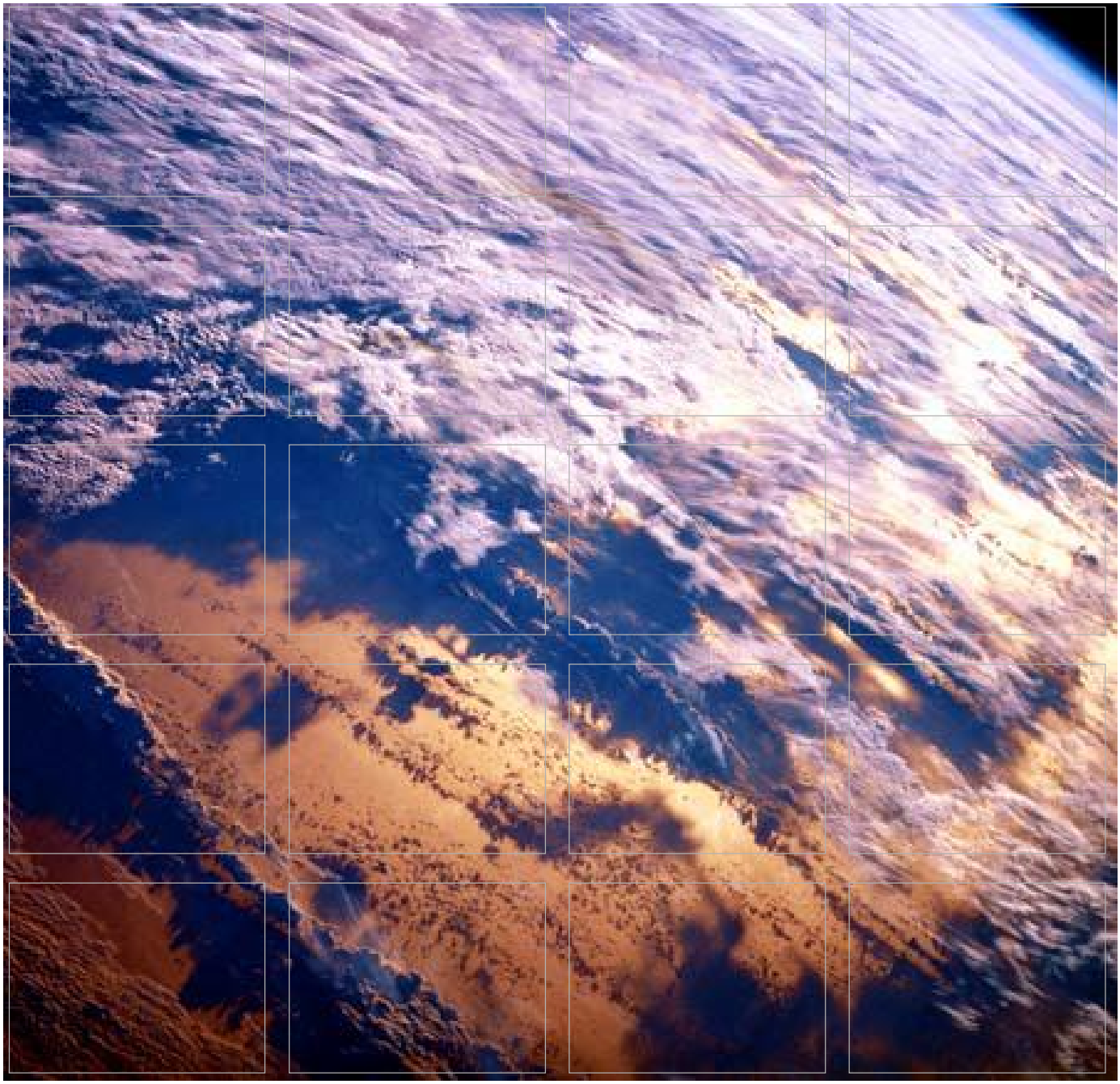

Proposed Renewable Diesel Plant

Pollution Control Study (PCS)

April 2008

www.erm.com

Delivering sustainable solutions in a more competitive world

Proposed Renewable Diesel Plant

Pollution Control Study (PCS)

Environmental Resources Management (S) Pte Ltd

180 Cecil Street
#11-02 Bangkok Bank Bldg
Singapore 069546
Telephone (65) 6324 9636
Facsimile (65) 6226 1636
Email ermsg@erm.com
Website: www.erm.com

Client	Project No
Neste Oil Singapore Pte Ltd	0067463

Project Summary	Date
Neste Oil Singapore Pte Ltd (Client) intends to setup a facility to produce Renewable Diesel by converting vegetable oil (e.g. palm, soybean, rapeseed oil) and animal fat to renewable hydrocarbon diesel oil on a site in Tuas. As part of the approval process with the Singapore governmental authorities for the required modifications, a PCS is required to evaluate the potential environmental impacts (associated with the plant operation) to its surrounding environment and public health. Client has commissioned ERM to conduct the PCS.	22 April 2008 Approved by David C Turberfield *Managing Partner* *ERM Singapore*

Revision	Description	By	Checked	Approved	Date
2	Final Report Rev 1	JV	DT	DT	22/04/08
1	Final Report	JV	MW	MW	11/04/08
0	Draft Report	LG/JV/ST/AW	DCT	DCT	17/12/07

This report has been prepared by Environmental Resources Management with all reasonable skill, care and diligence within the terms of the Contract with the client, incorporating our General Terms and Conditions of Business and taking account of the resources devoted to it by agreement with the client.

We disclaim any responsibility to the client and others in respect or any matters outside the scope of the above.

This report is confidential to the client and we accept no responsibility of whatsoever nature to any third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

Distribution

☒ Internal

☐ Public

☐ Confidential

Proposed Renewable Diesel Plant– Neste Oil (S) Pte Ltd

Pollution Control Study (PCS)

Neste Oil Singapore Pte Ltd
Level 18, Republic Plaza II
9 Raffles Place
Singapore 048619

Acknowledgement	Date 22.4.2008
On behalf of Neste Oil Singapore Pte Ltd, I hereby confirm that I have read, understood and agree with all of the statements and provisions made in the PCS undertaken for our facility named above by our Consultant, Environmental Resources Management.	Acknowledged by *Neste Oil Singapore Pte Ltd*

Delivering sustainable solutions in a more competitive world

5 AIR EMISSIONS & AIR QUALITY

5.1 SINGAPORE REGULATORY REQUIREMENTS AND STANDARDS

5.1.1 Air Emission Limits

The Pollution Control Department (PCD) of the National Environment Agency (NEA) is responsible for the regulation and enforcement of all matters related to air pollution. As of January 2001, the *Clean Air (Standards) Regulations*, which have been in force since 1978, were revised and replaced by the *Environmental Protection and Management (Air Impurities) Regulations 2001*. These regulations promulgate new emission standards, which are presented in *Table 5.1a*. The standards aim to control air emissions from industries to help maintain ambient air quality in Singapore. New industries and equipment or processes introduced by existing industries were required to comply with the revised standards from 1st January 2001. The *Code of Practice on Pollution Control (CoPPC – Section 4.2)* also stipulates provisions for the safe dispersion of flue gases.

Table 5.1a Singapore Air Emission Standards

	Substance	*Trade, industry, process, fuel burning equipment or industrial plant*	*Emission Limits*
(a)	Ammonia and ammonium compounds	Any trade, industry or process	76 mg/Nm^3 expressed as ammonia
(b)	Antimony and its compounds	Any trade, industry or process	5 mg/Nm^3 expressed as antimony
(c)	Arsenic and its compounds	Any trade, industry or process	1 mg/Nm^3 expressed as arsenic
(d)	Benzene	Any trade, industry or process	1 mg/Nm^3
(e)	Cadmium and its compounds	Any trade, industry or process	3 mg/Nm^3 expressed as cadmium
(f)	Carbon monoxide	Any trade, industry, process or fuel burning equipment	625 mg/Nm^3
(g)	Chlorine	Any trade, industry or process	32 mg/Nm^3
(h)	Copper and its compounds	Any trade, industry or process	5 mg/Nm^3 expressed as copper
(i)	Dioxins and furans	Any waste incinerator	1. 1.0 ng TEQ/Nm^3 for waste incinerators commissioned before 1st Jan 2001 2. 0.1 ng TEQ/Nm^3 for waste incinerators commissioned on or after 1st Jan 2001
(j)	Ethylene oxide	Any trade, industry or process	5 mg/Nm^3
(k)	Fluorine, hydrofluoric acid or inorganic fluorine compounds	Any trade, industry or process	50 mg/Nm^3 expressed as hydrofluoric acid
(l)	Formaldehyde	Any trade, industry or process	20 mg/Nm^3

	Substance	*Trade, industry, process, fuel burning equipment or industrial plant*	*Emission Limits*
(m)	Hydrogen chloride	Any trade, industry or process	200 mg/Nm^3
(n)	Hydrogen sulphide	Any trade, industry or process	7.6 mg/Nm^3
(o)	Lead and its compounds	Any trade, industry or process	5 mg/Nm^3 expressed as lead
(p)	Mercury and its compounds	Any trade, industry or process	3 mg/Nm^3 expressed as mercury
(q)	Oxides of nitrogen	Any trade, industry, process or fuel burning equipment	700 mg/Nm^3 expressed as nitrogen dioxide
(r)	Particulate substances including smoke, soot, dust, ash, fly-ash, cinders, cement, lime, alumina, grit and other solid particles of any kind	Any trade, industry, process, fuel burning equipment or industrial plant (except for any cold blast foundry cupolas)	1. 100 mg/Nm^3; or 2. Where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the particulate emissions from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 100 mg/Nm^3 and the particulate emissions from each of such flue, duct or chimney shall not exceed 200 mg/Nm^3 at any point in time. 3. Ringelmann No.1 or equivalent opacity (Not to exceed more than 5 minutes in any period of one hour)
(s)	Styrene monomer	Any trade, industry or process	100 mg/Nm^3
(t)	Sulphur dioxide (non-combustion sources)	Any trade, industry or process	500 mg/Nm^3
(u)	Sulphur trioxide and other acidic gases	The manufacture of sulphuric acid	500 mg/Nm^3 expressed as sulphur trioxide. Effluent gases shall be free from persistent mist.
(v)	Sulphur trioxide or sulphuric acid mist	Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid	100 mg/Nm^3 expressed as sulphur trioxide
(w)	Vinyl chloride monomer	Any trade, industry or process	20 mg/Nm^3

Notes:

1. The concentration of any substance specified in the first column emitted from any operation in any trade, industry, process, fuel burning equipment or industrial plant specified in the second column shall not at any point before admixture with air, smoke or other gases, exceed the limits specified in the third column.
2. Nm^3 is defined as that amount of gas which when dry, occupies a cubic metre at a temperature of 0 °C and an absolute pressure of 760 mmHg.

Source: Environmental Protection and Management (Air Impurities) Regulations 2001

It should be noted that Singapore only has SO_2 and SO_3 emission standards for non-combustion sources. NEA's approach to reducing SO_x emissions from combustion sources involves regulating the sulphur content in fuels.

In January 1997, the PCD implemented the *Source Emission Test Scheme*, under which industries are required to conduct source emission tests on their own, or engage NEA-accredited consultants to do so on their behalf. In addition, PCD conducts regular inspections of stationary sources of pollution to ensure compliance with air pollution control requirements as well as compliance with emission standards.

5.1.2 *Ambient Air Quality Standards*

Singapore does not have specific enforced ambient air quality standards. However, NEA makes reference and comparison to the United States Environmental Protection Agency (USEPA) Primary Air Quality Standards and the World Health Organisation (WHO) Guidelines for reporting ambient air quality status. These ambient air quality criteria are presented in *Table 5.1b*.

Table 5.1b USEPA and WHO Ambient Air Quality Standards

Pollutant	*Averaging Time*	*USEPA Primary Air Quality Standard*	*WHO Air Quality Guideline*
Gaseous			
SO_2	Annual mean	0.03 ppm	-
	24-hour	0.14 ppm[3]	20 μg/m³
CO	8 Hour	10 mg/m³	10 mg/m³
	1 Hour	40 mg/m³	30 mg/m³
NO_2	Annual mean	100 μg/m³	40 mg/m³
	1 hour	-	200 μg/m³
Ozone	1 hour	0.08 ppm[1]	-
	8 hour	0.12 ppm[2]	100 μg/m³
Particulate			
PM_{10}	Annual mean	(Revoked)[3]	20 μg/m³
	24 hour	150 μg/m³	50 μg/m³
$PM_{2.5}$	Annual mean	15 μg/m³	10 μg/m³
	24 hour	35 μg/m³	25 μg/m³
Lead	3 months	1.5 μg/m³	-
	1 year	-	0.5 – 1 μg/m³

Notes:

1. As of June 15, 2005 EPA revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone non-attainment areas in US (Early Action Compact Areas).
2. Not to be exceeded more than once per year.
3. Revoked due to lack of evidence linking health problems to long term exposure to coarse particle pollution, the agency revoked the annual PM_{10} standard in 2006 (effective December 17, 2006).

5.2 CURRENT BASELINE CONDITIONS

5.2.1 *Ambient Air Quality*

This sub-section presents a description of the ambient air quality in Singapore. Concentrations of ambient pollutants vary according to both time and location. They are affected by many factors, the most significant being the size, number and location of sources of emissions and the prevailing weather.

Data on ambient air quality has been gathered from NEA published information, which is summarised below.

5.2.1.1 *NEA Historical Ambient Air Quality Monitoring*

The NEA carries out routine monitoring of ambient air quality through the Telemetric Air Quality Monitoring and Management System (TAQMMS). This system comprises 13 remote monitoring stations which are located around Singapore and linked into a Central Control System (CCS). Most air quality monitoring stations are located on the Singapore mainland and are distributed amongst urban, industrial, suburban and roadside locations.

Table 5.2a presents overall ambient air quality data for the range of parameters monitored in 2006. As previously mentioned, the NEA assesses the results against WHO and the USEPA reference standards, as Singapore itself does not stipulate its own ambient air quality standards. The results indicate that in general, air quality as annual averages for the monitored parameters in Singapore is generally within USEPA, but has yet to fully follow the recently updated WHO air quality guidelines for PM_{10}, $PM_{2.5}$ and ozone. WHO has stipulated interim targets for such pollutants, intended as incremental steps in a progressive reduction of air pollution. Further details are available in the report WHO Air Quality Guidelines Global Update 2005 (*WHO 2005*).

Table 5.2a Ambient Air Quality for Singapore, Averaged for 2006

Pollutants Measured (annual mean values unless otherwise stated)	*Air Quality*	*Reference Standards*	
		USEPA Primary Air Quality Standards	*WHO Air Quality Guidelines*
Sulphur dioxide, SO_2 (24 hour)	135 μg/m³	365 μg/m³	-
Sulphur dioxide, SO_2	11 μg/m³	80 μg/m³	-
Nitrogen dioxide, NO_2	24 μg/m³	100 μg/m³	40 μg/m³
Respirable suspended particulates, PM_{10} (24-hour)[1]	228 μg/m³	150 μg/m³	50 μg/m³
Respirable suspended particulates, $PM_{2.5}$ (24-hour)[1]	80 μg/m³	35 μg/m³	25 μg/m³
Respirable suspended particulates, $PM_{2.5}$[1]	23 μg/m³	15 μg/m³	10 μg/m³
Carbon monoxide, CO (Ambient 1-hourly average)	3.7 mg/m³	40 mg/m³	30 mg/m³
Carbon monoxide, CO (Ambient 8-hourly average)	2.6 mg/m³	10 mg/m³	10 mg/m³

Pollutants Measured (annual mean values unless otherwise stated)	*Air Quality*	*Reference Standards*	
		USEPA Primary Air Quality Standards	*WHO Air Quality Guidelines*
Low- level ozone, O_3 (8-hour)	127 μg/m³	Should not exceed 157 μg/m³ on more than one occasion per year	100 μg/m³
Lead, Pb (3-month average; roadside monitoring)	< 0.1 μg/m³	1.5 μg/m³	-

Source: (NEA, 2007), p4

[1] PM_{10} and $PM_{2.5}$ readings were affected by trans-boundary smoke haze from the land and forest fires in the region.

These overall average data, however, are likely to mask some important regional and temporal variations in air quality for the following reasons:

- The majority of heavy and polluting industries are located in the western half of Singapore (Jurong) and south-western offshore islands (Pulau Bukom, Pulau Busing, etc.); and

- During the seasonal monsoon conditions, prevailing winds blow from the northeast during December through to March (NE Monsoon) and from the southwest from June to September (SW Monsoon). Given that the majority of heavy and polluting industries are located in Jurong (including port activities), it is likely that ambient air quality in western Singapore will deteriorate during the SW Monsoon period (June to September). Monsoon winds could also transport air pollutants from industrial sources in nearby Batam, Indonesia (southeast of Singapore) and Johor, Malaysia (north of Singapore).

NEA published data (*NEA, 2004*) confirms that air quality around the industrial areas (comprising the Jurong West, Jurong East, Clementi and Bukit Batok areas) is generally of a lower quality than that in suburban and urban monitoring stations in central and eastern Singapore.

5.2.1.2 *Other Emission Sources in the Area*

The Plant will be located at Tuas South Avenue 9, which is situated in the south western region of Singapore. Surrounding areas around the south west consists of a mix of industrial and commercial land use.

The Tuas Industrial Park (near the Plant) and the other surrounding areas are designated *inter alia* for clean/light/general industries as well as for general utilities. Singapore's main petrochemical refining and chemical manufacturing hub lies to the south east of the Plant. Most heavy and potentially hazardous or polluting industries have intentionally been grouped on this island as part of the Urban Redevelopment Authority's (URA) Master Plans. There are also a range of other industrial land-uses and facilities, both on the southwest coast of mainland Singapore in Jurong and Tuas, and on the surrounding outlying

islands (including Pulau Bukom, Pulau Busing, etc.). Industries that are potential sources of major air emissions in proximity to the Plant include:

- *Pulau Seraya Power Station*: It has a generation capacity of 3,100 MW. The power station will generate SO_2, NO_x and other emissions typical of gas and orimulsion-fired power generation. Other utilities suppliers, including SUT Sakra and SUT Seraya, will also generate air emissions through both electricity generation as well as waste treatment services.

- *The ExxonMobil refineries* on Jurong Island (Pulau Pesek and Pulau Ayer Chawan), and the *Shell refinery* on Pulau Bukom, which process crude oil through distillation, cracking and other conversion processes into kerosene, bitumen, fuel oil, diesel, LPG, naphtha, lube oil, solvents and sulphur. These three refineries have a combined capacity in excess of 1,062,000 barrels per day. Emissions from routine operations will include SO_2, NO_x, hydrocarbons and particulate matter.

- *Chemical factories on Jurong Island* including PTCS (ethylene, propylene, benzene, etc.); Chemical Industries (chlorine); EGS (ethylene oxide and ethylene glycol); Celanese (VAM); Eastman and Sumitomo. These facilities will produce a wide range of emissions given the varied production processes and products of the numerous facilities.

Given that Singapore is one of the largest ports in the world, shipping and associated port activities are also likely to be a significant source of air pollution in the area, especially given that ships are fuelled by heavy blended fuel-oils and have few emission controls.

Given this concentration of sources around the site, it can be seen that the proposed Plant is only one of many facilities generating air pollutants. It is considered unlikely that operation of the Plant will produce significant impact on ambient air quality compared to the larger sources in the area.

5.3 IMPACT SEVERITY CRITERIA

Impact severity criteria used here to assess air quality and air emissions issues are presented below:

Severity	*Definitions*
Slight	• Air quality impacts are well within ambient criteria • Emissions are well below statutory emission limits
Low	• Air quality impacts are within ambient criteria • Emissions are within statutory emission limits
Medium	• Air quality impacts result in occasional exceedance of ambient criteria (limited periods of exceedance) • Occasional breach of statutory emission limits
High	• Air quality impacts routinely exceed ambient criteria (extended periods of exceedance) • Repeated breaches of statutory emission limits

These severity criteria are combined with the events likelihood per the impact significance matrix in *Section 2.3.5*.

5.4 *ASSESSMENT OF IMPACTS*

The impacts of the principal operational air emissions (fugitive) from the proposed Plant are evaluated in the following sections.

5.4.1 *Point Source Emissions*

5.4.1.1 *Hot Oil System Stack*

A stack approximately 35 m high will be installed at the hot oil system. The details of the exhaust gases were not available at the time of writing. The Client's hot oil vendor will ensure safe dispersion of gases at the ground level.

5.4.1.2 *Flare Stack*

Flue gas emissions from the flare during maximum emergency relief case is about 3,200 tonnes/h with 0 % excess air. The flue gas contains about 6,3 vol-% of carbon dioxide, < 150 mg/Nm^3 NO_x, < 50 CO mg/Nm^3. Maximum emergency relief case can occur during a fire at the plant.

During emergency depressurisation of the process total of 20.5 tonnes of hydrogen, hydrocarbons and some hydrogen sulphide are released and burned through the flare in 15 minutes. The amount of flue gas generated from the burning of 20.5 tonnes of hydrogen/hydrocarbon gas mixture is 33.4 tonnes of CO_2, 64.9 tonnes of water, 60 kg of SO_2 and 400 tonnes of nitrogen. Thus the total amount of flue gas is 498.3 tonnes per one emergency depressurisation. The maximum number of emergency depressurisations per day is 4. In the worst case the amount of flue gases released to the atmosphere as a result of emergency depressurisations is 4*498.3 tonnes/day = 1993.2 tonnes/day. The calculation of flue gas flow rate is based on 0 % excess air.

During normal operation only the pilots of the flare are burning. The flue gas generated by the pilots is 130 kg/h of flue gas with 0% excess air. The destruction removal efficiency (DRE) of the flare is > 99 % under proper operating conditions (proper flow of steam to the flare in relation with the hydrocarbon flow).

5.4.2 *Fugitive Emissions*

Fugitive emissions from each bulk storage tank were estimated using the API developed software programme, TANKS (version 4.0). A detailed emissions report reproduced from the TANKS 4.0 programme for maximum and minimum emissions is presented in *Annex D*. The TANKS calculations for hydrocarbon fugitive emissions were based on the following key assumptions/ scenarios:

- Tank contents were based on information provided by the Client;

- Tank diameter and height according to information provided in *Table 5.4b* below. The maximum height that can be modelled in TANKS is 19.81 m (65 ft). Hence, for the tanks containing fatty acid distillate and pretreated feedstock, the height of the tank has been taken as 19.81 m (65 ft);

- TANKS default values were assumed for tank construction (including paint characteristics, rim-seal systems and deck characteristics);

- All tanks have been modelled containing residual oil no. 6 except bionaptha which was modelled as Gasoline (RVP 11 with vapour pressure of 8.66 psia) due to limitations with the TANKS model;

- Bionaphtha tank has a vertical fixed roof with internal floating mechanism. It has been assumed that the internal floating roof will capture the fugitive emissions prior to being exposed to the fixed roof, therefore, the model has been run for only the internal floating roof;

- The average height was assumed to be the maximum height (90% of total height); and

- Singapore meteorological data was used.

Key inputs used for the TANKS model are as follows:

Table 5.4b ***Input details for TANKS***

Raw material	No. of tanks	Tank Type	Tank orientation	Tank height (in m)	Tank diameter (in m)	Liquid height (in m)	Turnover per year
Feedstock	3	Vertical Fixed Roof	Vertical	20	42	18	14.52
Fatty acid distillate	1	Vertical Fixed Roof	Vertical	18	34.3	16.2	7.81
Pretreated feedstock	1	Vertical Fixed Roof	Vertical	18	34.3	16.2	72.73
Bionaphtha	2	Vertical fixed roof with intl floating	Vertical	15	26	13.5	12.09

Fugitive emissions from the storage tanks in the absence of any control measures are shown in the *Table 5.4c*.

Table 5.4c ***Fugitive emissions of stored Vegetable Oils/Animal Fats and Hydrocarbons***

Product	Emissions (kg/year)	% of annual throughput
Feedstock (3 nos.)	20	2×10^{-8} %
Fatty acid distillate (1 no.)	7	6×10^{-8} %
Pretreated feedstock (1 no.)	34	3×10^{-8} %
Bionaphtha (2 nos.)	7,302	5.6×10^{-5} %

5.4.2.1 *Sources of Impact*

The principal fugitive emissions sources include the following:

- Seal losses from floating roof bulk tanks;
- Displacement of vapours during loading and unloading; and
- Process and utility equipment (valve seals, flanges, pump seals, etc.).

5.4.2.2 *Controls*

Fugitive emission control measures in place include the following:

- The tanks (except bionaphtha tank) have nitrogen blanketing to reduce fugitive emissions from leaking into the environment;
- The bionaptha tank has a fixed roof tank outer to the internal floating roof to capture fugitive releases;
- Regular monitoring and maintenance of pump seals, compressor seals and pressure relief devices;
- Tank externals are painted with reflective colours to limit changes in temperature/ pressure of stored product due to solar insulation;
- Standard Operating Procedures (SOP) to minimise emissions to air/ exposure to vapours during filling and emptying activities etc.;
- Provision of appropriate personnel protective equipment in accordance with respective MSDS, eg. respirators, during the handling of materials/ chemicals; and
- Provision of well-ventilated areas or local exhaust ventilation for confined areas.

5.4.2.3 *Evaluation of Impacts*

In evaluating impacts of fugitive emissions from the storage and handling of hydrocarbons on the environment and public health, it was assessed that the emission of VOCs from the tanks onsite is negligible.

Given the low emission quantities, the severity of the occurrence of fugitive emissions is likely to be low. The occurrence of these releases is considered *unlikely* based on the controls in place. Hence, it is expected that such an occurrence will result in **negligible** impacts.

The evaluation of impact is summarized as follows:

Category	Performance
Activity	Fugitive emissions from bulk storage tanks
Specification	VOC emission quantities
Receptor	Workers in plant area, adjacent facilities
Impact	Air quality
Impact Magnitude	Emission limits for to air exceeded
Impact Severity	Slight ▒ Low Medium High
Likelihood	Unlikely
Significance	**Negligible**

5.5 *SUMMARY OF AIR QUALITY ASSESSMENT*

In summary, based on preliminary design data and the qualitative analysis that followed, the proposed Plant will:

- Comply with Singapore air emissions regulations and guidelines; and
- Not give rise to significant air-related public health concerns due to the expected emissions.