground level would be negligible. The methanol tank is also a cone roof type with nitrogen blanketing.

Bund Overtopping

Although all the storage tanks are located in bunds, impoundment bunds may not be 100% effective in containing spills, especially large spills from catastrophic failure of a tank. A fraction of the tank contents may overtop the bund wall. This is considered in the analysis.

Tank Fires

Tank fires may occur due to ignition of vents from the tank or due to roof failure or ignition of the vapour space in the tank. This may lead to a fire on tank top. This scenario is considered more likely for the methanol tank (there is only one tank with an inventory of less than $500m^3$) which has a low flash point. All other tanks hold material with a very high flash point and hence ignition leading to a fire is very low. In any case, the radiation effects from a tank fire is limited to the plant boundary and hence the risk of fatality offsite due to a tank fire is negligible.

8.5.5 Process Related Hazards

Biogas Hazards

The biogas generated from the IC Reactor (average flow about 80 m^3 hr^{-1}) will be temporarily stored in the biogas buffer tank of 30 m^3 capacity, under the working pressure of 2.5 to 3.8 kPa and a maximum pressure of up to 5.5 kPa (0.055 barg). A preliminary quantitative assessment using the PHAST model of the potential consequences of a biogas leak or loss of containment demonstrated that due to the low working/maximum pressures and low gas inventory, the potential consequence distances would be small (less than 10 m) and would not affect the off-site population. Nevertheless, for completeness, this hazard is included in the assessment.

Hazards from Loading/unloading Areas

Hazards may also come from the loading and unloading of materials from/onto road tankers and sea barges. Failure of the unloading hoses and piping during the transport of methanol and other flammable materials from barges and road tankers is considered in this study to investigate the effect of a leakage assuming typical unloading rates.

A spontaneous failure of a road tanker may result in a pool fire and has also been considered.

Methanol road tankers would be used only sporadically, when the barge transport is not possible (e.g. during typhoons). The frequency of their failure and resulting pool or flash fires, adjusted by the presence factor, are below 1 x 10^{-9} per year, a frequency threshold below which hazardous events are normally not considered in QRAs. Specifically, a road tanker rupture frequency of 2×10^{-6} per tanker-year is used. With 2 deliveries (each lasting 1 hour) per day for 10 days during typhoons, the presence factor is (2/24) x (10/365) = 0.0023. With an ignition probability of 0.08 (*Section 8.6*), the frequency of a fire becomes 3.6×10^{-10} per year. The leak frequency is a little higher at 2×10^{-6} per tanker-year, but the ignition probability is lower and the fire frequency still below 10^{-9} per year. Thus, the risk due to failures of methanol road tankers is considered to be negligible.

Process Building

There are a number of vessels and equipment in the process building that can fail, the main hazard being a release of flammable materials. A release of most of the materials would simply lead to a pool fire. The process area is fully enclosed in a building with a curbed area to contain spills. A fire within the process building would not affect anyone offsite. Even if the fire protection systems were to fail and a pool fire escalated to affect the building itself, the escalation would be gradual. The normal response time[1] of the Hong Kong fire services (FSD) to an emergency call is likely to be around 10 minutes for this location, and so there would be sufficient time for persons offsite to evacuate and avoid danger. Pool fires within the process building are therefore considered to pose negligible risk.

Some equipment items, such as the high pressure reactor, have sufficient pressure to produce a jet fire in case of release. However, similar arguments apply and the jet fire will be contained within the building and will not impact anyone offsite. Jet fires are therefore considered to pose negligible risk.

Releases of methanol, however, pose greater risks. Methanol has a higher vapour pressure and may lead to the accumulation of flammable vapours, particularly when released at elevated temperatures such as from the esterification reactor. Upon ignition, a vapour cloud explosion could occur within the process building due to the high level of confinement and congestion. This scenario is considered in the analysis.

The effects of methanol being released through the ventilation exhaust vent on the roof are also considered.

(1) According to a recent Hong Kong Civil Service report (www.csb.gov.hk/hkgcsb/doclib/showcasing_fsd_e.pdf), 94% of fire emergency calls to urban locations are attended within 6 minutes, while the attendance time is 9 to 23 minutes for isolated locations. Thus, we may conservatively adopt an expected response time of 10 minutes for this location.

8.5.6 External Hazards

The concern here is with those hazards that are outside the control of the operating personnel but could still pose a threat to the installation. Such hazards are termed as 'external hazards' because they are independent of the operations on-site but can lead to major hazard scenarios. These external hazard events include the following:

- Earthquake;
- Aircraft crash;
- Helicopter crash;
- Typhoons (Storm Surge and Flooding);
- Tsunami;
- Landslide;
- Subsidence;
- Vandalism, sabotage, terrorist attack, acts of war;
- Lightning strike;
- Accidents at neighbouring facilities; and
- Vehicle impact.

Since these events are independent of the operations protection against them needs to be incorporated into the system's design. Design criteria for the protection of hazardous chemical plants against such events are well established, and are generally dependent on the geographical location of the plant. Additional criteria could also be imposed (for instance development of hazardous chemical plants is subject to stricter planning regulations in areas of high seismic activity).

However, if a major accident occurs despite the fulfilment of the relevant design standards and regulatory criteria, the consequences of this event could be catastrophic. In examining the consequences of a major accident from this source, the examination should be made in the context of the overall situation. For example, if an earthquake, winds or floods of sufficient intensity occurs at a chemical plant complying with relevant design and regulatory criteria, what will be the direct consequences of that occurrence (fatalities due to building collapse, induced landslides, etc.) are typically greater than the indirect consequences as a result of failure of the plant. Each of these hazards is further discussed in the following subsections.

Earthquake

An earthquake has the potential to cause damage to storage tanks, pipework and process vessels. Damage to pipework could be due to ground movement/vibration, with guillotine failure of pipes possibly resulting. Loss of containment from a process vessel could result due to:

- Vessel structural support failure;
- Building roof/structure collapse; and
- Vibration induced stress failure.

Vibration and ground movement can also lead to the failure of storage tanks.

Studies by the Geotechnical Engineering Office[1] and Civil Engineering Services Department [2] conducted in the last decades indicate that Hong Kong SAR is a region of low seismicity. The seismicity in Hong Kong is considered similar to that of areas of Central Europe and the Eastern areas of the USA. As Hong Kong is a region of low seismicity, an earthquake is an unlikely event. The generic failure frequencies adopted in this study are based on historical incidents that include earthquakes in their cause of failure. Since Hong Kong is not at disproportionate risk from earthquakes compared to similar facilities worldwide, it is deemed appropriate to use these generic frequencies without adjustment. There is no need to address earthquakes separately as they are already included in the generic failure rates.

Aircraft Crash

The proposed biodiesel facility is more than 30km away from the Hong Kong's international airport (see *Figure 8.5a*). The frequency of aircraft crash was estimated using the methodology of the HSE [3]. The model takes into account specific factors such as the target area of the proposed hazard site and its longitudinal (x) and perpendicular (y) distances from the runway threshold (see *Figure 8.5b*).

The crash frequency per unit ground area (per km^2) is calculated as:

$$g(x,y) = NRF(x,y) \qquad (1)$$

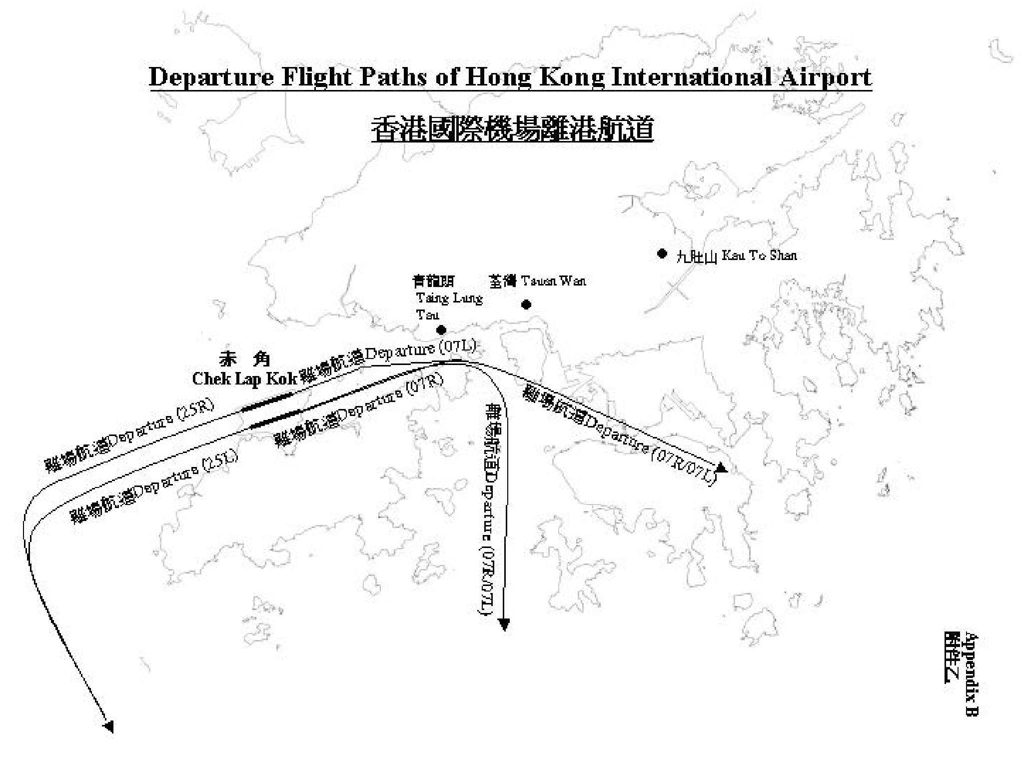
where N is the number of runway movements per year and R is the probability of an accident per movement (landing or take-off). $F(x,y)$ gives the spatial distribution of crashes and is given by:

(1) GEO, Seismic hazard analysis of the Hong Kong region, GEO Report No. 65, Geotechnical Engineering Office, Government of the Hong Kong SAR, 2002.

(2) GCO, Review of earthquake data for the Hong Kong region, GCO Publication No. 1/91, Civil Engineering Services Dept., Hong Kong Government, 1991.

(3) Byrne, J. P., The calculation of aircraft crash risk in the UK, Health and Safety Executive, HSE\R150, 1997.

Figure 8.5a Flight Paths at Hong Kong International Airport



Landings

$$F_L(x,y)=\frac{(x+3.275)}{3.24}e^{\frac{-(x+3.275)}{1.8}}\left[\frac{56.25}{\sqrt{2\pi}}e^{-0.5(125y)^2}+0.625e^{-\frac{|y|}{0.4}}+0.005e^{-\frac{|y|}{5}}\right] \qquad (2)$$

for $x > -3.275$ km

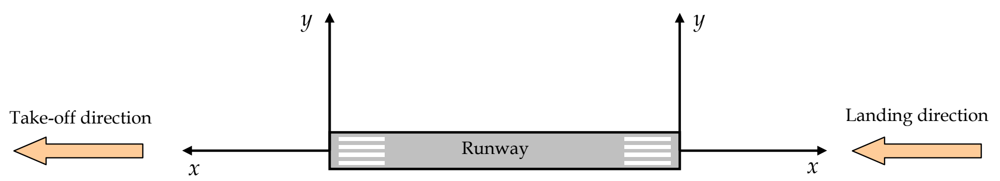
Take-off

$$F_T(x,y)=\frac{(x+0.6)}{1.44}e^{\frac{-(x+0.65)}{1.2}}\left[\frac{46.25}{\sqrt{2\pi}}e^{-0.5(125y)^2}+0.9635e^{-4.1|y|}+0.08e^{-|y|}\right] \qquad (3)$$

for $x > -0.6$ km

Equations 2 and *3* are valid only for the specified range of *x* values. If *x* lies outside this range, the impact probability is zero.

Figure 8.5b ***Aircraft Crash Coordinate System***



NTSB data (1) for fatal accidents in the U.S. involving scheduled airline flights during the period 1986-2005 are given in *Table 8.5h*. The 10-year moving average suggests a downward trend with recent years showing a rate of about 2×10^{-7} per flight. However, only 13.5% of accidents are associated with the approach to landing, 15.8% are associated with take-off and 4.2% are related to the climb phase of the flight (2). The accident frequency for the approach to landings hence becomes 2.7×10^{-8} per flight and for take-off/climb 4.0×10^{-8} per flight. The number of flights at Chek Lap Kok in 2007 was about 300,000 (3).

Considering landings on runway 25R for example, the values for *x* and *y* according to *Figure 8.5b* are 32km and 14km respectively. Applying *Equation 2* gives $F_L = 1.02\times10^{-11}$ km^{-2}. Substituting this into *Equation 1* gives:

$$g(x,y)=NRF(x,y)=\frac{300{,}000}{8}\times2.7\times10^{-8}\times1.02\times10^{-11}=1.03\times10^{-14}\,/\,year\,/\,km^2$$

(1) www.ntsb.gov/aviation/table6.htm

(2) Annual review of aircraft accident data: US General Aviation, Calendar year 2001, National Transport Safety Board.

(3) Civil Aviation Department, Facts and Statistics, Government of Hong Kong SAR.

The number of plane movements has been divided by 8 to take into account that half of movements are take-offs and only a quarter of landings use runway 25R. This effectively assumes that each runway is used equally and the wind blows in each direction with equal probability.

Table 8.5h ***U.S Scheduled Airline Accident Rate***

Year	Accident rate per 1,000,000 flights for accidents involving fatalities	10-year moving average accident rate per 1,000,000 flights
1986	0.14	-
1987	0.41	-
1988	0.27	-
1989	1.10	-
1990	0.77	-
1991	0.53	-
1992	0.53	-
1993	0.13	-
1994	0.51	0.451
1995	0.12	0.475
1996	0.38	0.464
1997	0.30	0.446
1998	0.09	0.354
1999	0.18	0.295
2000	0.18	0.261
2001	0.19	0.208
2002	0.00	0.215
2003	0.2	0.173
2004	0.09	0.188
2005	0.27	

The target area is estimated at 20,000m^2 or 0.02km^2. This gives a frequency for crashes into the biodiesel plant associated with landings on runway 25R as much less than 10^{-9} per year.

The combined frequency of all take-off and landing crashes onto the biodiesel plant from activities on all runways is much less than 10^{-9} per year. The risk of aircraft crash is therefore negligible.

Helicopter Crash

A helicopter landing pad is situation to the north of the site, in the unoccupied lot labelled as 'B' in *Figure 8.3a*. The landing pad is used rarely, however, with a frequency of less than once per year. The distance to nearest storage tank is about 130m.

The approach, landing and take-off stages of a flight are associated with the highest risk of helicopter crashes. Historical incidents show that helicopter accidents during take-off and landings are confined to a small area around the helipad [1]. 93% of accidents occur within 100m of the helipad. The remaining 7% occur between 100 and 200m of the helipad.

Data from offshore helicopter activities [2] gives a helipad related helicopter crash frequency of 2.9×10^{-6} per flight stage (i.e. per take-off and landing). However, most of these incidents are minor such as heavy landings. For a helicopter incident to damage a facility, it must be a serious, uncontrolled impact. Only accidents involving fatalities were therefore considered in the analysis. 4% of incidents resulted in one or fatalities and so the frequency of uncontrolled crashes was estimated at $2.9\times10^{-6}\times0.04 = 1.2\times10^{-7}$ per flight stage. For one flight per year using the helipad, the frequency becomes 1.2×10^{-7} per year.

The storage tanks are approximately 130m from the helipad. Only 7% of accidents occur within the range of 100 to 200m. The probability of a helicopter crashing into a storage tank may be calculated as:

$$1.27\times10^{-7}\times0.07\times\frac{\pi6^2}{\pi\left(200^2-100^2\right)}=1.1\times10^{-11}\ \text{per year}$$

where a typical storage tank has been estimated to be 6m in radius. The frequency of damage by helicopters is very small compared to the process related failures. For example, the generic failure frequency adopted for catastrophic failure of a tank is 5×10^{-6} per year (*Section 8.6*). The contribution from helicopters to the frequency of tank or equipment failure may therefore be neglected with negligible error.

Typhoons (Storm Surge and Flooding)

Flotation of piping and tanks is possible if equipment becomes submerged in water.

Flooding from heavy rainfall is not possible due to the coastal location of the site. The primary hazard from typhoons is the storm surge and waves, which if combined with a high tide could lead to flooding of the site. Winds, and to a lesser extent pressure, cause a rise in sea level in coastal areas. In general, storm surges are limited to several meters.

The foundation of the storage tanks varies from 4.4m to -0.1m above sea level, however all are surrounded by a bund wall which is 6.25m above sea level. The process buildings are 4.9 meters above sea level and are therefore protected against any risk from storm surge, wave and other causes of flooding.

(1) Byrne, J. P., The calculation of aircraft crash risk in the UK, Health and Safety Executive report HSE\R150, 1997.

(2) www.epd.gov.hk/eia/register/report/eiareport/eia_1252006/html/eiareport/Part2/Section13/Sec2_13AnnexA5.htm

Tsunami

Similar to storm surges, the main hazard from tsunamis is the rise in sea level and possible floatation of piping and tanks. The highest rise in sea level ever recorded in Hong Kong due to a tsunami was 0.3m high, and occurred as a result of the 1960 earthquake in Chile, the largest earthquake ever recorded in history at magnitude 9.5 on the Richter scale. The effect of a tsunami on the biodiesel plant is therefore considered negligible.

The reason for the low impact of tsunamis on Hong Kong may be explained by the extended continental shelf in the South China Sea which effectively dissipates the energy of a tsunami, and also the presence of the Philippine Islands and Taiwan which act as an effective barrier against seismic activity in the Pacific (1). Secondary waves that pass through the Luzon Strait diffract and lose energy as they traverse the South China Sea.

Seismic activity within the South China Sea area may also produce tsunamis. Earthquakes on the west coast of Luzon in the Philippines have produced localised tsunamis but there is no record of any observable effects in Hong Kong.

Damage from tsunamis is therefore considered to pose negligible risk.

Subsidence

For subsidence to result in failure of pipework or vessels, the ground movement must be relatively sudden and severe. Normal subsidence events will occur gradually over a period of months and thus appropriate mitigating action can be taken to prevent failures. In the worst cases, the plant would be shut down and the relevant equipment isolated and emptied.

The biodiesel plant will be built on a reclaimed land but the reclamation was completed more than 10 years ago, so any settling will have already taken place. Also, appropriate foundation work will be undertaken for the site. No undue risk from subsidence is therefore expected and failures due to this are deemed to be included in generic failure frequencies.

Intentional Acts

The risks from intentional acts such as sabotage, vandalism and terrorist attacks are difficult to quantify. Sabotage and arson together are believed to be involved in around 1% of all major incidents at chemical facilities, where the cause is known (2). Terrorist attacks on chemical sites are, however, extremely rare in developed countries (3). Hong Kong is an area where such activities are very rare. At the proposed site, physical security will meet normal standards

(1) Lee, B. Y., Report of Hong Kong in the international tsunami seminar in the western pacific region, Tokyo, Japan, 7-12 March 1988.

(2) Crowl, A. D. and Louvar, J. F., *Chemical Process Safety: Fundamentals with Applications*, 2nd ed., Prentice Hall, p. 16 (2002).

(3) www.law.umaryland.edu/marshall/crsreports/crsdocuments/RL31530B_02142005.pdf)

for a facility of this type, including access control via manned gate, a physical wall or gate surrounding the entire site, and video surveillance. Moreover, the site is unlikely to be of interest to terrorists or outside saboteurs because (1) it is not located close to a major population centre, (2) the maximum possible scale of any intentional incident is rather small, and (3) the nature of the business is environmentally positive and so it is unlikely to be targeted by eco-activists. Based on these considerations, intentional acts are considered to pose negligible risk.

Lightning strikes

Lightning strikes have led to a number of major accidents world-wide. For example, a contributory cause towards the major fire at the Texaco refinery in the UK in 1994 was thought to be an initial lightning strike on process pipework.

The installation will be protected with lighting conductors to safety earth direct lightning strikes. The grounding will be inspected regularly. The potential for a lighting strike to hit the facility and cause a release event is therefore deemed to be unlikely. Failures due to lightning strikes are taken to be covered by generic failure frequencies.

Risks from Neighbouring Facilities

Hong Kong Oxygen (HKO) has a facility about 400m to the north of the proposed biodiesel plant. HKO provides compressed gases such as acetylene, hydrogen, argon, nitrogen, oxygen, compressed air etc. These are for welding applications as well as medical and special uses. Since these gases are contained in compressed gas cylinders, a fire at the site could lead to explosions with fragments travelling sufficient distance to strike storage tanks and equipment within the biodiesel plant. The main concern is an impact on one of the storage tanks leading to a tank leak.

A past incident in 1992 at the Castle Peak Power Plant involved a hydrogen explosion and produced a fragment that travelled 500m. This demonstrates that it is feasible for incidents at HKO to impact on the biodiesel plant.

Lees (1) reviews past incidents involving BLEVE type explosions and notes that missile fragments are generated in about 80% of cases. Missile fragments may be produced by ejection of a single item such as the valve assembly, or by disintegration of the vessel. In reviewing a number of past incidents, Lees observes that the number of fragments produced per explosion can be up to about 30. Lees also assesses the distance travelled by fragments, from which it may be estimated that less than 10% will fall within the range of 400m to 500m.

Combining this information, the probability of a storage tank being hit by an explosion fragment may be estimated:

(1) Lees, F. P., Loss prevention in the Process Industries, Second Edition, 1996

$$30 \times 0.8 \times 0.1 \times \frac{\pi 6^2}{\pi \left(500^2 - 400^2\right)} = 9.6 \times 10^{-4} \text{ per explosion}$$

where it has been assumed that the radius of a storage tank is about 6m (one of the larger tanks).

No information is available on the facilities and equipment at HKO, so the frequency of explosions was therefore estimated as follows. The frequency of a gas leak from a compressed gas cylinder is about 10^{-5} per year (1). Assuming a typical fire frequency of 1×10^{-4} per year on a conservative basis, and assuming that every fire results in a single cylinder explosion, the number of fragments colliding with one of the storage tanks within the biodiesel plant would be:

$$1 \times 10^{-4} \times 9.6 \times 10^{-4} \cong 1 \times 10^{-7} \text{ per year}$$

If a fragment were to strike a storage tank, it could potentially cause damage to the tank, and result in a leak that would be contained by the bund. The generic failure frequency being adopted in this study for leaks from storage tanks is 10^{-4} per year (*Section 8.6*). The frequency of damage from explosion fragments from HKO is much less than this and therefore the risks from HKO may be considered to be included in the generic frequencies for tank failures.

Vehicle Impact

Only authorised vehicles will be allowed within the site and the speed limit will be strictly enforced. Thus, the possibility of an accident where a vehicle impacts equipment causing failure is considered to be remote. Also, since all the tanks are located in bunded areas and the process equipment is in enclosed process buildings, vehicle impact is considered as highly improbable. Vehicle impacts are therefore considered to pose negligible risk.

Conclusion on External Hazards

All external hazards either make site specific contributions to failure frequencies that have been quantified as negligible, or are shown to be already covered in the generic frequencies.

8.5.7 *Potential Hazardous Outcomes*

As seen from the incident review and discussions above, the following hazardous outcomes may result from leaks of materials such as biodiesel, gas oil or methanol:

(1) Guidelines for Quantitative Risk Assessment, The "Purple Book", Committee for the prevention of disasters, first edition, 1999

Pool Fire

A pool fire occurs when a flammable liquid is spilt onto the ground and ignited. If the release source is protected by a bund, the maximum size of the pool fire is limited by the bund area; such case is sometimes termed a 'bund fire'. The possibility of bund overtopping has also been considered for catastrophic tank failures.

Jet Fire

A jet fire may occur in case of immediate ignition of a pressurised release of flammable liquid or gas. In this biodiesel plant, the only item of equipment under significant pressure is the high pressure esterification reactor. A jet fire from this equipment will be contained by the process building and will not affect offsite population. Jet fires are therefore considered to pose negligible risk.

Flash Fire

Following a release of a gas, or liquid with sufficient volatility, a large vapour cloud may form around the release point. If this cloud is not ignited immediately, it will move with the wind and be diluted as a result of air entrainment.

The dispersing vapour cloud may subsequently come in contact with an ignition source and burn rapidly with a sudden flash. If the source of material which created the cloud is still present, then the fire will flash back to the source generating a pool fire. Direct contact with the burning vapours may cause fatalities but the short duration of the flash fire means that thermal radiation effects are not significant outside the cloud and thus no fatalities are expected outside of the flash fire envelope.

Vapour Cloud Explosion

If a flammable vapour is allowed to accumulate in a confined and/or congested area, and is subsequently ignited, an explosion (Vapour Cloud Explosion or VCE) may result. At the biodiesel plant, the methanol storage tank will be located outdoors in an open area. The impact of a release leading to a VCE onsite has been considered. The process building, is confined and heavily congested and so VCEs are considered in this area.

Toxic Release

(a) Ingestion of Methanol

Methanol is toxic by ingestion. In the event of a catastrophic release of methanol from the storage tank, a person nearby may be affected by the surge of methanol overtopping the bund, and involuntarily ingest some of the liquid.

The fatal dose is around 100mL [(1)]. However, symptoms take several hours to emerge, and during this time, antidotes can be administered. Also, tank failure modelling indicates that no methanol will be released offsite in a catastrophic release (see *Table 8.7a*). Thus, the overall risk from methanol ingestion is considered to be negligible.

(b) Inhalation of Methanol Vapour

If methanol is released without ignition, offsite population may be exposed to a toxic risk from the vapour, although the inhalation toxicity of methanol is relatively low. Dispersion of unignited methanol clouds is included in the assessment.

8.5.8 Formulation of Representative Hazardous Scenarios

Based on the above discussions, a list of accident scenarios is produced for further analysis (see *Table 8.5i*). The assumed leak sizes for tanks and process vessels are based on the largest instrument tapping or other nozzle that is potentially vulnerable to damage. Leak losses of 5% and 15% from barges correspond to the figures assumed in the PAFF report [(2)].

(1) http://en.wikipedia.org/wiki/Methanol

(2) Engineering Safety and Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility, Environmental Impact Assessment Report, Feb 2007.

Table 8.5i Hazardous Scenarios Considered

Section No.	Section Code	Description	Equipment Tag	Hazardous Material	Physical State	Temp. (°C)	Press. (barg)	Inventory (kg)	Leak Size	Potential Outcomes
Tank farm										
1	T1/T2	Crude grease trap waste storage tank	B100300/ B100400	Fats & oils	Liquid	Amb.	0	1,270,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
2	T3	Cleaned grease trap waste storage tank	B100500	Fats & oils	Liquid	Amb.	0	863,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
3	T4/T5	Crude waste cooking oil storage tank	B100600/ B100700	Fats & oils	Liquid	Amb.	0	41,100	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
4	T6	Cleaned waste cooking oil storage tank	B100800	Fats & oils	Liquid	Amb.	0	863,100	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
5	T7	PFAD storage tank	B100900	Fats & oils	Liquid	Amb.	0	1,270,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
6	T8	Crude animal fats storage tank	B100100	Fats & oils	Liquid	Amb.	0	426,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
7	T9	Cleaned animal fats storage tank	B100200	Fats & oils	Liquid	Amb.	0	426,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
8	T10	Methanol storage tank	B102400	Methanol	Liquid	Amb.	0	309,000	6″ leak	Bund fire, flash fire, VCE, toxic release
									Catastrophic rupture	Pool fire with bund overtopping, flash fire, toxic release, VCE, tank fire
9	T14	Infineum (additive) storage tank	B102200	Naphtha, distillates	Liquid	Amb.	0	41,100	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
10	T15/ T16	Quality biodiesel storage tank	B200500/ B200600	Biodiesel	Liquid	Amb.	0	363,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
11	T17	Biodiesel-Europe storage tank	B200700	Biodiesel	Liquid	Amb.	0	1,797,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
12	T18	Biodiesel-Hong Kong storage tank	B200800	Biodiesel	Liquid	Amb.	0	870,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
13	T19	Glycerine storage tank	B202100	Glycerine, FFA	Liquid	Amb.	0	510,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
14	T21	Bioheating oil storage tank	B202200	Bioheating	Liquid	Amb.	0	150,000	6″ leak	Bund fire

Section No.	Section Code	Description	Equipment Tag	Hazardous Material	Physical State	Temp. (°C)	Press. (barg)	Inventory (kg)	Leak Size	Potential Outcomes
				oil						
									Catastrophic rupture	Pool fire with bund overtopping
15	T22	Gas oil storage tank	B102300	Gas oil	Liquid	Amb.	0	74,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
16	T24	Crude waste cooking oil	B101000	Fats & oils	Liquid	Amb.	0	1,022,000	6″ leak	Bund fire
									Catastrophic rupture	Pool fire with bund overtopping
17	G01	Biogas buffer tank	V601	Biogas	Gas	Amb.	0	20	2″ leak	Flash fire
									Catastrophic rupture	Flash fire
Process Area										
18	P01	Esterification with catalyst	B10200/ B10400	11%wt methanol	Liquid	72	0.05	89,534	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
19	P02	Methanol buffer tank	B111100	95% methanol	Liquid	60	0.05	9060	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
20	P03	Pipe reactor	SP112000	40%wt methanol	Liquid	260	100	6600	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
21	P04	Methanol recycle tank	B72300	100%wt methanol	Liquid	60	0.05	16308	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
22	P05	MEK buffer tank	B20500	84%wt methanol	Liquid	50	0.05	12728	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
23	P06	GLP settling tank	B60300	51%wt methanol	Liquid	50	0.05	12949	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
24	P07	GLP collection tank	B50100	33%wt methanol	Liquid	65	0.05	103950	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
25	P08	Acidulation tank	B50400	38%wt methanol	Liquid	65	0.05	17160	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
26	P09	FFA buffer tank	B50900	5%wt	Liquid	65	0.05	15456	1″ leak	VCE, toxic release

Section No.	Section Code	Description	Equipment Tag	Hazardous Material	Physical State	Temp. (°C)	Press. (barg)	Inventory (kg)	Leak Size	Potential Outcomes
				methanol						
									Catastrophic rupture	VCE, toxic release
27	P10	Neutralization tank	B60100	51%wt methanol	Liquid	65	0.05	21105	1″ leak	VCE, toxic release
									Catastrophic rupture	VCE, toxic release
Marine scenarios										
29	M01	Biodiesel/PFAD barge	-	Biodiesel/ PFAD	Liquid	Amb.	0	1,000,000	5%, 15% leaks	Pool fire on sea surface
									Catastrophic rupture	Pool fire on sea surface
30	M02	Methanol barge[1]	-	Methanol	Liquid	Amb.	0	1,000,000	5%, 15% leaks	No effect
									Catastrophic rupture	Tank fire
31	M03	Methanol ISO-tanker[1]	-	Methanol	Liquid	Amb.	0	16,000	1″ leak	Pool fire, flash fire, toxic
									Catastrophic rupture	Pool fire, flash fire, toxic
Transport scenarios										
32	L01	Unloading line from jetty to tanks	-	Biodiesel/ PFAD	Liquid	Amb.	4	71,000	2″ leak	Pool fire
									Full bore rupture	Pool fire
33	L02	Unloading line from jetty to tanks		Methanol	Liquid	Amb.	4	65,000	2″ leak	Pool fire, flash fire, toxic release
									Full bore rupture	Pool fire, flash fire, toxic release
34	RT1	Road tanker for fats & oils	-	GTW, WCO, Gas Oil, animal fats, Glycerine	Liquid	Amb.	0	9,000	1″ leak	Pool fire
									Catastrophic rupture	Pool fire
35	L03	Road tanker unloading line		Fats & oils, biodiesel	Liquid	Amb.	4	4,300	1″ leak	Pool fire
									Full bore rupture	Pool fire

[1] Methanol is anticipated to be delivered either by barges or by ISO-tanker barges. Both are therefore considered in the analysis.

8.6 *FREQUENCY ESTIMATION*

8.6.1 *Release Frequencies*

Frequency estimation involves estimating the likelihood of occurrence of each of the representative release events identified in *Table 8.5i*. The Consultants 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. Event tree analysis is used where a release can lead to different outcomes such as pool fires or flash fires.

8.6.2 *Ignition Probability*

Equipment in the process areas will be fire and explosion rated to minimise sources of ignition. The highest temperature equipment in the process area is 260°C, below the auto-ignition temperature of all materials handled in the area. Therefore, there are expected to be few ignition sources within the process building. In outside areas, the main ignition source is likely to be trucks delivering feedstock.

This study adopts generic ignition probabilities adapted from Cox, Lees and Ang(1) , which are summarised in *Table 8.6a*.The ignition probabilities for liquids are understood to apply to liquids above their flash point. These are therefore appropriate for methanol which has a flash point of 11°C.

Other materials have a higher flash point, significantly higher in most cases. A lower ignition probability is appropriate for these materials. A factor of 10 reduction is assumed, to give the ignition probabilities summarised in *Table 8.6b*.

Table 8.6a ***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 ignition probabilities are further split between immediate ignition and delayed ignition, in equal proportions. Immediate ignition will give rise to a pool fire, while delayed ignition of a volatile substance may cause a flash fire or vapour cloud explosion.

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

Table 8.6b Ignition Probabilities used in this Study

Leak Size	Ignition Probability		
	Biogas	Methanol	Other flammable/combustible substances
Minor (< 1 kg s^{-1})	0.01	0.01	0.001
Major (1 – 50 kg s^{-1})	0.07	0.03	0.003
Massive (> 50 kg s^{-1})	0.30	0.08	0.008

For ignition of releases within buildings, some adjustments have been made to the ignition probabilities above to take account of the mitigation provided by ventilation system.

8.6.3 *Transport*

Barges

1,000 tonnes barges will be used for transporting both feedstock and final products to and from the plant. The frequency for loss of containment is estimated based on the frequency of collisions and groundings.

The collision frequency adopted in PAFF (1) is 3.5×10^{-5} per encounter. The encounter frequency is given as 0.69 per km. The same is applied to the current study. This effectively assumes that the marine traffic near the proposed biodiesel site is similar to that near the Permanent Aviation Fuel Facility, which is considered a conservative assumption. The interaction distance is 0.1 km as only marine transport within 100 m of the jetty is considered for this study. Therefore the collision frequency is given as $3.5\times10^{-5} \times 0.69 \times 0.1 = 2.4\times10^{-6}$ per visit. In addition, a spill probability of 0.015 is included to take into account that only 1.5% of all collisions lead to a loss of containment event. Therefore the frequency for loss of containment due to collision becomes 3.6×10^{-8} per visit.

Similar calculations are applied to groundings. While the water depth is sufficient for a barge to dock at the jetty without grounding, the barge may collide with the sloping sea wall if it goes off course or loses control. The possibility of grounding is therefore included in the analysis. The adopted frequency for grounding in PAFF is 4.3×10^{-6} per km travelled. Applying a distance of 100m for the approach, and a spill probability of 0.03, gives a base frequency for loss of containment due to grounding as 1.3×10^{-8} per visit.

There are on average 4 shipments per week for the biodiesel plant, 2 for biodiesel, 1 for PFAD and 1 for methanol, all using 1,000 tonne barges. The maximum loading and unloading rate is specified as 500 m^3/hr, however 12 hours is assumed to be the average time spent at the jetty for each barge.

(1) Engineering Safety & Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility – Environmental Impact Assessment Report, Feb 2007, Table 10.5 and section 10.3.3, page 10-21.

The frequency data adopted in the PAFF study is for double hull tankers, while the barges used by the biodiesel plant will be single-walled liquid tankers. The frequency of collision for both types of tankers will be the same; however the probability of spillage following a collision for a single hull barge will be higher than that of the double hull tanker. A correction factor is needed to allow for the lower integrity of a single hull barge. In comparing data published in the "Purple Book", the frequency for large leaks from a single hull tanker is 16.7 times higher than for a double hull. This factor of 16.7 was therefore applied to the data to give a failure frequency of 6.0×10^{-7} per visit due to collisions and 2.2×10^{-7} per visit due to groundings. The combined frequency becomes 8.2×10^{-7} per visit.

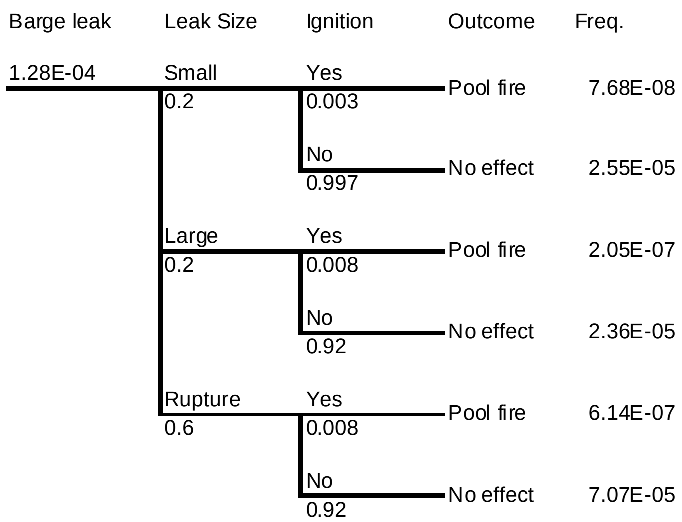
Three different leak sizes are modelled as indicated in *Table 8.6c*.

Table 8.6c ***Barge Leak Size Distribution*** (1)

Leak Size	Description	Probability
Small	5% of inventory released in 20 min	20%
Large	15% of inventory released in 20 min	20%
Rupture	100% of inventory released instantaneously	60%

An event tree for biodiesel/Palm Oil Fatty Acid Distillate (PFAD) barges is shown in *Figure 8.6a*. With 3 barges per week for these materials, the initiating frequency becomes 1.28×10^{-4} per year. Since both immediate and delayed ignition result in a pool fire, no distinction is made between immediate and delayed ignition.

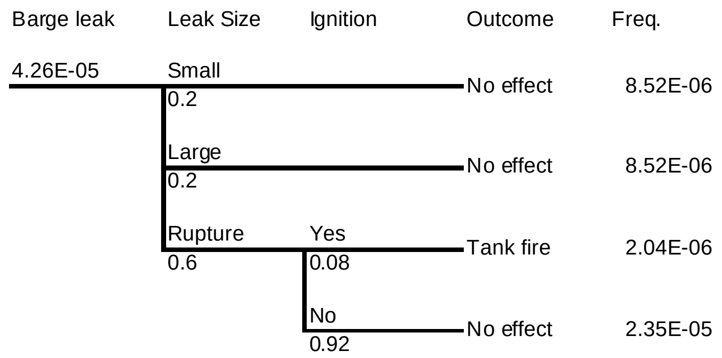
Figure 8.6a ***Event Tree for Biodiesel/PFAD Barge***



(1) Engineering Safety & Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility – Environmental Impact Assessment Report, Feb 2007, Table 10.4, page 10.20. The leak sizes are derived from the values shown in the PAFF report (0.3%, 1%, 7%) multiplied by 15 (because the Biodiesel plant barges will have only a single compartment instead of 15 compartments for the PAFF). The size probabilities are taken directly from the PAFF report, with the 'rupture' and 'multiple rupture' cases combined to give 60% for 'rupture'.

Similarly, an event tree for a methanol barge is shown in *Figure 8.6b*. Since methanol is miscible with water, if there is a leak, methanol will simply pour into the water with no effect. A large rupture may lead to a tank fire on the barge if ignited and so this scenario was considered in the analysis.

Figure 8.6b Event Tree for Methanol Barge



ISO-tanker barges may be used rather than normal liquid tanker type barges. ISO-tankers would then be unloaded at the jetty using a reachstacker and loaded onto a flatbed truck for delivery to the tank farm. Since this delivery method for methanol would be used only occasionally, a factor of 1/52 (one week per year) is applied in the risk calculation. The ISO-tankers are considered similar to road tankers, which have a rupture frequency of 2×10^{-6} per tanker-year and a leak frequency of 5×10^{-6} per tanker-year [1], based on failure frequencies given in the Purple Book. These are increased by a factor of 10 to reflect the higher risks associated with the additional handling.

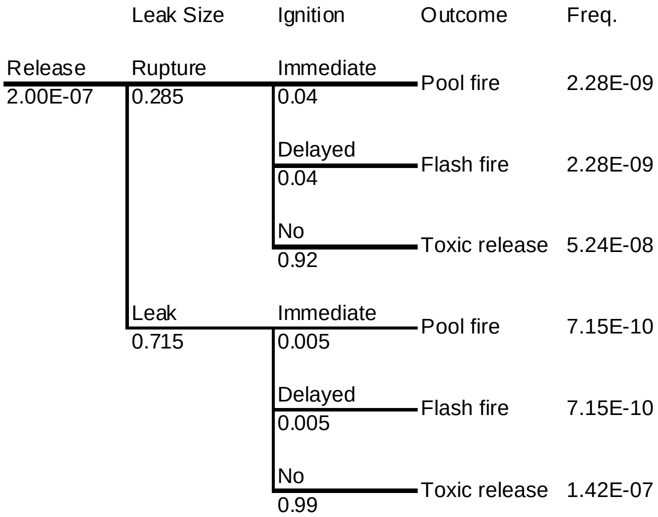
One barge per week is anticipated for delivering methanol to the $500m^3$ storage tank. Assuming that a complete filling is required, and the capacity of each ISO-tanker is $20m^2$, 25 ISO-tankers per week would be required. It is further assumed that 1 hour of handling is required to unload an ISO-tanker. The leak frequency may then be calculated as $5\times10^{-6} \times 10$ (handling factor) $\times$ 25/168 (hours per week) $\times$ 1/52 (one week per year) = 1.43×10^{-7} per year, and rupture frequency as 5.71×10^{-8} per year.

An event tree for ISO-tanker leaks is shown in *Figure 8.6c*. Immediate ignition, delayed ignition and unignited releases are considered. An ignition probability of 0.08 is used for methanol, based on figures for a large liquid release from Lees [1]. This is distributed equally between immediate and delayed ignition to give 0.04 each.

Operation with either 1,000 tonne methanol barges or ISO-tanker barges will be used. Since these events are not expected to contribute significantly to the overall risks, both are included in the analysis. The risks are essentially double counted and hence the approach is conservative.

(1) Ite, P. J., Fitzpatrick, R. D., and Hurst, N. W., Risk assessment for the siting and developments near liquefied petroleum installations, IChemE Symposium Series No. 110, 1988.

Figure 8.6c Event Tree for ISO-Tanker Failure



Road Tankers

A road tanker rupture frequency is assigned as 2×10^{-6} per tanker-year and a 1″ leak frequency of 5×10^{-6} per tanker-year [(2)]. This frequency is modified to take into account presence factors, assuming that each tanker will be present within the plant area one hour per visit.

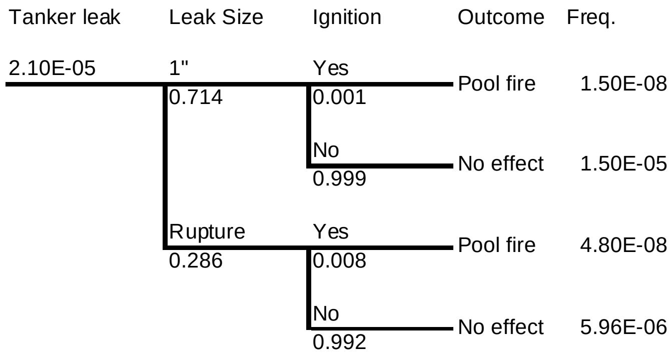
The event tree for crude oil (GTW, WCO, gas oil, animal fats, glycerine) is shown in *Figure 8.6d*. With 72 road tankers per day, each spending 1 hour on site, this is equivalent to 3 tankers present on a continuous basis. The initiating event frequency then becomes $(2\times10^{-6} + 5\times10^{-6})$ x 3 = 2.1×10^{-5} per year. The relative leak size probability is $(5\times10^{-6})/(2\times10^{-6} + 5\times10^{-6})$ = 0.714 for a 1″ leak and $(2\times10^{-6})/(2\times10^{-6} + 5\times10^{-6})$ = 0.286 for rupture.

Biodiesel shipping out by 20 m^3 road tankers is anticipated during adverse weather when barges cannot be used. Biodiesel transport by road tanker is assumed to take place 10 days per year, with 10 tankers a day present at the premises for 1 hour each. With such a low presence factor and low ignition probability of 0.008, the frequency of biodiesel fires due to tanker leaks is below 10^{-9} per year and is therefore considered to pose negligible risk. Similarly, methanol may be delivered by road tankers when marine operations are not possible but the frequency is again below 10^{-9} per year.

(1) Lees, F. P., Loss prevention in the Process Industries, Second Edition, 1996.

(2) Ite, P. J., Fitzpatrick, R. D., and Hurst, N. W., Risk assessment for the siting and developments near liquefied petroleum installations, IChemE Symposium Series No. 110, 1988.

Figure 8.6d Event Tree for Fats/ Oils Road Tanker



Unloading/Loading Lines and Hoses

Hoses, piping and connection errors are considered for the loading/unloading from road tankers and barges. Failure frequencies are obtained from:

- The failure frequencies of hoses, 9×10^{-8} per hour, is taken from Blything (1);
- Hose disconnection error and failure to rectify is taken from LPG experience in Hong Kong with 1 incident in 31,718 operations per day and 5 years of data: 1.7×10^{-8} per operation;
- Hose misconnection error and failure to rectify is based on experience in Hong Kong with LPG with 2 incidents in 31,718 operations per day and 5 years of data: 3.5×10^{-8} per operation; and
- Piping failure frequencies are taken from the "Purple Book", assuming a length of 150m from the jetty to the tank farm. Piping lengths from road tanker bays to storage tanks are estimated from plot layouts.

Hoses and piping are combined into a single scenario, with frequencies summed, since the consequences of leaks are essentially identical. 90% of leaks are assumed to be small leaks, modelled as 2". The remaining 10% of leaks are assumed to be full bore ruptures. Hose failure frequencies are quoted on a per hour basis. These are multiplied by the hours of operation for each type of barge and road tanker. Piping frequencies are per year, and hence are also corrected to take into account the fractional period of time in operation. It is assumed that unloading from barges is performed at a rate of about $100m^3$/hr so that unloading to the 500 m^3 methanol storage tank would require 5 hours, while loading/unloading of PFAD and biodiesel barges would take 10 hours. Road tankers are assumed to be on site for about 1 hour, however, actual pumping time is estimated at 20 minutes. Thus, operating fractions are calculated as (total transfer time per year) / (number of

(1) Blything, K. W. & Reeves, A. B., An initial prediction of the BLEVE frequency of a 100 tonne butane storage vessel, SRD report R488, August 1988.

hours per year). For example, the methanol barge operating fraction is obtained by (52 operations/year x 5 h/operation) / (24 x 365) = 0.030.

A summary of the resulting leak frequencies is shown in *Table 8.6d*.

Table 8.6d Failure Frequency for Unloading Operations

	Pipe Length (m)	Operating fraction	Small Leak Freq. (yr^{-1})	Rupture Freq. (yr^{-1})
Jetty Operations				
Methanol	150	0.030	2.57×10^{-5}	3.06×10^{-6}
PFAD	150	0.059	4.90×10^{-5}	5.84×10^{-6}
Biodiesel	150	0.12	9.80×10^{-5}	1.17×10^{-5}
Road Tanker Operations				
Gas oil	50	0.014	2.83×10^{-5}	3.20×10^{-6}
Trap grease, crude	75	0.83	1.74×10^{-3}	1.98×10^{-4}
Animal fat, crude	40	0.056	1.12×10^{-4}	1.26×10^{-5}
WCO, crude	40	0.069	1.40×10^{-4}	1.58×10^{-5}
Bioheating oil	50	0.014	2.83×10^{-5}	3.20×10^{-6}
Glycerine	75	0.028	5.80×10^{-5}	6.61×10^{-6}

An example event tree for fats and oils is shown in *Figure 8.6e*. This is similar to previous event trees except that unloading hoses and line can be isolated and operations are manned so it is assumed that 90% of leaks can be isolated quickly before any hazardous outcomes occur. The event tree for methanol unloading (see *Figure 8.6f*) is similar.

Figure 8.6e Generic Event Tree for Fats & Oils Unloading Hose/Lines

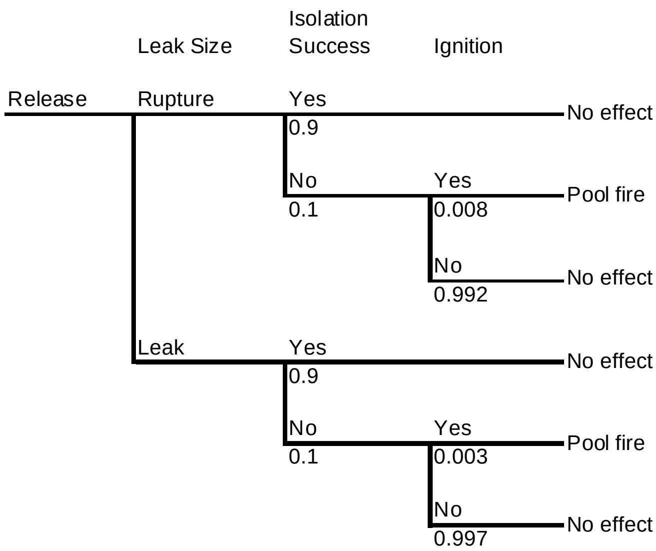
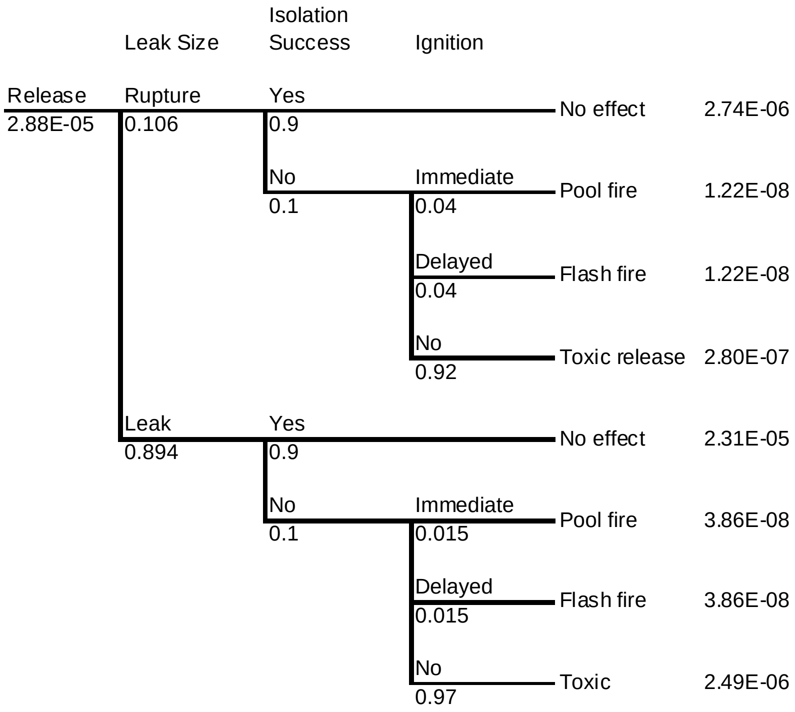


Figure 8.6f   Event Tree for Methanol Unloading Hose/Line



8.6.4   Tank Farm

Two release scenarios are considered for each tank: a leak through a 6″ diameter hole and a catastrophic rupture (releasing 100% of the tank contents instantaneously). A 6″ release is chosen to correspond to the size of tank connections. All leaks are taken to be confined to the bund and so this choice of 6″, although larger than normally considered for leaks, is not expected to have any impact on the results.

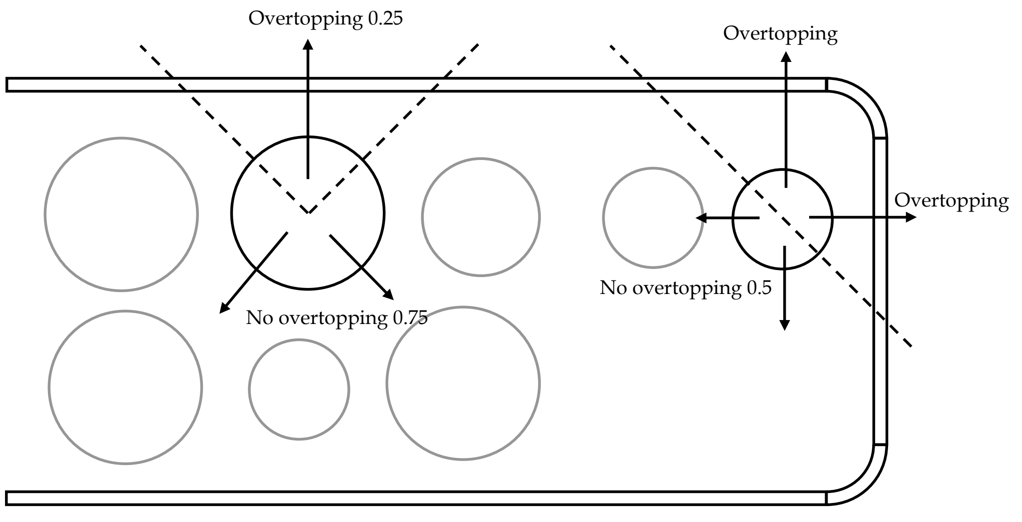
Bund Overtopping

An atmospheric storage tank is assigned a catastrophic rupture frequency of 5×10^{-6} per year and a leak frequency of $1x10^{-4}$ per year (1). The possibility of bund overtopping is considered for tank rupture scenarios. The proportion of tank contents that overtop the bund depends on the geometry, specifically the hydrostatic head of liquid, the height of the bund wall and the distance of the bund from the tank. For the biodiesel site, the likelihood of bund overtopping is therefore estimated based on the orientation of a release in relation to the nearest bund wall. Directions are considered in quadrants (see *Figure 8.6g*). The probability of a release being directed towards the nearest bund wall is taken to be 0.25, while the probability of a leak being directed towards the inner regions of the impoundment area is taken as 0.75. For tanks located in the corner of the bund area, the probability of overtopping is taken as 0.5. The

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

methanol tank has bund walls in close proximity to the tank on 3 sides; the probability of overtopping is therefore taken as 0.75 for this tank.

Figure 8.6g ***Bund Overtopping Considerations***



A generic event tree for feedstock, biodiesel etc. is shown in *Figure 8.6h*, and an event tree for the methanol tank is shown in *Figure 8.6i*.

Bund Overflowing

It would, in theory, be possible to release the contents of more than one tank into a bund at the same time. Bunds are required to have a capacity of at least 110% the capacity of the largest tank. In the biodiesel tank farm, bunds containing multiple tanks have a capacity of at least 150% of the largest tank. To cause overflowing, two large tanks would need to fail and be filled to near full capacity at time of failure. A tank fire leading to subsequent escalation to other tanks is calculated below:

The frequency of bund fire from all causes, including escalation, can be taken as 1.2×10^{-5} (1). The risk at the proposed plant is further reduced because:

- Bunds are equipped with fire fighting measures such as heat detectors connected to the fire alarm, deluge systems (to cool tanks and pipelines threatened by fire), a manually operated AFFF foam system with 100% redundancy backup;
- Bunds can be drained to remove flammable/combustible material. This will limit the duration of a bund fire;
- Tank failure below the liquid level is normally not to be expected during

(1) Engineering Safety & Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility – Environmental Impact Assessment Report, Feb 2007, sections 10.5.4 and 10.5.7.2.

an external fire, because of the cooling effect from the liquid.

The maximum duration of a bund fire incident resulting from tank rupture can be estimated as follows. We consider the worst case of tank T17 rupturing and spilling its entire contents of biodiesel into bund 2B; the biodiesel then ignites and burns without any mitigation. The area of the fire is 526m^2 and the burning rate 0.04kg s^{-1} m^{-2}. (1) The maximum volume of biodiesel in T17 is 2140m^3, corresponding to 1,881,000kg. Thus the burning time t_B can be estimated as:

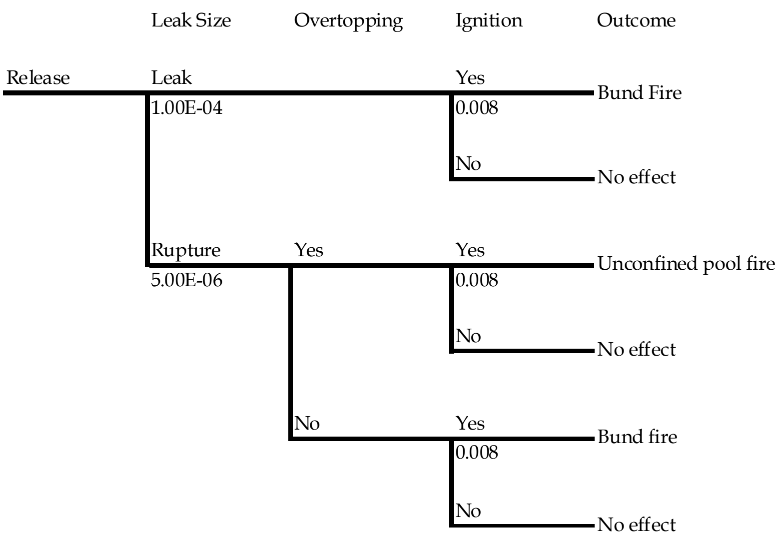
$$t_B = \frac{1{,}881{,}000}{0.04 \times 526} = 89{,}400\,\text{s} = 24.8\ \text{hours}$$

Thus, a bund fire incident can be expected to last only a day. The frequency of 2 out of the 8 tanks in bund 2A randomly failing within a day may be estimated from:

$$8 \times 10^{-4} \times 7 \times 10^{-4} \times \frac{1}{365} \times 0.008 = 1.2 \times 10^{-11} \quad \text{per year}$$

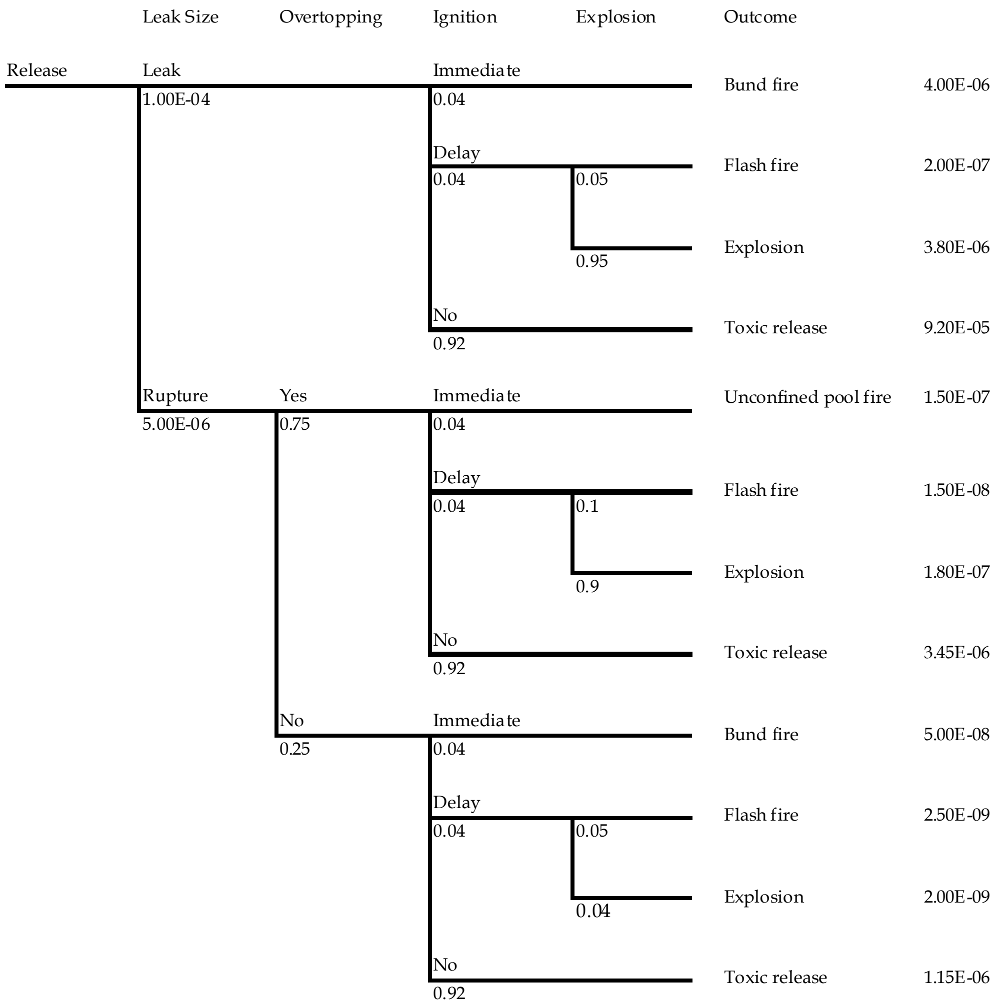
where 10^{-4} per year is the leak frequency of a tank and 0.008 is the ignition probability. The resulting frequency of an overflowing pool fire was hence estimated to be below 10^{-9} per year and was therefore considered to pose negligible risk. Tank to tank escalation may occur but this would take many hours allowing ample time for evacuation of the surrounding area (see PAFF EIA (1) section 10.5.4.2).

Figure 8.6h Event Tree for Feedstock/Biodiesel Storage Tank



(1) http://users.wpi.edu/~ierardi/FireTools/pool_fires.html. Transformer oil is used as a proxy for biodiesel in this calculation, as it has a similar flash point to biodiesel.

Figure 8.6i Event Tree for Methanol Storage Tank



8.6.5 Process Area

Following the discussions given in *Section 8.5.5*, pool fires within the process building are not expected to create hazards that affect offsite population. Only leaks of methanol leading to vapour cloud explosions within the building and toxic releases from the ventilation system are considered in the analysis. Frequencies for loss of containment scenarios in the process area, for equipment handling methanol, are estimated based on the failure rate of the process vessels/reactor vessels (1), except for the pipe reactor for which pipe failure frequencies have been adopted. The leak frequency for process vessels is taken as 10^{-4} per year and the rupture frequency is 10^{-5} per year. For the pipe reactor, the length of the pipe was calculated to be 350m based on equipment specifications. The failure frequency was taken as 5×10^{-7} m^{-1} y^{-1} for leaks and 10^{-7} m^{-1} y^{-1} for ruptures. Taking into consideration the number of vessels in each part of the plant, the leak frequencies are as summarised in *Table 8.6e*.

(1) Committee for the Prevention of Disasters, Guidance for Quantitative Risk Assessment, the "Purple Book", first edition, 1999.

Table 8.6e Failure Frequencies in Process Area

	No. Vessels	Leak Freq. (per year)	Rupture Freq. (per year)
Esterification vessel	2	2×10^{-4}	2×10^{-5}
Methanol buffer tank	1	1×10^{-4}	1×10^{-5}
Pipe reactor	350m	1.75×10^{-4}	3.5×10^{-5}
Methanol recycle tank	1	1×10^{-4}	1×10^{-5}
MEK buffer tank	2	2×10^{-4}	2×10^{-5}
GLP settling tank	1	1×10^{-4}	1×10^{-5}
GLP collection tank	1	1×10^{-4}	1×10^{-5}
Acidulation tank	1	1×10^{-4}	1×10^{-5}
FFA buffer tank	1	1×10^{-4}	1×10^{-5}
Neutralization tank	2	2×10^{-4}	2×10^{-5}

An example event tree for methanol release (from Process Vessels) and methanol release (from Reactor) inside the process building is shown in *Figure 8.6j* and *Figure 8.6k* respectively. The effect of emergency isolation and ventilation in the event tree analysis are discussed below.

Emergency Isolation

Safety interlocks for emergency shutdown will be provided for systems within process area. The primary purpose of isolation is to minimize inventory available for release by means of tripping pumps or actuating emergency isolation valves.

The probability of actuating an isolation depends on the ability to detect a leak, the integrity of the interlock system and the response time for closing the valve/tripping a pump. Isolation can be actuated by gas detection as well as deviation in process parameters (a leak in a system would usually be accompanied by process upset which can be detected by process parameters like flow, pressure and temperature). Gas detectors will be provided at strategic locations throughout the plant where there is a potential for gas leak. The interlock system is relatively reliable and can be expected to respond positively in 90% to 95% of the demands calculated based on typical failure rates suggested by Lees (1).

For the purpose of this study, reliability of 90% is assumed where an isolation system can be actuated within 5min from when a leak occurred. This can significantly reduce the released inventory, thus the strength of explosion and likelihood of vapor cloud ignition. Release duration of 15 min is assumed for isolation failure.

For vessel ruptures, isolation failure has been assumed.

(1) Lees, F. P., Loss Prevention in The Process Industries, Second edition, 1996.

Emergency Ventilation

Emergency ventilation will be provided in the process building, in accordance with the relevant design codes, such IP 15 : Area Classification Code for Installations Handling Flammable Liquids, IEC 60079, Part 10 :2002 Electrical Apparatus for Explosive Gas Atmospheres and NFPA 30 : The Flammable and Combustible Liquids Code. It is assumed in the analysis that this emergency ventilation will be designed such as to prevent the accumulation of flammable concentrations of vapours, ie the ventilation rate will be sufficient to bring down the concentration to 50% of lower explosive limit (LEL). Also, the ventilation system will be designed to avoid any stagnant pockets. Hence, the likelihood of vapour cloud ignition will be significantly reduced. The emergency ventilation is assumed to have a reliability of 90%.

Figure 8.6j Event Tree for Methanol (Process Vessels) Release inside Process Building

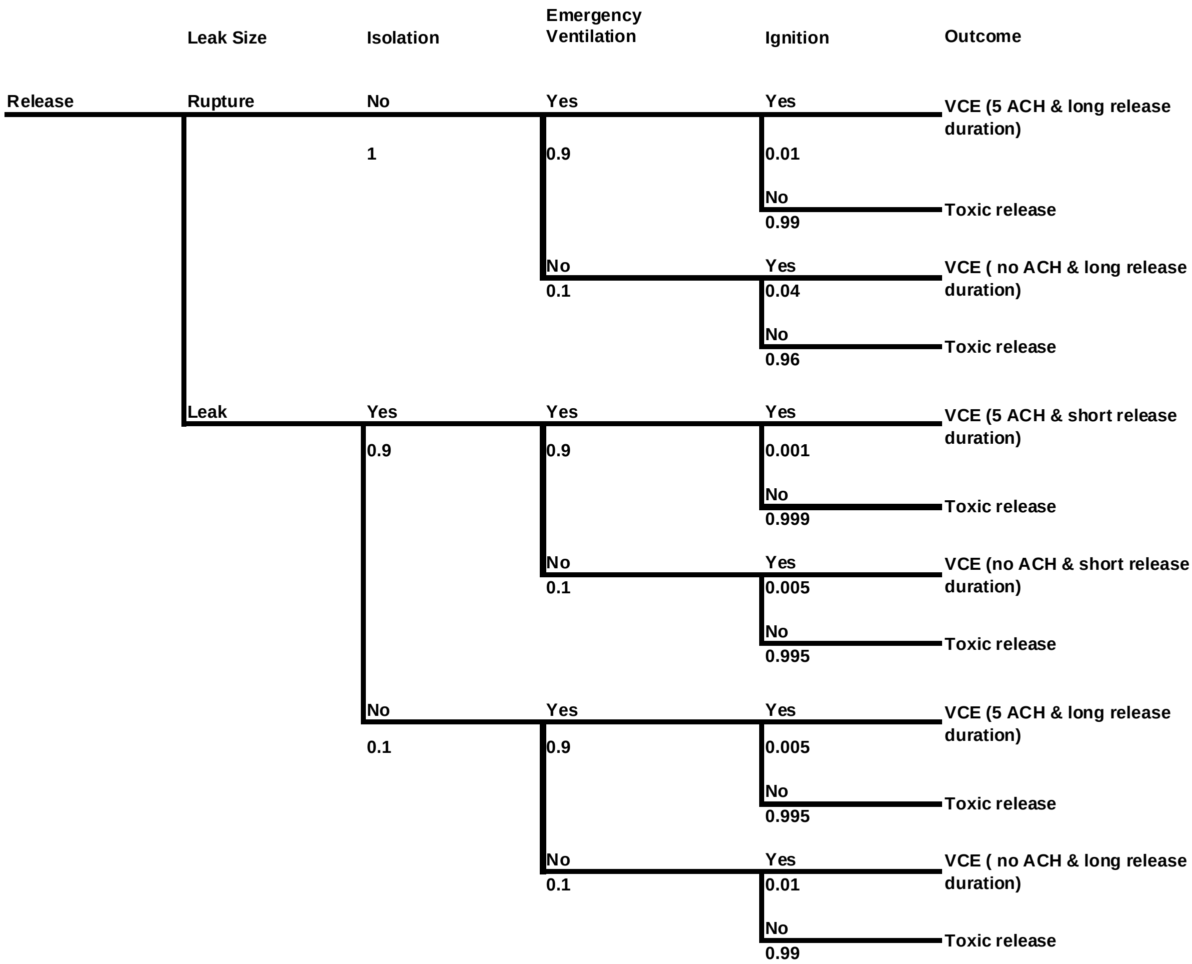
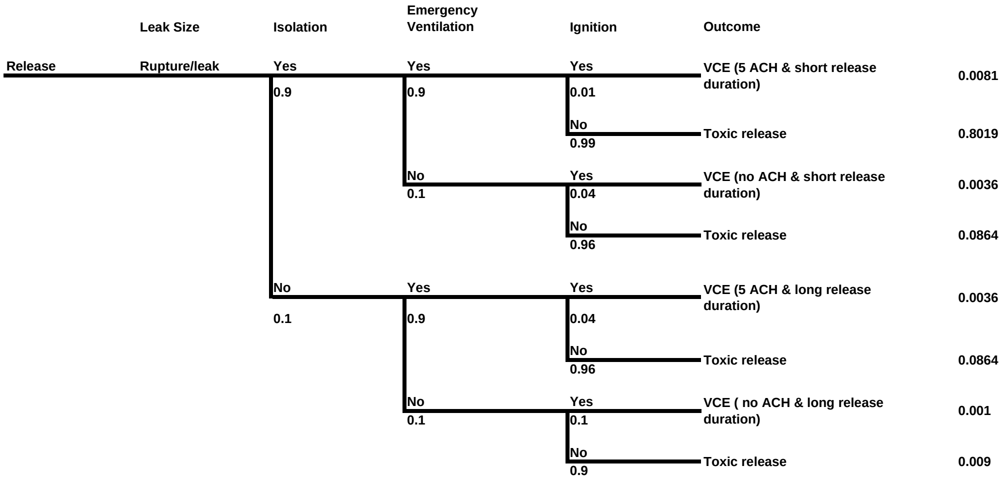


Figure 8.6k Event Tree for Methanol (Reactor) Release inside Process Building



Frequency of Maintenance Related Incidents

Based on past incidents in the bio-diesel industry and the general process industry, maintenance related incidents are found to be a significant contributor. Therefore the frequency and consequence of such incidents are assessed separately below.

Possible maintenance-related causes of an explosion in the process area of the proposed biodiesel plant include:

- Failure to purge equipment of flammable substances prior to opening or hot work
- Failure to purge equipment of air prior to introducing flammable substances
- Spillage from pump during maintenance or changeover to/from spare pump
- Spillage or leak from drain valve used for draining or purging

An example event tree for potential air ingress scenario into process equipment is shown below. The general practices followed in the industry for purging of equipment include pressure purging (ie repeated pressurisation and depressurisation with nitrogen to remove any flammables and this process is repeated several times) or flow purging (where the equipment or piping is continuously purged with nitrogen for several hours). This purging step is carried out after isolation of an equipment and prior to opening. Similarly, this step is carried out after completion of maintenance and before flammables are introduced. At the end of the purging step, the equipment atmosphere is tested for flammables or air as applicable, using portable instruments for gas analysis. There are strict procedures followed in chemical process industry for purging and testing and similar procedures will be adopted in this plant. It is also important that the purging operation is independently verified by another operator, to reduce the risk of human error. In some plants, the supervisor will also check plant records (e.g. pressure recording charts) to verify the purging procedure. All of these checks are normally built into the permit-to-work system for maintenance. It is assumed that the operator of the proposed plant will ensure that appropriate cross-checking procedures of this type are developed and followed, and the internal atmosphere of the plant equipment is tested using a gas analyzer before introduction of the process materials.

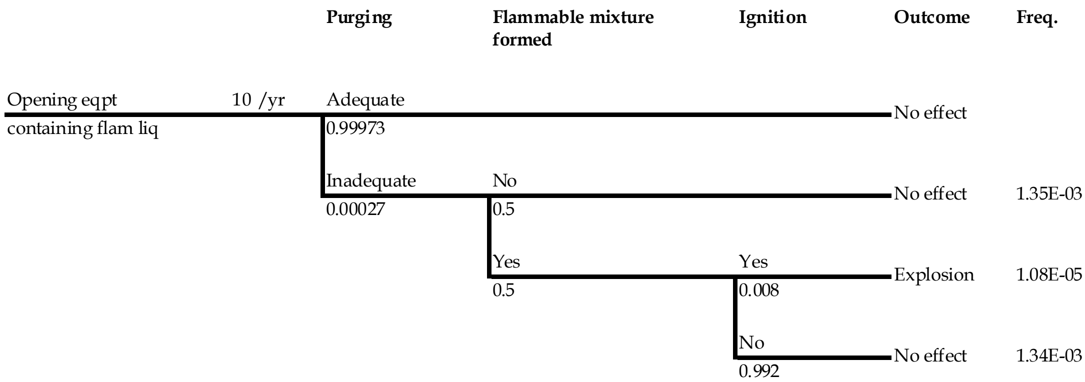
In order to estimate the likelihood of human error in carrying out the task of purging, generic human error probabilities are adopted [Ref: Lees, F. P., Loss Prevention in the Process Industry, Second Edition, 1996, Human Factors and Human Error, Chapter 14, Table 14.26]. A nominal human unreliability of 0.003 is assumed for the task of purging. A nominal human unreliability of 0.09 is assumed for the task of testing by an independent operator following the purging step. This gives an overall human unreliability of 0.00027.

In order for an internal explosion to be possible, it is also necessary to have a significant volume of flammable vapour/air mixture. Depending on the plant configuration, the incoming process material may simply sweep the air away without significant mixing, leading to little or no possibility of an explosion. This is reflected in the event tree below as 'Explosive mixture formed', with an assumed probability of 0.5.

The frequency of maintenance events resulting in air ingress is taken conservatively as 10 times per year. Major maintenance is normally undertaken during shutdown once every 1-2 years, but it may occasionally be necessary to open plant equipment for emergency repairs between shutdowns. The number of such operations assumed as ten may be slightly conservative.

The ignition probability is taken as 0.008. This is based on the values of 0.01 to 0.08 (depending on quantity) adopted for unconfined methanol vapour explosions (see *Table 8.6b*), reduced to take account of the fact that there is no ignition sources inside the equipment except hot surfaces, and these will be below the autoignition temperature of methanol.

Figure 8.6l Event Tree for Example Maintenance Scenario



Based on the above, the frequency of an internal explosion is derived as 1.08×10^{-5} per year. All of the equipment in this plant is operating at atmospheric pressure, except for the reactor which is a pipe. Hence the impact of an internal explosion will be limited as compared to that from a high pressure equipment, since the explosion energy imparted to fragments in a vessel burst is a function of the initial pressure. Referring to the incident in Castle Peak power plant in Hong Kong, where an internal explosion in a high pressure hydrogen equipment led to projection of fragments 500m away (although it did not cause any offsite fatality, there were two onsite fatalities), a similar scenario in this plant could lead to one or more fragments being projected offsite. Assuming a probability of 10% that any of the fragments could hit an individual, the overall frequency of this scenario with potential for fatality is estimated as 1.08×10^{-6} per year. The actual frequency is expected to be lower since the fragments will be contained by the building walls/ structure. As a conservative assumption, it is assumed that such an incident could cause two fatalities. This scenario is carried forward as a separate scenario in the derivation of FN curve and PLL to represent the potential for incidents leading to an internal explosion causing fragment hazards to public offsite. This scenario has been considered for future population case. For the current population, there is only one building at the Gammon site, with a much smaller footprint area, and shielded by the building in the project site.

There is some uncertainty in the estimation of the frequency and consequence of such events as it relies largely on the effectiveness of the procedures and the management systems in place. These are not developed yet and has been assumed to be of similar standard as those adopted by well managed companies in the process industry and the best practices adopted by companies in Hong Kong, such as those operating LPG, flammable liquids, and gas.

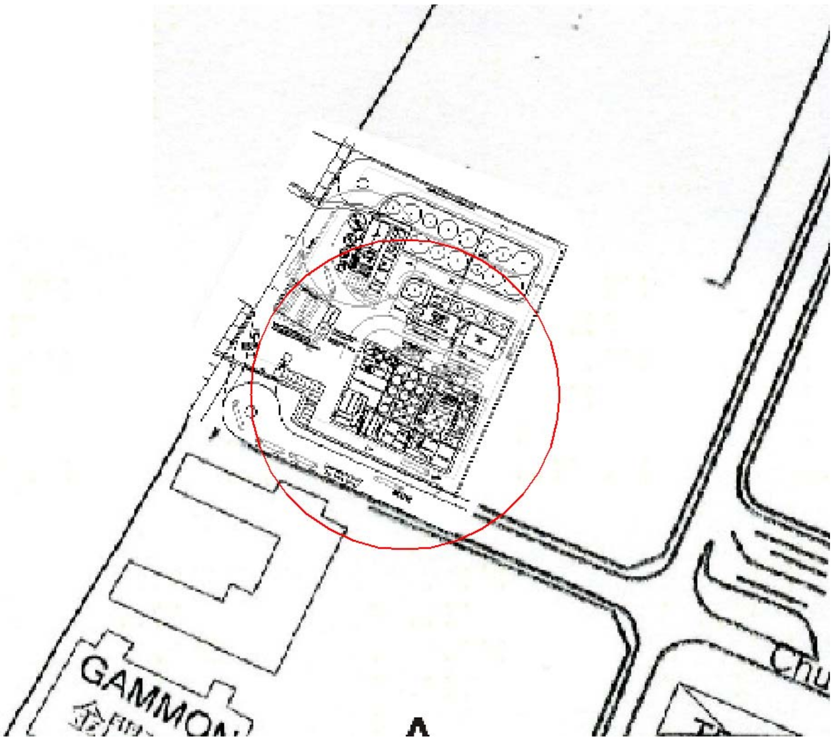
With regard to other maintenance related scenarios which lead to a spill inside the process building, their frequency of incidence is included in the base case frequency. These types of incidents are not specific to biodiesel facilities and could, in principle, occur in any plant handling flammable liquids. Also, since the vapour or liquid spill volume from such an incident is likely to be small, the explosion itself will cause little damage or harm.

Escalation Caused by Vapour Cloud Explosion in the Process Building

Vapour cloud explosion in the process building can potentially damage the storage tanks in the tank farm. Overpressure of 3 psi can cause uplifts (half tilted) of the tanks [(1)], which might lead to catastrophic rupture. In the worst case, the 3 psi blast wave can affect multiple tanks on site.

(1) Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers, *Guidelines for Consequence Analysis of Chemical Releases*, p.139-140, 1999.

Figure 8.6m ***Maximum area affected by vapour cloud explosion (process building) at an overpressure of 3 psi***



The fat preparation room and steam boiler room are located between the main process building and the tank farm, providing protection for most of the storage tanks from the blast wave. However, T10 (methanol storage tank) and T7 (PFAD storage tank) are directly exposed and may be seriously damaged. Considering all the vapour cloud explosion scenarios that can reach these tanks at an overpressure of 3 psi, the frequency of explosions causing rupture of T10 is estimated as 2.59×10^{-6} per year, and the frequency causing rupture of T7 is estimated as 1.59×10^{-6} per year. These frequencies are obtained by adding up the frequencies of all the relevant scenarios, as indicated in *Table 8.6f*. Catastrophic loss of containment from T10 and T7 could lead to overtopping of their bunds, followed by potential pool fire in the plant. These scenarios are shown in *Table 8.5i* and the consequences are detailed in *Table 8.7g*. Based on the analysis carried for bund overtopping due to the failure of these tanks, no spillage beyond the plant boundary is expected.

Table 8.6f ***Frequency of tank failure due to escalation from explosion in process building***

Equipment involved in initial incident	Rupture/Leak	Isolation Successful	Ventilation Successful	Freq. of Incident	Tanks Affected
Esterification with catalyst	Rupture	N	Y	1.80E-07	T7, T10
Esterification with catalyst	Rupture	N	N	8.00E-08	T7, T10
Esterification with catalyst	Leak	N	N	2.00E-08	T10
Methanol buffer tank	Rupture	N	N	4.00E-08	T7, T10
Methanol buffer tank	Leak	N	N	1.00E-08	T10
Pipe reactor	Rupture	N	Y	1.26E-07	T10
Pipe reactor	Rupture	N	N	3.50E-08	T7, T10

Equipment involved in initial incident	Rupture/Leak	Isolation Successful	Ventilation Successful	Freq. of Incident	Tanks Affected
Pipe reactor	Leak	N	Y	6.30E-07	T10
Pipe reactor	Leak	N	N	1.75E-07	T7, T10
Pipe reactor	Rupture	Y	N	1.26E-07	T7, T10
Pipe reactor	Leak	Y	N	6.30E-07	T7, T10
MEK buffer tank	Rupture	N	N	8.00E-08	T7, T10
MEK buffer tank	Leak	N	N	2.00E-08	T10
GLP collection tank	Rupture	N	Y	9.00E-08	T10
GLP collection tank	Rupture	N	N	4.00E-08	T7, T10
GLP collection tank	Leak	N	N	1.00E-08	T10
Acidulation tank	Rupture	N	N	4.00E-08	T7, T10
Acidulation tank	Leak	N	N	1.00E-08	T10
FFA buffer tank	Rupture	N	N	4.00E-08	T7, T10
FFA buffer tank	Leak	N	N	1.00E-08	T10
Neutralization tank	Rupture	N	N	8.00E-08	T7, T10
Neutralization tank	Leak	N	N	2.00E-08	T10
Methanol recycle tank	Rupture	N	N	4.00E-08	T7, T10
Methanol recycle tank	Leak	N	N	1.00E-08	T10
GLP settling tank	Rupture	N	N	4.00E-08	T10
Total frequency for rupture of T10 due to escalation				2.59E-06	
Total frequency for rupture of T7 due to escalation				1.59E-06	

8.6.6 *Summary of Scenario Outcome Frequencies*

Combining the initiating event frequency with probabilities for each branch of the event trees gives the outcome frequency for each scenario. A complete list of these scenarios and their frequencies is provided in *Table 8.6g* and *Table 8.6h*.

Table 8.6g Outcome Event Frequencies (Tank farm, Marine and Transport Scenarios)

Section No.	**Section Code**	**Description**	**Equipment Tag**	**Outcome Frequency (per year)**									
				Leak					**Rupture**				
				Bund fire	**Pool fire (unconfined)**	**Flash fire**	**VCE**	**Toxic**	**Bund fire**	**Pool fire (unconfined)**	**Flash fire**	**VCE**	**Toxic**
Tank farm													
1	T1/T2	Crude grease trap waste storage tank	B100300/ B100400	1.6×10^{-6}					6.0×10^{-8}	2.0×10^{-8}			
2	T3	Cleaned grease trap waste storage tank	B100500	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			
3	T4/T5	Crude waste cooking oil storage tank	B100600/ B100700	1.6×10^{-6}					6.0×10^{-8}	2.0×10^{-8}			
4	T6	Cleaned waste cooking oil storage tank	B100800	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			
5	T7	PFAD storage tank	B100900	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8} (f) $1.59\text{x}10^{-6}$ (g)			
6	T8	Crude animal fats storage tank	B100100	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			
7	T9	Cleaned animal fats storage tank	B100200	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			
8	T10	Methanol storage tank	B102400	4.0×10^{-6}		2.0×10^{-7}	3.8×10^{-6}	9.2×10^{-5}	5.0×10^{-8}	1.5×10^{-7} (f) $2.59\text{x}10^{-6}$ (g)	2.5×10^{-9} (a) 1.5×10^{-8} (b)	2.0×10^{-9} (a) 1.8×10^{-7} (b)	1.15×10^{-6}
9	T14	Infineum (additive) storage tank	B102200	8.0×10^{-7}					2.0×10^{-8}	2.0×10^{-8}			
10	T15/ T16	Quality biodiesel storage tank	B200500/ B200600	1.6×10^{-6}					6.0×10^{-8}	2.0×10^{-8}			
11	T17	Biodiesel-Europe storage tank	B200700	8.0×10^{-7}					2.0×10^{-8}	2.0×10^{-8}			
12	T18	Biodiesel-Hong Kong storage tank	B200800	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			

Section No.	Section Code	Description	Equipment Tag	Outcome Frequency (per year)									
				Leak					Rupture				
				Bund fire	Pool fire (unconfined)	Flash fire	VCE	Toxic	Bund fire	Pool fire (unconfined)	Flash fire	VCE	Toxic
13	T19	Glycerine storage tank	B202100	8.0×10^{-7}					2.0×10^{-8}	2.0×10^{-8}			
14	T21	Bioheating oil storage tank	B202200	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			
15	T22	Gas oil storage tank	B102300	8.0×10^{-7}					3.0×10^{-8}	1.0×10^{-8}			
16	T24	Crude waste cooking oil	B101000	8.0×10^{-7}					2.0×10^{-8}	2.0×10^{-8}			
17	G01	Biogas buffer tank	V601			1.0×10^{-4}					5.0×10^{-6}		
Marine scenarios													
29	M01	Biodiesel/PFAD barge	-		7.68×10^{-8} (c) 2.05×10^{-7} (d)					6.14×10^{-7}			
30	M02	Methanol barge	-							2.04×10^{-6} (e)			
31	M03	Methanol ISO-tanker	-		7.15×10^{-10}	7.15×10^{-10}		1.42×10^{-7}		2.28×10^{-9}	2.28×10^{-9}		5.24×10^{-8}
Transport scenarios													
32	L01	Unloading line from jetty to tanks (biodiesel/PFAD)	-		4.41×10^{-8}					1.40×10^{-8}			
33	L02	Unloading line from jetty to tanks (methanol)			3.86×10^{-8}	3.86×10^{-8}		2.49×10^{-6}		1.22×10^{-8}	1.22×10^{-8}		2.80×10^{-7}
34	RT1	Road tanker for fats & oils	-		1.50×10^{-8}					4.80×10^{-8}			
35	L03	Road tanker unloading line	-		6.33×10^{-7}					1.92×10^{-7}			

Notes:

(a) Flash fire frequency for a vapour cloud from bund area

Section No.	Section Code	Description	Equipment Tag	Outcome Frequency (per year)									
				Leak					Rupture				
				Bund fire	Pool fire (unconfined)	Flash fire	VCE	Toxic	Bund fire	Pool fire (unconfined)	Flash fire	VCE	Toxic

(b) Flash fire frequency for vaporisation from a liquid pool that overtopped the bund

(c) Small leaks releasing 5% of inventory within 20 minutes

(d) Large leaks releasing 15% of inventory within 20 minutes

(e) Since methanol is miscible with water, leakage into sea will have no effect. This scenario is therefore modelled as a tank fire on the barge

(f) Generic outcome frequency for rupture of tanks T7 and T10 leading to unconfined pool fire

(g) Outcome frequency for rupture of tanks T7 and T10 triggered by VCE inside process building, leading to unconfined pool fire (derived from Table 8.6f)

Table 8.6h Outcome Event Frequencies (Process Area)

Section No.	Section Code	Description	Equipment Tag		Outcome Frequency (per year)							
					Leak				Rupture			
					Isolation failure, ventilation success	Isolation failure, ventilation failure	Isolation success, ventilation success	Isolation success, ventilation failure	Isolation failure, ventilation success	Isolation failure, ventilation failure	Isolation success, ventilation success	Isolation success, ventilation failure
18	P01	Esterification with catalyst	B10200, B10400	VCE	9.00x10^{-8}	2.00 x10^{-8}	1.62 x10^{-7}	9.00 x10^{-8}	1.80 x10^{-7}	8.00 x10^{-8}	NA	NA
				Toxic	1.79x10^{-5}	1.98 x10^{-6}	1.62 x10^{-4}	1.79 x10^{-5}	1.78 x10^{-5}	1.92 x10^{-6}	NA	NA
19	P02	Methanol buffer tank	B111100	VCE	4.50x10^{-8}	1.00 x10^{-8}	8.10 x10^{-8}	4.50 x10^{-8}	9.00 x10^{-8}	4.00 x10^{-8}	NA	NA
				Toxic	8.96x10^{-6}	9.90 x10^{-7}	8.09 x10^{-5}	8.96 x10^{-6}	8.91 x10^{-6}	9.60 x10^{-7}	NA	NA
20	P03	Pipe reactor	SP112000	VCE	6.30x10^{-7}	1.75 x10^{-7}	1.42 x10^{-6}	6.30 x10^{-7}	1.26 x10^{-7}	3.50 x10^{-8}	2.84 x10^{-7}	1.26 x10^{-7}
				Toxic	1.51x10^{-5}	1.58 x10^{-6}	1.40 x10^{-4}	1.51 x10^{-5}	3.02 x10^{-6}	3.15 x10^{-7}	2.81 x10^{-5}	3.02 x10^{-6}
21	P04	Methanol recycle tank	B72300	VCE	4.50x10^{-8}	1.00 x10^{-8}	8.10 x10^{-8}	4.50 x10^{-8}	9.00 x10^{-8}	4.00 x10^{-8}	NA	NA
				Toxic	8.96x10^{-6}	9.90 x10^{-7}	8.09 x10^{-5}	8.96 x10^{-6}	8.91 x10^{-6}	9.60 x10^{-7}	NA	NA
22	P05	MEK buffer tank	B20500, B20600	VCE	9.00x10^{-8}	2.00 x10^{-8}	1.62 x10^{-7}	9.00 x10^{-8}	1.80 x10^{-7}	8.00 x10^{-8}	NA	NA
				Toxic	1.79x10^{-5}	1.98 x10^{-6}	1.62 x10^{-4}	1.79 x10^{-5}	1.78 x10^{-5}	1.92 x10^{-6}	NA	NA
23	P06	GLP settling tank	B60300	VCE	4.50x10^{-8}	1.00 x10^{-8}	8.10 x10^{-8}	4.50 x10^{-8}	9.00 x10^{-8}	4.00 x10^{-8}	NA	NA
				Toxic	8.96 x10^{-6}	9.90 x10^{-7}	8.09 x10^{-5}	8.96 x10^{-6}	8.91 x10^{-6}	9.60 x10^{-7}	NA	NA
24	P07	GLP collection tank	B50100	VCE	4.50 x10^{-8}	1.00 x10^{-8}	8.10 x10^{-8}	4.50 x10^{-8}	9.00 x10^{-8}	4.00 x10^{-8}	NA	NA
				Toxic	8.96 x10^{-6}	9.90 x10^{-7}	8.09 x10^{-5}	8.96 x10^{-6}	8.91 x10^{-6}	9.60 x10^{-7}	NA	NA
25	P08	Acidulation tank	B50400	VCE	4.50 x10^{-8}	1.00 x10^{-8}	8.10 x10^{-8}	4.50 x10^{-8}	9.00 x10^{-8}	4.00 x10^{-8}	NA	NA
				Toxic	8.96 x10^{-6}	9.90 x10^{-7}	8.09 x10^{-5}	8.96 x10^{-6}	8.91 x10^{-6}	9.60 x10^{-7}	NA	NA
26	P09	FFA buffer tank	B50900	VCE	4.50 x10^{-8}	1.00 x10^{-8}	8.10 x10^{-8}	4.50 x10^{-8}	9.00 x10^{-8}	4.00 x10^{-8}	NA	NA
				Toxic	8.96 x10^{-6}	9.90 x10^{-7}	8.09 x10^{-5}	8.96 x10^{-6}	8.91 x10^{-6}	9.60 x10^{-7}	NA	NA
27	P10	Neutralization tank	B60100	VCE	9.00 x10^{-8}	2.00 x10^{-8}	1.62 x10^{-7}	9.00 x10^{-8}	1.80 x10^{-7}	8.00 x10^{-8}	NA	NA
				Toxic	1.79 x10^{-5}	1.98 x10^{-6}	1.62 x10^{-4}	1.79 x10^{-5}	1.78 x10^{-5}	1.92 x10^{-6}	NA	NA
28	Internal explosion due to maintenance scenario								1.08 x 10^{-6} (rupture frequency due to internal explosion)			

8.7 *CONSEQUENCE ANALYSIS*

8.7.1 *Physical Effects Modelling*

In this study, the physical effects models included in the PHAST v6.51 suite of models were used to assess the effects zones for the hazardous outcomes of concern:

- Pool fire;
- Flash fire;
- Vapour cloud explosion in the process area; and
- Toxic releases of methanol.

Pool Fires

The pool formed from a 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 is confined by a bund or, for unconfined releases, until an equilibrium is reached between discharge rate and vaporisation rate.

Bund Overtopping

The tank farm was assessed in particular detail in the current study. While the bund capacity is large enough to contain spills from the storage tanks, 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, part of the inventory 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 then cover a larger area.

The fraction of inventory that overtops the bund was modelled using the relationship of Thyer et al (1):

$$Q = 0.044 - 0.264 \ln (h_1/H) - 0.116 \ln (r_1/H)$$

where h_1 is the bund wall height, H is the tank liquid level and r_1 is the distance from the centre of the tank to the bund wall. Applying this relation to the storage tanks gives the calculations shown in *Table 8.7a;* the results are summarized in *Table 8.7b*. Overtopping of the site boundary wall, at a distance of r_2 from the tank centre, is also considered where there is a significant direct path from the tank to the boundary wall, not obstructed by

(1) Thyer, A. M., Hirst, I. L. and Jagger, S. F., Bund overtopping – the consequence of catastrophic tank failure, *Journal of Loss Prevention in the Process Industries*, Vol. 15, p.357-363, 2002.

other tanks, buildings or additional bund walls. The height of the boundary wall h_2 is taken as 2m.

This modelling was done based on experiments with water. It can be argued, however, that the higher viscosity of biodiesel and feedstock oils used in the proposed plant would result in greatly decreased overtopping. The grounds for this argument are as follows. Theoretical studies by Greenspan and Young[(1)] indicate that the extent of overtopping is related linearly to the velocity of the wave front from the tank to the bund wall, as follows:

$$Q = \frac{H}{R}\int_0^T u_w c_w^2 \, dt$$

where H is the tank liquid level, R is the tank radius, T is the elapsed time since the rupture, u_w is the mean velocity of the wave front, and c_w is the height by which the wave height exceeds the bund wall height. If it is conservatively assumed that c_w for a viscous liquid will be equal to that for a free-flowing liquid, it can be deduced that Q is directly proportional to u_w

Next, we consider the definition of the dynamic viscosity, μ:

$$\tau = \mu \frac{dc}{dy}$$

where τ is the shear force between liquid layers in a flowing liquid, and dc/dy is the difference in velocity between two layers separated by a depth y. Given a constant τ, which will be induced by the head in the tank, there is an inverse relationship between shear velocity and viscosity. If we extrapolate from shear velocity between layers of liquid (dc/dy) to wave front velocity u_w (i.e. the velocity difference between the top and bottom of the flowing liquid layer), it is reasonable to deduce an approximately inverse linear relationship between Q, the fraction of overtopping, and μ.

Typical viscosities for the combustible liquids in the proposed plant at 40 C are as follows: water, 0.658 cP; methanol, 0.39 cP [(2)]; biodiesel, 3.5 cP; vegetable oil feedstock, 30 cP; Infineum, 661 cP. Thus, the overtopping values derived from Thyer's formula above may be adjusted by a factor of (0.658 / 0.39) = 1.69 for methanol, (0.658 / 3.5) = 0.19 for biodiesel, (0.658 / 30) = 0.022 for vegetable oils, and (0.658 / 661) = 0.0010 for Infineum. The adjusted values of Q are shown in the final column of *Table 8.7a.* No adjustment has been applied to crude grease trap waste as this material is around 85% water.

(1) Greenspan, H.P., and Young, R.E. Flow over a Containment Dyke. *J. Fluid Mechanics*, Vol. 87, p.179-192 (1978).

(2) Estimated value based on extrapolation from published data at 20 C and 25 C.

Table 8.7a ***Bund overtopping calculations***

Tank ID	Description	Bund ID	Bund wall height h_1 (m)	Maximum tank liquid level relative to bund floor H_1, H_2 (m)	Shortest distance from centre of tank to bund wall r_1 (m)	Site wall height relative to bund floor h_2 (m)	Shortest distance from centre of tank to site boundary r_2 (m)	Fraction Over-topping Bund Q_1	Fraction Over-topping Site Wall Q_2	Fraction Reaching Outside Site Boundary $Q_1 \times Q_2$	$Q_1 \times Q_2$ adjusted for viscosity
T1	Crude grease trap waste storage tank	2A	3.15	13.8	7.4	3.5	30.1	0.51	0 (Obstructed)	0	0
T2	Crude grease trap waste storage tank	2A	3.15	13.8	7.4	3.5	17.8	0.51	0.38	0.19	0.19
T3	Cleaned grease trap storage tank	2A	3.15	13.8	7.4	3.5	17.8	0.51	0.38	0.19	0.004
T4	Crude WCO storage tank	2E	1.85	7.6	3.4	2.2	43.7	0.51	0 (Obstructed)	0	0
T5	Crude WCO storage tank	2E	1.85	7.6	3.4	2.2	36.3	0.51	0 (Obstructed)	0	0
T6	Cleaned WCO storage tank	2A	3.15	13.8	7.4	3.5	17.8	0.51	0.38	0.19	0.004
T7	PFAD storage tank	2A	3.15	13.8	7.4	3.5	53.6	0.51	0 (Obstructed)	0	0
T8	Crude animal fat storage tank	2A	3.15	10.9	7.4	3.5	17.8	0.42	0.29	0.12	0.003
T9	Cleaned animal fat storage tank	2A	3.15	10.9	7.4	3.5	N/A	0.42	0 (Obstructed)	0	0
T10	Methanol storage tank	2C	4.55	9.2	5.2	4.9	N/A	0.30	0 (Obstructed)	0	0
T14	Infineum (additive) storage tank	2F	1.85	4.7	3.3	2.2	13.7	0.33	0.12	0.04	0.000

Tank ID	Description	Bund ID	Bund wall height h_1 (m)	Maximum tank liquid level relative to bund floor H_1, H_2 (m)	Shortest distance from centre of tank to bund wall r_1 (m)	Site wall height relative to bund floor h_2 (m)	Shortest distance from centre of tank to site boundary r_2 (m)	Fraction Over-topping Bund Q_1	Fraction Over-topping Site Wall Q_2	Fraction Reaching Outside Site Boundary $Q_1 \times Q_2$	$Q_1 \times Q_2$ adjusted for viscosity
T15	Quality biodiesel storage tank	2B	6.35	9.8	8.0	6.7	18.4	0.18	0.07	0.01	0.002
T16	Quality biodiesel storage tank	2B	6.35	9.8	8.0	6.7	18.4	0.18	0.07	0.01	0.002
T17	Biodiesel-Europe storage tank	2B	6.35	17.4	8.0	6.7	18.4	0.40	0.29	0.12	0.022
T18	Biodiesel-Hong Kong storage tank	2B	6.35	13.2	6.5	6.7	N/A	0.32	0 (Obstructed)	0	0
T19	Glycerin storage tank	2A	3.15	9.8	5.3	3.5	17.8	0.41	0.25	0.10	0.000
T21	Bioheating oil storage tank	2B	6.35	7.2	6.5	6.7	N/A	0.09	0 (Obstructed)	0	0
T22	Gas oil storage tank	2F	1.85	5.5	4.5	2.2	42.9	0.36	0 (Obstructed)	0	0
T24	Crude WCO storage tank	2B	6.35	14.7	7.4	6.7	18.2	0.35	0.23	0.08	0.002

Table 8.7b Bund Overtopping Results

Tank ID	Description	$Q_1 \times Q_2$ adjusted for viscosity	Maximum inventory in tank T_V (m^3)	Spill offsite = $T_V \times Q_1 \times Q_2$ (m^3)	Offsite Pool area (m^2)	Offsite pool diameter (m)
T2	Crude grease trap waste storage tank	0.19	1420	269.9	14103	134
T3	Cleaned grease trap storage tank	0.004	965	3.9	380	22
T6	Cleaned WCO storage tank	0.004	965	3.9	380	22
T8	Crude animal fat storage tank	0.003	477	1.4	154	14
T15	Quality biodiesel storage tank	0.002	427	0.9	154	14
T16	Quality biodiesel storage tank	0.002	427	0.9	154	14
T17	Biodiesel-Europe storage tank	0.022	2111	46.5	4301	74
T24	Crude WCO storage tank	0.002	1143	2.3	254	18

The data in *Table 8.7a/b* is based on the conservative assumption of the tanks being 100% full. Lower liquid levels will produce substantially less overtopping, according to Thyer's formula given above. Also, it may be noted that crude grease trap waste storage tank, which is the feedstock contains a high proportion of water (up to 80%). Hence this liquid is not combustible. However, this liquid has been assumed as combustible for the analysis here due to the uncertainty in the water content and as worst case assumption.

The modelling of leaks from storage tanks were modelled as follows:

- Small leaks were assumed to be contained by the bund;
- Bund overtopping was considered for tank rupture scenarios. The likelihood of overtopping was estimated based on release orientation with respect to the bund wall (see *Section 8.6.4*);
- Single overtopping of the bund was considered for all tanks. The resulting pool fire was then modelled as an unconfined pool with contents equal to the liquid fraction that overtopped the bund. In cases where the pool size extended beyond the site perimeter wall, the pool size was limited by the site wall. Essentially, it was assumed that the perimeter wall would contain these large pools;

- Double overtopping of both the bund and site wall was considered only for those tanks listed in Table 8.7b. Double overtopping is modelled as an unconfined pool within the plant and a separate unconfined pool outside the perimeter wall, each with their own ignition probability.

The effects of pool fires and bund fires are modelling using the same methodology as adopted in the PAFF EIA study (1). The flame drag distance is calculated using the Moorhouse correlation in the HSE review (2).

$$\frac{D'}{D} = 1.5\left(Fr_{10}\right)^{0.069}$$

$$Fr_{10} = \frac{U_{10}^2}{gD}$$

Fr_{10} = Froude number of pool fire based on windspeed at a height of 10m.

U_{10} = windspeed at a height of 10m.

D' = flame dragged diameter of pool fire (m).

D = pool fire diameter (m).

The flame drag effects as estimated above are considered. Where the flame drag is not significant, a minimum drag distance of 3 m is taken, which is a conservative estimation. Any person outdoors caught within the flame envelope is assumed to be fatally injured (ie 100% fatality). For person indoors (ie inside a building that lies within the flame envelope considering drag), a fatality probability of 10% is assumed to account for potential secondary fires. Anyone outside the flame envelope can escape and hence no fatality is expected.

Geometry and Location of Offsite Pool Fires

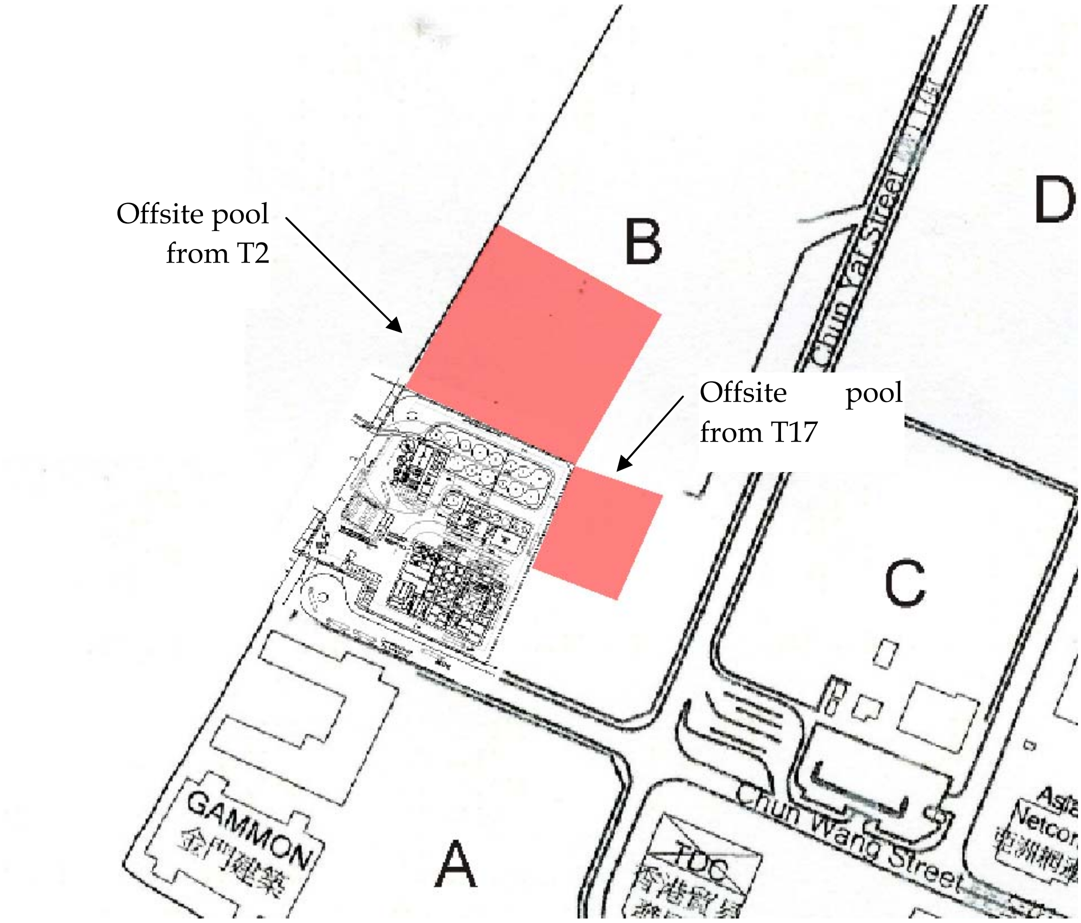
The area of liquid pools offsite arising from overtopping of the site boundary wall has been modelled using PHAST. The equivalent circular pool diameter is calculated. The location of pools offsite is assumed to be adjacent to the site boundary and directly opposite the source of the spill. Examples for T2 (crude grease trap waste) and T17 (biodiesel) are shown in *Figure 8.7a.*

(1) Engineering Safety and Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility, Environmental Impact Assessment Report, Feb 2007.

(2) Development of pool fire thermal radiation model, HSE contract research report No. 96/1996, p39-41.

Figure 8.7a   Model of Offsite Pool Geometry

Note: the illustration shows notional pool zones of the same area as the circular pools modelled by PHAST.



Flash Fires

Only methanol has sufficient vapour pressure to produce a flammable vapour cloud. For methanol releases, if there is no immediate ignition, the vapour may disperse before subsequently encountering an ignition source. The vapour cloud will then burn with a flash back to the source of the leak. A flash fire is assumed to be fatal to anyone caught within the flash fire envelope, although the short duration of a flash fire means that radiation effects are negligible. The fatality probability is therefore zero for persons outside the flash fire envelope. Persons indoors are assumed to be offered some protection by the building and a fatality probability of 0.1 is applied.

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 the lower flammability limit concentration (LFL).

The consequence modelling demonstrated that flash fire distances are not large, extending a maximum of 45m from the methanol storage tank and 53m from a leak in the unloading hose. These are insufficient to affect offsite areas but are nevertheless retained in the modelling.

The possibility of a vapour cloud dispersing from the ventilation exhaust on the roof of the process building was also considered but consequence distances were less than 20m. If ignited, there would be no impact at ground level and the fire would flash back to the process building resulting in a confined vapour cloud explosion (VCE). The consequences of the VCE are more severe than the flash fire from the vent and hence these events were modelled as a VCE.

Vapour Cloud Explosions

The process building is confined and congested with process vessels. A VCE is possible if flammable concentrations of methanol occur and is ignited. VCE in the process building is modelled using the TNO Multi Energy explosion model included in the PHAST suite. The multi-Energy Method is a relatively simple model to determine the blast from VCE as a function of explosion characteristic to distance to the explosion sources and is widely used to obtain a conservative quantification of the explosion strength. The following highlights the key conservative assumptions of the model:

- Based on a review of experimental data by Kineslla(1), the maximum overpressure generated from an explosion relates also to ignition energy. This is particularly true for less reactive material such as methanol which requires a larger ignition energy to produce a strong explosion.

- TNO-ME also assumes that the potential explosion source is filled with a stoichiometric fuel-air mixture and the corresponding quantities of combustion energy is then applied for estimating the explosion characteristic. This is a very conservative approach as it assumes the entire energy contributing to the blast whereas only a portion of the vapour cloud will be at the optimum stoichiometric condition in reality. Indeed, the TNO report(2) also suggests that a gas explosion shows a gradual development under most circumstances. Such a development implies that a portion of the flammable mass is burned at a low combustion rate which will not contribute to the blast of the specified high strength.

Based on the method suggested by GAME (guidance for the application of the multi-energy model) (2) , TNO curve 9 is used in the calculation considering the size and confinement of the potential explosion site, obstacle size, volume blockage ratio and material characteristic.

(1) Daniel A Crowl, Understanding explosions, centre for chemical process (CCPS)

(2) GAME: development of guidance for the application of the multi-energy method, Health & Safety Executive Contract Research Report 202/1998

The walls of the process building are metal clad. It is assumed that these will do little to contain explosion overpressures and hence the effects of explosions will have impact outside the building.

Process vessels containing methanol tend to be at slightly elevated temperatures near the boiling point of methanol. Calculations demonstrated that the vaporisation rate upon release can be significant. The modelling took the following approach:

- If emergency ventilation is successfully activated (in 90% of cases), the methanol vapour cloud generated will be diluted and vented from the building at a rate of minimum of 5 air changes per hour [It is noted that higher air change may be required as per design codes, such as IP 15]. The concentration within the building was then calculated by solving the differential equation:

$$V\frac{dC}{dt} = \dot{m} - bC$$

where V is the volume of the building (m^3), $\dot{m}$ is the release rate of methanol (kg/s), b is the ventilation rate (m^3/s) and C is the concentration of methanol vapour within the building (kg/m^3). This gives the concentration as a function of time and ignition is assumed to occur at the highest concentration.

- If the emergency ventilation fails to activate, no mechanical ventilation is assumed to continue during an incident. Also, there is assumed to be no natural ventilation. Natural ventilation is not practicable in Ex-classified zones (that is, zones where a flammable atmosphere may exist, requiring the use of non-sparking electrical equipment and tools), because flammable vapours may escape into non-flameproofed zones outside.

- The calculated concentration is then compared to the LEL (Lower Explosion Limit) concentration of methanol. Ignition or explosion is not considered if the calculated concentration is below the LFL concentration. However, it is possible that local pockets of methanol vapour may remain at a concentration above LFL, due to uneven ventilation. In view of this, explosion has been considered for all the methanol release scenarios, including scenarios for which the calculated concentration is below LEL, to account for any localized high concentration. For these scenarios, the flammable mass is estimated based on the average concentration inside the building, which is lower as compared to the worst case scenario of ventilation failure

- For vessel ruptures, the entire contents of the vessel are assumed to be released instantaneously. This forms a liquid pool on the floor, which then vaporises. The pool is assumed to be confined to the process building due to the provision of curbed areas and the vaporisation rate was determined from PHAST. All vapour is assumed to be methanol since this is the only volatile component used in the process building.

- For leaks from process vessels, the discharge rate of material is calculated based on pressure (including head of liquid within vessel). The procedure is then similar to that adopted for ruptures. A liquid pool is formed from which vaporisation occurs and the transient concentration within the building is calculated.

The fatality probability for VCEs is taken from CIA guidelines (1). The fatality probability is higher indoors because of the increased risk from flying debris such as breaking windows (see *Table 8.7c*).

Table 8.7c ***End Point Criteria for Vapour Cloud Explosions***

Overpressure (psi)	Fatality Probability (outdoors)	Fatality Probability (indoors)
5	0.09	0.55
3	0.02	0.15
1	0.00	0.01

Toxic Releases

Methanol is mildly toxic and so the toxic effects were modelled for methanol vapour clouds where ignition does not occur. The lethal concentration in 50% of rats (LC_{50}) is reported as 64,000ppm for a 4 hour exposure. To interpret this in terms of toxicity to humans, the method of Lees (2) was adopted. This is based on a probit equation of the form:

$$Y = k_1 + k_2 \ln C^n t$$

where Y is the probit, k_1 and k_2 are constants with k_2 taken to be unity, n is assumed to be 2 and t is the exposure time. For a 10 minute exposure, the LC_{50} concentration becomes 313,500 ppm. This is scaled by a factor of 0.25 to convert rat dose to human dose, giving an LC_{50} for humans of 78,384 ppm/10min. 50% fatality occurs for a probit of 5.0. The probit equation may therefore be solved for this boundary condition to obtain the constant k_1. This results in the following probit equation used in the current study:

$$Y = -19.841 + \ln C^n t$$

where C is in ppm and t is in minutes. This gives the fatality probabilities summarised in *Table 8.7d*, assuming 10 minute exposure.

(1) Chemical Industry Association, Guidance for the location and design of occupied buildings on chemical manufacturing sites, CIA/CISHEC/9802/CP/500/2M, Feb 1998.

(2) Lees, F. P., Loss Prevention in The Process Industries, Second edition, 1996.

Table 8.7d End Point Criteria for Toxic Releases

Methanol Concentration (ppm)	Fatality Probability (outdoors)	Fatality Probability (indoors)
190,000	0.99	0.099
113,000	0.9	0.09
59,000	0.5	0.05
31,000	0.1	0.01
18,500	0.01	0.001

Smoke Dispersion

The tank farm consists of about a dozen large storage tanks containing heavy hydrocarbons including crude vegetable oil, biodiesel, and glycerine. In case of ignition on loss of containment, incomplete combustion of crude oil and biodiesel will generate thick black smoke and potentially hazardous gases including carbon monoxide, nitrogen oxides and sulphur oxides. In the case of large diameter bund fires, a substantial volume of smoke may be produced.

However, smoke from such fire will be buoyant and tends to rise and has minimum impact on ground level population. This was observed in the Buncefield incident, for example [1]. In the following analysis, the approach taken in the PAFF report [2], was adopted whereby the smoke plume is considered to rise at an angle determined by the prevailing wind speed.

Based on Tseung Kwan O meteorological data (2003-2007) [3], the wind speed is 3 m/s or below for 95% of the time. Thus, a 5 m/s wind is assumed, to assess the worst-case impact of the smoke plume on the adjacent buildings. The results are summarized in *Table 8.7e* below.

In terms of existing buildings, the closest high rise building in the vicinity is the Dream City development in Tseung Kwan O area 86. It is about 800m north of the biodiesel plant, so any smoke plume will be well clear of the development once it has travelled that distance. Smoke will, therefore, pose no significant risk to the current population of the surrounding area.

For future developments, general buildings in the industrial estate are assumed to have a maximum height of 30 m. Therefore, they may be affected by the smoke plume at a distance of 10 m from the biodiesel plant boundary.

(1) Buncefield Major Incident Investigation, Initial Report to the Health and Safety Commission and the Environment Agency of the investigation into the explosions and fires at the Buncefield oil storage and transfer depot, Hemel Hempstead, on 11 December 2005, Buncefield Major Incident Investigation Board.

(2) Engineering Safety and Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility, Environmental Impact Assessment Report, Feb 2007.

(3) Hong Kong Observatory, private communication.

Table 8.7e *Buildings adjacent to the biodiesel plant affected by smoke plume*

Distance of building from the biodiesel site boundary (m)	Minimum height of the building that can be affected by the smoke plume (m)
0	0
5	6
10	13
20	26
30	39
40	52
50	66

The occupants inside the building in the vicinity of the biodiesel plant could be exposed to potentially toxic smoke due to the combined incapacitation effects of CO_2 (causing hyperventilation) and CO (toxic narcosis). The composition of smoke plume of heavy hydrocarbons is estimated as about 11.8% CO_2 and 800 ppm of CO (1). At 800 ppm CO, the time required for incapacitation is about 48 seconds and at 300 ppm, the time required is 20 min.

The time between arrival of the smoke plume and harm to the building's occupants is estimated as follows. The smoke could penetrate and diffuse inside the impacted building through the heating, ventilating and air-conditioning (HVAC) system. The air exchange rate of a typical office building is estimated as (2):

$\lambda = 0.87 + 0.13\, u_m$ for an exposed site,

$\lambda = 0.88$ for a sheltered site ($u_m < 4.2$ m/s),

$\lambda = 0.22\, u_m$ for a sheltered site ($u_m > 4.2$ m/s).

Where λ is the building air exchange rate and u_m is the wind speed.

To calculate the variation of indoor concentration of toxic gases with time, it is assumed (1) the outdoor concentration is steady and the same as the concentration in the smoke plume, (2) any gas that penetrates the building is mixed immediately and perfectly with all the air in the building to produce a uniform concentration. Under these conservative assumptions, the rate of change of the indoor concentration is simply proportional to the concentration driving force, given by

$$\frac{dC_i}{dt} = \lambda\left(C_0 - C_i\right)$$

(1) Engineering Safety & Risk, Environmental Assessment Services for Permanent Aviation Fuel Facility – Environmental Impact Assessment Report, Feb 2007, section 10.2.6.2, page 10.17.

(2) Hong Kong Water Supplies Department, Reassessment of Chlorine Hazard for Eight Existing Water Treatment Works: Methodology Report, Sept 1997.

Where C_i is the indoor concentration (ppm), C_o is the outdoor concentration (ppm), and λ is the building air exchange rate (air changes per hour). The indoor concentration is thus given by

$$C_i = C_0 \, (1\text{-}\exp(-\lambda t))$$

Where *t* is the time elapsed since the arrival of the smoke plume.

From this analysis, the minimum time to reach 300 ppm CO inside the building (CO in the smoke plume: 800 ppm) can be determined as 32 min (λ > 0.87). Considering the time required for the incapacitation at 300 ppm CO is 20 min, there is no fatality in the first 20 min starting from the impact of the smoke plume. Furthermore, 20 min is usually sufficient to evacuate the occupants inside the building. Therefore, the risk of fatalities caused by the smoke plume is assessed to be negligible. This analysis on smoke impacts is applicable to buildings outside the flame envelope. For those buildings inside the flame envelope, a fatality probability of 10% is assumed as described in the earlier paragraphs under pool fire/ bund fire impacts.

Smoke from Offsite Pool Fire

Under certain scenarios, combustible liquid (chiefly biodiesel) spilt onsite may exceed the site boundary and possibly ignite, causing an offsite pool fire. Smoke from this fire could also affect surrounding buildings, and this could potentially cause a greater effect than onsite fire because the pool fire may be closer to the affected buildings.

To analyze this situation, we have considered the duration of the worst-case offsite pool fire. The maximum pool volume is calculated as 270 m^3 (see *Table 8.7a*), leading to a pool area of 1.41 x 10^4 m^2, and this burns at a rate 0.039 kg s^{-1} m^{-2} (1) Thus, the duration of the worst pool fire is 894kg/m^3 x 270 m^3 / (0.039 kg s^{-1} m^{-2} x 1.41 x 10^4 m^2) = 7.3 min. Since this is considerably less than the 20 min required to build up a hazardous concentration of CO indoors, the offsite pool fire can be considered to pose negligible risk.

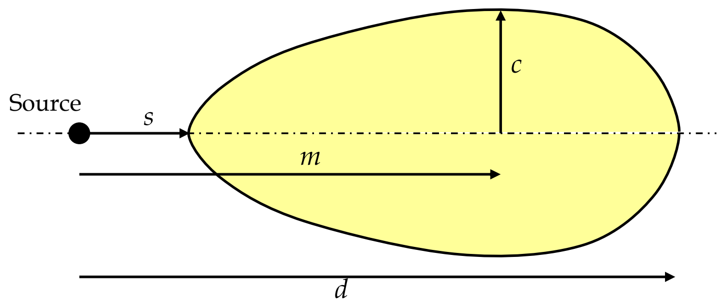
8.7.2 *Consequence Analysis Results*

Detailed results of the consequence analysis conducted for this risk assessment are shown in *Table 8.7f*, which tabulate the effect zones associated with various end points of the hazardous outcomes considered. Consequence results are presented in terms of:

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

These dimensions (*Figure 8.7b*) are utilized within the risk integration software to define the footprint area of the hazard and calculate the number of people affected based on the meteorological data and population distribution.

Figure 8.7b Presentation of Consequence Results



(1) http://users.wpi.edu/~ierardi/FireTools/pool_fires.html, assuming burning liquid is equivalent to transformer oil (flash point = 140degC, similar to biodiesel).

Table 8.7f Consequence Distances

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
1	T1/T2	Crude GTW storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
			Rupture (over-topping)	Pool fire (unconfined, outside site)	Flame zone	67	67	-67	0	67	67	-67	0	67	67	-67	0	67	67	-67	0
					Drag zone	70	70	-70	0	71	71	-71	0	71	71	-71	0	78	78	-78	0
2	T3	Cleaned GTW storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
			Rupture topping)	Pool fire (unconfined, outside site)	Flame zone	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
					Drag zone	14	14	-14	0	14	14	-14	0	14	14	-14	0	15	15	-15	0
3	T4/T5	Crude WCO storage tank	Leak	Bund fire	Flame zone	8	8	-8	0	8	8	-8	0	8	8	-8	0	8	8	-8	0
					Drag zone	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
			Rupture	Bund fire	Flame zone	8	8	-8	0	8	8	-8	0	8	8	-8	0	8	8	-8	0
					Drag zone	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
			Rupture	Pool fire	Flame zone	48	48	-48	0	48	48	-48	0	48	48	-48	0	48	48	-48	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
			(over-topping)	(unconfined)	Drag zone	51	51	-51	0	52	52	-52	0	52	52	-52	0	57	57	-57	0
4	T6	Cleaned WCO storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
			Rupture (over-topping)	Pool fire (unconfined, outside site)	Flame zone	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
					Drag zone	14	14	-14	0	14	14	-14	0	14	14	-14	0	15	15	-15	0
5	T7	PFAD storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
6	T8	Crude animal fats storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
			Rupture (over-topping)	Pool fire (unconfined, outside site)	Flame zone	7	7	-7	0	7	7	-7	0	7	7	-7	0	7	7	-7	0
					Drag zone	10	10	-10	0	10	10	-10	0	10	10	-10	0	10	10	-10	0
7	T9	Clean animal fats storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
8	T10	Methanol storage tank	Leak	Bund fire	Flame zone	7	7	-7	0	7	7	-7	0	7	7	-7	0	7	7	-7	0
					Drag zone	10	10	-10	0	10	10	-10	0	10	10	-10	0	10	10	-10	0
				Flash fire	LFL	29	6	0	25	20	1	0	6	26	1	0	14	23	1	0	12
				VCE	5 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					3 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					1 psi	22	22	-22	0	13	13	-13	0	14	14	-14	0	14	14	-14	0
				Toxic release	190,000 ppm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					113,000 ppm	13	1	0	5	12	1	0	5	12	1	0	5	12	1	0	5
					59,000 ppm	33	11	0	28	24	1	0	7	34	1	0	20	28	1	0	18
					31,000 ppm	43	24	0	33	37	2	0	8	58	3	0	40	42	3	0	28
					18,500 ppm	51	35	0	40	50	2	0	8	74	4	0	50	51	4	0	38
			Rupture	Bund fire	Flame zone	7	7	-7	0	7	7	-7	0	7	7	-7	0	7	7	-7	0
					Drag zone	10	10	-10	0	10	10	-10	0	10	10	-10	0	10	10	-10	0
				Flash fire	LFL	23	17	-15	6	24	13	-12	4	26	14	-13	4	36	11	-9	3
				VCE	5 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					3 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					1 psi	65	65	-65	0	63	63	-63	0	65	65	-65	0	65	65	-65	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				Toxic release	190,000 ppm	10	9	-8	2	12	11	-10	2	12	11	-10	2	13	10	-8	3
					113,000 ppm	14	11	-10	3	14	11	-10	3	14	11	-10	3	17	11	-9	3
					59,000 ppm	28	20	-16	7	33	15	-14	5	33	16	-14	6	49	13	-10	10
					31,000 ppm	43	31	-23	11	58	21	-16	14	62	22	-16	14	89	17	-13	25
					18,500 ppm	55	41	-29	11	68	26	-19	25	81	27	-19	25	114	23	-14	46
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
				Flash fire	LFL	38	25	-16	12	32	14	-12	5	38	15	-12	8	45	13	-9	5
				VCE	5 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					3 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					1 psi	85	85	-85	0	65	65	-65	0	65	65	-65	0	65	65	-65	0
				Toxic release	190,000 ppm	11	10	-9	0	10	10	-9	0	10	10	-9	0	14	11	-9	3
					113,000 ppm	20	13	-10	6	15	10	-10	2	17	12	-11	2	19	13	-10	3
					59,000 ppm	45	30	-20	14	45	16	-13	13	52	18	-13	13	58	15	-11	11
					31,000 ppm	69	50	-31	17	69	24	-17	33	81	28	-17	38	106	22	-15	38
					18,500 ppm	186	67	-47	23	87	34	-20	44	106	38	-20	54	133	30	-17	85
9	T14	Infineum storage tank	Leak	Bund fire	Flame zone	6	6	-6	0	6	6	-6	0	6	6	-6	0	6	6	-6	0
					Drag zone	9	9	-9	0	9	9	-9	0	9	9	-9	0	9	9	-9	0
			Rupture	Bund fire	Flame zone	6	6	-6	0	6	6	-6	0	6	6	-6	0	6	6	-6	0
					Drag zone	9	9	-9	0	9	9	-9	0	9	9	-9	0	9	9	-9	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	60	60	-60	0	59	59	-59	0	59	59	-59	0	59	59	-59	0
					Drag zone	63	63	-63	0	64	64	-64	0	64	64	-64	0	71	71	-71	0
10	T15/ T16	Quality biodiesel storage tank	Leak	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture	Pool fire	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***
			(over-topping)	(unconfined)	Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
			Rupture	Pool fire	Flame zone	7	7	-7	0	7	7	-7	0	7	7	-7	0	7	7	-7	0
			(over-topping)	(unconfined, outside site)	Drag zone	10	10	-10	0	10	10	-10	0	10	10	-10	0	10	10	-10	0
11	T17	Biodiesel-Europe storage tank	Leak	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture (over-topping)	Pool fire (unconfined, inside site)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
			Rupture (over-topping)	Pool fire (unconfined, outside site)	Flame zone	37	37	-37	0	37	37	-37	0	37	37	-37	0	37	37	-37	0
					Drag zone	40	40	-40	0	41	41	-41	0	41	41	-41	0	45	45	-45	0
12	T18	Biodiesel-Hong Kong storage tank	Leak	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
13	T19	Glycerine storage tank	Leak	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0
			Rupture	Bund fire	Flame zone	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					Drag zone	23	23	-23	0	23	23	-23	0	23	23	-23	0	25	25	-25	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
14	T21	Bioheating oil storage tank	Leak	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
15	T22	Gas oil storage tank	Leak	Bund fire	Flame zone	6	6	-6	0	6	6	-6	0	6	6	-6	0	6	6	-6	0
					Drag zone	9	9	-9	0	9	9	-9	0	9	9	-9	0	9	9	-9	0
			Rupture	Bund fire	Flame zone	6	6	-6	0	6	6	-6	0	6	6	-6	0	6	6	-6	0
					Drag zone	9	9	-9	0	9	9	-9	0	9	9	-9	0	9	9	-9	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	74	74	-74	0	74	74	-74	0	74	74	-74	0	74	74	-74	0
					Drag zone	77	77	-77	0	78	78	-78	0	78	78	-78	0	86	86	-86	0
16	T24	Crude WCO storage tank	Leak	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture	Bund fire	Flame zone	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					Drag zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	23	23	-23	0
			Rupture (over-topping)	Pool fire (unconfined)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
						9	9	-9	0	9	9	-9	0	9	9	-9	0	9	9	-9	0
			Rupture	Pool fire	Flame zone																

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
			(over-topping)	(unconfined, outside site)	Drag zone	12	12	-12	0	12	12	-12	0	12	12	-12	0	12	12	-12	0
17	G01	Biogas buffer tank	Rupture	Flash fire	LFL	3	3	-3	0	4	3	-3	0	3	3	-3	0	6	3	-3	0
18	P01	Esterification with catalyst	Rupture	VCE (isolation failure, ventilation success)	5 psi 3 psi 1 psi	51 70 165	51 70 165	-51 -70 -165	0 0 0	51 70 165	51 70 165	-51 -70 -165	0 0 0	51 70 165	51 70 165	-51 -70 -165	0 0 0	51 70 165	51 70 165	-51 -70 -165	0 0 0
			Rupture	VCE (isolation failure, ventilation failure)	5 psi 3 psi 1 psi	57 79 184	57 79 184	-57 -79 -184	0 0 0	57 79 184	57 79 184	-57 -79 -184	0 0 0	57 79 184	57 79 184	-57 -79 -184	0 0 0	57 79 184	57 79 184	-57 -79 -184	0 0 0
			Leak	VCE (isolation failure, ventilation success)	5 psi 3 psi 1 psi	22 30 72	22 30 72	-22 -30 -72	0 0 0	22 30 72	22 30 72	-22 -30 -72	0 0 0	22 30 72	22 30 72	-22 -30 -72	0 0 0	22 30 72	22 30 72	-22 -30 -72	0 0 0
				VCE (isolation failure, ventilation failure)	5 psi 3 psi 1 psi	45 62 146	45 62 146	-45 -62 -146	0 0 0	45 62 146	45 62 146	-45 -62 -146	0 0 0	45 62 146	45 62 146	-45 -62 -146	0 0 0	45 62 146	45 62 146	-45 -62 -146	0 0 0
				VCE (isolation success, ventilation success)	5 psi 3 psi 1 psi	13 19 44	13 19 44	-13 -19 -44	0 0 0	13 19 44	13 19 44	-13 -19 -44	0 0 0	13 19 44	13 19 44	-13 -19 -44	0 0 0	13 19 44	13 19 44	-13 -19 -44	0 0 0
				VCE (isolation success, ventilation failure)	5 psi 3 psi 1 psi	25 35 83	25 35 83	-25 -35 -83	0 0 0	25 35 83	25 35 83	-25 -35 -83	0 0 0	25 35 83	25 35 83	-25 -35 -83	0 0 0	25 35 83	25 35 83	-25 -35 -83	0 0 0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***
19	P02	Methanol buffer tank	Rupture	VCE (isolation failure, ventilation success)	5 psi 3 psi 1 psi	25 34 80	25 34 80	-25 -34 -80	0 0 0	25 34 80	25 34 80	-25 -34 -80	0 0 0	25 34 80	25 34 80	-25 -34 -80	0 0 0	25 34 80	25 34 80	-25 -34 -80	0 0 0
				VCE (isolation failure, ventilation failure)	5 psi 3 psi 1 psi	55 76 178	55 76 178	-55 -76 -178	0 0 0	55 76 178	55 76 178	-55 -76 -178	0 0 0	55 76 178	55 76 178	-55 -76 -178	0 0 0	55 76 178	55 76 178	-55 -76 -178	0 0 0
			Leak	VCE (isolation failure, ventilation success)	5 psi 3 psi 1 psi	17 24 57	17 24 57	-17 -24 -57	0 0 0	17 24 57	17 24 57	-17 -24 -57	0 0 0	17 24 57	17 24 57	-17 -24 -57	0 0 0	17 24 57	17 24 57	-17 -24 -57	0 0 0
				VCE (isolation failure, ventilation failure)	5 psi 3 psi 1 psi	36 50 118	36 50 118	-36 -50 -118	0 0 0	36 50 118	36 50 118	-36 -50 -118	0 0 0	36 50 118	36 50 118	-36 -50 -118	0 0 0	36 50 118	36 50 118	-36 -50 -118	0 0 0
				VCE (isolation success, ventilation success)	5 psi 3 psi 1 psi	11 16 38	11 16 38	-11 -16 -38	0 0 0	11 16 38	11 16 38	-11 -16 -38	0 0 0	11 16 38	11 16 38	-11 -16 -38	0 0 0	11 16 38	11 16 38	-11 -16 -38	0 0 0
				VCE (isolation success, ventilation failure)	5 psi 3 psi 1 psi	21 29 69	21 29 69	-21 -29 -69	0 0 0	21 29 69	21 29 69	-21 -29 -69	0 0 0	21 29 69	21 29 69	-21 -29 -69	0 0 0	21 29 69	21 29 69	-21 -29 -69	0 0 0
20	P03	Pipe reactor	Rupture	VCE (isolation failure,	5 psi	41	41	-41	0	41	41	-41	0	41	41	-41	0	41	41	-41	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				ventilation success)																	
					3 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					1 psi	134	134	-134	0	134	134	-134	0	134	134	-134	0	134	134	-134	0
				VCE (isolation failure, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
				VCE (isolation success, ventilation success)	5 psi	32	32	-32	0	32	32	-32	0	32	32	-32	0	32	32	-32	0
					3 psi	45	45	-45	0	45	45	-45	0	45	45	-45	0	45	45	-45	0
					1 psi	105	105	-105	0	105	105	-105	0	105	105	-105	0	105	105	-105	0
				VCE (isolation success, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	41	41	-41	0	41	41	-41	0	41	41	-41	0	41	41	-41	0
					3 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					1 psi	134	134	-134	0	134	134	-134	0	134	134	-134	0	134	134	-134	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***
				VCE (isolation failure, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
				VCE (isolation success, ventilation success)	5 psi	32	32	-32	0	32	32	-32	0	32	32	-32	0	32	32	-32	0
					3 psi	45	45	-45	0	45	45	-45	0	45	45	-45	0	45	45	-45	0
					1 psi	105	105	-105	0	105	105	-105	0	105	105	-105	0	105	105	-105	0
				VCE (isolation success, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
21	P04	Methanol recycle tank	Rupture	VCE (isolation failure, ventilation success)	5 psi	29	29	-29	0	29	29	-29	0	29	29	-29	0	29	29	-29	0
					3 psi	40	40	-40	0	40	40	-40	0	40	40	-40	0	40	40	-40	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
					1 psi	95	95	-95	0	95	95	-95	0	95	95	-95	0	95	95	-95	0
				VCE (isolation failure, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					3 psi	26	26	-26	0	26	26	-26	0	26	26	-26	0	26	26	-26	0
					1 psi	61	61	-61	0	61	61	-61	0	61	61	-61	0	61	61	-61	0
				VCE (isolation failure, ventilation failure)	5 psi	38	38	-38	0	38	38	-38	0	38	38	-38	0	38	38	-38	0
					3 psi	53	53	-53	0	53	53	-53	0	53	53	-53	0	53	53	-53	0
					1 psi	125	125	-125	0	125	125	-125	0	125	125	-125	0	125	125	-125	0
				VCE (isolation success, ventilation success)	5 psi	12	12	-12	0	12	12	-12	0	12	12	-12	0	12	12	-12	0
					3 psi	17	17	-17	0	17	17	-17	0	17	17	-17	0	17	17	-17	0
					1 psi	40	40	-40	0	40	40	-40	0	40	40	-40	0	40	40	-40	0
				VCE (isolation success, ventilation	5 psi	22	22	-22	0	22	22	-22	0	22	22	-22	0	22	22	-22	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***	***d***	***c***	***s***	***m***
				failure)																	
					3 psi	31	31	-31	0	31	31	-31	0	31	31	-31	0	31	31	-31	0
					1 psi	73	73	-73	0	73	73	-73	0	73	73	-73	0	73	73	-73	0
22	P05	MEK buffer tank	Rupture	VCE (isolation failure, ventilation success)	5 psi	24	24	-24	0	24	24	-24	0	24	24	-24	0	24	24	-24	0
					3 psi	33	33	-33	0	33	33	-33	0	33	33	-33	0	33	33	-33	0
					1 psi	78	78	-78	0	78	78	-78	0	78	78	-78	0	78	78	-78	0
				VCE (isolation failure, ventilation failure)	5 psi	53	53	-53	0	53	53	-53	0	53	53	-53	0	53	53	-53	0
					3 psi	73	73	-73	0	73	73	-73	0	73	73	-73	0	73	73	-73	0
					1 psi	171	171	-171	0	171	171	-171	0	171	171	-171	0	171	171	-171	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	17	17	-17	0	17	17	-17	0	17	17	-17	0	17	17	-17	0
					3 psi	23	23	-23	0	23	23	-23	0	23	23	-23	0	23	23	-23	0
					1 psi	55	55	-55	0	55	55	-55	0	55	55	-55	0	55	55	-55	0
				VCE (isolation failure, ventilation failure)	5 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
					3 psi	49	49	-49	0	49	49	-49	0	49	49	-49	0	49	49	-49	0
					1 psi	115	115	-115	0	115	115	-115	0	115	115	-115	0	115	115	-115	0
				VCE	5 psi	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				(isolation success, ventilation success)																	
					3 psi	15	15	-15	0	15	15	-15	0	15	15	-15	0	15	15	-15	0
					1 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
				VCE (isolation success, ventilation failure)	5 psi	21	21	-21	0	21	21	-21	0	21	21	-21	0	21	21	-21	0
					3 psi	29	29	-29	0	29	29	-29	0	29	29	-29	0	29	29	-29	0
					1 psi	68	68	-68	0	68	68	-68	0	68	68	-68	0	68	68	-68	0
23	P06	GLP settling tank	Rupture	VCE (isolation failure, ventilation success)	5 psi	21	21	-21	0	21	21	-21	0	21	21	-21	0	21	21	-21	0
					3 psi	29	29	-29	0	29	29	-29	0	29	29	-29	0	29	29	-29	0
					1 psi	70	70	-70	0	70	70	-70	0	70	70	-70	0	70	70	-70	0
				VCE (isolation failure, ventilation failure)	5 psi	47	47	-47	0	47	47	-47	0	47	47	-47	0	47	47	-47	0
					3 psi	65	65	-65	0	65	65	-65	0	65	65	-65	0	65	65	-65	0
					1 psi	152	152	-152	0	152	152	-152	0	152	152	-152	0	152	152	-152	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
					3 psi	16	16	-16	0	16	16	-16	0	16	16	-16	0	16	16	-16	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
					1 psi	38	38	-38	0	38	38	-38	0	38	38	-38	0	38	38	-38	0
				VCE (isolation failure, ventilation failure)	5 psi	25	25	-25	0	25	25	-25	0	25	25	-25	0	25	25	-25	0
					3 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
					1 psi	81	81	-81	0	81	81	-81	0	81	81	-81	0	81	81	-81	0
				VCE (isolation success, ventilation success)	5 psi	8	8	-8	0	8	8	-8	0	8	8	-8	0	8	8	-8	0
					3 psi	12	12	-12	0	12	12	-12	0	12	12	-12	0	12	12	-12	0
					1 psi	28	28	-28	0	28	28	-28	0	28	28	-28	0	28	28	-28	0
				VCE (isolation success, ventilation failure)	5 psi	15	15	-15	0	15	15	-15	0	15	15	-15	0	15	15	-15	0
					3 psi	22	22	-22	0	22	22	-22	0	22	22	-22	0	22	22	-22	0
					1 psi	51	51	-51	0	51	51	-51	0	51	51	-51	0	51	51	-51	0
24	P07	GLP collection tank	Rupture	VCE (isolation failure, ventilation success)	5 psi	42	42	-42	0	42	42	-42	0	42	42	-42	0	42	42	-42	0
					3 psi	59	59	-59	0	59	59	-59	0	59	59	-59	0	59	59	-59	0
					1 psi	138	138	-138	0	138	138	-138	0	138	138	-138	0	138	138	-138	0
				VCE (isolation failure, ventilation	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				failure)																	
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	19	19	-19	0	19	19	-19	0	19	19	-19	0	19	19	-19	0
					3 psi	26	26	-26	0	26	26	-26	0	26	26	-26	0	26	26	-26	0
					1 psi	62	62	-62	0	62	62	-62	0	62	62	-62	0	62	62	-62	0
				VCE (isolation failure, ventilation failure)	5 psi	39	39	-39	0	39	39	-39	0	39	39	-39	0	39	39	-39	0
					3 psi	54	54	-54	0	54	54	-54	0	54	54	-54	0	54	54	-54	0
					1 psi	127	127	-127	0	127	127	-127	0	127	127	-127	0	127	127	-127	0
				VCE (isolation success, ventilation success)	5 psi	12	12	-12	0	12	12	-12	0	12	12	-12	0	12	12	-12	0
					3 psi	17	17	-17	0	17	17	-17	0	17	17	-17	0	17	17	-17	0
					1 psi	40	40	-40	0	40	40	-40	0	40	40	-40	0	40	40	-40	0
				VCE (isolation success, ventilation failure)	5 psi	23	23	-23	0	23	23	-23	0	23	23	-23	0	23	23	-23	0
					3 psi	31	31	-31	0	31	31	-31	0	31	31	-31	0	31	31	-31	0
					1 psi	74	74	-74	0	74	74	-74	0	74	74	-74	0	74	74	-74	0
25	P08	Acidulation tank	Rupture	VCE	5 psi	27	27	-27	0	27	27	-27	0	27	27	-27	0	27	27	-27	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				(isolation failure, ventilation success)																	
					3 psi	37	37	-37	0	37	37	-37	0	37	37	-37	0	37	37	-37	0
					1 psi	88	88	-88	0	88	88	-88	0	88	88	-88	0	88	88	-88	0
				VCE (isolation failure, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	17	17	-17	0	17	17	-17	0	17	17	-17	0	17	17	-17	0
					3 psi	23	23	-23	0	23	23	-23	0	23	23	-23	0	23	23	-23	0
					1 psi	55	55	-55	0	55	55	-55	0	55	55	-55	0	55	55	-55	0
				VCE (isolation failure, ventilation failure)	5 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
					3 psi	48	48	-48	0	48	48	-48	0	48	48	-48	0	48	48	-48	0
					1 psi	113	113	-113	0	113	113	-113	0	113	113	-113	0	113	113	-113	0
				VCE (isolation success, ventilation success)	5 psi	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
					3 psi	15	15	-15	0	15	15	-15	0	15	15	-15	0	15	15	-15	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
					1 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
				VCE (isolation success, ventilation failure)	5 psi	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					3 psi	28	28	-28	0	28	28	-28	0	28	28	-28	0	28	28	-28	0
					1 psi	66	66	-66	0	66	66	-66	0	66	66	-66	0	66	66	-66	0
26	P09	FFA buffer tank	Rupture	VCE (isolation failure, ventilation success)	5 psi	27	27	-27	0	27	27	-27	0	27	27	-27	0	27	27	-27	0
					3 psi	38	38	-38	0	38	38	-38	0	38	38	-38	0	38	38	-38	0
					1 psi	89	89	-89	0	89	89	-89	0	89	89	-89	0	89	89	-89	0
				VCE (isolation failure, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
			Leak	VCE (isolation failure, ventilation success)	5 psi	18	18	-18	0	18	18	-18	0	18	18	-18	0	18	18	-18	0
					3 psi	25	25	-25	0	25	25	-25	0	25	25	-25	0	25	25	-25	0
					1 psi	58	58	-58	0	58	58	-58	0	58	58	-58	0	58	58	-58	0
				VCE (isolation failure, ventilation	5 psi	37	37	-37	0	37	37	-37	0	37	37	-37	0	37	37	-37	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				failure)																	
					3 psi	51	51	-51	0	51	51	-51	0	51	51	-51	0	51	51	-51	0
					1 psi	119	119	-119	0	119	119	-119	0	119	119	-119	0	119	119	-119	0
				VCE (isolation success, ventilation success)	5 psi	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
					3 psi	15	15	-15	0	15	15	-15	0	15	15	-15	0	15	15	-15	0
					1 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
				VCE (isolation success, ventilation failure)	5 psi	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					3 psi	28	28	-28	0	28	28	-28	0	28	28	-28	0	28	28	-28	0
					1 psi	66	66	-66	0	66	66	-66	0	66	66	-66	0	66	66	-66	0
27	P10	Neutralization tank	Rupture	VCE (isolation failure, ventilation success)	5 psi	28	28	-28	0	28	28	-28	0	28	28	-28	0	28	28	-28	0
					3 psi	39	39	-39	0	39	39	-39	0	39	39	-39	0	39	39	-39	0
					1 psi	92	92	-92	0	92	92	-92	0	92	92	-92	0	92	92	-92	0
				VCE (isolation failure, ventilation failure)	5 psi	57	57	-57	0	57	57	-57	0	57	57	-57	0	57	57	-57	0
					3 psi	79	79	-79	0	79	79	-79	0	79	79	-79	0	79	79	-79	0
					1 psi	184	184	-184	0	184	184	-184	0	184	184	-184	0	184	184	-184	0
			Leak	VCE	5 psi	17	17	-17	0	17	17	-17	0	17	17	-17	0	17	17	-17	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				(isolation failure, ventilation success)																	
					3 psi	23	23	-23	0	23	23	-23	0	23	23	-23	0	23	23	-23	0
					1 psi	55	55	-55	0	55	55	-55	0	55	55	-55	0	55	55	-55	0
				VCE (isolation failure, ventilation failure)	5 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
					3 psi	49	49	-49	0	49	49	-49	0	49	49	-49	0	49	49	-49	0
					1 psi	114	114	-114	0	114	114	-114	0	114	114	-114	0	114	114	-114	0
				VCE (isolation success, ventilation success)	5 psi	11	11	-11	0	11	11	-11	0	11	11	-11	0	11	11	-11	0
					3 psi	15	15	-15	0	15	15	-15	0	15	15	-15	0	15	15	-15	0
					1 psi	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
				VCE (isolation success, ventilation failure)	5 psi	20	20	-20	0	20	20	-20	0	20	20	-20	0	20	20	-20	0
					3 psi	28	28	-28	0	28	28	-28	0	28	28	-28	0	28	28	-28	0
					1 psi	67	67	-67	0	67	67	-67	0	67	67	-67	0	67	67	-67	0
29	M01	Biodiesel/PFAD barge	Small	Pool fire (on sea)	Flame zone	43	43	-43	0	43	43	-43	0	43	43	-43	0	43	43	-43	0
					Drag zone	46	46	-46	0	47	47	-47	0	47	47	-47	0	52	52	-52	0
			Large	Pool fire (on sea)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
					Drag zone	78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
			Rupture	Pool fire	Flame zone	193	193	-193	0	193	193	-193	0	193	193	-193	0	193	193	-193	0
				(on sea)		196	196	-196	0	196	196	-196	0	196	196	-196	0	210	210	-210	0
					Drag zone																
30	M02	Methanol barge	Rupture	Tank fire	Flame zone	13	13	-13	0	13	13	-13	0	13	13	-13	0	13	13	-13	0
						16	16	-16	0	16	16	-16	0	16	16	-16	0	17	17	-17	0
					Drag zone																
31	M03	Methanol ISO-tanker	Leak	Pool fire	Flame zone	12	12	-12	0	12	12	-12	0	12	12	-12	0	11	11	-11	0
						15	15	-15	0	15	15	-15	0	15	15	-15	0	16	16	-16	0
					Drag zone																
				Flash fire	LFL	13	7	0	9	8	1	0	5	10	2	0	6	0	0	0	0
				Toxic release	190,000 ppm	8	3	0	5	2	1	0	1	4	1	0	2	0	0	0	0
					113,000 ppm	10	5	0	7	6	1	0	3	7	1	0	4	0	0	0	0
					59,000 ppm	14	9	0	10	9	2	1	6	12	2	1	7	1	1	0	1
					31,000 ppm	19	13	0	12	12	2	0	9	15	3	0	11	3	1	0	2
					18,500 ppm	22	17	0	15	14	3	0	11	18	4	0	14	4	3	0	3
			Rupture	Pool fire	Flame zone	35	35	-35	0	35	35	-35	0	35	35	-35	0	35	35	-35	0
						38	38	-38	0	39	39	-39	0	39	39	-39	0	43	43	-43	0
					Drag zone																
				Flash fire	LFL	14	8	-5	5	10	4	-4	0	10	4	-4	0	11	4	-4	0
				Toxic release	190,000 ppm	4	3	-3	0	4	3	-3	0	4	3	-3	0	4	3	-3	0
					113,000 ppm	5	4	-4	0	5	4	-4	0	5	4	-4	0	5	4	-4	0
					59,000 ppm	17	10	-7	5	14	5	-5	2	14	5	-5	2	18	5	-5	2
					31,000 ppm	25	18	-10	8	30	8	-6	10	30	9	-6	10	34	7	-6	12
					18,500 ppm	35	23	-15	10	38	12	-7	22	38	14	-7	22	43	10	-7	25
32	L01	Unloading hose/line from jetty (biodiesel/PFAD)	Leak	Pool fire	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
				(on sea)		78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
					Drag zone																
			Rupture	Pool fire	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
				(on sea)		78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
					Drag zone																
33	L02	Unloading hose/line from jetty (methanol)	Leak	Pool fire	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
				(on sea)		78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
					Drag zone																

Section No.	Section Code	Description	Leak Size	Outcome	End Point Criteria	Weather State 1.5F				Weather State 3B				Weather State 3D				Weather State 6D			
						d	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*	*d*	*c*	*s*	*m*
				Flash fire	LFL	47	26	5	31	19	18	5	14	21	21	5	14	18	11	5	15
				Toxic release	190,000 ppm	9	1	6	8	9	1	6	8	9	1	6	8	9	1	6	8
					113,000 ppm	15	10	5	10	9	1	6	8	9	1	6	8	9	1	6	8
					59,000 ppm	58	40	5	40	23	23	5	14	26	26	5	14	22	20	5	15
					31,000 ppm	84	80	5	57	41	38	5	14	47	40	5	15	37	32	5	15
					18,500 ppm	105	111	5	74	51	46	5	14	63	48	5	13	48	40	5	15
			Rupture	Pool fire (on sea)	Flame zone	75	75	-75	0	75	75	-75	0	75	75	-75	0	75	75	-75	0
						78	78	-78	0	79	79	-79	0	79	79	-79	0	87	87	-87	0
					Drag zone																
				Flash fire	LFL	53	20	5	15	24	16	5	16	27	17	5	16	24	13	5	18
				Toxic release	190,000 ppm	12	1	6	10	12	1	6	10	12	1	6	10	12	1	6	10
					113,000 ppm	17	9	5	12	12	1	5	10	12	1	5	10	12	1	5	10
					59,000 ppm	70	28	5	49	31	21	5	16	33	22	5	16	31	18	5	18
					31,000 ppm	102	66	5	75	56	33	5	16	63	33	5	16	55	29	5	17
					18,500 ppm	128	100	5	93	78	40	5	15	85	40	5	15	70	35	5	17
34	RT1	Road tanker for fats & oils	Leak	Pool fire	Flame zone	21	21	-21	0	21	21	-21	0	21	21	-21	0	21	21	-21	0
						24	24	-24	0	24	24	-24	0	24	24	-24	0	27	27	-27	0
					Drag zone																
			Rupture	Pool fire	Flame zone	24	24	-24	0	24	24	-24	0	24	24	-24	0	24	24	-24	0
						27	27	-27	0	27	27	-27	0	27	27	-27	0	30	30	-30	0
					Drag zone																
35	L03	Road tanker unloading line	Leak	Pool fire	Flame zone	39	39	-39	0	39	39	-39	0	39	39	-39	0	39	39	-39	0
						42	42	-42	0	43	43	-43	0	43	43	-43	0	47	47	-47	0
					Drag zone																
			Rupture	Pool fire	Flame zone	39	39	-39	0	39	39	-39	0	39	39	-39	0	39	39	-39	0
						42	42	-42	0	43	43	-43	0	43	43	-43	0	47	47	-47	0
					Drag zone																

8.8 RISK RESULTS

This section presents the risk results which are derived by combining the frequency of hazardous outcome events with the associated consequences. This is known as Risk Summation and was conducted using in-house software RISKPLOT™.

Societal Risks

The overall off-site Potential Loss of Life (PLL) value from the biodiesel plant was estimated as $6.83x10^{-7}$ per year for the existing population, increasing to $1.59x10^{-5}$ per year with the future population, once the industrial estate is fully developed. The main contributors to the societal risks are summarised in *Table 8.8a* and *Table 8.8b*. Vapour cloud explosions within the process building are the main contributors to the societal risk. Pool fires from tank leaks and unloading activities also make some contribution. The toxic effects of methanol are minimal and do not make significant contributions to the risks. Similarly, flash fires are only small contributors to the overall risk because of small dispersion distances.

Table 8.8a Main Contributors to Potential Loss of Life (PLL)

Current Population Scenario

Scenario	Scenario Description	Main Hazardous Chemical	PLL (per year)	%
P03 Pipe reactor	Leak leading to VCE (isolation success, ventilation failure)	Methanol	$1.64 x10^{-7}$	24.0%
P03 Pipe reactor	Leak leading to VCE (isolation failure, ventilation success)	Methanol	$7.59 x10^{-8}$	11.1%
P03 Pipe reactor	Leak leading to VCE (isolation success, ventilation success)	Methanol	$5.99 x10^{-8}$	8.8%
P03 Pipe reactor	Leak leading to VCE (isolation failure, ventilation failure)	Methanol	$4.55 x10^{-8}$	6.7%
M01 biodiesel/PFAD barge	Rupture leading to pool fire	Biodiesel	$3.67 x10^{-8}$	5.4%
P01 Esterification reactor with catalyst	Rupture leading to VCE (isolation failure, ventilation success)	Methanol	$3.57 x10^{-8}$	5.2%
P03 Pipe reactor	Rupture leading to VCE (isolation success, ventilation failure)	Methanol	$3.27 x10^{-8}$	4.8%

Scenario	Scenario Description	Main Hazardous Chemical	PLL (per year)	%
T10 Methanol tank, T7 PFAD storage tank	Tank rupture leading to pool fire with overtopping (VCE escalation)	Methanol, PFAD	2.35 x10^{-8}	3.4%
P01 Esterification reactor	Rupture leading to VCE (isolation failure, ventilation failure)	Methanol	2.08 x10^{-8}	3.0%
P10 Neutralization tank	P10 rupture leading to VCE (isolation failure, ventilation failure)	Methanol	2.08 x10^{-8}	3.0%
Total (including all scenarios)			**6.83 x10^{-7}**	**100%**

Future Population Scenario

Scenario	Scenario Description	Main Hazardous Chemical	PLL (per year)	%
P03 Pipe reactor	Leak leading to VCE (isolation success, ventilation failure)	Methanol	2.97 x10^{-6}	18.7%
Maintenance error	Internal explosion in process building	Methanol	2.16 x10^{-6} (a)	13.6%
T10 Methanol tank, T7 PFAD storage tank	Tank rupture leading to pool fire with overtopping (VCE escalation)	Methanol, PFAD	1.71 x10^{-6}	10.8%
T10 Methanol storage tank	Rupture leading to pool fire with overtopping (VCE escalation)	Methanol	1.08 x10^{-6}	6.8%
P03 Pipe reactor	Leak leading to VCE (isolation failure, ventilation failure)	Methanol	8.25 x10^{-7}	5.2%
P03 Pipe reactor	Leak leading to VCE (isolation failure, ventilation success)	Methanol	8.18 x10^{-7}	5.1%
P03 Pipe reactor	Leak leading to VCE (isolation success, ventilation success)	Methanol	5.98 x10^{-7}	3.8%
P03 Pipe reactor	Rupture leading to VCE (isolation success, ventilation failure)	Methanol	5.94 x10^{-7}	3.7%
P01 Esterification reactor with catalyst	Rupture leading to VCE (isolation failure, ventilation success)	Methanol	5.47 x10^{-7}	3.4%

Scenario	Scenario Description	Main Hazardous Chemical	PLL (per year)	%
P01 Esterification reactor with catalyst	Rupture leading to VCE (isolation failure, ventilation failure)	Methanol	3.77 x10^{-7}	2.4%
Total (including all scenarios)			**1.59x10^{-5}**	**100%**

Note:

(a) This figure is double the frequency value derived from the event tree in *Figure 8.6l* because two fatalities have been assumed (see Page 74).

Table 8.8b *PLL Breakdown by Systems (Future Population)*

System	PLL (per year)	%
Process	1.14 x 10^{-5}	72%
Tank Farm	3.59 x 10^{-6}	22%
Transport	8.76 x 10^{-7}	6%
Total	1.59 x 10^{-5}	100%

The FN curve for current population and future population are presented and compared with the *Hong Kong Risk Guidelines* in *Figure 8.8a* and *Figure 8.8b.*

For the current population scenario, there is only one office building of Gammon with a population of about 50 that lies within the consequence zone of 1 psi. This results in fractional fatalities as the fatality probability is 1% of persons indoor within the 1psi zone. For the current population scenario, the marine population is also affected by pool fire events from loading/ unloading operations. This scenario also results in fractional fatalities as the population is distributed over an area in Junk Bay. These outcomes with fractional fatalities have been included in the PLL estimation. These scenarios have also been represented in the FN curve by converting the PLL into an equivalent frequency of one fatality and the same is shown on the FN curve *in Figure 8.8a.*

Considering the potential future development in the vicinity of this plant (although of industrial in nature), the FN curve for future case is higher than the current case. Also, the predicted fatality range is wider.

The risks for both current and future population case lie within the acceptable region of the *Hong Kong Risk Guidelines*.

Figure 8.8a *FN Curves for Current and Future Population and their Comparison with the HK Societal Risk Guidelines*

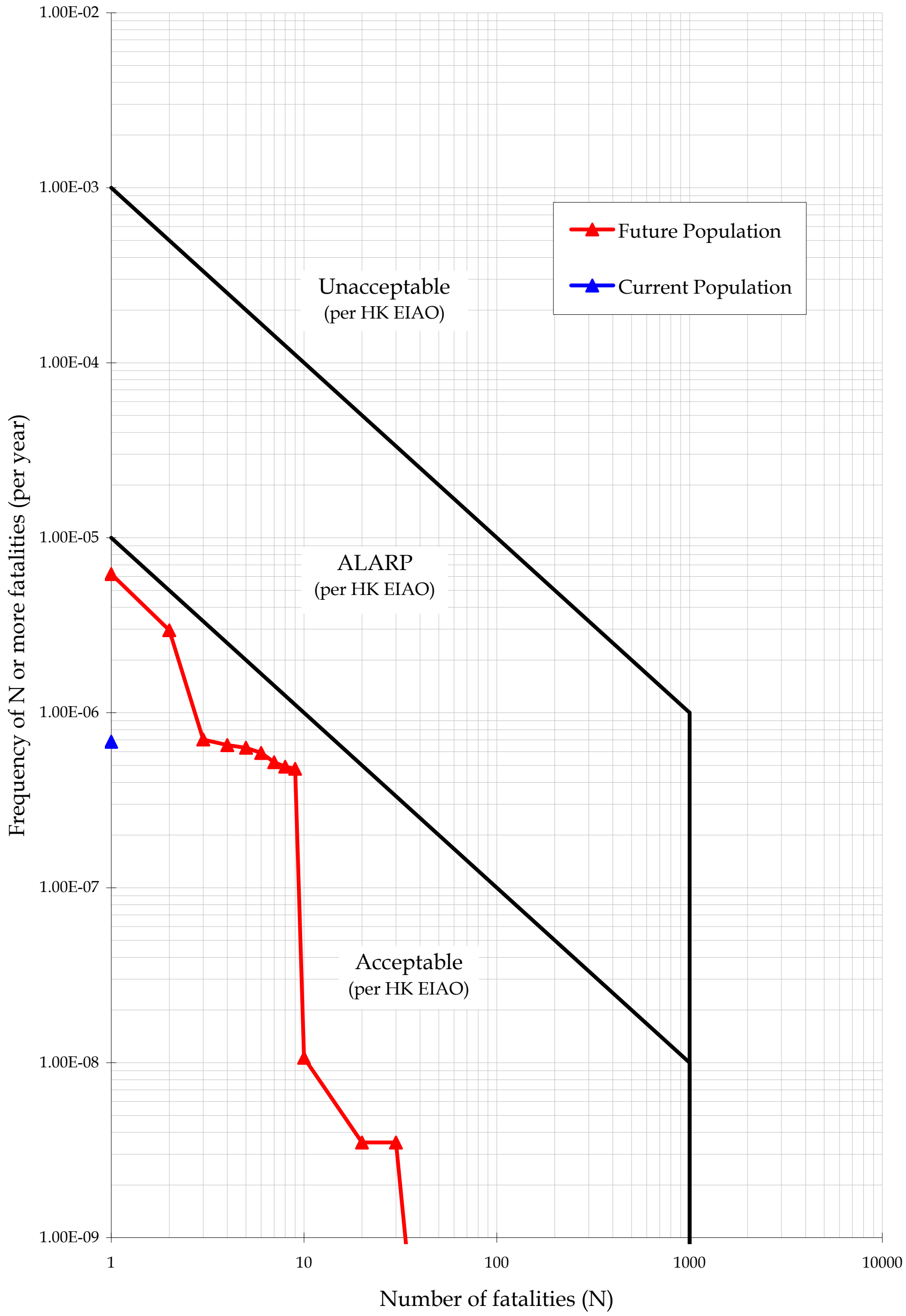
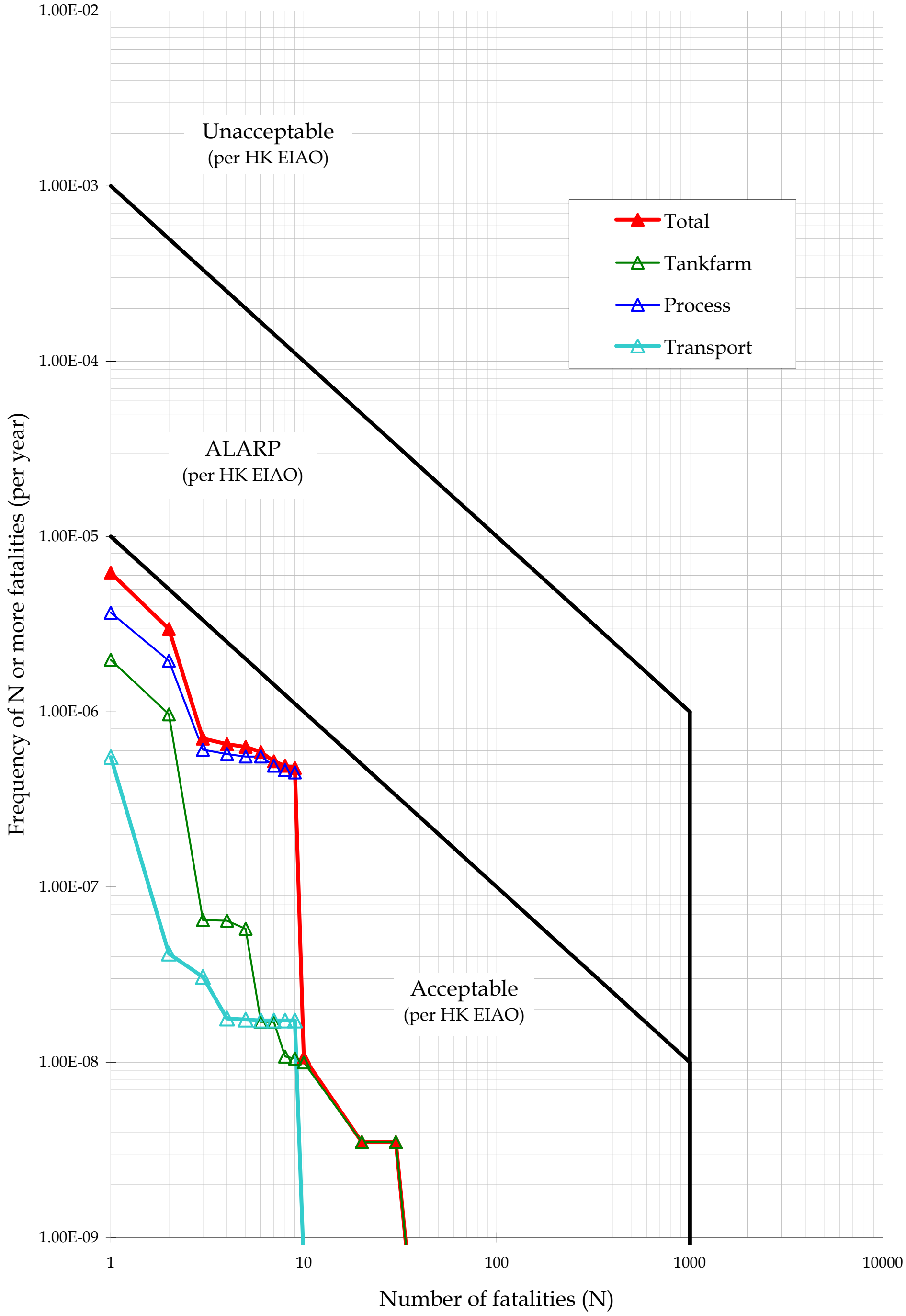


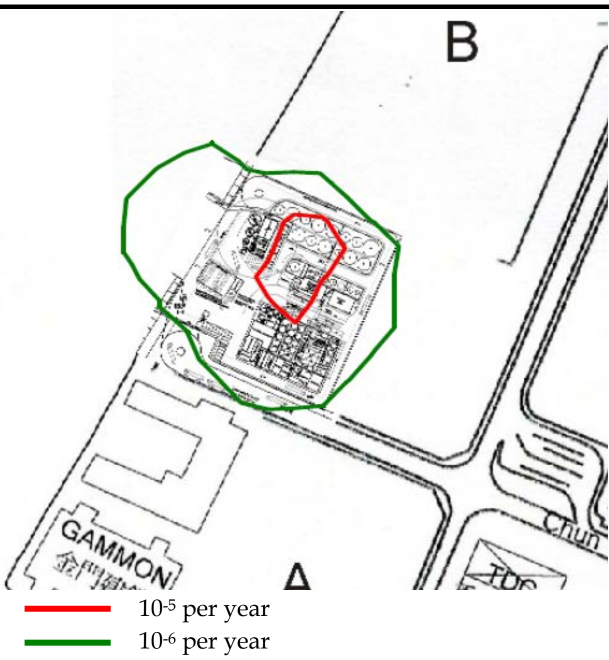
Figure 8.8b ***FN Curves of Future Population and their Comparison with the HK Societal Risk Guidelines (Breakdown by Operational Areas)***



Individual Risk

The individual risk contours for the biodiesel plant are shown in *Figure 8.8c.* These contours express the risk to a hypothetical individual present outdoors 100% of the time. As seen from the figure, the 10^{-5} per year contour does not extend beyond plant boundary. Individual risk from the plant is therefore considered acceptably low and complies with the Hong Kong individual risk guidelines which state that the individual risk off-site should not exceed 10^{-5} per year.

Figure 8.8c *Individual Risk Contours for Biodiesel Plant*



Cumulative Risk

The risks presented in *Figure 8.8c* represent the risks due to the biodiesel facility. The neighbouring Hong Kong Oxygen facility, some 400m away, also contains hazardous equipment and storage of compressed gases that may add to the risks from the biodiesel facility. Although no details of the Hong Kong Oxygen facility are available, it is expected that the main risks will originate from the storage of a large number of compressed gas cylinders. Consequence distances associated with such equipment have a very limited range because the inventory within each cylinder is small. Hence it may be expected that the risks will decrease rapidly with distance from the facility. The risk levels at the biodiesel facility, being 400m away, will be negligible. The scenario of projectiles from the Hong Kong Oxygen facility was addressed in this QRA and found to present insignificant incremental risks to the biodiesel facility.

Similarly, as seen from *Figure 8.8c*, the risk of hazards from the proposed biodiesel plant impacting on the Hong Kong Oxygen facility is insignificant. The risks decrease quickly offsite.

8.9 *MITIGATION MEASURES ASSUMED IN THE BASE CASE*

The following assumptions have been made in the base case analysis and hence these will require taking forward during the design and operations and need confirming:

- The process plant building will be provided with adequate number of gas detectors distributed over the various areas of potential leak sources to provide adequate coverage. A coverage factor of 90% for 1 out of *N* detectors for alarm to be ensured (i.e. the system will be designed so that at least one detector (out of the *N* detectors provided) triggers in 90% of occasions when a high concentration of flammables is present).

- Additional leak detection systems based on process parameters will be considered such as low pressure or others as applicable.

- Upon gas detection, the process system will be isolated. All pumps, motors will be stopped. Also, emergency shutdown valves will be provided at the liquid outlet connections of major equipments holding significant inventory of methanol (>5m3). Emergency shutdown system to meet a performance target of 90% for the reliability of the overall shutdown system

- Emergency ventilation system will be provided in accordance with relevant design codes for adequate ventilation of process areas inside buildings, to ensure that the ventilation rate is sufficient to bring down the concentration to 50% of lower explosive limit (LEL). Also, the ventilation system will be designed to avoid any stagnant pockets. Relevant codes include IP 15 : Area Classification Code for Installations Handling Flammable Liquids, IEC 60079, Part 10 :2002 Electrical Apparatus for Explosive Gas Atmospheres and NFPA 30 : The Flammable and Combustible Liquids Code. A performance target of 90% for the reliability of the ventilation system is to be achieved

- All electrical equipment inside the building will be classified in accordance with the electrical area classification requirements. No unclassified electrical equipment will be used during operations or maintenance.

- Reference will also be made to codes of practice and guidance issued in Europe that apply to places where explosive atmospheres may occur (called 'ATEX' requirements). These are covered as part of the European Directive: the Explosive Atmospheres Directive (99/92/EC) and the UK regulations, **Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)**. Where potentially explosive atmospheres may occur in the workplace, the requirements include, identifying and classifying (zoning) areas where potentially explosive atmospheres may occur; avoiding ignition sources in zoned areas, in particular those from electrical and mechanical equipment; where necessary, identifying the entrances to zoned areas; providing appropriate anti-static clothing for employees; and before they come into operation, verifying the overall explosion protection safety of areas where explosive atmospheres may occur. The code of practice and guidance cover among others Control and mitigation measures, Safe maintenance, repair and cleaning procedures.

- If there are any openings from the building, the near vicinity outside of such openings should also be meet with the area classification requirements as per the relevant code example IP 15.

- Gas detection in methanol storage area and emergency shutdown system on liquid inlet and outlet piping of methanol storage tank including automatic shutdown on high level will be provided.

- Online oxygen analysers will be provided in the closed vent system of process equipment located inside the process building to detect any air ingress into equipment due to a maintenance activity or during normal operation, for example due to nitrogen blanketing failure. Appropriate control and shutdown actions on high oxygen alarms will be designed as required. Also, portable gas analyzers will be used to test the internal atmosphere of process equipment after completion of maintenance.

- A preliminary process hazard analysis has been carried out as part of the basic design. Also, as part of this QRA study, a detailed hazard identification has been carried out. Further review of design safety measures will be performed as the design process continues, using a structured hazard identification process such as Hazard and Operability Study.

- The reliability requirements for process safety interlock systems will be determined following a structured process such as Safety Integrity Level determination and verification studies as per IEC 60508 and 60511.

- Safety Management Systems and Procedures will be developed to cover all aspects of operations and maintenance including safe handling of chemicals, safe operating and maintenance practices, operator training, employment of suitably qualified personnel with relevant process industry experience, period audit and review of the safety management systems and procedures etc. The systems and procedures will be in line with the best practices in the process industry and also reflect the high standards adopted in Hong Kong by companies operating in the LPG, flammable liquid and gas industry.

- In the event of any maintenance activity inside a building, procedures will be developed to ensure that flammable concentration build-up does not occur due to draining, opening of vessel or piping etc. The start-up and maintenance operations will be supervised and checked independently of the person undertaking such tasks, to provide a greater oversight.

- Also, the reliability of the nitrogen blanketing system will be ensured to minimise failures in the blanketing system leading to potential vapour releases from enclosed equipment inside the building. All vents from the process equipments inside the building will be routed to a safe location outside the building.

- Detailed emergency response plans will be developed to handle any impacts onsite and offsite due to any incident at the facility during loading/ unloading operations, transfer operations, storage tank farm operations and processing operations.

8.10 *FURTHER MITIGATION MEASURES*

Since both the individual and societal risks posed by the biodiesel plant to off-site population meet the criteria of Hong Kong Risk Guidelines, no further mitigation measures are required. Nevertheless, further voluntary risk reduction measures may be considered during the detailed design. As an example, consider:

- To minimise the spill vaporisation from a liquid pool, by a spill containment system which may be designed such that spills can be diverted and collected outside of the process building

8.11 *CONCLUSIONS*

The potential risks from the proposed biodiesel plant were assessed using a standard risk assessment methodology. The results show that both the societal and individual risks evaluated for the plant meet the acceptable criteria of the *Hong Kong Risk Guidelines*.

9 ENVIRONMENTAL MONITORING AND AUDIT

9.1 INTRODUCTION

This *Section* elaborates the EM&A requirements for the construction and operation of the Biodiesel Plant, based on the assessment results for the various environmental issues considered.

The objectives of undertaking EM&A for the Project are as follows:

- to provide a database against which the environmental impacts of the Project can be determined;
- to provide an early indication should any of the environmental control measures or practices fail to achieve the acceptable standards;
- to monitor the performance of the Project and the effectiveness of mitigation measures;
- to verify the environmental impacts predicted in this EIA;
- to determine project compliance with regulatory requirements, standards and government policies;
- to take remedial action if unexpected problems or unacceptable impacts arise; and
- to provide data to enable an environmental audit.

With respect to the findings and recommendations of the EIA study, the following sections describe the EM&A requirements during construction and operational phases of the Project. The Implementation Schedule, containing the recommended mitigation measures, monitoring and audit requirements, and implementation agent of the mitigation measures for the Project, is presented in *Annex D*.

9.2 AIR QUALITY

9.2.1 Construction Phase

As no adverse dust impact is anticipated, no dust monitoring (in terms of TSP) is required. However, monthly site audits will be conducted to ensure the implementation of suitable dust control measures and good site practices recommended in *Section 4.7.1*.

9.2.2 Operational Phase

Monitoring of the emissions of the boiler stack, biogas flare (if in operation) and process building, and odour concentrations at the final scrubber stack will be carried out. Odour patrols along the Project Site boundary will also be conducted. The purpose of the monitoring is to ensure the emissions from the boiler, biogas flare, process building and final scrubber are operated under its design conditions and emission limits.

Monitoring Parameter, Location and Frequency

The operating conditions (ie exhaust gas temperature and velocity) of the boiler, biogas flare (if in operation), and process building stacks will be monitored at monthly intervals for a period of 12 months after the commissioning of the biodiesel plant. If the monitoring results of the first year monitoring meet the limit level, the monitoring will be reduced to half-yearly intervals for the whole operational stage. For odour monitoring at the final air scrubber, the monitoring will be conducted for the first two operational years of the biodiesel plant. *Table 9.2a* summarizes the monitoring parameters, locations and frequency of the emissions from these stacks.

Table 9.2a Monitoring Parameters, Locations and Frequency of the Stacks [(a)]

Stacks	Monitoring Frequency	Parameters
Boiler	• Monthly for the first 12 months of operation. If the monitoring results of the first year monitoring meet the limit level, the monitoring will be reduced to half-yearly intervals for the whole operational stage	Laboratory analysis for: • NO_x • CO • NMOC • SO_2 During measurement: • Exhaust gas temperature • Exhaust gas velocity (m s^{-1})
Biogas Flare (if in operation)	• Monthly for the first 12 months of operation. If the monitoring results of the first year monitoring meet the limit level, the monitoring will be reduced to half-yearly intervals for the whole operational stage	Laboratory analysis for: • NO_x • CO • NMOC • SO_2 During measurement: • Exhaust gas temperature • Exhaust gas velocity (m s^{-1})
Process Building	• Monthly for the first 12 months of operation. If the monitoring results of the first year monitoring meet the limit level, the monitoring will be reduced to half-yearly intervals for the whole operational stage	Laboratory analysis for: • Acetyldehyde • Methanol During measurement: • Exhaust gas temperature • Exhaust gas velocity (m s^{-1})

Stacks	Monitoring Frequency	Parameters
Final Air Scrubber	• Monthly for the first 2 years of operation	Laboratory analysis for: • Odour concentration (OU s^{-1}) During measurement: • Exhaust gas temperature • Exhaust gas velocity (m s^{-1})
Note: (a) Monitoring will not be carried out during raining days.		

Monitoring Methodology

Table 9.2b summarises the monitoring methodologies for NO_x, CO, NMOCs, SO_2, acetyldehyde, methanol and odour. Monitoring will be carried out according to the requirements set out in the relevant USEPA methods or equivalent methods.

Table 9.2b Monitoring Methodology

Stacks	Parameter	Recommended Method [(a)]
Boiler	• NO_x	• USEPA Method 7
	• CO	• USEPA Method 10B
	• SO_2	• USEPA Method 3
	• NMOCs	• USEPA Method TO-14
	• Exhaust gas temperature	• USEPA 40 CFR Part 60
	• Exhaust gas velocity / flow rate	• USEPA Method 2D
Biogas Flare (if in operation)	• NO_x	• USEPA Method 7
	• CO	• USEPA Method 10B
	• SO_2	• USEPA Method 3
	• NMOCs	• USEPA Method TO-14
	• Exhaust gas temperature	• USEPA 40 CFR Part 60
	• Exhaust gas velocity / flow rate	• USEPA Method 2D
Process Building	• Acetyldehyde	• USEPA Method TO-14
	• Methanol	• USEPA Method TO-14
	• Exhaust gas temperature	• USEPA 40 CFR Part 60
	• Exhaust gas velocity / flow rate	• USEPA Method 2D
Final Scrubber	• Odour • Exhaust gas temperature • Exhaust gas velocity / flow rate	Air sampling • Grab sampling by using Teflon bag Laboratory analysis • Forced-choice Dynamic Olfactometer according to Eurpean Standard Method (EN13725)
Note: (a) Reference to http://www.epa.gov/ttn/emc/promgate.html		

Performance Compliance

The limit levels for NO_x, CO, NMOC and SO_2 emissions from the boiler stack and biogas flare; acetaldehyde and methanol emissions from the stack of process building and odour concentration of the exhaust gas of final air scrubber presented in *Table 9.2c* will be met. The exhaust gas temperature and velocity will comply with the design parameters of the stacks. In case of non-compliance with the limit levels, more frequent monitoring and actions in accordance with the Event and Action Plan will be implemented.

Table 9.2c Limit Levels for Various Parameters of the Stacks

Stack	Parameters	Limit Level
Boiler	NO_x	0.66 g s^{-1} (based on volume of oil consumed)
	CO	0.17 g s^{-1} (based on volume of oil consumed)
	SO_2	0.24 g s^{-1} (based on volume of oil consumed)
	NMOC	1.13 x 10^{-2} g s^{-1} (if biogas is burnt) at 0^oC, 1 atm
	Exhaust gas pressure	1 atm
	Exhaust gas temperature	100°C (minimum)
	Exhaust gas velocity	7 m s^{-1} (minimum)
Biogas Flare (if in operation)	NO_x	0.015 g s^{-1}
	CO	0.005 g s^{-1}
	SO_2	1.07x10^{-3} g s^{-1}
	NMOC	4.9x10^{-4} g s^{-1}
	Exhaust gas pressure	1 atm
	Exhaust gas temperature	815°C (minimum)
	Exhaust gas velocity	0.54 m s^{-1} (minimum)
Process Building	Acetyldehyde	0.028 g s^{-1}
	Methanol	0.028 g s^{-1}
	Exhaust gas temperature	35°C (minimum)
	Exhaust gas velocity	0.79 m s^{-1} (minimum)
Final Scrubber	Odour	200.3 OU s^{-1}
	Exhaust gas temperature	ambient
	Exhaust gas velocity	0.7 m s^{-1} (minimum)

Odour Patrol

Odour patrol will be carried out along the Project Site boundary on monthly basis during the first year of the operation of the biodiesel plant. If there is no exceedance of action limit or there is no substantiated odour compliant during the first year of operation, the monitoring frequency will be reduced to quarterly intervals in the second year of the operation. During the second year of operation, if the action level is triggered, the frequency will be resumed to monthly until compliance with the action level for three consecutive months is obtained and the frequency will be reduced to quarterly interval thereafter. If the action level is not triggered for four consecutive quarterly monitoring, the monitoring can be terminated.

The patrol will be conducted a trained personnel/competent person who should have a specific sensitivity to a reference odour (i.e. on reference materials n-butanol with the concentration of 50ppm in nitrogen (v/v)).

The parameter, location and frequency of odour patrol are summarized in *Table 9.2d*.

Table 9.2d Parameter, Location and Frequency for Odour Patrol

Patrol Location	Patrol Frequency	Parameters
Patrol along Biodiesel Plant Site Boundary	Two times a day, one in the morning and one in the afternoon	Odour Intensity (see *Table 9.2e*)

The odour intensity detected during the patrol will be categorised as in *Table 9.2e.*

Table 9.2e Odour Intensity Level

Class	Odour Intensity	Description
0	Not Detected	No odour perceived or an odour so weak that it cannot be easily characterised or described
1	Slight	Identified odour, slight
2	Moderate	Identified odour, moderate
3	Strong	Identified odour, strong
4	Extreme	Severe odour

Odour patrol will be conducted by a trained personnel/competent person patrolling and sniffing along the Project Site boundary to detect any odour. The trained personnel/competent person shall:

- Have their individual odour threshold of n-butanol in nitrogen gas in the range of 20 to 80 ppb/v required by the Europoean Standard Method (EN 13725);
- Be free from any respiratory diseases;
- Not be allowed to smoke, eat, drink (except water) or use chewing gum or sweets 30 minutes before and during the odour patrol; and
- Take great care not to cause any interference with their own perception or that of others by lack of personal hygiene or the use of perfumes, deodorants, body lotions or cosmetics.

The trained personnel/competent person shall use their noise (olfactory sensors) to sniff odours along the patrol route. The main odour emission sources and the areas to be affected by the odour nuisance shall be identified.

Table 9.2f shows the action and limit levels to be used for odour patrol. When the action and limit levels are triggered, investigation will be carried out to identify the cause of exceedance and actions in accordance with the *Event and Action Plan* will be taken.

Table 9.2f *Action and Limit Levels for Odour*

Parameter	Action Level	Limit Level
Perceived odour intensity and odour complaint	• Odour intensity ≥ Class 2 received; or • One substantiated complaint received	• Odour intensity ≥ Class 3 recorded on 2 consecutive patrols [(a) (b)]

Notes:
(a) Either Class 3-strong or Class 4-extreme odour intensity.
(b) The exceedances of the odour intensity do not need to be recorded at the same location.

Event and Action Plan

The Project Proponent and the Contractor will take the actions in accordance with the Event and Action Plan in *Table 9.2g* when the action or limit levels are exceeded.

Table 9.2g *Event and Action Plan for Air Quality Monitoring During Operational Phase*

Event	Action
Exceedance of Limit Level of stack emission	• Repeat measurement to confirm findings • Identify source(s) and investigate the cause(s) of exceedance • Rectify any unacceptable performance • Propose and implement remedial measures or amend design as required
Exceedance of Action Level for odour	• Identify source/reason of exceedance or complaint • Rectify any unacceptable practice • Amend working methods as required • Implement amended working methods, if necessary
Exceedance of Limit Level for Odour	• Identify source/reason of exceedance or complaint • Rectify any unacceptable practice • Propose and implement remedial measures or amend design as required

9.3 NOISE

9.3.1 Construction Phase

The EIA study predicted that the noise levels at the identified representative NSRs due to the construction activities of the Project were well below the respective noise criteria and no NSRs would be adversely affected by the construction noise, given a large separation distance (more than 700m) between the NSRs and the Project Site. Noise monitoring during construction phase is considered not necessary. However, monthly site inspections will be carried out during construction to audit the compliance of the Contractor with regard to noise control and to recommend further mitigation measures if found to be necessary.

9.3.2 *Operational Phase*

No adverse noise impacts were predicted at the identified representative NSRs during the operational phase and hence no operational phase monitoring is required.

9.4 *WATER QUALITY*

9.4.1 *Construction Phase*

The impact assessment (see *Section 6.5*) has evaluated that there would be no adverse water quality impacts arising from the construction activities on the Water Sensitive Receivers (WSRs) within the Study Area. As a result, it is considered that environmental monitoring of water quality is not required. Nevertheless, monthly site inspections will be undertaken to ensure that the recommended mitigation measures are properly implemented during construction. The site audit frequency will be increased to weekly intervals during the piling works.

9.4.2 *Operational Phase*

The impact assessment (see *Section 6.6*) indicates that adverse water quality impacts on the WSRs within the Study Area are not expected from the operational activities. However, to ensure that the stormwater or effluent discharged from the Project Site will comply with the discharge standards, the quality of the stormwater/effluent will be monitored at the terminal manholes of the stormwater and foul water drainage systems on a monthly basis. Parameters to be monitored will include:

- Stormwater discharge from the site: Oil and grease and suspended solids;
- Treated effluent from the WWTP: Parameters listed in Table 1 of the Technical Memorandum on Standards for Effluents Discharged to Drainage and Sewerage Systems, Inland and Coastal Water or those specified in the *WPCO* licence.

If the monitoring results indicate exceedance of relevant effluent standards (stormwater or treated effluent) to be agreed with the Authority, the actions stipulated in *Table 9.4a* should be taken.

Table 9.4a ***Event and Action Plan for Water Quality Monitoring During Operational Phase***

Event	**Action**
Exceedance of relevant effluent standards (stormwater or treated effluent)	• Repeat measurement to confirm findings • Identify source(s) and investigate the cause(s) of exceedance • Rectify any unacceptable performance • Propose and implement remedial measures or amend design as required

9.5 MARINE ECOLOGY

9.5.1 Construction Phase

No dredging of marine sediment will be required for the marine works. Potential impacts to marine ecological resources arising from the construction works will be associated mainly with the construction of the jetty by piling. The jetty will be constructed in the form of a piled deck. Bore piles will be driven through the existing rubble mound seawall. There will be a direct loss of a small stretch of low ecological value intertidal and subtidal hard-substrata habitats associated with the artificial seawall. However, the pile surfaces can serve as artificial habitats for settlement and re-colonisation of marine assemblages. Residual impacts are expected to be low.

Other potential impacts to marine ecological resources, which may be caused by changes in water quality and hydrodynamic regime, and accidental spillage of raw materials and biodiesel during the construction and operation of the biodiesel plant, will be negligible and minimal with the implementation of the recommended mitigation measures and good site practices.

No environmental monitoring is thus considered necessary during the construction and operation phases of the Project. Monthly site inspections will be carried out during construction phase.

9.6 RISK MANAGEMENT

It is recommended that the mitigation measures recommended in *Section 8.9* should be audited during the detailed design stage and before the operation of the plant to ensure that:

- they have been properly incorporated into the design of the plant;
- control and management measures are clearly described in the detailed Emergency Response Plan; and
- be properly installed and implemented.

10 CONCLUSIONS AND SUMMARY OF ENVIRONMENTAL OUTCOMES

10.1 INTRODUCTION

This *Section* summarises the environmental outcomes associated with the construction and operation of the proposed biodiesel plant at TKOIE.

10.2 AIR QUALITY

10.2.1 Construction Phase

The Project Site has been formed and is currently vacant. No major earthworks will be required for the site formation works and only minor excavation works will be required for the construction of the foundation works and site utilities. The storage tanks and process equipment will be pre-fabricated off-site and assembled on site using hydraulic and tower cranes and hence minimal dust will be generated from this activity. Dust generated from the minor excavation works and concreting works for the construction of site buildings will be minimal.

The jetty will be constructed in form of a piled deck and no dredging of marine sediment will be required. Marine piles will be drilled through the existing rubble mound seawall to the competent bearing strata by a piling rig placed on a temporary steel platform. Concrete infill to piles will be undertaken prior to placement of trellis beam and pre-cast concrete panels. The dust and air emissions generated from the marine works will be minimal.

With the implementation of dust suppression measures stipulated under the *Air Pollution Control (Construction Dust) Regulation* and the adoption of good site practices, no adverse construction dust impact is anticipated. Dust monitoring during the construction phase is therefore considered not necessary.

Monthly site audits will be undertaken to ensure the implementation of recommended dust control measures and good site practices during construction phase.

10.2.2 Operational Phase

The stacks of the boiler and biogas flare (if in operation), and the exhaust of the Process Building are the major emission sources associated with the operation of the biodiesel plant. Nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), non-methane organic compounds (NMOC) are the principal emission of concerns of the boiler and biogas flare stacks, and methanol and acetyldehyde (as one of the impurities of methanol) are the principal emissions of concerns for the exhaust of the Process Building. The assessment indicates that the operation of the proposed biodiesel plant together with the existing air emission sources in the TKOIE, will not cause adverse air quality impacts at the identified Air Sensitive Receivers (ASRs). The predicted concentrations of pollutants are well below the respective criteria.

The potential odour impact due to the discharge of exhaust air from the final air scrubber of the on-site wastewater treatment plant has been evaluated. After scrubbing, the odour concentration will be significantly reduced. The predicted odour concentrations at the identified ASR are well below the odour criterion. The operation of the biodiesel plant will not cause adverse odour impacts to the identified ASRs.

The concentrations of NO_x, CO, SO_2 and NMOC in the flue gas of the stacks of the boiler and biogas flare (if in operation) and the concentrations of methanol and acetyldehyde from the exhaust pipe of process building will be monitored for during the operation of the biodiesel plant.

Odour concentration at the stack of the final air scrubber will be monitored for the first two years of operation of the biodiesel plant and odour patrols along the Project Site boundary will also be carried out to confirm that the operation of biodiesel plant will not cause adverse odour impacts.

With the implementation of proper design, the recommended mitigation measures and monitoring programme, it is concluded that the construction and operation of the biodiesel plant will not cause adverse air quality impacts and will comply with the *EIAO-TM* requirements.

10.3 NOISE

10.3.1 Construction Phase

The predicted construction noise levels at the identified NSRs range from 48 dB(A) to 64 dB(A) and 48 to 55dB(A) for residential premises and an educational institution, respectively. These levels are well below the noise criteria of 75 and 70 dB(A) for domestic premises and educational institutions, respectively. Therefore, the identified NSRs within the Study Area will not be adversely affected by the construction of the Project. Good construction site practices (see *Section 5.7*) will be implemented by the Contractor to further minimise the noise impact.

Noise monitoring during construction phase is considered not necessary. However, monthly site inspections will be carried out to audit the compliance of the Contractor with regard to noise control and to recommend further mitigation measures if found to be necessary.

10.3.2 Operational Phase

The operational noise impact assessment was undertaken based on a set of conservative assumptions. To minimise potential noise impact to NSRs, all noisy equipment in the fat preparation plant, wastewater treatment plant, steam boiler room and process building will be located within completely enclosed buildings or complete noise enclosures. Due to the large separation distances between the identified NSRs and the noise sources at the biodiesel plant, the predicted noise levels at the NSRs due to the operation of the biodiesel plant range from 40to 49 dB(A) and 36 to 45 dB(A) during the day-time and night-time periods, respectively. These noise levels comply with the corresponding day-time and night-time noise criteria of 60 and 50 dB(A).

In view of the predicted insignificant noise impact during the operational phase, noise monitoring work is considered to be not necessary.

10.4 WATER QUALITY

10.4.1 Construction Phase

The construction works for the Project will mainly be land-based. With respect to the nature and relatively small scale of the land based construction activities, the potential water quality impacts are considered minimal with the implementation of the good practices outlined in *ProPECC PN 1/94* "*Construction Site Drainage*".

The proposed jetty (50m long and 26m wide) will be in a form of a reinforced concrete deck supported by the marine piles. No dredging or reclamation works will be required. A total of about 60 piles (approximate diameter of 1 m each) will be constructed. Bore piles will be driven through the existing rubble mound seawall. The water quality impacts due to the piling activities will be minimal and no adverse water quality impact is anticipated.

The cross-sectional area of each pile underwater has been estimated to be $0.8m^2$. It is estimated that the volume of each pile underwater will range from $0.8\ m^3$ to $9.6m^3$. 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. It is not expected that the piles will result in any adverse impact to the water flow regime at the jetty during the operational phase.

As no adverse water quality impact is anticipated, no water quality monitoring is considered necessary during the construction phase.

10.4.2 Operational Phase

A surface water drainage system will be provided to collect stormwater runoff from the Project Site. Clean stormwater runoff will be segregated from potential contaminated areas. The stormwater from the potential contaminated areas will be collected and diverted to the on-site wastewater treatment plant for treatment.

Wastewater from the biodiesel production process will be collected and treated prior to discharge to the foul sewer leading to the Tseung Kwan O Sewage Treatment Works.

Bund wall will be provided at the tank farm (including the storage tank of the raw materials/products) and the process tanks within the Process Building to contain any spillage of materials (the wall is designed to hold 110% of the largest tank) within the bunded area. The floor of the bunded area will also be paved with concrete and coated with waterproofing material. It will effective prevent any spill from seeping into the soil. The bunded area will be provided with a sump pit(s) with a manually controlled valve/penstock which is normally close. The sump pit will also be equipped with a level switch instrument to detect the water level. The sensor will be connected to an alarm of the PCS-system. Spill/leak within the bunded area will be cleaned up immediately. All surface water discharged from the bunded area will pass through an oil interceptor before discharge into the stormwater drainage system of the TKOIE. No surface water will be automatically drained from the bunded area.

All materials to be used and stored on site (except for the gas oil) are biodegradable and hence the potential for land contamination or environmental pollution due to the spillage during handling and transfer, and leakage of tanks will less severe. Nevertheless, the plant/equipment and tank farm are designed to comply with relevant local regulations and standards. Measures have been put in place to prevent spillage of materials during handling and transfer. For example, dry coupling will be used to connect two loading/unloading pipes or a flexible hose to a transfer pipe in order to avoid any leakage of the materials at the joint. The loading/unloading area will be bunded to contain any potential spillage of materials. In addition, 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 contained and the spill be absorbed by appropriate absorbents. The area will be properly washed and the wastewater will be conveyed to the on-site wastewater treatment plant for treatment. For accidental spills during the transportation of biodiesel off the site, retainer booms will be deployed around the barge and the contaminated areas to prevent the spillage spreading. An outline emergency response plan related to pollution prevention and management has been prepared which will form the basis of the detailed plan. A detailed plan which will detail emergency actions will be prepared during the detailed design stage.

Based on the above and with the provision of appropriate mitigation measures, no adverse water quality impacts are anticipated. Stormwater and effluent discharged from the site will be monitored to ensure the discharge will comply with the requirements of the *Water Pollution Control Ordinance* Licence.

10.5 MARINE ECOLOGY

10.5.1 Construction Phase

No dredging or reclamation works will be required. Permanent loss of a small stretch [(1)] of low ecological value marine habitat at the artificial seawall is expected due to the marine works for jetty construction. Pile surfaces can, however, serve as artificial habitats for the settlement and recolonisation of marine assemblages. Residual impacts are expected to be low.

(1) A total of approximately 48 m^2, which is about 3% of the total area of the jetty will be loss due to marine piling.

As no adverse water quality impact is expected due to construction activities, there will be no secondary impacts to ecology. It is considered that environmental monitoring is not required. Nevertheless, monthly site inspections will be undertaken to ensure that the recommended mitigation measures on water quality are properly implemented such that secondary adverse impacts on marine ecological resources can be avoided and minimised.

10.5.2 Operational Phase

As no adverse water quality and hydrodynamic impacts are expected due to the operation of the biodiesel plant, the potential impacts to marine ecological resources are expected to be minimal. No adverse impacts to marine ecology are expected.

No monitoring and audit will be required during the operational phase.

10.6 RISK ASSESSMENT

A quantitative risk assessment (QRA) has been conducted for the operational phase of the Project. The potential risks to the off-site population have been estimated based on the population levels (including the planned population at the vacant land adjacent to the biodiesel plant). The assessment shows that the principal hazards to the public are related to catastrophic failures of the biodiesel and methanol storage tanks. Potential explosion of methanol vapours in the process area that can result from a methanol leak also contributes to the overall risk levels. Other hazardous scenarios considered were found to pose lower risks to the off-site population.

The overall risk levels estimated for the operational phase of the Project are relatively low. Individual risk levels at the Project Site boundary are predicted to be well below the criterion of 1×10^{-5} per year (1). The societal risks expressed in the form of a FN curve lie within the "acceptable" region of Hong Kong Risk Guidelines. Therefore the Hazard to Life criteria stipulated in Annex 4 of *EIAO-TM* are met.

It is recommended that the mitigation measures recommended in *Section 8.9* should be audited during the detailed design stage and before the operation of the plant to ensure that:

- they have been properly incorporated into the design of the plant;
- control and management measures are clearly described in the detailed Emergency Response Plan; and
- be properly installed and implemented.

(1) As seen from the *Figure 8.2b*, the 1.0×10^{-5} per year individual risk contour does not extend beyond site boundary. Individual risk from the biodiesel plant is therefore considered acceptably low.

10.7 *ENVIRONMENTAL OUTCOMES*

The environmental impact assessment (covering air quality, noise, water quality, marine ecology and hazard to life) has concluded that no unacceptable environmental impacts are envisaged due to the construction and operation of the Project. No long-term unacceptable impact on the environment is anticipated.

10.8 *ENVIRONMENTAL BENEFITS*

The proposed biodiesel plant will use multi-feedstock which consists of waste cooking oil (WCO), oil and grease recovered from grease trap waste (GTW), PFAD (a distillate from palm oil) and animal fats. It not only offers a convenient recycling outlet for GTW and WCO but also converts the oil and grease recovered from these wastes into useful products. The Project also offers a cleaner alternative to diesel fuel to the Hong Kong market.

Annex A

Air Quality Supporting Information

Annex A1

Emission Estimation

Annex A1 Air Emission Rate Calculation

Air emissions (Criteria pollutants)

Parameter		Unit	Boiler stack (Oil Mixture) Mixture of gas oil (80%) and bioheating oil (20%)	Boiler stack biogas	
Steam + thermal oil (power required)		kW	9200	-	(given by BDI-Biodiesel)
Calorific value of bioheating oil		MJ/kg	37		(given by BDI-Biodiesel)
Total calorific value of bioheating oil		MJ/hr	33146		(37 MJ/kg x 895.8 kg/hr)
Density of biodiesel/bioheating oil		kg/m3	900		
Biodiesel/bioheating oil required		tonnes/day	21.5	-	(given by BDI-Biodiesel)
		kg/hr	895.8		(Maximum hourly flow rate)
		m3/hr	0.995		(895.8 kg/hr / 900 kg/m3)
Calorific value of biogas		MJ/m3		36	(given by BDI-Biodiesel)
Biogas consumption (eqivalent to biodiesel consumption)		m3/hr		920.7	(33,146 MJ/hr / 36 MJ/m3)
Average biogas production		m3/hr		80.0	
Operating hour		hr	24		
No. of emission points		-	1		
Stack height		m above gd	31		
Stack diameter		m	0.75		
Exhaust temp.		K	373		
Exhaust velocity		m/s	7		
Exhaust flowrate		m3/hr	11133.0		
Emission factor	NOx	mg/m3	2.40E+06	150	(Oil Mixture: @ exhaust temp, based on volume oil consumed; biogas : @0°C, 1atm, ref: Guidance for Monitoring Enclosed Landfill Gas Flares)
	CO	mg/m3	6.00E+05	50	(Oil Mixture: @ exhaust temp, based on volume oil consumed; biogas : @0°C, 1atm, ref: Guidance for Monitoring Enclosed Landfill Gas Flares)
	SO2	mg/m3	8.64E+05	2.13	(Oil Mixture: @ exhaust temp, based on volume oil consumed, ref to APC (Fuel Restriction) Rg; biogas : @ exhaust temp & see below calculation)
	H2S in biogas	ppm	-	10	(at 30°C, given by client)
	NMOCs	mg/m3	-	5	(@0°C, 1atm, ref: Guidance for Monitoring Enclosed Landfill Gas Flares)
Emission factor at exhaust temp (373K)	NOx	mg/m3	same as above	109.8	
	CO	mg/m3	same as above	36.6	
	SO2	mg/m3	same as above	2.13	(biogas : see below calculation)
	H2S in biogas	ppm	-	10	(at 30°C, given by client)
	NMOCs	mg/m3	-	3.7	
Emission rate	NOx	g/s	0.66	0.34	
	NO2	g/s	0.13	0.07	
	CO	g/s	0.17	0.11	
	SO2	g/s	0.24	0.01	
	NMOCs	g/s	-	0.01	

- (yellow) assumed by ERM (reference to EPD's modelling guidelines)
- (green) assumed to be similar to diesel and reference to USEPA AP-42.
- (orange) assumed to be similar to landfill gas & reference to UK Guidance on the Management of Landfill Gas
- (pink) reference to Air Pollution Control (Fuel Restriction) Regulation (Amendment 2008)
- (blue) emission rate calculated based on the volume of oil mixture consumed
- (purple) emission rate calculated based on the exhaust flow rate and emission factor at 373K

Parameter		Unit	biogas flare	
Designed flare capacity		m3/hr	150	
Operating hour		hr	24	
No. of emission points		-	1	
Stack height		m above gd	12.5	
Stack diameter		m	0.96	
Exhaust temp.		K	1,088	
Exhaust velocity		m/s	0.54	
Exhaust flowrate		m3/hr	1407.1	
Emission factor	NOx	mg/m3	150	(@0°C, 1atm, ref: Guidance for Monitoring Enclosed Landfill Gas Flares)
	CO	mg/m3	50	(@0°C, 1atm, ref: Guidance for Monitoring Enclosed Landfill Gas Flares)
	NMOCs	mg/m3	5	(@0°C, 1atm, ref: Guidance for Monitoring Enclosed Landfill Gas Flares)
	H2S	ppm	10	(at 30°C, given by client)
Emission factor at exhaust temp (1088K)	NOx	mg/m3	37.6	(150 mg/m3 x (273) / 1088)
	CO	mg/m3	12.5	(50 mg/m3 x (273) / 1088)
	NMOCs	mg/m3	1.3	(5 mg/m3 x (273) / 1088)
	H2S	ppm	10	(at 30°C, given by client)
Emission rate	NOx	g/s	0.015	
	NO2	g/s	0.003	
	CO	g/s	0.005	
	NMOCs	g/s	4.90E-04	
	SO2	g/s	1.07E-03	

- (grey) emission rate calculated based on the exhaust flow rate and emission factor at 1088K
- (amber) emission rate calculated based on the volume of biogas consumed

Calculation of SO2 emission rate from H2S emission

Parameter	Unit	biogas flare	
H2S concentration (in ppm) in biogas	ppm	10	(at 30oC, provided by Client)
Molecular weight of H2S	-	34	
Flowrate of biogas	m3/hr	150	(max flare capacity)
Conc of H2S (in g/m3) in raw biogas @ 30oC	g/m3	0.01	(ppm x MW / (22.414x(273+30)/(273)) / 1000)
Mass of H2S	g/s	5.69E-04	(conc of H2S (in g/m3) x biogas flowrate)
Mole ratio of H2S / SO2	-	1:1	(2H2S + 3O2 ---> 2SO2 + 2H2O)
Molecular weight of SO2	-	64	
Mass of SO2	g/s	1.07E-03	(mass of H2S x (64 / 34)}
Exhaust flowrate at 1088°K	m3/hr	1407	
Emission concentration of SO2 at exhaust (1088°K)	mg/m3	2.74	(mass of SO2 / exhaust flowrate)

Parameter	Unit	boiler	
H2S concentration (in ppm) in biogas	ppm	10	(provided by Client)
Molecular weight of H2S		34	
Flowrate of biogas	m3/hr	920.7	(Equivalent biogas consumption rate)
Conc of H2S (in g/m3) in raw biogas @ 30oC	g/m3	0.01	(ppm x MW / (22.414x(273+30)/(273)) / 1000)
Mass of H2S	g/s	3.50E-03	(conc of H2S (in g/m3) x biogas flowrate)
Mole ratio of H2S / SO2	-	1:1	(2H2S + 3O2 ---> 2SO2 + 2H2O)
Molecular weight of SO2	-	64	
Mass of SO2	g/s	6.58E-03	(mass of H2S x (64 / 34)}
Exhaust flowrate at 373oK	m3/hr	11133	
Emission concentration of SO2 at exhaust (373oK)	mg/m3	2.13	(mass of SO2 / exhaust flowrate)

Other organics

Source	air pollutant	URF (ug/m3)-1	chronic Rfc ug/m3	Acute Rfa ug/m3	
derivatives of glycerine like	dimethyl ether	-	-	-	
ester & acid	methyl butyrate	-	-	-	
impurities of methanol	acetone	-	-	-	
	methanol	-	4000	2.80E+04	(RC_c & RC_A : CARB/OEHHA)
	acetaldehyde	2.70E-06	9	-	(URF & RC_c: CARB/OEHHA)

Parameter	Unit	Exhaust from Process E.01a	
Exhaust gas flow	m3/hr	50	
Exhaust gas velocity	m/s	0.79	
Exhaust gas temp	oC	35	normal
		45	max.
	oK	308	normal
		318	max.
Methanol	mg/m3	2000	max. @ exhaust temp.
Stack height	m above gd	22.8	
Stack diameter	m	0.15	
No. of emission points	-	1	
Emission rate of methanol / acetyldehyde (impurities of mathanol)	g/s	0.028	(Since the quantity of acetaldehyde emitted is not known, it is assumed that the emission of acetaldehyde is similar to that of methanol)

Calculation of SO2 emission rate for Vacant Sites in TKOIE

Parameter	Unit	biogas flare	
SO2 Emission Factor	g/L	0.864	(upper limit of SO2 emission factor in Air Pollution Control (Fuel Restriction) Regulation Amendment 2008 by EPD)
Total Diesel Oil Consumption Rate	m3/day	52.6	(excluding 4m3/day by HESAL)
Number of Emission Sources	-	21	(listed in approved EIA report of Fill Bank at Tseung Kwan O Area 137)
Operation Hours	hrs	10.00	(assumed in approved EIA report of Fill Bank at Tseung Kwan O Area 137)
SO2 Emission Rate	g/s	0.06	

Calculation of CO emission rate for Vacant Sites in TKOIE

Parameter	Unit	biogas flare	
CO Emission Factor	kg/m3	0.6	(USEPA Compilation of Air Pollutants Emission Factors, 5th Edition (AP42))
Total Diesel Oil Consumption Rate	m3/day	52.6	(excluding 4m3/day by HESAL)
Number of Emission Sources	-	21	(listed in approved EIA report of Fill Bank at Tseung Kwan O Area 137)
Operation Hours	hrs	10.00	(assumed in approved EIA report of Fill Bank at Tseung Kwan O Area 137)
CO Emission Rate	g/s	0.042	

Annex A2

Emission Testing Results

EXECUTIVE SUMMARY PROVISIONAL RESULTS

01.06.2006

Release Point:	Biodiesel Stack 80% bio : 20 % Diesel		Ref. Conditions		273K, 101.3KPa, 3% O_2, dry gas	
Determinand	Run No.	Time	Accred. Yes/No	Concentration Measurement mg/m^3	Uncertainty %	Mass Emission Rate kg/hr
Carbon Dioxide	1	1414-1514	Yes	7.2%	4,7	-
Oxides of Nitrogen	1	1414-1514	Yes	247,3	4,1	0,85
Carbon Monoxide	1	1414-1514	Yes	10,2	4,7	0,03
Sulphur Dioxide	1	1414-1514	Yes	53,2	7,4	0,18

Release Point:	Biodiesel Stack 80% bio : 20 % Diesel		Ref. Conditions		Stack conditions	
Determinand	Run No.	Time	Accred. Yes/No	Concentration Measurement mg/m^3	Uncertainty %	Mass Emission Rate kg/hr
Carbon Dioxide	1	1414-1514	Yes	7.2%	4,7	-
Oxides of Nitrogen	1	1414-1514	Yes	69,4	4,1	0,83
Carbon Monoxide	1	1414-1514	Yes	1,9	4,7	0,02
Sulphur Dioxide	1	1414-1514	Yes	14,8	7,4	0,18

02.06.2006

Release Point:	Biodiesel Stack 100 % Diesel		Ref. Conditions		273K, 101.3KPa, 3% O_2, dry gas	
Determinand	Run No.	Time	Accred. Yes/No	Concentration Measurement mg/m^3	Uncertainty %	Mass Emission Rate kg/hr
Carbon Dioxide	2	0929-1029	Yes	10.0%	4,7	-
Oxides of Nitrogen	2	0929-1029	Yes	216,1	4,1	1,01
Carbon Monoxide	2	0929-1029	Yes	<2,0	4,7	<0,01
Sulphur Dioxide	2	0929-1029	Yes	192,6	7,4	0,90

Release Point:	Biodiesel Stack 100 % Diesel		Ref. Conditions		Stack conditions	
Determinand	Run No.	Time	Accred. Yes/No	Concentration Measurement mg/m^3	Uncertainty %	Mass Emission Rate kg/hr
Carbon Dioxide	2	0929-1029	Yes	10.0%	4,7	-
Oxides of Nitrogen	2	0929-1029	Yes	79,9	4,1	0,98
Carbon Monoxide	2	0929-1029	Yes	<2,0	4,7	<0,02
Sulphur Dioxide	2	0929-1029	Yes	73,9	7,4	0,91

Annex A3

Odour Emission Estimation

Annex A3 - Odour Emission Estimation

Odour emissions

Parameter	**Unit**	**Caustic Scrubber**	
Operating Hour	hr	24	
No. of stack	-	1	
Vent duct height	m above gd	13.8	
Vent duct diameter	m	1.2	(according to Vent Gas Treatment Paper)
exhaust air temp.	K	ambient	
exhaust air flowrate	m3/hr	2800	
exhaust air velocity	m/s	0.7	
Odour conc.	OU/m3	257.6	
Odour emission rate	OU/s	200.4	

Annex A4

Detailed Assessment Results

Annex A4 Detailed Assessment Results

Nitrogen Dioxide (NO2)

bg 63 ug/m3

Scenario 1 - Normal Condition (Biodiesel Plant (boiler) + HAECO + TKOIE emissions)

Table A4-1			Hourly (Biodiesel Plant - Boiler ONLY)													Hourly (HAECO + TKOIE Emission)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	6.0	6.6	8.5	16.8	31.0	-	-	-	-	-	-	-	-	3.8	3.8	3.9	6.9	17.8	-	-	-	-	-	-	-	-	18
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	3.1	3.8	6.0	16.1	34.0	-	-	-	-	-	-	-	-	3.1	3.1	3.2	3.5	7.0	-	-	-	-	-	-	-	-	7
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	3.5	3.6	4.6	8.8	14.2	-	-	-	-	-	-	-	-	3.5	3.5	3.7	6.5	11.0	-	-	-	-	-	-	-	-	11
A4	Hong Kong Aero Engine Services Ltd	30	3.6	3.6	3.9	4.8	6.2	-	-	-	-	-	-	-	-	3.2	3.3	3.4	12.5	21.1	-	-	-	-	-	-	-	-	21
A5	HAECO	30	4.0	4.0	4.1	4.2	5.3	-	-	-	-	-	-	-	-	4.0	4.0	4.1	4.5	8.2	-	-	-	-	-	-	-	-	8
A6-1	Asia Netcom HK Limited	30	4.6	4.7	4.7	5.1	11.0	-	-	-	-	-	-	-	-	3.4	3.5	3.6	6.6	17.3	-	-	-	-	-	-	-	-	17
A6-2	Asia Netcom HK Limited	30	4.4	4.4	4.6	5.3	12.4	-	-	-	-	-	-	-	-	3.5	3.6	4.1	146.9	126.4	-	-	-	-	-	-	-	-	147
A7	Mei Ah Centre	30	4.5	4.6	4.6	5.2	10.3	-	-	-	-	-	-	-	-	3.5	3.6	4.2	25.3	32.7	-	-	-	-	-	-	-	-	33
A8	Wellcome Co. Ltd (Storage)	30	3.8	3.8	3.9	4.4	5.9	-	-	-	-	-	-	-	-	2.9	3.0	3.9	13.3	26.0	-	-	-	-	-	-	-	-	26
A9	Hitachi Tseung Kwan O Centre	30	3.7	3.7	3.7	3.9	6.3	-	-	-	-	-	-	-	-	3.7	3.7	3.7	3.9	4.6	-	-	-	-	-	-	-	-	5
A10	Next Media Apple Daily	30	4.2	4.3	4.6	5.7	8.7	-	-	-	-	-	-	-	-	5.9	5.9	5.9	5.9	6.0	-	-	-	-	-	-	-	-	6
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	4.5	4.5	4.8	6.8	10.8	-	-	-	-	-	-	-	-	8.8	8.8	8.9	9.3	14.0	-	-	-	-	-	-	-	-	14
A12-1	TVB City	30	3.5	3.5	3.6	3.6	4.2	-	-	-	-	-	-	-	-	3.6	3.6	3.7	6.8	16.9	-	-	-	-	-	-	-	-	17
A12-2	TVB City	30	4.0	4.0	4.0	4.4	7.9	-	-	-	-	-	-	-	-	3.7	3.8	3.9	13.5	21.7	-	-	-	-	-	-	-	-	22
A12-3	TVB City	30	3.6	3.7	3.7	3.7	4.6	-	-	-	-	-	-	-	-	3.0	3.1	5.2	34.6	47.3	-	-	-	-	-	-	-	-	47
A13	Yan Hing Industrial Building	30	4.0	4.0	4.0	4.1	6.7	-	-	-	-	-	-	-	-	3.1	3.1	3.2	5.3	11.7	-	-	-	-	-	-	-	-	12
A14	Next Media Apple Daily	30	3.8	3.8	3.8	3.9	5.3	-	-	-	-	-	-	-	-	2.6	2.6	2.7	3.0	4.5	-	-	-	-	-	-	-	-	4
A15	Avery Dennison	30	2.6	2.6	2.6	4.9	9.0	-	-	-	-	-	-	-	-	3.8	3.8	3.8	3.9	4.1	-	-	-	-	-	-	-	-	4
A16	Varitronix Limited	30	4.5	4.6	4.8	5.5	7.7	-	-	-	-	-	-	-	-	7.2	7.2	7.2	7.3	7.3	-	-	-	-	-	-	-	-	7
A17	Committed HSBC Office	30	2.6	2.6	2.7	3.1	3.7	-	-	-	-	-	-	-	-	9.4	9.4	9.4	31.3	40.9	-	-	-	-	-	-	-	-	41
A18	Eastern Pacific Electronics	30	4.8	4.8	5.4	8.1	12.2	-	-	-	-	-	-	-	-	13.1	13.1	13.1	13.1	13.1	-	-	-	-	-	-	-	-	13
A19	Hospital Aided Primary &	30	4.3	4.3	4.5	5.7	10.0	-	-	-	-	-	-	-	-	15.0	15.0	15.2	16.6	27.9	-	-	-	-	-	-	-	-	28
A20-1	LOHAS Park - 1	200	3.1	3.1	3.3	4.2	5.8	15.7	30.4	39.6	35.5	22.2	9.4	5.6	2.3	8.5	8.5	8.5	8.5	8.5	11.1	16.8	21.4	23.4	22.9	21.7	22.3	41.1	41
A20-2	LOHAS Park - 2	200	3.7	3.7	3.8	4.2	5.1	7.2	8.9	9.7	9.4	8.0	6.0	4.7	2.8	11.6	11.6	11.6	11.6	11.7	11.8	17.3	22.5	25.2	25.1	23.1	21.1	27.8	28
A20-3	LOHAS Park - 3	200	2.0	2.0	2.1	2.2	2.7	3.4	4.1	4.4	4.4	4.2	3.6	2.8	1.4	15.2	15.2	15.3	15.4	15.6	21.2	37.2	50.8	54.1	47.0	39.3	35.2	65.4	65
A21	Chiaphua-Shinko Centre	30	3.4	3.4	3.4	4.5	6.7	-	-	-	-	-	-	-	-	12.3	12.3	12.3	12.3	12.3	-	-	-	-	-	-	-	-	12

Table A4-2			Hourly (Biodiesel Plant - Boiler + TKOIE + HAECO Emission)													Hourly (Biodiesel Plant - Boiler + TKOIE + HAECO + Background Emission)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	7.28	7.83	9.57	17.75	33.53	-	-	-	-	-	-	-	-	70.3	70.8	72.6	80.7	96.5	-	-	-	-	-	-	-	-	96.5
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	5.20	5.91	8.26	17.97	35.99	-	-	-	-	-	-	-	-	68.2	68.9	71.3	81.0	99.0	-	-	-	-	-	-	-	-	99.0
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	3.46	3.58	4.55	8.85	14.18	-	-	-	-	-	-	-	-	66.5	66.6	67.6	71.8	77.2	-	-	-	-	-	-	-	-	77.2
A4	Hong Kong Aero Engine Services Ltd	30	3.56	3.64	3.87	12.49	21.08	-	-	-	-	-	-	-	-	66.6	66.6	66.9	75.5	84.1	-	-	-	-	-	-	-	-	84.1
A5	HAECO	30	4.09	4.11	4.15	4.45	8.16	-	-	-	-	-	-	-	-	67.1	67.1	67.2	67.5	71.2	-	-	-	-	-	-	-	-	71.2
A6-1	Asia Netcom HK Limited	30	4.65	4.68	4.77	6.62	17.30	-	-	-	-	-	-	-	-	67.6	67.7	67.8	69.6	80.3	-	-	-	-	-	-	-	-	80.3
A6-2	Asia Netcom HK Limited	30	4.38	4.44	4.62	146.89	126.40	-	-	-	-	-	-	-	-	67.4	67.4	67.6	209.9	189.4	-	-	-	-	-	-	-	-	209.9
A7	Mei Ah Centre	30	4.60	4.65	5.59	26.66	34.75	-	-	-	-	-	-	-	-	67.6	67.6	68.6	89.7	97.8	-	-	-	-	-	-	-	-	97.8
A8	Wellcome Co. Ltd (Storage)	30	3.86	3.88	4.02	13.27	25.96	-	-	-	-	-	-	-	-	66.9	66.9	67.0	76.3	89.0	-	-	-	-	-	-	-	-	89.0
A9	Hitachi Tseung Kwan O Centre	30	4.08	4.10	4.15	4.34	6.25	-	-	-	-	-	-	-	-	67.1	67.1	67.1	67.3	69.3	-	-	-	-	-	-	-	-	69.3
A10	Next Media Apple Daily	30	5.86	5.87	5.88	5.93	8.70	-	-	-	-	-	-	-	-	68.9	68.9	68.9	68.9	71.7	-	-	-	-	-	-	-	-	71.7
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	9.08	9.10	9.18	9.58	14.00	-	-	-	-	-	-	-	-	72.1	72.1	72.2	72.6	77.0	-	-	-	-	-	-	-	-	77.0
A12-1	TVB City	30	4.12	4.14	4.19	6.84	16.86	-	-	-	-	-	-	-	-	67.1	67.1	67.2	69.8	79.9	-	-	-	-	-	-	-	-	79.9
A12-2	TVB City	30	4.37	4.37	4.40	13.54	21.69	-	-	-	-	-	-	-	-	67.4	67.4	67.4	76.5	84.7	-	-	-	-	-	-	-	-	84.7
A12-3	TVB City	30	3.81	3.81	5.23	34.60	47.28	-	-	-	-	-	-	-	-	66.8	66.8	68.2	97.6	110.3	-	-	-	-	-	-	-	-	110.3
A13	Yan Hing Industrial Building	30	4.12	4.14	4.17	5.32	11.72	-	-	-	-	-	-	-	-	67.1	67.1	67.2	68.3	74.7	-	-	-	-	-	-	-	-	74.7
A14	Next Media Apple Daily	30	4.05	4.06	4.09	4.19	5.33	-	-	-	-	-	-	-	-	67.1	67.1	67.1	67.2	68.3	-	-	-	-	-	-	-	-	68.3
A15	Avery Dennison	30	3.75	3.76	3.79	5.08	8.97	-	-	-	-	-	-	-	-	66.8	66.8	66.8	68.1	72.0	-	-	-	-	-	-	-	-	72.0
A16	Varitronix Limited	30	7.23	7.24	7.25	7.28	10.55	-	-	-	-	-	-	-	-	70.2	70.2	70.2	70.3	73.5	-	-	-	-	-	-	-	-	73.5
A17	Committed HSBC Office	30	9.42	9.42	9.43	31.31	40.88	-	-	-	-	-	-	-	-	72.4	72.4	72.4	94.3	103.9	-	-	-	-	-	-	-	-	103.9
A18	Eastern Pacific Electronics	30	13.20	13.20	13.21	13.22	16.28	-	-	-	-	-	-	-	-	76.2	76.2	76.2	76.2	79.3	-	-	-	-	-	-	-	-	79.3
A19	Hospital Aided Primary &	30	15.12	15.16	15.34	16.56	28.14	-	-	-	-	-	-	-	-	78.1	78.2	78.3	79.6	91.1	-	-	-	-	-	-	-	-	91.1
A20-1	LOHAS Park - 1	200	8.84	8.84	8.84	8.84	8.84	15.96	30.87	40.28	36.50	23.73	21.75	22.26	41.15	71.8	71.8	71.8	71.8	71.8	79.0	93.9	103.3	99.5	86.7	84.7	85.3	104.1	104.1
A20-2	LOHAS Park - 2	200	11.91	11.91	11.91	11.92	11.93	11.95	17.35	22.52	25.17	25.08	23.08	21.13	27.80	74.9	74.9	74.9	74.9	74.9	74.9	80.3	85.5	88.2	88.1	86.1	84.1	90.8	90.8
A20-3	LOHAS Park - 3	200	15.36	15.37	15.40	15.53	15.73	21.20	37.22	50.83	54.15	46.97	39.26	35.22	65.41	78.4	78.4	78.4	78.5	78.7	84.2	100.2	113.8	117.1	110.0	102.3	98.2	128.4	128.4
A21	Chiaphua-Shinko Centre	30	12.37	12.37	12.37	12.36	12.44	-	-	-	-	-	-	-	-	75.4	75.4	75.4	75.4	75.4	-	-	-	-	-	-	-	-	75.4

Table A4-3

ASRs	Description	Approx. Maximum height of bldg (m above gd)	Daily (Biodiesel Plant - Boiler ONLY) 1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Daily (Biodiesel Plant - TKOIE + HAECO Emission ONLY) 1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Highest
A1	Gammon Skanka	30	1.7	1.9	2.5	5.0	8.3	-	-	-	-	-	-	-	-	0.8	0.8	0.8	1.5	3.5	-	-	-	-	-	-	-	-	3.5
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.6	0.7	1.4	4.6	10.7	-	-	-	-	-	-	-	-	0.8	0.8	0.8	0.9	1.1	-	-	-	-	-	-	-	-	1.1
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.6	0.7	0.9	1.5	2.2	-	-	-	-	-	-	-	-	1.0	1.0	1.1	1.5	2.0	-	-	-	-	-	-	-	-	2.0
A4	Hong Kong Aero Engine Services Ltd	30	0.2	0.2	0.2	0.3	0.4	-	-	-	-	-	-	-	-	0.6	0.6	0.6	2.2	3.6	-	-	-	-	-	-	-	-	3.6
A5	HAECO	30	0.3	0.3	0.3	0.4	0.4	-	-	-	-	-	-	-	-	0.5	0.5	0.6	0.9	1.7	-	-	-	-	-	-	-	-	1.7
A6-1	Asia Netcom HK Limited	30	0.3	0.3	0.3	0.5	0.7	-	-	-	-	-	-	-	-	0.6	0.6	0.7	1.0	2.0	-	-	-	-	-	-	-	-	2.0
A6-2	Asia Netcom HK Limited	30	0.3	0.3	0.3	0.5	0.9	-	-	-	-	-	-	-	-	0.7	0.7	0.7	31.2	16.4	-	-	-	-	-	-	-	-	31.2
A7	Mei Ah Centre	30	0.3	0.3	0.3	0.5	0.8	-	-	-	-	-	-	-	-	0.7	0.7	0.8	2.8	3.7	-	-	-	-	-	-	-	-	3.7
A8	Wellcome Co. Ltd (Storage)	30	0.3	0.3	0.3	0.3	0.6	-	-	-	-	-	-	-	-	0.8	0.8	1.0	2.0	3.9	-	-	-	-	-	-	-	-	3.9
A9	Hitachi Tseung Kwan O Centre	30	0.4	0.4	0.4	0.5	0.7	-	-	-	-	-	-	-	-	1.0	1.0	1.1	1.2	1.4	-	-	-	-	-	-	-	-	1.4
A10	Next Media Apple Daily	30	0.4	0.4	0.4	0.5	0.7	-	-	-	-	-	-	-	-	1.3	1.3	1.3	1.3	1.5	-	-	-	-	-	-	-	-	1.5
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	1.2	1.2	1.3	1.6	2.4	-	-	-	-	-	-	-	-	1.3	1.3	1.3	1.4	2.8	-	-	-	-	-	-	-	-	2.8
A12-1	TVB City	30	0.6	0.6	0.6	0.7	0.7	-	-	-	-	-	-	-	-	0.7	0.7	0.7	1.2	3.4	-	-	-	-	-	-	-	-	3.4
A12-2	TVB City	30	0.2	0.2	0.2	0.4	0.6	-	-	-	-	-	-	-	-	0.7	0.7	0.8	1.8	4.2	-	-	-	-	-	-	-	-	4.2
A12-3	TVB City	30	0.3	0.3	0.3	0.3	0.4	-	-	-	-	-	-	-	-	0.8	0.8	1.0	7.2	11.6	-	-	-	-	-	-	-	-	11.6
A13	Yan Hing Industrial Building	30	0.3	0.3	0.3	0.4	0.6	-	-	-	-	-	-	-	-	0.8	0.9	1.0	1.3	1.9	-	-	-	-	-	-	-	-	1.9
A14	Next Media Apple Daily	30	0.2	0.2	0.2	0.3	0.5	-	-	-	-	-	-	-	-	1.0	1.0	1.0	1.2	1.6	-	-	-	-	-	-	-	-	1.6
A15	Avery Dennison	30	0.3	0.3	0.4	0.5	0.8	-	-	-	-	-	-	-	-	1.0	1.0	1.0	1.2	1.4	-	-	-	-	-	-	-	-	1.4
A16	Varitronix Limited	30	0.5	0.5	0.6	0.7	1.1	-	-	-	-	-	-	-	-	1.4	1.4	1.4	1.5	1.5	-	-	-	-	-	-	-	-	1.5
A17	Committed HSBC Office	30	0.3	0.3	0.3	0.3	0.4	-	-	-	-	-	-	-	-	1.5	1.5	1.5	2.9	5.7	-	-	-	-	-	-	-	-	5.7
A18	Eastern Pacific Electronics	30	1.2	1.3	1.4	2.1	3.1	-	-	-	-	-	-	-	-	2.5	2.5	2.5	2.6	2.6	-	-	-	-	-	-	-	-	2.6
A19	Hospital Aided Primary &	30	0.7	0.7	0.8	1.1	1.8	-	-	-	-	-	-	-	-	3.0	3.1	3.1	4.8	8.4	-	-	-	-	-	-	-	-	8.4
A20-1	LOHAS Park - 1	200	0.4	0.4	0.5	0.5	0.9	1.8	3.0	3.7	3.2	2.0	0.9	0.4	0.2	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.9	2.0	1.7	2.2	3.1	5.8	5.8
A20-2	LOHAS Park - 2	200	0.8	0.8	0.9	1.0	1.2	1.4	1.6	1.6	1.5	1.3	1.0	0.7	0.4	1.2	1.2	1.2	1.2	1.2	1.4	1.7	2.1	2.5	2.8	3.1	3.5	5.3	5.3
A20-3	LOHAS Park - 3	200	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.4	0.2	2.4	2.4	2.4	2.5	2.6	3.0	5.1	7.0	7.6	7.0	6.3	7.0	9.6	9.6
A21	Chiaphua-Shinko Centre	30	1.0	1.0	1.0	1.2	1.5	-	-	-	-	-	-	-	-	1.8	1.8	1.8	1.8	1.9	-	-	-	-	-	-	-	-	1.9

Table A4-4			Daily (Biodiesel Plant - Boiler + TKOIE + HAECO Emission)													Daily (Biodiesel Plant - Boiler + TKOIE + HAECO Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	2.2	2.5	3.1	5.8	9.3	-	-	-	-	-	-	-	-	65.2	65.5	66.1	68.8	72.3	-	-	-	-	-	-	-	-	72.3
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	1.2	1.4	1.8	4.7	11.0	-	-	-	-	-	-	-	-	64.2	64.4	64.8	67.7	74.0	-	-	-	-	-	-	-	-	74.0
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	1.0	1.0	1.1	1.5	2.3	-	-	-	-	-	-	-	-	64.0	64.0	64.1	64.5	65.3	-	-	-	-	-	-	-	-	65.3
A4	Hong Kong Aero Engine Services Ltd	30	0.6	0.6	0.6	2.2	3.6	-	-	-	-	-	-	-	-	63.6	63.6	63.6	65.2	66.6	-	-	-	-	-	-	-	-	66.6
A5	HAECO	30	0.6	0.6	0.7	0.9	1.7	-	-	-	-	-	-	-	-	63.6	63.6	63.7	63.9	64.7	-	-	-	-	-	-	-	-	64.7
A6-1	Asia Netcom HK Limited	30	0.6	0.6	0.7	1.0	2.0	-	-	-	-	-	-	-	-	63.6	63.6	63.7	64.0	65.0	-	-	-	-	-	-	-	-	65.0
A6-2	Asia Netcom HK Limited	30	0.8	0.8	0.8	31.2	16.4	-	-	-	-	-	-	-	-	63.8	63.8	63.8	94.2	79.4	-	-	-	-	-	-	-	-	94.2
A7	Mei Ah Centre	30	0.9	0.9	0.9	2.9	3.9	-	-	-	-	-	-	-	-	63.9	63.9	63.9	65.9	66.9	-	-	-	-	-	-	-	-	66.9
A8	Wellcome Co. Ltd (Storage)	30	0.8	0.8	1.0	2.0	3.9	-	-	-	-	-	-	-	-	63.8	63.8	64.0	65.0	66.9	-	-	-	-	-	-	-	-	66.9
A9	Hitachi Tseung Kwan O Centre	30	1.0	1.0	1.1	1.2	1.4	-	-	-	-	-	-	-	-	64.0	64.0	64.1	64.2	64.4	-	-	-	-	-	-	-	-	64.4
A10	Next Media Apple Daily	30	1.3	1.3	1.3	1.5	2.1	-	-	-	-	-	-	-	-	64.3	64.3	64.3	64.5	65.1	-	-	-	-	-	-	-	-	65.1
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	1.8	1.8	1.9	2.3	3.2	-	-	-	-	-	-	-	-	64.8	64.8	64.9	65.3	66.2	-	-	-	-	-	-	-	-	66.2
A12-1	TVB City	30	0.9	1.0	1.0	1.5	3.4	-	-	-	-	-	-	-	-	63.9	64.0	64.0	64.5	66.4	-	-	-	-	-	-	-	-	66.4
A12-2	TVB City	30	0.7	0.7	0.8	1.8	4.2	-	-	-	-	-	-	-	-	63.7	63.7	63.8	64.8	67.2	-	-	-	-	-	-	-	-	67.2
A12-3	TVB City	30	0.8	0.8	1.0	7.2	11.6	-	-	-	-	-	-	-	-	63.8	63.8	64.0	70.2	74.6	-	-	-	-	-	-	-	-	74.6
A13	Yan Hing Industrial Building	30	0.8	0.9	1.0	1.3	1.9	-	-	-	-	-	-	-	-	63.8	63.9	64.0	64.3	64.9	-	-	-	-	-	-	-	-	64.9
A14	Next Media Apple Daily	30	1.0	1.0	1.0	1.2	1.6	-	-	-	-	-	-	-	-	64.0	64.0	64.0	64.2	64.6	-	-	-	-	-	-	-	-	64.6
A15	Avery Dennison	30	1.0	1.0	1.0	1.2	1.6	-	-	-	-	-	-	-	-	64.0	64.0	64.0	64.2	64.6	-	-	-	-	-	-	-	-	64.6
A16	Varitronix Limited	30	1.4	1.4	1.4	1.5	2.0	-	-	-	-	-	-	-	-	64.4	64.4	64.4	64.5	65.0	-	-	-	-	-	-	-	-	65.0
A17	Committed HSBC Office	30	1.7	1.7	1.7	2.9	5.7	-	-	-	-	-	-	-	-	64.7	64.7	64.7	65.9	68.7	-	-	-	-	-	-	-	-	68.7
A18	Eastern Pacific Electronics	30	2.8	2.8	2.8	3.1	4.0	-	-	-	-	-	-	-	-	65.8	65.8	65.8	66.1	67.0	-	-	-	-	-	-	-	-	67.0
A19	Hospital Aided Primary &	30	3.3	3.3	3.4	5.4	9.3	-	-	-	-	-	-	-	-	66.3	66.3	66.4	68.4	72.3	-	-	-	-	-	-	-	-	72.3
A20-1	LOHAS Park - 1	200	1.0	1.0	1.0	1.1	1.4	2.4	3.7	4.6	4.4	3.6	3.2	3.5	6.0	64.0	64.0	64.0	64.1	64.4	65.4	66.7	67.6	67.4	66.6	66.2	66.5	69.0	69.0
A20-2	LOHAS Park - 2	200	1.5	1.5	1.6	1.8	2.2	2.7	3.2	3.6	3.9	4.0	4.1	4.3	5.7	64.5	64.5	64.6	64.8	65.2	65.7	66.2	66.6	66.9	67.0	67.1	67.3	68.7	68.7
A20-3	LOHAS Park - 3	200	2.6	2.6	2.6	2.7	2.9	3.2	5.4	7.4	8.0	7.3	6.3	7.0	9.7	65.6	65.6	65.6	65.7	65.9	66.2	68.4	70.4	71.0	70.3	69.3	70.0	72.7	72.7
A21	Chiaphua-Shinko Centre	30	2.3	2.3	2.4	2.7	3.1	-	-	-	-	-	-	-	-	65.3	65.3	65.4	65.7	66.1	-	-	-	-	-	-	-	-	66.1

Table A4-5

			Annual Average (Biodiesel Plant - Boiler + TKOIE + HAECO Emission)													Annual Average (Biodiesel Plant - Boiler + TKOIE + HAECO Emission + Background)													
ASRs	Description	Approx. Maximum height of bldg (m above gd)	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Highest
A1	Gammon Skanka	30	0.59	0.63	0.78	1.42	2.49	-	-	-	-	-	-	-	-	63.6	63.6	63.8	64.4	65.5	-	-	-	-	-	-	-	-	65.5
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.39	0.42	0.53	1.09	2.20	-	-	-	-	-	-	-	-	63.4	63.4	63.5	64.1	65.2	-	-	-	-	-	-	-	-	65.2
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.23	0.24	0.26	0.35	0.55	-	-	-	-	-	-	-	-	63.2	63.2	63.3	63.4	63.6	-	-	-	-	-	-	-	-	63.6
A4	Hong Kong Aero Engine Services Ltd	30	0.19	0.21	0.25	0.54	1.12	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.5	64.1	-	-	-	-	-	-	-	-	64.1
A5	HAECO	30	0.17	0.18	0.20	0.32	0.58	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.6	-	-	-	-	-	-	-	-	63.6
A6-1	Asia Netcom HK Limited	30	0.20	0.21	0.23	0.31	0.49	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.5	-	-	-	-	-	-	-	-	63.5
A6-2	Asia Netcom HK Limited	30	0.20	0.20	0.25	1.93	2.39	-	-	-	-	-	-	-	-	63.2	63.2	63.2	64.9	65.4	-	-	-	-	-	-	-	-	65.4
A7	Mei Ah Centre	30	0.19	0.20	0.21	0.28	0.45	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A8	Wellcome Co. Ltd (Storage)	30	0.21	0.22	0.24	0.37	0.64	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.4	63.6	-	-	-	-	-	-	-	-	63.6
A9	Hitachi Tseung Kwan O Centre	30	0.22	0.22	0.23	0.27	0.35	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A10	Next Media Apple Daily	30	0.25	0.25	0.26	0.32	0.42	-	-	-	-	-	-	-	-	63.2	63.2	63.3	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.40	0.41	0.44	0.58	0.86	-	-	-	-	-	-	-	-	63.4	63.4	63.4	63.6	63.9	-	-	-	-	-	-	-	-	63.9
A12-1	TVB City	30	0.20	0.21	0.25	0.46	0.92	-	-	-	-	-	-	-	-	63.2	63.2	63.3	63.5	63.9	-	-	-	-	-	-	-	-	63.9
A12-2	TVB City	30	0.12	0.14	0.18	0.45	1.03	-	-	-	-	-	-	-	-	63.1	63.1	63.2	63.4	64.0	-	-	-	-	-	-	-	-	64.0
A12-3	TVB City	30	0.13	0.14	0.18	0.52	1.19	-	-	-	-	-	-	-	-	63.1	63.1	63.2	63.5	64.2	-	-	-	-	-	-	-	-	64.2
A13	Yan Hing Industrial Building	30	0.17	0.18	0.19	0.26	0.39	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A14	Next Media Apple Daily	30	0.18	0.18	0.19	0.23	0.32	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.2	63.3	-	-	-	-	-	-	-	-	63.3
A15	Avery Dennison	30	0.19	0.19	0.20	0.24	0.32	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.2	63.3	-	-	-	-	-	-	-	-	63.3
A16	Varitronix Limited	30	0.24	0.25	0.27	0.35	0.50	-	-	-	-	-	-	-	-	63.2	63.3	63.3	63.4	63.5	-	-	-	-	-	-	-	-	63.5
A17	Committed HSBC Office	30	0.19	0.20	0.25	0.64	1.41	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.6	64.4	-	-	-	-	-	-	-	-	64.4
A18	Eastern Pacific Electronics	30	0.35	0.36	0.38	0.47	0.62	-	-	-	-	-	-	-	-	63.4	63.4	63.4	63.5	63.6	-	-	-	-	-	-	-	-	63.6
A19	Hospital Aided Primary &	30	0.36	0.37	0.40	0.60	1.01	-	-	-	-	-	-	-	-	63.4	63.4	63.4	63.6	64.0	-	-	-	-	-	-	-	-	64.0
A20-1	LOHAS Park - 1	200	0.15	0.15	0.15	0.16	0.19	0.25	0.32	0.37	0.37	0.33	0.28	0.26	0.28	63.1	63.1	63.2	63.2	63.2	63.2	63.3	63.4	63.4	63.3	63.3	63.3	63.3	63.4
A20-2	LOHAS Park - 2	200	0.24	0.24	0.25	0.27	0.30	0.34	0.40	0.44	0.45	0.44	0.41	0.40	0.42	63.2	63.2	63.2	63.3	63.3	63.3	63.4	63.4	63.5	63.4	63.4	63.4	63.4	63.5
A20-3	LOHAS Park - 3	200	0.35	0.35	0.36	0.40	0.47	0.57	0.69	0.80	0.85	0.84	0.82	0.80	0.88	63.4	63.4	63.4	63.4	63.5	63.6	63.7	63.8	63.8	63.8	63.8	63.8	63.9	63.9
A21	Chiaphua-Shinko Centre	30	0.34	0.34	0.35	0.37	0.42	-	-	-	-	-	-	-	-	63.3	63.3	63.3	63.4	63.4	-	-	-	-	-	-	-	-	63.4

Scenario 2 - Emergency Condition (Biodiesel Plant (biogas flare) + HAECO + TKOIE emissions)

Table A4-6			Hourly (Biodiesel Plant - Biogas Flare ONLY)													Hourly (HAECO + TKOIE Emission ONLY)													
ASRs	Description	Approx. Maximum height of bldg (m above gd)	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Highest
A1	Gammon Skanka	30	2.11	2.20	2.50	2.85	2.26	-	-	-	-	-	-	-	-	3.8	3.8	3.9	6.9	17.8	-	-	-	-	-	-	-	-	18
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.85	0.92	1.19	2.00	3.56	-	-	-	-	-	-	-	-	3.1	3.1	3.2	3.5	7.0	-	-	-	-	-	-	-	-	7
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.50	0.52	0.59	0.84	1.15	-	-	-	-	-	-	-	-	3.5	3.5	3.7	6.5	11.0	-	-	-	-	-	-	-	-	11
A4	Hong Kong Aero Engine Services Ltd	30	0.53	0.54	0.57	1.17	1.75	-	-	-	-	-	-	-	-	3.2	3.3	3.4	12.5	21.1	-	-	-	-	-	-	-	-	21
A5	HAECO	30	0.44	0.44	0.45	0.88	1.24	-	-	-	-	-	-	-	-	4.0	4.0	4.1	4.5	8.2	-	-	-	-	-	-	-	-	8
A6-1	Asia Netcom HK Limited	30	0.49	0.50	0.53	0.75	1.17	-	-	-	-	-	-	-	-	3.4	3.5	3.6	6.6	17.3	-	-	-	-	-	-	-	-	17
A6-2	Asia Netcom HK Limited	30	0.51	0.52	0.55	1.14	1.68	-	-	-	-	-	-	-	-	3.5	3.6	4.1	146.9	126.4	-	-	-	-	-	-	-	-	147
A7	Mei Ah Centre	30	0.48	0.48	0.50	1.00	1.44	-	-	-	-	-	-	-	-	3.5	3.6	4.2	25.3	32.7	-	-	-	-	-	-	-	-	33
A8	Wellcome Co. Ltd (Storage)	30	1.04	1.04	1.02	0.92	0.71	-	-	-	-	-	-	-	-	2.9	3.0	3.9	13.3	26.0	-	-	-	-	-	-	-	-	26
A9	Hitachi Tseung Kwan O Centre	30	0.96	0.96	0.94	0.84	0.65	-	-	-	-	-	-	-	-	3.7	3.7	3.7	3.9	4.6	-	-	-	-	-	-	-	-	5
A10	Next Media Apple Daily	30	0.35	0.35	0.34	0.30	0.24	-	-	-	-	-	-	-	-	5.9	5.9	5.9	5.9	6.0	-	-	-	-	-	-	-	-	6
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	1.18	1.17	1.15	1.04	0.80	-	-	-	-	-	-	-	-	8.8	8.8	8.9	9.3	14.0	-	-	-	-	-	-	-	-	14
A12-1	TVB City	30	0.41	0.41	0.45	0.82	1.13	-	-	-	-	-	-	-	-	3.6	3.6	3.7	6.8	16.9	-	-	-	-	-	-	-	-	17
A12-2	TVB City	30	0.36	0.36	0.36	0.54	0.74	-	-	-	-	-	-	-	-	3.7	3.8	3.9	13.5	21.7	-	-	-	-	-	-	-	-	22
A12-3	TVB City	30	0.20	0.20	0.20	0.20	0.19	-	-	-	-	-	-	-	-	3.0	3.1	5.2	34.6	47.3	-	-	-	-	-	-	-	-	47
A13	Yan Hing Industrial Building	30	0.35	0.35	0.35	0.40	0.56	-	-	-	-	-	-	-	-	3.1	3.1	3.2	5.3	11.7	-	-	-	-	-	-	-	-	12
A14	Next Media Apple Daily	30	0.43	0.43	0.42	0.37	0.29	-	-	-	-	-	-	-	-	2.6	2.6	2.7	3.0	4.5	-	-	-	-	-	-	-	-	4
A15	Avery Dennison	30	0.41	0.40	0.39	0.35	0.28	-	-	-	-	-	-	-	-	3.8	3.8	3.8	3.9	4.1	-	-	-	-	-	-	-	-	4
A16	Varitronix Limited	30	0.93	0.93	0.91	0.81	0.64	-	-	-	-	-	-	-	-	7.2	7.2	7.2	7.3	7.3	-	-	-	-	-	-	-	-	7
A17	Committed HSBC Office	30	0.74	0.73	0.72	0.64	0.50	-	-	-	-	-	-	-	-	9.4	9.4	9.4	31.3	40.9	-	-	-	-	-	-	-	-	41
A18	Eastern Pacific Electronics	30	0.19	0.19	0.19	0.17	0.15	-	-	-	-	-	-	-	-	13.1	13.1	13.1	13.1	13.1	-	-	-	-	-	-	-	-	13
A19	Hospital Aided Primary &	30	0.20	0.20	0.19	0.17	0.15	-	-	-	-	-	-	-	-	15.0	15.0	15.2	16.6	27.9	-	-	-	-	-	-	-	-	28
A20-1	LOHAS Park - 1	200	0.20	0.20	0.19	0.18	0.15	0.12	0.09	0.07	0.05	0.05	0.04	0.04	0.03	8.5	8.5	8.5	8.5	8.5	11.1	16.8	21.4	23.4	22.9	21.7	22.3	41.1	41
A20-2	LOHAS Park - 2	200	0.47	0.47	0.45	0.39	0.30	0.20	0.13	0.10	0.06	0.05	0.04	0.04	0.03	11.6	11.6	11.6	11.6	11.7	11.8	17.3	22.5	25.2	25.1	23.1	21.1	27.8	28
A20-3	LOHAS Park - 3	200	0.68	0.68	0.66	0.58	0.46	0.32	0.18	0.11	0.08	0.05	0.04	0.04	0.03	15.2	15.2	15.3	15.4	15.6	21.2	37.2	50.8	54.1	47.0	39.3	35.2	65.4	65
A21	Chiaphua-Shinko Centre	30	0.13	0.13	0.13	0.12	0.10	-	-	-	-	-	-	-	-	12.3	12.3	12.3	12.3	12.3	-	-	-	-	-	-	-	-	12

Table A4-7

ASRs	Description	Approx. Maximum height of bldg (m above gd)	Hourly (Biodiesel Plant - Biogas Flare + TKOIE + HAECO Emission)													Hourly (Biodiesel Plant - Biogas flare + TKOIE + HAECO Emission + Background)													
			1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Highest
A1	Gammon Skanka	30	3.8	3.8	3.9	6.9	17.8	-	-	-	-	-	-	-	-	66.8	66.8	66.9	69.9	80.8	-	-	-	-	-	-	-	-	80.8
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	3.1	3.1	3.2	3.5	7.0	-	-	-	-	-	-	-	-	66.1	66.1	66.2	66.5	70.0	-	-	-	-	-	-	-	-	70.0
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	3.5	3.5	3.7	6.5	11.0	-	-	-	-	-	-	-	-	66.5	66.5	66.7	69.5	74.0	-	-	-	-	-	-	-	-	74.0
A4	Hong Kong Aero Engine Services Ltd	30	3.2	3.3	3.4	12.5	21.1	-	-	-	-	-	-	-	-	66.2	66.3	66.4	75.5	84.1	-	-	-	-	-	-	-	-	84.1
A5	HAECO	30	4.0	4.0	4.1	4.5	8.2	-	-	-	-	-	-	-	-	67.0	67.0	67.1	67.5	71.2	-	-	-	-	-	-	-	-	71.2
A6-1	Asia Netcom HK Limited	30	3.4	3.5	3.6	6.6	17.3	-	-	-	-	-	-	-	-	66.4	66.5	66.6	69.6	80.3	-	-	-	-	-	-	-	-	80.3
A6-2	Asia Netcom HK Limited	30	3.5	3.6	4.1	146.9	126.4	-	-	-	-	-	-	-	-	66.5	66.6	67.1	209.9	189.4	-	-	-	-	-	-	-	-	209.9
A7	Mei Ah Centre	30	3.5	3.6	4.2	25.3	32.7	-	-	-	-	-	-	-	-	66.5	66.6	67.2	88.3	95.7	-	-	-	-	-	-	-	-	95.7
A8	Wellcome Co. Ltd (Storage)	30	2.9	3.0	3.9	13.3	26.0	-	-	-	-	-	-	-	-	65.9	66.0	66.9	76.3	89.0	-	-	-	-	-	-	-	-	89.0
A9	Hitachi Tseung Kwan O Centre	30	3.7	3.7	3.7	3.9	4.6	-	-	-	-	-	-	-	-	66.7	66.7	66.7	66.9	67.6	-	-	-	-	-	-	-	-	67.6
A10	Next Media Apple Daily	30	5.9	5.9	5.9	5.9	6.0	-	-	-	-	-	-	-	-	68.9	68.9	68.9	68.9	69.0	-	-	-	-	-	-	-	-	69.0
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	8.8	8.8	8.9	9.3	14.0	-	-	-	-	-	-	-	-	71.8	71.8	71.9	72.3	77.0	-	-	-	-	-	-	-	-	77.0
A12-1	TVB City	30	3.6	3.6	3.7	6.8	16.9	-	-	-	-	-	-	-	-	66.6	66.6	66.7	69.8	79.9	-	-	-	-	-	-	-	-	79.9
A12-2	TVB City	30	3.7	3.8	3.9	13.5	21.7	-	-	-	-	-	-	-	-	66.7	66.8	66.9	76.5	84.7	-	-	-	-	-	-	-	-	84.7
A12-3	TVB City	30	3.0	3.1	5.2	34.6	47.3	-	-	-	-	-	-	-	-	66.0	66.1	68.2	97.6	110.3	-	-	-	-	-	-	-	-	110.3
A13	Yan Hing Industrial Building	30	3.1	3.1	3.2	5.3	11.7	-	-	-	-	-	-	-	-	66.1	66.1	66.2	68.3	74.7	-	-	-	-	-	-	-	-	74.7
A14	Next Media Apple Daily	30	2.6	2.6	2.7	3.0	4.5	-	-	-	-	-	-	-	-	65.6	65.6	65.7	66.0	67.5	-	-	-	-	-	-	-	-	67.5
A15	Avery Dennison	30	3.8	3.8	3.8	3.9	4.1	-	-	-	-	-	-	-	-	66.8	66.8	66.8	66.9	67.1	-	-	-	-	-	-	-	-	67.1
A16	Varitronix Limited	30	7.2	7.2	7.2	7.3	7.3	-	-	-	-	-	-	-	-	70.2	70.2	70.2	70.3	70.3	-	-	-	-	-	-	-	-	70.3
A17	Committed HSBC Office	30	9.4	9.4	9.4	31.3	40.9	-	-	-	-	-	-	-	-	72.4	72.4	72.4	94.3	103.9	-	-	-	-	-	-	-	-	103.9
A18	Eastern Pacific Electronics	30	13.1	13.1	13.1	13.1	13.1	-	-	-	-	-	-	-	-	76.1	76.1	76.1	76.1	76.1	-	-	-	-	-	-	-	-	76.1
A19	Hospital Aided Primary &	30	15.0	15.0	15.2	16.6	27.9	-	-	-	-	-	-	-	-	78.0	78.0	78.2	79.6	90.9	-	-	-	-	-	-	-	-	90.9
A20-1	LOHAS Park - 1	200	8.5	8.5	8.5	8.5	8.5	11.1	16.8	21.4	23.4	22.9	21.7	22.3	41.1	71.5	71.5	71.5	71.5	71.5	74.1	79.8	84.4	86.4	85.9	84.7	85.3	104.1	104.1
A20-2	LOHAS Park - 2	200	11.6	11.6	11.6	11.6	11.7	11.8	17.3	22.5	25.2	25.1	23.1	21.1	27.8	74.6	74.6	74.6	74.6	74.7	74.8	80.3	85.5	88.2	88.1	86.1	84.1	90.8	90.8
A20-3	LOHAS Park - 3	200	15.2	15.2	15.3	15.4	15.6	21.2	37.2	50.8	54.1	47.0	39.3	35.2	65.4	78.2	78.2	78.3	78.4	78.6	84.2	100.2	113.8	117.1	110.0	102.3	98.2	128.4	128.4
A21	Chiaphua-Shinko Centre	30	12.3	12.3	12.3	12.3	12.3	-	-	-	-	-	-	-	-	75.3	75.3	75.3	75.3	75.3	-	-	-	-	-	-	-	-	75.3

Table A4-8			Daily (Biodiesel Plant - Biogas Flare ONLY)													Daily (Biodiesel Plant - TKOIE + HAECO Emission ONLY)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	0.51	0.54	0.64	0.78	0.59	-	-	-	-	-	-	-	-	0.8	0.8	0.8	1.5	3.5	-	-	-	-	-	-	-	-	3.5
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.35	0.39	0.49	0.72	0.72	-	-	-	-	-	-	-	-	0.8	0.8	0.8	0.9	1.1	-	-	-	-	-	-	-	-	1.1
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.04	0.05	0.05	0.14	0.22	-	-	-	-	-	-	-	-	1.0	1.0	1.1	1.5	2.0	-	-	-	-	-	-	-	-	2.0
A4	Hong Kong Aero Engine Services Ltd	30	0.04	0.05	0.07	0.16	0.24	-	-	-	-	-	-	-	-	0.6	0.6	0.6	2.2	3.6	-	-	-	-	-	-	-	-	3.6
A5	HAECO	30	0.05	0.06	0.09	0.17	0.23	-	-	-	-	-	-	-	-	0.5	0.5	0.6	0.9	1.7	-	-	-	-	-	-	-	-	1.7
A6-1	Asia Netcom HK Limited	30	0.05	0.05	0.05	0.07	0.12	-	-	-	-	-	-	-	-	0.6	0.6	0.7	1.0	2.0	-	-	-	-	-	-	-	-	2.0
A6-2	Asia Netcom HK Limited	30	0.04	0.04	0.05	0.11	0.17	-	-	-	-	-	-	-	-	0.7	0.7	0.7	31.2	16.4	-	-	-	-	-	-	-	-	31.2
A7	Mei Ah Centre	30	0.03	0.03	0.05	0.10	0.14	-	-	-	-	-	-	-	-	0.7	0.7	0.8	2.8	3.7	-	-	-	-	-	-	-	-	3.7
A8	Wellcome Co. Ltd (Storage)	30	0.15	0.15	0.15	0.13	0.10	-	-	-	-	-	-	-	-	0.8	0.8	1.0	2.0	3.9	-	-	-	-	-	-	-	-	3.9
A9	Hitachi Tseung Kwan O Centre	30	0.17	0.17	0.17	0.15	0.12	-	-	-	-	-	-	-	-	1.0	1.0	1.1	1.2	1.4	-	-	-	-	-	-	-	-	1.4
A10	Next Media Apple Daily	30	0.05	0.05	0.05	0.05	0.04	-	-	-	-	-	-	-	-	1.3	1.3	1.3	1.3	1.5	-	-	-	-	-	-	-	-	1.5
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.34	0.34	0.33	0.30	0.23	-	-	-	-	-	-	-	-	1.3	1.3	1.3	1.4	2.8	-	-	-	-	-	-	-	-	2.8
A12-1	TVB City	30	0.08	0.09	0.10	0.19	0.26	-	-	-	-	-	-	-	-	0.7	0.7	0.7	1.2	3.4	-	-	-	-	-	-	-	-	3.4
A12-2	TVB City	30	0.04	0.04	0.06	0.10	0.14	-	-	-	-	-	-	-	-	0.7	0.7	0.8	1.8	4.2	-	-	-	-	-	-	-	-	4.2
A12-3	TVB City	30	0.02	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	0.8	0.8	1.0	7.2	11.6	-	-	-	-	-	-	-	-	11.6
A13	Yan Hing Industrial Building	30	0.03	0.03	0.03	0.04	0.06	-	-	-	-	-	-	-	-	0.8	0.9	1.0	1.3	1.9	-	-	-	-	-	-	-	-	1.9
A14	Next Media Apple Daily	30	0.06	0.06	0.06	0.05	0.04	-	-	-	-	-	-	-	-	1.0	1.0	1.0	1.2	1.6	-	-	-	-	-	-	-	-	1.6
A15	Avery Dennison	30	0.08	0.08	0.08	0.07	0.05	-	-	-	-	-	-	-	-	1.0	1.0	1.0	1.2	1.4	-	-	-	-	-	-	-	-	1.4
A16	Varitronix Limited	30	0.13	0.13	0.12	0.11	0.09	-	-	-	-	-	-	-	-	1.4	1.4	1.4	1.5	1.5	-	-	-	-	-	-	-	-	1.5
A17	Committed HSBC Office	30	0.10	0.10	0.10	0.09	0.07	-	-	-	-	-	-	-	-	1.5	1.5	1.5	2.9	5.7	-	-	-	-	-	-	-	-	5.7
A18	Eastern Pacific Electronics	30	0.06	0.06	0.06	0.05	0.04	-	-	-	-	-	-	-	-	2.5	2.5	2.5	2.6	2.6	-	-	-	-	-	-	-	-	2.6
A19	Hospital Aided Primary &	30	0.05	0.05	0.05	0.04	0.04	-	-	-	-	-	-	-	-	3.0	3.1	3.1	4.8	8.4	-	-	-	-	-	-	-	-	8.4
A20-1	LOHAS Park - 1	200	0.06	0.06	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.9	2.0	1.7	2.2	3.1	5.8	5.8
A20-2	LOHAS Park - 2	200	0.08	0.08	0.08	0.07	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.01	1.2	1.2	1.2	1.2	1.2	1.4	1.7	2.1	2.5	2.8	3.1	3.5	5.3	5.3
A20-3	LOHAS Park - 3	200	0.14	0.13	0.13	0.12	0.09	0.06	0.04	0.02	0.01	0.01	0.01	0.00	0.00	2.4	2.4	2.4	2.5	2.6	3.0	5.1	7.0	7.6	7.0	6.3	7.0	9.6	9.6
A21	Chiaphua-Shinko Centre	30	0.04	0.04	0.04	0.03	0.03	-	-	-	-	-	-	-	-	1.8	1.8	1.8	1.8	1.9	-	-	-	-	-	-	-	-	1.9

Table A4-9			Daily (Biodiesel Plant - Biogas Flare + TKOIE + HAECO Emission)													Daily (Biodiesel Plant - Biogas flare + TKOIE + HAECO Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	1.0	1.0	1.1	1.5	3.5	-	-	-	-	-	-	-	-	64.0	64.0	64.1	64.5	66.5	-	-	-	-	-	-	-	-	66.5
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.8	0.8	0.8	1.1	1.6	-	-	-	-	-	-	-	-	63.8	63.8	63.8	64.1	64.6	-	-	-	-	-	-	-	-	64.6
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	1.0	1.0	1.1	1.5	2.0	-	-	-	-	-	-	-	-	64.0	64.0	64.1	64.5	65.0	-	-	-	-	-	-	-	-	65.0
A4	Hong Kong Aero Engine Services Ltd	30	0.6	0.6	0.7	2.2	3.6	-	-	-	-	-	-	-	-	63.6	63.6	63.7	65.2	66.6	-	-	-	-	-	-	-	-	66.6
A5	HAECO	30	0.5	0.5	0.6	0.9	1.7	-	-	-	-	-	-	-	-	63.5	63.5	63.6	63.9	64.7	-	-	-	-	-	-	-	-	64.7
A6-1	Asia Netcom HK Limited	30	0.6	0.6	0.7	1.0	2.0	-	-	-	-	-	-	-	-	63.6	63.6	63.7	64.0	65.0	-	-	-	-	-	-	-	-	65.0
A6-2	Asia Netcom HK Limited	30	0.7	0.7	0.7	31.2	16.4	-	-	-	-	-	-	-	-	63.7	63.7	63.7	94.2	79.4	-	-	-	-	-	-	-	-	94.2
A7	Mei Ah Centre	30	0.7	0.7	0.8	2.8	3.7	-	-	-	-	-	-	-	-	63.7	63.7	63.8	65.8	66.7	-	-	-	-	-	-	-	-	66.7
A8	Wellcome Co. Ltd (Storage)	30	0.8	0.8	1.0	2.0	3.9	-	-	-	-	-	-	-	-	63.8	63.8	64.0	65.0	66.9	-	-	-	-	-	-	-	-	66.9
A9	Hitachi Tseung Kwan O Centre	30	1.0	1.0	1.1	1.2	1.4	-	-	-	-	-	-	-	-	64.0	64.0	64.1	64.2	64.4	-	-	-	-	-	-	-	-	64.4
A10	Next Media Apple Daily	30	1.3	1.3	1.3	1.4	1.5	-	-	-	-	-	-	-	-	64.3	64.3	64.3	64.4	64.5	-	-	-	-	-	-	-	-	64.5
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	1.5	1.5	1.6	1.7	2.8	-	-	-	-	-	-	-	-	64.5	64.5	64.6	64.7	65.8	-	-	-	-	-	-	-	-	65.8
A12-1	TVB City	30	0.7	0.7	0.7	1.2	3.4	-	-	-	-	-	-	-	-	63.7	63.7	63.7	64.2	66.4	-	-	-	-	-	-	-	-	66.4
A12-2	TVB City	30	0.7	0.7	0.8	1.8	4.2	-	-	-	-	-	-	-	-	63.7	63.7	63.8	64.8	67.2	-	-	-	-	-	-	-	-	67.2
A12-3	TVB City	30	0.8	0.8	1.0	7.2	11.6	-	-	-	-	-	-	-	-	63.8	63.8	64.0	70.2	74.6	-	-	-	-	-	-	-	-	74.6
A13	Yan Hing Industrial Building	30	0.8	0.9	1.0	1.3	1.9	-	-	-	-	-	-	-	-	63.8	63.9	64.0	64.3	64.9	-	-	-	-	-	-	-	-	64.9
A14	Next Media Apple Daily	30	1.0	1.0	1.0	1.2	1.6	-	-	-	-	-	-	-	-	64.0	64.0	64.0	64.2	64.6	-	-	-	-	-	-	-	-	64.6
A15	Avery Dennison	30	1.0	1.0	1.0	1.2	1.4	-	-	-	-	-	-	-	-	64.0	64.0	64.0	64.2	64.4	-	-	-	-	-	-	-	-	64.4
A16	Varitronix Limited	30	1.4	1.4	1.4	1.5	1.5	-	-	-	-	-	-	-	-	64.4	64.4	64.4	64.5	64.5	-	-	-	-	-	-	-	-	64.5
A17	Committed HSBC Office	30	1.5	1.5	1.5	2.9	5.7	-	-	-	-	-	-	-	-	64.5	64.5	64.5	65.9	68.7	-	-	-	-	-	-	-	-	68.7
A18	Eastern Pacific Electronics	30	2.6	2.6	2.6	2.6	2.6	-	-	-	-	-	-	-	-	65.6	65.6	65.6	65.6	65.6	-	-	-	-	-	-	-	-	65.6
A19	Hospital Aided Primary &	30	3.1	3.1	3.2	4.8	8.4	-	-	-	-	-	-	-	-	66.1	66.1	66.2	67.8	71.4	-	-	-	-	-	-	-	-	71.4
A20-1	LOHAS Park - 1	200	0.8	0.8	0.8	0.9	1.1	1.2	1.5	1.9	2.0	1.7	2.2	3.1	5.8	63.8	63.8	63.8	63.9	64.1	64.2	64.5	64.9	65.0	64.7	65.2	66.1	68.8	68.8
A20-2	LOHAS Park - 2	200	1.2	1.2	1.2	1.2	1.2	1.4	1.8	2.2	2.5	2.8	3.1	3.5	5.3	64.2	64.2	64.2	64.2	64.2	64.4	64.8	65.2	65.5	65.8	66.1	66.5	68.3	68.3
A20-3	LOHAS Park - 3	200	2.5	2.5	2.5	2.5	2.7	3.0	5.1	7.0	7.6	7.0	6.3	7.0	9.6	65.5	65.5	65.5	65.5	65.7	66.0	68.1	70.0	70.6	70.0	69.3	70.0	72.6	72.6
A21	Chiaphua-Shinko Centre	30	1.8	1.8	1.8	1.8	2.0	-	-	-	-	-	-	-	-	64.8	64.8	64.8	64.8	65.0	-	-	-	-	-	-	-	-	65.0

Table A4-10			Annual Average (Biodiesel Plant - Biogas Flare + TKOIE + HAECO Emission)													Annual Average (Biodiesel Plant - Biogas flare + TKOIE + HAECO Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	0.45	0.46	0.50	0.62	0.81	-	-	-	-	-	-	-	-	63.4	63.5	63.5	63.6	63.8	-	-	-	-	-	-	-	-	63.8
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.31	0.32	0.35	0.48	0.69	-	-	-	-	-	-	-	-	63.3	63.3	63.4	63.5	63.7	-	-	-	-	-	-	-	-	63.7
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.23	0.23	0.25	0.33	0.49	-	-	-	-	-	-	-	-	63.2	63.2	63.3	63.3	63.5	-	-	-	-	-	-	-	-	63.5
A4	Hong Kong Aero Engine Services Ltd	30	0.19	0.20	0.25	0.54	1.11	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.5	64.1	-	-	-	-	-	-	-	-	64.1
A5	HAECO	30	0.17	0.17	0.20	0.32	0.57	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.6	-	-	-	-	-	-	-	-	63.6
A6-1	Asia Netcom HK Limited	30	0.20	0.21	0.22	0.31	0.47	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.5	-	-	-	-	-	-	-	-	63.5
A6-2	Asia Netcom HK Limited	30	0.19	0.19	0.24	1.92	2.38	-	-	-	-	-	-	-	-	63.2	63.2	63.2	64.9	65.4	-	-	-	-	-	-	-	-	65.4
A7	Mei Ah Centre	30	0.19	0.19	0.21	0.28	0.42	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A8	Wellcome Co. Ltd (Storage)	30	0.21	0.22	0.24	0.37	0.63	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.4	63.6	-	-	-	-	-	-	-	-	63.6
A9	Hitachi Tseung Kwan O Centre	30	0.21	0.22	0.23	0.26	0.34	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.3	-	-	-	-	-	-	-	-	63.3
A10	Next Media Apple Daily	30	0.24	0.24	0.25	0.30	0.40	-	-	-	-	-	-	-	-	63.2	63.2	63.3	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.30	0.31	0.33	0.43	0.64	-	-	-	-	-	-	-	-	63.3	63.3	63.3	63.4	63.6	-	-	-	-	-	-	-	-	63.6
A12-1	TVB City	30	0.19	0.21	0.25	0.45	0.89	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.5	63.9	-	-	-	-	-	-	-	-	63.9
A12-2	TVB City	30	0.12	0.13	0.17	0.44	0.99	-	-	-	-	-	-	-	-	63.1	63.1	63.2	63.4	64.0	-	-	-	-	-	-	-	-	64.0
A12-3	TVB City	30	0.12	0.13	0.17	0.51	1.17	-	-	-	-	-	-	-	-	63.1	63.1	63.2	63.5	64.2	-	-	-	-	-	-	-	-	64.2
A13	Yan Hing Industrial Building	30	0.17	0.17	0.19	0.25	0.37	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A14	Next Media Apple Daily	30	0.17	0.18	0.19	0.23	0.30	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.2	63.3	-	-	-	-	-	-	-	-	63.3
A15	Avery Dennison	30	0.19	0.19	0.20	0.23	0.30	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.2	63.3	-	-	-	-	-	-	-	-	63.3
A16	Varitronix Limited	30	0.22	0.22	0.24	0.31	0.43	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A17	Committed HSBC Office	30	0.18	0.19	0.23	0.62	1.38	-	-	-	-	-	-	-	-	63.2	63.2	63.2	63.6	64.4	-	-	-	-	-	-	-	-	64.4
A18	Eastern Pacific Electronics	30	0.24	0.24	0.25	0.29	0.36	-	-	-	-	-	-	-	-	63.2	63.2	63.3	63.3	63.4	-	-	-	-	-	-	-	-	63.4
A19	Hospital Aided Primary &	30	0.30	0.30	0.33	0.50	0.86	-	-	-	-	-	-	-	-	63.3	63.3	63.3	63.5	63.9	-	-	-	-	-	-	-	-	63.9
A20-1	LOHAS Park - 1	200	0.12	0.12	0.12	0.13	0.15	0.18	0.21	0.24	0.26	0.25	0.24	0.23	0.26	63.1	63.1	63.1	63.1	63.2	63.2	63.2	63.2	63.3	63.2	63.2	63.2	63.3	63.3
A20-2	LOHAS Park - 2	200	0.17	0.17	0.17	0.18	0.20	0.23	0.28	0.32	0.34	0.34	0.33	0.33	0.38	63.2	63.2	63.2	63.2	63.2	63.2	63.3	63.3	63.3	63.3	63.3	63.3	63.4	63.4
A20-3	LOHAS Park - 3	200	0.31	0.31	0.32	0.35	0.41	0.50	0.61	0.71	0.77	0.77	0.76	0.76	0.85	63.3	63.3	63.3	63.3	63.4	63.5	63.6	63.7	63.8	63.8	63.8	63.8	63.9	63.9
A21	Chiaphua-Shinko Centre	30	0.28	0.28	0.28	0.29	0.31	-	-	-	-	-	-	-	-	63.3	63.3	63.3	63.3	63.3	-	-	-	-	-	-	-	-	63.3

Carbon Monoxide

bg 1181

Scenario 1 - Normal Condition (Biodiesel Plant (boiler) + HAECO + TKOIE emissions)

Table A4-11			Hourly (Biodiesel Plant - Boiler + HAECO + TKOIE Emission)													Hourly (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	9	10	12	23	43	-	-	-	-	-	-	-	-	1190	1191	1193	1204	1224	-	-	-	-	-	-	-	-	1,224
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	6	7	10	23	46	-	-	-	-	-	-	-	-	1187	1188	1191	1204	1227	-	-	-	-	-	-	-	-	1,227
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	5	5	6	12	19	-	-	-	-	-	-	-	-	1186	1186	1187	1193	1200	-	-	-	-	-	-	-	-	1,200
A4	Hong Kong Aero Engine Services Ltd	30	5	5	5	12	21	-	-	-	-	-	-	-	-	1186	1186	1186	1193	1202	-	-	-	-	-	-	-	-	1,202
A5	HAECO	30	5	5	5	6	8	-	-	-	-	-	-	-	-	1186	1186	1186	1187	1189	-	-	-	-	-	-	-	-	1,189
A6-1	Asia Netcom HK Limited	30	6	6	6	7	17	-	-	-	-	-	-	-	-	1187	1187	1187	1188	1198	-	-	-	-	-	-	-	-	1,198
A6-2	Asia Netcom HK Limited	30	6	6	6	143	123	-	-	-	-	-	-	-	-	1187	1187	1187	1324	1304	-	-	-	-	-	-	-	-	1,324
A7	Mei Ah Centre	30	6	6	6	26	35	-	-	-	-	-	-	-	-	1187	1187	1187	1207	1216	-	-	-	-	-	-	-	-	1,216
A8	Wellcome Co. Ltd (Storage)	30	5	5	5	13	26	-	-	-	-	-	-	-	-	1186	1186	1186	1194	1207	-	-	-	-	-	-	-	-	1,207
A9	Hitachi Tseung Kwan O Centre	30	5	5	5	6	8	-	-	-	-	-	-	-	-	1186	1186	1186	1187	1189	-	-	-	-	-	-	-	-	1,189
A10	Next Media Apple Daily	30	9	9	9	9	11	-	-	-	-	-	-	-	-	1190	1190	1190	1190	1192	-	-	-	-	-	-	-	-	1,192
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	13	13	13	13	14	-	-	-	-	-	-	-	-	1194	1194	1194	1194	1195	-	-	-	-	-	-	-	-	1,195
A12-1	TVB City	30	5	5	5	7	16	-	-	-	-	-	-	-	-	1186	1186	1186	1188	1197	-	-	-	-	-	-	-	-	1,197
A12-2	TVB City	30	6	6	6	13	21	-	-	-	-	-	-	-	-	1187	1187	1187	1194	1202	-	-	-	-	-	-	-	-	1,202
A12-3	TVB City	30	5	5	5	34	46	-	-	-	-	-	-	-	-	1186	1186	1186	1215	1227	-	-	-	-	-	-	-	-	1,227
A13	Yan Hing Industrial Building	30	5	5	5	6	11	-	-	-	-	-	-	-	-	1186	1186	1186	1187	1192	-	-	-	-	-	-	-	-	1,192
A14	Next Media Apple Daily	30	5	5	5	5	7	-	-	-	-	-	-	-	-	1186	1186	1186	1186	1188	-	-	-	-	-	-	-	-	1,188
A15	Avery Dennison	30	5	5	6	6	12	-	-	-	-	-	-	-	-	1186	1186	1187	1187	1193	-	-	-	-	-	-	-	-	1,193
A16	Varitronix Limited	30	11	11	11	11	13	-	-	-	-	-	-	-	-	1192	1192	1192	1192	1194	-	-	-	-	-	-	-	-	1,194
A17	Committed HSBC Office	30	13	13	13	31	40	-	-	-	-	-	-	-	-	1194	1194	1194	1212	1221	-	-	-	-	-	-	-	-	1,221
A18	Eastern Pacific Electronics	30	16	16	16	16	20	-	-	-	-	-	-	-	-	1197	1197	1197	1197	1201	-	-	-	-	-	-	-	-	1,201
A19	Hospital Aided Primary &	30	18	18	18	19	28	-	-	-	-	-	-	-	-	1199	1199	1199	1200	1209	-	-	-	-	-	-	-	-	1,209
A20-1	LOHAS Park - 1	200	14	14	14	14	14	21	40	53	48	31	28	33	68	1195	1195	1195	1195	1195	1202	1221	1234	1229	1212	1209	1214	1249	1,249
A20-2	LOHAS Park - 2	200	18	18	18	18	18	18	18	23	26	28	27	27	44	1199	1199	1199	1199	1199	1199	1199	1204	1207	1209	1208	1208	1225	1,225
A20-3	LOHAS Park - 3	200	19	19	19	19	19	21	38	52	57	52	47	52	110	1200	1200	1200	1200	1200	1202	1219	1233	1238	1233	1228	1233	1291	1,291
A21	Chiaphua-Shinko Centre	30	17	17	17	17	17	-	-	-	-	-	-	-	-	1198	1198	1198	1198	1198	-	-	-	-	-	-	-	-	1,198

Table A4-12

			8-hour (Biodiesel Plant - Boiler + HAECO + TKOIE Emission)													8-hour (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	Description	Approx. Maximum height of bldg (m above gd)	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Highest
A1	Gammon Skanka	30	4.8	5.1	6.2	10.2	18.6	-	-	-	-	-	-	-	-	1186	1186	1187	1191	1200	-	-	-	-	-	-	-	-	1,200
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	2.8	3.1	4.1	10.1	23.9	-	-	-	-	-	-	-	-	1184	1184	1185	1191	1205	-	-	-	-	-	-	-	-	1,205
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	2.2	2.2	2.5	3.8	5.3	-	-	-	-	-	-	-	-	1183	1183	1183	1185	1186	-	-	-	-	-	-	-	-	1,186
A4	Hong Kong Aero Engine Services Ltd	30	1.5	1.5	1.7	5.8	10.5	-	-	-	-	-	-	-	-	1182	1182	1183	1187	1191	-	-	-	-	-	-	-	-	1,191
A5	HAECO	30	1.7	1.7	1.8	2.1	2.9	-	-	-	-	-	-	-	-	1183	1183	1183	1183	1184	-	-	-	-	-	-	-	-	1,184
A6-1	Asia Netcom HK Limited	30	1.8	1.8	1.9	2.6	4.6	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1186	-	-	-	-	-	-	-	-	1,186
A6-2	Asia Netcom HK Limited	30	2.0	2.0	2.1	72.0	28.0	-	-	-	-	-	-	-	-	1183	1183	1183	1253	1209	-	-	-	-	-	-	-	-	1,253
A7	Mei Ah Centre	30	2.1	2.1	2.4	7.9	10.1	-	-	-	-	-	-	-	-	1183	1183	1183	1189	1191	-	-	-	-	-	-	-	-	1,191
A8	Wellcome Co. Ltd (Storage)	30	2.3	2.4	2.6	5.1	10.0	-	-	-	-	-	-	-	-	1183	1183	1184	1186	1191	-	-	-	-	-	-	-	-	1,191
A9	Hitachi Tseung Kwan O Centre	30	2.6	2.6	2.7	3.0	3.4	-	-	-	-	-	-	-	-	1184	1184	1184	1184	1184	-	-	-	-	-	-	-	-	1,184
A10	Next Media Apple Daily	30	3.6	3.6	3.7	4.0	4.5	-	-	-	-	-	-	-	-	1185	1185	1185	1185	1186	-	-	-	-	-	-	-	-	1,186
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	5.2	5.2	5.3	5.7	9.0	-	-	-	-	-	-	-	-	1186	1186	1186	1187	1190	-	-	-	-	-	-	-	-	1,190
A12-1	TVB City	30	2.3	2.4	2.5	3.4	8.5	-	-	-	-	-	-	-	-	1183	1183	1184	1184	1190	-	-	-	-	-	-	-	-	1,190
A12-2	TVB City	30	1.8	1.9	2.0	5.1	9.7	-	-	-	-	-	-	-	-	1183	1183	1183	1186	1191	-	-	-	-	-	-	-	-	1,191
A12-3	TVB City	30	2.0	2.0	2.9	17.7	27.1	-	-	-	-	-	-	-	-	1183	1183	1184	1199	1208	-	-	-	-	-	-	-	-	1,208
A13	Yan Hing Industrial Building	30	2.0	2.1	2.2	2.7	4.1	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1185	-	-	-	-	-	-	-	-	1,185
A14	Next Media Apple Daily	30	2.1	2.1	2.2	2.7	3.6	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1185	-	-	-	-	-	-	-	-	1,185
A15	Avery Dennison	30	2.4	2.4	2.4	2.6	2.9	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1184	-	-	-	-	-	-	-	-	1,184
A16	Varitronix Limited	30	4.0	4.0	4.1	4.1	4.3	-	-	-	-	-	-	-	-	1185	1185	1185	1185	1185	-	-	-	-	-	-	-	-	1,185
A17	Committed HSBC Office	30	4.7	4.7	4.7	7.7	14.4	-	-	-	-	-	-	-	-	1186	1186	1186	1189	1195	-	-	-	-	-	-	-	-	1,195
A18	Eastern Pacific Electronics	30	6.6	6.6	6.6	6.6	7.4	-	-	-	-	-	-	-	-	1188	1188	1188	1188	1188	-	-	-	-	-	-	-	-	1,188
A19	Hospital Aided Primary &	30	8.1	8.1	8.3	12.5	20.2	-	-	-	-	-	-	-	-	1189	1189	1189	1194	1201	-	-	-	-	-	-	-	-	1,201
A20-1	LOHAS Park - 1	200	3.1	3.1	3.1	3.1	3.1	4.4	8.4	11.1	10.2	6.7	6.6	8.4	15.3	1184	1184	1184	1184	1184	1185	1189	1192	1191	1188	1188	1189	1196	1,196
A20-2	LOHAS Park - 2	200	5.1	5.1	5.1	5.1	5.1	5.2	5.8	6.5	6.5	6.5	6.4	7.6	15.0	1186	1186	1186	1186	1186	1186	1187	1188	1187	1187	1187	1189	1196	1,196
A20-3	LOHAS Park - 3	200	8.3	8.3	8.3	8.5	8.7	9.1	15.3	20.9	22.8	20.9	18.3	20.4	35.1	1189	1189	1189	1189	1190	1190	1196	1202	1204	1202	1199	1201	1216	1,216
A21	Chiaphua-Shinko Centre	30	7.3	7.3	7.3	7.3	8.0	-	-	-	-	-	-	-	-	1188	1188	1188	1188	1189	-	-	-	-	-	-	-	-	1,189

Scenario 2 - Emergency Condition (Biodiesel Plant (biogas flare) + HAECO + TKOIE emissions)

Table A4-13			Hourly (Biodiesel Plant - Biogas Flare + HAECO + TKOIE Emission)													Hourly (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	5	5	5	7	17	-	-	-	-	-	-	-	-	1186	1186	1186	1188	1198	-	-	-	-	-	-	-	-	1,198
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	4	4	4	5	7	-	-	-	-	-	-	-	-	1185	1185	1185	1186	1188	-	-	-	-	-	-	-	-	1,188
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	3	3	4	6	11	-	-	-	-	-	-	-	-	1184	1184	1185	1187	1192	-	-	-	-	-	-	-	-	1,192
A4	Hong Kong Aero Engine Services Ltd	30	3	3	3	12	21	-	-	-	-	-	-	-	-	1184	1184	1184	1193	1202	-	-	-	-	-	-	-	-	1,202
A5	HAECO	30	4	4	4	4	8	-	-	-	-	-	-	-	-	1185	1185	1185	1185	1189	-	-	-	-	-	-	-	-	1,189
A6-1	Asia Netcom HK Limited	30	3	3	4	6	17	-	-	-	-	-	-	-	-	1184	1184	1185	1187	1198	-	-	-	-	-	-	-	-	1,198
A6-2	Asia Netcom HK Limited	30	3	3	4	143	123	-	-	-	-	-	-	-	-	1184	1184	1185	1324	1304	-	-	-	-	-	-	-	-	1,324
A7	Mei Ah Centre	30	3	3	4	25	32	-	-	-	-	-	-	-	-	1184	1184	1185	1206	1213	-	-	-	-	-	-	-	-	1,213
A8	Wellcome Co. Ltd (Storage)	30	3	3	4	13	26	-	-	-	-	-	-	-	-	1184	1184	1185	1194	1207	-	-	-	-	-	-	-	-	1,207
A9	Hitachi Tseung Kwan O Centre	30	5	5	5	6	7	-	-	-	-	-	-	-	-	1186	1186	1186	1187	1188	-	-	-	-	-	-	-	-	1,188
A10	Next Media Apple Daily	30	9	9	9	9	9	-	-	-	-	-	-	-	-	1190	1190	1190	1190	1190	-	-	-	-	-	-	-	-	1,190
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	13	13	13	13	14	-	-	-	-	-	-	-	-	1194	1194	1194	1194	1195	-	-	-	-	-	-	-	-	1,195
A12-1	TVB City	30	4	4	4	7	16	-	-	-	-	-	-	-	-	1185	1185	1185	1188	1197	-	-	-	-	-	-	-	-	1,197
A12-2	TVB City	30	4	4	4	13	21	-	-	-	-	-	-	-	-	1185	1185	1185	1194	1202	-	-	-	-	-	-	-	-	1,202
A12-3	TVB City	30	3	3	5	34	46	-	-	-	-	-	-	-	-	1184	1184	1186	1215	1227	-	-	-	-	-	-	-	-	1,227
A13	Yan Hing Industrial Building	30	3	3	3	5	11	-	-	-	-	-	-	-	-	1184	1184	1184	1186	1192	-	-	-	-	-	-	-	-	1,192
A14	Next Media Apple Daily	30	3	3	3	3	4	-	-	-	-	-	-	-	-	1184	1184	1184	1184	1185	-	-	-	-	-	-	-	-	1,185
A15	Avery Dennison	30	5	5	6	6	6	-	-	-	-	-	-	-	-	1186	1186	1187	1187	1187	-	-	-	-	-	-	-	-	1,187
A16	Varitronix Limited	30	11	11	11	11	11	-	-	-	-	-	-	-	-	1192	1192	1192	1192	1192	-	-	-	-	-	-	-	-	1,192
A17	Committed HSBC Office	30	13	13	13	31	40	-	-	-	-	-	-	-	-	1194	1194	1194	1212	1221	-	-	-	-	-	-	-	-	1,221
A18	Eastern Pacific Electronics	30	15	15	15	15	15	-	-	-	-	-	-	-	-	1196	1196	1196	1196	1196	-	-	-	-	-	-	-	-	1,196
A19	Hospital Aided Primary &	30	18	18	18	18	27	-	-	-	-	-	-	-	-	1199	1199	1199	1199	1208	-	-	-	-	-	-	-	-	1,208
A20-1	LOHAS Park - 1	200	14	14	14	14	14	14	17	22	25	27	28	33	68	1195	1195	1195	1195	1195	1195	1198	1203	1206	1208	1209	1214	1249	1,249
A20-2	LOHAS Park - 2	200	17	17	17	17	17	17	18	23	26	28	27	27	44	1198	1198	1198	1198	1198	1198	1199	1204	1207	1209	1208	1208	1225	1,225
A20-3	LOHAS Park - 3	200	19	19	19	19	19	21	38	52	57	52	47	52	110	1200	1200	1200	1200	1200	1202	1219	1233	1238	1233	1228	1233	1291	1,291
A21	Chiaphua-Shinko Centre	30	17	17	17	17	17	-	-	-	-	-	-	-	-	1198	1198	1198	1198	1198	-	-	-	-	-	-	-	-	1,198

Table A4-14			8-hour (Biodiesel Plant - Biogas Flare + HAECO + TKOIE Emission)													8-hour (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	2.2	2.4	2.8	3.8	8.1	-	-	-	-	-	-	-	-	1183	1183	1184	1185	1189	-	-	-	-	-	-	-	-	1,189
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	2.0	2.0	2.0	2.3	3.2	-	-	-	-	-	-	-	-	1183	1183	1183	1183	1184	-	-	-	-	-	-	-	-	1,184
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	2.2	2.2	2.5	3.4	4.4	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1185	-	-	-	-	-	-	-	-	1,185
A4	Hong Kong Aero Engine Services Ltd	30	1.5	1.5	1.7	5.8	10.5	-	-	-	-	-	-	-	-	1182	1182	1183	1187	1191	-	-	-	-	-	-	-	-	1,191
A5	HAECO	30	1.7	1.7	1.8	2.1	2.9	-	-	-	-	-	-	-	-	1183	1183	1183	1183	1184	-	-	-	-	-	-	-	-	1,184
A6-1	Asia Netcom HK Limited	30	1.7	1.7	1.8	2.6	4.6	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1186	-	-	-	-	-	-	-	-	1,186
A6-2	Asia Netcom HK Limited	30	1.7	1.7	1.8	72.0	28.0	-	-	-	-	-	-	-	-	1183	1183	1183	1253	1209	-	-	-	-	-	-	-	-	1,253
A7	Mei Ah Centre	30	1.7	1.7	1.9	7.4	9.6	-	-	-	-	-	-	-	-	1183	1183	1183	1188	1191	-	-	-	-	-	-	-	-	1,191
A8	Wellcome Co. Ltd (Storage)	30	2.1	2.2	2.5	5.1	10.0	-	-	-	-	-	-	-	-	1183	1183	1183	1186	1191	-	-	-	-	-	-	-	-	1,191
A9	Hitachi Tseung Kwan O Centre	30	2.3	2.3	2.4	2.8	3.3	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1184	-	-	-	-	-	-	-	-	1,184
A10	Next Media Apple Daily	30	3.6	3.6	3.6	3.7	3.9	-	-	-	-	-	-	-	-	1185	1185	1185	1185	1185	-	-	-	-	-	-	-	-	1,185
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	4.6	4.6	4.7	5.2	6.0	-	-	-	-	-	-	-	-	1186	1186	1186	1186	1187	-	-	-	-	-	-	-	-	1,187
A12-1	TVB City	30	1.9	1.9	2.0	3.0	8.5	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1190	-	-	-	-	-	-	-	-	1,190
A12-2	TVB City	30	1.8	1.8	2.0	5.1	9.7	-	-	-	-	-	-	-	-	1183	1183	1183	1186	1191	-	-	-	-	-	-	-	-	1,191
A12-3	TVB City	30	2.0	2.0	2.8	17.7	27.1	-	-	-	-	-	-	-	-	1183	1183	1184	1199	1208	-	-	-	-	-	-	-	-	1,208
A13	Yan Hing Industrial Building	30	2.0	2.1	2.2	2.7	4.1	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1185	-	-	-	-	-	-	-	-	1,185
A14	Next Media Apple Daily	30	2.1	2.1	2.2	2.7	3.6	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1185	-	-	-	-	-	-	-	-	1,185
A15	Avery Dennison	30	2.3	2.3	2.4	2.5	2.9	-	-	-	-	-	-	-	-	1183	1183	1183	1184	1184	-	-	-	-	-	-	-	-	1,184
A16	Varitronix Limited	30	4.0	4.0	4.1	4.1	4.2	-	-	-	-	-	-	-	-	1185	1185	1185	1185	1185	-	-	-	-	-	-	-	-	1,185
A17	Committed HSBC Office	30	4.7	4.7	4.7	7.7	14.4	-	-	-	-	-	-	-	-	1186	1186	1186	1189	1195	-	-	-	-	-	-	-	-	1,195
A18	Eastern Pacific Electronics	30	6.5	6.5	6.5	6.6	6.6	-	-	-	-	-	-	-	-	1188	1188	1188	1188	1188	-	-	-	-	-	-	-	-	1,188
A19	Hospital Aided Primary &	30	7.7	7.7	7.9	12.1	19.9	-	-	-	-	-	-	-	-	1189	1189	1189	1193	1201	-	-	-	-	-	-	-	-	1,201
A20-1	LOHAS Park - 1	200	2.7	2.7	2.7	2.7	2.7	2.7	2.9	4.0	4.8	5.6	6.6	8.4	15.3	1184	1184	1184	1184	1184	1184	1184	1185	1186	1187	1188	1189	1196	1,196
A20-2	LOHAS Park - 2	200	4.2	4.2	4.2	4.3	4.3	4.4	4.4	4.8	5.3	5.5	5.4	7.0	14.7	1185	1185	1185	1185	1185	1185	1185	1186	1186	1186	1186	1188	1196	1,196
A20-3	LOHAS Park - 3	200	7.8	7.8	7.8	8.0	8.3	8.6	14.8	20.3	22.3	20.6	18.1	20.4	35.1	1189	1189	1189	1189	1189	1190	1196	1201	1203	1202	1199	1201	1216	1,216
A21	Chiaphua-Shinko Centre	30	6.9	6.9	6.9	6.9	6.9	-	-	-	-	-	-	-	-	1188	1188	1188	1188	1188	-	-	-	-	-	-	-	-	1,188

Sulphur Dioxide (SO2)

bg 19

Scenario 1 - Normal Condition (Biodiesel Plant (boiler) + HAECO + TKOIE emissions)

Table A4-15			Hourly (Biodiesel Plant - Boiler + HAECO + TKOIE Emission)													Hourly (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	12.8	13.8	16.9	32.3	60.5	-	-	-	-	-	-	-	-	31.8	32.8	35.9	51.3	79.5	-	-	-	-	-	-	-	-	79.5
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	8.6	10.0	14.3	32.2	65.5	-	-	-	-	-	-	-	-	27.6	29.0	33.3	51.2	84.5	-	-	-	-	-	-	-	-	84.5
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	6.4	6.6	8.4	16.3	26.2	-	-	-	-	-	-	-	-	25.4	25.6	27.4	35.3	45.2	-	-	-	-	-	-	-	-	45.2
A4	Hong Kong Aero Engine Services Ltd	30	6.6	6.7	7.2	17.4	29.4	-	-	-	-	-	-	-	-	25.6	25.7	26.2	36.4	48.4	-	-	-	-	-	-	-	-	48.4
A5	HAECO	30	7.5	7.5	7.6	8.0	11.4	-	-	-	-	-	-	-	-	26.5	26.5	26.6	27.0	30.4	-	-	-	-	-	-	-	-	30.4
A6-1	Asia Netcom HK Limited	30	8.6	8.6	8.8	9.4	24.1	-	-	-	-	-	-	-	-	27.6	27.6	27.8	28.4	43.1	-	-	-	-	-	-	-	-	43.1
A6-2	Asia Netcom HK Limited	30	8.1	8.2	8.5	205.0	176.4	-	-	-	-	-	-	-	-	27.1	27.2	27.5	224.0	195.4	-	-	-	-	-	-	-	-	224.0
A7	Mei Ah Centre	30	8.5	8.5	8.8	37.8	49.4	-	-	-	-	-	-	-	-	27.5	27.5	27.8	56.8	68.4	-	-	-	-	-	-	-	-	68.4
A8	Wellcome Co. Ltd (Storage)	30	7.1	7.1	7.4	18.3	35.6	-	-	-	-	-	-	-	-	26.1	26.1	26.4	37.3	54.6	-	-	-	-	-	-	-	-	54.6
A9	Hitachi Tseung Kwan O Centre	30	7.4	7.4	7.5	7.8	11.5	-	-	-	-	-	-	-	-	26.4	26.4	26.5	26.8	30.5	-	-	-	-	-	-	-	-	30.5
A10	Next Media Apple Daily	30	8.1	8.1	8.6	10.7	16.1	-	-	-	-	-	-	-	-	27.1	27.1	27.6	29.7	35.1	-	-	-	-	-	-	-	-	35.1
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	9.1	9.1	9.4	12.7	20.3	-	-	-	-	-	-	-	-	28.1	28.1	28.4	31.7	39.3	-	-	-	-	-	-	-	-	39.3
A12-1	TVB City	30	6.9	6.9	6.9	9.5	23.5	-	-	-	-	-	-	-	-	25.9	25.9	25.9	28.5	42.5	-	-	-	-	-	-	-	-	42.5
A12-2	TVB City	30	7.6	7.6	7.6	18.9	30.3	-	-	-	-	-	-	-	-	26.6	26.6	26.6	37.9	49.3	-	-	-	-	-	-	-	-	49.3
A12-3	TVB City	30	7.0	7.0	7.3	48.3	66.0	-	-	-	-	-	-	-	-	26.0	26.0	26.3	67.3	85.0	-	-	-	-	-	-	-	-	85.0
A13	Yan Hing Industrial Building	30	7.6	7.6	7.6	7.9	16.4	-	-	-	-	-	-	-	-	26.6	26.6	26.6	26.9	35.4	-	-	-	-	-	-	-	-	35.4
A14	Next Media Apple Daily	30	7.4	7.4	7.4	7.6	9.8	-	-	-	-	-	-	-	-	26.4	26.4	26.4	26.6	28.8	-	-	-	-	-	-	-	-	28.8
A15	Avery Dennison	30	5.9	5.9	5.9	9.1	16.6	-	-	-	-	-	-	-	-	24.9	24.9	24.9	28.1	35.6	-	-	-	-	-	-	-	-	35.6
A16	Varitronix Limited	30	8.5	8.6	9.0	10.5	18.2	-	-	-	-	-	-	-	-	27.5	27.6	28.0	29.5	37.2	-	-	-	-	-	-	-	-	37.2
A17	Committed HSBC Office	30	6.4	6.4	6.5	43.7	57.0	-	-	-	-	-	-	-	-	25.4	25.4	25.5	62.7	76.0	-	-	-	-	-	-	-	-	76.0
A18	Eastern Pacific Electronics	30	9.0	9.1	10.3	16.8	28.2	-	-	-	-	-	-	-	-	28.0	28.1	29.3	35.8	47.2	-	-	-	-	-	-	-	-	47.2
A19	Hospital Aided Primary &	30	8.2	8.3	8.6	22.9	39.3	-	-	-	-	-	-	-	-	27.2	27.3	27.6	41.9	58.3	-	-	-	-	-	-	-	-	58.3
A20-1	LOHAS Park - 1	200	6.9	6.9	6.9	8.2	11.3	29.0	56.2	73.1	65.6	41.1	17.6	11.6	10.0	25.9	25.9	25.9	27.2	30.3	48	75	92	85	60	37	31	29	92.1
A20-2	LOHAS Park - 2	200	7.0	7.0	7.2	7.9	11.1	16.6	22.7	31.4	32.0	28.7	23.0	16.2	20.0	26.0	26.0	26.2	26.9	30.1	35.6	41.7	50.4	51.0	47.7	42.0	35.2	39.0	51.0
A20-3	LOHAS Park - 3	200	6.7	6.7	7.0	8.8	12.2	27.6	48.7	65.7	67.2	52.6	40.9	29.4	27.0	25.7	25.7	26.0	27.8	31.2	46.6	67.7	84.7	86.2	71.6	59.9	48.4	46.0	86.2
A21	Chiaphua-Shinko Centre	30	7.5	7.5	7.6	11.4	20.4	-	-	-	-	-	-	-	-	26.5	26.5	26.6	30.4	39.4	-	-	-	-	-	-	-	-	39.4

Table A4-16			Daily (Biodiesel Plant - Boiler + HAECO + TKOIE Emission)													Daily (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	3.9	4.3	5.5	10.3	16.7	-	-	-	-	-	-	-	-	22.9	23.3	24.5	29.3	35.7	-	-	-	-	-	-	-	-	35.7
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	2.0	2.2	3.0	8.6	20.1	-	-	-	-	-	-	-	-	21.0	21.2	22.0	27.6	39.1	-	-	-	-	-	-	-	-	39.1
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	1.4	1.4	1.6	2.8	4.1	-	-	-	-	-	-	-	-	20.4	20.4	20.6	21.8	23.1	-	-	-	-	-	-	-	-	23.1
A4	Hong Kong Aero Engine Services Ltd	30	0.9	0.9	0.9	3.1	5.0	-	-	-	-	-	-	-	-	19.9	19.9	19.9	22.1	24.0	-	-	-	-	-	-	-	-	24.0
A5	HAECO	30	1.0	1.0	1.0	1.3	1.7	-	-	-	-	-	-	-	-	20.0	20.0	20.0	20.3	20.7	-	-	-	-	-	-	-	-	20.7
A6-1	Asia Netcom HK Limited	30	0.8	0.8	0.9	1.4	2.7	-	-	-	-	-	-	-	-	19.8	19.8	19.9	20.4	21.7	-	-	-	-	-	-	-	-	21.7
A6-2	Asia Netcom HK Limited	30	1.0	1.0	1.0	43.5	22.8	-	-	-	-	-	-	-	-	20.0	20.0	20.0	62.5	41.8	-	-	-	-	-	-	-	-	62.5
A7	Mei Ah Centre	30	1.1	1.1	1.2	3.8	4.7	-	-	-	-	-	-	-	-	20.1	20.1	20.2	22.8	23.7	-	-	-	-	-	-	-	-	23.7
A8	Wellcome Co. Ltd (Storage)	30	1.0	1.0	1.1	2.4	4.8	-	-	-	-	-	-	-	-	20.0	20.0	20.1	21.4	23.8	-	-	-	-	-	-	-	-	23.8
A9	Hitachi Tseung Kwan O Centre	30	1.3	1.4	1.4	1.7	2.1	-	-	-	-	-	-	-	-	20.3	20.4	20.4	20.7	21.1	-	-	-	-	-	-	-	-	21.1
A10	Next Media Apple Daily	30	1.4	1.4	1.5	1.8	2.5	-	-	-	-	-	-	-	-	20.4	20.4	20.5	20.8	21.5	-	-	-	-	-	-	-	-	21.5
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	2.7	2.7	2.8	3.7	5.4	-	-	-	-	-	-	-	-	21.7	21.7	21.8	22.7	24.4	-	-	-	-	-	-	-	-	24.4
A12-1	TVB City	30	1.6	1.6	1.7	2.2	4.8	-	-	-	-	-	-	-	-	20.6	20.6	20.7	21.2	23.8	-	-	-	-	-	-	-	-	23.8
A12-2	TVB City	30	1.0	1.0	1.1	2.4	5.9	-	-	-	-	-	-	-	-	20.0	20.0	20.1	21.4	24.9	-	-	-	-	-	-	-	-	24.9
A12-3	TVB City	30	1.1	1.1	1.4	10.1	16.2	-	-	-	-	-	-	-	-	20.1	20.1	20.4	29.1	35.2	-	-	-	-	-	-	-	-	35.2
A13	Yan Hing Industrial Building	30	1.1	1.1	1.2	1.6	2.3	-	-	-	-	-	-	-	-	20.1	20.1	20.2	20.6	21.3	-	-	-	-	-	-	-	-	21.3
A14	Next Media Apple Daily	30	1.2	1.2	1.2	1.5	2.0	-	-	-	-	-	-	-	-	20.2	20.2	20.2	20.5	21.0	-	-	-	-	-	-	-	-	21.0
A15	Avery Dennison	30	1.2	1.2	1.3	1.6	2.3	-	-	-	-	-	-	-	-	20.2	20.2	20.3	20.6	21.3	-	-	-	-	-	-	-	-	21.3
A16	Varitronix Limited	30	1.6	1.6	1.7	2.2	3.0	-	-	-	-	-	-	-	-	20.6	20.6	20.7	21.2	22.0	-	-	-	-	-	-	-	-	22.0
A17	Committed HSBC Office	30	1.1	1.2	1.2	4.0	8.0	-	-	-	-	-	-	-	-	20.1	20.2	20.2	23.0	27.0	-	-	-	-	-	-	-	-	27.0
A18	Eastern Pacific Electronics	30	2.9	3.0	3.3	4.5	6.4	-	-	-	-	-	-	-	-	21.9	22.0	22.3	23.5	25.4	-	-	-	-	-	-	-	-	25.4
A19	Hospital Aided Primary &	30	2.8	2.9	3.4	7.8	13.2	-	-	-	-	-	-	-	-	21.8	21.9	22.4	26.8	32.2	-	-	-	-	-	-	-	-	32.2
A20-1	LOHAS Park - 1	200	1.4	1.4	1.4	1.6	2.3	3.9	6.2	7.5	6.6	4.3	2.5	1.7	1.5	20.4	20.4	20.4	20.6	21.3	22.9	25.2	26.5	25.6	23.3	21.5	20.7	20.5	26.5
A20-2	LOHAS Park - 2	200	2.5	2.5	2.6	2.9	3.4	4.1	4.7	5.1	5.1	4.7	4.1	3.3	2.4	21.5	21.5	21.6	21.9	22.4	23.1	23.7	24.1	24.1	23.7	23.1	22.3	21.4	24.1
A20-3	LOHAS Park - 3	200	2.8	2.8	2.9	3.3	3.9	4.4	7.3	9.7	10.1	8.3	5.8	5.0	4.3	21.8	21.8	21.9	22.3	22.9	23.4	26.3	28.7	29.1	27.3	24.8	24.0	23.3	29.1
A21	Chiaphua-Shinko Centre	30	3.5	3.5	3.7	4.2	4.8	-	-	-	-	-	-	-	-	22.5	22.5	22.7	23.2	23.8	-	-	-	-	-	-	-	-	23.8

Table A4-17			Annual Average (Biodiesel Plant - Boiler + HAECO + TKOIE Emission)													Annual Average (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	0.92	1.00	1.27	2.39	4.24	-	-	-	-	-	-	-	-	19.92	20.00	20.27	21.39	23.24	-	-	-	-	-	-	-	-	23.24
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.57	0.62	0.82	1.79	3.75	-	-	-	-	-	-	-	-	19.57	19.62	19.82	20.79	22.75	-	-	-	-	-	-	-	-	22.75
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.31	0.32	0.35	0.48	0.76	-	-	-	-	-	-	-	-	19.31	19.32	19.35	19.48	19.76	-	-	-	-	-	-	-	-	19.76
A4	Hong Kong Aero Engine Services Ltd	30	0.23	0.25	0.31	0.68	1.45	-	-	-	-	-	-	-	-	19.23	19.25	19.31	19.68	20.45	-	-	-	-	-	-	-	-	20.45
A5	HAECO	30	0.20	0.21	0.23	0.34	0.57	-	-	-	-	-	-	-	-	19.20	19.21	19.23	19.34	19.57	-	-	-	-	-	-	-	-	19.57
A6-1	Asia Netcom HK Limited	30	0.25	0.26	0.28	0.39	0.62	-	-	-	-	-	-	-	-	19.25	19.26	19.28	19.39	19.62	-	-	-	-	-	-	-	-	19.62
A6-2	Asia Netcom HK Limited	30	0.23	0.24	0.30	2.62	3.24	-	-	-	-	-	-	-	-	19.23	19.24	19.30	21.62	22.24	-	-	-	-	-	-	-	-	22.24
A7	Mei Ah Centre	30	0.23	0.23	0.25	0.32	0.52	-	-	-	-	-	-	-	-	19.23	19.23	19.25	19.32	19.52	-	-	-	-	-	-	-	-	19.52
A8	Wellcome Co. Ltd (Storage)	30	0.26	0.27	0.29	0.46	0.80	-	-	-	-	-	-	-	-	19.26	19.27	19.29	19.46	19.80	-	-	-	-	-	-	-	-	19.80
A9	Hitachi Tseung Kwan O Centre	30	0.26	0.27	0.28	0.33	0.42	-	-	-	-	-	-	-	-	19.26	19.27	19.28	19.33	19.42	-	-	-	-	-	-	-	-	19.42
A10	Next Media Apple Daily	30	0.29	0.30	0.31	0.38	0.52	-	-	-	-	-	-	-	-	19.29	19.30	19.31	19.38	19.52	-	-	-	-	-	-	-	-	19.52
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.57	0.59	0.63	0.84	1.24	-	-	-	-	-	-	-	-	19.57	19.59	19.63	19.84	20.24	-	-	-	-	-	-	-	-	20.24
A12-1	TVB City	30	0.22	0.23	0.27	0.48	0.92	-	-	-	-	-	-	-	-	19.22	19.23	19.27	19.48	19.92	-	-	-	-	-	-	-	-	19.92
A12-2	TVB City	30	0.15	0.17	0.22	0.59	1.39	-	-	-	-	-	-	-	-	19.15	19.17	19.22	19.59	20.39	-	-	-	-	-	-	-	-	20.39
A12-3	TVB City	30	0.16	0.18	0.23	0.70	1.61	-	-	-	-	-	-	-	-	19.16	19.18	19.23	19.70	20.61	-	-	-	-	-	-	-	-	20.61
A13	Yan Hing Industrial Building	30	0.22	0.22	0.24	0.31	0.47	-	-	-	-	-	-	-	-	19.22	19.22	19.24	19.31	19.47	-	-	-	-	-	-	-	-	19.47
A14	Next Media Apple Daily	30	0.22	0.22	0.23	0.28	0.37	-	-	-	-	-	-	-	-	19.22	19.22	19.23	19.28	19.37	-	-	-	-	-	-	-	-	19.37
A15	Avery Dennison	30	0.23	0.24	0.25	0.29	0.39	-	-	-	-	-	-	-	-	19.23	19.24	19.25	19.29	19.39	-	-	-	-	-	-	-	-	19.39
A16	Varitronix Limited	30	0.30	0.30	0.33	0.44	0.65	-	-	-	-	-	-	-	-	19.30	19.30	19.33	19.44	19.65	-	-	-	-	-	-	-	-	19.65
A17	Committed HSBC Office	30	0.21	0.22	0.28	0.83	1.89	-	-	-	-	-	-	-	-	19.21	19.22	19.28	19.83	20.89	-	-	-	-	-	-	-	-	20.89
A18	Eastern Pacific Electronics	30	0.47	0.48	0.51	0.66	0.89	-	-	-	-	-	-	-	-	19.47	19.48	19.51	19.66	19.89	-	-	-	-	-	-	-	-	19.89
A19	Hospital Aided Primary &	30	0.45	0.47	0.51	0.80	1.39	-	-	-	-	-	-	-	-	19.45	19.47	19.51	19.80	20.39	-	-	-	-	-	-	-	-	20.39
A20-1	LOHAS Park - 1	200	0.20	0.20	0.20	0.22	0.26	0.35	0.47	0.54	0.52	0.43	0.34	0.27	0.21	19.20	19.20	19.20	19.22	19.26	19.35	19.47	19.54	19.52	19.43	19.34	19.27	19.21	19.54
A20-2	LOHAS Park - 2	200	0.33	0.34	0.34	0.37	0.42	0.48	0.56	0.61	0.61	0.57	0.50	0.44	0.36	19.33	19.34	19.34	19.37	19.42	19.48	19.56	19.61	19.61	19.57	19.50	19.44	19.36	19.61
A20-3	LOHAS Park - 3	200	0.45	0.45	0.46	0.52	0.61	0.75	0.91	1.04	1.08	1.02	0.92	0.82	0.67	19.45	19.45	19.46	19.52	19.61	19.75	19.91	20.04	20.08	20.02	19.92	19.82	19.67	20.08
A21	Chiaphua-Shinko Centre	30	0.43	0.43	0.44	0.48	0.56	-	-	-	-	-	-	-	-	19.43	19.43	19.44	19.48	19.56	-	-	-	-	-	-	-	-	19.56

Scenario 2 - Emergency Condition (Biodiesel Plant (biogas flare) + HAECO + TKOIE emissions)

Table A4-18			Hourly (Biodiesel Plant - Biogas Flare + HAECO + TKOIE Emission)													Hourly (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	3.5	3.5	3.5	9.6	24.8	-	-	-	-	-	-	-	-	22.5	22.5	22.5	28.6	43.8	-	-	-	-	-	-	-	-	43.8
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	3.6	3.6	3.6	4.3	9.8	-	-	-	-	-	-	-	-	22.6	22.6	22.6	23.3	28.8	-	-	-	-	-	-	-	-	28.8
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	4.8	4.9	5.1	9.1	15.3	-	-	-	-	-	-	-	-	23.8	23.9	24.1	28.1	34.3	-	-	-	-	-	-	-	-	34.3
A4	Hong Kong Aero Engine Services Ltd	30	4.5	4.6	4.8	17.4	29.4	-	-	-	-	-	-	-	-	23.5	23.6	23.8	36.4	48.4	-	-	-	-	-	-	-	-	48.4
A5	HAECO	30	5.6	5.6	5.7	6.2	11.4	-	-	-	-	-	-	-	-	24.6	24.6	24.7	25.2	30.4	-	-	-	-	-	-	-	-	30.4
A6-1	Asia Netcom HK Limited	30	4.8	4.9	5.0	9.2	24.1	-	-	-	-	-	-	-	-	23.8	23.9	24.0	28.2	43.1	-	-	-	-	-	-	-	-	43.1
A6-2	Asia Netcom HK Limited	30	4.9	5.0	5.7	205.0	176.4	-	-	-	-	-	-	-	-	23.9	24.0	24.7	224.0	195.4	-	-	-	-	-	-	-	-	224.0
A7	Mei Ah Centre	30	4.9	5.0	5.9	35.3	45.6	-	-	-	-	-	-	-	-	23.9	24.0	24.9	54.3	64.6	-	-	-	-	-	-	-	-	64.6
A8	Wellcome Co. Ltd (Storage)	30	4.0	4.1	4.3	18.3	35.6	-	-	-	-	-	-	-	-	23.0	23.1	23.3	37.3	54.6	-	-	-	-	-	-	-	-	54.6
A9	Hitachi Tseung Kwan O Centre	30	3.1	3.1	3.2	3.5	5.1	-	-	-	-	-	-	-	-	22.1	22.1	22.2	22.5	24.1	-	-	-	-	-	-	-	-	24.1
A10	Next Media Apple Daily	30	3.1	3.1	3.1	3.4	6.6	-	-	-	-	-	-	-	-	22.1	22.1	22.1	22.4	25.6	-	-	-	-	-	-	-	-	25.6
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	3.9	4.0	4.4	8.8	19.5	-	-	-	-	-	-	-	-	22.9	23.0	23.4	27.8	38.5	-	-	-	-	-	-	-	-	38.5
A12-1	TVB City	30	5.0	5.0	5.1	9.5	23.5	-	-	-	-	-	-	-	-	24.0	24.0	24.1	28.5	42.5	-	-	-	-	-	-	-	-	42.5
A12-2	TVB City	30	5.2	5.3	5.5	18.9	30.3	-	-	-	-	-	-	-	-	24.2	24.3	24.5	37.9	49.3	-	-	-	-	-	-	-	-	49.3
A12-3	TVB City	30	4.3	4.3	7.3	48.3	66.0	-	-	-	-	-	-	-	-	23.3	23.3	26.3	67.3	85.0	-	-	-	-	-	-	-	-	85.0
A13	Yan Hing Industrial Building	30	4.3	4.4	4.5	7.4	16.4	-	-	-	-	-	-	-	-	23.3	23.4	23.5	26.4	35.4	-	-	-	-	-	-	-	-	35.4
A14	Next Media Apple Daily	30	3.5	3.5	3.5	4.2	6.2	-	-	-	-	-	-	-	-	22.5	22.5	22.5	23.2	25.2	-	-	-	-	-	-	-	-	25.2
A15	Avery Dennison	30	3.1	3.1	3.1	4.0	5.7	-	-	-	-	-	-	-	-	22.1	22.1	22.1	23.0	24.7	-	-	-	-	-	-	-	-	24.7
A16	Varitronix Limited	30	3.2	3.2	3.2	4.1	8.1	-	-	-	-	-	-	-	-	22.2	22.2	22.2	23.1	27.1	-	-	-	-	-	-	-	-	27.1
A17	Committed HSBC Office	30	3.6	3.7	6.5	43.7	57.0	-	-	-	-	-	-	-	-	22.6	22.7	25.5	62.7	76.0	-	-	-	-	-	-	-	-	76.0
A18	Eastern Pacific Electronics	30	4.5	4.5	4.6	6.3	17.6	-	-	-	-	-	-	-	-	23.5	23.5	23.6	25.3	36.6	-	-	-	-	-	-	-	-	36.6
A19	Hospital Aided Primary &	30	5.9	6.1	7.5	22.9	38.9	-	-	-	-	-	-	-	-	24.9	25.1	26.5	41.9	57.9	-	-	-	-	-	-	-	-	57.9
A20-1	LOHAS Park - 1	200	3.8	3.8	3.8	3.8	7.8	14.0	20.9	25.8	26.4	22.4	16.0	10.1	10.0	22.8	22.8	22.8	22.8	26.8	33.0	39.9	44.8	45.4	41.4	35.0	29.1	29.0	45.4
A20-2	LOHAS Park - 2	200	6.1	6.2	6.3	6.7	9.4	15.4	22.7	31.4	32.0	28.7	23.0	16.2	20.0	25.1	25.2	25.3	25.7	28.4	34.4	41.7	50.4	51.0	47.7	42.0	35.2	39.0	51.0
A20-3	LOHAS Park - 3	200	6.6	6.6	6.9	8.8	12.2	27.6	48.7	65.7	67.2	52.6	40.9	29.4	27.0	25.6	25.6	25.9	27.8	31.2	46.6	67.7	84.7	86.2	71.6	59.9	48.4	46.0	86.2
A21	Chiaphua-Shinko Centre	30	7.3	7.4	7.6	8.3	15.6	-	-	-	-	-	-	-	-	26.3	26.4	26.6	27.3	34.6	-	-	-	-	-	-	-	-	34.6

Table A4-19			Daily (Biodiesel Plant - Biogas Flare + HAECO + TKOIE Emission)													Daily (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background)													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	1.16	1.16	1.19	2.15	4.86	-	-	-	-	-	-	-	-	20.2	20.2	20.2	21.1	23.9	-	-	-	-	-	-	-	-	23.9
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	1.13	1.14	1.16	1.23	1.63	-	-	-	-	-	-	-	-	20.1	20.1	20.2	20.2	20.6	-	-	-	-	-	-	-	-	20.6
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	1.35	1.39	1.54	2.11	2.69	-	-	-	-	-	-	-	-	20.4	20.4	20.5	21.1	21.7	-	-	-	-	-	-	-	-	21.7
A4	Hong Kong Aero Engine Services Ltd	30	0.74	0.76	0.90	3.12	5.02	-	-	-	-	-	-	-	-	19.7	19.8	19.9	22.1	24.0	-	-	-	-	-	-	-	-	24.0
A5	HAECO	30	0.75	0.76	0.80	0.98	1.43	-	-	-	-	-	-	-	-	19.8	19.8	19.8	20.0	20.4	-	-	-	-	-	-	-	-	20.4
A6-1	Asia Netcom HK Limited	30	0.76	0.80	0.92	1.41	2.68	-	-	-	-	-	-	-	-	19.8	19.8	19.9	20.4	21.7	-	-	-	-	-	-	-	-	21.7
A6-2	Asia Netcom HK Limited	30	0.69	0.69	0.86	43.49	22.77	-	-	-	-	-	-	-	-	19.7	19.7	19.9	62.5	41.8	-	-	-	-	-	-	-	-	62.5
A7	Mei Ah Centre	30	0.86	0.86	0.89	3.50	4.50	-	-	-	-	-	-	-	-	19.9	19.9	19.9	22.5	23.5	-	-	-	-	-	-	-	-	23.5
A8	Wellcome Co. Ltd (Storage)	30	0.91	0.94	1.08	2.36	4.84	-	-	-	-	-	-	-	-	19.9	19.9	20.1	21.4	23.8	-	-	-	-	-	-	-	-	23.8
A9	Hitachi Tseung Kwan O Centre	30	1.12	1.13	1.15	1.24	1.37	-	-	-	-	-	-	-	-	20.1	20.1	20.2	20.2	20.4	-	-	-	-	-	-	-	-	20.4
A10	Next Media Apple Daily	30	1.12	1.12	1.14	1.18	1.30	-	-	-	-	-	-	-	-	20.1	20.1	20.1	20.2	20.3	-	-	-	-	-	-	-	-	20.3
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	1.17	1.18	1.21	1.87	3.87	-	-	-	-	-	-	-	-	20.2	20.2	20.2	20.9	22.9	-	-	-	-	-	-	-	-	22.9
A12-1	TVB City	30	0.80	0.81	0.84	1.65	4.80	-	-	-	-	-	-	-	-	19.8	19.8	19.8	20.6	23.8	-	-	-	-	-	-	-	-	23.8
A12-2	TVB City	30	0.91	0.93	1.02	2.44	5.89	-	-	-	-	-	-	-	-	19.9	19.9	20.0	21.4	24.9	-	-	-	-	-	-	-	-	24.9
A12-3	TVB City	30	1.12	1.13	1.43	10.11	16.22	-	-	-	-	-	-	-	-	20.1	20.1	20.4	29.1	35.2	-	-	-	-	-	-	-	-	35.2
A13	Yan Hing Industrial Building	30	1.12	1.14	1.20	1.63	2.27	-	-	-	-	-	-	-	-	20.1	20.1	20.2	20.6	21.3	-	-	-	-	-	-	-	-	21.3
A14	Next Media Apple Daily	30	1.18	1.19	1.23	1.51	2.05	-	-	-	-	-	-	-	-	20.2	20.2	20.2	20.5	21.0	-	-	-	-	-	-	-	-	21.0
A15	Avery Dennison	30	1.17	1.18	1.19	1.33	1.54	-	-	-	-	-	-	-	-	20.2	20.2	20.2	20.3	20.5	-	-	-	-	-	-	-	-	20.5
A16	Varitronix Limited	30	1.12	1.13	1.13	1.16	1.34	-	-	-	-	-	-	-	-	20.1	20.1	20.1	20.2	20.3	-	-	-	-	-	-	-	-	20.3
A17	Committed HSBC Office	30	1.05	1.05	1.06	4.04	7.96	-	-	-	-	-	-	-	-	20.1	20.1	20.1	23.0	27.0	-	-	-	-	-	-	-	-	27.0
A18	Eastern Pacific Electronics	30	1.60	1.61	1.62	1.75	1.96	-	-	-	-	-	-	-	-	20.6	20.6	20.6	20.8	21.0	-	-	-	-	-	-	-	-	21.0
A19	Hospital Aided Primary &	30	2.12	2.21	2.58	6.57	11.55	-	-	-	-	-	-	-	-	21.1	21.2	21.6	25.6	30.5	-	-	-	-	-	-	-	-	30.5
A20-1	LOHAS Park - 1	200	0.99	1.00	1.07	1.32	1.56	1.64	2.05	2.62	2.73	2.36	1.78	1.31	1.24	20.0	20.0	20.1	20.3	20.6	20.6	21.1	21.6	21.7	21.4	20.8	20.3	20.2	21.7
A20-2	LOHAS Park - 2	200	1.30	1.30	1.31	1.36	1.44	1.65	2.31	2.97	3.13	2.71	2.27	1.99	2.00	20.3	20.3	20.3	20.4	20.4	20.6	21.3	22.0	22.1	21.7	21.3	21.0	21.0	22.1
A20-3	LOHAS Park - 3	200	2.17	2.19	2.25	2.49	2.85	3.86	6.63	8.96	9.43	7.89	5.61	4.99	4.14	21.2	21.2	21.3	21.5	21.8	22.9	25.6	28.0	28.4	26.9	24.6	24.0	23.1	28.4
A21	Chiaphua-Shinko Centre	30	1.97	1.97	1.98	2.14	2.54	-	-	-	-	-	-	-	-	21.0	21.0	21.0	21.1	21.5	-	-	-	-	-	-	-	-	21.5

Table A4-20

ASRs	Description	Approx. Maximum height of bldg (m above gd)	Annual Average (Biodiesel Plant - Biogas Flare + HAECO + TKOIE Emission) 1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m
A1	Gammon Skanka	30	0.478	0.488	0.524	0.682	0.973	-	-	-	-	-	-	-	-
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.407	0.416	0.445	0.575	0.818	-	-	-	-	-	-	-	-
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.294	0.301	0.323	0.424	0.619	-	-	-	-	-	-	-	-
A4	Hong Kong Aero Engine Services Ltd	30	0.221	0.235	0.293	0.669	1.417	-	-	-	-	-	-	-	-
A5	HAECO	30	0.184	0.191	0.215	0.320	0.523	-	-	-	-	-	-	-	-
A6-1	Asia Netcom HK Limited	30	0.240	0.246	0.267	0.368	0.574	-	-	-	-	-	-	-	-
A6-2	Asia Netcom HK Limited	30	0.215	0.220	0.281	2.599	3.178	-	-	-	-	-	-	-	-
A7	Mei Ah Centre	30	0.215	0.219	0.232	0.303	0.456	-	-	-	-	-	-	-	-
A8	Wellcome Co. Ltd (Storage)	30	0.245	0.252	0.281	0.440	0.771	-	-	-	-	-	-	-	-
A9	Hitachi Tseung Kwan O Centre	30	0.253	0.256	0.266	0.309	0.392	-	-	-	-	-	-	-	-
A10	Next Media Apple Daily	30	0.272	0.276	0.291	0.353	0.469	-	-	-	-	-	-	-	-
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.337	0.346	0.376	0.521	0.811	-	-	-	-	-	-	-	-
A12-1	TVB City	30	0.188	0.199	0.237	0.435	0.843	-	-	-	-	-	-	-	-
A12-2	TVB City	30	0.142	0.156	0.211	0.566	1.294	-	-	-	-	-	-	-	-
A12-3	TVB City	30	0.153	0.164	0.219	0.681	1.582	-	-	-	-	-	-	-	-
A13	Yan Hing Industrial Building	30	0.201	0.205	0.222	0.294	0.430	-	-	-	-	-	-	-	-
A14	Next Media Apple Daily	30	0.210	0.213	0.223	0.266	0.347	-	-	-	-	-	-	-	-
A15	Avery Dennison	30	0.223	0.226	0.234	0.271	0.341	-	-	-	-	-	-	-	-
A16	Varitronix Limited	30	0.243	0.249	0.268	0.353	0.518	-	-	-	-	-	-	-	-
A17	Committed HSBC Office	30	0.179	0.191	0.250	0.787	1.836	-	-	-	-	-	-	-	-
A18	Eastern Pacific Electronics	30	0.250	0.252	0.262	0.308	0.404	-	-	-	-	-	-	-	-
A19	Hospital Aided Primary &	30	0.332	0.341	0.378	0.616	1.106	-	-	-	-	-	-	-	-
A20-1	LOHAS Park - 1	200	0.142	0.142	0.145	0.157	0.182	0.220	0.267	0.303	0.311	0.289	0.252	0.219	0.183
A20-2	LOHAS Park - 2	200	0.182	0.183	0.186	0.200	0.227	0.271	0.327	0.376	0.394	0.378	0.346	0.318	0.286
A20-3	LOHAS Park - 3	200	0.346	0.350	0.360	0.404	0.485	0.606	0.751	0.874	0.926	0.897	0.822	0.742	0.616
A21	Chiaphua-Shinko Centre	30	0.317	0.318	0.321	0.331	0.348	-	-	-	-	-	-	-	-

ASRs	Description	Annual Average (Biodiesel Plant - Boiler + HAECO + TKOIE Emission + Background) 1.5m	5m	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m	120m	Highest
A1	Gammon Skanka	19.48	19.49	19.52	19.68	19.97	-	-	-	-	-	-	-	-	19.97
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	19.41	19.42	19.44	19.58	19.82	-	-	-	-	-	-	-	-	19.82
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	19.29	19.30	19.32	19.42	19.62	-	-	-	-	-	-	-	-	19.62
A4	Hong Kong Aero Engine Services Ltd	19.22	19.24	19.29	19.67	20.42	-	-	-	-	-	-	-	-	20.42
A5	HAECO	19.18	19.19	19.21	19.32	19.52	-	-	-	-	-	-	-	-	19.52
A6-1	Asia Netcom HK Limited	19.24	19.25	19.27	19.37	19.57	-	-	-	-	-	-	-	-	19.57
A6-2	Asia Netcom HK Limited	19.22	19.22	19.28	21.60	22.18	-	-	-	-	-	-	-	-	22.18
A7	Mei Ah Centre	19.22	19.22	19.23	19.30	19.46	-	-	-	-	-	-	-	-	19.46
A8	Wellcome Co. Ltd (Storage)	19.24	19.25	19.28	19.44	19.77	-	-	-	-	-	-	-	-	19.77
A9	Hitachi Tseung Kwan O Centre	19.25	19.26	19.27	19.31	19.39	-	-	-	-	-	-	-	-	19.39
A10	Next Media Apple Daily	19.27	19.28	19.29	19.35	19.47	-	-	-	-	-	-	-	-	19.47
A11	Hong Kong Oxygen Acetylene Co. Ltd	19.34	19.35	19.38	19.52	19.81	-	-	-	-	-	-	-	-	19.81
A12-1	TVB City	19.19	19.20	19.24	19.44	19.84	-	-	-	-	-	-	-	-	19.84
A12-2	TVB City	19.14	19.16	19.21	19.57	20.29	-	-	-	-	-	-	-	-	20.29
A12-3	TVB City	19.15	19.16	19.22	19.68	20.58	-	-	-	-	-	-	-	-	20.58
A13	Yan Hing Industrial Building	19.20	19.21	19.22	19.29	19.43	-	-	-	-	-	-	-	-	19.43
A14	Next Media Apple Daily	19.21	19.21	19.22	19.27	19.35	-	-	-	-	-	-	-	-	19.35
A15	Avery Dennison	19.22	19.23	19.23	19.27	19.34	-	-	-	-	-	-	-	-	19.34
A16	Varitronix Limited	19.24	19.25	19.27	19.35	19.52	-	-	-	-	-	-	-	-	19.52
A17	Committed HSBC Office	19.18	19.19	19.25	19.79	20.84	-	-	-	-	-	-	-	-	20.84
A18	Eastern Pacific Electronics	19.25	19.25	19.26	19.31	19.40	-	-	-	-	-	-	-	-	19.40
A19	Hospital Aided Primary &	19.33	19.34	19.38	19.62	20.11	-	-	-	-	-	-	-	-	20.11
A20-1	LOHAS Park - 1	19.14	19.14	19.15	19.16	19.18	19.22	19.27	19.30	19.31	19.29	19.25	19.22	19.18	19.31
A20-2	LOHAS Park - 2	19.18	19.18	19.19	19.20	19.23	19.27	19.33	19.38	19.39	19.38	19.35	19.32	19.29	19.39
A20-3	LOHAS Park - 3	19.35	19.35	19.36	19.40	19.49	19.61	19.75	19.87	19.93	19.90	19.82	19.74	19.62	19.93
A21	Chiaphua-Shinko Centre	19.32	19.32	19.32	19.33	19.35	-	-	-	-	-	-	-	-	19.35

Acetyldehyde

URF 2.70E-06

Table A4-21			Annual Average (Biodiesel Plant - Process Building)														Individual Risk													Highest	
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Chronic Ref. Conc.**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Conc.**	**Risk**
A1	Gammon Skanka	30	0.860	0.906	1.033	1.272	1.139	-	-	-	-	-	-	-	-	9	2.3E-06	2.4E-06	2.8E-06	3.4E-06	3.1E-06	-	-	-	-	-	-	-	-	1.27	3.43E-06
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.830	1.030	1.622	2.895	2.431	-	-	-	-	-	-	-	-	9	2.2E-06	2.8E-06	4.4E-06	7.8E-06	6.6E-06	-	-	-	-	-	-	-	-	2.90	7.82E-06
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.300	0.303	0.311	0.319	0.284	-	-	-	-	-	-	-	-	9	8.1E-07	8.2E-07	8.4E-07	8.6E-07	7.7E-07	-	-	-	-	-	-	-	-	0.32	8.61E-07
A4	Hong Kong Aero Engine Services Ltd	30	0.103	0.103	0.102	0.098	0.086	-	-	-	-	-	-	-	-	9	2.8E-07	2.8E-07	2.8E-07	2.6E-07	2.3E-07	-	-	-	-	-	-	-	-	0.10	2.78E-07
A5	HAECO	30	0.105	0.105	0.104	0.099	0.087	-	-	-	-	-	-	-	-	9	2.8E-07	2.8E-07	2.8E-07	2.7E-07	2.3E-07	-	-	-	-	-	-	-	-	0.10	2.83E-07
A6-1	Asia Netcom HK Limited	30	0.085	0.085	0.084	0.081	0.071	-	-	-	-	-	-	-	-	9	2.3E-07	2.3E-07	2.3E-07	2.2E-07	1.9E-07	-	-	-	-	-	-	-	-	0.08	2.28E-07
A6-2	Asia Netcom HK Limited	30	0.076	0.076	0.075	0.072	0.063	-	-	-	-	-	-	-	-	9	2.0E-07	2.0E-07	2.0E-07	1.9E-07	1.7E-07	-	-	-	-	-	-	-	-	0.08	2.05E-07
A7	Mei Ah Centre	30	0.062	0.062	0.061	0.058	0.051	-	-	-	-	-	-	-	-	9	1.7E-07	1.7E-07	1.7E-07	1.6E-07	1.4E-07	-	-	-	-	-	-	-	-	0.06	1.67E-07
A8	Wellcome Co. Ltd (Storage)	30	0.051	0.051	0.050	0.048	0.042	-	-	-	-	-	-	-	-	9	1.4E-07	1.4E-07	1.4E-07	1.3E-07	1.1E-07	-	-	-	-	-	-	-	-	0.05	1.37E-07
A9	Hitachi Tseung Kwan O Centre	30	0.036	0.036	0.035	0.034	0.030	-	-	-	-	-	-	-	-	9	9.7E-08	9.6E-08	9.6E-08	9.1E-08	8.0E-08	-	-	-	-	-	-	-	-	0.04	9.65E-08
A10	Next Media Apple Daily	30	0.041	0.041	0.040	0.038	0.034	-	-	-	-	-	-	-	-	9	1.1E-07	1.1E-07	1.1E-07	1.0E-07	9.1E-08	-	-	-	-	-	-	-	-	0.04	1.10E-07
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.154	0.155	0.158	0.160	0.142	-	-	-	-	-	-	-	-	9	4.2E-07	4.2E-07	4.3E-07	4.3E-07	3.8E-07	-	-	-	-	-	-	-	-	0.16	4.31E-07
A12-1	TVB City	30	0.155	0.155	0.154	0.146	0.127	-	-	-	-	-	-	-	-	9	4.2E-07	4.2E-07	4.1E-07	3.9E-07	3.4E-07	-	-	-	-	-	-	-	-	0.16	4.19E-07
A12-2	TVB City	30	0.069	0.069	0.068	0.064	0.056	-	-	-	-	-	-	-	-	9	1.9E-07	1.9E-07	1.8E-07	1.7E-07	1.5E-07	-	-	-	-	-	-	-	-	0.07	1.86E-07
A12-3	TVB City	30	0.065	0.065	0.064	0.061	0.053	-	-	-	-	-	-	-	-	9	1.8E-07	1.8E-07	1.7E-07	1.6E-07	1.4E-07	-	-	-	-	-	-	-	-	0.07	1.76E-07
A13	Yan Hing Industrial Building	30	0.048	0.048	0.048	0.045	0.040	-	-	-	-	-	-	-	-	9	1.3E-07	1.3E-07	1.3E-07	1.2E-07	1.1E-07	-	-	-	-	-	-	-	-	0.05	1.30E-07
A14	Next Media Apple Daily	30	0.036	0.036	0.036	0.034	0.030	-	-	-	-	-	-	-	-	9	9.8E-08	9.7E-08	9.6E-08	9.1E-08	8.0E-08	-	-	-	-	-	-	-	-	0.04	9.77E-08
A15	Avery Dennison	30	0.026	0.026	0.026	0.024	0.021	-	-	-	-	-	-	-	-	9	7.0E-08	7.0E-08	6.9E-08	6.6E-08	5.8E-08	-	-	-	-	-	-	-	-	0.03	7.00E-08
A16	Varitronix Limited	30	0.056	0.056	0.056	0.053	0.046	-	-	-	-	-	-	-	-	9	1.5E-07	1.5E-07	1.5E-07	1.4E-07	1.2E-07	-	-	-	-	-	-	-	-	0.06	1.52E-07
A17	Committed HSBC Office	30	0.053	0.053	0.052	0.049	0.043	-	-	-	-	-	-	-	-	9	1.4E-07	1.4E-07	1.4E-07	1.3E-07	1.2E-07	-	-	-	-	-	-	-	-	0.05	1.44E-07
A18	Eastern Pacific Electronics	30	0.111	0.111	0.109	0.102	0.090	-	-	-	-	-	-	-	-	9	3.0E-07	3.0E-07	2.9E-07	2.8E-07	2.4E-07	-	-	-	-	-	-	-	-	0.11	3.00E-07
A19	Hospital Aided Primary &	30	0.097	0.097	0.097	0.094	0.083	-	-	-	-	-	-	-	-	9	2.6E-07	2.6E-07	2.6E-07	2.5E-07	2.2E-07	-	-	-	-	-	-	-	-	0.10	2.61E-07
A20-1	LOHAS Park - 1	200	0.020	0.019	0.019	0.018	0.017	0.015	0.012	0.010	0.008	0.006	0.005	0.005	0.004	9	5.3E-08	5.3E-08	5.2E-08	5.0E-08	4.5E-08	3.9E-08	3.2E-08	2.6E-08	2.1E-08	1.7E-08	1.4E-08	1.3E-08	9.8E-09	0.02	5.27E-08
A20-2	LOHAS Park - 2	200	0.049	0.049	0.048	0.046	0.042	0.035	0.028	0.022	0.016	0.013	0.010	0.009	0.006	9	1.3E-07	1.3E-07	1.3E-07	1.2E-07	1.1E-07	9.5E-08	7.6E-08	5.8E-08	4.4E-08	3.4E-08	2.8E-08	2.3E-08	1.7E-08	0.05	1.32E-07
A20-3	LOHAS Park - 3	200	0.028	0.028	0.027	0.026	0.024	0.021	0.017	0.013	0.010	0.008	0.007	0.006	0.004	9	7.5E-08	7.5E-08	7.4E-08	7.1E-08	6.5E-08	5.5E-08	4.5E-08	3.5E-08	2.8E-08	2.2E-08	1.8E-08	1.6E-08	1.2E-08	0.03	7.48E-08
A21	Chiaphua-Shinko Centre	30	0.061	0.060	0.060	0.057	0.051	-	-	-	-	-	-	-	-	9	1.6E-07	1.6E-07	1.6E-07	1.5E-07	1.4E-07	-	-	-	-	-	-	-	-	0.06	1.63E-07

Methanol

Table A4-22			Hourly (Biodiesel Plant - Process Building)														
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**	**Acute Ref. Conc.**
A1	Gammon Skanka	30	10.5	11.1	12.6	15.5	13.9	-	-	-	-	-	-	-	-	15.5	28,000
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	13.2	17.6	30.5	58.9	48.7	-	-	-	-	-	-	-	-	58.9	28,000
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	10.0	10.1	10.4	10.6	9.4	-	-	-	-	-	-	-	-	10.6	28,000
A4	Hong Kong Aero Engine Services Ltd	30	5.2	5.2	5.2	5.0	4.4	-	-	-	-	-	-	-	-	5.2	28,000
A5	HAECO	30	6.8	6.8	6.8	6.5	5.7	-	-	-	-	-	-	-	-	6.8	28,000
A6-1	Asia Netcom HK Limited	30	7.1	7.1	7.1	6.8	6.0	-	-	-	-	-	-	-	-	7.1	28,000
A6-2	Asia Netcom HK Limited	30	6.3	6.3	6.3	6.0	5.3	-	-	-	-	-	-	-	-	6.3	28,000
A7	Mei Ah Centre	30	5.4	5.4	5.3	5.1	4.5	-	-	-	-	-	-	-	-	5.4	28,000
A8	Wellcome Co. Ltd (Storage)	30	7.0	7.0	7.0	6.7	5.9	-	-	-	-	-	-	-	-	7.0	28,000
A9	Hitachi Tseung Kwan O Centre	30	6.2	6.2	6.1	5.8	5.1	-	-	-	-	-	-	-	-	6.2	28,000
A10	Next Media Apple Daily	30	3.0	3.0	3.0	2.8	2.5	-	-	-	-	-	-	-	-	3.0	28,000
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	6.9	7.0	7.3	7.7	6.9	-	-	-	-	-	-	-	-	7.7	28,000
A12-1	TVB City	30	6.4	6.4	6.4	6.1	5.3	-	-	-	-	-	-	-	-	6.4	28,000
A12-2	TVB City	30	4.0	4.0	4.0	3.8	3.3	-	-	-	-	-	-	-	-	4.0	28,000
A12-3	TVB City	30	5.8	5.8	5.7	5.4	4.7	-	-	-	-	-	-	-	-	5.8	28,000
A13	Yan Hing Industrial Building	30	5.8	5.8	5.8	5.5	4.8	-	-	-	-	-	-	-	-	5.8	28,000
A14	Next Media Apple Daily	30	6.2	6.2	6.2	5.8	5.1	-	-	-	-	-	-	-	-	6.2	28,000
A15	Avery Dennison	30	3.3	3.2	3.2	3.1	2.7	-	-	-	-	-	-	-	-	3.3	28,000
A16	Varitronix Limited	30	6.5	6.5	6.5	6.1	5.3	-	-	-	-	-	-	-	-	6.5	28,000
A17	Committed HSBC Office	30	2.2	2.2	2.2	2.1	1.8	-	-	-	-	-	-	-	-	2.2	28,000
A18	Eastern Pacific Electronics	30	5.1	5.1	5.0	4.7	4.1	-	-	-	-	-	-	-	-	5.1	28,000
A19	Hospital Aided Primary &	30	5.7	5.7	5.7	5.6	4.9	-	-	-	-	-	-	-	-	5.7	28,000
A20-1	LOHAS Park - 1	200	3.9	3.9	3.9	3.6	3.1	2.5	1.7	1.1	0.8	0.6	0.4	0.4	0.3	3.9	28,000
A20-2	LOHAS Park - 2	200	4.6	4.6	4.5	4.3	3.7	2.9	2.0	1.2	0.8	0.6	0.4	0.4	0.3	4.6	28,000
A20-3	LOHAS Park - 3	200	1.3	1.3	1.2	1.2	1.0	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.2	1.3	28,000
A21	Chiaphua-Shinko Centre	30	4.7	4.7	4.7	4.4	3.9	-	-	-	-	-	-	-	-	4.7	28,000

Table A4-23			**Annual Average (Biodiesel Plant - Process Building)**														
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**	**Chronic Ref. Conc.**
A1	Gammon Skanka	30	0.860	0.906	1.033	1.272	1.139	-	-	-	-	-	-	-	-	1.27	4,000
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	0.830	1.030	1.622	2.895	2.431	-	-	-	-	-	-	-	-	2.90	4,000
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	0.300	0.303	0.311	0.319	0.284	-	-	-	-	-	-	-	-	0.32	4,000
A4	Hong Kong Aero Engine Services Ltd	30	0.103	0.103	0.102	0.098	0.086	-	-	-	-	-	-	-	-	0.10	4,000
A5	HAECO	30	0.105	0.105	0.104	0.099	0.087	-	-	-	-	-	-	-	-	0.10	4,000
A6-1	Asia Netcom HK Limited	30	0.085	0.085	0.084	0.081	0.071	-	-	-	-	-	-	-	-	0.08	4,000
A6-2	Asia Netcom HK Limited	30	0.076	0.076	0.075	0.072	0.063	-	-	-	-	-	-	-	-	0.08	4,000
A7	Mei Ah Centre	30	0.062	0.062	0.061	0.058	0.051	-	-	-	-	-	-	-	-	0.06	4,000
A8	Wellcome Co. Ltd (Storage)	30	0.051	0.051	0.050	0.048	0.042	-	-	-	-	-	-	-	-	0.05	4,000
A9	Hitachi Tseung Kwan O Centre	30	0.036	0.036	0.035	0.034	0.030	-	-	-	-	-	-	-	-	0.04	4,000
A10	Next Media Apple Daily	30	0.041	0.041	0.040	0.038	0.034	-	-	-	-	-	-	-	-	0.04	4,000
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.154	0.155	0.158	0.160	0.142	-	-	-	-	-	-	-	-	0.16	4,000
A12-1	TVB City	30	0.155	0.155	0.154	0.146	0.127	-	-	-	-	-	-	-	-	0.16	4,000
A12-2	TVB City	30	0.069	0.069	0.068	0.064	0.056	-	-	-	-	-	-	-	-	0.07	4,000
A12-3	TVB City	30	0.065	0.065	0.064	0.061	0.053	-	-	-	-	-	-	-	-	0.07	4,000
A13	Yan Hing Industrial Building	30	0.048	0.048	0.048	0.045	0.040	-	-	-	-	-	-	-	-	0.05	4,000
A14	Next Media Apple Daily	30	0.036	0.036	0.036	0.034	0.030	-	-	-	-	-	-	-	-	0.04	4,000
A15	Avery Dennison	30	0.026	0.026	0.026	0.024	0.021	-	-	-	-	-	-	-	-	0.03	4,000
A16	Varitronix Limited	30	0.056	0.056	0.056	0.053	0.046	-	-	-	-	-	-	-	-	0.06	4,000
A17	Committed HSBC Office	30	0.053	0.053	0.052	0.049	0.043	-	-	-	-	-	-	-	-	0.05	4,000
A18	Eastern Pacific Electronics	30	0.111	0.111	0.109	0.102	0.090	-	-	-	-	-	-	-	-	0.11	4,000
A19	Hospital Aided Primary &	30	0.097	0.097	0.097	0.094	0.083	-	-	-	-	-	-	-	-	0.10	4,000
A20-1	LOHAS Park - 1	200	0.020	0.019	0.019	0.018	0.017	0.015	0.012	0.010	0.008	0.006	0.005	0.005	0.004	0.02	4,000
A20-2	LOHAS Park - 2	200	0.049	0.049	0.048	0.046	0.042	0.035	0.028	0.022	0.016	0.013	0.010	0.009	0.006	0.05	4,000
A20-3	LOHAS Park - 3	200	0.028	0.028	0.027	0.026	0.024	0.021	0.017	0.013	0.010	0.008	0.007	0.006	0.004	0.03	4,000
A21	Chiaphua-Shinko Centre	30	0.061	0.060	0.060	0.057	0.051	-	-	-	-	-	-	-	-	0.06	4,000

Odour

Table A4-24			5-second Odour Level													
ASRs	**Description**	**Approx. Maximum height of bldg (m above gd)**	**1.5m**	**5m**	**10m**	**20m**	**30m**	**40m**	**50m**	**60m**	**70m**	**80m**	**90m**	**100m**	**120m**	**Highest**
A1	Gammon Skanka	30	2.7	2.6	2.6	2.0	1.1	-	-	-	-	-	-	-	-	2.7
A2	Proposed Industrial Site (No committed uses at the time of preparation of EIA)	30	2.2	2.2	2.2	1.8	1.0	-	-	-	-	-	-	-	-	2.2
A3	Hong Kong Trade Development Council Exhibition Services & Logistic Centre	30	1.0	1.0	0.9	0.8	0.6	-	-	-	-	-	-	-	-	1.0
A4	Hong Kong Aero Engine Services Ltd	30	1.1	1.2	1.2	1.0	0.5	-	-	-	-	-	-	-	-	1.2
A5	HAECO	30	0.9	0.9	0.8	0.7	0.4	-	-	-	-	-	-	-	-	0.9
A6-1	Asia Netcom HK Limited	30	0.6	0.6	0.6	0.5	0.4	-	-	-	-	-	-	-	-	0.6
A6-2	Asia Netcom HK Limited	30	1.1	1.1	1.1	0.9	0.5	-	-	-	-	-	-	-	-	1.1
A7	Mei Ah Centre	30	0.9	0.9	0.9	0.7	0.4	-	-	-	-	-	-	-	-	0.9
A8	Wellcome Co. Ltd (Storage)	30	0.5	0.5	0.6	0.5	0.3	-	-	-	-	-	-	-	-	0.6
A9	Hitachi Tseung Kwan O Centre	30	0.5	0.5	0.5	0.4	0.3	-	-	-	-	-	-	-	-	0.5
A10	Next Media Apple Daily	30	0.3	0.3	0.2	0.2	0.2	-	-	-	-	-	-	-	-	0.3
A11	Hong Kong Oxygen Acetylene Co. Ltd	30	0.5	0.5	0.5	0.4	0.3	-	-	-	-	-	-	-	-	0.5
A12-1	TVB City	30	0.7	0.7	0.7	0.6	0.4	-	-	-	-	-	-	-	-	0.7
A12-2	TVB City	30	0.5	0.5	0.5	0.4	0.2	-	-	-	-	-	-	-	-	0.5
A12-3	TVB City	30	0.2	0.2	0.2	0.2	0.1	-	-	-	-	-	-	-	-	0.2
A13	Yan Hing Industrial Building	30	0.3	0.3	0.3	0.2	0.2	-	-	-	-	-	-	-	-	0.3
A14	Next Media Apple Daily	30	0.2	0.2	0.2	0.2	0.2	-	-	-	-	-	-	-	-	0.2
A15	Avery Dennison	30	0.3	0.3	0.3	0.2	0.2	-	-	-	-	-	-	-	-	0.3
A16	Varitronix Limited	30	0.4	0.4	0.4	0.3	0.2	-	-	-	-	-	-	-	-	0.4
A17	Committed HSBC Office	30	0.4	0.4	0.4	0.3	0.2	-	-	-	-	-	-	-	-	0.4
A18	Eastern Pacific Electronics	30	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	0.1
A19	Hospital Aided Primary &	30	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	0.1
A20-1	LOHAS Park - 1	200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	0.1
A20-2	LOHAS Park - 2	200	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.3
A20-3	LOHAS Park - 3	200	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.3
A21	Chiaphua-Shinko Centre	30	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	0.1

Annex B

Noise Assessment Supporting Information

Annex B1

Construction PME Plant Inventory and Programme

Annex B1-1

Anticipated PME Plant Inventory during Construction Phase

No.	Activities		Sub-activities	Plant	CNP /BS 5228 ref.	No. of PME	Unit SWL, dB(A)	SWL, dB(A)	SWL for each Activities, dB(A)
1	**Foundation works**	1a	Jetty	Piling rig	note (1)	1	110	110	**111**
				Derrick barge	CNP 061	1	104	104	
				Air Compressor, air flow > 10m3/min and < 30m3/min	CNP 002	1	102	102	
		1b	Building	Air Compressor, air flow > 10m3/min and < 30m3/min	CNP 002	2	102	105	**105**
		1c	Tanks	Excavator/loader, wheeled/tracked	CNP 081	3	112	117	**120**
				Compactor, vibratory	CNP 050	1	105	105	
				Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	
				Concrete lorry mixer	CNP 044	3	109	114	
2	**Site formation work**			Excavator/loader, wheeled/tracked	CNP 081	3	112	117	**120**
				Compactor, vibratory	CNP 050	1	105	105	
				Concrete lorry mixer	CNP 044	5	109	116	
3	**Drainage works and surface channels**	3a	Underground structures	Excavator/loader, wheeled/tracked	CNP 081	3	112	117	**121**
				Compactor, vibratory	CNP 050	1	105	105	
				Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	
				Concrete lorry mixer	CNP 044	4	109	115	
		3b	Concrete U-channels	Excavator/loader, wheeled/tracked	CNP 081	2	112	115	**118**
				Concrete lorry mixer	CNP 044	2	109	112	
				Crane, mobile/barge mounted (diesel)	CNP 048	1	112	112	
4	**Underground pipes and ducts**			Excavator/loader, wheeled/tracked	CNP 081	2	112	115	**120**
				Lorry, gross vehicle weight > 38 tonne	CNP 141	2	112	115	
				Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	
				Concrete lorry mixer	CNP 044	2	109	112	
5	**EVA, bund wall and floor**	5a	EVA	Compactor, vibratory	CNP 050	2	105	108	**118**
				Excavator/loader, wheeled/tracked	CNP 081	2	112	115	
				Concrete pump, stationary/lorry mounted	CNP 047	2	109	112	
				Concrete lorry mixer	CNP 044	2	109	112	
		5b	Bund wall and floor	Crane, mobile/barge mounted (diesel)	CNP 048	3	112	117	**120**
				Concrete lorry mixer	CNP 044	5	109	116	
				Concrete pump, stationary/lorry mounted	CNP 047	1	109	109	
6	**Superstructure**	6a	Steel tanks erection	Crane, tower (electric)	CNP 049	2	95	98	**115**
				Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	
		6b	Main building erection	Crane, tower (electric)	CNP 049	2	95	98	**115**
				Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	
		6c	Other structures	Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	**117**
				Concrete lorry mixer	CNP 044	2	109	112	
7	**Pipe Gantry**			Crane, mobile/barge mounted (diesel)	CNP 048	2	112	115	**115**
8	**Fire services, electrical and mechanical installation**			Crane, mobile/barge mounted (diesel)	CNP 048	4	112	118	**118**

Note: (1) SWL refer to the document prepared by the Noise Control Authority (http://www.epd.gov.hk/epd/english/application_for_licences/guidance/files/OtherSWLe.pdf)

Annex B1-2

Programme for Construction of Biodiesel Plant

No.	Activities			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
				Construction Month																	
1	Foundation works	1a	Jetty							Y	Y	Y									
		1b	Building							Y	Y	Y									
		1c	Tanks							Y	Y	Y									
2	Site formation work												Y	Y							
3	Drainage works and surface channels	3a	Underground structures									Y	Y	Y	Y	Y	Y				
		3b	Concrete U-channels									Y	Y	Y	Y	Y	Y				
4	Underground pipes and ducts														Y	Y	Y	Y			
5	EVA, bund wall and floor	5a	EVA														Y	Y	Y		
		5b	Bund wall and floor									Y	Y	Y	Y	Y	Y				
6	Superstructure	6a	Steel tanks erection									Y	Y	Y	Y	Y					
		6b	Main building erection									Y	Y	Y	Y						
		6c	Other structures										Y	Y	Y	Y	Y	Y	Y		
7	Pipe Gantry															Y	Y	Y	Y		
8	Fire services, electrical and mechanical installation															Y	Y	Y	Y		

Annex B2

Inventory of Fixed Plant Noise Sources during Operational Phase

Annex B2

Inventory of Fixed Plant Noise Sources during Operational Phase

No.	Area	Fixed Plant Items	TM ref	Specified Maximum Sound Power Level (SWL), dB(A)	Specified Maximum Sound Pressure Level (SPL)	Quantity	Remarks
1	Tank Farm	Pumps [1]	-	-	85 dB(A), free-field at 1m	10	Within complete noise enclosures with no opening facing LOHAS parks
2	Fat Preparation Plant	Pumps [1]	-	-	85 dB(A), free-field at 1m	6	Within completely enclosed building
3		Compressor [2]	CNP 002	102	-	1	Within completely enclosed building
4		Water cooling tower [3]	-	102	-	1	Outdoor at roof top level
5	Office	Air-cooled chiller [4]	-	102	-	1	Outdoor at roof top level
6	Steam Boiler Room	Steam boiler plant	-	-	85 dB(A), free-field at 1m	1	Within completely enclosed building
7		Thermal fluid heater	-	-	85 dB(A), free-field at 1m	1	Within completely enclosed building
8	Process Building	Pumps [1]	-	-	85 dB(A), free-field at 1m	40	Within completely enclosed building
9		Agitators	-	-	85 dB(A), free-field at 1m	13	Within completely enclosed building
10	Waste Water Treatment Plant	Pumps [1]	-	-	85 dB(A), free-field at 1m	10	Within complete noise enclosures with no opening facing LOHAS parks
11		Dewatering plant	-	-	85 dB(A), free-field at 1m	1	Within completely enclosed building
12		Blower	-	-	85 dB(A), free-field at 1m	1	Within completely enclosed building
13	Jetty	Barge [2]	CNP 061	104	-	1	Outdoor
14		Gantry, electric [2]	CNP 049	95	-	1	Outdoor
15	Loading/Unloading Area	Tanker [5]	-	105	-	7	Outdoor

Notes:

[1] Specification for pump provided by the supplier was given in the attached. The supplier confirmed that the SPL given in the specification was measured in accordance with *DIN 45 635: Measurement of Noise emitted by Machines* . The SPL of 72 ± 3dB(A) was measured at 1m away from the pump, which is equivalent to SWL of 83dB(A), ie (75 + 8) dB(A). This SWL is 2dB(A) below the assumed SWL of 85dB(A) as employed in the noise assessment.

[2] Reference was made from GW-TM for the sound power levels (SWL) for compressor, barge and gantry.

[3] Water cooling tower with motor power of 30kW, ie equivalent to horsepower of 40hp, will be used for the Fat Preparation Plant. Reference was made from the *Good Practices on Ventilation System Noise Control* prepared by EPD for the SWL of water cooling tower with horsepower of 40hp.

[4] Specification for air-cooled chiller provided by the supplier was given in the attached. The maximum SPL is 85 dB(A) measured at 1.5m, which is equivalent to SWL of 97dB(A), ie (85 + 12) dB(A). This SWL is 5dB(A) below the assumed SWL of 102dB(A) as employed in the noise assessment.

[5] Reference was made from the document prepared by the Noise Control Authority for lorry with 5.5 tonne < gross vehicle weight < 38 tonne (http://www.epd.gov.hk/epd/english/application_for_licences/guidance/files/OtherSWLe.pdf) for the SWL of tanker.

Data Sheet

Type:	***ICB 80-50-200 S1NL2-1502***	**VOGEL-order no.:**	***328.151-29***
Your order no.:	***BDI/061423***	**Pos. no. / Item no.:**	***P 100800***
Customer:	***BDI Biodiesel International AG***		

Handled liquid:		***Oil***		
Temperature:	°C	***50***		
Density (rho):	kg/dm3	***0,923***		
Viscosity:	cSt	***85***		
Capacity:	m3/h	***50***		
Discharge:	mFLS	***41***		
Power consumption at rho:	kW	***11***		
Motor power requiered:	kW	***15***		
Speed:	min-1	***2940***		
Impeller diameter:	mm	***189***		
Suction flange:		***DN 80***	***PN 16***	Direction: ***axial***
Discharge flange:		***DN 50***	***PN 16***	Direction: ***upwards***
Max. test pressure:	bar	***24***		
Max. casing-operation-pressure:	bar	***16***		

Lubrication: ***Grease lubrication - the pump shaft is guided in the ball bearings of the motor.***

Shaft sealing: ***Single Mech. Seal Without Shaft Sleeve (Design Code S1..2)***
Additional data ***With unbalanced mechanical seal M7N 33 Q1Q1VGG SiC/SiC/Viton***

Materials:	*Impeller*	***0.6025***
	Casing	***0.7043***
	Casing cover	***0.7043***
	Shaft	***1.4462***

Motor:		***1LA7164-2AA61-Z***
Nominal power:	kW	***15***
Voltage:	VΔ	**3x400**
Frequency:	Hz	***50***
Speed:	min-1	***2940***
Rated current:	A	***26,5***
Model:		***B5***
Isolation class:		***F***
Protection class:		***IP55***
Additional data:		***160M***
Manufacturer:		***Siemens***
Sound pressure level pump with motor:	dB(A)	***72±3***
Weight unit:	kg	***~137***

ITT Industries
Engineered for life

B.A.C. Cooling Tower Selection Program

Release 6.10 NA

Program data and calculations are correct as of Mar. 10, 2005.

To:	Ms. Kan		**Inquiry No.:**	
Attn:			**Project Name:**	HK Bio-deisel
From:	Joel Ulep		**Date:**	Nov. 17, 2008

Sound Data Inputs

Product Line:	FXT
Model:	FXT-160
Fan Motor:	Standard
Total Fan Motor Power per Unit:	5.595 kW
Number of Units:	1

Sound Data, per Unit

		---- Sound Pressure Levels (dB)* ----										
		Top		End		Air Inlet		End		Back		Sound Power
Ctr. Band	Ctr. Frq. (Hz)	1.5 m.	15.2 m.	1.5 m.	15.2 m.	1.5 m.	15.2 m.	1.5 m.	15.2 m.	1.5 m.	15.2 m.	Levels (PWL) '
1	63	79	69	81	72	87	75	81	72	84	74	105
2	125	80	65	75	68	84	72	75	68	83	70	101
3	250	75	65	73	67	83	70	73	67	82	69	100
4	500	69	59	68	61	82	65	68	61	79	64	95
5	1000	64	54	63	53	80	67	63	53	78	65	94
6	2000	60	51	52	46	77	63	52	46	71	60	90
7	4000	58	47	48	42	73	58	48	42	65	53	85
8	8000	56	46	44	26	69	54	44	26	62	49	81
	dBA	72	61	69	62	85	71	69	62	82	69	

*dB re 0.0002 microbar
'dB re 10E-12 Watt

Sound data is for one standard, single-cell unit and does not indicate effects of nonstandard motors, multiple-cell units, or sound-attenuating accessories. Please contact your local B.A.C. sales representative for such ratings.

Annex B3

Construction Noise Impact Assessment

Annex B3-1

Summary of Predicted Construction Noise Levels

		Predicted Construction Noise Level (dB(A))																									Max. CNL dB(A)
	NSR Location	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**	**M22**	**M23**	**M24**	**M25**	
A86R1	Planned Residential Development in Area 86							58	58	63	64	64	64	64	64	62	60										64
CSS1	Creative Secondary School							48	48	54	54	54	54	55	55	53	51										55
IR1	Island Resort, Siu Sai Wan							48	48	53	53	53	54	54	54	52	50										54

Annex B3-2

Noise Assessment for Construction of Biodiesel Plant

NSR: A86R1 Planned Residential Development in Area 86

No.	Activities			SWL dB(A)	Distance from source to NSP, m	Corr. For Distance dB(A)	Corr. For façade dB(A)	Predicted Construction Noise Level (dB(A))																		Max. CNL dB(A)
								M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	
1	Foundation works	1a	Jetty	111	820	-66	3							48	48	48										
		1b	Building	105	820	-66	3							42	42	42										
		1c	Tanks	120	820	-66	3							57	57	57										
2	Site formation work			120	820	-66	3										56	56								
3	Drainage works and surface channels	3a	Underground structures	121	820	-66	3									57	57	57	57	57	57					
		3b	Concrete U-channels	118	820	-66	3									55	55	55	55	55	55					
4	Underground pipes and ducts			120	820	-66	3												57	57	57	57				
5	EVA, bund wall and floor	5a	EVA	118	820	-66	3														55	55	55			
		5b	Bund wall and floor	120	820	-66	3									57	57	57	57	57	57					
6	Superstructure	6a	Steel tanks erection	115	820	-66	3									52	52	52	52	52						
		6b	Main building erection	115	820	-66	3									52	52	52	52							
		6c	Other structures	117	820	-66	3										54	54	54	54	54	54	54			
7	Pipe Gantry			115	820	-66	3													52	52	52	52			
8	Fire services, electrical and mechanical installation			118	820	-66	3													55	55	55	55			
							Predicted Noise Levels, dB(A)							58	58	63	64	64	64	64	64	62	60			64

Note:

Distance Correction for PMEs = $10*\log(2*PI*r^2)$

Annex B3-3

Noise Assessment for Construction of Biodiesel Plant

NSR: CSS1 Creative Secondary School

No.	Activities			SWL dB(A)	Distance from source to NSP, m	Corr. For Distance dB(A)	Corr. For façade dB(A)	Predicted Construction Noise Level (dB(A))																		Max. CNL dB(A)
								M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	
1	Foundation works	1a	Jetty	111	2380	-76	3							39	39	39										
		1b	Building	105	2380	-76	3							32	32	32										
		1c	Tanks	120	2380	-76	3							48	48	48										
2	Site formation work			120	2380	-76	3										47	47								
3	Drainage works and surface channels	3a	Underground structures	121	2380	-76	3									48	48	48	48	48	48					
		3b	Concrete U-channels	118	2380	-76	3									46	46	46	46	46	46					
4	Underground pipes and ducts			120	2380	-76	3												48	48	48	48				
5	EVA, bund wall and floor	5a	EVA	118	2380	-76	3														46	46	46			
		5b	Bund wall and floor	120	2380	-76	3									47	47	47	47	47	47					
6	Superstructure	6a	Steel tanks erection	115	2380	-76	3									43	43	43	43	43						
		6b	Main building erection	115	2380	-76	3									43	43	43	43							
		6c	Other structures	117	2380	-76	3										44	44	44	44	44	44	44			
7	Pipe Gantry			115	2380	-76	3													42	42	42	42			
8	Fire services, electrical and mechanical installation			118	2380	-76	3													46	46	46	46			
							Predicted Noise Levels, dB(A)							48	48	54	54	54	54	55	55	53	51			55

Note:

Distance Correction for PMEs = $10*\log(2*PI*r^2)$

Annex B3-4

Noise Assessment for Construction of Biodiesel Plant

NSR: IR1 Island Resort, Siu Sai Wan

No.	Activities			SWL dB(A)	Distance from source to NSP, m	Corr. For Distance dB(A)	Corr. For façade dB(A)	Predicted Construction Noise Level (dB(A)) M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	Max. CNL dB(A)
1	Foundation works	1a	Jetty	111	2600	-76	3							38	38	38										
		1b	Building	105	2600	-76	3							32	32	32										
		1c	Tanks	120	2600	-76	3							47	47	47										
2	Site formation work			120	2600	-76	3										46	46								
3	Drainage works and surface channels	3a	Underground structures	121	2600	-76	3									47	47	47	47	47	47					
		3b	Concrete U-channels	118	2600	-76	3									45	45	45	45	45	45					
4	Underground pipes and ducts			120	2600	-76	3												47	47	47	47				
5	EVA, bund wall and floor	5a	EVA	118	2600	-76	3														45	45	45			
		5b	Bund wall and floor	120	2600	-76	3									47	47	47	47	47	47					
6	Superstructure	6a	Steel tanks erection	115	2600	-76	3									42	42	42	42	42						
		6b	Main building erection	115	2600	-76	3									42	42	42	42							
		6c	Other structures	117	2600	-76	3										43	43	43	43	43	43	43			
7	Pipe Gantry			115	2600	-76	3													42	42	42	42			
8	Fire services, electrical and mechanical installation			118	2600	-76	3													45	45	45	45			
							Predicted Noise Levels, dB(A)							48	48	53	53	53	54	54	54	52	50			54

Note:

Distance Correction for PMEs = 10*log(2*PI*r^2)

Annex B4

Operational Noise Impact Assessment

Annex B4-1

Summary of Predicted Noise Levels due to the Operation of Biodiesel Plant - Fixed Plant Operation

NSRs		**Predicted Noise Level (dB(A))**	
		Daytime	**Night-time**
A86R1	Planned Residential Development in Area 86	49	47
A86S1	Planned School in Area 86	48	46
IR1	Island Resort, Siu Sai Wan	40	38

Annex B4-2

Noise Assessment for Operation of Biodiesel Plant - Fixed Plant Operation

NSR: A86R1 Planned Residential Development in Area 86

No.	Area	Fixed Plant Items	TM ref	SWL, dB(A)	SPL at 1m, dB(A)	Quantity	% on time	Distance from source to NSR (d2),m	Corrections For: Quantity dB(A) [1]	Distance dB(A) [2]	Distance dB(A) [3]	Façade dB(A)	Barrier dB(A) [4]	% on time dB(A) [5]	Reflection dB(A) [6]	Predicted Noise Level (dB(A) $L_{eq, 30min}$)
Daytime Period (between 0700 to 2300 hours)																
1	Tank Farm	Pumps	-	-	85	10	100%	800	10		-58.1	3	-20	0		20
2	Fat Preparation Plant	Pumps	-	-	85	6	100%	865	8		-58.7	3	-20	0		17
3		Compressor	CNP 002	102	-	1	100%	865	0	-66.7		3	-20	0		18
4		Water cooling tower	-	102	-	1	100%	865	0	-66.7		3	0	0	3	41
5	Office	Air-cooled chiller	-	102	-	1	100%	880	0	-66.9		3	0	0	3	41
6	Steam Boiler Room	Steam boiler plant	-	-	85	1	100%	880	0		-58.9	3	-20	0		9
7		Thermal fluid heater	-	-	85	1	100%	880	0		-58.9	3	-20	0		9
8	Process Building	Pumps	-	-	85	40	100%	890	16		-59.0	3	-20	0		25
9		Agitators	-	-	85	13	100%	890	11		-59.0	3	-20	0		20
10	Waste Water Treatment Plant	Pumps	-	-	85	10	100%	825	10		-58.3	3	-20	0		20
11		Dewatering plant	-	-	85	1	100%	825	0		-58.3	3	-20	0		10
12		Blower	-	-	85	1	100%	825	0		-58.3	3	-20	0		10
13	Jetty	Barge	CNP 061	104	-	1	50%	800	0	-66.0		3	0	-3		38
14		Gantry, electric	CNP 049	95	-	1	50%	800	0	-66.0		3	0	-3		29
15	Loading/Unloading Area	Tanker	-	105	-	7	50%	860	8	-66.7		3	0	-3		47
															Total Predicted Noise Level during Daytime Period, dB(A)	**49**
Night-time Period (between 2300 to 0700 hours)																
1	Tank Farm	Pumps	-	-	85	10	100%	800	10		-58.1	3	-20	0		20
2	Fat Preparation Plant	Pumps	-	-	85	6	100%	865	8		-58.7	3	-20	0		17
3		Compressor	CNP 002	102	-	1	100%	865	0	-66.7		3	-20	0		18
4		Water cooling tower	-	102	-	1	100%	865	0	-66.7		3	0	0	3	41
6	Steam Boiler Room	Steam boiler plant	-	-	85	1	100%	880	0		-58.9	3	-20	0		9
7		Thermal fluid heater	-	-	85	1	100%	880	0		-58.9	3	-20	0		9
8	Process Building	Pumps	-	-	85	40	100%	890	16		-59.0	3	-20	0		25
9		Agitators	-	-	85	13	100%	890	11		-59.0	3	-20	0		20
10	Waste Water Treatment Plant	Pumps	-	-	85	10	100%	825	10		-58.3	3	-20	0		20
11		Dewatering plant	-	-	85	1	100%	825	0		-58.3	3	-20	0		10
12		Blower	-	-	85	1	100%	825	0		-58.3	3	-20	0		10
13	Jetty	Barge	CNP 061	104	-	1	50%	800	0	-66.0		3	0	-3		38
14		Gantry, electric	CNP 049	95	-	1	50%	800	0	-66.0		3	0	-3		29
15	Loading/Unloading Area	Tanker	-	105	-	5	50%	860	7	-66.7		3	0	-3		45
															Total Predicted Noise Level during Night-time Period, dB(A)	**47**

Notes:

[1] Correction for quantity = 10*log(Quantity)

[2] Distance correction for SWL = $-10\log(2\pi(d2)^2)$

[3] Distance correction for SPL = -20*log(d2)

[4] All noisy equipment will be located within completely enclosed buildings or complete noise enclosures. The complete noise enclosures will be internally lined with minimum 50mm thick sound absorbing material and will be provided with silencers at outlet and inlet of the enclosure. Reference was made from the *Good Practices on Pumping System Noise Control* prepared by EPD for the noise reduction of 20dB(A) provided by this type of complete enclosure.

[5] Correction for % on time = -10*log(% on time)

[6] The locations of outdoor noise sources will be decided during the detail design stage.
In order to assess the worst case scenario, cooling towers located at outdoor roof of the Fat Preparation Plant building and office are assumed to be located near the acoustically hard surface and the receivers are assumed to be located to the opposite side of reflective surface. Reflection of 3 dB(A) was included in the calculation.

Annex B4-3

Noise Assessment for Operation of Biodiesel Plant - Fixed Plant Operation

NSR: A86S1 Planned School in Area 86

No.	Area	Fixed Plant Items	TM ref	SWL, dB(A)	SPL at 1m, dB(A)	Quantity	% on time	Distance from source to NSR (d2),m	Corrections For: Quantity dB(A) [1]	Distance dB(A) [2]	Distance dB(A) [3]	Façade dB(A)	Barrier dB(A) [4]	% on time dB(A) [5]	Reflection dB(A) [6]	Predicted Noise Level (dB(A) $L_{eq, 30min}$)
Daytime Period (between 0700 to 2300 hours)																
1	Tank Farm	Pumps	-	-	85	10	100%	920	10		-59.3	3	-20	0		19
2	Fat Preparation Plant	Pumps	-	-	85	6	100%	970	8		-59.7	3	-20	0		16
3		Compressor	CNP 002	102	-	1	100%	970	0	-67.7		3	-20	0		17
4		Water cooling tower	-	102	-	1	100%	970	0	-67.7		3	0	0	3	40
5	Office	Air-cooled chiller	-	102	-	1	100%	970	0	-67.7		3	0	0	3	40
6	Steam Boiler Room	Steam boiler plant	-	-	85	1	100%	970	0		-59.7	3	-20	0		8
7		Thermal fluid heater	-	-	85	1	100%	970	0		-59.7	3	-20	0		8
8	Process Building	Pumps	-	-	85	40	100%	990	16		-59.9	3	-20	0		24
9		Agitators	-	-	85	13	100%	990	11		-59.9	3	-20	0		19
10	Waste Water Treatment Plant	Pumps	-	-	85	10	100%	955	10		-59.6	3	-20	0		18
11		Dewatering plant	-	-	85	1	100%	955	0		-59.6	3	-20	0		8
12		Blower	-	-	85	1	100%	955	0		-59.6	3	-20	0		8
13	Jetty	Barge	CNP 061	104	-	1	50%	950	0	-67.5		3	0	-3		36
14		Gantry, electric	CNP 049	95	-	1	50%	950	0	-67.5		3	0	-3		27
15	Loading/Unloading Area	Tanker	-	105	-	7	50%	995	8	-67.9		3	0	-3		46
Total Predicted Noise Level during Daytime Period, dB(A)																**48**
Night-time Period (between 2300 to 0700 hours)																
1	Tank Farm	Pumps	-	-	85	10	100%	920	10		-59.3	3	-20	0		19
2	Fat Preparation Plant	Pumps	-	-	85	6	100%	970	8		-59.7	3	-20	0		16
3		Compressor	CNP 002	102	-	1	100%	970	0	-67.7		3	-20	0		17
4		Water cooling tower	-	102	-	1	100%	970	0	-67.7		3	0	0	3	40
6	Steam Boiler Room	Steam boiler plant	-	-	85	1	100%	970	0		-59.7	3	-20	0		8
7		Thermal fluid heater	-	-	85	1	100%	970	0		-59.7	3	-20	0		8
8	Process Building	Pumps	-	-	85	40	100%	990	16		-59.9	3	-20	0		24
9		Agitators	-	-	85	13	100%	990	11		-59.9	3	-20	0		19
10	Waste Water Treatment Plant	Pumps	-	-	85	10	100%	955	10		-59.6	3	-20	0		18
11		Dewatering plant	-	-	85	1	100%	955	0		-59.6	3	-20	0		8
12		Blower	-	-	85	1	100%	955	0		-59.6	3	-20	0		8
13	Jetty	Barge	CNP 061	104	-	1	50%	950	0	-67.5		3	0	-3		36
14		Gantry, electric	CNP 049	95	-	1	50%	950	0	-67.5		3	0	-3		27
15	Loading/Unloading Area	Tanker	-	105	-	5	50%	995	7	-67.9		3	0	-3		44
Total Predicted Noise Level during Night-time Period, dB(A)																**46**

Notes:

[1] Correction for quantity = 10*log(Quantity)

[2] Distance correction for SWL = -10*log(2π(d2)^2)

[3] Distance correction for SPL = -20*log(d2)

[4] All noisy equipment will be located within completely enclosed buildings or complete noise enclosures. The complete noise enclosures will be internally lined with minimum 50mm thick sound absorbing material and will be provided with silencers at outlet and inlet of the enclosure. Reference was made from the *Good Practices on Pumping System Noise Control* prepared by EPD for the noise reduction of 20dB(A) provided by this type of complete enclosure.

[5] Correction for % on time = -10*log(% on time)

[6] The locations of outdoor noise sources will be decided during the detail design stage.
In order to assess the worst case scenario, cooling towers located at outdoor roof of the Fat Preparation Plant building and office are assumed to be located near the acoustically hard surface and the receivers are assumed to be located to the opposite side of reflective surface. Reflection of 3 dB(A) was included in the calculation.

Annex B4-4

Noise Assessment for Operation of Biodiesel Plant - Fixed Plant Operation

NSR: IR1 Island Resort, Siu Sai Wan

No.	Area	Fixed Plant Items	TM ref	SWL, dB(A)	SPL at 1m, dB(A)	Quantity	% on time	Distance from source to NSR (d2),m	Corrections For: Quantity dB(A) [1]	Distance dB(A) [2]	Distance dB(A) [3]	Façade dB(A)	Barrier dB(A) [4]	% on time dB(A) [5]	Reflection dB(A) [6]	Predicted Noise Level (dB(A) $L_{eq, 30min}$)
Daytime Period (between 0700 to 2300 hours)																
1	Tank Farm	Pumps	-	-	85	10	100%	2640	10		-68.4	3	-20	0		10
2	Fat Preparation Plant	Pumps	-	-	85	6	100%	2635	8		-68.4	3	-20	0		7
3		Compressor	CNP 002	102	-	1	100%	2635	0	-76.4		3	-20	0		9
4		Water cooling tower	-	102	-	1	100%	2635	0	-76.4		3	0	0	3	32
5	Office	Air-cooled chiller	-	102	-	1	100%	2640	0	-76.4		3	0	0	3	32
6	Steam Boiler Room	Steam boiler plant	-	-	85	1	100%	2640	0		-68.4	3	-20	0		0
7		Thermal fluid heater	-	-	85	1	100%	2640	0		-68.4	3	-20	0		0
8	Process Building	Pumps	-	-	85	40	100%	2570	16		-68.2	3	-20	0		16
9		Agitators	-	-	85	13	100%	2570	11		-68.2	3	-20	0		11
10	Waste Water Treatment Plant	Pumps	-	-	85	10	100%	2620	10		-68.4	3	-20	0		10
11		Dewatering plant	-	-	85	1	100%	2620	0		-68.4	3	-20	0		0
12		Blower	-	-	85	1	100%	2620	0		-68.4	3	-20	0		0
13	Jetty	Barge	CNP 061	104	-	1	50%	2580	0	-76.2		3	0	-3		28
14		Gantry, electric	CNP 049	95	-	1	50%	2580	0	-76.2		3	0	-3		19
15	Loading/Unloading Area	Tanker	-	105	-	7	50%	2580	8	-76.2		3	0	-3		37
															Total Predicted Noise Level during Daytime Period, dB(A)	**40**
Night-time Period (between 2300 to 0700 hours)																
1	Tank Farm	Pumps	-	-	85	10	100%	2640	10		-68.4	3	-20	0		10
2	Fat Preparation Plant	Pumps	-	-	85	6	100%	2635	8		-68.4	3	-20	0		7
3		Compressor	CNP 002	102	-	1	100%	2635	0	-76.4		3	-20	0		9
4		Water cooling tower	-	102	-	1	100%	2635	0	-76.4		3	0	0	3	32
6	Steam Boiler Room	Steam boiler plant	-	-	85	1	100%	2640	0		-68.4	3	-20	0		0
7		Thermal fluid heater	-	-	85	1	100%	2640	0		-68.4	3	-20	0		0
8	Process Building	Pumps	-	-	85	40	100%	2570	16		-68.2	3	-20	0		16
9		Agitators	-	-	85	13	100%	2570	11		-68.2	3	-20	0		11
10	Waste Water Treatment Plant	Pumps	-	-	85	10	100%	2620	10		-68.4	3	-20	0		10
11		Dewatering plant	-	-	85	1	100%	2620	0		-68.4	3	-20	0		0
12		Blower	-	-	85	1	100%	2620	0		-68.4	3	-20	0		0
13	Jetty	Barge	CNP 061	104	-	1	50%	2580	0	-76.2		3	0	-3		28
14		Gantry, electric	CNP 049	95	-	1	50%	2580	0	-76.2		3	0	-3		19
15	Loading/Unloading Area	Tanker	-	105	-	5	50%	2580	7	-76.2		3	0	-3		36
															Total Predicted Noise Level during Night-time Period, dB(A)	**38**

Notes:

[1] Correction for quantity = 10*log(Quantity)

[2] Distance correction for SWL = -10*log(2π(d2)^2)

[3] Distance correction for SPL = -20*log(d2)

[4] All noisy equipment will be located within completely enclosed buildings or complete noise enclosures. The complete noise enclosures will be internally lined with minimum 50mm thick sound absorbing material and will be provided with silencers at outlet and inlet of the enclosure. Reference was made from the *Good Practices on Pumping System Noise Control* prepared by EPD for the noise reduction of 20dB(A) provided by this type of complete enclosure.

[5] Correction for % on time = -10*log(% on time)

[6] The locations of outdoor noise sources will be decided during the detail design stage.
In order to assess the worst case scenario, cooling towers located at outdoor roof of the Fat Preparation Plant building and office are assumed to be located near the acoustically hard surface and the receivers are assumed to be located to the opposite side of reflective surface. Reflection of 3 dB(A) was included in the calculation.

Annex C

Data of Marine Ecological Baseline Surveys in April 2008

Table C1 *Tier I Information: Ecological and Physical Attributes along REA Transects at Depth between -2 to -4m CD*

Transect	Ecological attributes (% cover)							Physical attributes (% cover)				
	HC	DC	SC	BC	TA	MA	CA	LB	SB	RBL	SN	SL
T2	1	0	1	1	2	2	3	3	2	0	0	3
T4	1	0	0	0	0	0	3	5	2	0	0	0
T6	0	0	0	0	0	0	2	4	3	0	0	0
T8	1	0	0	0	0	0	2	5	2	0	0	0

Note: LB – Large boulders (> 50 cm), SB – small boulders (<50 cm), RBL – Rubble, SN – Sand, SL – Silt, HC – Hard Coral, DC – Dead Coral, SC – Soft Coral, BC – Black Coral.
Values are rank scores for benthic cover, where 0 = 0%, 1 = <1 %, 2 = 2 – 10 %, 3 = 11 – 30 %, 4 = 31 – 50 %, 5 = 51 – 75 % and 6 = 76 – 100 %.

Table C2 *Tier I Information for the Deeper Subtidal Benthic Communities – Ecological and Physical Attributes along REA Transects at Depth between -4 to -6m CD*

Transect	Ecological attributes (% cover)							Physical attributes (% cover)				
	HC	DC	SC	BC	TA	MA	CA	LB	SB	RBL	SN	SL
T1	0	0	1	1	0	0	1	2	3	0	0	4
T3	0	0	0	0	0	0	0	5	0	0	0	0
T5	1	0	0	0	0	0	3	5	1	0	0	0
T7	1	0	0	0	0	0	2	5	2	0	0	2

General remark on presentation of the REA data:

Ecological attributes and substratum types. LB – Large boulders (> 50 cm), SB – small boulders (<50 cm), RBL – Rubble, SN – Sand, SL – Silt, HC – Hard Coral, DC – Dead Coral, SC – Soft Coral, BC – Black Coral. Values are rank scores for benthic cover, where 0 = 0%, 1 = <1 %, 2 = 2 – 10 %, 3 = 11 – 30 %, 4 = 31 – 50 %, 5 = 51 – 75 % and 6 = 76 – 100 %.

Table C3 Tier II Information: Species Inventory and Abundance Rating along REA Transects at Depth between -2 to -4m CD

TKO APRIL 2008 - Shallow REA transects			**Site Location (Natural or Artificial)**	N	A	A	A
			Name	T2	T4	T6	T8
Hard corals	**Acroporidae**	*Montipora*	*venosa*	1	0	0	0
	Siderastreidae	*Psammocora*	*superficialis*	1	0	0	0
	Dendrophylliidae	*Turbinaria*	*peltata*	1	0	0	0
	Faviidae	*Cyphastrea*	*serailia*	2	0	0	0
		Oulastrea	*crispata*	0	2	0	1
	Poritidae	*Goniopora*	*stutchburyi*	2	0	0	0
Octocorals	**Plexauridae**	*Euplexaura*	**sp.**	1	0	0	0
		Echinomuricea	**sp.**	0	0	0	0
Others	**Ceriantipatharia**	**Cerianthids**	**Tube anemones**	1	0	0	0
	Crustacea	*Balanus*	**sp.**	4	5	4	4
	Bryozoans	*Schizoporella*	*errata*	2	0	0	0
	Cnidaria	*Entacmaea*	*quadricolor*	3	0	0	0
	Ascidiacea	*Styela*	*plicata*	1	0	0	1
	Bivalves	*Saccostrea* **(Rock oyster)**		3	2	4	4
	Urchins	*Diadema*	*setosum*	2	2	3	2
		Anthocidaris	*crassispina*	0	2	0	2
		Salmacis	*sphaeroides*	2	0	0	0
	Holothurians	*Holothuria*	*leucospilota*	0	0	1	1
		Sigmadocia	**symbiotica**	0	0	0	0
	Polychaetes	*Sabella* **sp.**		3	0	1	1
	Algae	**Coralline red algae**		4	3	2	2
		Dictyota	**sp.**	0	0	0	0

Table C4 *Tier II Information for the deeper subtidal communities – Ecological and Physical Attributes along REA Transects at Depth between -4 to -6m CD*

TKO APRIL 2008 - Deeper REA transects			**Site Location (Natural or Artificial)**	N	A	A	A
			Name	T1	T3	T5	T7
Hard corals	**Acroporidae**	*Montipora*	*venosa*	0	0	0	0
	Siderastreidae	*Psammocora*	*superficialis*	0	0	1	1
	Dendrophylliidae	*Turbinaria*	*peltata*	0	0	0	0
	Faviidae	*Cyphastrea*	*serailia*	0	0	0	0
		Oulastrea	*crispata*	0	0	0	2
	Poritidae	*Goniopora*	*stutchburyi*	0	0	0	0
Octocorals	**Plexauridae**	*Euplexaura*	**sp.**	1	0	0	0
		Echinomuricea	**sp.**	2	0	0	0
Others	**Ceriantipatharia**	**Cerianthids**	**Tube anemones**	1	0	0	0
	Crustacea	*Balanus*	**sp.**	0	5	4	4
	Bryozoans	*Schizoporella*	*errata*	0	0	0	0
	Cnidaria	*Entacmaea*	*quadricolor*	1	0	0	0
	Ascidiacea	*Styela*	*plicata*	0	0	0	1
		Saccostrea **(Rock oyster)**		4	5	4	4
	Urchins	*Diadema*	*setosum*	3	2	2	2
		Anthocidaris	*crassispina*	1	2	0	0
		Salmacis	*sphaeroides*	1	0	0	0
	Holothurians	*Holothuria*	*leucospilota*	0	1	1	0
	Polychaetes	*Sabella* **sp.**		2	0	0	1
	Algae	**Coralline red algae**		3	0	0	0

Table C5 *Summary List of Coral Species Recorded during the REA Surveys in April 2008*

Coral type	**Genus/ Species**	**Hong Kong Distribution/ Abundance Rating***
Hard coral	*Montipora venosa*	Uncommon
	Psammocora superficialis	Abundant
	Turbinaria peltata	Common
	Cyphastrea serailia	Dominant
	Oulastrea crispata	Common
	Goniopora stutchburyi	Common
Gorgonian	*Euplexaura* sp.	Abundant
	Echinomuricea sp.	Abundant

*Distribution/abundance rating based on Chan et al. (2005)[1] and Lee and Ang (2007)[2]

(1) Alan Chan, Choyce Choi, Denise McCorry, Khaki Chan, M W Lee and Ang Put Jr. (2005). *Field Guide to Hard Coral of Hong Kong*. Friends of the Country Parks.

(2) [2]MW Lee and Put O Ang (2007) The distribution and community structure of octocorals in eastern waters of Hong Kong SAR. M. Phil thesis submitted to The Chinese University of Hong Kong.

Table C6 *Summary Information on the Hard Corals Recorded Along the Transect Lines*

Transect:	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Water depth (m below CD)	4-6	2-4	4-6	2-4	4-6	2-4	4-6	2-4
No. of hard coral colonies	0	7	0	2	1	0	3	1
No. of hard coral species	0	5	0	1	1	0	2	1
No. of movable colonies	0	0	0	0	0	0	0	0
No. of immovable colonies	0	7	0	2	1	0	3	1
Size range of colonies (cm)	<10	10-50	--	<10	<10	--	<10	<10

Table C7 *Summary List of Fish Species Observed during the REA Surveys in April 2008*

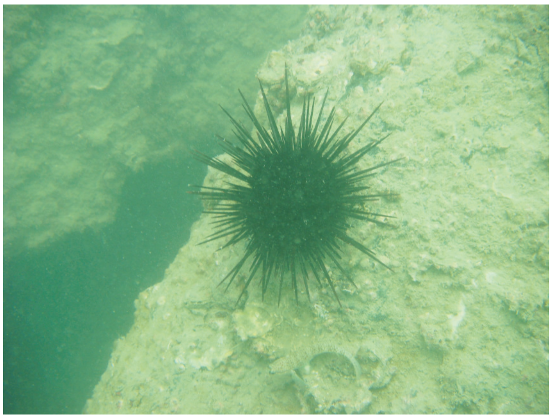
Genus/species	**Hong Kong Distribution/ Abundance Rating***
Chelonodon patoca (Milkspotted pufferfish)	Common
Istigobius diadema (Urchin goby)	Common
Scarpaenopsis cirrhosa (Weedy stingfish)	Widespread
Chromis notata (Pearl-spot chromis)	Common
Entomacrodus stelliferlighti (Stellar Rockhopper)	Common
Antennarius nummifer (Spotfin frogfish)	Rare

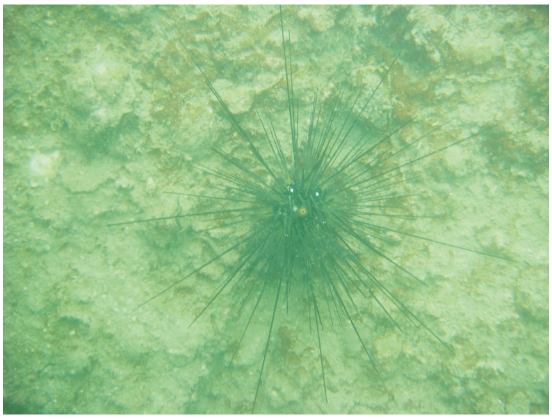
*Distribution/abundance rating based on Sadovy and Cornish (2000)

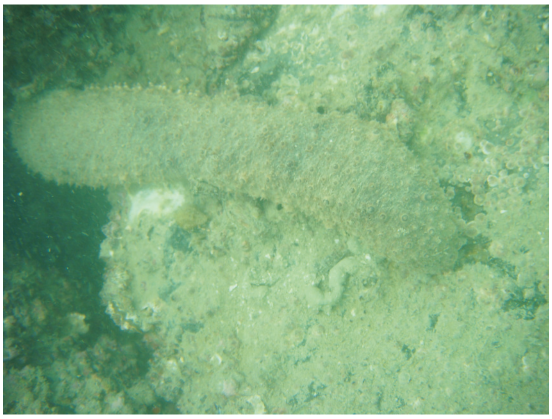
Table C8 ***Mean Abundance per Quadrat (Mean ± SD) of Intertidal Fauna and Percentage Cover (%) of Sessile Fauna and Flora recorded on Artificial Shoreline Transects (T1 and T2) and Natural Rocky Shore (T3) on Tseung Kwan O on April 2008***

	High-Intertidal Zone			**Mid-Intertidal Zone**			**Low-Intertidal Zone**		
Flora/Fauna	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Snail									
Chlorostoma argyrostoma						0.1±0.3			
Lunella coronata						0.8±1.0			3.4±3.0
Monodonta labio				4.2±5.2	4.4±4.7	9.3±10.8	0.9±1.0	2.2±1.6	1.5±1.8
Morula musiva				0.5±1.6	0.3±0.7		0.3±0.7	0.2±0.4	0.5±0.8
Neria albicilla				0.5±0.8		0.5±1.3			
Echinolittorina trochoides			13.6±14.8						
Echinolittorina radiata	0.7±1.9	0.3±0.5	17.7±18.3						
Peasiella sp.			1.3±4.1						
Planaxis sulcatus						7.9±20.0			5.7±16.6
Chiton									
Acanthopleura japonica				0.8±1.5	1.6±1.5		1.8±3.1	1.8±3.5	0.1±0.3
Limpet									
Nipponacmea concinna				12.3±14.2	4.9±7.9	3.1±3.1	14.1±17.7	24.5±16.0	5.5±8.6
Patelloida pygmaea		0.5±0.8	0.8±2.5	1.3±1.3	3.1±4.2	4.6±5.4	0.5±0.8	3.3±3.0	1.0±1.9
Patelloida saccharina				2.6±4.3	2.5±3.7		0.2±0.4	6.8±12.0	0.3±0.9
Siphonaria japonica					0.4±1.0	1.3±1.6		0.1±0.3	0.7±0.9
Siphonaria laciniosa				0.1±0.3			1.2±1.8	1.1±2.2	0.4±1.0
Others									
Crustacea sp.A (juvenile)					2.0±6.3				
Sea anemones									0.1±0.3
Percentage Coverage (%)									
Bivalve									
Saccostrea cucullata				3.5±6.7	7.3±10.1	33.5±38.2	56.0±35.6	12.5±25.5	50.0±46.1

	High-Intertidal Zone			Mid-Intertidal Zone			Low-Intertidal Zone		
Flora/Fauna	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Algae									
Ulva sp.						0.5±1.6			
Gelidium pusillum						4.0±12.6			11.5±30.0
Ralfsia expansa									27.5±40.6
Corallina sessilis									0.3±0.9
Hildenbrandia occidentalis						2.0±6.3			
Cyanobacteria									
Kyrtuthrix maculans				2.6±4.3	2.5±3.7		0.2±0.4	6.8±12.0	0.3±0.9


Anthocidaris crassispina on artificial seawall (large rock substrate with silt and remnants of oysters and barnacles).


Diadema setosum on artificial seawall (large rock substrate with silt and remnants of oysters and barnacles).


Holothuria leucospilota


Chelonodon patoca


Istigobius diadema


Scarpaenopsis cirrhosa


Patch of smaller rocks atypical the main large rock composition of the artificial seawall


Muddy bottom in the deep water of natural shoreline of T1.

Figure C1

Marine fauna and seabed condition recorded during the dive survey

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Environmental Resources Management

Annex D

Implementation Schedule

D1 IMPLEMENTATION SCHEDULE

D1.1 INTRODUCTION

This *Annex* summarises all the mitigation measures recommended in the EIA study and presents them in the form of an Implementation Schedule in accordance with the requirements of Section 3.4.7.3 of the *EIA Study Brief No. ESB-178/2007*.

The Implementation Schedule has the following column headings:

EIA Ref

This denotes the section number or reference from the main text of the *EIA Report*.

EM&A Ref

This denotes the sequential number of each of the recommended mitigation measures specified in the Implementation Schedule.

Recommended Mitigation Measures

This denotes the recommended mitigation measures, courses of action or subsequent deliverables that are to be adopted, undertaken or delivered to avoid, reduce or ameliorate predicted environmental impacts.

Objectives of the Recommended Measures and Main Concerns to be Addressed

This denotes the objectives of the recommended mitigation measures and main concerns to be addressed in the EIA study.

Location

This indicates the spatial area in which the recommended mitigation measures are to be implemented together with details of the programming or timing of their implementation.

Who to Implement the Measure

This denotes where the responsibility lies for the implementation of the recommended mitigation measures.

When to Implement the Measures

This denotes the stage at which the recommended mitigation measures are to be implemented either during the Design, Construction or Operation phases.

What Requirements or Standards for the Measures to Achieve

This defines the controlling legislation that is required to be complied with.

Table D1.1a Implementation Schedule

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
Air Quality – Construction Phase									
4.7.1	AQ1	• 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;	To minimise potential dust nuisance	Main haul road	Contractor		✓		*Air Pollution Control (Construction Dust) Regulations* *HKAQO and EIAO-TM Annex 4*
4.7.1	AQ2	• Effective dust screens, sheeting or netting will be provided to enclose the scaffolding from the ground level of the facility during the building construction;	To minimise potential dust nuisance	All construction works area	Contractor		✓		*Air Pollution Control (Construction Dust) Regulations* *HKAQO and EIAO-TM Annex 4*
4.7.1	AQ3	• All debris and materials will be covered or stored in a sheltered debris collection area;	To minimise potential dust nuisance	All construction works area	Contractor		✓		*Air Pollution Control (Construction Dust) Regulations* *HKAQO and EIAO-TM Annex 4*
4.7.1	AQ4	• Hoarding from ground level will be provided along the entire length of the site boundary except for a site entrance or exit;	To minimise potential dust nuisance	Site boundary and entrance	Contractor		✓		*Air Pollution Control (Construction Dust) Regulations*

(1) D=Design; C=Construction; O=Operation

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? [1] D	C	O	What requirements or standards for the measure to achieve?
									HKAQO and EIAO-TM Annex 4
4.7.1	AQ5	• Every stockpile of dusty materials will be covered entirely by impermeable sheeting or placed in an area sheltered on the top and the 3 sides;	To minimise potential dust nuisance	All construction works area	Contractor		✓		*Air Pollution Control (Construction Dust) Regulations* *HKAQO and EIAO-TM Annex 4*
4.7.1	AQ6	• Regular maintenance and checking of the diesel powered mechanical equipment will be adopted to avoid any black smoke emissions and to minimize gaseous emissions.	To minimise potential black smoke emission	All construction works area	Contractor		✓		*Good Site Practice*
4.7.1	AQ6	• Monthly site audits will be conducted to ensure the implementation of suitable dust control measures and good site practices	To minimise potential dust nuisance and black smoke emission	All construction works area	Contractor		✓		-
Air Quality – Operational Phase									
4.4.2	AQ7	• During berthing of the marine vessel at the jetty, the main engine of the vessel will be switched off to minimise emissions. The power supply to the marine vessels will be provided by an on-site power supply.	To minimise air quality impact	At the jetty	Operator			✓	-
4.9.2	AQ8	• NO_x, CO, SO_2 and NMOC concentrations in the flue gas of the stacks of the boilers and biogas flare (if in operation), methanol and acetyldehyde concentrations in the vent gas of process building, and odour concentration at the stack of the final air scrubber will be monitored on monthly basis for the first year of the operation. If the results of the first year monitoring meet the limit levels, the monitoring will be reduced to half-year intervals for the operational stage.	To minimise air quality impact	Emission monitoring : boiler stack, biogas flare (if in operation), vent pipe of process building and final air scrubber stack Odour patrol : along	Operator			✓	-

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? [1] D	C	O	What requirements or standards for the measure to achieve?
		Exhaust gas temperature and exhaust gas velocity will also be monitored at the same frequency.		the Project Site boundary					
4.9.2	AQ9	• Odour concentration at the stack of the final air scrubber will be monitored on monthly basis for the first two years of the operation. Exhaust gas temperature and exhaust gas velocity of the final scrubber will also be monitored at the same frequency.	To minimise odour nuisance	Emission monitoring : final air scrubber stack	Operator			✓	-
4.9.2	AQ10	• Odour patrol will be carried out along the Project Site boundary on monthly basis during the first year of the operation of the biodiesel plant. If there is no exceedance of action limit or there is no substantiated odour compliant during the first year of operation, the monitoring frequency will be reduced to quarterly intervals in the second year of the operation. During the second year of operation, if the action level is triggered, the frequency will be resumed to monthly until compliance with the action level for three consecutive months is obtained and the frequency will be reduced to quarterly interval thereafter. If the action level is not triggered for four consecutive quarterly monitoring, the monitoring can be terminated.	To minimise odour nuisance	Along Project Site boundary	Operator			✓	-
Noise – Construction Phase									
5.7.1	N1	Adopt good site practice listed below: • Only well-maintained plant will be operated on-site and plant will be serviced regularly during the construction program; • Silencers or mufflers on construction equipment will be	To further minimise potential construction noise nuisance.	All construction works area	Contractor		✓		*Noise Control Ordinance (NCO)* and *Annex 5* of *EIAO-TM*

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? [(1)]			What requirements or standards for the measure to achieve?
						D	C	O	
		utilized and will be properly maintained during the construction program; • Mobile plant, if any, will be sited as far from NSRs as possible; • Machines and plant (such as trucks) that may be in intermittent use will be shut down between work periods or will be throttled down to a minimum; • Plant known to emit noise strongly in one direction will, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and • Material stockpiles and other structures will be effectively utilised, wherever practicable, in screening noise from on-site construction activities.							
Noise – Operational Phase									
5.7.2	N2	Adopt good site practice listed below: • Choose quieter equipment; • Include noise levels specification when ordering new plant items; • Locate fixed plant items or noise emission points away from the NSRs as far as practicable; • Provide complete noise enclosures for all outdoor pumps with no opening facing the LOHAS parks; • Locate noisy machines in enclosed plant rooms or buildings; and • Develop and implement a regularly scheduled plant	To further minimise potential operational noise nuisance.	Within the Project Site	Contractor/ Operator	✓		✓	*Noise Control Ordinance (NCO)* and *Annex 5 of EIAO-TM*

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1)			What requirements or standards for the measure to achieve?
						D	C	O	
		maintenance programme so that plant items are properly operated and serviced. The programme will be implemented by properly trained personnel.							
Water Quality – Construction Phase									
6.7.1	WQ1	<u>Piling Activities</u> • Silt curtain will be installed around the marine piling area to contain any suspended mud and sediments generated during the piling works. Silt removal facilities such as silt traps or sedimentation facilities will be provided to remove silt particles from groundwater (if pumping is required) to meet the requirements of the *TM* standard under the *WPCO*. The design of silt removal facilities will be based on the guidelines provided in *ProPECC PN 1/94*. All drainage facilities and erosion and sediment control structures will be inspected monthly and maintained to ensure proper and efficient operation at all times and particularly during rainstorms.	To minimise potential water quality impacts arising from the land based piling works	The piling area and the construction works area	Contractor		✓		*ProPECC PN 1/94* *WPCO Cap 358AK– Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal*
6.7.1	WQ2	<u>Construction Site Run-off and Drainage</u> • Silt removal facilities such as silt traps or sedimentation facilities will be provided to remove silt particles from runoff to meet the requirements of the *TM* standard under the *WPCO*. The design of silt removal facilities will be based on the guidelines provided in *ProPECC PN 1/94*. All drainage facilities and erosion and sediment control structures will be inspected monthly and maintained to ensure proper and efficient operation at all times and particularly during rainstorms.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94* *WPCO Cap 358AK– Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal*

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
6.7.1	WQ3	• Careful programming of the works to minimise surface excavations for the construction works during the wet season. If excavation of soil cannot be avoided during the wet season, exposed slope surfaces will be covered by a tarpaulin or other means. Other measures that need to be implemented before, during, and after rainstorms are summarised in *ProPECC PN 1/94*.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94*
6.7.1	WQ4	• Exposed soil surfaces will be protected by paving or fill material as soon as possible to reduce the potential of soil erosion.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94*
6.7.1	WQ5	• Open stockpiles of construction materials or construction wastes on-site of more than $50m^3$ will be covered with tarpaulin or similar fabric during rainstorms. These materials will not be placed near the seawall area.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94*
6.7.1	WQ6	<u>General Construction Activities</u> • Debris and refuse generated on-site will be collected, handled and disposed of properly to avoid entering the nearby water sensitive receivers (WSRs). Stockpiles of cement and other construction materials will be kept covered when not being used.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94*
6.7.1	WQ7	• Oils and fuels will only be used and stored in designated areas which have pollution prevention facilities. All fuel tanks and storage areas will be provided with locks and be sited on sealed areas, within bunds of a capacity equal to 110% of the storage capacity of the largest tank. The bund will be drained of rainwater after a rain event.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94*
6.7.1	WQ8	<u>Sewage generated from On-site Workforce</u>	To minimise potential water quality impacts	All construction works area	Contractor		✓		*WPCO*

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? [(1)] D	C	O	What requirements or standards for the measure to achieve?
		• Temporary sanitary facilities, such as portable chemical toilets, will be provided on-site. A specialised contractor will be responsible for regular collection and appropriate disposal of the sewage and maintenance of these facilities.	arising from on-site sewage generation						*Waste Disposal Ordinance (WDO)*
6.10	WQ9	• Monthly site inspections will be carried out during construction to ensure that the mitigation measures listed above are properly implemented. The site audit frequency will be increased to weekly intervals during the piling works.	To prevent water quality impact	All construction works area	Contractor		✓		
Water Quality – Operational Phase									
6.7.2	WQ10	<u>Spillage of Raw Materials and Biodiesel Products</u> • Should a spill arise, the following actions will be taken: - **Within the loading/unloading area:** The bunded loading and unloading area will be paved with an impermeable surface and spills will be intercepted and collected by the collection drains. The contaminated wastewater will be transferred to the on-site wastewater treatment plant for treatment. - **Spillage on site:** The spill will be contained and removed by using appropriate absorbent or dispersant. The spillage area will be cleaned up immediately. The wastewater will collected and treated at the on-site wastewater treatment plant. - **During transportation:** Retainer booms will be used to create a wrap around the barge and the	To minimise potential water quality impacts on surface water arising from accidental spillage of raw materials and biodiesel products	Biodiesel Plant	Operator			✓	*WPCO* *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Inshore Waters (Water-TM)*

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
		contaminated areas to prevent the spillage spreading. Absorbents will be used to absorb the waste in the confined area.							
6.7.2	WQ11	• A detailed emergency response plan will be developed prior to the commencement of the operation of the biodiesel plant to stipulate the actions to be taken in case accidental spills occurred and prevent any spillages from discharge into the sea.	To minimise potential water quality impacts on surface water arising from accidental spillage of raw materials and biodiesel products	Biodiesel Plant	Operator		✓		
6.7.2	WQ12	• Implementation of the control and actions described in the emergency response plan.	To minimise potential water quality impacts on surface water arising from accidental spillage of raw materials and biodiesel products	Biodiesel Plant	Operator			✓	
6.7.2	WQ13	• The training for the staff for awareness of the potential environmental risk association with spillage of materials and proper implementation of the control measures and emergency responses described in the emergency response plan. The training will include all possible risks, which can be occurred when handling different materials (eg methanol, acids and bases, biodiesel, etc) and the necessary clean up procedures. Training will make reference to the MSDS (Material safety data sheets) so that the staff will be fully conversant with the potential risks and environmental implications associated with spillage of materials.	To minimise potential water quality impacts on surface water arising from accidental spillage of raw materials and biodiesel products	Biodiesel Plant	Operator			✓	

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
6.10	WQ14	• During the operation phase, the quality of the stormwater/effluent will be monitored at the terminal manholes of the stormwater and foul water drainage systems on a monthly basis. Parameters to be monitored will include: - Stormwater discharge from the site: oil and grease and suspended solids; and - Treated effluent from the wastewater treatment plant: Parameters listed in Table 1 of the Technical Memorandum on Standards for Effluents Discharged to Drainage and Sewerage Systems, Inland and Coastal Water or those specified in the *WPCO* licence.	To prevent water quality impact	Biodiesel Plant	Operator			✓	*WPCO*
Ecology – Construction Phase									
7.11	EC1	• Mitigation measures for minimising water quality impacts are presented in detail above (EM&A Ref WQ1 to WQ8). These measures will be properly implemented and good construction practices will be adopted to minimise potential adverse impacts to marine ecological resources.	To minimise potential water quality impacts arising from the construction works	All construction works area	Contractor		✓		*ProPECC PN 1/94*
Ecology – Operational Phases									
7.11	EC2	• Mitigation measures for minimising water quality impacts are presented in detail above (EM&A Ref WQ9 and WQ10). These measures will be properly implemented and good operational practices will be adopted to minimise potential adverse impacts to marine ecological resources.	To minimise potential water quality and ecological impacts on arising from accidental spillage of raw materials and biodiesel products	Biodiesel Plant	Operator			✓	*WPCO* *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage*

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
									Systems, Inland and Inshore Waters (Water-TM)
7.11	EC3	• Once available, the location of the piles will be reviewed to determine the possibility of preventing direct loss of hard coral colony and other marine organisms caused by the piling footprint.	To prevent direct impact on the identified coral along the seawall	Jetty area	Contractor		✓		
Risk									
8.9	R1	• The process plant building will be provided with adequate number of gas detectors distributed over the various areas of potential leak sources to provide adequate coverage. A coverage factor of 90% for 1 out of N detectors for alarm to be ensured (i.e. the system will be designed so that at least one detector (out of the N detectors provided) triggers in 90% of occasions when a high concentration of flammables is present).	To prevent build up of flammable vapours within the process building	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R2	• Additional leak detection systems based on process parameters will be considered such as low pressure or others as applicable.	To prevent and control leakage of materials from process tanks	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R3	• Upon gas detection, the process system will be isolated. All pumps, motors will be stopped. Emergency shutdown valves will also be provided at the liquid outlet connections of major equipments holding significant inventory of methanol (>5m^3). Emergency shutdown system will be designed to meet a performance target of 90% for the reliability of the overall shutdown system.	To prevent build up of flammable vapours within the process building	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R4	• Emergency ventilation system will be provided in accordance with relevant design codes for adequate ventilation of process areas inside buildings, to ensure that	To prevent build up of flammable vapours within the process	Process building	Design Engineer and Operator	✓	✓	✓	

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
		the ventilation rate is sufficient to bring down the concentration to 50% of lower explosive limit (LEL). The ventilation system will be designed to avoid any stagnant pockets in accordance with relevant codes (e.g. IP 15 : Area Classification Code for Installations Handling Flammable Liquids, IEC 60079, Part 10 :2002 Electrical Apparatus for Explosive Gas Atmospheres and NFPA 30 : The Flammable and Combustible Liquids Code). A performance target of 90% for the reliability of the ventilation system is to be achieved.	building						
8.9	R5	• All electrical equipment inside the building will be classified in accordance with the electrical area classification requirements. No unclassified electrical equipment will be used during operations or maintenance.	To avoid ignition sources	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R6	• Reference will also be made to codes of practice and guidance issued in Europe that apply to places where explosive atmospheres may occur (called 'ATEX' requirements). These are covered as part of the European Directive: the Explosive Atmospheres Directive (99/92/EC) and the UK regulations, Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). Where potentially explosive atmospheres may occur in the workplace, the requirements include, identifying and classifying (zoning) areas where potentially explosive atmospheres may occur; avoiding ignition sources in zoned areas, in particular those from electrical and mechanical equipment; where necessary, identifying the entrances to zoned areas; providing appropriate anti-static clothing for employees; and before they come into operation, verifying the overall explosion protection safety of areas where explosive atmospheres may occur. The code of practice	To avoid ignition sources	Process building	Design Engineer and Operator	✓	✓	✓	

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
		and guidance cover among others control and mitigation measures, safe maintenance, repair and cleaning procedures.							
8.9	R7	• If there are any openings from the building, the near vicinity outside of such openings should also be met with the area classification requirements as per the relevant code example IP 15.	To avoid ignition sources	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R8	• Gas detection will be provided in methanol storage area and emergency shutdown system on liquid inlet and outlet piping of methanol storage tank including automatic shutdown on high level will be provided.	To prevent build up of flammable vapours within the process building and to minimise leakage of materials from process tanks	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R9	• Online oxygen analysers will be provided in the closed vent system of process equipment located inside the process building to detect any air ingress into equipment due to a maintenance activity or during normal operation, for example due to nitrogen blanketing failure. Appropriate control and shutdown actions on high oxygen alarms will be designed as required. Also, portable gas analyzers will be used to test the internal atmosphere of process equipment after completion of maintenance	To prevent risk of explosion in the processing equipment	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R10	• A preliminary process hazard analysis has been carried out as part of the basic design. Also, as part of this QRA study, a detailed hazard identification has been carried out. Further review of design safety measures will be performed as the design process continues, using a structured hazard identification process such as Hazard and Operability Study.	To further minimise risks associated with the operation of the plant	-	Design Engineer and Operator	✓			

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D	C	O	What requirements or standards for the measure to achieve?
8.9	R11	• The reliability requirements for process safety interlock systems will be determined following a structured process such as Safety Integrity Level determination and verification studies as per IEC 60508 and 60511.	To prevent and control leakage of materials from process tanks	Process building	Design Engineer and Operator	✓	✓	✓	
8.9	R12	• Safety Management Systems and Procedures will be developed to cover all aspects of operations and maintenance including safe handling of chemicals, safe operating and maintenance practices, operator training, employment of suitably qualified personnel with relevant process industry experience, period audit and review of the safety management systems and procedures etc. The systems and procedures will be in line with the best practices in the process industry and also reflect the high standards adopted in Hong Kong by companies operating in the LPG, flammable liquid and gas industry.	To prevent and minimise risk to on-site staff and off-site population	Whole Site	Operator		✓	✓	
8.9	R13	• In the event of any maintenance activity inside a building, procedures will be developed to ensure that flammable concentration build-up does not occur due to draining, opening of vessel or piping etc. The start-up and maintenance operations will be supervised and checked independently of the person undertaking such tasks, to provide a greater oversight.	To prevent release and accumulation of flammable vapours within the process building	Process building	Operator		✓	✓	
		• Also, the reliability of the nitrogen in the blanketing system will be ensured to minimise failure of blanketing leading to potential vapour releases from enclosed equipment inside the building. All vents from the process equipments inside the building will be routed to a safe location outside the building.	To prevent release and accumulation of flammable vapours within the process building	Process building	Operator		✓	✓	
8.9	R14	• Detailed emergency response plans will be developed to handle any impacts on-site and off-site due to any incident	To avoid fire or explosion due to	Whole Site	Operator		✓	✓	

EIA Ref.	EM&A Ref	Environmental Protection Measures	Objectives of the Recommended Measure & Main Concerns to address	Location of the Measures	Who to implement the measure?	When to implement the measure? (1) D C O	What requirements or standards for the measure to achieve?
		at the facility during loading/ unloading operations, transfer operations, storage tank farm operations and processing operations.	operation of the plant				

Annex E

Characteristics of Bioheating Oil

E1 CHARACTERISTICS OF BIOHEATING OIL

E1.1 CHEMICAL COMPOSITION

Bioheating oil is the residue out of the biodiesel distillation. It consists of:

40-80 %wt	Methyl ester
1-30 % wt	Dimere Methyl ester (depending on polymers from Used Cooking Oil)
1- 25 % wt	Mono,-Di- and Triglycerides
1- 5 % wt	Fatty acids
1- 5 % wt	Organic components from feedstock (colour, non saponifiable)
0.1 – 0.4 % wt	Ash
max. 2,000 ppm	Sulphur (depending on feedstock)

E1.2 PHYSICAL PROPERTIES:

General information	
• Physical condition	liquid at temperatures above 60 to 80 ^{o}C
• colour	dark brown or black
• odour	characteristic, depending on feedstock
Flashpoint	about 170^{o}C
Inflammation temperature	about 400^{o}C
Explosion hazard	at ambient temperature the product does not represent an explosion hazard
Density at 40%.	approx. 914 kg/m^3 to 935 kg/m^3
Density at 80%	approx. 885 kg/m^3 to 907 kg/m^3
Viscosity at 40%	50mm^2/s to 500 mm^2/s
Viscosity at 80%	13mm^2/s to 50 mm^2/s
Flammability	at ambient temperature auto-ignition of the product is not possible
Electrical conductivity	0.2 µS/cm
Dielectricity constant	3.9

E1.3 COMPARISON OF BIODIESEL WITH BIOHEATING OIL

	Unit	Biodiesel		Bioheating Oil	
		Min.	Max.	Min.	Max.
Ester-content	% (m/m)	96.5		40	80
Density at 15°C	kg/m^3	860	900	914 (40°C)	935 (40°C)
Viscosity at 40°C	Mm^2/s	3.50	5.00	50	500
Flash point	°C	120	-	187	-
Sulphur content	mg/kg	-	10	58	2,000
Linolenic acid – methylester	% (m/m)	-	12.0	-	12.0
Methanol content	% (m/m)	-	0.20	0.0	0.05
Monoglyceride content	% (m/m)	-	0.80	1-25%	
Diglyceride content	% (m/m)	-	0.20	1-25%	
Triglyceride content	% (m/m)	-	0.20	1-25%	
Free glycerol	% (m/m)	-	0.200	0	0.02
Total glycerol	% (m/m)	-	0.25	2.38	5.83

Annex F

Outline Emergency Response Plan

F1 OUTLINE EMERGENCY RESPONSE PLAN

F1.1 INTRODUCTION

A detailed emergency response plan for the operation of the biodiesel plant will be developed after the completion of the detailed design of the plant. The following sections outline the general requirements of the plan respect to prevention and management of the risk of pollution and will form the basis for the development of the detailed plan.

F1.2 POLLUTION PREVENTION AND CONTROL MEASURES

F1.2.1 Loading and Loading of Materials

Loading and unloading of materials should be carried out by trained personnel of the biodiesel plant and in accordance with the operational procedures established by plant manager.

Loading and Unloading at the Jetty

The operator at the jetty should closely liaise with the operator on the barge to ensure that all the connections are secured. The operators should closely monitor the loading and loading operation to ensure no spillage or leakage of material during the operation. Should there be a leak, the operator at the jetty should immediately press the emergency stop of the pumps and close the valve to minimise the leak.

Loading at the Grease Trap Waste Unloading Area

The operator should check the joint connection of the discharge pipe of the grease trap waste (GTW) tanker and the reception pipe of the unloading station to ensure that it is properly connected and secured. The operator should closely monitor the loading operation to ensure no spillage or leakage of material during the operation. Should there be a leak, the operator should instruct the driver of the tanker to close the discharge valve of the tanker to stop further leak. The spill should be cleaned up immediately by washing down to the drainage system. The wastewater will be pumped to the wastewater treatment plant for treatment.

F1.2.2 Prevention of Leakage of Materials from Tank Farm and Process Tanks

All storage tanks should be hydro-tested with water (according the designed test pressure) before used. The tanks should be provided with a leak detection system. The integrity of the tanks should be inspected regularly in accordance with the requirements of the relevant Building Regulations.

Bund wall should be provided in the tank farm (including the storage tank of the raw materials/products) and the process tanks within the Process

Building to contain any spillage of materials (the wall should be designed to hold at least 110% of the volume of the largest tank) within the bunded area. The floor of the bunded area should be paved with concrete block and coated with waterproofing membrane. This will effective prevent any spill from seeping into the soil.

The bunded area should be provided with a sump pit(s) with a manually controlled valve/penstock which should normally be closed. All surface water discharged from the bunded area should pass through an oil interceptor. No surface water will be automatically drained from the bunded area. The plant operator should check the valves/penstocks on a daily basis to ensure that they are closed. The operator should also check that the valves/penstocks are closed before the tank is receiving stock. The water level within the interceptor should be inspected regularly to ensure that oily water cannot pass directly to the outlet. During each regular check, the operator will turn the interceptor outlet valve to confirm that it operates easily and can be shut tight when necessary.

During rainstorm, the operator should observe the rainwater collected within the bunded and will manually open the valve of the sump pit of the bunded area to allow an appropriate flow to pass through the oil interceptor.

The sump pit should also be equipped with a level switch instrument to detect the water level. The sensor should be connected to an alarm of the PCS-system. Spill/leak within the bunded area should be cleaned up immediately. If a large spill/leak is detected, the materials should be pumped out and reuse, where appropriate. Otherwise the material should be disposed of as a chemical waste to the Chemical Waste Treatment Centre. If the leak is from the GTW and Waste Cooking Oil (WCO) storage tanks, the materials will be pumped to other GTW storage tanks or to the on-site wastewater treatment plant for treatment.

F1.2.3 Prevention of Leakage from Pipe Bridge

After installation, the pipelines should be tested (pressure test with water). The pipes on the pipe bridge should be welded so that there will be no connection (eg flanges and valves) on the pipe bridge outside the bunded area. Flanges and valves should only be located within/above a bunded area (eg Process Building, tank farm, Technic Room). The pipelines should be visual inspected on a regularly basis and tested as necessary.

To prevent the pipe bridge against any traffic collisions, the bottom line of the bridge should be at least 4.5m above ground level. At the site entrance, a "height check/control" should be installed to ensure that vehicles taller than 4m will not been allowed to enter the site unless it is escorted by senior site operator to ensure that the vehicle will not drive near the pipe bridge. The columns of the pipe bridge at the street level should be protected by barriers and sufficient clearance from the road.

F1.2.4 *Loading/Unloading Stations at the GTW Unloading Area and Jetty*

At the loading and unloading stations, the following control measures should be implemented:

- Dry couplings should be used to connect the pipes with the truck or barge;
- The GTW unloading area should be paved with concrete and the drainage should be separated from the stormwater drainage system. The drainage should be connected to the on-site wastewater treatment plant. For the unloading area at the jetty area, the gate valve of the sump pit of the bunded area should be closed to ensure any spillage will be contained and collected. This avoids direct discharge of any spill to the stormwater drainage system.
- Emergency stops of loading and unloading should be installed at all stations.
- The loading and unloading operation should be carried out by trained operators.

F1.2.5 *Monitoring of Effluent Discharge from the Site*

The water discharged from the oil interceptor will be checked to ensure that the effluent comply with the discharge standards prior discharge to the stormwater system.

The quality of the effluent discharge from the terminal manhole of the site to the public sewer of the TKO Industrial Estate will be monitored in accordance with the requirements of the *Water Pollution Control Ordinance* Licence.

F1.3 *MARINE POLLUTION EQUIPMENT*

The following marine pollution equipment will be maintained at the jetty area.

- Boom: the total length of the boom will not be less 2.5 times the maximum length of the marine vessel delivering the raw materials and exporting the biodiesel;
- Ancillary equipment necessary for the proper deployment of the boom; and
- Appropriate absorbent materials for the PFAD, methanol and biodiesel.

F1.4 *CLEAN UP PROCEDURES FOR SPILLAGE OF MATERIALS ON SITE*

There is potential for spillage of biodiesel, PFAD and methanol during the loading/unloading operations at the jetty area. Dry coupling should be used to connect two loading/unloading pipes or a flexible hose to a transfer pipe in order to avoid any leakage of the materials at the joint. The loading/ unloading area should be surrounded by covered surface channel to contain any potential spillage of materials. In addition, the operations should be undertaken at the paved loading/ unloading station and should be manned by trained staff and closely monitored with flow control equipment. Any spillages should be contained and the spill be absorbed by appropriate absorbents. The area should be properly washed and the wastewater should be conveyed to the on-site wastewater treatment plant for treatment.

For accidental spills that could occur during transportation of biodiesel from the site, retainer booms should be used to create a warp around the barge and the contaminated areas to prevent the spillage spreading. The spill should be absorbed by appropriate absorbents. If there is leak of the methanol, it should let the methanol to vapour as quickly as possible so that the vapour will be diluted below the flammable concentration.

F1.5 TRAINING OF SITE PERSONNEL

Induction training for all site personnel will include the emergency contingency plan of the site. Refresher training will be provided to the key operation staff on an annual basis.

The training will include all possible risks, which can be occurred when handling different materials (eg methanol, acids and bases, biodiesel, etc), health and safety measures and the necessary clean up procedures. Training will make reference to the MSDS (Material safety data sheets) so that the staff will be fully conversant with the potential risks and environmental implications associated with spillage of materials.

The training will also include the operation of the clean up equipment.

F1.6 EMERGENCY CONTACTS

The detailed emergency response plan should include the contact person, telephone numbers and addressed of the following organisation.

- Plant Manager;
- Regional Office (East), Environmental Compliance Division of EPD;
- TKO Ambulance/Fire Station;
- TKO Police Station;
- Marine Department;
- Manager of the TKOIE, Hong Kong Science and Technology Park; and
- Sai Kung District Office.