Environmental Social and Health Impact Assessment (ESHIA) for Proposed Pengerang Energy Complex (PEC), Pengerang Industrial Park, Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim

Prepared for

Pengerang Energy Complex Sdn Bhd

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ESC

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Environmental Social and Health Impact Assessment for Proposed Pengerang Energy Complex (PEC), Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim

For Pengerang Energy Complex Sdn Bhd

For and on behalf of
EnviroSolutions & Consulting Sdn Bhd,

Approved by,

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Group Director
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Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ALARP	As Low As Reasonably Practicable
APCS	Air Pollution Control System
APHA	American Health Public Association
API	Air Pollution Index
ASTDR	Agency for Toxic Substances and Disease Registry
ASR	Air Sensitive Receptor
ASU	Air Separation Unit
BAT	Best Available Techniques Economically Achievable/ Best Available Technology
BED	Basic Engineering Design
BMP	Best Management Practices
BOD	Biological Oxygen Demand
B-T	Benzene-Toluene
C_3	Propane
C_4	Butane
C_5	Pentane
CAGR	Compound Annual Growth Rate
CCR	Continuous Catalytic Reforming
CEMS	Continuous Emission Monitoring System
CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora
CM	Compliance Monitoring
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CO_2	Carbon Dioxide
CP	Cleaner Production
CPESC	Certified Professional in Erosion and Sediment Control
CRP	Contaminant Removal Process
CTF	Central Tank Facility
CUF	Common Utility Facilities
DAHS	Data Acquisition and Handling System
DEBZ	Diethylbenzene
DED	Detailed Engineering Design
DEM	Digital Elevation Model
DHT	Diesel Hydrotreating
DID	Department of Irrigation and Drainage
DoE	Department of Environment
Doe-CLM	DoE's Contaminated Land Management and Control Guidelines 2009
DOSH	Department of Occupational Safety and Health
DWT	Dead Weight Tonnes
EB	Ethylbenzene
ED	Extractive Distillation
EDP	Emergency Depressurizing
EHS	Environmentally Hazardous Substance

EIA	Environmental Impact Assessment
EIMAS	Environmental Institute of Malaysia
EMP	Environmental Management Plan
ERC	Emergency Response Centre
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESA	Environmentally Sensitive Areas
ESC	EnviroSolutions & Consulting Sdn Bhd
ESCP	Erosion and Sedimentation Control Plan
ESD	Emergency Shut Down
ESI	Environmental Scoping Information
ETP	Economic Transformation Programme
FBR	Full Boiling Range
FRC	Flow Record and Control
GDP	Gross Domestic Product
GLC	Ground Level Concentrations
GNI	Gross National Income
H_2S	Hydrogen Sulphide
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HCL	Hydrogen Chloride
HIA	Health Impact Assessment
HIRARC	Hazard Identification, Risk Assessment and Risk Control
HR	Human Resource
HRA	Health Risk Assessment
IC	Incident Commander
ICC	Incident Commander Centre
IETS	Industrial Effluent Treatment System (WWTP)
IFC	International Finance Corporation
ILO	International Labour Organisation
IM	Impact Monitoring
IMT	Incident Management Team
IR	Individual Risk
ISBL	Inside Battery Limits
IUCN	International Union for Conservation of Nature
JCorp	Johor Corporation
JKR	Public Works Department
JPBD	Jabatan Perancangan Bandar dan Desa
JPDC	Johor Petroleum Development Corporation
JPS	Jabatan Perairan dan Saliran
JSIC	Johor State Investment Centre
KHT	Kerosene Hydrotreating
KMTA	Kilometric tonnes annum
kMtpd	kilometric tonnes per day
KEJORA	Lembaga Kemajuan Johor Tenggara
KOPEJA	Koperasi Pengerang Jaya Johor Berhad

LDAR	Leak Detection and Repair
LD-P2M2	Land Disturbing Pollution Prevention and Mitigation Measures
L_{eq}	Equivalent Continuous Noise Level
LKIM	Lembaga Kemajuan Ikan Malaysia
L_{max}	Maximum Sound Level
L_{min}	Minimum Sound Level
LNG	Liquefied Natural Gas
LoC	Loss of Containment
LPG	Liquified Petroleum Gas
LSFO	Low Sulphur Fuel Oil
MAAQS	Malaysia Ambient Air Quality Standard
MAE	Major Accidents Event
MBR	Membrane Bioreactor System (MBR)
MEA	Mono-Ethanol Amine
MIAC	Maximum Incremental Average Concentration
MITI	Ministry of International Trade and Industry
MLD	Million Litres Per Day
MLSS	Mixed Liquor Suspended Solids
MMtpa	Million metric tonnes per annum
MOS	Margin of Safety
MTPA	Metric Tonnes Per Annum
MX	Metaxylene
NASA	National Aeronautics and Space Administration
NH_3	Ammonia
NH_3-N	Ammoniacal Nitrogen
NHT	Naphtha Hydrotreating
NKEA	National Key Economic Area
NMVOC	Non-Methane Volatile Organic Compound
NO_2	Nitrogen Dioxide
NWQS	National Water Quality Standards
O_2	Oxygen
O_3	Ozone
ORP	Olefin Reduction Process
OSBL	Outside Battery Limits
OSC	On Scene Commander
OX	Orthoxylene
P2M2	Pollution Prevention and Mitigation Measures
PAH	Polyaromatic Hydrocarbon
PAMER	PIPC Raw Water Supply Project
PCP	Project Closure Plan
PCS	Pollution Control System
PDT	Pengerang Deepwater Terminal
PDT2	Second Pengerang Deepwater Terminal
PE	Population Equivalent
PET	Polyethylene Terephthalate
PETRONAS	Petroliam Nasional Berhad

PFD	Process Flow Diagram
PGP	Pengerang Gas Pipeline
PGU	Peninsular Gas Utilisation
PIC	Pengerang Integrated Complex
PIP	Pengerang Industrial Park
PIPC	Pengerang Integrated Petroleum Complex
PM	Performance Monitoring
PM	Particulate Matter
PM_{10}	10 microns in size
PMIP	Pengerang Maritime Industrial Park
PO_4	Phosphate
PPE	Personal Protective Equipment
PRefChem	Pengerang Refining and Petrochemical
PRPC	Petronas Refinery & Petrochemical Corporation
PSA	Pressure Swing Adsorption
PVC	Polyvinyl chloride
PX	Paraxylene
QRA	Quantitative Risk Assessment
RAPID	Refinery and Petrochemical Integrated Development
RGT2	Re-gasification Terminal 2
RWTP	Raw Water Treatment Plan (RWTP)
SAJ	Syarikat Air Johor
SBR	Sequencing Batch Reactor
SCBA	Self Containing Breathing Apparatus
SEA	Social Economic Assessment
SEA	South East Asia
SIA	Social Impact Assessment
SO_2	Sulphur Dioxide
SR	Societal Risk
SRTM	Shuttle Radar Topography Mission
SRU	Sulphur Recovery Unit
SSL	Site Screening Levels
SVOC	Semi-Volatile Organic Compounds
TDP	Toluene Disproportionation
TDS	Total Dissolved Solids
TGCU	Tailgas Clean-up Unit
TIA	Traffic Impact Analysis
TMBZ	Trimethylbenzene
TPH	Petroleum Hydrocarbons
TMDL	Total Maximum Daily Load
TTMBZ	Tetramethylbenzene
ToR	Terms of Reference
ToRAC	ToR Adequacy Check
TRC	Technical Review Committee
TSS	Total Suspended Solid
TWA	Time-Weighted Average

UF	Utilities and Facilities
ULCC	Ultra Large Crude Carriers
ULSD	Ultra Low Sulphur Diesel
UOP	Universal Oil Products
UPENJ	Unit Perancang Ekonomi Negeri Johor
USEPA	US Environmental Protection Agency
USLE	Revised Universal Soil Loss Equation
VCE	Vapour Cloud Explosion
VLCC	Very Large Crude Carriers
VOC	Volatile Organic Compound
WMC	Waste Management Centre
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

1 INTRODUCTION

This document presents the Environmental Social and Health Impact Assessment (ESHIA) for the proposed project entitled **Proposed Pengerang Energy Complex (PEC), Pengerang Industrial Park, Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim**.

The proposed Pengerang Energy Complex is planned as a world-scale condensate splitter and aromatics complex, on a 250-acre site in the Pengerang Industrial Park (PIP) that is situated within the Pengerang Integrated Petroleum Complex (PIPC). The production capacity of the PEC is about 5.844 Million metric tonnes per annum (MMtpa), or 16.7 kilometric tonnes per day (kMtpd), of aromatic petrochemicals and oil products, which will be processed from 6.324 MMtpa of condensate feedstock.

The proposed location of the complex is within the proposed Pengerang Industrial Park (PIP) in Mukim (Precinct) Pengerang, Kota Tinggi District, Johor, Malaysia (*Figure 1*).

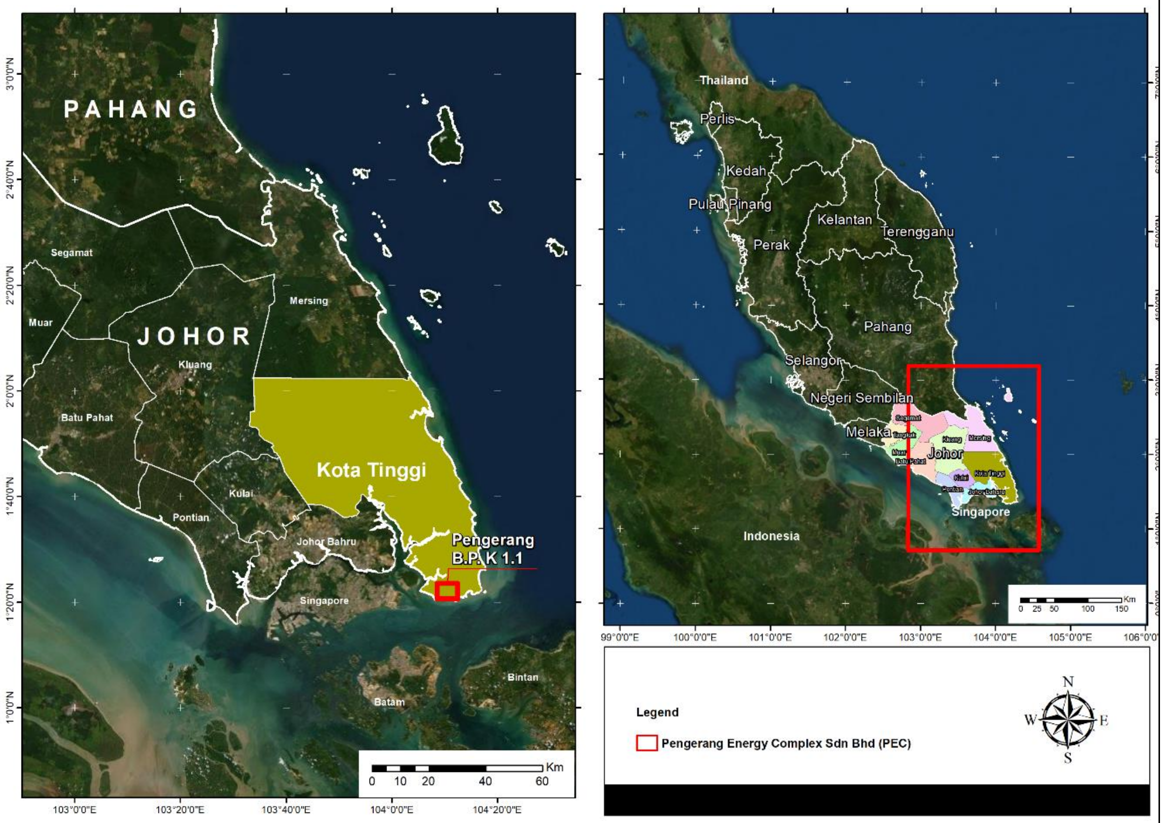


Figure 1 – Site Location

1.1 Objectives

Objectives of the ESHIA:

- Identify and analyse sensitive components of the existing environment.
- Determine the type, nature and significance of the probable environmental and/or social impacts (positive, negative, direct and indirect, reversible and irreversible, short term and long term) during construction and operation phases.
- Identify and recommend practical and cost-effective mitigation measures early in the process to eliminate, minimise, mitigate or avoid any negative environmental and/or social impacts resulting from the project.
- Recommend a framework for an environmental and social management/monitoring plans for the project in order to eliminate and/or minimise the potential negative environmental and/or social impacts.
- Ensure that all stakeholders deemed to be influenced by the project activities are fully considered and that communication systems are established during the assessment process and remain effective throughout the life of the activities.

1.2 ESHIA Scope of Work

In general, the scope of work of this ESHIA can be summarised as follows:

- Identify all applicable local, national and international environmental regulations and standards that the project must meet;
- Undertake all necessary field assessment studies to define the existing baseline conditions in the study area;
- Develop a consultation process and relation and communication strategy to ensure that all stakeholders are consulted and are kept informed throughout all stages of the study;
- Develop an Environmental Management Plan including recommendations regarding mitigation measures, emergency response, monitoring, staffing, and training the project should implement to prevent or reduce significant negative impacts; and
- Prepare a draft ESHIA for review and due diligence process, which will be updated, as appropriate, for submission to applicable environmental agencies and lending institutions.

1.3 Project Proponent

The Project Proponent, or project owner, is Pengerang Energy Complex Sdn. Bhd. (PEC). Details pertaining to the Project Proponent are as follows:

Contact Person	: **Chong Ying Haur**
Designation	: **Director, PEC**
Office Address	: 1 Raffles Quay #21-02, One Raffles Quay North Tower, Singapore 048583
Telephone	: (+65) 6536 7055
Email	: ying.haur.chong@chemoneholdings.com

1.3.1 ESHIA Consultant

EnviroSolutions & Consulting Sdn Bhd (ESC) has been appointed as the lead Environmental Consultancy to manage the ESHIA for the PEC project and to prepare the *PEC ESHIA Report*. Enquiries and correspondence pertaining to this report can be made to:

EnviroSolutions & Consulting Sdn Bhd (*Company No.: 737279-T*)
WeWork Mercu 2, Level 40, No. 3 Jalan Bangsar,
KL ECO City, Persekutuan Kuala Lumpur,
59200, Malaysia

Contact Person : **Andrew Young**
Designation : **Group Director**
Email : andrew@envirosc.com

2 REGULATORY FRAMEWORK, STANDARDS AND GUIDELINES

For the purpose of the project the following legislations and requirements were reviewed:

- Environmental Quality Act 1974 (Act 127);
- Occupational Safety and Health Act 1994 (Act 514);
- Factories and Machinery Act 1967 (Act 139);
- International Finance Corporation's (IFC) Environmental and Social Sustainability Performance Standards;
- International Finance Corporation's (IFC) Environmental, Health and Safety Guidelines for General Guidelines;
- International Finance Corporation's (IFC) Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing;
- Equator Principles; and
- OECD Guidelines for Multinational Enterprises.

3 PROJECT DESCRIPTION

3.1 Project Siting

The proposed PEC will comprise of two main processing sections: the condensate splitting plant, which produces Full Boiling Range (FBR) naphtha as feedstock to the aromatics plant, the second main section. Feedstocks are processed using standard oil refining 'unit operations' that utilise heating, cooling, fractionation, reforming and distillation processes. The PEC will utilise refining and aromatics technologies supplied by Honeywell UOP, the globally leading vendor that also supplied technology to the very similar, ChemOne developed, Jurong Aromatics Complex (JAC or SAR-2) in Singapore, commissioned in 2014 with 70% of proposed PEC capacity at 4,364 MMtpa of condensate.

Other facilities on site will include intermediate feed and product tank farms, several steam boilers, a wastewater treatment plant (WWTP), pipelines and the on-site utilities/ buildings, as shown schematically in *Figure 2.* Other third parties at the PIPC will supply the PEC with raw water, nitrogen gas, electrical power and natural gas.

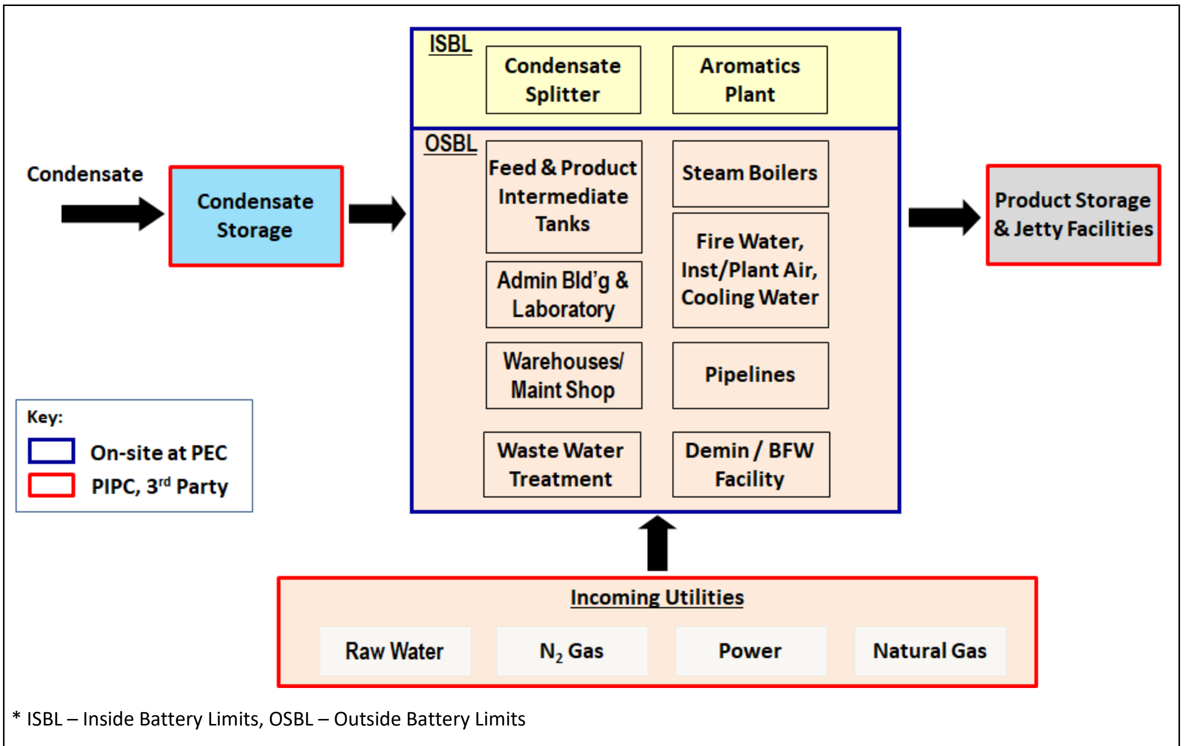


Figure 2 – PEC Processing Sections and Supporting Facilities Schematic

3.2 Site Layout & Elements

The proposed PEC will comprise the following key elements:

- Condensate Splitter;
- Aromatics Plant;
- An elevated flare;
- Bulk storage area;
- Wastewater treatment plant; and
- Office and administrative buildings.

Figure 3 below shows the conceptual layout plan of the PEC. The scope of this report comprises the major process areas detailed within the plan, which include:

- Condensate Splitter Section
  - Sour Water Stripping / Sulphur Recovery / Amine Regeneration / Spent Caustic Treatment DHT (C2 AREA); and
  - Prefractionation, KHT (C1 AREA).
- Aromatics Plant
  - Naphtha Hydrotreating unit; / CCR Platforming and Regeneration unit / Olefin Reduction Process unit (R1 AREA);
  - Sulfolane unit / BT/ Tatoray unit (A1 AREA);
  - Xylene / Parex (A2 AREA); and
  - Isomar unit (A3 AREA).
- Support facilities
  - 16 emissions stacks serving 10 furnace stacks, 3 vent stacks, 3 boiler stacks

- 1 Elevated Flare stack for emergency use
- Onsite tankage for bulk storage for chemicals
- Waste water treatment plant
- Offices and other Site support facilities

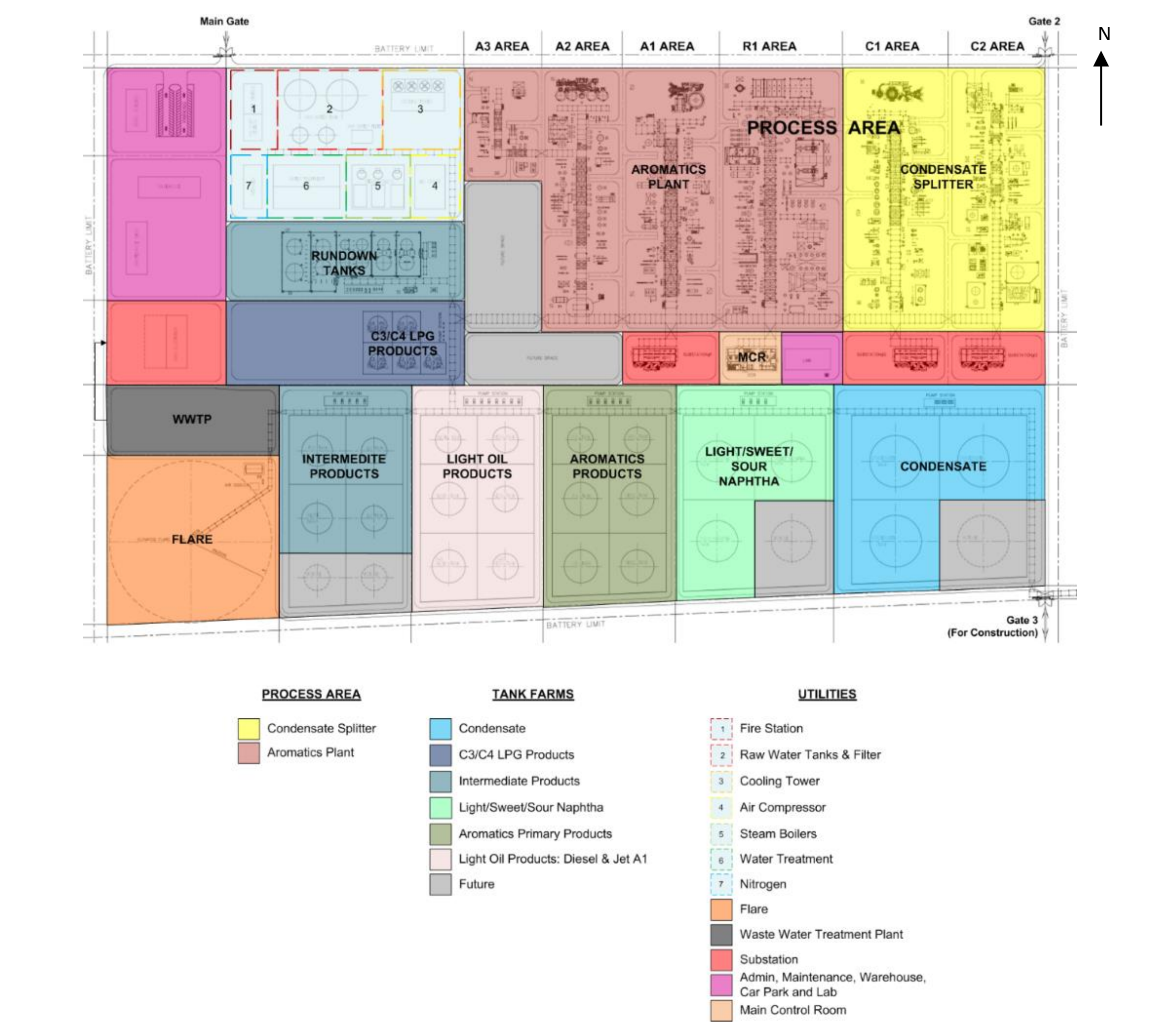


Figure 3 – PEC Conceptual Layout Plan

As indicated in the conceptual layout plan above, the flare system will be located on the southwest corner of the plot while the warehouse and associated buildings are located on the northwest portion of the plot.

3.3 Process Description

3.3.1 Process Overview

The PEC will be divided into two main sections, the ‘condensate splitting plant’ and the ‘aromatics plant’. The condensate splitting plant will produce intermediate naphtha as feedstock for the aromatics plant and various petroleum products including LPG i.e. C_3 (propane), C_4 (butane and isobutane), Ultra Low Sulphur Diesel (ULSD) and Low Sulphur Fuel Oil (LSFO). The feedstock for the aromatics plant, intermediate naphtha, will be processed in the aromatics plant to produce paraxylene, and benzene and sulphur as its by product (*Table 1*).

Table 1: PEC Facility Production Capacities of Products, Co-Products and By-Products

Primary Products	Capacity (metric tonnes per annum)
Benzene	656,000
Paraxylene	1,505,000
Sub-total aromatics	2,161,000
Co-Products	**Capacity (metric tonnes per annum)**
Jet Fuel	926,000
Diesel (ULSD)	1,396,000
C_3 / C_4 LPG	298,000
Fuel Oils (LSFO)	154,000
Light Naphtha	887,000
By-Products	**Capacity (metric tonnes per annum)**
Sulphur	11,000
Hydrogen Rich Gas	11,000
Sub-total oil products	3,683,000
TOTAL PRODUCTION CAPACITY	5,844,000
Hydrogen Rich Gas	254,000
Fuel gas (DC2 Off gas)/ Light Ends	226,000
Sub-total utilised on-site	480,000

Note:

1. Primary and oil products exported for sale, together with sulphur by-product, other by-products used on site in process or as fuel

Figure 3 provides the conceptual plan layout as an overview of the processes in the form of a simplified process flow diagram (PFD) for the PEC.

Principle operations at the proposed PEC are planned as follows:

- Feedstock, import and storage.
- Other raw materials.
- Processing.
- Supporting facilities and utilities.
- Products.

Figure 4 provides an overview of the processes in the form of a simplified process flow diagram (PFD) for the PEC.

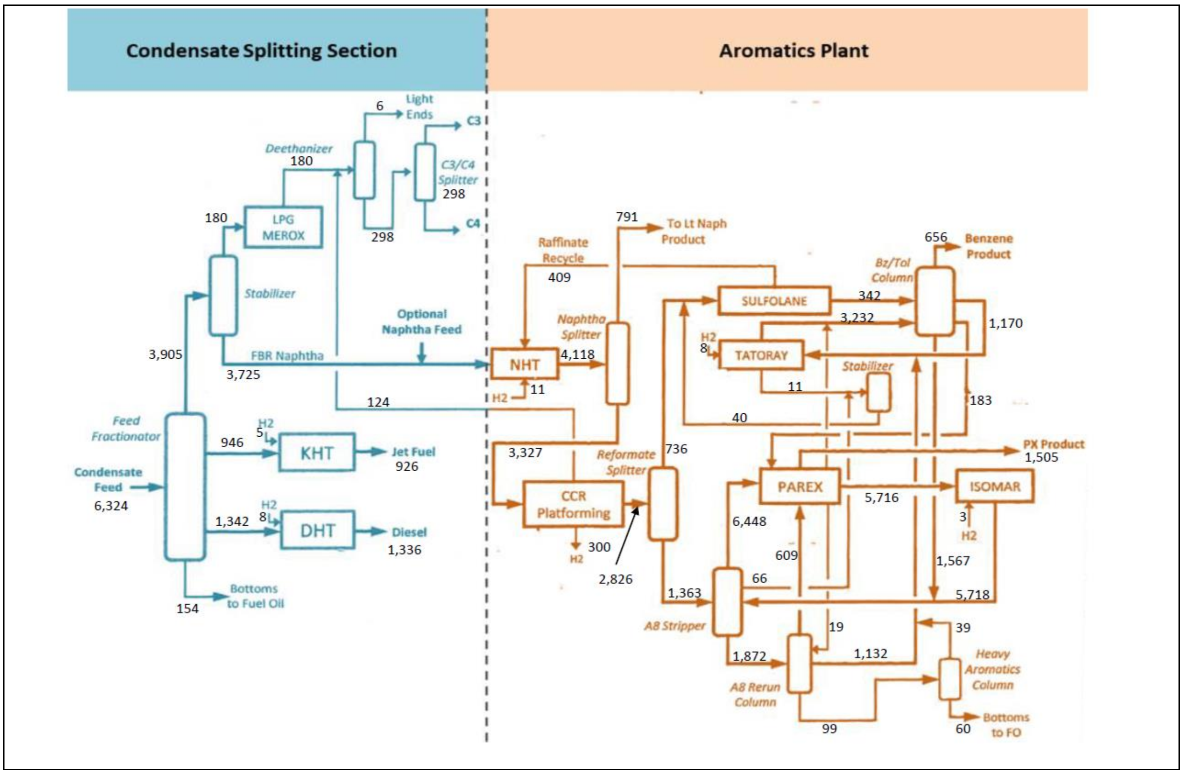


Figure 4 – PEC Simplified Process Flow Diagram

3.3.2 Emissions, Effluents and Waste Inventory

An inventory of principal emissions, effluents and wastes that are expected to be generated during operation of the PEC facility are presented in the following sections. The emission scheme block diagram is presented in *Figure 5*. It should be noted that the presented streams are the best estimates on the basis of currently available design information.

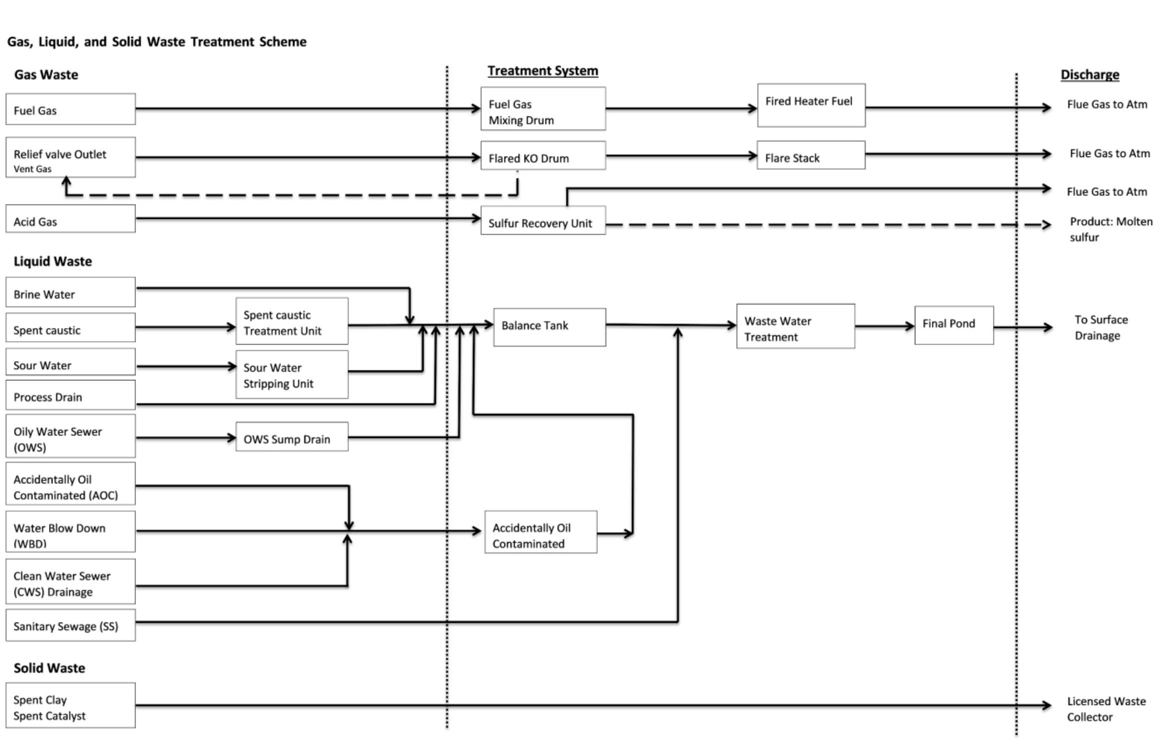


Figure 5 – Waste Treatment Scheme Block Diagram

4 ANALYSIS OF ALTERNATIVES

4.1 No Project

The 'no-project option' would mean that the PEC facility will not materialise and Malaysia would not have gained a USD 3.38 billion investment, besides the other socio-economic benefits spin-off from this investment, as well as the development of new downstream industry.

4.2 Site Selection Options

In brief, PEC had chosen Pengerang, Johor to set up the PEC facility for the following reasons:

- Located near the Petronas's USD 27 billion RAPID in the PIPC which can provide feedstock and can share the excellent infrastructure, common utilities and supporting services;
- Direct access to international shipping channels via Pengerang Deepwater Terminal (PDT)'s deep water (24m) port facilities with third party bulk storage facilities; and
- Being located strategically close to the markets and outlets for its products.

Three (3) optional sites were considered for the development of the PEC facility; the sites are located about 2.5 km apart. Given all three sites are within the PIPC area, there are little differences amongst them in terms of environmental, socio and economic aspects. Of the 3 options, PEC ultimately chose the proposed site in JCorp's designated PIP.

4.3 Alternative Technology

The PEC products, Benzene and Xylene, can be manufactured via a number of different processes, namely catalytic reforming, toluene hydrodealkylation, toluene disproportionation, transalkylation and steam cracking. Catalytic reforming and steam cracking are the two processes which use more abundant naturally occurring commodities (such as condensate) which are cheaper feedstock than the toluene feedstock required for the alternative manufacturing processes listed above.

The technologies are offered by a number of companies including UOP (Universal Oil Products), Axens, ExxonMobil, Toray, and SK Corporation. UOP of America has been identified as the only supplier who is able to supply the complete package by providing a single integrated advanced technology encompassing condensate splitter process, catalytic cracking, product purification and the conversion of toluene to benzene and xylene, whilst still ensuring economic attractiveness and environmental performance.

5 RECEIVING ENVIRONMENT - ENVIRONMENTAL AND SOCIAL BASELINE IN 5 KM RADIUS

5.1 Site and Surrounding Land Use

The PEC site terrain is undulating, varying in elevation by over 40m, from less than 20 meter above mean sea level (m. amsl) at is western end to over 60 m amsl at the top of a small hill in the eastern triangular section.

Figure 6 shows the area estimates on a land use plan within the site boundaries. It is noted that, other than as specified, no other sensitive land use was observed within the site boundaries.

Other sensitive receptors such as hospitals/clinics, schools, day-care facilities, elderly housing and convalescent facilities were not found within a 500 m to 1 km of the project boundary. The nearest village, Kg. Lepau, is about 2 km to the northwest of the site.

Residential Settlements

There are no large population centres near (< 5 km) to the PEC other than workers housing at the PIC. The nearest residential settlements/ occupied premises, comprise several small villages (Kg. Lepau being the closest), two resorts, one with residential units under development, and an ongoing residential/ commercial development.

The most sizeable settlements in the immediate area are outside the adopted 5 km EIA study boundary; Kg. Sg. Rengit- by a few hundred meters, Pengerang, 7.3 km southwest of the PEC site and Taman Bayu Damai, a constructed settlement built to re-locate those directly impacted by the Phase 1 PIPC/ PIC/ RAPID to the east of the PIPC, near Tanjung Penyusup.

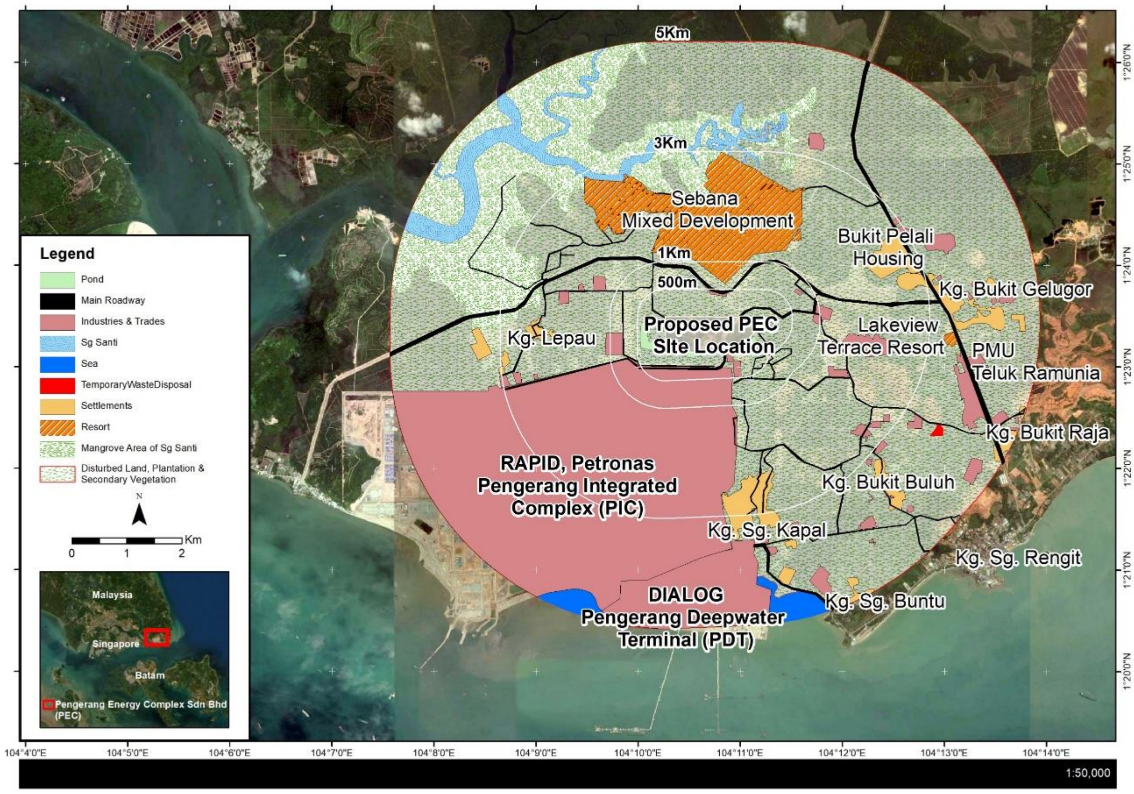


Figure 6 – Schematic Land Use Map – 5km Radius

5.2 Physical

5.2.1 Topography

The PEC site is situated in a generally low-lying area although the site is hilly and undulating. However, these contours d will have changed due to the construction activities associated with the temporary RAPID Access Road.

5.3 Geology

5.3.1 Geology

Based on the 2014 geological map of Peninsular Malaysia by the Department of Mineral and Geoscience, the PEC project area is characterised by Permian Sedimentary Rocks as part of Palaeozoic rocks that are distributed along east Johor. These sedimentary rocks consist of phylite, slate, and shale with subordinate sandstone and schist. In this area, there is a prominent development of limestone and volcanic characteristics; mainly rhyolitic to andesitic in composition.

5.4 Soils

Based on the soil map, the proposed site is located on 2 different soils. The western part of the proposed site is located in soils of the alluvial plains and low terraces with organic soils with Gley soils while the eastern part of the proposed site is located on soils o the intermediate and high terraces with red yellow loatosols and Gley soils on subrecent alluvium.

5.4.1 Baseline Soil Sampling

Baseline soil sampling was conducted on 12th and 13th December 2018 at six (6) locations.

All the borehole drillings were carried out using the percussion drill with hollow stem auger to a maximum depth of 5 meter below ground level (mbgl). A total of eight (8) samples were collected for laboratory analysis.

Laboratory analysis was conducted for the following parameters: 13 heavy metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc), total petroleum hydrocarbons (TPH), volatile organic compounds (VOC) and semi-volatile organic compounds (SVOC).

The soil was mainly sand and silt. A layer of topsoil was found at all boreholes. At boreholes BH1, BH3 and BH6, which was on the southern section of the site, the soil was mainly peat with heavy organic material and shallow groundwater table. The result from the laboratory analysis were compared against the Site Screening Levels (SSL) for Industrial Soil of the DoE's Contaminated Land Management and Control Guidelines 2009. Based on the lab results, the parameters were all below the respective SSL.

5.5 Hydrology

The closest river to the proposed project site is Sungai Lepau, located at the southern boundary of the site and flows in the Northeast direction into Sungai Santi. Sg. Lepau is a tributary of Sg. Santi, which ultimately flows into the Straits of Singapore, to the south. Other tributaries in Sg Santi include Sungai Sebina, Sungai Pelantar, and Sungai Jelutong.

5.5.1 Baseline Surface Water Quality

The baseline river water sampling was conducted in October 2018. A total of six (6) samples were collected for lab analysis.

Samples were analysed for Conductivity, pH, Salinity, Temperature, Total Dissolved Solids, Total Suspended Solids, Turbidity, Colour, Biochemical Oxygen Demand, Chemical Oxygen Demand, Ammonia as N, Total Coliform, Dissolved Oxygen and Total Faecal Coliform.

Results were compared against the National Water Quality Standards (NWQS). The results for all sampling points were generally within Class II of the NWQS, except for total coliform count.

5.5.2 Flood

Based on the flood data provided by Department of Drainage (DID), the only area that is prone to flooding within 5 km radius of the project site is Kg. Lepau. There were records of flood cases in Kg. Lepau in the year of 2014, 2015, 2016, and 2017.

5.6 Groundwater Sampling

All soil borings were converted into 50 mm-diameter temporary groundwater monitoring wells for collection of groundwater samples. Following well installation, a groundwater sample was collected from each of the groundwater monitoring wells, as well as an additional sample for quality assurance/quality control purposes. A total of 7 groundwater samples were collected for laboratory analysis.

Laboratory analysis for groundwater samples are the same parameters as the soil lab analysis.

The results were compared to SSL in the DoE-CLM Guidelines. All results were below the respective SSL.

5.7 Air Quality

No major sources of air pollution were identified whilst on site. Based on data from the DOE's Environmental Quality Report 2016, the air quality, expressed through the Air Pollution Index, in Kota Tinggi was considered as "Good" air quality with a reported total of 190 days of "Good" air quality in 2016.

There is one ambient air quality monitoring station installed at Kg. Lepau. Only data from July to December 2017 was available. According to the data provided by DoE, $PM_{2.5}$ exceeded the Malaysian Ambient Air Quality Standards (MAAQS) for all 6 months, while NO_2 was detected higher than the standard in July and November, and PM_{10} was above the standard in December.

5.7.1 Baseline Ambient Air Quality Sampling

Baseline ambient air sampling was conducted from 24th September to 5th October 2018 at eight (8) locations. Sampling was conducted by a SAMM-accredited laboratory. Samples were sent for laboratory analysis for the following parameters: Particulate Matter (PM_{10}), Particulate Matter ($PM_{2.5}$), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), and Carbon Monoxide (CO). The results showed that PM_{10} and $PM_{2.5}$ levels were over the Malaysian Ambient Air Quality Standards (MAAQS), and hydrogen sulphide (H_2S) levels were abnormally high with no source of the pollution identified.

As there were doubts over the results from the first sampling event, additional baseline ambient air sampling was conducted from 10th April to 12th April 2019 at the same 8 sampling locations. A different, SAMM-accredited laboratory, was used for the sampling activities.

The results from the additional sampling were all below the MAAQS except for $PM_{2.5}$ at station A2. The possible sources of the dust pollution observed in the site surrounding are the ongoing construction works and vehicles at PIPC, from the road traffic along unpaved roads and nearby land clearing activities.

Another round of baseline monitoring for the same parameters and locations was conducted from 29th April to 1st May 2019. The results were all below the MAAQS.

5.8 Noise

Baseline environmental noise level sampling was conducted in October 2018. A total of six (6) sampling points were identified.

Results were compared with the maximum permissible sound level set in the Planning Guidelines for Environmental Noise Limits and Control. When compared to the permissible sound level, the existing baseline already exceeded the maximum sound level of 50dB and 40dB for day time and night time, respectively. Based on field observations, the possible high noise sources in the site surrounding are from the construction works and vehicles, road traffic flow and occasional plant noise from the RAPID project site.

5.9 Social Impact Assessment

5.9.1 Identified Sensitive Receptors

Among the identified receptors with 5 km of the PEC site are (*Table 2*) two resorts, and five residential settlements as follows:

Table 2: Identified Sensitive Receptors Surrounding the Proposed PEC

Receptor	Name
Resort	
Sebana Mixed Development Lakeview Terrace Resort	Sebana Mixed Development Lakeview Terrace Resort
Settlements	
Kg. Lepau Kg. Bukit Gelugor Kg. Bukit Raja Kg. Bukit Buluh Kg. Sg Buntu Bukit Pelali development	Settlements of Kg. Lepau Settlements of Kg. Bukit Gelugor Settlements of Kg. Bukit Raja Settlements of Kg. Bukit Buluh Settlements of Kg. Sg Buntu Residents

5.9.2 Social Impact Assessment

With respect to this Project, three (3) on-site investigations as well as consultation with an officer of PBT Pengerang were undertaken in March, July and September 2018. The site visits allowed the study team to visually survey the immediate impact zone and to identify potential sensitive receptors and vulnerable stakeholders.

Two categories of stakeholders identified for this Project include:

1) Affected parties are directly affected by or have interest in the Project and who need to be engaged to identify impacts and their significance, as well as in decision-making or advice on mitigation and management measures.

2) Other interested parties who may have interested in the Project and who could affect or benefit from the Project in some way.

5.10 Flora & Fauna

JCorp are responsible for site clearance, site formation and to provide a prepared, pre-levelled site with certification the land has been re-zoned for industrial use.

The nearby land clearing and construction activities at RAPID site and surrounding infrastructure have changed and would have impacted the presence of fauna on this site. As such, it is concluded that the baseline flora and fauna conditions at the time of site survey are of very little natural ecological resources of conservation value left on-site.

6 ENVIRONMENTAL, SOCIAL AND HEALTH IMPACT ASSESSMENT (ESHIA) APPROACH & METHODOLOGY

6.1 ESHIA Approach

Impact of major activities of the project during the construction and operation were first identified based on the project description and various releases into the environment from the project. The resulting impacts are identified by combining information provided in ISO 14004:1996 with the environmental and social sensitivities. Wherever interactions exist between the identified aspects and sensitivities, they are further analysed to determine the potential impacts from the project. The impacts may be beneficial/adverse, direct/indirect, reversible/irreversible and short term/long term. It may also be noted that several activities may contribute to an impact.

The assessment of potential impacts is carried out utilising both qualitative and quantitative assessment techniques. The qualitative assessment is used whereby the impacts are rated as 'low', 'medium', 'high', or 'critical'. This rating is based on two parameters, i.e., the severity of impact (consequence) and the likelihood of occurrence of the aspect. The severity depends on the nature and size of the activity/aspect and the environmental/social sensitivity, while the likelihood depends upon the nature of the activity/aspect and the control measures in place. After considering the control measures, the assessment of the significance of residual environmental impacts has been undertaken by combining the estimates for the severity of the impact and the likelihood of its occurrence.

7 PROJECT IMPACTS AND MITIGATION MEASURES

This section explores the potential impacts that may arise as a result of implementation of the proposed project and the proposed mitigation measures. *Table 3* presents the summary of impacts and mitigation.

Table 3: Summary of Impacts and Mitigation Measures

Issue	Impact	Impact	Mitigation	Residual Impact
Construction Phase				
Site Clearing	• Change in existing profile and drainage pattern of the land; • Clearing vegetation from large areas and exposing edible soil may lead to dust generation and sediment run-off; • Loss of agricultural land due to land acquisition for industrial development; and • Generation of solid waste in the form of construction spoils.	Low	• Exposed site should be kept to a minimum during construction; • Completed areas should be hard surfaced/ re-vegetated as soon as possible; • Temporary drainage with appropriate capacity to be provided prior to the site clearing activities; • Soil stabilisation technique to be implemented where turfing, paving and engineering measures to protect from erosion; • Temporary measures such as plastic sheets should be used to protect the exposed slopes; and • Ensure proper housekeeping and cleanliness of the site throughout the construction period.	Low
Water Quality	• Sedimentation from the erosion of the exposed site surfaces might cause the drainage to clog and the increased of surface runoff could result in potential flooding; • Water pollution due to sediment load in construction water and wastewater from construction camps; and • Impact on the local water source (Sg. Lepau) from runoff.	Low	• Regular maintenance of the permanent drainage is required to ensure the discharge water quality; • Provision of check dams in the drain to help reduce the concentration of the sediments/ silts; • Temporary toilets and washing facilities shall be equipped with sanitary facilities to ensure that the wastewater will be treated prior to discharging into any drainage system or river; • Any spillage from fuel storage tank shall be contained within the containment bund of 110% capacity of the largest tank. The storage containers or tanks must be covered at all times; and • Water quality monitoring shall be conducted upon commencement of construction works and the data shall be compared with the baseline study and also Standard A of the *Environmental Quality (Industrial Effluents) Regulation 2009*.	Low
Air Quality	• Dust pollution due to excavation, backfilling and concreting, hauling and dumping of earth materials and construction spoils; • Fugitive dust due to the movement of construction vehicles on exposed soil, construction material handling and wind erosion; and • Combustion emission from diesel engine	Low	• Exposed soil areas and on-site roads should be dampened with water; • Stockpile of construction materials will either be covered or dampened with water to minimise dust generation; • Vehicle wheel-wash facilities should be provided at the exit of the project site and wherever practical to reduce quantities of soil tracked out of the site and onto local roads; • Vehicles on-site speed restriction should be imposed to reduce dust	Low

Issue	Impact	Impact	Mitigation	Residual Impact
	construction vehicles and machineries may affect the ambient air quality.		generation; • Vehicles transporting earth and construction materials are required to cover its load with secured load covers extending over the tail and side boards; • A good standard of housekeeping should be maintained which consist of regular cleaning, sweeping and washing of road to further reduce dust generation; • Implementation of manufacturer recommended maintenance programs for all construction vehicles and machineries; and • Installing and maintaining emission control devices, such as catalytic converters.	
Noise	• Noise generated from construction tools and machineries; • The increases of vehicle entering and exiting the Project site may as well increase the noise pollution surrounding the area. Road J52 will be utilised during construction phase of this Project and vehicles particularly heavy vehicles such as lorries and trucks are expected to increase in number and therefore will increase the noise level; and • Noise pollution may cause hazards to health especially to the workers. Hypertension, hearing loss and sleep disturbances are some of potential health hazards cause by noise pollution.	Low	• Only well-maintained equipment should be operated on-site and regular service/ maintenance shall be conducted for each equipment that produce high noise emissions; • Silencers/ mufflers on construction equipment which produces high noise emissions should be utilised and maintained regularly; • Hoarding shall be constructed prior to the commencement of construction works and any construction activities that has potential of emitting high noise level shall be limited to daylight hours only (7.00 am – 7.00 pm); • Reducing speed limits of heavy vehicles and ensure all heavy vehicles e.g. trucks are maintained properly; • Monitoring for noise level during construction shall be carried out regularly to control the noise emission which may affect the sensitive receptors; and • Protective equipment such as ear-muff shall be provided to workers handling/ operating the high noise equipment to prevent from hearing impairment.	Negligible
Soil & Groundwater	• Soil erosion and off-site siltation due to the exposure of soil surfaces to rain, wind and movement of construction vehicles during site clearing, earth moving and excavation activities; • Soil and groundwater contamination due to accidental spillage of fuel and oil; • Impacts associated to improper on-site waste	Low	• Exposed site areas should be kept to a minimum during the construction of the new facilities and completed areas should be hard surfaced/re-vegetated as soon as practicable; • Provision of effective construction site run-off controls such as controlled discharge and temporary drains; • Proper management of refuelling activities, waste storage and disposal; • Hard surfaced re-fuelling areas;	Low

Issue	Impact	Impact	Mitigation	Residual Impact
	disposal practices and management; and • Excavation and associated pipe-laying activities.		• Drip collection devices to be readily available for use anywhere in the site in case of a spillage incident; • In-place spill response and clean-up procedures; and • Temporary fuel storage tanks constructed with adequate secondary containment.	
Wastes	• Contamination to soil and groundwater due to leaks or spills on unpaved ground; • Contamination to surface water bodies due to leaks or spills into drains and waterways; and • Potential fire hazard.	Medium	• All wastes will be properly segregated by type to ensure that incompatible wastes are stored separately; • Recyclable waste will be recovered and recycle on-site. • Third-party waste management companies will be engaged for recovering and recycling waste that cannot be handled on-site; • Ensure that the waste storage facilities are capable of containing the predicted waste volume in a manner that is unlikely to cause damage to the environment nor cause any harm on the wellbeing on the personnel on-site; • Wastes that will be disposed off-site will be fully documented in which the details of the waste, types, quantity, recipient, location of disposal will be recorded prior leaving the site; and • Wastes that will be disposed off-site will only be handled and transferred by parties that are licensed to transport and/or treat or dispose the waste in accordance to Malaysia Regulations.	Low
Health & Safety	• Exposure to dust, chemicals, hazardous or flammable materials; • Slips, trips and falls; • Over exertion; • Working at heights; • Moving machinery; • Struck by objects; • Working in confined spaces; and • Hazard (including failure of building structure, injuries as a consequence of falls or contact with heavy equipment, and dust) posed to the public while accessing PEC facility.	Medium	• Ensuring compliance with the *Occupational Safety and Health Act 1994, Factories and Machinery Act 1967, Petroleum Safety Measures Act 1984* and Codes of Practice and guidelines as administered by the Department of Occupational Safety and Health (DOSH). • Carry out comprehensive risk-based job safety/hazard analysis for all tasks; • Ensuring site design takes into account health & safety considerations; • Ensure adequate fire detection and response measures are put in place; • Ensure provision of trained first aid staff on site at all times and appropriate siting of first aid stations and equipment; • Provision of suitable PPE to protect sight, hearing, skin and respiratory systems etc; • Provision of adequate lighting and ventilation in all areas; • Provision of adequate toilet and shower facilities and clean eating area; • Ensure all staff and visitors are provided with adequate basic OHS	Minor

Issue	Impact	Impact	Mitigation	Residual Impact
			training and orientation; • Inclusion of buffer strips or other methods of physical separation around the facility to protect the public from major hazards associated with incidents, failure, as well as nuisance issues related to noise, dust, or other emissions; • Application of locally regulated or internationally recognized building codes to ensure structures are designed and constructed in accordance with sound architectural and engineering practice, including aspects of fire prevention and response; • Engineers and architects responsible for designing and constructing facilities, building, plants and other structures should certify the applicability and appropriateness of the structural criteria employed.	
Human Health Assessment	• Increase of sexually transmitted diseases (STDs) or other diseases that may be brought in by foreign workers. • Increase of dust emission due to construction activities.	Low	• Conduct health screening for all foreign workers; • Provide adequate sanitation facilities for workers.	Low
Socio-Economics	• The Project is also expected to generate a number of spin-off businesses along the supply value chain	Positive	• communicate with the community on a regular basis the construction schedule and heavy vehicle movement	Positive
Operational Phase				
Air Quality	• Increase in pollutant SO_X, NO_X, CO and PM10 which may affect the health of workers.	Medium	• The facility will have a CEMS to assess compliance determinations or determination of exceedances of the *Environmental Quality (Clean Air) Regulations 2014*; • Have a DOE-certified competent person to operate APCS. • Conduct regular maintenance on all air pollution control equipment to ensure emissions are below the levels stipulated in the *Environmental Quality (Clean Air) Regulations 2014*.	Low
Noise	• Tinnitus caused by loud noise from machinery (ringing, buzzing or whistling in the ears, when there is no external sound); • Hearing loss whether is temporary, acoustic trauma and permanent hearing loss; and	Low	• Best practice procedures (such as turning off equipment when not in use); • Regular equipment maintenance; and • Noise prevention and mitigation measures such as silencer, relocation of equipment, replacement with lower noise level, and personal protective	Low

Issue	Impact	Impact	Mitigation	Residual Impact
	• Other health problems such as increased heart rate, increased breathing rate, hypertension, sleep disturbance, lack of concentration and fatigue and aggression.		equipment etc. should be applied where predicted or measured noise impacts from the facility or operation exceed the applicable noise level.	
Waste	• Contamination to soil and groundwater due to leaks or spills on unpaved ground; • Contamination to surface water bodies due to leaks or spills into drains and waterways; and • Potential fire hazard.	Low	• The facility will be managed in such a way as to minimise the generation of wastes; • Where possible wastes will be recovered or recycled on site; • External companies capable of recovering or recycling wastes, that cannot be handled on site, will be contracted for waste removal whenever practicable; • Spent catalysts from liquid or gas phase hydrogenation of olefins, diolefins and sulphur will be sent for off-site metals recovery • All wastes will be segregated by type ensuring that incompatible wastes are stored separately; • Waste storage facilities should be suitable for the purpose by ensuring that waste containers/storage areas are capable of containing predicted waste volumes in a manner unlikely to cause damage to the environment or harm to human health; • Waste designated for off-site disposal will be fully documented to include details of waste type, quantity, recipient, final destination and all other relevant information prior to leaving the site; • Have a DOE-certified competent person to manage scheduled waste; and • Waste designated for off-site disposal will only be transferred by such party that can demonstrate that they are licensed to transport and/or treat or dispose of the waste in accordance with Malaysian Regulations.	Low
Effluent Discharge	• Chemical hazard and pollution of Sg. Lepau; • Chemicals from wastewater treatment plant can cause airborne hazards that will affect human health. Inhaling the chemicals may cause respiratory infection, eye irritation, depression, central nervous system damage and poisoning; and • The airborne hazards will create an unpleasant odour caused by the chemicals from the wastewater treatment plant.	Medium	• The site storm and wastewater conveyance system shall be designed to ensure pre-segregation of non-contaminated and contaminated and/or potentially contaminated water; • The clean water system shall collect clean storm water from areas not normally subjected to contamination, which is directly discharged from the facility via the storm water discharge channel, via an effluent screen pit;	Low

Issue	Impact	Impact	Mitigation	Residual Impact
			• There will be a slop oil tanks which has a storage volume of 10,000m^3 to hold the skimmed oil. The oil will be used for on-site reprocessing; • All process wastewater and wastewater from the flare and other emission control equipment shall be directed to the dedicated wastewater treatment facility on site; • Treated waste water will be discharged to on-site final pond with a holding volume of 10,000m^3; • Monitoring of the effluent discharge on quarterly basis shall be conducted to ensure the wastewater treatment plant is operating at optimum level; and • Have a DOE-certified competent person to operate the WWTP.	
Human Health Assessment	• Modest impact on human health and well-being (e.g. noise, light, odour, dust, injuries to individuals).	Low	• Conduct regular monitoring of air pollutant levels close to sensitive receptors as to ensure the security of human health in surrounding PEC area. • Conduct regular maintenance on all air pollution control equipment to ensure emissions are below the levels stipulated in the *Environmental Quality (Clean Air) Regulations 2014*; • The continuous emission monitoring systems is recommended to be installed to track the irregularities and the emission trend of the pollutants. • Accumulation of hazardous ambient levels is necessary to be prevented by automatic shutdown within 30 minutes under the emergency of circumstances whenever pollutants are monitored impacting closest settlements during operational stage.	Low
Health & Safety	• Exposure to dust, chemicals, hazardous or flammable materials; • Slips, trips & falls; • Over exertion; • Working at heights; • Moving machinery; • Struck by objects; • Working in confined spaces; • Exposure to noise and vibration. • Facility-specific occupational health and safety hazards	Low	• Ensuring compliance with the *Occupational Safety and Health Act 1994, Factories and Machinery Act 1967, Petroleum Safety Measures Act 1984,* and Codes of Practice and guidelines as administered by DOSH. • Carry out comprehensive risk-based job safety/hazard analysis for all operational tasks. • Ensure adequate fire detection and response measures are put in place; • Ensure provision of trained first aid staff on site at all times and appropriate siting of first aid stations and equipment; • Equipment to be designed/purchased to minimise risks of accidental human entanglement in moving parts; • Provision of suitable PPE to protect sight, hearing, skin and respiratory	Low

Issue	Impact	Impact	Mitigation	Residual Impact
			systems etc; • Provision of adequate lighting and ventilation in all areas; • Provision of adequate toilet and shower facilities and clean eating area; • Ensure all staff and visitors are provided with adequate basic OHS training and orientation; • Emergency Response Plan and Transport Emergency Response Plan will be prepared and followed at all time; • Facility shall provide information and involve the communities in emergency preparedness and response plans and relevant drills in case of major accident; • Driver transporting chemicals and plant operators will be trained and/or certified to handle the chemicals and response during emergency; • All spills should be avoided and precautions should be taken to control and minimize them; • Adequate ventilation should be provided in all areas where hazardous and toxic products are handled; • Air extraction and filtration should be provided in all indoor areas where emissions and dust can be generated; • Gas detectors should be installed in hazard areas • Storage tanks should not be located close to installations where there is a risk of fire or explosion; • Pipelines shall be maintained;	
Socio-Economics	• Employment and Business Opportunities • Changes in Demographic Character • Increasing cost of living	Positive	• Project Proponent could consider participating in the skill training and certification programme for locals to ensure that they have local workers with the right skill set	Positive

8 CUMULATIVE IMPACT ASSESSMENT

CIA was carried out in line with the IFC Good Practice Handbook Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. CIA was conducted for Air Quality, Noise, Water, Critical/ Natural Habitat, Influx of Workers and Traffic.

<u>Air Quality</u>

Based on the assessment, there are several residential areas within close proximity of PEC and RAPID. The local population in these residential areas may potentially be affected by the increase of air pollutant from both PEC and RAPID processes.

Nevertheless, the cumulative contribution in consideration of RAPID overall development may result in elevated NO_2 short term averaging time namely 1-hours averaging time towards the surrounding areas particularly during worst-case meteorological condition. The contribution of Particulate Matters from the RAPID development and PEC is expected to be minimal. Exceedance to the adopted ambient standard/guideline was due to the elevated PM particularly $PM_{2.5}$ in the surrounding areas.

Furthermore, there is expected to be no significant contribution of air pollutants to the nearest receptor at the neighbouring country namely Pulau Tekong is anticipated during normal operation of the proposed plant. Therefore, the receptor sensitivity is considered as medium.

As such, the significance of NO_2, SO_2, CO, $PM_{2.5}$, H_2S, and HCl emission during the operational stage on air quality due to the Project contribution has been identified as **Medium** based on an assessed medium impact severity and medium receptor sensitivity.

<u>Noise</u>

The potential impact of noise to residential receptors during the operational phase is expected to be Low as the nearest residential areas are located at least 1 km away. Nevertheless, a screening exercise using CadnaA noise model, similar with the assessment for construction period was carried out to confirm this statement.

As per previous noise assessment (construction period), the same identified Noise Sensitive Receptors (NSRs) were predicted at 1.5 m relative from the ground level. No terrain screening was considered in this assessment.

It is noted that the existing baseline noise level in the surrounding area of the site has already exceeded the permissible sound level set in the First Schedule: Recommended Permissible Sound Level (L_{Aeq}) By Receiving Land Use for New Development (Low Density Residential – 55 dBA [Daytime] and 50 dBA [Night-time]) and Second Schedule: Recommended Permissible Sound Level (L_{Aeq}) By Receiving Land Use for Existing Land Use for Built Up Areas (Low Density Residential – 60 dBA [Daytime] and 55 dBA [Night-time]) as per the Schedule of Permissible Sound Levels of the Guidelines for Environmental Noise Limits and Control (2019). Hence, the Third Schedule: Recommended Permissible Sound Level (L_{Aeq}) To Be Maintained At The Existing Noise Climate applies where the Recommended Permissible Levels is the **Existing L_{Aeq}**.

Based on the predicted cumulative noise levels both daytime and night-time during the operational period, the existing baseline will be met. Hence, the noise contribution from the Project towards the identified NSRs would be **negligible.**

<u>Water</u>

In consideration of the total cumulative impact of both of construction and operational phase of PEC and RAPID on Sg. Lepau, the severity of the impact has been identified as medium.

The receptor sensitivity is considered as medium. This is because the discharge of construction and runoff and wastewater effluents onto Sg. Lepau may potentially change the water quality of Sg. Lepau. Furthermore, there are several aquaculture activities in Sg. Santi in which Sg, Lepau will eventually flown into. However, all discharge wastewater effluents will be treated to Standard A of the *Environmental Quality (Industrial Effluents) Regulations 2009* prior to discharge.

As such, the significance of the cumulative impact of effluent discharge onto Sg. Lepau has been identified as **Medium** based on an assessed medium impact severity and medium receptor sensitivity.

Critical/ Natural Habitat

Sungai Santi Forest Reserve is the only designated critical habitat area in Pengerang area and is home to various species of flora and fauna. It is located approximately 3 km from both PEC and RAPID. Although the development of RAPID, PIP and PEC will not directly impact Sungai Santi Forest Reserve, the discharge of effluents into Sg. Lepau from both RAPID and PEC during its construction and operation phase may influence the river water quality of Sg. Santi which will subsequently affect the flora and fauna species in Sungai Santi Forest Reserve.

Although the effluents from both PEC and PIP will be discharged into Sg. Lepau, the potential impacts on water quality are expected to be **low** and manageable, provided that each responsible party ensures that their effluents are treated in compliance with the regulation prior to discharge and the mitigation measures that will be utilised is properly maintained and working in optimum condition. Furthermore, the discharge of effluents from RAPID to the southern coastal area will not cause a significant impact to the marine coastal ecosystem as there is no critical marine habitat recorded in the area.

Influx of Workers

Although PEC will be bringing in 7,000 workers during construction phase, RAPID will be withdrawing a total of 38,000 workers during the same period. Therefore, the total amount of workers in Pengerang area during construction phase of PEC will be significantly reduced. The number of workers will continue to reduce after completion of the project and during operational phase.

Cost of living in Pengerang has increase significantly since the construction of RAPID. However, local communities such as Kg. Lepau residents took advantage of the incoming workers to their area by providing rental houses. The rentals range between RM5,000 to RM8,000 a month depending on the type of houses and facilities provided in the house. Furthermore, local communities affected by RAPID project are currently generating income by providing services and other business opportunities in Pengerang area. With the upcoming PEC project, it is expected to contribute to an improved household disposable income for locals, increase job and business opportunities, and improved infrastructure and facilities.

The significance of the influx of workers has been identified as **Positive**.

9 QUANTITATIVE RISK ASSESSMENT

Based on the QRA results, it is concluded that the PEC Plant satisfies the *DoE Risk Acceptance Criteria* for Individual Risk as:

- The 1×10^{-5} fatalities per year contour remains within the industrial area; and
- The 1×10^{-6} fatalities per year contour does not encroach to any public areas, such as residential areas, schools, hospitals.

Therefore, no additional mitigation measures are deemed to be mandatory to further reduce the risks associated with the PEC.

The Societal Risk associated with the PEC Plant is found to be within the tolerable region. Therefore, it can be concluded risks are acceptable and no additional mitigation measures are required to reduce risks to a level *as low as reasonably practical (ALARP)*.

10 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

To ensure that PEC's environmental objectives are achieved for the Project, an Environmental and Social Management Plan (ESMP) is to be developed to ensure compliance with the requirements of the *Environmental Quality Act 1974* as well as the IFC's and Equator Principle's general framework relating to prevention, abatement and mitigation of environmental and social impacts resulted from the facility operation.

11 CONCLUSION

The ESHIA has evaluated the potential impacts of the construction and operation of the PEC facility. In particular, the assessment has included dispersion modelling for potential air emissions from the PEC facility and its impact upon ambient air quality in receptor locations. Also conducted was the health impact assessment, social impact assessment and quantitative risk assessment.

The study assessment found that the majority of the impacts were considered to be "Low". Additionally, based on the QRA results, it was concluded that the PEC facility satisfies the DoE Risk Acceptance Criteria for Individual Risk.

The assessment indicates that, with the adoption of the mitigation measures, the overall environmental impacts of construction and operation of the PEC facility is not expected to be significant as long as the controls described within this report are implemented.

1 INTRODUCTION

This document presents the Environmental Social and Health Impact Assessment (ESHIA) for the proposed project entitled **Proposed Pengerang Energy Complex (PEC), Pengerang Industrial Park, Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim**.

The proposed Pengerang Energy Complex is planned as a world-scale condensate splitter and aromatics complex, on a 250-acre site in the Pengerang Industrial Park (PIP) that is situated within the Pengerang Integrated Petroleum Complex (PIPC). The production capacity of the PEC is about 5.844 Million metric tonnes per annum (MMtpa), or 16.7 kilometric tonnes per day (kMtpd), of aromatic petrochemicals and oil products, which will be processed from 6.324 MMtpa of condensate feedstock.

The technology provider for this project has been carefully selected for developing the proposed project. UOP of America has been identified as the only supplier who is able to supply the complete package by providing a single integrated advanced technology, encompassing condensate splitter process, catalytic reforming, product purification and the conversion of toluene to benzene and xylene, whilst ensuring economic attractiveness and environmental performance.

The proposed location of the complex is within the proposed Pengerang Industrial Park (PIP) in Mukim (Precinct) Pengerang, Kota Tinggi District, Johor, Malaysia is shown in *Figure 1.1* while *Figure 1.2* shows the Site & Study Boundary of the proposed project.

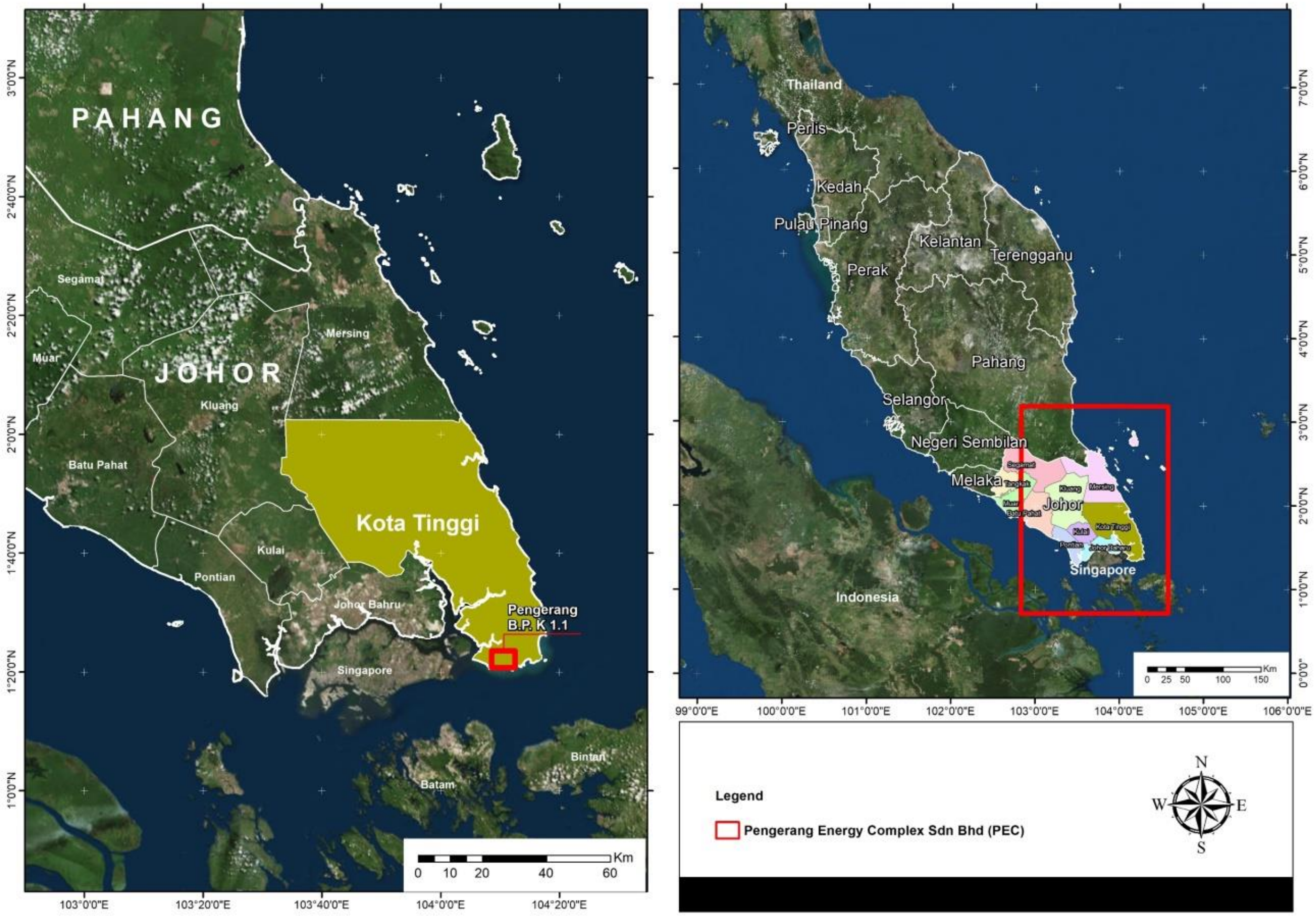


Figure 1.1 – Site Location

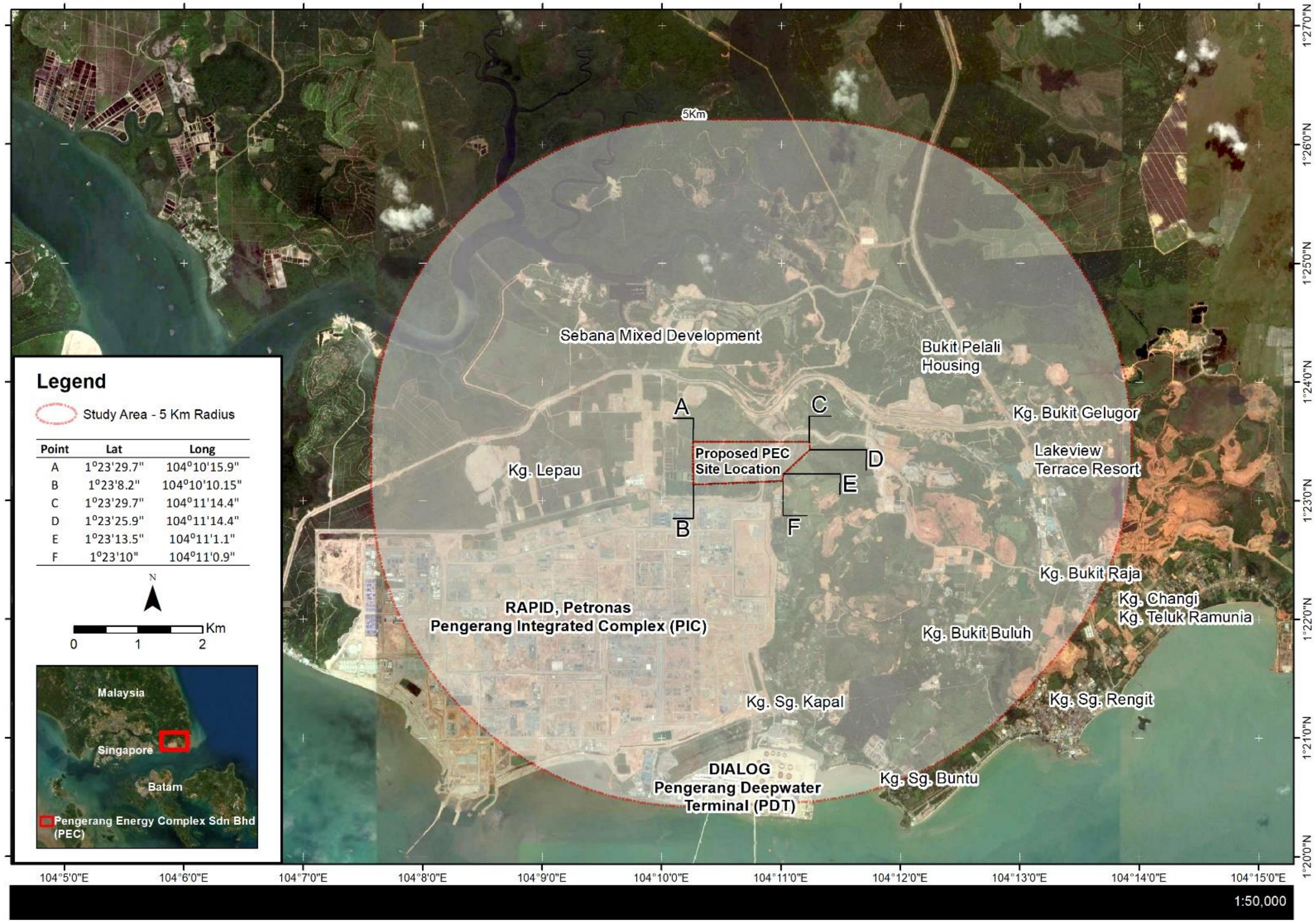


Figure 1.2 – Site & Study Boundary
Source: ESRI, GE Image 2016 & ESC

1.1 Objectives of the Environmental, Social and Health Impact Assessment

The ESHIA has been conducted to ensure that the relevant national and international regulatory requirements are met and that the project would be conducted in an environmentally sustainable manner to meet or surpass the environmental and social requirements of relevant authorities in Malaysia, international standards and guideline as well as the lenders requirements.

These include but are not limited to:

- Malaysian Environmental Quality Act 1974 and its corresponding regulations;
- Malaysian Occupational Safety and Health Act 1994 and its related regulations;
- Malaysian Factories and Machinery Act 1967 and its related regulations;
- International Finance Corporation (IFC) Performance Standards for the management of social and environmental risks and impacts along with its related and applicable guidelines;
- The IFC's Environmental, Health and Safety Guidelines and other relevant World Bank guidelines and standards, as applicable; and
- Equator Principles.

Objectives of the ESHIA include:

- Identify and analyse sensitive components of the existing environment.
- Determine the type, nature and significance of the probable environmental and/or social impacts (positive, negative, direct and indirect, reversible and irreversible, short term and long term) during construction and operation phases.
- Identify and recommend practical and cost-effective mitigation measures early in the process to eliminate, minimise, mitigate or avoid any negative environmental and/or social impacts resulting from the project.
- Recommend a framework for an environmental and social management/monitoring plans for the project in order to eliminate and/or minimise the potential negative environmental and/or social impacts.
- Ensure that all stakeholders deemed to be influenced by the project activities are fully considered and that communication systems are established during the assessment process and remain effective throughout the life of the activities.

1.2 ESHIA Scope of Work

The scope of the ESIA will incorporate the requirements of the Malaysian regulators, project proponent, IFC and lenders; and will cover a range of potential project effects that could impact the local and regional biophysical and socio-economic environment. In general, the scope of work of this ESHIA can be summarised as follows:

- Identify all applicable local, national and international environmental regulations and standards that the project must meet;
- Undertake all necessary field assessment studies to define the existing baseline conditions in the study area;
- Develop a consultation process and relation and communication strategy to ensure that all stakeholders are consulted and are kept informed throughout all stages of the study;
- Develop an Environmental Management Plan including recommendations regarding mitigation measures, emergency response, monitoring, staffing, and training the project should implement to prevent or reduce significant negative impacts; and
- Prepare a draft ESHIA for review and due diligence process, which will be updated, as appropriate, for submission to applicable environmental agencies and lending institutions.

ESC shall follow up/liaise with the relevant agencies and the Project Lender's representative for comments to ensure the required environmental approvals for the project are obtained.

1.3 Project Proponent

The Project Proponent, or project owner, is Pengerang Energy Complex Sdn. Bhd. (PEC). Details pertaining to the Project Proponent are as follows:

Contact Person	: **Chong Ying Haur**
Designation	: **Director, PEC**
Office Address	: 1 Raffles Quay #21-02, One Raffles Quay North Tower, Singapore 048583
Telephone	: (+65) 6536 7055
Email	: ying.haur.chong@chemoneholdings.com

1.3.1 Company's Policy and Environmental Principles

PEC's Environmental Policy is shown in *Figure 1.3*.

PENGERANG ENERGY COMPLEX SDN BHD

Environmental Policy Statement

PEC has been conceived as a World Class processor of Condensates to competitively produce Oil Products and Aromatics Products to satisfy growing need and demand for such products in South East Asia and North Asia, providing both long term employment and opportunity for the community whilst minimising possible negative impact on the eco system and social infrastructure.

PEC will base its operations in Pengerang, Johor State, Malaysia and will utilise latest generation proven technology from recognised Global providers offering optimised production, safety, waste, environmental performance and utilities consumption.

PEC will work closely with State and Central Government organisations to ensure that it's activities and actions are consistent with mandated objectives whilst also compatible with Global Guidelines.

PEC is committed to responsible HSE and Social Performance management through both the Construction and Operations phases of its activities, and to positive inclusion of the local community.

PEC's policy is to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. It is committed to continuous efforts to improve environmental performance throughout its operations.

PEC will achieve this through commitment to:

- Comply with all applicable environmental laws and regulations (WB Guidelines, Malaysian regulations) and apply recognized international standards where laws and regulations do not exist;
- Manage environmental risks by identifying and assessing environmental hazards, implementing and monitoring controls, and assigning specific risk owners;
- Review regularly the environmental impact of plant activities, endeavour to reduce overall environmental impact and prevent waste using best practice techniques;
- Involve employees in company's environmental programme and provide necessary training to enable them to discharge their responsibilities;
- Sustain a programme of continual improvement in environmental performance by setting targets, implementing improvement programs and monitoring progress;
- Work with key suppliers to encourage them to develop environmental best practice;
- Improve the sustainability of operations and resource efficiency by reducing resource consumption and waste generation
- Communicate with the public on environmental matters and share company's experience with others to facilitate improvements in industry performance;

These aims and objectives are fully supported by the Owners and Management of PEC

Chong Ying Haur
Director, Pengerang Energy Complex Sdn Bhd
Date: 21 Jun 2019

Figure 1.3 – PEC's Environmental Policy

1.4 ESHIA Consultant

EnviroSolutions & Consulting Sdn Bhd (ESC) has been appointed as the lead Environmental Consultancy to manage the ESHIA for the PEC project and to prepare the *PEC ESHIA Report*. Enquiries and correspondence pertaining to this report can be made to:

EnviroSolutions & Consulting Sdn Bhd (*Company No.: 737279-T*)
WeWork Mercu 2, Level 40, No. 3 Jalan Bangsar,
KL ECO City, Persekutuan Kuala Lumpur,
59200, Malaysia

Contact Person : **Andrew Young**
Designation : **Group Director**
Email : andrew@envirosc.com

1.5 Report Layout

The report is structured as follows:

Chapter 1 – Introduction

Chapter 2 – Regulatory Framework, Standards and Guidelines

Chapter 3 – Project Description

Chapter 4 – Analysis of Alternatives

Chapter 5 – Receiving Environment - Environmental and Social Baseline in 5 km Radius

Chapter 6 – ESHIA Approach and Methodology

Chapter 7 – Impacts Assessment and Mitigation Measures

Chapter 8 – Quantitative Risk Assessment

Chapter 9 – Environmental and Social Management Plan

Chapter 10 – Information Disclosure, Consultation and Participation

Chapter 11 – Conclusion

Appendices

2 REGULATORY FRAMEWORK, STANDARDS AND GUIDELINES

Policy and Regulatory Framework is defined as the existence of the necessary infrastructure which supports the control, direction or implementation of a proposed or adopted course of action, rule, principle and law. In Malaysia, ministries are the highest bodies in the federal administrative machinery. Each ministry is responsible for formulating, planning, controlling and coordinating government policies pertaining to its functions. The second highest agencies in Malaysia is government departments which responsible for implementing government policies.

2.1 National Regulatory Framework Review

For the purpose of the project the following legislations and requirements were reviewed:

- Environmental Quality Act 1974 (Act 127);
- Occupational Safety and Health Act 1994 (Act 514);
- Factories and Machinery Act 1967 (Act 139);
- International Finance Corporation's (IFC) Environmental and Social Sustainability Performance Standards;
- International Finance Corporation's (IFC) Environmental, Health and Safety Guidelines for General Guidelines;
- International Finance Corporation's (IFC) Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing;
- Equator Principles; and
- OECD Guidelines for Multinational Enterprises.

Applicable legislation, regulations, guidance and strategies enacted by the Malaysian governments regarding environmental, safety and health are described in *Table 2.1* below.

Table 2.1: Applicable Regulations and Requirements

	Act/ Regulation/ Policy	Brief Description
1.	Environmental Quality Act 1974 (Act 127)	An act relating to the prevention, abatement, control of pollution and enhancement of the environment. It controls all activities relating to the discharge of wastes into the environment and for preventing or controlling pollution and protecting and enhancing the quality of the environment. Applicable regulations in the EQA are: 1. EQ (Licensing) Regulations 1977; 2. EQ (Scheduled Wastes) Regulations 2005; 3. EQ (Sewage) Regulations 2009; 4. EQ (Industrial Effluent) Regulations 2009; and 5. EQ (Clean Air) Regulations 2014.
2.	Occupational Safety and Health Act 1994 (Act 514)	This act provides the legislative framework for the safety, health and welfare among all Malaysian workforces. The principle is to prevent and protect the workers against

	Act/ Regulation/ Policy	Brief Description
		hazards and its risks in connection with their activities at work. Applicable regulations in the OPSHA are: 1. OSH (Safety and Health Committee) Regulations 1996; 2. OSH (Safety and Health Officer) Regulations 1997; 3. OSH (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations 2004; and 4. OSH (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013.
3.	Factories and Machinery Act 1967 (Act 139)	Factories and Machinery Act is an act to provide for the control of factories with respect to matters relating to the safety, health and welfare of person therein, the registration and inspection of machinery and for matters connected therewith. Applicable related to FMA are: 1. FM (Steam Boiler and Unfired Pressure Vessel) Regulations 1970; 2. FM (Electric Passenger and Good Lifts) Regulations 1970; 3. FM (Fencing of Machinery and Safety) Regulations 1970; 4. FM (Person-in-Charge) Regulations 1970; 5. FM (Safety, Health and Welfare) Regulations 1970; 6. FM (Notification, Certificate of Fitness and Inspection) Regulations 1970; 7. FM (Building Operations and Works of Engineering Construction (Safety)) Regulations 1986; and 8. FM (Noise Exposure) Regulations 1989.
4.	International Finance Corporation's Environmental and Social Sustainability Performance Standards	The IFC Performance Standards offer helpful guidance on the requirements including reference materials and on good sustainability practices to improve project performance.
5.	International Finance Corporation's Environmental, Health and Safety General Guidelines	This EHS general guideline is a technical document providing approach to managing issues associated with environment such as air, water, noise and land pollution as well as issues related to the health and safety of the workers. This guideline also provides the performance levels and measures in line with the good international industry practice.

	Act/ Regulation/ Policy	Brief Description
	International Finance Corporation's Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing	The EHS Guidelines include information relevant to Large Volume petroleum-based Organic Chemicals (LVOC) projects and facilities. This document provides a summary of the most significant EHS issues associated with LVOC manufacturing facilities, which occur during the operational phase, along with recommendations for their management.
6.	Equator Principles	The Equator Principles (EP) comprise a group of ten principles voluntarily adopted by the Equator Principle Financial Institutions (EPFIs) in order to ensure that the projects funded by them are developed in a manner that is socially responsible and reflect sound environmental management practices.
7.	OECD Guidelines for Multinational Enterprises	The Guidelines are recommendations jointly addressed by governments to multinational enterprises. They provide principles and standards of good practice consistent with applicable laws and internationally recognised standards. Observance of the Guidelines by enterprises is voluntary and not legally enforceable. Nevertheless, some matter covered by the Guidelines may also be regulated by national law or international commitments such as bribery and extortion.

2.1.1 Malaysia Labour Law

In Malaysia, related employment law that regulates employers, workers and work environment are:

1. Workmen's Compensation Act 1952;
2. Employment Act 1955, Trade Unions Act 1959;
3. Children and Young Persons (Employment) Act 1966;
4. Industrial Relations Act 1967;
5. Factories and Machineries Act 1967;
6. Employees' Social Security Act 1969;
7. Employment (Termination and Lay-Off Benefits) Regulations 1980;
8. Employees' Provident Fund Act 1991;
9. Occupational Safety and Health Act 1994; and
10. Employment Insurance System Act 2018.

2.1.2 Environmental Quality Act

Environmental Quality Act 1974 (Act 127) is an act relating to the prevention, abatement, control of pollution and enhancement of the environment. The EQA outlined national environmental standards for element such as water quality, effluent discharge, air quality and noise level.

2.1.3 Air Quality Regulations

An air quality standard to be used is in accordance with the Environmental Quality (Clean Air) Regulations 2014 for operational stage and Malaysia Ambient Air Quality Standard.

2.1.3.1 Malaysia Ambient Air Quality Standard (MAAQS)

A new Ambient Air Quality was established in order to replace the older Malaysia Ambient Air Quality Guidelines that has been used since 1989. The new Ambient Air Quality Standard adopt 6 air pollutants criteria that include 5 existing air pollutants which are particulate matter with the size less than 10 micron (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and ground level ozone (O_2) as well as 1 additional parameter which is particulate matter with the size less than 2.5 micron ($PM_{2.5}$). The air pollutants concentration limit will be strengthened in stages until 2020. There are 3 interim targets set which include interim target 1 (T-1) in 2015, interim target 2 (T-2) in 2018 and the full implementation of the standard in 2020.

Table 2.2: Malaysian Ambient Air Quality Standard

Pollutants	Averaging Time	Ambient Air Quality Standard (µg/m^3)		
		IT-1 (2015)	IT-2 (2018)	Standard (2020)
Particulate Matter with the size of less than 10 micron (PM_{10})	1 Year	50	45	40
	24 Hour	150	120	100
Particulate Matter with the size of less than 2.5 micron ($PM_{2.5}$)	1 Year	35	25	15
	24 Hour	75	50	35
Sulphur Dioxide (SO_2)	1 Year	350	300	250
	24 Hour	105	90	80
Nitrogen Dioxide (NO_2)	1 Year	320	300	280
	24 Hour	75	75	70
Ground Level Ozone (O_3)	1 Year	200	200	180
	8 Hour	120	120	100
*Carbon Monoxide (CO)	1 Year	35	35	30
	8 Hour	10	10	10

*mg/m^3

2.1.3.2 Environmental Quality (Clean Air) Regulations 2014

The EQ (Clean Air) Regulations 2014 is applicable for:

a) Any premises used for any industrial or trade purposes, or on which matter is burnt in connection with any industrial or trade purposes, including burning of waste, whether or not the premises are prescribed under section 18 of the Act;

b) Any other premises or process that discharges or is capable of discharging air pollutants into the open air;

c) Any industrial plant; and

d) Any fuel burning equipment.

Limit values in these Regulations are divided into two (2) categories, Limit Values and Technical Standard (General) and Limit Values and Technical Standards (By Activity or Industry).

2.1.4 Noise

DoE published *The Planning Guidelines for Environmental Noise Limits and Control* which provide noise acceptance criteria for quantitative assessment of noise to define disturbance or otherwise. Based on the guideline, there are six (6) schedules to be referred to depending on the location and receiver. Each schedule prescribes different limits and the limits are:

Table 2.3: Schedule of Permissible Sound Levels

Schedule 1: Maximum Permissible Sound Level (L_{Aeq}) by Receiving Land Use for Planning and New Development		
Receiving Land Use Category	**Day Time 7.00 am – 10.00 pm**	**Night Time 10.00 pm – 7.00 am**
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas	50 dBA	40 dBA
Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas	55 dBA	45 dBA
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential – Commercial)	60 dBA	50 dBA
Commercial Business Zone	65 dBA	55 dBA
Designated Industrial Zone	70 dBA	60 dBA

Schedule 2: Maximum Permissible Sound Level (L_{Aeq}) of New Development (Roads, Rails, Industrial) in Areas of Existing High Environmental Noise Climate		
Receiving Land Use Category	**Day Time 7.00 am – 10.00 pm**	**Night Time 10.00 pm – 7.00 am**
Noise Sensitive Area, Low Density Residential	L_{90} + 10 dBA	L_{90} + 5 dBA
Suburban and Urban Residential Area	L_{90} + 10 dBA	L_{90} + 10 dBA
Commercial, Business	L_{90} + 10 dBA	L_{90} + 10 dBA
Industrial	L_{90} + 10 dBA	L_{90} + 10 dBA

L_{90} is the measured ninety percentile sound level for the respective time period of the existing areas of interest in the absence of the proposed new development.

Schedule 3: Maximum Permissible Sound Level (L_{Aeq}) to be Maintained at the Existing Noise Climate		
Existing Levels	**New Desirable Levels**	**Maximum Permissible Levels**
L_{Aeq}	L_{Aeq}	L_{Aeq} + 3 dBA

Schedule 4: Limiting Sound Level (L_{Aeq}) from Road Traffic (for Proposed New Roads and/ or Redevelopment of Existing Roads)		
Receiving Land Use Category	**Day Time 7.00 am – 10.00 pm**	**Night Time 10.00 pm – 7.00 am**
Noise Sensitive Areas, Low Density Residential	55 dBA	50 dBA
Suburban Residential (Medium Density)	60 dBA	55 dBA
Urban Residential (High Density)	65 dBA	60 dBA

Schedule 4: Limiting Sound Level (L_{Aeq}) from Road Traffic (for Proposed New Roads and/ or Redevelopment of Existing Roads)		
Receiving Land Use Category	**Day Time 7.00 am – 10.00 pm**	**Night Time 10.00 pm – 7.00 am**
Commercial, Business	70 dBA	60 dBA
Industrial	75 dBA	65 dBA

Schedule 5: Limiting Sound Level (L_{Aeq}) for Railways Including Transits (for New Development and Re-Alignments)			
Receiving Land Use Category	**Day Time 7.00 am – 10.00 pm**	**Night Time 10.00 pm – 7.00 am**	**L_{max} (Day & Night)**
Noise Sensitive Areas, Low Density Residential	60 dBA	50 dBA	74 dBA
Suburban Residential (Medium Density)	65 dBA	60 dBA	80 dBA
Commercial, Business	70 dBA	65 dBA	80 dBA
Industrial	75 dBA	65 dBA	NA

Schedule 6: Maximum Permissible Sound Levels (Percentile L_n and L_{max}) of Construction, Maintenance and Demolition Work by Receiving Land Use				
Receiving Land Use Category	**Noise Parameter**	**Day Time 7.00 am – 7.00 pm**	**Evening 7.00 pm – 10.00 pm**	**Night Time 10.00 pm – 7.00 pm**
Residential (Note 2**)	L_{90}	60 dBA	55 dBA	*(Note 1)
	L_{10}	75 dBA	70 dBA	*
	L_{max}	90 dBA	85 dBA	*
Commercial (Note 2**)	L_{90}	65 dBA	60 dBA	NA
	L_{10}	75 dBA	70 dBA	NA
Industrial	L_{90}	70 dBA	NA	NA
	L_{10}	80 dBA	NA	NA

Notes:

**1. At these times the maximum permissible levels as stipulated in the Schedule 1 for the respective residential density type shall apply. This may mean that no noisy construction work can take place during these hours.*

***2. A reduction of these levels in the vicinity of certain institutions such as schools, hospital, mosque and noise sensitive premises (apartments, residential dwellings, hotel) may be exercised by the local authorities or Department of Environment.*
Where the affected premises are noise sensitive, the limits of the Schedule 1 shall apply.

3. In the event that the existing ambient sound level (L_{90}) without construction, maintenance and demolition works higher than the L_{90} limit of the above Schedule the higher measured ambient L_{90} sound level; shall prevail. In this case, the maximum permissible L_{90} sound level shall not exceed the Ambient L_{90} level + 10 dBA, or the above Schedule L_{10} whichever is the higher.

4. NA = Not Applicable

2.1.5 Soil & Groundwater

In Malaysia, there are a series of guidelines for soil and groundwater published by the DoE namely Contaminated Land Management and Control Guidelines. These guidelines are:

1. Malaysian Recommended Site Screening Levels for Contaminated Land;
2. Assessment and Reporting Contaminated Sites; and
3. Remediation of Contaminated Sites.

The guidelines are prepared according to the United States Environmental Protection Agency (USEPA) and the limits for Site Screening Levels (SSLs) were referred from the USEPA guidelines. The USEPA SSLs table provides the SSLs for four (4) different categories of scenarios that direct contact exposure pathways:

a) Residential soils
b) Industrial soil
c) Ambient air
d) Tap water

Soil and groundwater concentration will be compared against the respective SSLs depending on the land use and exposure scenario at the subject land property.

2.1.6 Water Quality

In Malaysia, there are two (2) regulations related to water quality, Sewage and Industrial Effluent, which mostly referred to during operational phase and two (2) standards as guidelines for river and marine water quality.

2.1.6.1 Environmental Quality (Sewage) Regulations 2009

The regulations are applicable to any premises which discharge sewage onto or into any soil, or into any inland waters or Malaysian waters, other than any housing or commercial development or both having population equivalent of less than one hundred and fifty (<150). According to Second Schedule of the *Environmental Quality (Sewage) Regulations 2009,* there are three (3) different Acceptable Conditions of Sewage Discharge of Standard A and B which are:

1. Acceptable conditions for new sewage treatment system;
2. Acceptable conditions for existing sewage treatment system (approved before January 1999); and
3. Acceptable conditions for existing sewage treatment system (approved after January 1999).

2.1.6.2 Environmental Quality (Industrial Effluent) Regulations 2009

The *Environmental Quality (Industrial Effluent) Regulations 2009* is applicable to any premises which discharge or release industrial effluent or mixed effluent, onto or into any soil, or into inland waters or Malaysian waters, other than the premises as specified in the First Schedule.

The limit value for industrial effluent and mixed effluent discharge is listed under Fifth Schedule for Standards A and B. The limits are as shown in *Table 2.4* below.

Table 2.4: Acceptable Conditions for Discharge of Industrial Effluent or Mixed Effluent of Standards A and B

Parameters	Unit	Standard	
		A	B
Temperature	°C	40	40
pH Value	-	6.0 – 9.0	5.5 – 9.0
BOD_5 at 20°C	mg/L	20	50
Suspended Solids	mg/L	50	100
Mercury	mg/L	0.005	0.05
Cadmium	mg/L	0.01	0.02
Chromium, Hexavalent	mg/L	0.05	0.05
Chromium, Trivalent	mg/L	0.20	1.00
Arsenic	mg/L	0.05	0.10
Cyanide	mg/L	0.05	0.10
Lead	mg/L	0.10	0.50
Copper	mg/L	0.20	1.00
Manganese	mg/L	0.20	1.00
Nickel	mg/L	0.20	1.00
Tin	mg/L	0.20	1.00
Zinc	mg/L	2.00	2.00
Boron	mg/L	1.00	4.00
Iron (Fe)	mg/L	1.00	5.00
Silver	mg/L	0.10	1.00
Aluminium	mg/L	10.00	15.00
Selenium	mg/L	0.02	0.50
Barium	mg/L	1.00	2.00
Fluoride	mg/L	2.00	5.00
Formaldehyde	mg/L	1.00	2.00
Phenol	mg/L	0.001	1.00
Free Chlorine	mg/L	1.00	2.00
Sulphide	mg/L	0.50	0.50
Oil and Grease	mg/L	1.00	10.00
Ammoniacal Nitrogen	mg/L	10.00	20.00
Colour	ADMI*	100.00	200.00

*ADMI – American Dye Manufacturer Institute

2.1.7 Waste Management

2.1.7.1 Environmental Quality (Scheduled Wastes) Regulations 2005

The *Environmental Quality (Scheduled Wastes) Regulations 2005* replaced the *Environmental Quality (Scheduled Wastes) Regulations 1989.* Under these regulations, 77 types of scheduled wastes listed in the First Schedule are divided into 5 categories namely:

1. SW 1 – Metal and metal-bearing wastes (10 types of scheduled wastes);
2. SW 2 – Wastes containing principally inorganic constituents which contain metals and organic materials (7 types of scheduled wastes);

3. SW 3 – Waste containing principally organic constituents which may contain metals and inorganic materials (27 types of scheduled wastes);
4. SW 4 – Waste which may contain either inorganic or organic constituents (32 types of scheduled wastes); and
5. SW 5 – Other wastes (1 type of scheduled waste).

There are 17 regulations under the *Environmental Quality (Scheduled Wastes) Regulations 2005* which include:

1. Regulation 1: Citation and commencement
2. Regulation 2: Interpretation
3. Regulation 3: Notification of the generation of scheduled wastes
4. Regulation 4: Disposal of scheduled wastes
5. Regulation 5: Treatment of scheduled wastes
6. Regulation 6: recovery of material or product from scheduled wastes
7. Regulation 7: Application for special management of scheduled wastes
8. Regulation 8: Responsibility of waste generator
9. Regulation 9: Storage of scheduled wastes
10. Regulation 10: Labelling of scheduled wastes
11. Regulation 11: Waste generator shall keep an inventory of scheduled wastes
12. Regulation 12: Information to be provided by waste generator, contractor and occupier of prescribed premises
13. Regulation 13: Scheduled wastes transported outside waste generator's premises to be accompanied by information
14. Regulation 14: Spill or accidental discharge
15. Regulation 15: Conduct of training
16. Regulation 16: Compounding of offences
17. Regulation 17: Revocation

2.1.8 Land and Infrastructure

2.1.8.1 Land Development Act 1956

The *Land Development Act 1956* is an act to provide for the establishment of a Federal development authority and local development boards to promote and carry out projects for land development and settlement, for making funds available therefore, and for purposes connected therewith. The act comprises of 7 parts, which are:

1. Part I: Introductory
2. Part II: Federal Land Development Authority
3. Part III: Local Land Development Boards
4. Part IV: Corporation
5. Part V: Regulation and Incorporation of Boards and Corporation

6. Part VII: Movable and Immovable Property
7. Part VIII: General

2.1.8.2 Road Transport Act 1987

The *Road Transport Act 1987* is an act to make provision for:

- Motor vehicles and traffic in streets and other thing that have linkages with roads and vehicles;
- Protection of third parties against risks arising from the use of motor vehicles;
- Co-ordination and control of means of and facilities for transport;
- Co-ordination and control of means of and facilities for construction and adaptation of motor vehicles; and
- Connected purposes.

The act comprises of 7 parts namely:

1. Part I: Preliminary
2. Part II: Classification, Registration and Licensing of Motor Vehicles and Drivers
3. Part IIA: Periodic Inspection of Motor Vehicles
4. Part IIB: Foreign Motor Vehicles
5. Part III: Roads
6. Part IV: Provision Against Third Party Risks Arising Out of the Use of Motor Vehicles
7. Part V: Offences and Miscellaneous Provisions

2.1.9 Occupational Health and Safety

2.1.9.1 Occupational Safety and Health Act 1994

The *Occupational Safety and Health Act 1994* or Act 514 provides the legislative framework for the safety, health and welfare among all Malaysian workforces. The principle is to prevent and protect the workers against hazards and its risk in connection with their activities at work. It requires all companies to establish and document:

1. Safety and health policy;
2. Duties of the employer, employees and the safety and health officers;
3. The safety and health committee of companies; and
4. Occupational safety and health inspection and officers.

The purposes of this Act are:

1. To secure the safety, health and welfare or persons at work against hazards and risks arising out of the activities of person at work;
2. To protect person at place of work, other than persons at work, against risks arising out of the activities of persons at work;
3. To promote an occupational environment for persons at work which is adapted to their physiological and psychological needs; and

4. To provide the means whereby the associated occupational safety and health legislation may be progressively replaced by a system of regulations and approved industry codes of practice operating in combination with the provision of this Act designed to maintain or improve the standards of safety and health.

There are 8 parts in total for this Act. The parts are:

1. Part I: Preliminary
2. Part II: Appointment of Officers
3. Part III: National Council for Occupational Safety and Health
4. Part IV: General Duties of Employers and Self-Employed Persons
5. Part V: Genera; Duties of Designers, Manufacturers and Suppliers
6. Part VI: General Duties of Employees
7. Part VII: Safety and Health Organizations
8. Part VIII: Notification of Accidents, Dangerous Occurrence, Occupational Poisoning and Occupational Disease and Injury
9. Part IX: Prohibition Against Use of Plant or Substance
10. Part X: Industry Codes of Practice
11. Part XI: Enforcement and Investigation
12. Part XII: Liability for Offences
13. Part XIII: Appeals
14. Part XIV: Regulations
15. Part XV: Miscellaneous

2.1.10 Other National Regulatory Requirements

2.1.10.1 National Policy on Environment

The Policy aims at continued economic, social and cultural progress of Malaysia and enhancement of the quality of life of its people, through environmentally sound and sustainable development. The Policy aims at achieving:

- A clean, safe, healthy and productive environment for present and future generations;
- The conservation of the country's unique and diverse cultural and natural heritage with effective participation by all sectors of society; and
- A sustainable lifestyle and pattern of consumption and production.

Malaysia's national environmental policy emphasises on:

- Exercising respect and care for the environment in accordance with the highest moral and ethical standards;
- Conserving the natural ecosystems to ensure the integrity of biodiversity and life support systems;
- Ensuring continuous improvement in the productivity and quality of the environment while pursuing economic growth and human development objectives;

- Managing natural resources utilisation to sustain the resources base and prevent degradation of the environment;
- Integrating environmental dimensions in the planning and implementation of the policies, objectives and mandates of all sectors to protect environment;
- Strengthening the role of the private sector in the environmental protection and management;
- Ensuring the highest commitment to environmental protection and accountability by all decision-makers in the public and private sectors., resource users, non-governmental organisations and the general public in formulating, planning and implementing their activities; and
- Participating actively and effectively in regional and global efforts towards environmental conservation and enhancement.

2.1.11 Guidelines

In Malaysia, guidelines are published to specify further requirement and details based on the regulations. These guidelines are published by relevant authorities such as Department of Environment (DoE) and Department of Occupational Safety and Health (DOSH). The list of guidelines and publisher are as shown in *Table 2.5* below.

Table 2.5: List of Guidelines in Malaysia

Guidelines/ Code of Practice	Publisher	Year of Published
Environmental Impact Assessment (EIA) Guideline in Malaysia		2016
Contaminated Land Management and Control Guidelines No. 1: Malaysian Recommended Site Screening Levels for Contaminated Land	DoE	June 2009
Contaminated Land Management and Control Guidelines No. 2: Assessing and Reporting Contaminated Sites		
Contaminated Land Management and Control Guidelines No. 3: Remediation of Contaminated Sites		
Guidelines for the Classification of Used Electrical and Electronic Equipment in Malaysia – 2nd Edition		2010
Guidelines on the Disposal of Chemical Wastes from Laboratories – 2nd Edition		May 2015
A Guide for Investors – 11th Edition		October 2010
Guidelines on Environmentally Sound Co-Processing of Scheduled Wastes in Cement Industry – 1st Edition		May 2015
EIA Guidelines for Petrochemical Industries		2018
EIA Guidelines for Risk Assessment		2004
EIA Guidelines for Development in Coastal Areas and Marine Parks		2017
EIA Guidelines for Development in National and State Parks		2017
EIA Guidelines for Development in Slopes and Hill		2017

Guidelines/ Code of Practice	Publisher	Year of Published
Areas		
Guidance for the Industry on the Notification and Registration Scheme of Environmentally Hazardous Substances (EHS) in Malaysia – 2nd Edition		2012
Guidance Document for Fuel Burning Equipment and Air Pollution Control System		-
Guidance Document on Health Impact Assessment in EIA		2012
Guidance Document on Fugitive Emission Control		-
Guidance Document on Leak Detection and Repair		-
Guidelines on the Use of Oil Spill Dispersant in Malaysia – 2nd Revision		July 2016
Guidelines for Packaging, Labelling and Storage of Scheduled Wastes in Malaysia		-
Guidelines for Siting and Zoning of Industry and Residential Areas – 2nd Revision		October 2012
The Planning Guidelines for Environmental Noise Limits and Control – 2nd Edition		2007
Guidelines on Occupational Safety and Health for Seating at Work		2002
Guidelines on Occupational Safety and Health for Standing at Work		2002
Guidelines on Occupational Vibration	DOSH	2003
Guidelines on Occupational Safety and Health for Working with Video Display Units (VDU's) – 1st Edition		June 2003
Industry Code of Practice on Indoor Air Quality		2010
Storage, Handling and Transportation of Liquefied Petroleum Gases LPG) – Code of Practice – 3rd Revision	DoSM	2013
Guidelines for Asbestos Removal		2017
Guidelines on Occupational Safety and Health in the Office		1996
Guidelines for the Preparation of a Chemical Register		September 2000
Guidelines for the Prevention of Falls at Workplace		March 2007
Guidelines on First-Aid in the Workplace – 2nd Edition		2004
Guidelines on the Control of Chemicals Hazardous to Health	DOSH	2001
Guidelines on the Use of PPE Against Chemical Hazards		October 2005
Guidelines on Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations (NADOPOD)		2004
Industry Code of Practice on Chemicals Classification and Hazard Communication		2014
Assessment of the Health Risks Arising from the Use		2000

Guidelines/ Code of Practice	Publisher	Year of Published
of Hazardous Chemicals in the Workplace (A Manual of Recommended Practice 2nd Edition)		
Guidelines on Heat Stress Management at Workplace		2016
Industry Code of Practice for Safe Working in a Confined Space		2010
Guidelines for Approval of Hoisting Machine Design		November 2017
Guidelines on Storage of Hazardous Chemicals: A guide for Safe Warehousing of Packaged Hazardous Chemicals		2005

*DoE – Department of Environment

DOSH – Department of Safety and Health

DoSM – Department of Standard Malaysia

2.1.12 Applicable International Convention, Requirements, Guidelines and Other Evaluation Criteria

2.1.12.1 International Finance Corporation's Environmental and Social Sustainability Performance Standards

The IFC Performance Standards offer helpful guidance on the requirements including reference materials and on good sustainability practices to improve project performance. There are eight (8) Performance Standards (PS):

1. PS 1: Assessment and Management of Environmental and Social Risks and Impacts
2. PS 2: Labour and Working Conditions
3. PS 3: Resource Efficiency and Pollution Prevention
4. PS 4: Community, Health and Safety
5. PS 5: Land Acquisition and Involuntary Resettlement
6. PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
7. PS 7: Indigenous People
8. PS 8: Cultural Heritage

Performance Standards (PS)	Brief Description and Application	PEC Compliance Measures
PS 1: Assessment and Management of Environmental and Social Risks and Impacts	PS 1 underscores the importance of managing the environmental and social performance throughout the life of project. It applies to business activities with environmental and/ or social risks and/ or impacts. For this project, proponent should conduct a comprehensive full-scale ESHIA. The key process elements of an ESHIA generally consist of (i) initial screening of the project and scoping of the assessment process; (ii) examination of alternatives; (iii) stakeholder identification (focusing on those directly affected) and gathering of environmental and social baseline data; (iv) impact identification, prediction and evaluation of residual impacts; and (vii) documentation of the assessment process (i.e., ESHIA report).	PEC, through ESC has conducted and produced an ESHIA adhering to the IFC's PSs. The ESHIA is prepared to comply with the national standards, rules and regulations as well as the requirements of IFC performance standards and EHS guidelines
PS 2: Labour and Working Conditions	PS 2 recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental right of workers e.g. child labour and occupational safety and health. The requirements set out in PS 2 have been in part guided by a number of international convention and instruments, including those of the International Labour Organisation (ILO) and the United Nations (UN). The implementation of the actions necessary to meet the requirements is managed through the proponent's Environmental and Social Management System (ESMS). The ESMS will incorporate the following elements: (i) policy; (ii)	Labour and working conditions has been addressed in Chapter 7 Project Impact and Management of the ESHIA report. Furthermore, proponent shall comply with any regulations pertaining to the labour e.g., Employment Act 1955 and Children and Young Persons (Employment) Act 1966.

Performance Standards (PS)	Brief Description and Application	PEC Compliance Measures
	identification of risks and impacts; (iii) management programs; (iv) organisation capacity and competency; (v) emergency preparedness and response; (vi) stakeholder engagement; and (vii) monitoring and review.	
PS 3: Resource Efficiency and Pollution Prevention	PS 3 recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water and land and consume finite resources in a manner that may threaten people and the environment at the local, regional and global levels. During the project life-cycle, proponent will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and technique that are best suited to avoid, or where avoidance is not possible, minimise adverse impacts on human health and the environment.	Chapter 5 Receiving Environment – Environmental and Social Baseline in the ESHIA report discussed the baseline condition of the project site while in Chapter 7 Project Impact and Management detailed out the mitigation measures proposed by the proponent for this project.
PS 4: Community, Health and Safety	PS 4 addresses proponent's responsibility in promoting the health, safety and security of the public as well as to avoid or minimise the risks and impacts to community health, safety and security that may arise from project related activities.	The community safety and health issues have been discussed in detail in *Appendix A* (Health Impact Assessment) of the ESHIA report.
PS 5: Land Acquisition and Involuntary Resettlement	PS 5 is related to the land acquisition and resettlements. Proponent is responsible to avoid any involuntary resettlement by establishing a proper ESMP that will include compensation details and grievance mechanism.	The project did require any acquisition of land as the land is owned by the state of Johor (KEJORA land – KEJORA is a regional development agency setup under the Ministry of Rural and Regional Development which covers the area of Southeast Johor. It was established on 1 June 1972) and hence does not trigger the requirement of PS 5: Land Acquisition and Involuntary Resettlement.

Performance Standards (PS)	Brief Description and Application	PEC Compliance Measures
PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	The requirements of this PS are applied to projects (i) located in modified, natural and critical habitats; (ii) that potentially impact on or are dependence on ecosystem service over which the client has direct management control or significant influence; or (iii) that include the production of living natural resources (e.g., agriculture, animal husbandry, fisheries, forestry).	The project site will be handed over to proponent after the site is clear and levelled. Therefore, there will be no flora and fauna left in the project site. Nevertheless, the ESHIA has included Sg. Santi Forest Reserve in Chapter 5 as it is located approximately 2.5 km from the project site.
PS 7: Indigenous People	This PS applies to communities or groups of Indigenous Peoples who maintain a collective attachment i.e., whose identify as group or community is linked, to distinct habitats or ancestral territories and the natural resources therein. It may also apply to communities or groups that have lost collective attachment to distinct habitats or ancestral territories in the project area, occurring within the concerned group members' lifetime, because of forced severance, conflict, government resettlement programs, dispossession of their lands, natural disasters, or incorporation of such territories into an urban area.	PS 7 is not applicable as it is not located in an area with indigenous people.
PS 8: Cultural Heritage	PS 8 aims to ensure that proponent protect cultural heritage in the course of their project activities. The requirements are based in part on standards set by the Convention on Biological Diversity.	PS 8 is not applicable as it is not located in an area with cultural heritage.

2.1.12.2 International Finance Corporation's Environmental, Health and Safety General Guidelines

This EHS general guideline is a technical document providing approach to managing issues associated with environment such as air, water, noise and land pollution as well as issues related to the health and safety of the workers. This guideline also provides the performance levels and measures in line with the good international industry practice. The General EHS Guidelines are organized as follows:

1. Environmental
   - 1.1. Air Emission and Ambient Air Quality
   - 1.2. Energy Conservation
   - 1.3. Wastewater and Ambient Water Quality
   - 1.4. Water Conservation
   - 1.5. Hazardous Material Management
   - 1.6. Waste Management
   - 1.7. Noise
   - 1.8. Contaminated Land
2. Occupational Health and Safety
   - 2.1. General Facility Design and Operation
   - 2.2. Communication and Training
   - 2.3. Physical Hazards
   - 2.4. Chemical Hazards
   - 2.5. Biological Hazards
   - 2.6. Radiological Hazards
   - 2.7. Personal Protective Equipment (PPE)
   - 2.8. Special hazard Environments
   - 2.9. Monitoring
3. Community Health and Safety
   - 3.1. Water Quality and Availability
   - 3.2. Structural Safety of Project Infrastructure
   - 3.3. Life and Fire Safety (L&FS)
   - 3.4. Traffic Safety
   - 3.5. Transport of Hazardous Materials
   - 3.6. Disease Prevention
   - 3.7. Emergency Preparedness and Resource
4. Construction and Decommissioning
   - 4.1. Environment
   - 4.2. Occupational Health & Safety
   - 4.3. Community Health & Safety

2.1.12.3 International Finance Corporation's Environmental, Health and Safety for Large Volume Petroleum-based Organic Chemicals Manufacturing

The EHS Guidelines include information relevant to Large Volume petroleum-based Organic Chemicals (LVOC) projects and facilities. This document provides a summary of the most significant EHS issues associated with LVOC manufacturing facilities, which occur during the operational phase, along with recommendations for their management. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines document. The guidelines cover the production of following products:

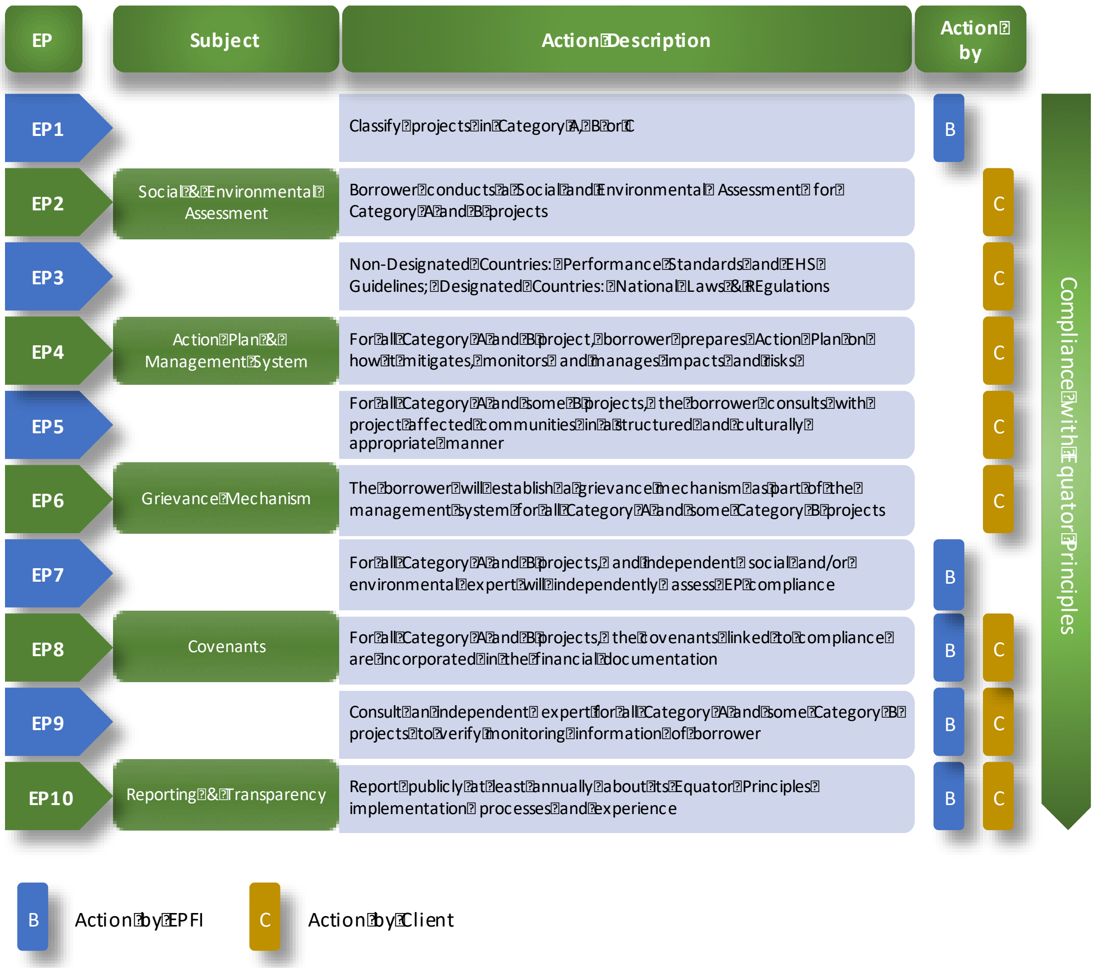
- **Lower Olefins** from virgin naphtha, natural gas and gas oil with special reference to ethylene and propylene and general information about main co-products (C4, C5 streams, pyrolytic gasoline (py-gas)), as valuable feedstock for organic chemical manufacturing;
- **Aromatics** with special reference to the following compound: benzene, toluene and xylenes by extraction or extractive distillation from pyrolytic gasoline (py-gas); ethylbenzene and styrene by dehydrogenation, or oxidation with propylene oxide co-production; and cumene and its oxidation to phenol and acetone;
- **Oxygenated Compounds** with special reference to the following compounds: formaldehyde by methanol oxidation; MTBE (methyl t-butyl ether) from methanol and isobutene; ethylene oxide by ethylene oxidation; and terephthalic acid by oxidation of p-xylene; acrylic esters by propylene oxidation to acrolein and acrylic acid plus acrylic acid esterification;
- **Nitrogenated Compounds** with special reference to the following compounds: acrylonitirite by propylene ammoxidation, with co-production of hydrogen cyanide, caprolactam form cyclohexanone; nitrobenzene by benzene direct nitration; and toluene diisocyanate (TDI) from toluene; and
- **Halogenated Compounds** with special reference to the following compounds: ethylene dichloride (EDC) by ethylene chlorination and production of vinyl chloride (VCM) by dehydrochlorination of EDC as well by ethylene oxychlorination.

2.1.12.4 Equator Principles

The Equator Principles (EP) comprise a group of ten principles voluntarily adopted by the Equator Principle Financial Institutions (EPFIs) in order to ensure that the projects funded by them are developed in a manner that is socially responsible and reflect sound environmental management practices. The EPs are as follows:

- *Principle 1*: Review and Categorisation
- *Principle 2*: Social and Environmental Assessment
- *Principle 3*: Applicable Social and Environmental Standards
- *Principle 4*: Action Plan and Management System
- *Principle 5*: Consultation and Disclosure
- Principle 6: Grievance Mechanism
- *Principle 7*: Independent review
- *Principle 8*: Covenants
- *Principle 9*: Independent Monitoring & Reporting
- *Principle 10*: Reporting & Transparency

The *Figure 2.1* below shows the 10 EPs, the action required to implement them and its related responsible party.



**"Client" refers to the EPFI's clients i.e. the borrowers.*

Figure 2.1 – 10 Equator Principles

Simply put, EP1 and 7 are the responsibility of the EPFI, while EP2-6 are obligations to be fulfilled by the project proponent. EP8-10 can either be the responsibility of the EPFI or the project proponent or both.

By adhering to the Equator Principles, EPFIs are committed to ensure that its borrowers in Project Finance and related transactions perform an Environmental and Social (E&S) Assessment. In this E&S Assessment, the borrowers have to demonstrate that they meet national laws and regulations and/or the requirements of two international standards set by the International Finance Corporation (IFC):

1) The IFC Performance Standards (PS) on Social and Environmental Sustainability ('Performance Standards').
2) The IFC Industry Specific Environmental, Health and Safety Guidelines ('EHS Guidelines').

As such, the IFC Performance Standards serve as the key to Equator Principles compliance as illustrated in *Figure 2.2* below.

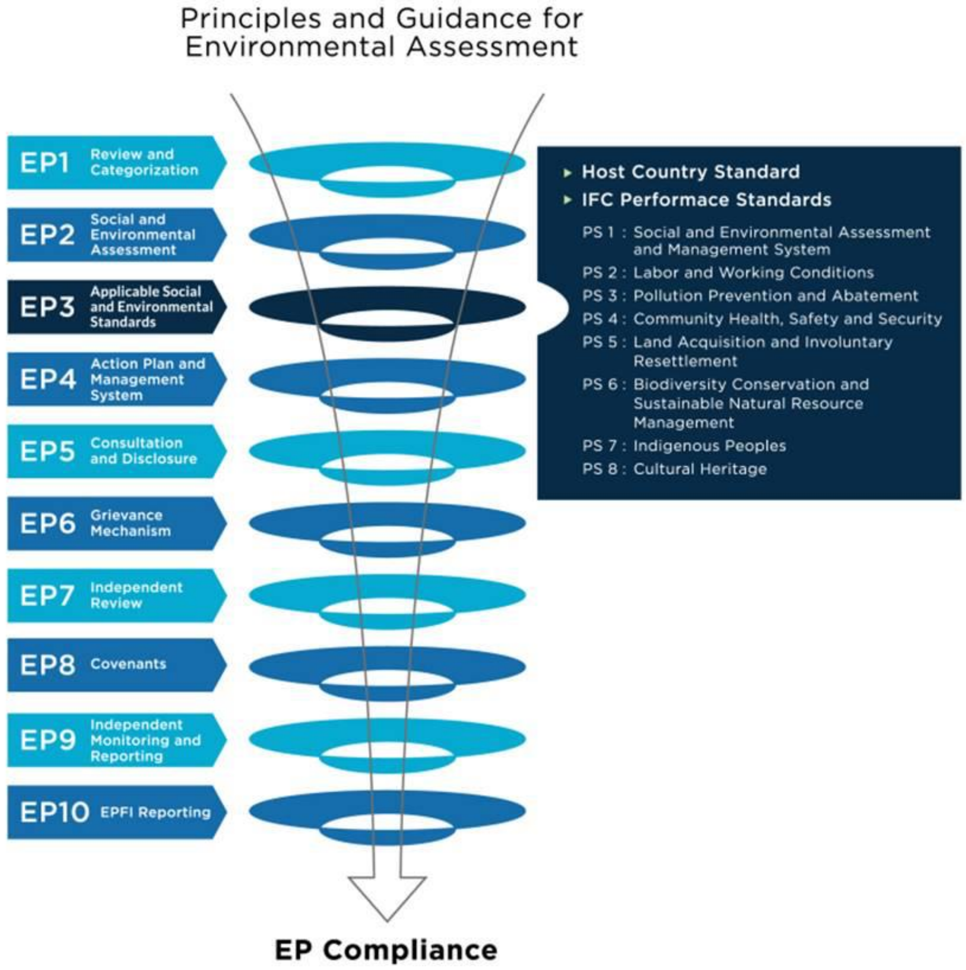


Figure 2.2 – Equator Principles Compliance

The applicability of each of the principles with respect to proposed PEC project is discussed below:

Equator Principle	Brief Description and Application	PEC Compliance Measures
Principle 1: Review and Categorisation	As the project is seeking financing from EPFIs, the project has to be categorized based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of IFC. The categories are: *Category A* – Projects with potential significant adverse environmental and social risks and/or impacts that are diverse, irreversible or unprecedented; *Category B* – Projects with potential limited adverse environmental and social risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and *Category C* – Projects with minimal or no adverse environmental and social risks and/or impacts.	Categorisation conducted by the EPFI. PEC is categorised as "*Category B*" as the project's impacts are generally site specific and while a few of them may be irreversible, the mitigation measure can be readily designed. Furthermore, the project: • Do not affect vulnerable groups; • Do not affect ethnic minorities; • Do not involve involuntary displacement/resettlement; and • Do not affect significant cultural heritage sites.
Principle 2: Social and Environmental Assessment	An Environmental Social and Health Impact Assessment (ESHIA) has to be carried out for the project to addresses relevant social and environmental impacts and risks of the proposed project and also propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.	PEC, through ESC has conducted and produced an ESHIA adhering to the IFC's PSs. The ESHIA addresses IFC' PS 1-4 and PS 6, i.e.: • PS 1: Assessment and Management of Environmental and Social Risks and Impacts • PS 2: Labor and Working Conditions • PS 3: Resource Efficiency and Pollution Prevention • PS 4: Community Health, Safety, and Security • PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources The project has not acquired any settlement land and hence does not trigger the requirement of PS 5: Land Acquisition and Involuntary Resettlement. The project is not located in an

Equator Principle	Brief Description and Application	PEC Compliance Measures
		area with cultural heritage and indigenous people and as such PS 7: Indigenous Peoples and PS 8: Cultural Heritage will also not be relevant.
Principle 3: Applicable Social and Environmental Standards	This Principle requires the Environment and Social Assessment to refer to the applicable IFC Performance Standards and the Industry Specific EHS Guidelines including the project's overall compliance with, or justified deviation from, the respective Performance Standards and EHS Guidelines.	The ESHIA is prepared to comply with the national standards, rules and regulations as well as the requirements of IFC performance standards and EHS guidelines.
Principle 4: Action Plan and Management System	The action plan will describe and prioritise the actions needed to implement mitigation measures, corrective actions and monitoring measures necessary to manage the impacts and risks identified in the Assessment.	The action plan is included in Chapter 8 Environmental and Social Management Plan of the ESHIA.
Principle 5: Consultation and Disclosure	The project affected communities are required to be consulted in a structured and culturally appropriate manner.	Socio-economic study in the form of a limited Social Impact Assessment (SIA) was conducted for the ESHIA. The results of the study are included in Chapter 5 Receiving Environment – Environment & Social Baseline, Chapter 7 Project Impact and Management and Chapter 10 Information Disclosure, Consultation and Participation.
Principle 6: Grievance Mechanism	Proponent is required to establish a grievance mechanism as part of the management system.	Grievance mechanism has been discussed in *Appendix B* – Social Impact Assessment.
Principle 7: Independent review	An independent social or environmental expert, not directly associated with the project proponent or ESC, is required to review the Assessment, action plans and consultation process documentation in order to assist EPFI's due diligence, and assess Equator Principles compliance.	The EPFI will appoint an independent reviewer to evaluate and comment on the project proponent's ESHIA.
Principle 8: Covenants	The covenants would be a part of the contract documents between project proponent and financing agency as well as	E&S Covenants shall be embedded within the contracts drawn between project proponents and the contractors hired

Equator Principle	Brief Description and Application	PEC Compliance Measures
	contractors and technology suppliers.	for construction activities, technology providers and waste handlers. Periodic reporting to the EPFI may also be required depending on the EPFI's requirements.
Principle 9: Independent Monitoring & Reporting	EPFIs will, for all Category A Projects, and as appropriate, for Category B projects, require appointment of an independent environmental and/or social expert, or require that the borrower retain qualified and experienced external experts to verify its monitoring information which would be shared with EPFIs.	EPFI may appoint its own independent expert or require PEC to retain their E&S experts to assess the continuing environment and social impacts of the project to ensure ongoing monitoring and reporting after Financial Close and over the life of the loan. This requirement is dependent on the EPFI's requirements.
Principle 10: Reporting and Transparency	Reports of the EP implementation must be made publicly available.	PEC will make sure that a summary of the ESHIA is made available online for public review. Under the Malaysian EIA regulations, the EIA is subject to 1 month of public review prior to the EIA being approved. The public review was duly conducted from 27th May 2019 to 25th June 2019.

2.1.12.5 OECD Guidelines for Multinational Enterprises

The Guidelines are recommendations addressed by governments to multinational enterprise which aim to

- Ensure that the operations of these enterprises are in harmony with government policies;
- Strengthen the basis of mutual confidence between enterprises and the societies in which they operate;
- Help improve the foreign investment climate; and
- Enhance the contribution to sustainable development made by multinational enterprises.

There are 10 policies in OECD Guidelines which are:

1. General Policies

   The general policies contain specific recommendations to enterprises for example enterprises are encouraged to co-operate with governments in the development and implementation of policies and laws. It is also recommended for the enterprises to avoid making efforts to secure exemptions not contemplated in the statutory or regulatory framework related to human rights, environmental, health, safety, labour, taxation and financial incentives.

2. Disclosure

   Enterprises should ensure that timely and accurate information is disclosed on all material matters regarding their activities, structure, financial situation, performance, ownership and governance. The information should be disclosed for the enterprise as a whole, and, where appropriate along business lines or geographic areas. Disclosure policies of enterprises should be tailored to the nature, size and location of the enterprise, with due regard taken of costs, business confidentiality and other competitive concerns.

3. Human Rights

   Enterprises should, within the framework of internationally recognised human rights, the international human rights obligations of the countries in which they operate as well as relevant domestic laws and regulations.

4. Employment and Industrial Relations

   Multinational enterprises, while operating within the jurisdiction of particular countries, may be subject to national and international levels of regulation of employment and industrial relations matter.

5. Environment

   Enterprises should, within the framework of laws, regulations and administrative practices in the countries in which they operate, and in consideration of relevant international agreements, principles, objectives, and standards, take due account of the need to protect the environment, public health and safety, and generally to conduct their activities in a manner contributing to the wider goal of sustainable development.

6. Combating Bribery, Bribe Solicitation and Extortion

   Enterprises should not, directly or indirectly, offer, promise, give, or demand a bribe or other undue advantage to obtain or retain business or other improper advantage. Enterprises should resist the solicitation of bribes and extortion.

7. Consumer Interests

   When dealing with consumers, enterprises should act in accordance with fair business, marketing and advertising practices and should take all reasonable steps to ensure the quality and reliability of the goods and services that they provide.

8. Science and Technology

   In terms of science and technology, enterprises should endeavour to ensure that their activities are compatible with the science and technology policies and plans of the countries in which they operate and as appropriate contribute to the development of local and national innovative capacity.

9. Competition

   The goal of the competition policy is to contribute to overall welfare and economic growth by promoting market conditions in which the nature, quality and price of goods and services are determined by competitive market forces.

10. Taxation

    It is important that enterprises contribute to the public finances of host countries by making timely payment of their tax liabilities. In particular, enterprises should comply with both the letter and spirit of the tax laws and regulations of the countries in which they operate.

3 PROJECT DESCRIPTION

3.1 Project Overview

The proposed Pengerang Energy Complex is planned as a world-scale condensate splitter and aromatics complex, on a 250-acre site in the Pengerang Industrial Park (PIP) that is situated within the Pengerang Integrated Petroleum Complex (PIPC) (refer to Figure *3.1*). The production capacity of the PEC is about 5.844 Million metric tonnes per annum (MMtpa), or 16.7 kilometric tonnes per day (kMtpd), of aromatic petrochemicals and oil products, which will be processed from 6.324 MMtpa of condensate feedstock. It will use the latest generation of proven UOP technology which is considered the aromatics industry's Best Available Technology (BAT) supplier and assures process safety, environmental performance and production capacity.

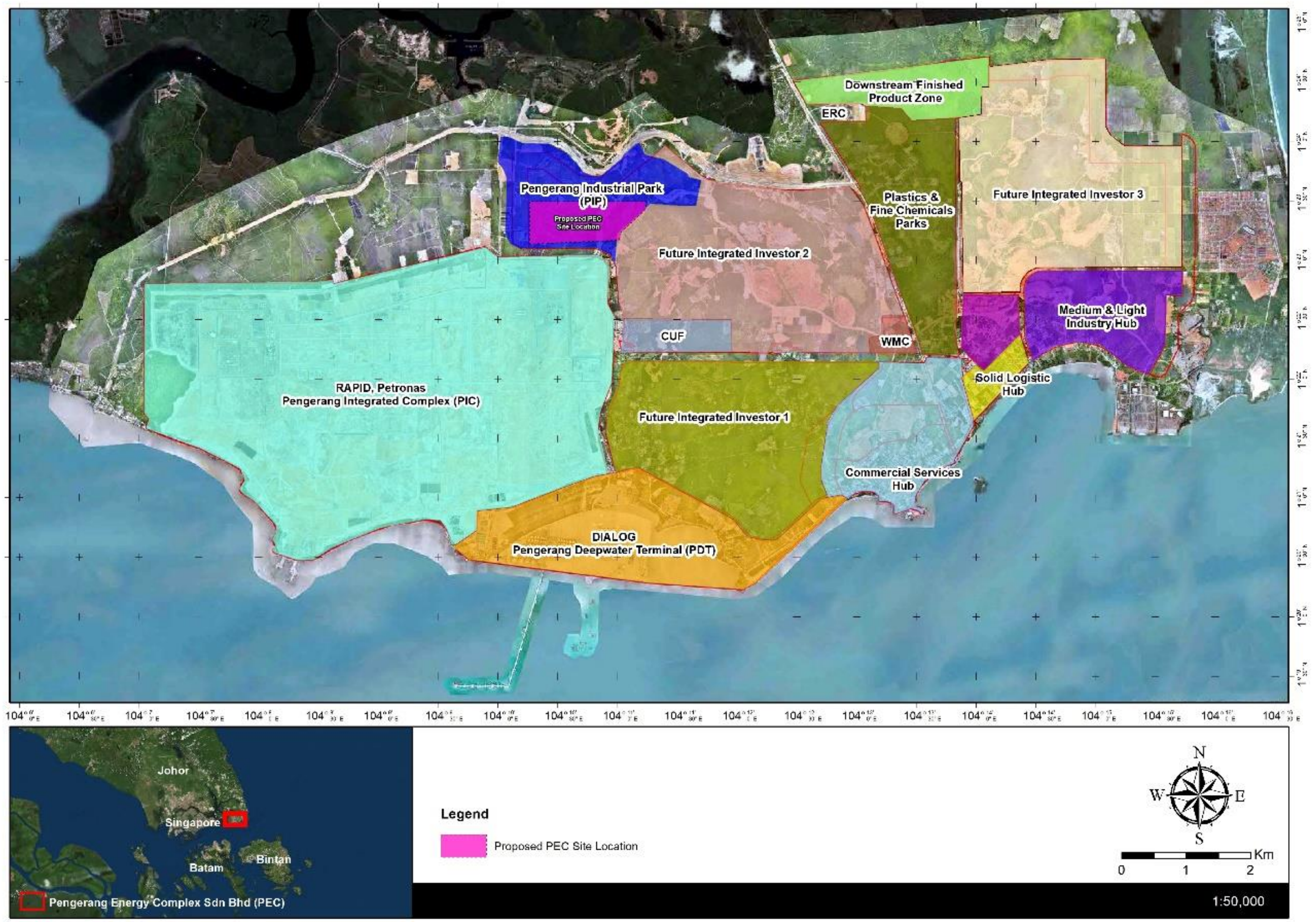


Figure 3.1 – Site Location within PIPC

The proposed PEC will comprise of two main processing sections: the condensate splitting plant, which produces Full Boiling Range (FBR) naphtha as feedstock to the aromatics plant, the second main section. Feedstocks are processed using standard oil refining 'unit operations' that utilise heating, cooling, fractionation, reforming and distillation processes. The PEC will utilise refining and aromatics technologies supplied by Honeywell UOP, the globally leading vendor that also supplied technology to the very similar, ChemOne developed, Jurong Aromatics Complex (JAC or SAR-2) in Singapore, commissioned in 2014 with 70% of proposed PEC capacity at 4,364 MMtpa of condensate.

Other facilities on site will include intermediate feed and product tank farms, several steam boilers, a wastewater treatment plant (WWTP), pipelines and the on-site utilities/ buildings, as shown schematically in *Figure 3.2.* Other third parties at the PIPC will supply the PEC with raw water, nitrogen gas, electrical power and natural gas.

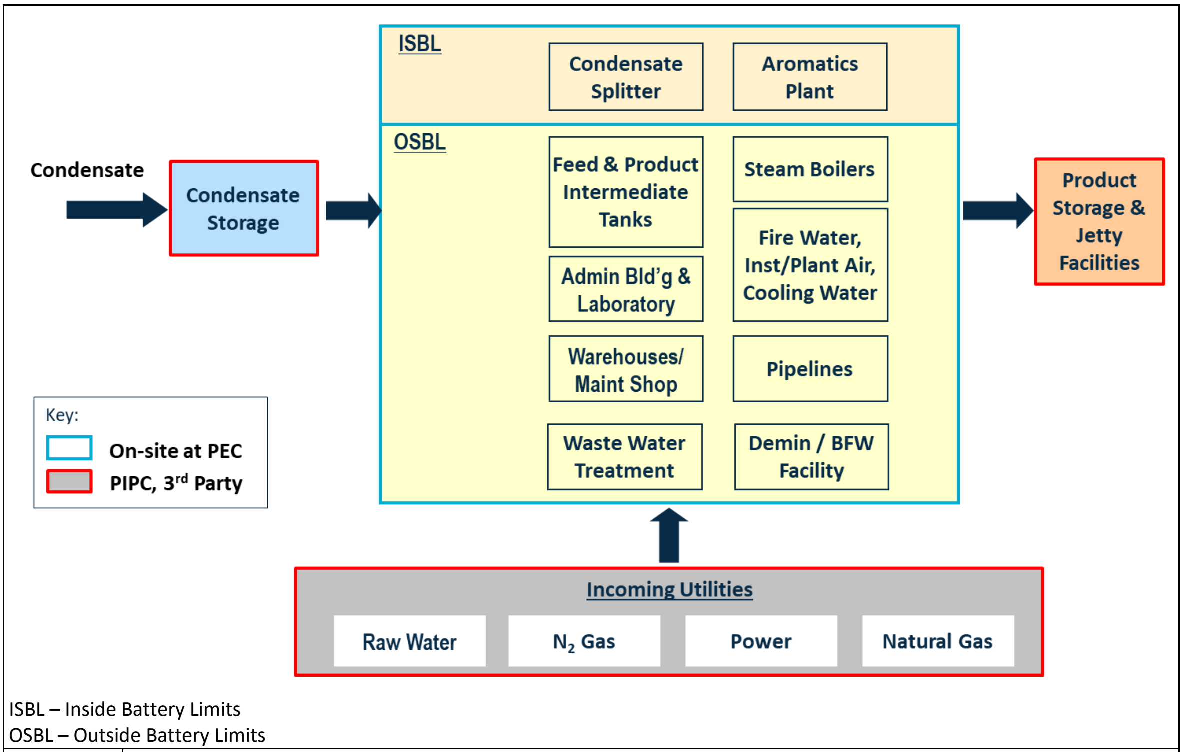


Figure 3.2 – PEC Processes and Facilities Schematic Diagram

3.2 Project Objectives

The PEC project is estimated to cost RM13.0 billion (~US$ 3.4 billion) and this scale of development will definitely spur more economic activities.

The PEC project is in-line with the Johor State Government's development policy to develop Pengerang into a major oil & gas, and petrochemical hub for Malaysia. The Pengerang Integrated Petroleum Complex (PIPC) is creating value to the downstream oil and gas value chain in Johor. Pengerang is considered a strategic location due to:

- Access to existing major international shipping lanes; Middle East –Singapore –China;
- Water depth of 24m enables Very Large Crude Carriers (VLCCs) and Ultra Large Crude Carriers (ULCCs) to berth right at the jetty;
- Safe and sheltered harbour;

- No breakwater required with sufficient seagoing passage for Very Large Crude Carriers (VLCCs) and Ultra Large Crude Carriers (ULCCs);
- Low negative socio-economic impact;
- Availability of sufficient development land;
- A single candidate plot in excess of 20,000 acres;
- Very few Environmentally Sensitive Areas (ESAs) which are easily preserved; and
- Proximity to an existing major trading hub adjacent to Singapore.

3.2.1 Malaysia Outlook

The National Key Economic Area (NKEA) is defined as an important driver of economic activities that potentially and directly contributes towards the Malaysian Economic Growth measurable by the National Gross Income (GNI) indicator. NKEA also creates job opportunities and attracts best of talents. The NKEA economic development also has a different approach whereby it will be led by the private sector and the government will support and act as facilitator.

There are twelve (12) NKEA as the core of Malaysia's Economic Transformation Program and 'oil, gas and energy' is one of them. The goals of this NKEA is the rejuvenation of existing oil fields, the development of marginal ones, the intensification of exploration activities and the building of a regional oil and gas storage as well as trading hub.

The oil, gas and energy NKEA is expected to deliver RM131.4 billion to the GNI. Consequently, it is expected to create an additional 52,300 jobs within the sector. The oil, gas and energy NKEA targets a five per cent annual growth from 2010 to 2020. The PEC is part of this initiative.

3.2.2 Product Demand and Supply

3.2.2.1 Benzene

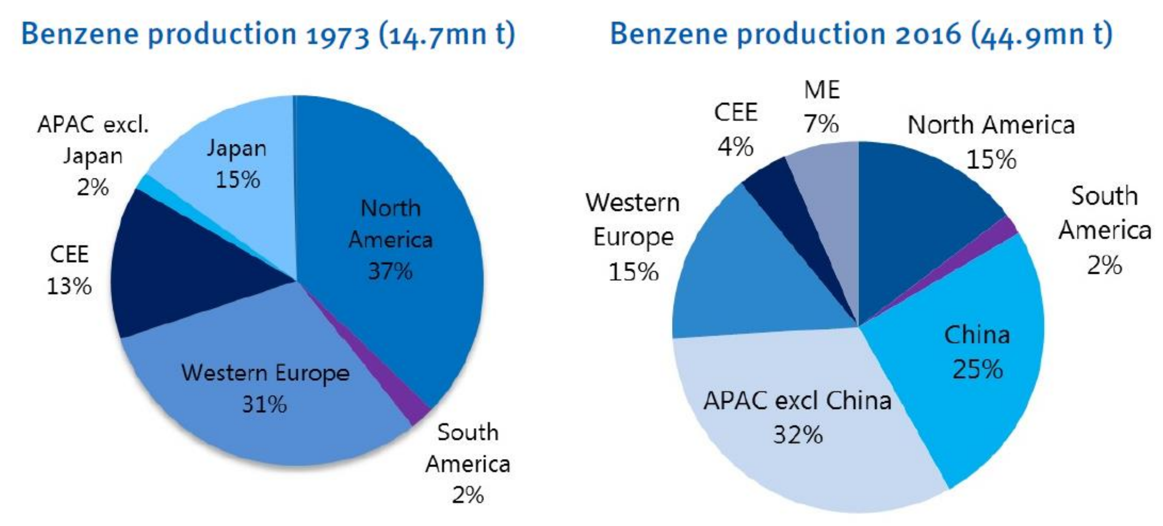
According to market analysts, the global benzene market is expected to grow at a compound annual growth rate (CAGR) of 4.42%, mainly driven by increased demand from derivatives, styrene, and cumene segments. One of the key growth contributors to the global benzene market is the increase in demand from the polyester industry, where styrene monomer is used for manufacturing textiles.

The toluene market is expected to grow at a CAGR of 3.2 % to reach USD31 billion by 2022. Its growth is mainly driven by the benzene and gasoline demand in the global market.

Major demand for aromatics is expected to come from the Asian region, since most of the derivative units (styrene, phenol, PET, and gasoline) are lined up in Asia. The automobile (4-5% growth) and construction sectors (5-6% growth) would be the key segments driving the demand. Around 1.5 Million MT capacity additions planned for styrene in Asia and the Middle East would also contribute to benzene's demand growth.

The global benzene market is expected to witness a CAGR of approximately 4.3% during the forecasted period due to the increase application of synthetic polymers, such as polyester and polystyrene in the end-user industries, such as textile, packaging, building & construction, and electrical & electronics.

Ethyl benzene is expected to be the fastest growing derivative market due to the increasing demand in styrene manufacturing industry. Styrene polymers have seen significant increase in its usage in various industries such as the synthetic rubbers and expanded polystyrene manufacturing industry. Polystyrene is utilised widely in packaging and construction. The growth of these end-user industries, especially in emerging markets, like China, India, and Russia is propelling the growth of the market size for styrene which subsequently, further improves the market for benzene as it is the key raw material for the production of styrene.



Source: Argus Media, 2017

Figure 3.3 – Benzene Production

In 2017, Asia Pacific was considered as the largest market for Benzene with a share of almost 50% in the global market. This region is also expected to be the fastest growing market during the forecasted period, with increasing markets for end-users like electronics and home appliances, packaging and construction in China, India, and ASEAN countries.

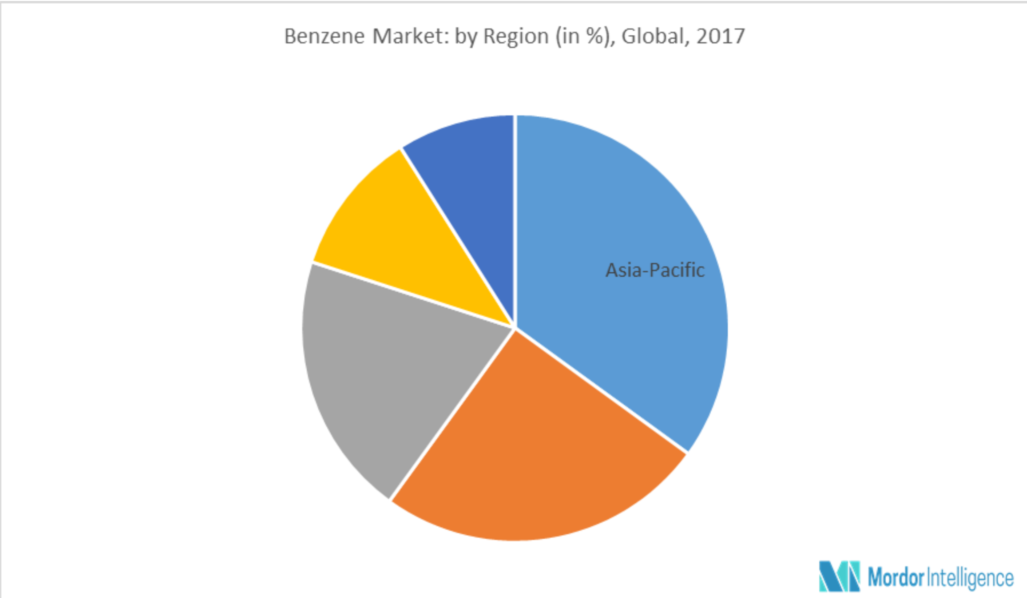


Figure 3.4 – Global Benzene Market 2017

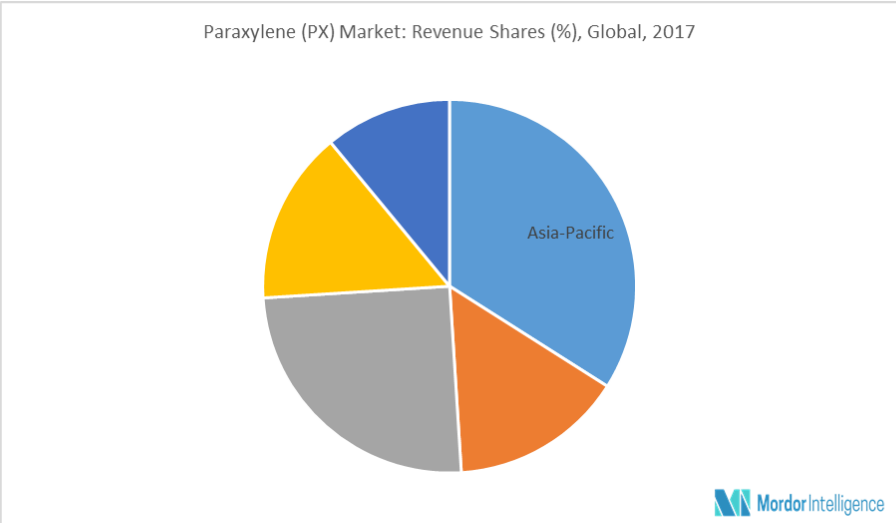
3.2.2.2 Paraxylene

The global Paraxylene (PX) market size was valued at USD 36.1 billion in 2016 and is expected to further increase by 10.5% by 2022 due to the increasing demand from polyester manufacturers. The PX market is projected to grow at a CAGR of 7.2%, due to the increasing demand from the Polyethylene Terephthalate (PET) segment and Asia is expected to remain as a demand-driving region for PX (Beroe, 2018).

Paraxylene is primarily used in the production of purified terephthalic acid (PTA) and dimethyl terephthalate (DMT). These products are essential in the Polyester manufacturing industry. Polyester products are utilised in wide range manufacturing industry such as textiles, packaging materials and construction materials.

Other than PTA and DMT, the increase of the demand of PET is another factor that further improves the market size of Paraxylene. PET is currently being utilised in various industry especially in the textiles and food and beverage industries. PET is preferred over different grades of polyester in these industries due to its low cost and greater physical properties.

In 2016, Asia Pacific was considered as the largest market for Paraxylene with a share of more than 79% in the global market. The market is projected to further increase by 2022 due to the increasing demand of Polyester fibers and rapid industrialisation from emerging economies such as India, Vietnam, Bangladesh, Indonesia and Thailand.



ESC

Figure 3.5 – Global Paraxylene Market 2017

The market size of Paraxylene in North America accounted for more than 11% in the global market in 2016. This is due to the unstable feedstock supply over the past few years and stringent regulation regarding the manufacturing of petrochemical products which has resulted in tight supply of Paraxylene.

3.2.3 Johor Economic Growth

The proposed project is expected to contribute directly to Johor's economic growth.

According to the Department of Statistics Malaysia, Johor's economic growth in 2017 was 6.2%, and was above the national average of 5.9%. Johor's Gross Domestic Product (GDP) per capita in 2017 was RM34,362 which is an increase from the previous year of RM32,005.

Johor is one of the three states that have a designated petrochemical zone. According to the Johor State Structure Plan 2020, the area in Pengerang has been designated for industrial development. This is reiterated in the Draft Johor State Structure Plan 2030 which states that Pengerang has been earmarked as an upstream oil & gas development cluster for Johor (*Figure 3.6*).

The Project will not only stimulate economic growth through development and employment opportunities, but also through construction of new housing areas and supporting infrastructure.

In addition to the oil & gas and petrochemical hub of southern Pengerang, the Johor government is also developing the Desaru Coast into a tourist attraction. Desaru Coast, approximately 30km northeast of PEC, is touted to be a premium integrated resort destination. Given these on-going and future activities, there is a rising demand for residential properties. According to news reports, Johor Petroleum Development Corp Bhd had forecast population in Pengerang would swell to 70,000 by 2020, from 30,000 in 2010, with a shortfall of at least 3,500 homes.

3.2.3.1 Support for the Oil & Gas Hub

According to the Ministry of International Trade and Industry (MITI), investments in Pengerang had hit RM15.3 billion in the first four months of 2018.

Pengerang Refining and Petrochemical (PRefChem) is a strategic alliance of two of the world's largest and most successful national oil companies - Petroliam Nasional Berhad (PETRONAS), the national oil company of Malaysia, and Saudi Aramco, the national oil company of Saudi Arabia. The total of Saudi Aramco's investment into Malaysia is US$7bil (RM28bil). PRefChem will operate a refinery, cracker and selected petrochemical facilities in the RAPID Project. The refinery complex has a capacity of 300,000 barrels of crude per day, and will produce a range of refined petroleum products, including low sulphur jet fuel, motor gasoline and diesel, meeting Euro 5 fuel specifications. It will also provide feedstock for the integrated petrochemical complex, with a nameplate capacity of 3.6 million metric tonne per annum (mtpa).

In summary, given the size of investment and the value-adding activities and technology for the petrochemical products by the proposed PEC project, this project is considered a strategic fit to the PIPC development, Johor's economy and the country's export growth as whole. As such, the economic multiplier effects are expected to be wide and very significant even at regional scale.

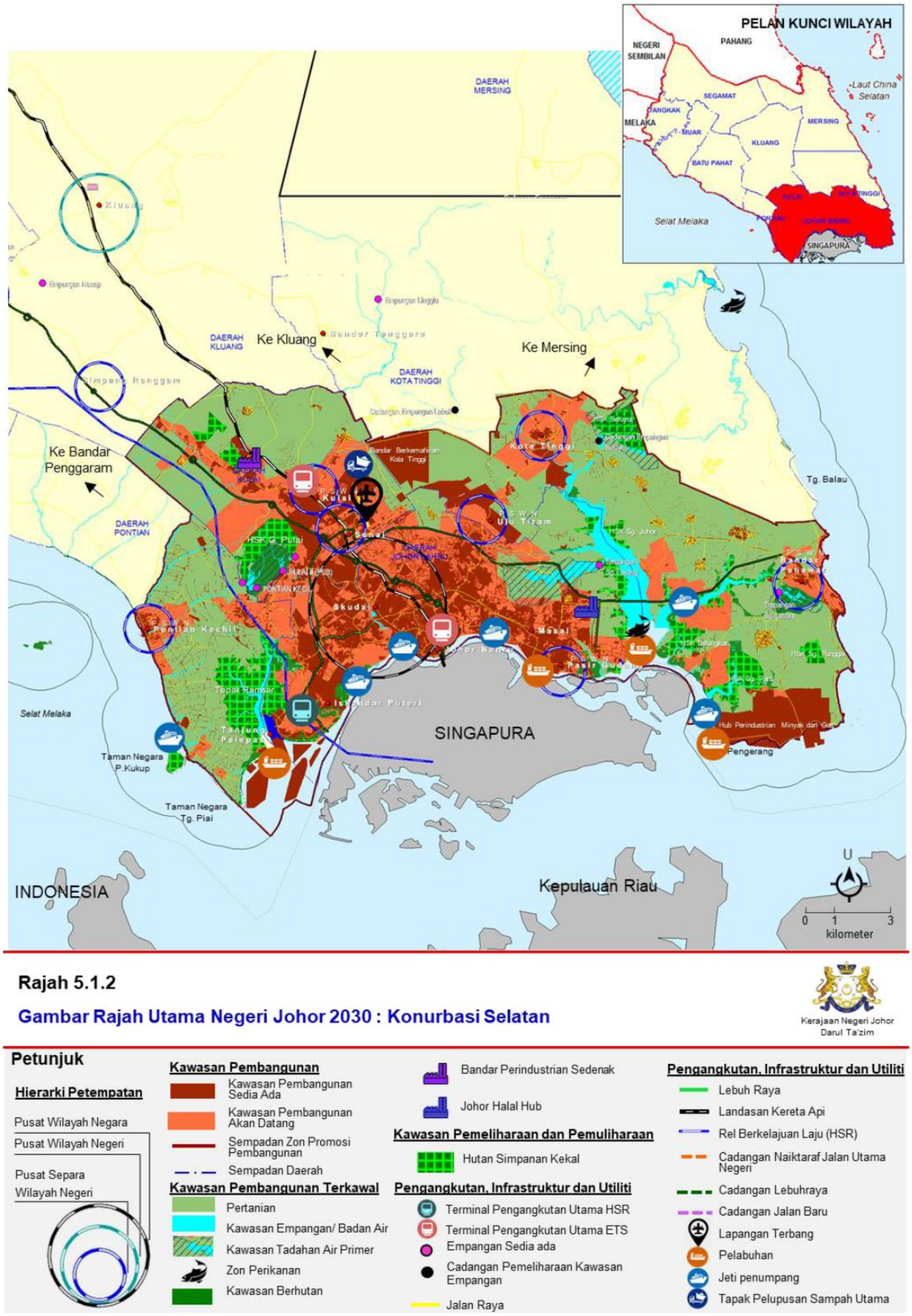


Figure 3.6 – Land Use Plan from Draft Johor State Structure Plan 2030

3.3 Project Siting

The facilities associated with the proposed Pengerang Energy Complex will be developed within the proposed Pengerang Industrial Park (PIP) in Pengerang Integrated Petroleum Complex, Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Ta'zim. PIP is part of the full PIPC development spearheaded by Johor Corporation (JCorp). The PIP is proposed to 787.6 acres of land within Mukim Pengerang, Daerah Kota Tinggi, Johor, in to heavy industrial estate. It would consist of industrial, commercial, green areas and as well as supporting facilities (JCorp EIA, 2018).

The PEC site is situated 7.5 km northeast of Pengerang and 6km northwest of Sungai Rengit. Singapore’s Pulau Tekong and Changi Airport lie 9 km and 17 km east of the site. Highways connect the PIPC to Johor Bahru, the state capital, and its airport, Senai. The direct distance between PEC and Johor Bahru, and PEC and Senai Airport is approximately 50 and 67 km, respectively, and it is also accessible by scheduled ferry from Singapore to Pengerang and to larger vessels via the PIPC’s Pengerang Deepwater Terminal (PDT). To the south is Petronas’s RAPID development.

3.4 Site Layout & Elements

The proposed PEC will comprise the following key elements:

- Condensate Splitter;
- Aromatics Plant;
- An elevated flare;
- Bulk storage area;
- Wastewater treatment plant; and
- Office and administrative buildings.

The main process areas of the PEC facility are the Condensate Splitter in the northeast corner of the layout, areas C1 and C2, and the Aromatics Plant in AREA R1 to AREA A3. The manufacturing process is supported by tankage for raw materials, intermediate and final products in day tanks, as well as a flare stack for safety purposes, a waste water treatment plant to treat liquid waste prior to discharge, as well as warehouse and office facilities.

Figure 3.7 below shows the conceptual layout plan of the PEC. The scope of this report is indicated in *Figure 3.7* and comprise the major process areas detailed within the plan, which include:

- Condensate Splitter Section
    - Sour Water Stripping / Sulphur Recovery / Amine Regeneration / Spent Caustic Treatment DHT (C2 AREA); and
    - Prefractionation, KHT (C1 AREA).
- Aromatics Plant
    - Naphtha Hydrotreating unit; / CCR Platforming and Regeneration unit / Olefin Reduction Process unit (R1 AREA);
    - Sulfolane unit / BT/ Tatoray unit (A1 AREA);
    - Xylene / Parex (A2 AREA); and
    - Isomar unit (A3 AREA).
- Support facilities
    - 15 emissions stacks serving 9 furnace stacks, 1 SRU thermal oxidiser 2 vent stacks, 3 boiler stacks

- 1 Elevated Flare stack for emergency use
- Onsite tankage for bulk storage for chemicals
- Waste water treatment plant
- Offices and other Site support facilities

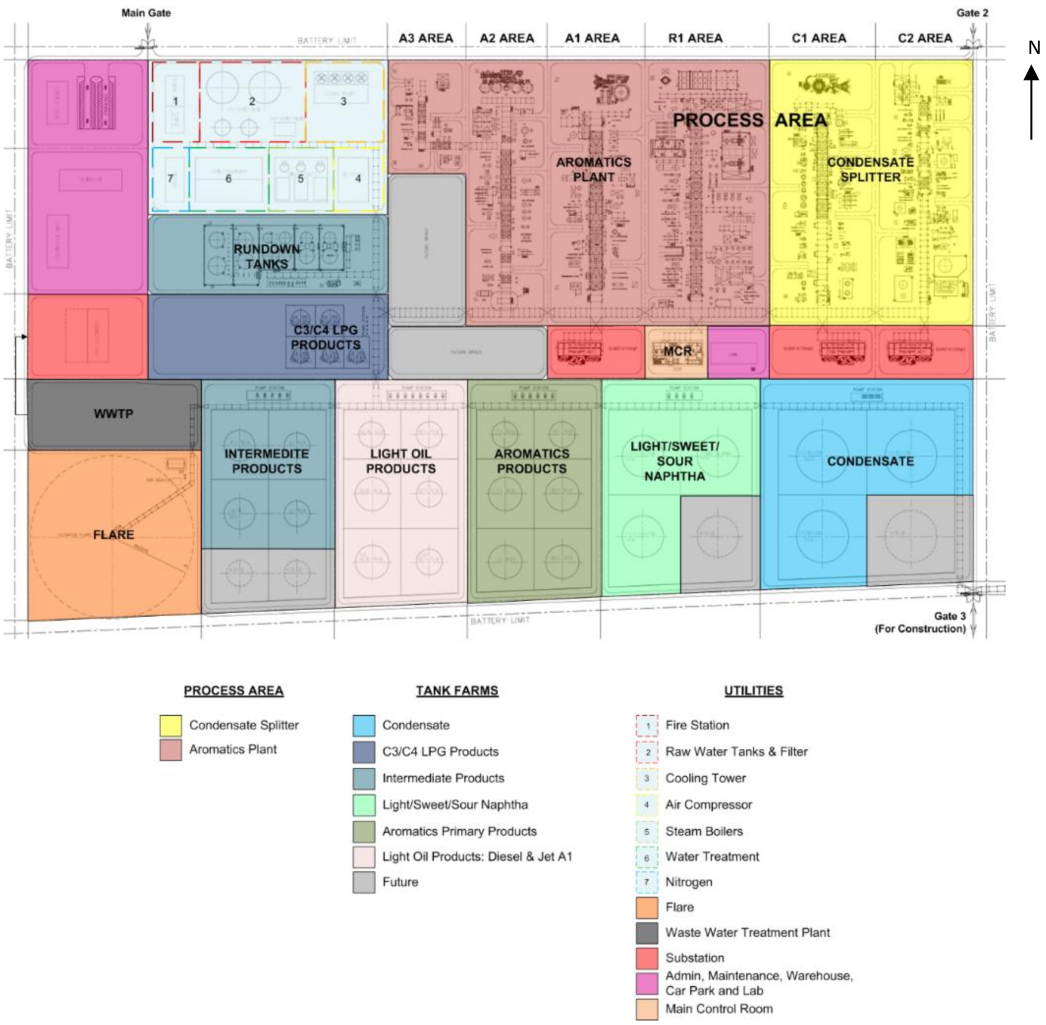


Figure 3.7 – PEC Conceptual Layout Plan

As indicated in the conceptual layout plan above, the flare system will be located on the southwest corner of the plot while the warehouse and associated buildings are located on the northwest portion of the plot.

The proposed main access to the PEC facility is from Jalan Kota Tinggi - Pengerang and the Main Gate Entrance is located at the northwest corner of the site. Other gates namely Gate 2 will be located in the northeast of the site and Gate 3 (for construction) will be located in the southeast part of the site.

3.4.1 Structures

The process plant, inclusive of onsite facilities, is to be located in the western part of the site and will occupy an area of ~67.7 ha or ~167 acres (~67% of the total site area, 250 acres), measuring roughly 1,095m in width and 618m in length. *Figure 3.8* shows the plant development footprint within the PEC site overlain on the site's satellite image.

Figure 3.8 – PEC Development Footprint of ~167 acres within the PEC site

Source: ChemOne with Google Earth Image, 2016

Tank Farms

The onsite bulk storage will be located to the south of the plot. Bulk storage tanks will be located within one of seven tank farms according to the following broad classifications:

- Condensate Tank Farm; located in the south-eastern corner of the site;
- Intermediate Tank Farm; intermediate tanks for raw diesel, raw kerosene, primary product day tanks, desorbent and plant inventory are located in the west part of the site immediately south of the water treatment and steam boilers area;
- Sphere Tank Farm; C3 LPG and C4 LPG, product, are located in a tank farm located immediately east of the main substation in the west corner of the site; and
- Product Storage Tank Farms; blended light sweet and sour naphtha tanks, aromatic product tanks (O-xylene, benzene, P-xylene), and oil product tanks (fuel oil, jet kerosene, diesel, heavy aromatics) are located in the southeast portion of the plot east to west respectively.

Process Areas

The main process areas are situated along the site's northern boundary, from east to west:

- Condensate Splitter Section:
  - Condensate fractionation unit comprising of the feed fractionator stabiliser (C1 AREA);
  - LPG Merox unit, kerosene hydrotreating unit (KHT) C1 AREA); and
  - DHT, Sour water stripper, sulphur recovery, amine regeneration, and spent caustic treatment units (C2 AREA).
- Aromatics Plant:
  - Naphtha hydrotreating unit (NHT), naphtha splitter, CCR platforming and regeneration unit, reformate splitter (R1 AREA);
  - Sulfolane unit, benzene/ toluene column, Tatoray unit (A1 AREA);
  - Xylene / Parex unit (A2 AREA); and
  - Isomar unit (A3 AREA).

Pipelines

Incoming pipelines to the site include condensate from the third-party bulk storage terminal, raw water and natural gas (from external suppliers). Outgoing pipelines from PEC may supply other users in the PIPC with light naphtha, C4 LPG and hydrogen. The remaining product export is via the same pipelines as condensate.

Condensate will be pumped from the 3rd party bulk storage terminal via the ~5.3 km dual pipelines held in the pipe racks supplied by PIPC, to the PEC site in the PIP.

Note that the environmental impacts evaluation and the corresponding mitigation measures of the pipelines are not addressed in this report.

3.4.2 Other Facilities

The laboratory, main control building, an admin building with a canteen and car park, as well as the site's fire station will be centrally located in the northwest part of the site. South of the admin building and car park are the maintenance shop and warehouse (which will be used for chemical and catalyst storage), with the wastewater treatment plant (WWTP) in the southeast corner of the carpark.

The northwest corner will house on-site utilities including raw water and firewater tanks, raw water treatment and demineralised water system, together with the sites boilers for steam supply, cooling water system, the main site electrical switchboard.

The buildings to be provided for the PEC facility are as described in *Table 3.1* below.

Table 3.1: PEC Facility - List of Buildings

Building	Dimensions (m)	No.	Area (m^2)	Structure	Wall	Remarks
Admin Building	24 x 48 2 Floors	1	2,304	Reinforced Concrete	Brick	-
Main Control Building	24 x 54 2 Floors	1	2,592	Reinforced Concrete	Reinforced Concrete	Blast Resistant
Substation (Process & Outside Battery Limits)	24 x 48 1 Floor	4	1,152 each	Reinforced Concrete	Reinforced Concrete	Blast Resistant for Process Substation
Main Substation (Power Receiving)	24 x 60 1 Floor	1	1,440	Reinforced Concrete	Brick	-
Laboratory	24 x 52 1 Floor	1	1,248	Reinforced Concrete	Reinforced Concrete	-
Utility Building	30 x 70 1 Floor	1	2,100	Steel Structure	Sandwich Panel	-
Maintenance Shop	30 x 60 1 Floor	1	1,800	Steel Structure	Sandwich Panel	-
Warehouse (Cat/Chem & Spare Parts)	24 x 70 1 Floor	1	1,800	Steel Structure	Sandwich Panel	-
Fire Station	15 x 24 1 Floor	1	360	Reinforced Concrete	Brick	

3.5 Raw Materials Supply and Characteristics

The PEC capacity for aromatics production is projected to be 2.161 million metric tonnes per annum (MMtpa) and 3.683 MMtpa for oil products from a feedstock input of 6.324 MMtpa of condensate. The primary feedstock to the PEC facility will be imported via the jetty and stored at the DIALOG Pengerang Deepwater Terminal (PDT).

Figure 3.9 provides a schematic overview of the PEC feedstock and product sales.

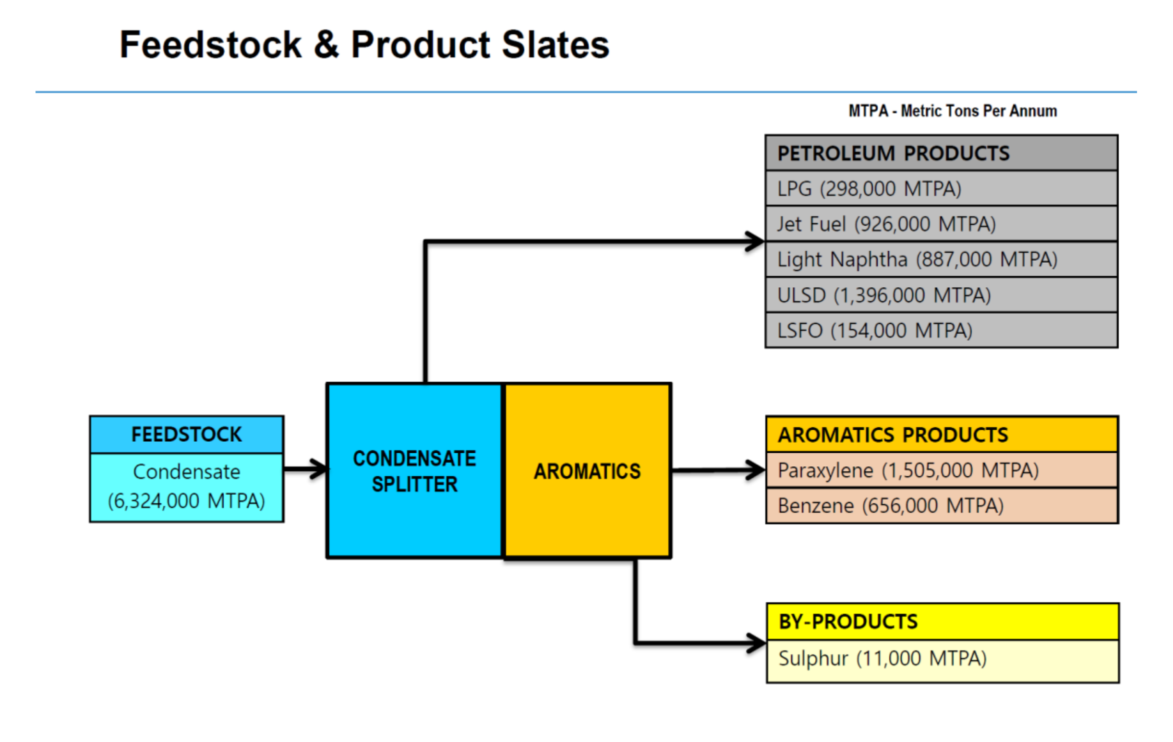


Figure 3.9 – PEC Feedstock and Product Slates
Source: PEC

The PEC's feedstock condensate will only be stored in limited quantity on site in 'weekly tanks' bulk storage with the main feedstock bulk storage managed by a third-party operator at a terminal in PDT CTF. Feedstock, in the form of condensate will be imported via marine vessels and unloaded by the 3rd party operator at a PEC dedicated jetty. It will be pumped from the 3rd party bulk storage terminal via ~5.3 km dual pipelines held in PIPC supplied pipe racks to the PEC site in the PIP.

PEC will have three aboveground bulk condensate tanks on site; with working capacity of 43,000 metric tonnes each, to receive and store the condensate from the jetty/ 3rd party terminal for daily consumption.

The specification for the typical feedstocks is shown in the Tables below.

Table 3.2: Indicative Material Requirements

Property	Specification (Typical)	Test Method
API Gravity	55.30	ASTM D 4052
SG at 15/15 °C	0.7574	ASTM D 1288
Exist, H_2S, mg/kg	<1	SMS 2268
Sulphur as Mercaptans, ppm		UOP 163
Total Sulphur, wt-%	0.245	ASTM D 2622
Total Nitrogen, ppm	14	ASTM D 5762
Basic Nitrogen, ppm		BHP Method 37
RVP, kPa (psi)	52.5 (7.6)	ASTM D 323
Acid Values (black oil), mg KOH/g	<0.01	SMS 2384
Viscosity @ 40°C, cSt	0.827	ASTM D 445
Aromatics (FIA) vol-%		
Saybolt Colour		ASTM D 156

Property	Specification (Typical)	Test Method
Copper Corrosion 3h@50°C		ASTM D 130
Pour Point, °C	-39	ASTM D 5853
Salt as NaCl, mg/kg	<1	IP 77
Sediment by extrac, wt-%	<0.01	ASTM D 473
Conrad. C Residue 10% btm		ASTM D 189
Ash 10% Btms		ASTM D 482
Asphaltenes 10% Btms		IP 143
Water Content, vol-%	<0.005	ASTM D 4006
Gross Heating Value, MJ/kg		
Nett Healing Value		
UOP K Factor		BHP Method 21
Carbon Content, wt-%		
Hydrogen Content, wt-%		
Copper, ppm	<1	IP 501
Iron, ppm	<1	IP 501
Potassium, ppm		ICPES
Mercury, ppm	<0.001	AAS Hydride
Arsenic, ppm	<0.01	AAS Hydride
Lead, ppm	<1	IP 501
Silica, ppm	<1	IP 501

Table 3.3: Specification of Condensate – Ras Gas (Typical)

Property	Specification									Test Method
	Cut Range									
DISTILLATION	Gas	C5 - 65°C	65-100°C	100-150°C	150-200°C	200-250°C	250-300°C	300-350°C	350 + °C	
Mass Yield, %	3.51	8.12	15.5	20.81	18.12	12.71	11.19	5.74	3.97	D 2892
Volume Yield, %	4.71	9.64	16.37	20.88	17.55	11.95	10.27	5.18	3.45	
SG at 15/15 °C		0.638	0.717	0.755	0.782	0.805	0.825	0.839		
Mercaptan sulphur, mg/kg			219	354	831	724	552			UOP 163
Sulphur, wt-%					0.438	0.278	0.27	0.32	0.68	D 2622
Sulphur, mg/kg		383	780	2143						D 3120
PNA, wt-% Paraffin		94.4	60.6	52.4	52.9					D 5443
Naphthene		3.7	27.6	29.6	27.3					
Aromatics		1.9	11.9	18.0	19.6					
Aromatics (FIA), vol-%					17.4	14.4	14.1			D 1319
Total Nitrogen, ppm						2	4	23	467	D 5762
Total Acid No, mg KOH/g					0.02		0.07			D 974
Viscosity @ 40°C, cSt						1.725	2.879	5.625	9.82	ASTM D 341

Property	Specification									Test Method
Smokepoint, mm					26.0	25.0	22.5			D 1322
Freezing Point, °C					<-60	-42	-18			D 2386
Cloud Point, °C						-39	-22	4		D 2500
Pour Point, °C							-24	3	>12	ASTM D 97
	Gas	C5 - 65°C	65-100°C	100-150°C	150-200°C	200-250°C	250-300°C	300-350°C	350 + °C	
Nickel, ppm									<1	
Vanadium, ppm									<1	
Sodium, pppm										IP 501
Copper, ppm									<1	
Iron, ppm									8	
Molybdenum, ppb										
Phosphorus, ppb										
Mercury, ppb		<1	<1	<0.5	<0.5		<0.5			AAS Hydride
Arsenic, ppb		<10	<10	<10	<10		<10			AAS Hydride
Lead, ppm					<1		<2			IP 501
Silicon, ppm					<1		1			IP 501

Table 3.4 Specification of Condensate (Sour) – South Pars Condensate (Typical)

Property	Specification							Test Method
	Cut Range							
	Whole	Gas	C5 - 60 °C	60-185°C	185-260°C	260-335°C	335+ °C	
Mass Yield, %		5.15	11.8	51.45	17.99	9.9	3.7	D2892/D5236
Volume Yield, %		6.4	13.5	51.4	16.65	8.85	3.2	
API Gravity	59.1							D 4052
SG at 15/15 °C	0.742							D 4052
Mercaptan sulphur, wt-%					0.0001			D 3227
Total Sulphur, wt-%							0.314	D4294
Total Sulphur, wtppm		1,017						D6667
Total Sulphur, wtppm	2,511		5,744	1,776	1,459	1,651		ASTM D 4294
RVP (psi)/ 37.8 °C								ASTM D 5191
Total Chloride, ppm			<1	<1				UOP 395
Total Acid No, mg KOH/g					0.011			
Viscosity @ 40 °C, cSt						5.8	14.8	ASTM D341

Property	Specification							Test Method
Saybolt Colour			+30	+30				ASTM D156
Copper Corrosion 3h@50°C		2a			1a	1b		ASTM D130
Pour Point, °C						-12	21	ASTM D97
Salt Content, lb/1000 bbls	<1							ASTM D3230
Water & Sediment, vol-%							<0.05	ASTM D1796
Water Content, vol-%	<0.05					<0.05	<0.05	ASTM D4006/D95
Sediment, vol-%	<0.05							D4007
Sediment by Extr, wt-%							0.01	D 473
Ash wt-%						0.001	0.001	ASTM D482
UOP K Factor								BHP Method 21
Nickel, ppm						<1		ICPES
Vanadium, ppm						<1	<1	ICPES
Sodium, ppm							<1	ICPES
Sodium, ppb				<100				ICPES
Copper, ppb				<100				ICPES
Iron, ppb				<100				ICPES
Molybdenum, ppb				<100				ICPES
Phosphorus, ppb				<100				ICPES
Silicon, ppb				1278				ICPES
Silicon, ppm						1	62	ICPES
Mercury, ppb			12	9		3		UOP 938
Arsenic, ppb			5	3		<75		AA Hydride
Lead, ppm						<1		ICPES
Lead, ppb			<3	7				IP 224

Table 3.5: Specification of Condensate (Sweet) - North West Shelf Condensate (Typical)

Site	Location (Typical)	Justification
API Gravity	60.3	ASTM D 4052
SG at 15/15 °C	0.7377	ASTM D 1298
Sulphur as Mercaptans, ppm	<1	
Total Sulphur, wt-%	<0.01	
Total Nitrogen, ppm	7.5	
Basic Nitrogen, ppm	2.0	BHP Method 37
RVP (psi) / 27.8 °C	9.3	ASTM D 5191
Total Acid No, mg KOH/g	<0.02	
Viscosity @ 40 °C, cSt	0.606	ASTM D341
Aromatics (FIA) vol-%	7.0	
Saybolt Colour	-15	ASTM D156
Copper Corrosion 3h@50°C	1A	ASTM D130

Site	Location (Typical)	Justification
Pour Point, °C,	-51	ASTM D97
Salt Content, lb/1000 bbls	<1	ASTM D3230
Sediment, wt-%	<0.01	ASTM D473
Conrad. C Residue 10% btm	0.06	ASTM D189
Ash 10% Btms	0.01	ASTM D482
Asphaltenes 10% Btms	<0.05	IP 143
Water Content, vol-%		IP 386
Gross Heating Value, MJ/kg	47.14	
Nett Heating Value,	43.98	
UOP K Factor	11.9	BHP Method 21
Carbon Content, wt-%	84.85	
Hydrogen Content, wt-%	15.14	
Nickel, ppm	<0.5	ICPES
Vanadium, ppm	<0.5	ICPES
Sodium, ppm	<0.5	ICPES
Copper, ppm	<0.5	ICPES
Iron, ppm	0.6	ICPES
Potassium, ppm	<0.5	ICPES
Mercury, ppb	25	ICPES
Arsenic, ppb	<5	ICPES
Lead, ppb	6	ICPES
Chloride, ppm	<1.0	

Other raw materials mostly comprise solid or liquid catalysts, in relatively small quantities, which will be stored in the warehouse – with appropriate safety precautions such as containment and segregation.

Table 3.6: Indicative Material Requirements

Chemicals	Consumption	Inventory	Delivery
Primary Feedstock			
Condensate	18,068 (MT/Day)	129,000 MT	Piped
Ammonia			
Condensate Fractionation Unit	28 kg/h	-	Vehicle delivery
Sodium Hydroxide (Caustic)			
Condensate Fractionation Unit	310 kg/h	-	Vehicle delivery
LPG Caustic Merox Unit	-		
Caustic - Prewash	-	3.6 m^3	Vehicle delivery
Caustic-Regeneration	-	33.1 m^3	Vehicle delivery
Corrosive Inhibitor: Unicor or Eq.			
Condensate Fractionation Unit			
Feed Fract Inhibitor Pumps 17 A/B	5.74 kg/h	24,108 kg	Vehicle delivery
Dist Fract Inhibitor Pumps 18 A/B	1.33 kg/h	5,586 kg	Vehicle delivery
Total	7.07 kg/h	29,696 kg	
Distillate Unionfining (KHT)	-	500 kg	
Distillate Unionfining (DHT)	-	1,095 kg	Vehicle delivery
Naphtha Hydrotreating	-	9,980 kg	Vehicle delivery

Chemicals	Consumption	Inventory	Delivery
De-Emulsifier			
Condensate Fractionation Unit	12.6 kg/h	52,920 kg	Vehicle delivery
Soda Ash & Sodium Nitrate			
Distillate Unionfining	-		
Soda Ash (Na_2CO_3)	-	10,978 kg	Vehicle delivery
Sodium Nitrate ($NaNO_3$)	-	1,100 kg	Vehicle delivery
DMDS			
Distillate Unionfining (KHT)	-	8,500 kg	Vehicle delivery
Distillate Unionfining (DHT)	-	45,310 kg	Vehicle delivery
Naphtha Hydrotreating	-	28,602 kg	Vehicle delivery
CCR Platforming	-	1,093 kg *	Vehicle delivery
Tatoray	-	32 kg	Vehicle delivery
Perchloroethylene			
CCR Platforming	-	1,110 kg	Vehicle delivery
CCR Regen	-	4,687 kg	Vehicle delivery
Clay			
BT Fractionator	176.9 m^3 (Annual Make-up)	353.7 m^3	Vehicle delivery
Xylene Fractionator	376 m^3 (Annual Make-up)	376 m^3	Vehicle delivery
Sulfolane			
Sulfolane Unit	15,023 kg	200,000 kg	Vehicle delivery
Monoethanolamine			
Sulfolane Unit	-	96 kg	Vehicle delivery
Antifoam [GE AF 9000, Dow AF A eq]			
Sulfolane Unit	-	2,500 kg	Vehicle delivery

***1) Ref. Technical Proposal**

Table 3.7: Estimated Make-up, Start-up and Daily Catalyst and Chemical Requirements

	Initial Inventory	Additional Consumption	Initial Inventory plus allowance
Condensate Splitter			
Catalyst			
Merox WS Catalyst	110 kg	-	130 kg
HYT 4118 – Dist Unionfining (KHT) Catalyst	16,677 kg	-	-
HYT 4118 – Dist Unionfining (DHT) Catalyst	56,117 kg	-	-
Aromatics Plant			
Catalyst			
H-15 ORP Catalyst	90,302 kg	-	-
HYT-1119 NHT Catalyst	59,790 kg	-	-
GB-346 NHT Guard Bed	108,545 kg	-	-
R-334 CCR Platf Catalyst	226,243 kg	2,286 kg (Annual make-up)	-

	Initial Inventory	Additional Consumption	Initial Inventory plus allowance
I-500A Isomar Catalyst	24,880 kg	-	-
I-500B Isomar Catalyst	41,467 kg	-	-
TA-32 Tatoray Catalyst	104,493 kg	-	-
Adsorbent & Desorbent			
Parex ADS-50/ADS-50L Adsorbent	1,124,533 kg	-	-
CLR-204 (Chloride Adsorbent)	131,291 kg	125,038 (Annual make-up)	-
MR-3 CRP Adsorbent	44,488 kg	-	-

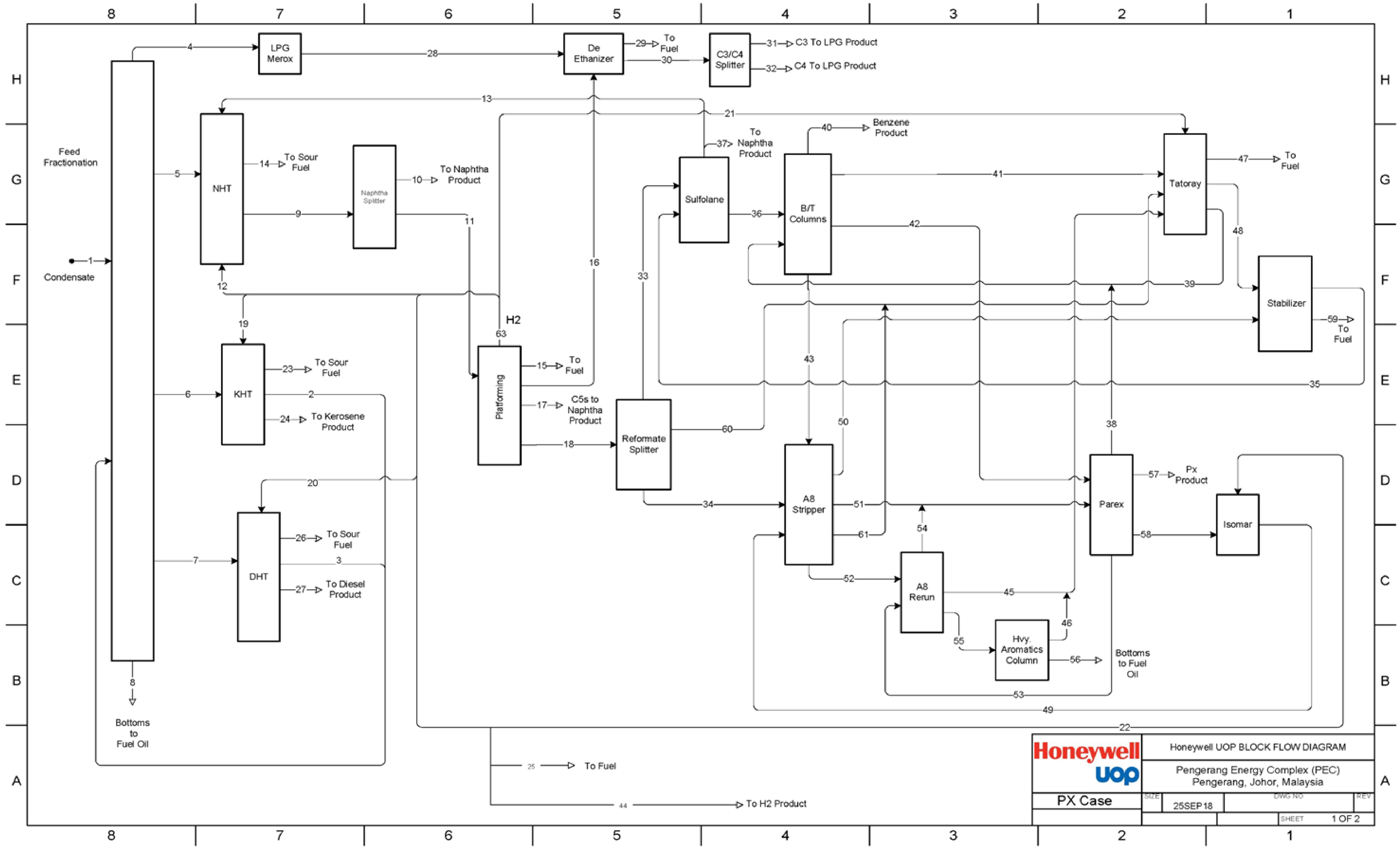
3.6 Process Description

3.6.1 Process Overview

The PEC will be divided into two main sections, the 'condensate splitting plant' and the 'aromatics plant'. The overview block flow process diagram as shown in *Figure 3.10* below provides a simplified block flow diagram for the plant.

The condensate splitting plant will produce intermediate naphtha as feedstock for the aromatics plant and various petroleum products including LPG i.e. C3 (propane), C4 (butane and isobutane), Ultra Low Sulphur Diesel (ULSD) and Low Sulphur Fuel Oil (LSFO). In the aromatics plant, the intermediate naphtha will be processed to produce paraxylene, and benzene and sulphur as its by-product.

Feedstocks will be processed using standard oil refining 'unit operations' that utilise heating, cooling, fractionation, reforming and distillation processes. The PEC will utilise the refining and aromatics technologies of Honeywell UOP, a globally leading vendor.



Unit Capacities	BPD	KMTA
Condensate	150275	6324
LPG Merox	6091	180
NHT	103407	4134
Naphtha Splitter	102937	4118
Platforming	80849	3327
KHT	21278	946
DHT	28699	1342
Reformate Splitter	60957	2826
Sulfolane	18705	776
BT Fractionation	73515	3576
Tatoray	64224	3119
A8 Stripper	179300	8648
A8 Rerun	38822	1891
OX Column	2004	99
Parex	145680	7058
Isomar	117757	5716

Overall Material Balance	BPD	KMTA
Feed		
Condensate	150275	6324
Products		
C3 LPG	2548	72
C4 LPG	7004	226
Benzene		656
Paraxylene		1505
Light Naphtha	24781	887
Kerosene	20929	926
Diesel	29918	1396
Fuel Oil		154
Excess H2		11
Sulphur		11
Fuel & Loss		480

Stream Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Description		Purch Cond	KHT Wld Naphtha	DHT Wld Naphtha	CFU LPG	CFU Naphtha	CFU Kerosene	CFU Diesel	CFU Residue	HT Naphtha	Nap Spltr Tops	Nap Spltr Bttms	H2 to NHT	Raffinate	NHT Offgas	CCR Fuel	CCR LPG	CCR C5	CCR Ref	H2 to KHT	H2 to DHT	H2 to Tatoray	H2 to Isomar	KHT Sour Offgas	HT Heavy Jet	H2 to Fuel	DHT Fuel	DHT HT Dsl
Mass Flow	KMTA	6324	17	4	180	3725	946	1342	154	4118	791	3327	11	409	27	6	124	71	2826	5	8	8	3	8	926	254	10	1336

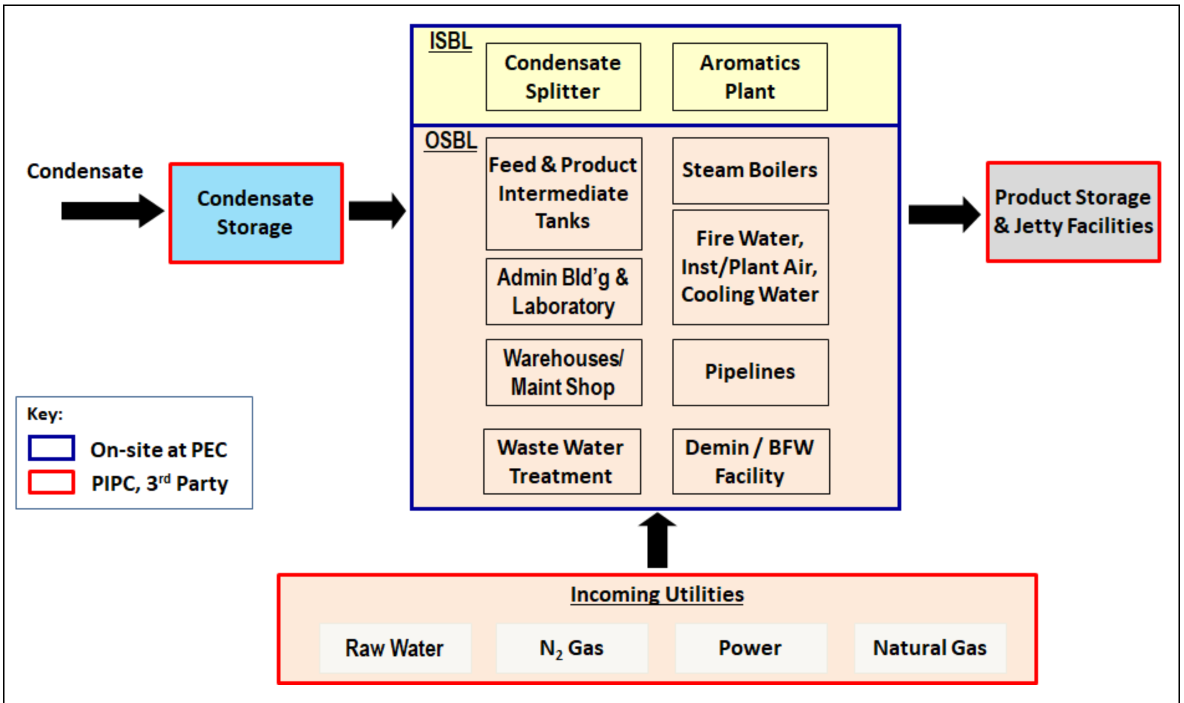
Stream Number		28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Description		Treated LPG	Sat C1/C2	Sat C3/C4	Sat C3	Sat Mxd C4	Ref Spltr Tops	Ref Spltr Btms	Stabilizer Bottoms	Extract	Raffinate to LN	Parex Des	TAT Product	Benzene	Toluene to Tatoray	Toluene to PX	BT Bttms	H2 to Product	A8 R Side	HAC Tops	TAT Fuel	TAT L Tops	Isomar Product	A8 S Tops	A8 S Side	A8 S Bottoms	Parex Bttm	A8 R Tops
Mass Flow	KMTA	180	6	298	72	226	736	1363	40	342	25	1	3232	656	1170	183	1567	11	1182	39	146	11	5718	66	6448	1872	19	609

Stream Number		55	56	57	58	59	60	61		63
Description		A8 R Bottoms	Hy Aromatics	PXY	Parex Raff	Stabilizer Fuel	Ref Spltr Side Draw	A8 Stripper OVHD Lqd		PLT H2
Mass Flow	KMTA	99	60	1505	5716	36	728	262		300

ESC

Figure3.10– UOP Block Flow Diagram

Source: PEC



* ISBL – Inside Battery Limits, OSBL – Outside Battery Limits

Figure 3.11 – PEC Processing Sections and Supporting Facilities Schematic Plan
Source: PEC

Main processing sections and the supporting facilities are schematically illustrated in *Figure 3.11* while the principal operations at the proposed PEC are planned as follows:

Principle operations at the proposed PEC are planned as follows:

- **Feedstock, import and storage:** The condensate feedstock is a blended low-density mixture of hydrocarbon liquids derived from raw natural gas extracted from oil and gas fields. Plant design is flexible enough to take various blends of condensate and/or imported naphtha as feedstock, including potentially from other oil refineries. Shipments of incoming condensate feedstock shipments to the PDT will be off-loaded at a third-party operated jetty and sent to storage an adjacent, third-party bulk terminal within the PDT Central Tank Facility (CTF) area.
- **Other raw materials** mostly comprise solid or liquid catalysts, in relatively small quantities, that will be delivered to the PEC site and stored in the warehouse.
- **Processing:** As and when needed, condensate is pumped via ~5.3km pipelines from the PDT to the PEC site's limited capacity (one week), on-site bunded bulk storage tank farm prior to processing. The proposed PEC comprises of two main processing sections; a condensate splitting plant, which produces the oil products and the full boiling range (FBR) naphtha that is the feedstock to the aromatics plant, the second main section.
- **Supporting facilities and utilities** on site will include the tank farms for condensate, intermediate products and products, steam boilers, raw and wastewater treatment plants, pipelines and the on-site utilities/ buildings (see *Figure 3.11*). A flare system for emergency flaring of raw materials (i.e. Condensate, semi-finished and finished product) will be located in the southwest corner of the site. Third parties will supply the PEC with raw water, nitrogen gas, electrical power and natural gas.

- **Products:** *Table 3.8* provides the full list of products, co products and by-products. By-product hydrogen rich gas, fuel gas, light ends and tail gas are used directly on-site in the process or as fuel for its fired heaters. All other products are stored in limited quantities in the onsite tank farms prior to transfer via pipeline to the PDT third party bulk storage terminal and its jetty.

Table 3.8: PEC Facility Production Capacities of Products, Co-Products and By-Products

Primary Products	Capacity (metric tonnes per annum)
Benzene	656,000
Paraxylene	1,505,000
Sub-total aromatics	**2,161,000**
Co-Products	**Capacity (metric tonnes per annum)**
Jet Fuel	926,000
Diesel (ULSD)	1,396,000
C_3 / C_4 LPG	298,000
Fuel Oils (LSFO)	154,000
Light Naphtha	887,000
By-Products	**Capacity (metric tonnes per annum)**
Sulphur	11,000
Hydrogen Rich Gas	11,000
Sub-total oil products	**3,683,000**
TOTAL PRODUCTION CAPACITY	**5,844,000**
Hydrogen Rich Gas	254,000
Fuel gas (DC2 Off gas)/ Light Ends	226,000
Sub-total utilised on-site	**480,000**

Note:
1. Primary and oil products exported for sale, together with sulphur by-product, other by-products used on site in process or as fuel

The PEC will utilise the refining and aromatics technologies of Honeywell UOP, the globally leading vendor. *Figure 3.10* provides an overview of the processes in the form of a simplified process flow diagram (PFD) for the PEC with the main operations summarised as follows:

- The condensate splitting section produces the intermediate naphtha that feeds the aromatics plant. Feedstock condensate is processed using standard oil refining 'unit operations' that utilise heating, cooling, fractionation, reforming and distillation processes. Condensate is desalted and processed in the feed fractionator, which splits the condensate into heavy naphtha and kerosene (jet fuel). This unit boils the condensate via steam and direct heating from a fuel burner.

  The remaining split hydrocarbon fractions are sent to the LPG Merox, kerosene or diesel hydrotreating units (KHT & DHT), where the gas and oil products undergo amine treating, hydrogenation, desulphurisation and processing to the various petroleum co- and by-products including light ends, C3 Liquefied Petroleum Gas (LPG) (propane), C4 LPG (butane and iso-butane), Ultra Low Sulphur Diesel (ULSD), Low Sulphur Fuel Oil (LSFO) and Jet Fuel (Jet-A1), that are sent to storage.
- In the **aromatics treatment complex** the intermediate naphtha feedstock is first hydrotreated in the naphtha hydrotreating unit (NHT) to remove sulphur, nitrogen and other contaminants and light naphtha separated in the naphtha splitter. The remaining heavy naphtha is then processed in the continuous catalytic reforming (CCR) platforming

and regeneration unit via catalytic reforming, or dehydrogenation in the presence of a catalyst at elevated temperature and pressure. Under these conditions, aliphatic/straight chain hydrocarbons form rings and lose hydrogen (by-product) to become aromatic/ring chain hydrocarbons (or BTX; Benzene-Toluene-Xylenes).

- The aromatic products of the reaction are then separated from the reaction mixture (or reformate) by Sulfolane solvent extraction and distillation. The Tatoray unit then converts toluene, the lower value aromatic-product, to xylene and benzene using the toluene disproportionation (TDP). This process reacts two toluene molecules together and rearranges the methyl groups from one toluene molecule to the other, a process that yields one benzene molecule and one xylene molecule, with molten sulphur as the by-product. Primary product benzene is separated and sent to storage. Xylenes are further processed in the Parex and Isomar units, via absorption and isomerisation to maximise production of the other high value primary product, paraxylene.

The following sub-sections further describe the main operations along with its respective major process units.

3.6.2 Condensate Splitting Complex

The condensate splitting complex will consist of the following major units:

- Condensate Fractionation Unit (AREA C1)
- LPG Merox Unit (AREA C1)
- Distillate Unionfining Unit – KHT (AREA C1)
- Distillate Unionfining Unit – DHT (AREA C2)

Detail descriptions of each unit in condensate splitting complex are as follows:

3.6.2.1 Condensate Fractionation Unit (AREA C1)

Condensate is initially passed through a desalting unit. Removed salt is sent as brine to the refinery waste water treatment plant (WWTP). The condensate is then processed in the fractionation unit. Fractionation has three major processes, a feed fractionator, a product fractionator, and a stabiliser.

The condensate first enters the **feed fractionator** at approximately 6,324 KMTA. This unit boils the condensate via steam and direct heating from a fuel burner in the reboiler. Ammonia and Unicor (corrosion inhibitor) are added to assist the process of splitting the condensate into two fractions, called overheads and bottoms. The process also produces sour water, which is sent to the sour water stripper. Point source emissions are generated from the reboiler and any other gases and air displaced from the equipment is channelled into the air treatment system, described later. Gaseous emissions are collected in the same manner as above.

A similar process splits the overheads into two further fractions. The overheads are gaseous LPG, which is routed to the LPG Merox unit. The bottom product is full boiling range (FBR) naphtha, the feedstock for the aromatics complex and sent to the naphtha hydrotreating unit. This unit may produce sour water, which is channelled to the sour water stripper.

The bottoms from the feed fractionator is split into three fractions and is heated via a fuel fired boiler and steam. The overheads from this process are routed to the KHT and DHT units at 946 and 1,342 KMTA respectively and is stored onsite, while the bottoms are sent directly to fuel oil storage. The product fractionator also has a side-cut which is re-routed to the distillate unionfining units.

Waste and emissions from this process include brine and sour water (sent to waste water treatment plant), point source gaseous emissions (2) from feed fractionator reboiler & product fractionator heater which will be released through their stacks, and displaced air which will be sent to the flare stack. The unit has several over-pressure vents to the flare stack, which may be activated in the event of overpressure, while air emissions are reprocessed in various subsequent units. No solid waste is expected.

3.6.2.2 LPG Merox Unit (AREA C1)

An LPG Extraction Merox Unit is designed to remove H_2S, COS and Mercaptans from the LPG required when further processing of C3 and C4 olefins in alkylation, polymerization or petrochemical synthesis is required. The capital-efficient Extractor Plus design is typically used in this service.

The Extractor Plus design incorporates caustic pre-treatment, mercaptan extraction and post-treatment into a single vessel, thereby offering a low capital cost alternative to other extraction processes. Typical product mercaptan levels can be controlled to less than 5 wppm[1].

The LPG from the condensate fractionation unit is processed in the caustic merox (LPG extraction) unit to reduce sulphur which occurs as mercaptans and hydrogen sulphide (H_2S) via the process shown schematically below. The pressure of LPG will be ~13.7 barg after flow record and control (FRC) and at a temperature of 40°C. The process uses steam. Normal feed rate to the unit would be 180 KMTA (6,091 barrels per stream day, BPSD). The first stage of the unit (not shown in *Figure 3.12*) is **an amine absorber** for H_2S removal.

The feed (after being treated in the amine absorber) flows to a caustic pre-wash prior to being charged to the **extractor**, with caustic (sodium hydroxide) solution, containing merox catalyst (cobalt phthalocyanine sulfolane compounds). Treated product is sent to storage.

Mercaptan rich caustic solution containing merox catalyst is injected with air and the mixture flows into the **oxidizer** where the dissolved mercaptans are catalytically oxidized to water insoluble disulphide oil. The oxidizer effluent flows to the **disulphide separator** where disulphide is removed. The disulphide oil is decanted in a disulphide sand filter and is sent to unionfining unit. Lean caustic is circulated from the disulphide separator to the extractor.

The unit will produce solid waste from the sand filter for off-site disposal through a licensed waste collector. Liquid wastes include spent caustic (from prewash and extraction) which will be sent to the spent caustic disposal system. Backwash water from sand filter and steam condensate from caustic heater will be sent to the waste water treatment plant. In addition, vent gas from disulphide separator generated will be incinerated in a heater fire box and will be sent to the flare stack. The unit has several over pressure vents to the flare stack, which may be activated in the event of over pressure, air emissions are reprocessed in various subsequent units.

[1] https://www.uop.com/processing-solutions/refining/gas-lpg-treating/#lpg-treating retrieved on 21st February 2019.

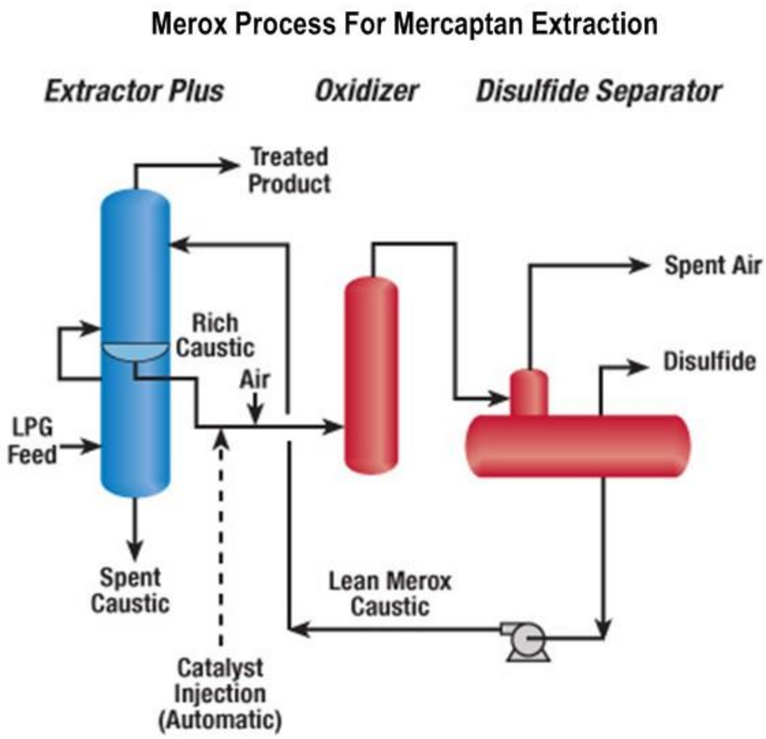


Figure 3.12 – LPG Merox Unit RFD*

Source: UOP

*RFD - representative flow diagram

3.6.2.3 Distillate Unionfining (KHT) Process Unit

KHT Distillate Unionfining Process Unit is divided into reactor and stripper sections (*Figure 3.13*). The unit consists of one reactor section with separate stripper section.

For KHT, two fired heaters with the following fuel requirement will be utilised:

- Charge Heater fuel fired: 3.27 MM kcal/hr
- Stripper Reboiler: 5.38 MM kcal/hr

The total fuel requirement is 8.65 MMkcal/hr. And for KHT fuel, internal fuel gas will be utilised.

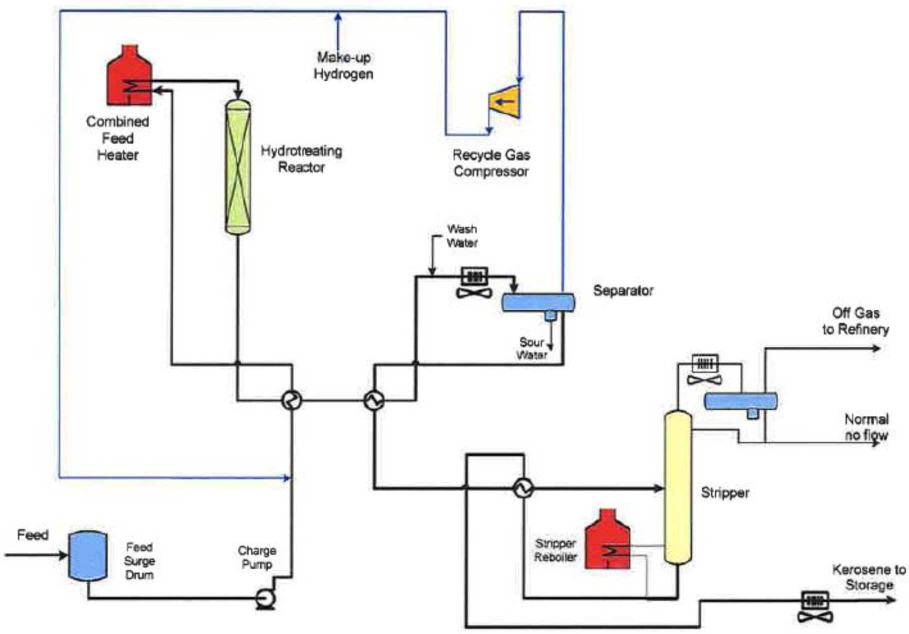


Figure 3.13 – KHT Distillate Unionfining Process Unit

Source: UOP

Reactor Section

Cold feed from storage is sent to the unit via a Coalescer to remove any free water, and is filtered to remove any particulate matter which could plug the reactor catalyst beds. For this type of feed the Filter is likely to be a cartridge type. The filtered feed is then routed to the Feed Surge Drum.

The unit feed is pumped from the Feed surge Drum via the high head multistage charge pump to the reactor system pressure. The feed is mixed with recycle gas and the combined feed is heated by the reactor effluent stream and then in the charge heater to the required reaction temperature before entering the reactor.

The reactor effluent is cooled against the combined feed stream and enters the Separator. The liquid from the Separator is routed to the Stripper column.

Prior to cooling in the product condenser wash water is injected into the reactor effluent stream to remove any ammonium salts that may deposit within the tubes of the air cooler.

The vapour from the Separator vessel is the recycle gas which is routed to the recycle gas compressor, mixed with the fresh feed and returned to the reactor system.

Improving the purity of the make-up H_2 will have impact on the catalyst quantity, reactor size and compression costs.

Makeup hydrogen is added to the reactor system via the makeup Gas Compressors. To minimise the capacity of the Recycle Gas Compressor the makeup gas is routed to the discharge of this compressor.

To avoid the formation of an emulsion, the liquid hydrocarbon and water phases in the Separator vessel are separated before being let down in pressure.

Stripper Section

The Stripper column is designed to remove the H_2S from the product. The column is fed from the separator. The separator liquid is heated against the Stripper bottoms stream prior to entry into the column.

The Stripper column overhead vapour is condensed and collected in the Stripper Receiver. The hydrocarbon liquid from the Stripper Receiver is the sour wild naphtha product which is sent to the refinery for further processing. Normally there is no liquid from the stripper receiver.

The Stripper column bottoms stream is the desulfurized product and is cooled against the cold Stripper feed. To produce a dry product the bottoms stream is further cooled before being sent to storage.

The unit will generate point source gas emissions from the fuel feed heater and it will be released through its stack. Gaseous emissions from air displacement and the steam stripper and over pressure vents to the flare stack may be activated in the event of over pressure. Sour water and amine waste water will be sent to the waste water treatment plant. Solid wastes including sulphur, wastes from the catalyst and salt drying beds will be sent for off-site disposal by a licensed waste collector.

3.6.2.4 Distillate Unionfining (DHT) Unit (AREA C2)

The unit processes the diesel fraction, from the condensate fractionation unit. The objective of the unit is to reduce the sulphur in the diesel to less than 10 wppm to meet the Euro-V fuel specification. The nominal feed rate is 1,342 KMTA (28,699 BPSD). This unit will produce a sweet fuel gas stream and an un-stabilised naphtha stream which is recycled in the condensate fractionation unit.

The unit comprises the reactor, separator, compressor, stripper, and diesel product section. The Feed enters the pressurised reactor and is combined with recycled gas and heated via a fuel boiler together with reactor effluent. The proposed design has only a single reactor with two catalyst beds and hydrogen quench. The two catalyst beds filter out fine particles such as corrosion products to avoid high-pressure drop across the catalyst bed during operation, followed by the desulphurisation catalyst. Subsequently the gas and liquid mixture is separated in the high-pressure separator unit. Water is injected into the reactor effluent ahead of the effluent air cooler to prevent the deposition of ammonium disulphide. Sour water is coalesced and removed from the boot of the separator, and sent to the flash drum.

High-purity (90%) make-up hydrogen, from the make-up gas compressor discharge, is mixed with the recycled gas at the suction of the recycle compressor and the combined recycle and make up gas stream is sent to the reactor system. The separator liquid is sent to the flash drum (low pressure separator) where the hydrocarbon liquid, flash gas and sour water are separated. The flash gas is sent to the amine absorber for H_2S removal. The flash drum liquid requires stripping to remove residual hydrogen sulphide, ammonia and light hydrocarbons. The steam stripper will generate off-gas, sour water and the diesel product. Diesel product with a moisture content less than 200 wppm will be achieved, by routing the diesel product through a product coalescer and salt dryer to remove the free water. The product is then sent to storage.

The unit will generate point source gas emissions from the fuel feed heater and it will be released through its stack. Gaseous emissions from air displacement and the steam stripper and over pressure vents to the flare stack may be activated in the event of over pressure. Sour water and amine waste water will be sent to the waste water treatment plant. Solid wastes including sulphur, wastes from the catalyst and salt drying beds will be sent for off-site disposal by a licensed waste collector.

3.6.2.5 Sulphur Recovery Unit (SRU)

The modified Claus (also known as conventional Claus) process is the workhorse in sulfur recovery, and is used worldwide in more plants than any other process. In the typical modified Claus process, the acid gas feed is partially oxidized to generate sulfur dioxide (SO_2), which then reacts with the remaining hydrogen sulfide (H_2S) over a catalyst to produce sulfur. Most Claus sulfur plants contain two or three catalytic stages and can achieve 94-97% sulfur recovery efficiency.

The Claus process utilizes the following chemical reactions to convert hydrogen sulfide to elemental sulfur:

(1) $H_2S + {}^3/_2\, O_2 \rightleftharpoons SO_2 + H_2O$

(2) $2\, H_2S + SO_2 \rightleftharpoons {}^3/_n S_n + H_2O$

The overall reaction for the process is:

(3) $3\, H_2S + {}^3/_2\, O_2 \rightleftharpoons {}^3/_n S_n + 3H_2O$

Most sulphur plants contain one non-catalytic conversion stage (the reactor furnace) and two or more catalytic conversion stages in series. The Claus reaction is highly exothermic, releasing a great deal of heat energy that can be recovered by generating steam in heat exchangers following the conversion stages.

<u>Modified Claus with Tailgas Cleanup</u>

In applications where a high level (more than 99.5%) of overall sulfur recovery is required, the Modified Claus Process coupled with an amine-based tailgas cleanup process is used. This process is the best widely-proven technology available in the industry for achieving overall sulfur recovery performance up to 99.9%. Ortloff has performed the detailed process engineering, specification, and design of more than fifteen amine-based tailgas cleanup units.

The tailgas cleanup process reduces all of the sulfur compounds in the tailgas leaving the front-end Claus sulfur plant back to hydrogen sulfide (H_2S), then uses selective amine absorption to remove the H_2S while allowing most of the carbon dioxide (CO_2) to “slip” by. The H_2S and CO_2 removed by the amine are stripped from the amine and recycled back to the Claus plant, allowing an overall sulfur recovery in excess of 99.5%. Depending on the performance required, the effluent from the tailgas cleanup unit (TGCU) can contain as little as 10 PPM of H_2S. This effluent is normally routed to a Tailgas Thermal Oxidizer to incinerate the H_2S and any other remaining sulfur compounds to sulfur dioxide (SO_2) before dispersion to the atmosphere. Effluent gas would meet regulatory requirement.

3.6.3 Aromatics Treatment Complex

The Aromatic treatment complex will consist of the following major units:

- Naphtha Hydro-treating Unit (NHT)
- Contaminant Removal Process Unit
- Continuous Catalytic Reforming (CCR) Platforming and Regeneration Unit
- Olefin Reduction Process Unit
- Sulfolane Unit
- Tatoray Unit
- Aromatic Fractionation Unit
- Parex Unit
- Isomar Unit

3.6.3.1 Naphtha Hydrotreating Unit (NHT)

FBR naphtha produced from the condensate splitting section is further treated in the NHT unit. NHT uses a selective catalyst HYT 1119, Aluminum Oxide, and GB-346 to hydrotreat with hydrogen rich gas to decompose organic sulphur, nitrogen and oxygen compounds in the naphtha prior to further processing in the CCR platforming unit. In addition, hydrotreating removes organometallic compounds (including mercury – see contaminant removal process below) and saturates olefinic compounds.

The unit comprises the following sections:

- Reaction Section – consists of a heat exchanger, fuel fired heater, reactor, separator, recycled gas compressor and ancillary equipment
- Stripper Section – comprises a stripper column, fuel fired reboiler, amine treater and ancillary equipment

The stripper net overhead gas is amine treated prior to being sent to fuel gas system.

3.6.3.2 Contaminant Removal Process (CRP) Unit (part of NHT)

The Contaminant Removal Process removes mercury and arsenic from the feedstocks through an adsorber. Mercury is a catalyst and adsorbent poison and is known to corrosively attack equipment made with aluminum, such as heat exchangers in gas processing plants or olefin complexes. Arsenic compounds are also catalyst poisons in many petrochemical processes.

The CRP is designed to reduce the mercury content of certain feeds to 5 ppb or less, and to remove the arsenic compounds typically present in light and heavy naphtha streams to less than 5 ppb. In addition to protecting equipment, catalyst and adsorbents, the CRP provides a means to control emissions of mercury and arsenic.

The regenerable adsorbent has a long useful life and when ultimately spent, has no detectable mercury level. Arsenic generally occurs only in combined forms. The various species of arsenic will be adsorbed by the non-regenerable material depending on the boiling points of the arsenic compounds present.

The NHT and CRP units will generate significant waste and gas streams, waste water may be contaminated with metals such as mercury and arsenic, and will be sent to the waste water treatment plant.

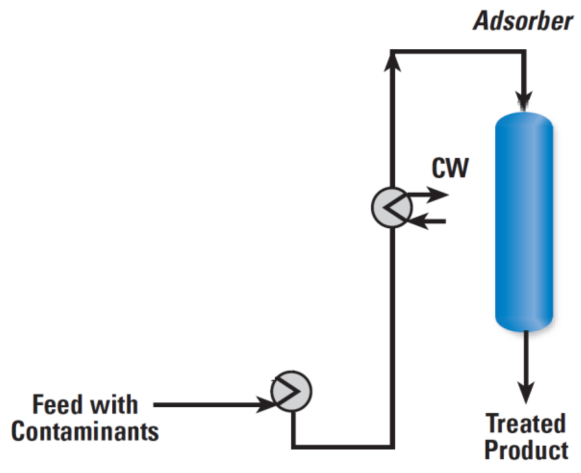


Figure 3.14 – Contaminant Removal Process (CRP) Unit
Source: UOP

3.6.3.3 Continuous Catalytic Reforming (CCR) Platforming and Regeneration Unit

The CCR platforming process produces aromatics and hydrogen from napthenes and paraffin at high severity, it is the only in the complex that creates aromatic rings. The rest of the complex is used to separate the various aromatic components into individual products and to convert undesired aromatics into additional high value products. Feed for the CCR platforming unit is the naphtha splitter bottoms from the NHT. This unit upgrades mercury depleted low octane hydrotreated heavy naphtha to produce 105 RONC reformate. Hydrogen, LPG and light ends are also produced in this process.

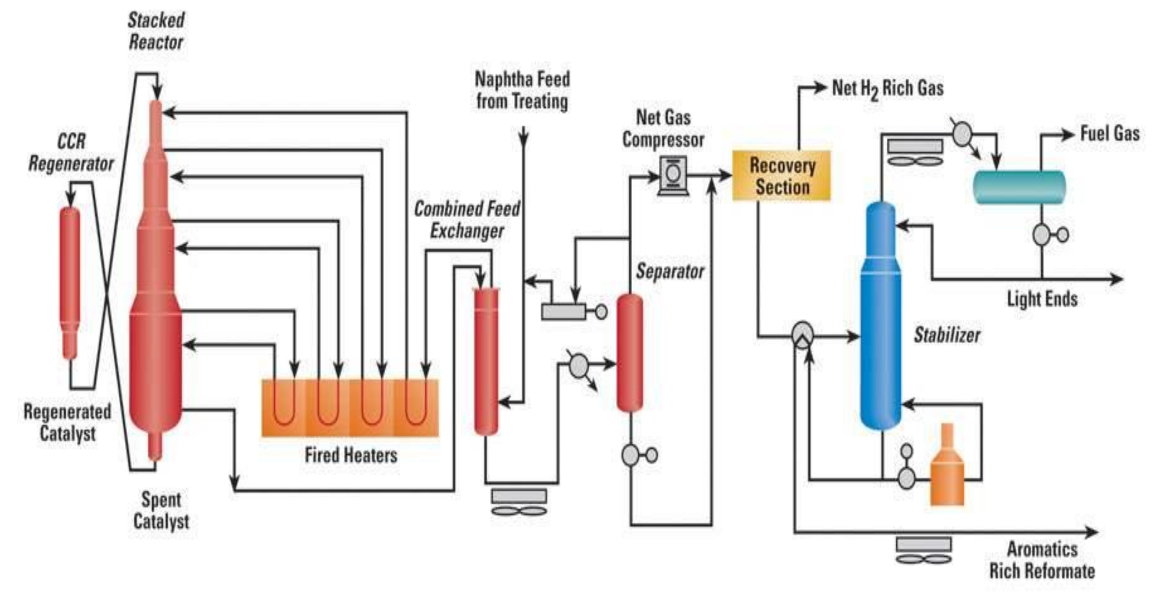


Figure 3.15 – Continuous Catalytic Reforming (CCR) Platforming and Regeneration Unit

Source: UOP

As shown in *Figure 3.15* above, the unit comprises a reaction section, recontact section and debutaniser section. The unit produces the following product streams:

- A hydrogen rich gas stream, which is routed to the NHT unit, isomar unit, tatoray unit and olefin reduction unit.
- An unstabilised LPG stream, which is routed to condensate splitting for combined treatment (de-ethaniser followed by C_3/ C_4 splitter)
- A reformate intermediate, which is sent to the reformate splitter.

The reaction section consists of four stacked radial flow reactors, fuel fired charge heater and inter-heaters, combined feed exchanger, separators, recycle gas compressor and their ancillary equipment. Four major reactions occur in the reactors including dehydrocyclisation, isomerisation, dehydrogenation, hydrocracking of large hydrocarbons to smaller hydrocarbons.

Vapor from the product separator is split into two streams: recycle gas and hydrogen rich net gas. The recycle compressor compresses the recycle gas while the net gas is sent to the product recovery section. The product recovery section consists of recontacting and net gas compression. The net gas from product recovery section flows to a Recovery Plus system to further improve the recovery of LPG.

Recontact section consists of a two-stage counter-current recontacting and net gas compression scheme plus a third stage of net gas compression. The recontact pressure is 31 barg. The hydrogen gas from the second stage compression and recontacting scheme is treated to remove chlorides and is sent to the NHT unit and isomar unit. The gas from the third stage compression goes to the tatoray and olefin reduction unit. The light ends from the second stage of the compression and recontacting scheme is sent to the de-ethaniser and C_3/ C_4 splitter, after chloride removal. As a result of chloride removal, chlorinated water from CCR platforming process will be collected and treated in waste water treatment plant on site.

3.6.3.4 CCR Catalyst Regeneration

The CCR platformer uses a movable bed of R-334 catalyst. Over time, coke will build up on the catalyst surface, reducing catalyst activity. Hence, the catalyst requires regeneration. During the regeneration process, the refinery will suffer production loss, which is the reason why UOP developed a major process enhancement by making the regeneration possible continuously, while the process is also taking place.

In UOP design, the catalyst is able to flow by gravity between reactors and is continuously regenerated. Catalyst regeneration will generate particulate which will be filtered prior to venting. Catalyst regeneration consists of four steps. The first three steps of coke burning, oxychlorination, and drying occur in the CCR Cyclemax® regeneration unit. The fourth step, reduction, occurs in the reduction zone on top of the reactor stack. The CCR Cyclemax® regeneration unit uses a pressurized regenerator design. The Chlorosorb® system, which recovers upto 99% of chlorides from the vent gas stream and recycles the chlorides back to the process, is also applied. Spent catalyst is used as chlorides adsorbent.

According to UOP, the unit has low emissions and high energy efficiency as the Chlorosorb® technology recycles chloride and reduces atmospheric emissions. Even so, the unit has several over pressure vents to the flare stack, which may be activated in the event of over pressure, other lights and gaseous fractions are reprocessed in various subsequent units.

There will be 3 natural gas fired charge heaters, inter-heaters no.1 to 3 and stabilizer reboiler heaters, whose emissions and will be released through combined stacks. In addition, vent gas, containing trace hydrogen chloride (HCL), will be produced from CCR disengaging hopper and will be released directly via a stack. Waste water containing ammonium chloride and trace hydrocarbons generated will be sent to the waste water treatment plant. Solid waste will include spent adsorbent (activated alumina) generated once every 6 months from the net gas clay treaters and will be sent for off-site disposal by a licensed waste collector.

3.6.3.5 Reformate Splitter

The reformate splitter reboils the intermediate product, bottoms from the debutanizer at the CCR. The bottoms are passed through the Olefin Reduction Process (ORP) prior to being sent to the xylene splitter. The top fraction is condensed and sent to the sulfolane unit. Vent gases are sent to the sulfolane vent tank and subsequently to the flare stack. The unit will produce solid waste when clay beds are changed and will be sent for off-site disposal by a licensed waste collector.

3.6.3.6 Olefin Reduction Process (ORP) Unit

ORP Unit uses a simple, fixed-bed reactor system where olefins in the reformate are selectively hydrogenated to their corresponding alkane or cycloalkane using hydrogen rich gas from the third compression stage of the CCR platforming unit. The unit includes a heat exchanger train and two swing-bed reactors.

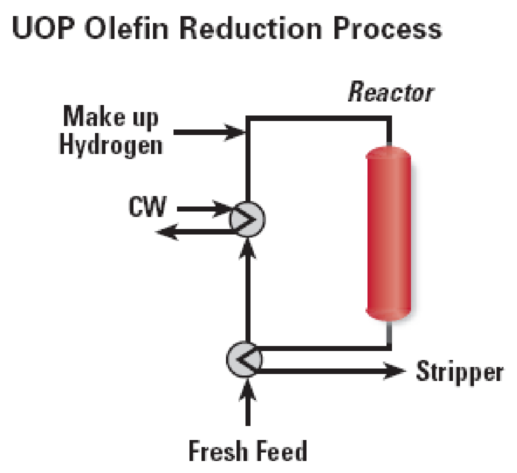


Figure 3.16 – Olefin Reduction Process (ORP) Unit
Source: UOP

3.6.3.7 Sulfolane Unit

The sulfolane process combines liquid-liquid extraction with extractive distillation to recover high purity aromatics. The unit extracts a benzene-toluene fraction, which is sent for further fractionation, where it is heated to produce the fractions for finished product and subsequently stored on-site. The unit also produces a raffinate product.

The feed to the sulfolane unit is the reformate splitter overhead liquid from the xylene fractionation unit and the stripper column bottoms from the isomar unit.

Sulfolane unit consists of, a feed surge drum, lean solvent section, extractive distillation (ED) column, recovery column, solvent separator, clay treaters, benzene column and their ancillary equipment. A plant inventory tank and sulfolane sump tank are also included.

The feed is routed to the ED Column via the Feed Surge Drum. The maximum temperature of the ED Column is 89°C and the maximum pressure is 1.1 barg. The lean solvent is added to the column above the feed inlet. Mono-ethanol amine (MEA), a gas washing solvent and an anti-foaming agent are also injected into the process. As the feed flows through the ED Column, aromatics are selectively dissolved in the solvent. A raffinate stream, very low in aromatics content, is withdrawn from the top of the ED Column.

The target recovery of benzene is 99.5% across the ED Column. Extracted aromatics are separated from the solvent in the recovery column as an overhead stream, and are clay treated in order to remove trace amounts of olefins and other impurities. The treated extract is sent to the benzene column. The bottoms stream from the recovery column is toluene, which is recycled to the ED column. Final product is sent to product storage tanks.

The process will generate air emissions (containing hydrocarbons) which are vented to air via a dedicated line to the knock out drum at the flare. Point source air emissions are generated from the gas fired fire heaters and toluene column reboiler stacks. Sour water is sent for reprocessing via the solvent sewer. Water with hydrocarbons generated from the ejector condensate drum and from the benzene-toluene fractionation unit is routed to the waste water treatment plant. Solid waste will include bentonite from the clay treaters and spent catalyst which is generated once every 3 years and will be sent for off-site disposal by a licensed waste collector. Sulfolane solvent with aromatic hydrocarbons is generated once every six months from the solvent regenerator and removed on a batch basis by a licensed waste collector.

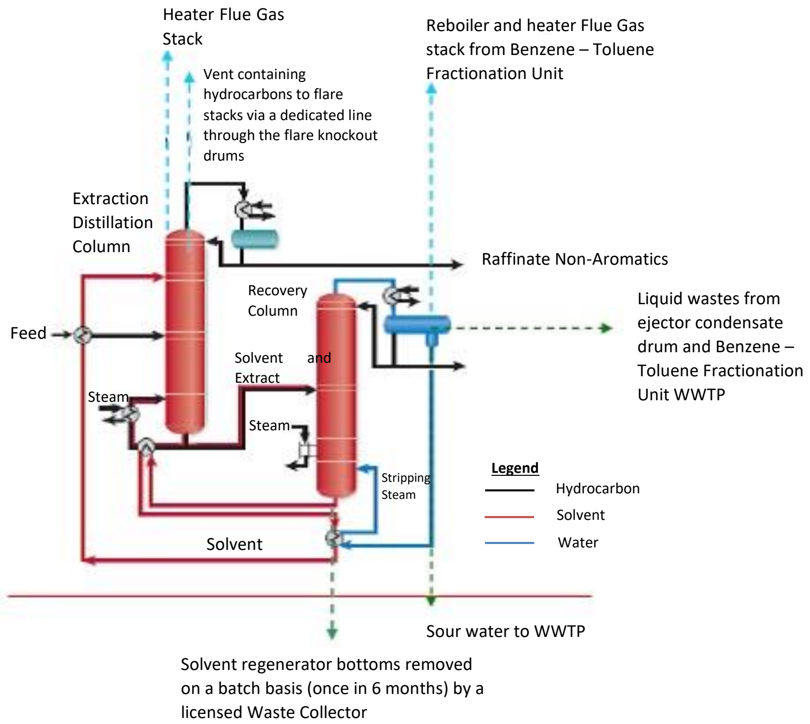


Figure 3.17 – ED Sulfolane Process Unit

Source: UOP

3.6.3.8 Tatoray Unit

The tatoray unit is used to selectively convert toluene C_9 – C_{10} to more valuable benzene and xylenes, over the TA-32 catalyst. The unit consists of a reaction section and a stripper section. A feed storage tank will feed the coolers and a feed pump.

The toluene xylene columns in the aromatic fractionation unit provide the feed to the reaction section. Hydrogen rich gas is also supplied from the CCR platforming unit. The two major reactions in the process are disproportionation and transkylation. Disproportionation converts toluene into benzene and xylene; and transkylation converts a mixture of toluene and C_9 – C_{10} aromatics into xylenes and benzene.

The reactor section consists of a feed surge drum, charge heater, reactor, combined feed exchanger, products condenser, products separator, recycle gas compressor and their ancillary equipment. The reaction will take place at a temperature of 368/ 500°C and a pressure of 29 barg.

The stripper section is designed to separate benzene cut from heavier hydrocarbons. The stripper section is fed by:

- Reaction section liquid product
- The isomar stabilizer overhead liquid
- Crude toluene from the parex finishing column
- The reformate from the ORP unit

Overheads from the stripper is cooled and separated into gas and liquid products. The stripper overhead gas is exported to the fuel gas system. The overhead liquid is sent to the stripper at the isomar unit.

The unit will produce point source emissions from the charge heater stack and stripper reboiler heater stack. Condensate from the separator and stripper will be sent to the waste water treatment plant. Solid waste generated once every 6 years from the catalysts (Alumnina/ Mordentite) will be sent for off-site disposal by a licensed waste collector. Regeneration waste gas (vent gas) from the tatoray unit will be produced during catalyst regeneration which occurs once in two years and will be released to the atmosphere. Water generated from the regenerator dryer package during catalyst regeneration will be sent to the waste water treatment plant.

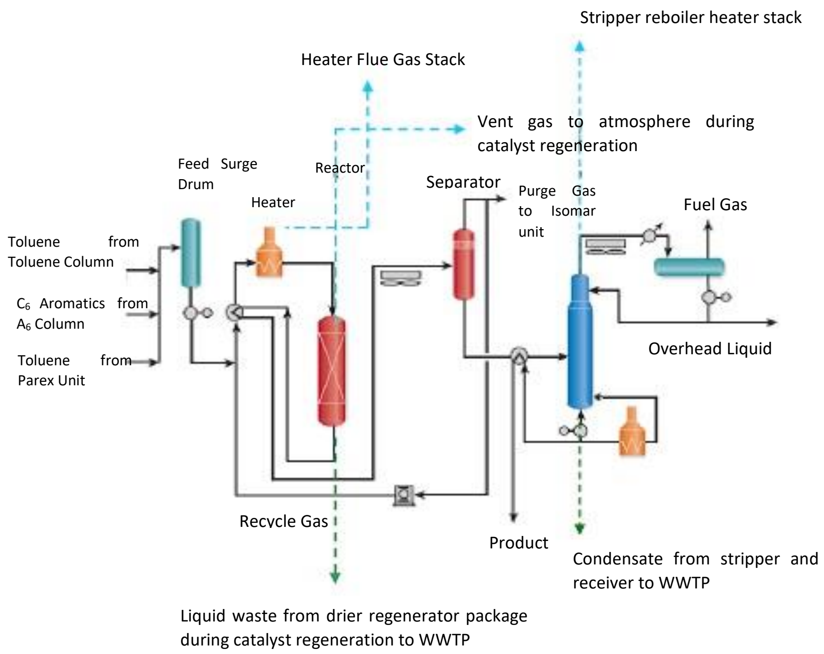


Figure 3.18 – Tatoray Process Unit

Source: UOP

3.6.3.9 Aromatic Fractionation Unit

The aromatic fractionation unit prepares feed for the parex and tatoray units. It also produces a toluene stream, which is fed to the sulfolane unit and the heavy aromatics product stream.

The unit consists of several columns, one each for toluene, xylene and heavy aromatics. Feed to the unit is the tatoray stripper bottoms and the isomar deheptaniser bottoms which is fed to the xylene column together with toluene column bottoms.

Products / Intermediates from the aromatic fractionation unit are:

- Xylene stripper overheads to the parex unit,
- Xylene Rerun Column
- Heavy aromatics column overhead contains C9 and C10 aromatics & is sent to the tatoray unit
- Heavy aromatics column bottoms are the heavy aromatics to be blended with diesel.

The stabilized reformate from the Depentanizer Column is sent to the Reformate Splitter section where the reformate is split into a light reformate stream, predominantly a C6/C7 cut, and C8+ heavy reformate.

The light reformate stream from the Reformate Splitter is taken overhead and sent to the ED Sulfolane Unit where the aromatics in the ED Sulfolane feed are recovered as an extract stream. The non-aromatics are rejected as raffinate stream; this stream is run down to by-product storage and is typically sold as isomerization unit feed, stream cracker feed or bending component. The aromatics-rich extract stream is clay treated and sent to the Benzene-Toluene Column, which also processes the Tatoray Stripper bottoms. The Benzene-Toluene Column is a dividing-wall column that provides the finished benzene product as an upper sidedraw, a toluene-rich stream as a lower sidedraw and a bottoms stream that is reach in $A8_{+}$. The toluene produced in the Benzene-Toluene Column is combined with A9/A10 recycle-comprised of the A8 Rerun Column sidedraw stream and the Heavy Aromatics Rectifier overhead- and is charged to the Tatoray Unit. Toluene desorbent make-up to the Parex unit is also provided by the Benzene-Toluene Column lower sidedraw when needed. The Benzene-Toluene Column bottoms stream is sent to the A8 Stripper.

The tatoray unit processes toluene from the Benzene-Toluene (B-T) column and A9/A10 from the A8 Rerun Column and Heavy Aromatics Rectifier to produce mixed xylenes and benzene. The tatoray unit reactor effluent is sent to the Tatoray Stripper Column, which removes hydrogen and light ends in the overhead vapor and some of the benzene in the overhead liquid. The A6+ Tatoray Stripper bottoms stream is sent to the Benzene-Toluene Column for fractionation of aromatics. The Tatoray Stripper overhead liquid combines with the A_8 Stripper overhead, and the combined stream is sent to stabilizer. The Tatoray Stripper vapor stream is sent to fuel gas.

The A8 Stripper processes the clay-treated heavy reformate from the Reformate Splitter bottoms, the B-T Column Bottoms, and the Isomar Hot and Cold Separator liquid streams. The A_8 Stripper produces a mixed xylenes sidedraw that is sent to the Parex Unit and an A_{9+} bottoms stream that is sent to the A_8 Rerun Column. The C7- overhead from the A8 Stripper is sent to the Stabilizer for recovery of benzene, toluene and fuel gas. The Stabilizer bottoms stream contains benzene and toluene and is sent to the ED Sulfolane Unit for aromatics recovery.

The A_8 Rerun Column is fed by the A8 Stripper bottoms and the A9+ bottoms from the Paraxylene Column. The A8 Rerun Column recovers mixed xylenes from the A8 Stripper bottoms as overhead, and it produces an A9/A10 vapor sidedraw that is sent to the Tatoray Unit and an A11+ bottoms astream that is sent to the Heavy Aromatics Rectifier.

The overhead from the Heavy Aromatics Rectifier, mainly A10, is combined with the A8 Rerun Column A9/A10 sidedraw as feed to the Tatoray. The A11+ bottoms stream from the Heavy Aromatics Rectifier is sent to diesel pool, or alternative uses as required.

The mixed xylenes from the sidedraw of the A8 Stripper are combined with the A8 Rerun Column overhead and set to the Parex Unit. In the Parex Unit, very high purity paraxylene (PX) product is recovered in the extract and paraxylene columns. The extract column is fed by the Parex extract stream, which contains PX and toluene desorbent. The bottoms stream rom the Extract Column is sent to the Paraxylene Column; Paraxylene Column overhead is the finished PX product. The Paraxylene Column bottoms stream contains A9+ with some xylene and is, therefore, returned to the A8 Rerun Column for fractionation of xylenes and A9/A10 from A11+.

The Parex Rafffinate Column is fed by the Parex raffinate stream, which is depleted of PX and contains ethylbenzene (EB), metaxylene (MX), orthoxylene (OX) and toluene desorbent. The Raffinate Column bottoms stream, which contains the PX-depleted xylenes, is sent to the Isomar Unit where xylene equilibrium is re-established and ethylbenzene is dealkylated to benzene. The Isomar Hot and Cold Seperator liquids are fed to the A8 stripper for separation of dissolved light ends, benzene, toluene, mixed xylenes and A9+.

The overhead streams from the Parex Extract and Raffinate Columns recycle the toluene desorbent to the Parex unit. A small desorbent drag stream is taken to the B-T Column, and make-up desorbent is recycled from the B-T Column to the Parex Unit.

3.6.3.10 Parex Unit

The parex unit recovers para-xylene from mixed xylenes, producing 1,505 kMTA of paraxylene at a minimum purity of 99.8%. The feed is the overhead liquid from the Xylene Column. The Unit extracts paraxylene from the feed using the ADS-50/ ADS-50L molecular sieve adsorbent and the toluene desorbent (low density Parex). The unit consists of a continuous adsorption and extract sections, raffiante and desorbent fractionation. Desorbent and plant inventory tanks are also included. The adsorption section consists of two adsorbent chambers.

Paraxylene extract is separated from the desorbent in the extract column. The paraxylene is further purified in the finishing column to final product specifications and initially sent to one of the two weekly tanks and then storage. The finishing column overhead liquid is sent to the stripper column in the tatoray unit. Desorbent is recycled to the adsorption section.

The raffinate is separated from the desorbent in the raffinate column and is then routed to the isomar unit. Desorbent is recycled to the adsorption section. The desorbent rerun column bottoms are routed to the heavy aromatics tank via the heavy aromatics product cooler in the aromatic fractionation unit.

Waste water produced from the raffinate column receiver and the finishing column receiver will be routed to the waste water treatment plant. Solid waste will include spent adsorbent (zeolite) from the adsorbent chambers and will be generated once every 10 years and will be sent for off-site disposal by a licensed waste collector.

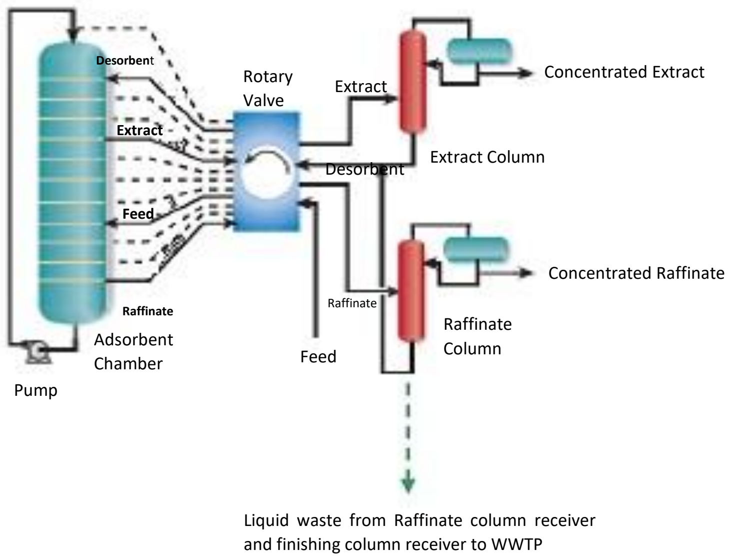


Figure 3.19 – Parex Process Unit
Source: UOP

3.6.3.11 Isomar Unit

The isomar unit increases the efficiency and reduces waste from the PEC facility by converting the raffinate feed from parex unit to a mixed xylene stream for further processing into product in the xylene column. The isomar unit consists of a reactor section and a fractionation section.

The reactor section consists of a catalytic reactor, combined feed exchanger, charge heater, product condenser, products separator, recycle gas compressor, and their ancillary equipment. Makeup hydrogen to the unit is supplied from the tatoray unit and from CCR platforming unit. The feed to the isomar unit is first combined with hydrogen-rich recycle gas and makeup gas to replace the small amount of hydrogen consumed in the isomar reactor. The combined feed is then pre-heated and vaporised by exchange with reactor effluent, and raised to reactor operating temperature (301°C) in a charge heater. The hot feed vapour is sent to the reactor, where it is passed through the catalyst. The reactor effluent is cooled by exchange with the combined feed and is then sent to the product separator.

The fractionation section consists of a deheptaniser column, clay treater, surge drum and their ancillary equipment. The maximum temperature of the deheptaniser column is 146°C and the maximum pressure is 3.4 barg. The liquid hydrocarbons from the product separator are mixed with the mixed xylene and are fed to the deheptaniser column. The deheptaniser removes the C7 minus material to allow the column bottoms material to be charged directly to the xylene column in the aromatic fractionation unit after clay treating.

The deheptaniser overhead liquid is routed to the stabiliser column in the tatoray unit. The deheptaniser column net overhead gas and product separator net gas from the unit is routed to fuel gas. Stripper column net bottoms will be routed to the sulfolane unit.

Waste water with aromatic hydrocarbons generated from the deheptaniser will be routed to the waste water treatment plant. The unit will produce point source emissions from the deheptaniser reboiler and charge heater stacks. Regeneration waste gas is vented to atmosphere during catalyst regeneration. Solid waste will include spent catalyst (Pt on silica-alumina) generated once every 6 years and spent clay and will be sent for off-site disposal by a licensed waste collector.

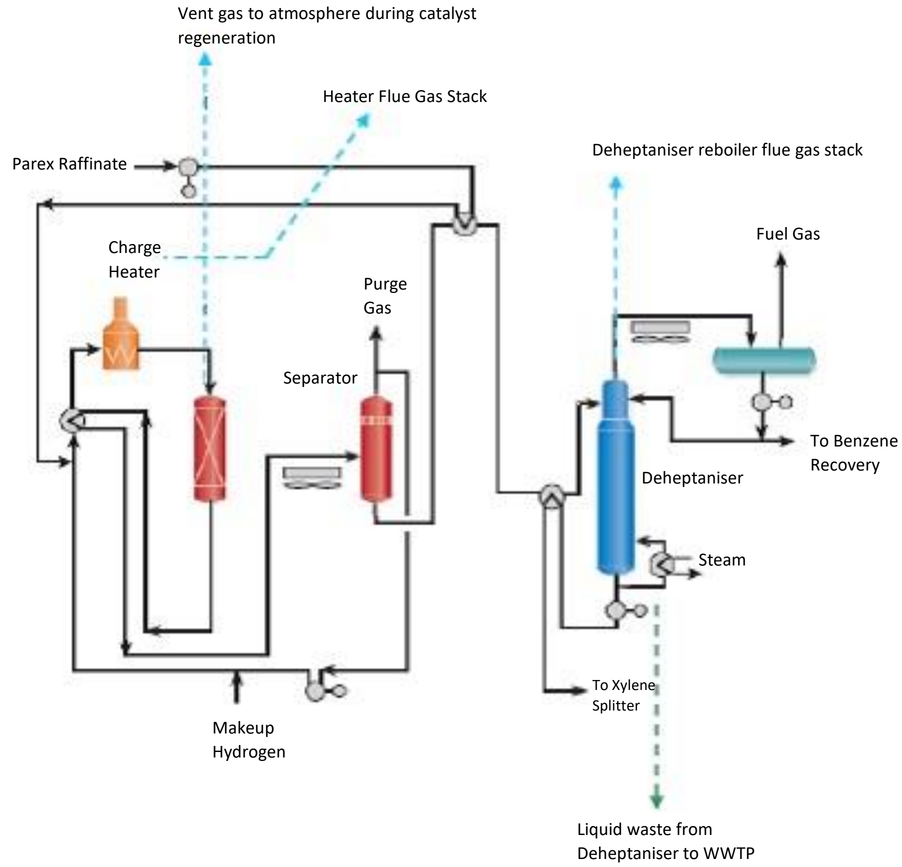


Figure 3.20 – Isomar Process Unit
Source: UOP

3.7 Emissions, Effluents and Waste Inventory

An inventory of principal emissions, effluents and wastes that are expected to be generated during operation of the PEC facility are presented in the following sections. The emission scheme block diagram is presented in *Figure 3.21*. It should be noted that the presented streams are the best estimates on the basis of currently available design information.

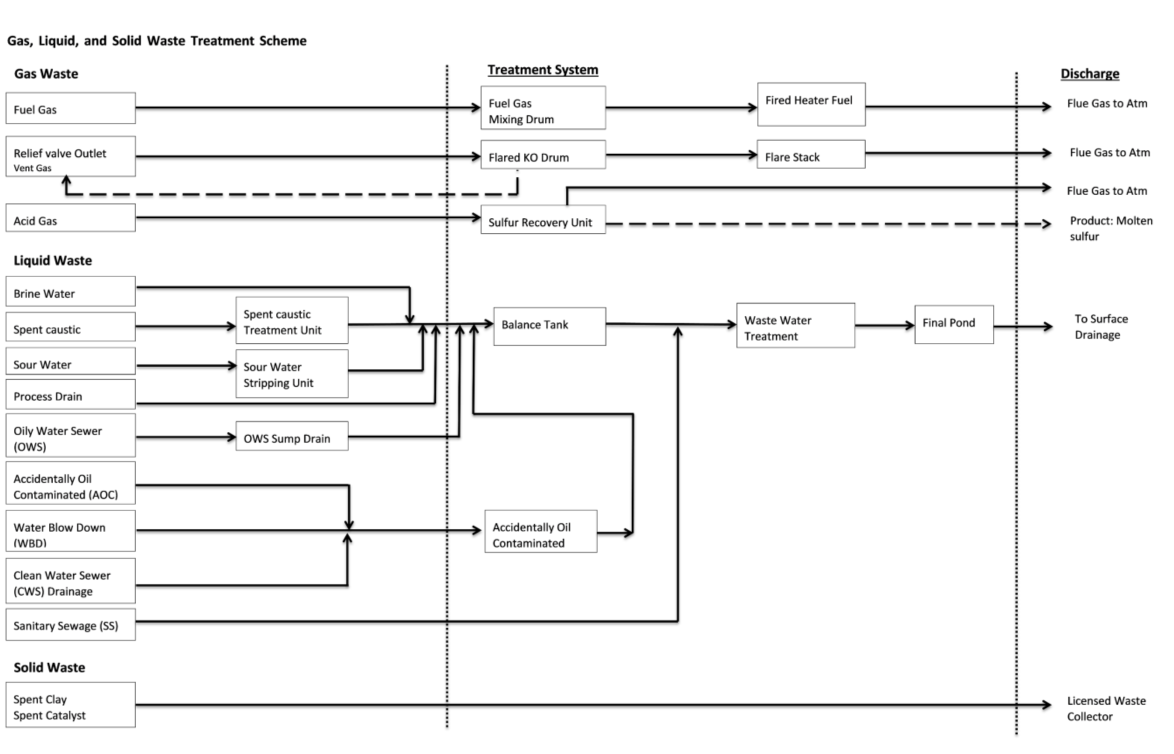


Figure 3.21 – Gas, Liquid, & Solid Waste Treatment Scheme Block Diagram
Source: ChemOne

3.7.1 Air Emissions, Effluents & Waste Inventory

3.7.1.1 Air Emissions Inventory

- 3 no's stacks for 3 steam boilers (2 operational, 1 on standby)
- 1 no's – flare stack
- 10 no's – charge heaters, re-boilers stacks, SRU thermal oxidiser
- 2 no's – vent gases from process areas
- Tankage & fugitives

3.7.1.2 Liquid Effluents Inventory

The principal effluent/discharge streams are from dilution steam blowdown and blowdown from cooling tower. Effluents with aromatic hydrocarbons are generated from majority of the process units, which will be sent to the waste water treatment plant. Sour water, wash water, and spent caustics produced will also be sent to the waste water treatment system and spent caustic (neutralisation) system respectively. The estimated quantity of final treated waste water will be up to a maximum of 2,400 m^3/day.

3.7.1.3 Liquid Waste Inventory

Liquid waste will include laboratory waste water and used contaminated oil. The quantity will be very minimal and trace oil is expected during general washing from laboratory instruments and its ancillaries.

3.7.1.4 Solid Waste Inventory

Generated solid wastes will include coke from steam boiler, waste parts, packaging materials, spent catalyst, and spent clay together with general refuse from offices and canteens. Wastes generated from waste parts, packaging materials, offices and canteens are considered as non-hazardous wastes and all other solid wastes generated will be treated as hazardous waste.

3.7.2 Air Emissions

The continuous emission points with potential air pollutants include (*Table 3.9*):

- **Flare system**: for safety purposes, the facility will install an elevated flare system, to enable emergency flaring of raw materials as pressure relief in abnormal and emergency conditions. Under normal operations, there will be no flaring, however a small pilot flame will be present to ensure combustion of any purge gas and to prevent any hazardous gases venting accidentally into the environment. The tanks and various process equipment (e.g. LPG Merox Unit disulphide separator, naphtha hydrotreating unit stripper receiver and equipment in the sulfolane unit) are connected to the flare knock out drums. The system is described in detail within the relevant section below.
- **Process equipment stacks**: air emissions from reboilers, heaters and other equipment within the process units will be released via nine dedicated individual stacks, and additional 3 stacks will serve 3 steam boilers. It should be noted that natural gas will be used as the fuel for all equipment to minimise emissions and enable compliance with regulatory requirements.

The non-continuous emission points with potential air pollutants include:

- **Emergency flaring**: refer above.
- **Vent gases from regeneration of catalyst**: vent gases from the isomar and tatoray units will take place once every two to three years and will vent non-controlled gases N_2, CO_2 and H_2O, for up to seven days at a time.
- **Diesel generator**: for emergency use only in power outage.
- **Fugitive emissions**: from tanks, pumps and flanges leaks, tank filling, and/or accidents may potentially occur from the filling of the tanks and from the refining processes if safety and leak controls fail. The facility will minimise fugitive emissions wherever practicable through the use of valves, flanges and other such equipment and will follow good design practice and equipment maintenance procedures.

Table 3.9: Sources of Continuous Potential Air Emissions

Source	Main Air Emission	Proposed Abatement Equipment
Flare – Combustion	CO_2, N_2 (Continuous emission of purge gas)	Discharge to flare system STACK 1
Charge Heater – Unit 320-H1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 2
Xylene Splitter Reboiler	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 3
Charge Heater Toluene Column	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 4
Charge Heater – Unit 200-H1 (NHT)	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 5
Charge Heater & NO1 Interheater – CCR Unit 300-H1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 6
Charge Heater & NO1 Interheater	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 7

Source	Main Air Emission	Proposed Abatement Equipment
CCR RCR Vent – Unit 312-ME8	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 8
Feed Fractionator Reboiler – 100-H1 and H2 (combined)	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 9
Combined Feed Heater DHT	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 10
KHT Furnaces – Units 120-H1 and H2	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 11
SRU Thermal Oxidiser – Unit 610-ME1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 12
CRP Vent – Unit 230-ME1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X	Discharge to STACK 13
3 X Steam Boiler	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_X (Continuous)	Discharge to STACKS 14, 15, 16

Table 3.10: Sources of Non-Continuous Potential Air Emissions

Source	Main Air Emission	Proposed Abatement Equipment
Flare Stack – Combustion	NO_X, VOC, CO, SO_2 (Emergency flaring)	Discharge to flare system STACK 1 (elevated flare)
Isomar Unit: Vent gas – regeneration waste gas from Isomar Unit	Vent gas: N_2, CO_2, H_2O (once every three years only)	Vent to atmosphere
Tatoray Unit: Vent gas – regeneration of waste gas	Vent gas: N_2, CO_2, H_2O (once every two years only)	Vent to Atmosphere
LPG Merox Unit: Disulfide separator vent	Vent gas: N_2, O_2, disulfide, mercaptan, hydrocarbon	Discharge to flare system STACK 1
Distillate Unionfining Unit: Ejector receiver	Vent gas: N_2, O_2, H_2S, C_1-C_4, NC6, naphtha, diesel	Discharge to flare system STACK 1
Diesel emergency generator	NO_X, CO, CO_2, SO_X, PM	Vent to Atmosphere
Fugitive emissions	VOC	Vent to Atmosphere

The proposed design of the PEC facility includes measures to collect and treat gases with potential air pollutants as regulated, which will be discussed below. Use of these abatement measures means there will be no potential sources of odour, and summarises the air emission treatment that will be used to ensure compliance.

3.7.2.1 Quality, Rates and Quantities of Air Emissions

The section below provides a summary of emission sources, pollutant, quantity and quality of air emissions. Gaseous emissions are broken down by source. It should be noted that detailed analysis of all expected emissions from the facility is undertaken and presented in the air dispersion study, available in *Appendix C* to this report, the section below summarises those findings.

The facility is designed such that the process outputs from one main section (i.e. condensate splitting section) are utilised in the second main section (i.e. aromatics treatment section). Expected air emissions vary depending on which process unit they are generated by from within the refining process.

Analysis of the expected air emissions, abatement technologies and final emissions is carried out for each process unit. Whenever possible, sources are analysed collectively in order to ensure the emissions derived from the worst-case scenario can be safely collected and treated prior to discharge to the atmosphere. To provide an overview, the maximum flow rates of off gases are presented.

3.7.2.2 Gas Emissions from Flare System (STACK 1) – Prior to Treatment

The facility will incorporate the generally accepted global standard of an elevated flare design of a pressure relief and elevated flare system to safely dispose of hydrocarbons produced during emergency situations. It should be noted that the only emergency situation considered is a complete loss of power to the proposed facility which represents a 'worst case' scenario considered very unlikely ever to occur. SOPs and PEC's ERP will be in place during the operational phase of the project. These documents (and associated training) will cause the control system to minimise the potential flow rates to the flare, ensuring that the maximum figure of 1,500 tonnes per hour (detailed below) will not be reached due to PEC's effective control systems.

Table 3.11: Flare Design and Operational Case Frequencies

Operation Cases	Relieving Rate, T/hr	Frequency	Constituents	Remarks
Normal operation	< 0.5	Continuous	N_2 purge + fugitives	No routine treatment, only fugitives (if present)
Start-up Shut-down	10~50	Once 3~4 years	SO_2, NO_X, CO, PM	Planned, minimize relieving rate & duration by proper operation procedure
Process upsets	< 50	Rare/Unlikely	SO_2, NO_X. CO, PM	Facility malfunction, poor operation skill etc.
Emergency situation	Max 1,500	Very unlikely	SO_2, NO_X, CO, PM	Extremely conservative calculation according to industrial standard, code

The elevated flare will be a minimum of 161 metres in height with a stack diameter of 2.0 metres. During normal operations and start-up/shut down, no small flame may be visible, further any visibility of elevated flare will be minimised via the use of steam injection that will render the flame more transparent whilst also ensuring 100% smokeless combustion is achieved. The smokeless capacity of the elevated flare is 10% of the maximum designed capacity or 150 tonnes per hour and the steam injection capability has been designed to cover up to a two-hour period for any single event.

3.7.2.3 Gas Emissions from Refining Process – Prior to Treatment

Air emissions are generated throughout the normal refining process. These will be generated during operations from various stationary point sources including reboiler stacks, heater stacks and vents.

Table 3.12: Emission Inventory from Different Point Sources

Stack	Estimated Quantity of Emission (kg/hr)						Concentration
	PM	SO_2	NO_X	CO	H_2S	HCl	
Stack 2	0.78	-	3.72	54.75	-	-	All stacks will be fired with low sulphur natural gas. All stacks will meet or be lower than requirements for gaseous emissions under the *Environmental Quality (Clean Air) Regulations 2014*
Stack 3	3.80	-	22.74	288.99	-	-	
Stack 4	1.92	-	9.98	126.86	-	-	
Stack 5	0.80	-	2.41	40.46	-	-	
Stack 6	2.47	-	15.74	192.08	-	-	
Stack 7	1.52	-	9.74	118.90	-	-	
Stack 8	-	-	-	-	-	0.91#	
Stack 9	2.14	-	11.28	133.57	-	-	
Stack 10	0.32	-	0.94	16.95	-	-	
Stack 11	0.32	-	7.06	3.21	-	-	
Stack 12	0.20	5.94	4.36	1.98*	0.30 #	-	
Stack 13	0.21	14.01	2.81	33.88	-	-	
Stack 14	1.23	-	27.05	12.29*	-	-	
Stack 15	1.23	-	27.05	12.29*	-	-	
Stack 16	1.23	-	27.05	12.29*	-	-	

Source: PEC (2019)
Note:
NO_X (Nitrogen Oxides) is conservatively assumed as 100% NO_2 (Nitrogen Dioxide)
Particulate Matters (PM) emission concentration is assumed to meet 5 mg/Nm^3 and PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
* Carbon Monoxide (CO) emission concentration for those indicated is assumed to meet 50 mg/Nm^3
# H_2S and HCl emission concentration is assumed to meet the CAR 2014 prescribed limit of 7.5 mg/Nm^3 and 200 mg/Nm^3 respectively
Volatile Organic Compounds (VOCs) were assumed to undergo complete combustion, negligible residue

3.7.3 Liquid Effluents

The schematic diagram of the wastewater treatment system is shown in *Figure 3.22*. An inventory of liquid effluents generated by the PEC facility is presented in *Table 3.13*. With the exception of effluents treated in the spent caustic treatment system or directed to the DHT feed surge drum, the majority of the effluents will be discharged to on-site waste water treatment plant.

The wastewater treatment process will utilise a Membrane Bioreactor System (MBR). The MBR is a process that combines a membrane ultra / micro filtration process and activated sludge process *Figure 3.24*). The membrane bioreactor facility consists of aerobic tank and anoxic tank. Membrane modules are immersed inside the aerobic tank where organic contents will be biologically degraded by activated sludge. The Mixed Liquor Suspended Solid (MLSS) concentration in the MBR System is 10 to 20 g/L compared to 3 to 4 g/L in conventional activated sludge systems, thus the retention time required is only 30% of conventional system. The membranes also separate suspended solids from liquid through the filtration process. As the pore size of the membrane is 0.1-micron, suspended solids are removed. The immersed membrane filtration process also eliminates the requirement for gravity sedimentation tank or clarifier required by conventional activated sludge systems. Through recirculation of MLSS from the aerobic tank to the anoxic tank, nitrate content is removed. Additional coagulant and flocculant dosing also can be incorporated for phosphorous removal.

Table 3.13: Liquid Effluent Inventory

Source	Nature	Quantity/Flow	Fate/ Comments
Domestic Effluent (Toilet, showers etc)	Domestic effluent	2.6 - 3.4 m^3/hr max flow intermittent	Routed to WWTP and then discharged to the surface drain
Condensate Fractionation Unit	Sour water	4.9 m^3/hr	Discharge routed to WWTP
Condensate Fractionation Unit	Brine water	53.5-m^3/hr	Discharge routed to WWTP
LPG Merox Unit – Caustic heater	Steam Condensate Temperature (max) – 100°C pH – 7 to 9	Continuous, and quantity depends on the amount required to heat 52°C	Discharge routed to WWTP via oily process water sewer
LPG Merox Unit – Sand Filter	Back wash water – various suspended matter	Intermittent Whenever pressure across Sand Filter is >0.14 bar. Flow rate: 0.64 m^3/hr per 1 m^3 of sand for approx. 1 hr	Discharge routed to WWTP via oily process water sewer
LPG Merox Unit	Disulphide oil without wash oil SG @ 38°C 1.0 (approx) Sulfur, wt-% 20-50 Color: Water white to pale green	Batch 1.7 L/kg of mercaptan S in feed.	To feed of DHT feed surge drum
LPG Merox Unit	Spent Caustic (prewash) % Spent: 50-70 Total alkalinity, wt-% NaOH: 6-7 Strong Alkalinity, wt-% NaOH: 2-3 Total S, wt-% 3-4 Mercaptide, wtppm S: trace Sodium Bisulphide (NaHS),wt-% 3-4 Sulphide (Na2S), wt-%: 3-4 Undissolved oil, vol-%: <1 Acid Oils, wt-%: 0-10 (*) Merox Catalyst (from Extrac Spent Caustic), wtppm 0-250	One-half of Caustic prewash vessel volume when caustic becomes 50-70% spent. Consumption in approx. 1.7 kg NaOH per kg H_2S in feed	Discharge routed to the spent caustic (neutralization) treatment system
LPG Merox Unit	Spent Caustic (extraction) % spent: 10-20 Total alkalinity, wt-% NaOH: 12-16 Strong Alkalinity, wt-% NaOH:	Batch (weekly or monthly): 11 kg NaOH per 1,000 m^3 per 1,000 wtppm RSH-S	Discharge routed to the spent caustic (neutralization) treatment system

Source	Nature	Quantity/Flow	Fate/ Comments
	10-12 Total S, wt-%: <1 Na2SxOy Mercaptide, wtppm S: 100 Sulphide (Na2S),wtppm <1 Disulphide, wtppm S: 50-200 Undissolved Oil, vol-% <1 Acid oils, vol-% 0-10(*) Merox catalyst, wtppm : 0-250	(mercaptide sulphur) Based on 10% spent from CO_2 or when diluted to a minimum 12% total alkalinity by water of reaction	
Distillate Unionfining (KHT) Unit	Amine waste water Sour Water	Not Applicable (NA)	To amine treatment unit/ to sour water stripper
Distillate Unionfining (DHT) Unit	Amine waste water Sour Water	NA	As above
AROMATICS PROCESS WASTE WATER			
Naphtha Prefractionation Unit	Water with hydrocarbon 18 mg/L propane, 276 mg/L butanes & 8 mg/L pentanes	0.85 m^3/hr max continuous	Discharge routed to WWTP Intermittent flow from the debutanizer receiver. Estimated duration of 8 hrs and on an occurrence of once per year .[(1)]
Naphtha Hydrotreating Unit	Water with 11mg/L NH_3 max, 2mg/L H_2S max, trace NaCl & trace hydrocarbon BOD = 100 mg/L COD = 250 mg/L Waste water with Mercury and Arsenic Condensate from the stripping unit Sour water	14 m^3/hr normal flow intermittent NA NA NA	Discharge routed to off-site WWTP. Continuous discharge from water washing of the NHT combined Feed Exchanger.[(1)] Rerouted back to CRP To condensate collection – back to boiler feed water system to sour water stripper
CCR Platformer	Water with NH_4Cl & trace hydrocarbons BOD = 100 mg/L COD = 250 mg/L	24.2 m^3/hr max flow intermittent	Discharge routed to WWTP. Occurs when the debutaniser column is flushed to remove salts. Estimated duration of 1.5hrs, occurs once every 3 months.[(1)]
Parex Unit – Raffinate column receiver	Water with aromatic hydrocarbons (0.11 wt%)[2] BOD = 1,692 mg/L COD = 3,385 mg/L	0.24-6.8 m^3/hr max flow intermittent	Discharge routed to WWTP. Intermittent production – on pump controlled. Estimated duration of 9 mins at max flow rate and

Source	Nature	Quantity/Flow	Fate/ Comments
			occurs one every 4 hours. (1)
Parex Unit– Finishing Column receiver	Water with aromatics (0.13wt%)[2] BOD = 2,000 mg/L COD = 4,000 mg/L	0.06- 5.0 m^3/hr max flow intermittent	Discharge routed to WWTP. Intermittent production – on pump controlled. Estimated duration of 4 mins at max flow rate and occurs one every 4 hours. (1) (2)
Isomar Unit – Deheptaniser	Water with aromatics (0.32 wt%)[2] BOD = 4,293 mg/L COD = 9,846 mg/L	0.44-0.88 m^3/hr max flow continuous	Discharge routed to WWTP. Normal flow is continuous. Max rate occurs during clay treater dry out, this occurs once every 4-6 months and for a period of 6 days. (1)
Sulfolane Unit – Ejector Condensate Drum	Water with aromatics (0.32 wt%)[2] BOD = 4,293 mg/L COD = 9,846 mg/L	0.48-1.94 m^3/hr max flow continuous	Discharge routed to WWTP. Normal flow is continuous. Max rate occurs during start up and it occurs for a period of 24 hours. (1)
Sulfolane Unit – Solvent regenerator bottoms	Sulfolane solvent with aromatics, polymers, inorganic solids and water.	11 m^3/batch (approximately once every 6 months)	Removed on a batch basis. Frequency depends on oxygen ingress to unit. Low oxygen ingress results in reduced frequency of dumping regenerator. Waste will be disposed off-site by a DOE- licensed waste collector
Sulfolane Unit	Sour water	NA	To sour water stripper
Benzene – Toluene Fractionation Unit	Water with aromatics (0.28 wt% Benzene) BOD = 4,000 mg/L COD = 8000 mg/L	0.16-1.3 m^3/hr max flow continuous	Discharge routed to the WWTP
Clay Treators Benzene Toluene Area	Water	5 m^3/hr intermittent	Discharge routed to WWTP. Average flow duration is 12 mins and occurs every 3 hours. Max rate occurs during clay treater steamout. Occurs once every 6 months and for a period of 6 days. (1)

Source	Nature	Quantity/Flow	Fate/ Comments
Tatoray – Regenerator Drier Package	Water	0.3 m^3/hr intermittent	Discharge routed to WWTP. Intermittent production from gas dryer package. The dryer package will operate approximately 15 days every year during regeneration of the catalyst.
Tatoray Unit	Condensate from stripper and receiver	NA	To condensate collection system
Clay Treators Xylene Area	Water	7.5 m^3/hr intermittent	Discharge routed to WWTP . Average flow duration is 12 mins and occurs every 3 hours. Max rate occurs during clay treater steamout. Occurs once every 6 months for a period of 1 day [(1)]
Process Tanks in Aromatics Area (Tankfarm Rundown)	SS = Max 100 mg/L Total Oil = 50-500mg/L N-NH_3 =5-25 mg/L BOD = 100-2,500 mg/L COD = 250-5,000 mg/L	3 m^3/hr continuous	Figure of 1 m^3/hr developed from data equivalent aromatic facilities. Discharge routed to WWTP
Aromatics Complex (Stormwater)	BOD = 50 mg/L (max)	14,820 m^3/hr intermittent	Discharge routed to WWTP
Aromatics Complex (Firewater)	-	3,772 m^3/hr intermittent	Based on largest firewater demand of 4190 m^3/hr and assuming a 10% evaporative loss. 3,772 m^3/hr are expected to enter the drains over a 4 our period. Discharge routed to WWTP
Washdown of Process Paved Areas	-	13.6 m^3/hr intermittent	Discharge routed to WWTP
Maintenance Flows	-	135 m^3/hr intermittent	Vessels will be steam-cleaned during maintenance, therefore discharge of aqueous effluent has been considered to be small. Discharge routed to WWTP

Source	Nature	Quantity/Flow	Fate/ Comments
Dumped Condensate	-	250 m^3/hr intermittent	Max flow based on worst case condition when the largest single condensate stream could be dumped due to contamination, for example. Flow estimated from UOP estimated utility requirements. Discharged to and recovered in a deaerator and sent to boiler as feed
Storage Tank Bunds	-	80 m^3/hr intermittent	Discharge routed to WWTP

Notes: (1) Data taken from List and Characteristics of Emissions and Effluents (3282-VZ- LS-T00523)
(2) Aromatics hydrocarbon content assumed to be Benzene for calculation of Theoretical Oxygen Demand (ThOD)
(*) Feedstock dependent

3.7.4 Solid Wastes

An inventory of scheduled wastes and general wastes from the PEC process areas is provided in *Table 3.14* and *Table 3.15*, respectively.

Table 3.14: Scheduled Waste Inventory

Source	Pollutant	Scheduled Waste Code	Quantity	Fate/ Comments
LPG Merox Unit – Sand Filter	8-16 mesh quartz of silica sand	SW 410 Rags, plastics, papers or filters contaminated with scheduled wastes	Intermittent m^3=0.137 x m^3/hr feed, every 5 yrs or longer	Sent to DOE licensed waste collector
(DHT) Unit – Salt drying beds	Solid waste		138,000	
Xylene fractionation Unit – Clay Treaters	Spent Clay		375.6 m^3	Waste generated once every 6 to 12 months.
Benzene Toluene Fractionation Unit – Clay Treaters	Spent Clay		643 m^3	Waste generated once every 6 to 12 months.
CRP	Spent Adsorbent		75 x 2 m^3	Waste generated once every 3 years.
CCR Platforming Process Unit – Net gas chloride Treaters	Spent Adsorbent (Activated alumina)		174 m^3	Waste generated once every 6 months.
Parex Process Unit – Adsorbent chambers	Spent Adsorbent (Zeolite)		3,082 m^3	Waste will be generated once every 10 years.
CCR Platforming Process Unit –	Spent Catalyst (Pt	SW 202 Waste catalysts	813.4 m^3	Waste generated once every 4 years.

Source	Pollutant	Scheduled Waste Code	Quantity	Fate/ Comments
Reactors	and other modifiers on alumina)			
Isomar Process Unit – Reactor	Spent Catalyst (Pt on silica – alumina)		125 m^3	Waste generated once every 10 years.
Tatoray Process Unit – Reactor	Spent Catalyst (Alumina/ Mordentite)		406.4 m^3	Waste generated once every 10 years.
Distillate Unionfining (KHT) Unit	Spent Catalyst		16,677 kg	Waste will be sent for off-site disposal by a licensed waste collector.
Distillate Unionfining (DHT) Unit	Spent Catalyst		56,117 kg	Waste will be sent for off-site disposal by a licensed waste collector.
Naphtha Hydrotreating Unit	Spent Catalyst		99 m^3	Waste generated once every 3 years.
Platforming Unit – Fines Collection Pot	Pt and other modifiers on Alumina		20 kg/day	Waste will be sent for off-site disposal by a licensed waste collector.

Table 3.15: General Waste Inventory

Source	Estimated Quantity	Fate/ Comments
Waste parts and packaging materials	1,000 kg/day	Waste will be disposed off-site by a licensed waste collector or will be returned to suppliers
Office wastes	100 kg/day	Waste will be disposed off-site by a licensed waste collector

3.8 Noise

Primary noise sources within the production facilities will include:

- Flare;
- Pumps;
- Coolers;
- Condensers;
- Compressors and steam turbines.

Apart from safety and health related requirements, the environmental requirement is a maximum noise level of 75dBA (daytime) and 65dBA (night time) at the site perimeter.

3.9 Utilities to be Constructed and Operated by PEC

In addition to the Process Areas described above, PEC will also set up the wastewater treatment plant, steam boilers, instrument air/plant air system, liquid nitrogen tank with vaporizer, potable water system and flare system. Buildings as listed in *Table 3.1* such as warehouse, etc. will also be constructed for use during the operations of the PEC facility.

3.9.1 Wastewater Treatment

All wastewater from the PEC facility will be treated in the on-site wastewater treatment plant (WWTP) and discharged after treatment to the surrounding PIP storm drainage system (*Figure 3.22*). The streams being treated include aromatic contaminated process effluent; heavily contaminated OWS and neutralised spent caustic and slop water.

Spent caustic will be directed into the Spent Caustic Treatment Unit while sour water will be treated in the Sour Water Stripper Unit prior to being sent to the WWTP. Brief descriptions of these treatment units are presented below.

Spent Caustic Treatment Unit

Spent caustic streams from the downstream of the oil and gas industry consist of very high Chemical Oxygen Demand (COD) levels and several other hazardous contaminants such as sulfides, mercaptans, sodium salts etc. According to the Seyedin, *et. al* (2018), the common treatment processes for spent caustic include chemical oxidation, neutralisation, dilution treatment and wet air oxidation (WAO). PEC will utilise the neutralisation treatment.

In the direct acid neutralisation treatment process, the spent caustic wastewater is acidified to release acidic components that were captured in the alkaline caustic solution. Sulphuric acid (98%) and hydrochloric acid are typically used. This results in sulphides and mercaptans being released as acid gases and naphthenic acids to be sprung as an oil layer.

Each spent caustics including mercaptides or sulphides may be oxidised before neutralisation to minimise COD of the final wastewater brine and sulphur amount of the neutraliser off-gas. The control of pH in the neutralisation stage is critical because the metallurgy is not designed for low pH operation (below 6). It is also important to minimise the production of gases such as H_2S from any remaining Na_2S and CO, from sodium carbonate. Any mercaptans released in the neutraliser will also result in a highly odorous brine solution.

The wastewater will then be sent to the wastewater treatment plant for further treatment.

Sour Water Stripper

The stripping process uses a gas stream to force both the hydrogen sulphide (H_2S) and ammonia (NH_3) out of the solution and into the gas phase for further treatment. Although air stripping can be used, steam stripping (which liberates more H_2S due to higher temperatures) is typically required in refinery sour water treatment to meet specifications for the stripped water.

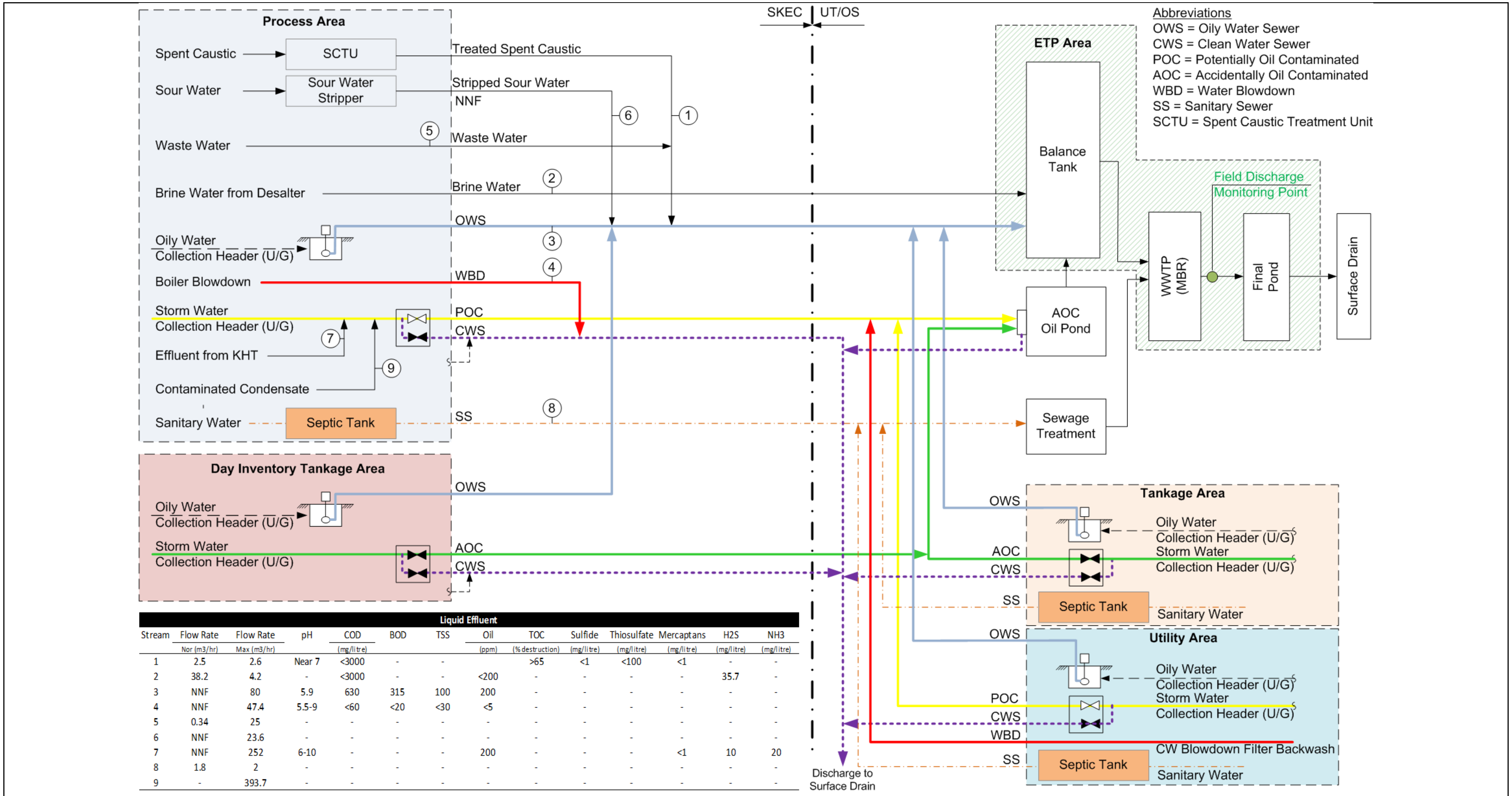
There are three distinct processing steps in the sour water stripping process: degasification, hydrogen (acid-gas) stripping and ammonia stripping.

During the degasification stage the sour water feed from the plant is cooled and fed to a degasser where dissolved hydrogen, methane and other light hydrocarbons are removed. These removed gases are known as sour gas and are pumped off to the Sulphur Recovery Unit (SRU). This degassed sour water is pumped into a storage tank that serves to dampen the flow rate and facilitates removal of entrained oil and solids.

The next step in the process is known as hydrogen sulphide stripping. The degassed sour water is fed to the acid gas or hydrogen sulphide stripper, which is a steam-reboiled distillation column.

The hydrogen sulphide, which is stripped overhead, is of high purity – an excellent feed for sulphur recovery units or sulfuric acid plants.

Next, the hydrogen sulphide stripper stream, containing all the ammonia in the feed water and some hydrogen sulphide, is fed directly to the ammonia stripper, which is a refluxed distillation column. In this column, essentially all ammonia and hydrogen sulphide are removed from the water. After exchanging heat with the hydrogen sulphide stripper feed, the stripped water is cooled and sent to the wastewater treatment plant.



Liquid Effluent

Stream	Flow Rate	Flow Rate	pH	COD	BOD	TSS	Oil	TOC	Sulfide	Thiosulfate	Mercaptans	H2S	NH3
	Nor (m3/hr)	Max (m3/hr)		(mg/litre)			(ppm)	(% destruction)	(mg/litre)	(mg/litre)	(mg/litre)	(mg/litre)	(mg/litre)
1	2.5	2.6	Near 7	<3000	-	-		>65	<1	<100	<1	-	-
2	38.2	4.2	-	<3000	-	-	<200	-	-	-	-	35.7	-
3	NNF	80	5.9	630	315	100	200	-	-	-	-	-	-
4	NNF	47.4	5.5-9	<60	<20	<30	<5	-	-	-	-	-	-
5	0.34	25	-	-	-	-	-	-	-	-	-	-	-
6	NNF	23.6	-	-	-	-	-	-	-	-	-	-	-
7	NNF	252	6-10	-	-	-	200	-	-	-	<1	10	20
8	1.8	2	-	-	-	-	-	-	-	-	-	-	-
9	-	393.7	-	-	-	-	-	-	-	-	-	-	-

Figure 3.22 – Schematic Drawing for Drainage and Effluent System

3.9.1.1 Process Area – Liquid Effluent

The typical flowrates from the main process and the weekly tank areas of the plant are shown below.

Table 3.16: Liquid Effluent Flow Rate

Stream	Flow Rate (m^3/hr)		Remark
	Normal	Max	
Oily Water Sewer	0.7	112	Routed to WWTP (Balance Tank) via OWS Sump
Waste Water	0.476	35	Routed to WWTP (Balance Tank)
Brine Water from Desalter	53.48	58.8	Routed to WWTP (Balance Tank)
Treated Spent Caustic from Spent Caustic Treatment Unit	6.3	7	Routed to WWTP (Balance Tank)
Stripped Sour Water		33.04	Normally No Flow Routed to WWTP (Balance Tank)
Water Blowdown Drain	33.18	66.36	Waste Boiler Blowdown Discharge to Surface Drain via CWS
Contaminated Condensate		551.18	Routed to WWTP (Accidental Oil Contaminated Pond) via POC
Sanitary Sewer	1.96	2.8	Routed to Sewage Treatment Plant
Clean Water Sewer		22,948.80	Discharge to Surface Drain
Potentially Oil Contaminated		196,980	Routed to ETP (Accidently Oil Contaminated Oil Pond)

Table 3.17: Week and Inventory Tankage Area

Stream	Flow Rate (m^3/hr)		Remark
	Normal	Max	
Oily Water Sewer	-	10.0	Routed to WWTP (Balance Tank) via OWS Sump
Clean Water Sewer	-	1,570	Discharge to Surface Drain
Accidentally Oil Contaminated	-	100	Routed to WWTP (AOC Oil Pond)

Please note that the values in *Table 3.16* and *Table 3.17* are approximations only. The actual values will be submitted along with the EMP for operational phase to the DOE prior to the start of operations.

3.9.1.2 Wastewater Treatment Plant

The WWTP consists of three major units, namely:

- Balancing Tank;
- Membrane Bio-reactor Treatment System (MBR); and
- Final Bio-pond.

Balancing Tank

Balancing Tank is also known as equalization tank or EQ Tank. As the flowrate and composition of the wastewater from the different process areas varies, all the wastewater streams will be directed into the Balancing Tank prior to being treated in the WWTP. Balancing tanks are intended to supply a secondary biological treatment system with a uniform flow of wastewater to allow more stable operating conditions. In this way, equipment may be sized to the average flow rather than to a peak flow. The balancing tank will have sufficient volume to permit a nonuniform flow of wastewater to be collected, mixed and pumped forward to a treatment system at a more uniform rate (*Figure 3.23*). Pumping is controlled by level sensors and its rate will vary according to the depth of liquid in the balancing tank.

The balancing tank will be mixed to prevent the settlement of solids and to ensure that the wastewater quality is as uniform as possible. To prevent anaerobic conditions and odours developing prior to treatment, the contents of the balancing tanks will also be aerated. A typical 500 m^3 balancing tank might require a constant mixing load of about 7 kW and an intermittent pumping load of 5 kW.

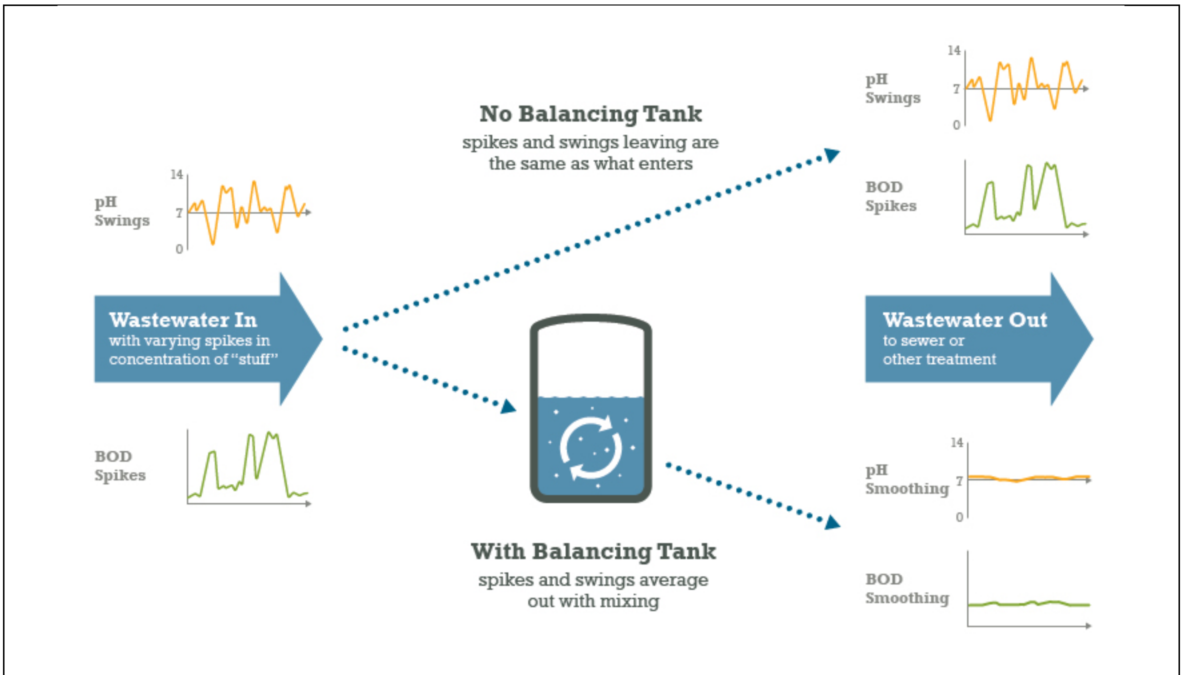


Figure 3.23 – Balancing Tank

Membrane Bio Reactor (MBR)

The wastewater treatment process will utilise a Membrane Bioreactor System (MBR). Industrial wastewater contains large amounts of suspended solids, high organic content and potential toxic substances. MBR is one of the efficient wastewater treatment technology which combines membrane separation and bioorganic technology in the system. MBR technology is characterised as a combination of biological wastewater treatment and membrane separation, by which biomass can be retained in the system without conventional gravity sedimentation. The process of MBR involves the use of both:

1. Suspended growth bioreactor for biochemical reaction (fermentation, bio-oxidant, nitrification and denitrification); and
2. Membrane separator for subsequent solids-liquid separation.

The typical MBR Process Flow Diagram is shown in *Figure 3.24*.

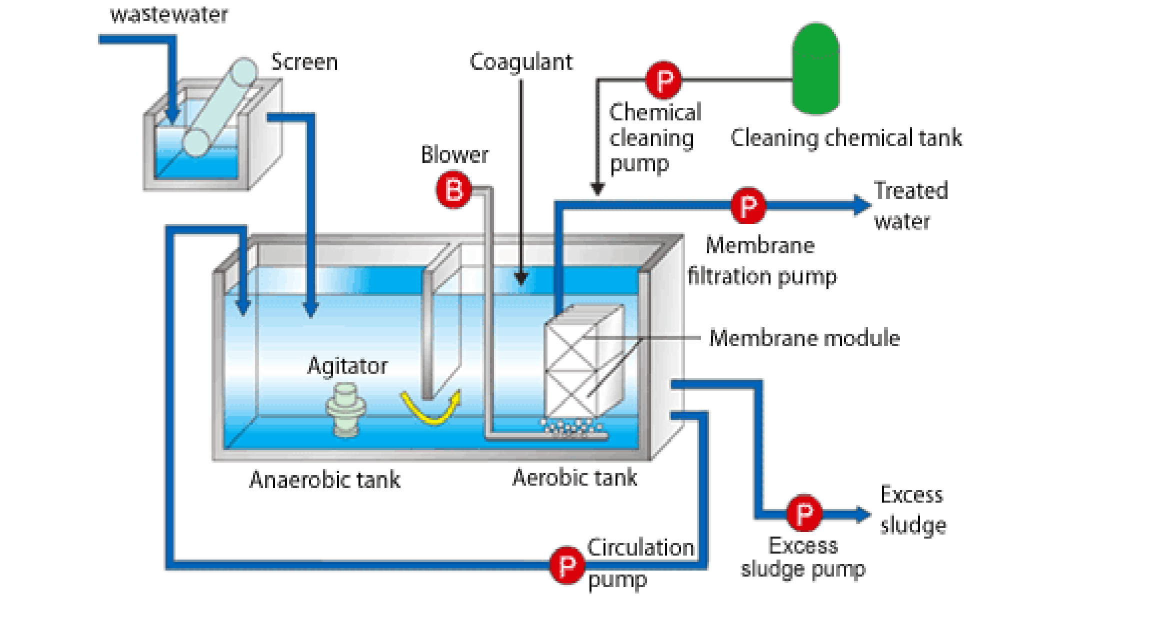


Figure 3.24 – Membrane Bioreactor System (MBR) General Process Flow Diagram
Source: Hitachi

The MBR facility will comprise an aerobic and an anaerobic/ anoxic tank. Membrane modules are immersed inside the aerobic tank where organic contents will be biologically degraded by activated sludge. The Mixed Liquor Suspended Solid (MLSS) concentration in the MBR system 10-20 g/L compared to 3-4 g/L in conventional system. The membranes also separate suspended solids from liquid through the filtration process. As the pore size of the membrane is typically 0.1-micron, suspended solids are removed. The immersed membrane filtration process also eliminates the requirement for gravity sedimentation tank or clarifier required by conventional activated sludge systems. Through recirculation of MLSS from aerobic tank to anaerobic/anoxic tank, nitrate content is removed. Additional coagulant and flocculant dosing will also be incorporated for phosphorous removal.

The contaminants that can be removed by using MBR are:

- Temperature (20 – 30°C);
- Ammoniacal Nitrogen (96 – 98%);
- Suspended solids (100%) – by using micro/ ultra-filtration membranes combined with anaerobic reactors;
- COD (98%) – by using micro/ ultra-filtration membranes combined with anaerobic reactors;
- Turbidity; and
- pH (6.8 – 7.6).

The removal efficiency depends on the types of membranes used for filtration. Typical membrane elements and cassette are shown in *Figure 3.25*. One of the main advantages of MBR systems is 100% removal of suspended solids from the effluent. MBR systems are also well suited for treating high strength wastewater with COD and BOD loads up to 13,000 mg/L and 6,500 mg/L, respectively.

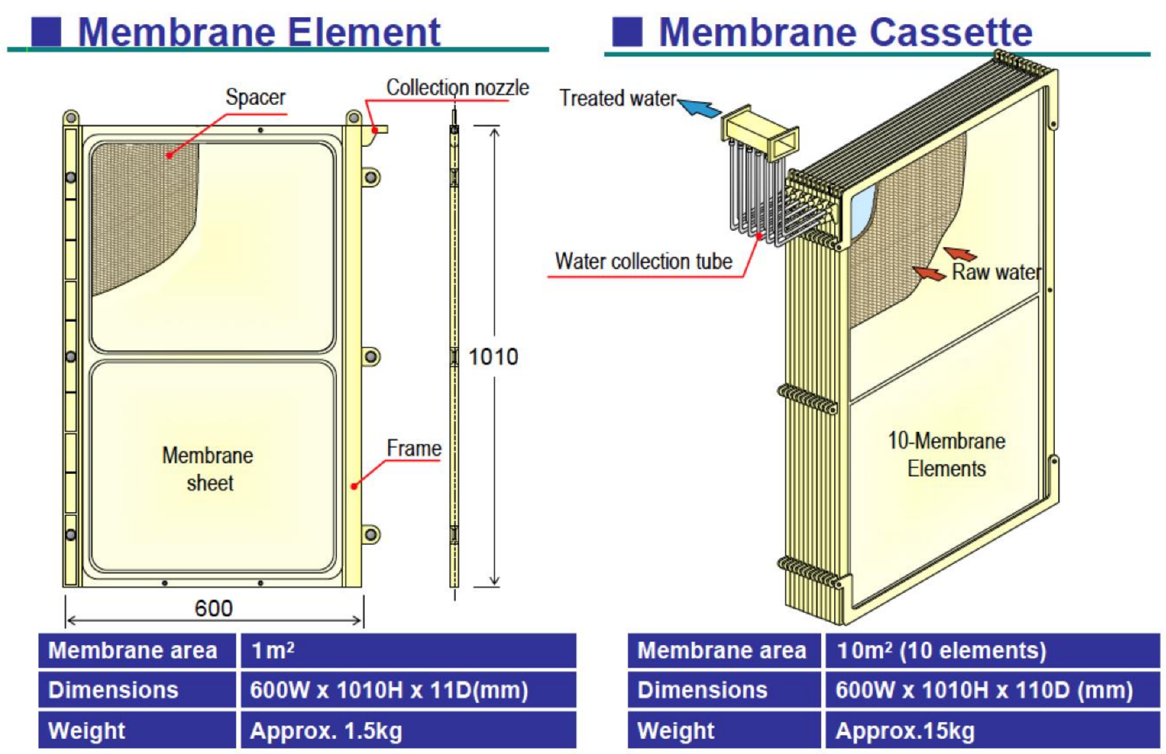


Figure 3.25 – Typical Membrane Element and Membrane Cassettes

A typical MBR effluent quality after treatment is shown in *Table 3.18* below.

Table 3.18: Typical MBR Effluent Quality

Parameter	Units	Typical Concentration	Standard A*
Effluent BOD	mg/L	<5	20
Effluent COD		<30	-
Effluent NH_3		<1	10
Effluent Total N		<10	-
Effluent Turbidity	NTU	<1	-
Effluent Phosphorus	mg/L	<0.5	-

For heavy metals in wastewater, a study was conducted to determine the removal efficiency of MBR. Based on the study, the average removal of metals/ metalloids by MBR was as follows:

- <30% for B, Ba, Al, Ni, Se and Zn;
- 40 – 70% for Pb, Hg, Cu, Ag, Cr and Co; and
- >70% for Fe.

Details of the removal efficiencies of heavy metals and the frequency of occurrence in petrochemical industry are as shown in *Table 3.19* below.

Table 3.19: Metal Occurrence and Removal of Metals/ Metalloids in MBR

Metal/ Metalloid	Frequency of Occurrence (%)	Influent Concentration (aver. ± var. coef.) (µg/L ± %)	Removal (aver. ± var. coef.) (%± %)	Standard A* (mg/L)
Al	100	74.90 ± 77.3	27.0 ± 32.6	10
Ag	5	0.27 ± 27.0	54.5 ± 6.5	-
As	91	2.38 ± 36.2	18.8 ± 25.6	0.05
Ba	100	20.12 ± 55.5	20.2 ± 26.7	1.0
Be	0	<0.50 ± 0.0	-	-
B	100	302.07 ± 68.9	17.2 ± 26.7	1.0
Cd	0	<0.50 ± 0.0	-	0.01
Co	21	0.33 ± 51.6	40.1 ± 32.3	-
Cr	98	11.81 ± 71.3	62.3 ± 32.4	0.20
Cr (VI)	0	<1	-	0.05
Cu	94	4.25 ± 87.8	41.4 ± 31.8	0.20
Fe	100	889.44 ± 61.6	85.0 ± 14.3	1.0
Hg	79	0.23 ± 58.2	52.1 ± 29.1	0.005
Mn	100	22.50 ± 55.8	66.3 ± 26.0	0.20
Mo	100	8.70 ± 34.8	13.6 ± 22.8	-
Ni	97	4.37 ± 72.1	25.0 ± 30.2	0.20
Pb	97	2.25 ± 110	45.4 ± 37.1	0.10
Sb	21	0.62 ± 38.9	38.1 ± 32.9	-
Se	56	4.28 ± 51.1	9.2 ± 23.1	0.02
Sn	72	1.54 ± 75.1	42.3 ± 31.2	0.20
Tl	0	<0.50 ± 0.0	-	-
Te	0	<0.50 ± 0.0	-	-
V	98	4.08 ± 82.5	31.3 ± 28.8	-
Zn	99	33.53 ± 77.1	28.2 ± 32.6	2.0

*Note: * means Standard A of the Acceptable Conditions for Discharge of Industrial Effluent or Mixed Effluent of Standards A and B, Environmental Quality (Industrial Effluent) Regulations 2009.*

The study for heavy metals removal was conducted by using the pilot MBR where the influent concentration is similar to the levels that usually occur in municipal wastewater treatment plants.

The typical properties of the wastewater going into the PEC WWTP (after the Balancing Tank) during normal operations are as follows:

Table 3.20: Typical Wastewater Properties

Typical Wastewater Properties (Normal Operations)	
Parameter	**Load**
Average Chemical Oxygen Demand	750 mg/L
Total Nitrogen (N)	100 mg/L
Total Dissolved Solids (TDS)	5,000 mg/L
Sulfate (SO_4)	500 mg/L
Total Suspended Solids (TSS)	250 mg/L
Oil and Grease	10 – 20 mg/L
pH	6 -9

The WWTP however, will be designed as follows (note that some parameters are designed to handle a higher load than what are expected normally):

Table 3.21: WWTP Design Basis

WWTP Design Basis	
Feed Rate	100 m^3/h
Operating Pressure:	3.0 kg/cm^2-g (min) 3.5 kg/cm^2-g (normal) 4.0 kg/cm^2-g (max)
Temperature	35° C (normal) 40° C (max)
Parameter	**Load**
Average Chemical Oxygen Demand	1,000 mg/L
Total Nitrogen (N)	100 mg/L
Total Phosphorus	30 mg/L
Total Dissolved Solids (TDS)	5,000 mg/L
Sulfate (SO4)	500 mg/L
Total Suspended Solids (TSS)	250 mg/L
Oil and Grease	100 mg/L
pH	6 – 9

Treated waste water is discharged to the on-site final bio-pond, which will have a holding volume of 10,000 m^3, prior to discharge to the PIP detention pond. The sludge generated from waste water treatment is periodically collected and disposed of as scheduled waste by a DOE-licensed waste collector, off-site.

3.9.2 Steam Boilers

To enable steam production to support the manufacturing process PEC will operate 3 Steam Boilers (2 operating continuously and 1 on standby). Each boiler will have a capacity of 220 t/hr producing 45 kg/cm^2 high pressure steam with firing by natural gas. Each boiler will have an individual stack (Modular Boiler system envisaged). Each stack height is estimated to be ~40 m with a stack diameter of ~2.6 m.

3.9.3 Instrument and Plant Air System

The instrument and plant air system consist of four non-lubricated (oil free) motor driven centrifugal compressors, each having a capacity of 4,500 Nm^3/hr. To ensure an uninterrupted supply of instrument air, normally three compressors will work to cater for the instrument and plant air requirement. Another one motor driven compressor will be on stand-by.

3.9.4 Nitrogen System

Nitrogen is required continuously for tank blanketing, for operation of CCR catalyst regeneration and to other process units. Nitrogen will be supplied from an external supplier with a normal pressure of 9° barg and 99.7% purity. The normal supply temperature shall be 20°C min and 40°C maximum.

3.9.5 Pressure Relief and Flare System

The design philosophy for the aromatics complex, is one of no continuous flaring of process gases, to minimise atmospheric emissions. However, a permanent pilot flame will burn continuously to ensure that successful ignition takes place in the event of plant upset or an emergency. For safety reasons, the flare piping network will be continuously purged with fuel gas or nitrogen.

A common flare header, single 161m high flare stack and associated facilities are provided for safe disposal of relief valve discharges, depressurizing loads, vents and excess gaseous products from the process plant and offsites and utilities. Vent lines condensate fractionation unit, NHT/CCR platforming unit, sulfolane/B-T extraction unit, xylene fractionation/ parex, tatoray, isomar units, tankages all run to the flare knockout drums. Total peak flare capacity of 1,500 MT/hr is expected.

Smokeless operation shall be provided for flare load up to 10% of the maximum load, using steam injection. Liquid hydrocarbons recovered in the flare knockout drum are pumped via the flare knockout drum cooler to the slop oil tank. Water from the flare seal drum is sent to the Oily Water Sewer. The maximum flaring period will be 30 minutes during electric power failure and instrument failure. See *Figure 3.26* below for the Flare System Diagram.

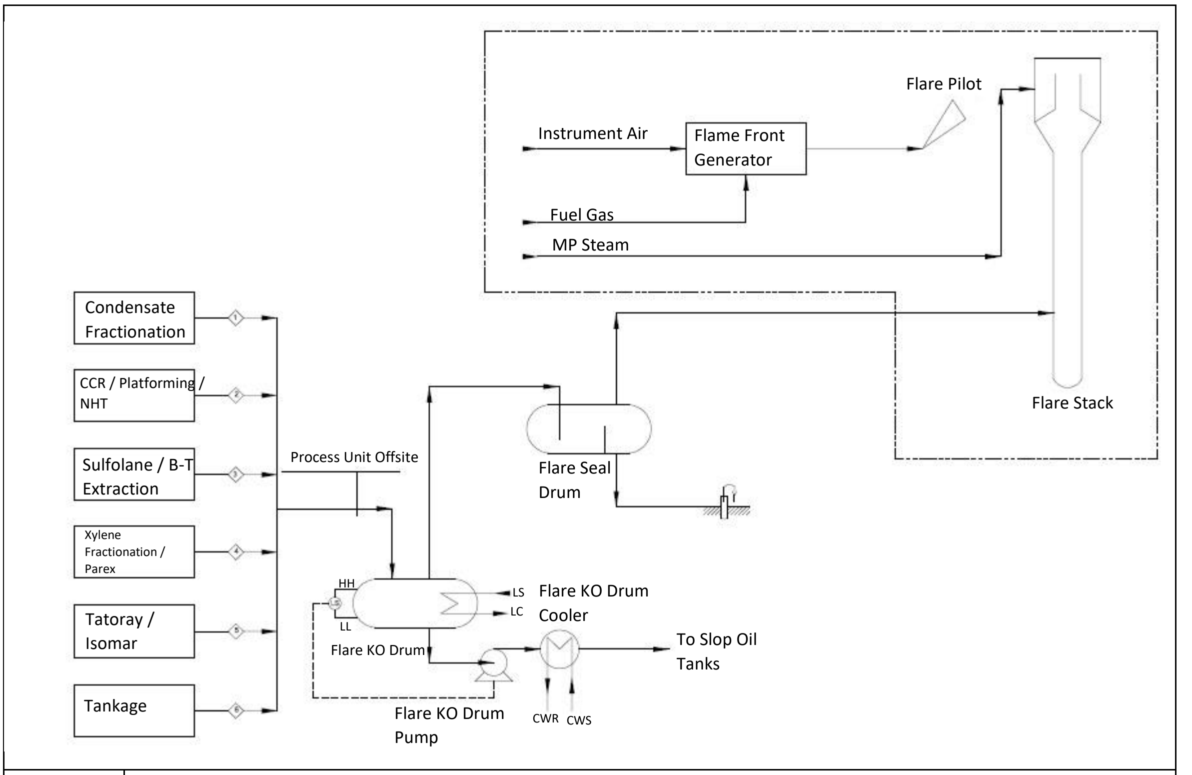


Figure 3.26 – Flare System Diagram

Source: ChemOne

The facility will also have a continuous emission monitoring system (CEMS) to assess compliance determinations or determination of exceedances of the standards.

CEMS (for steam boiler chimney and process heater stacks) will typically include:

- A NOx pollutant concentration monitor;
- A CO concentration monitor;
- Total Particulate Matter monitor;
- A volumetric flow monitor;
- A computer-based data acquisition and handling system for recording and performing calculations with the data.

3.9.6 Potable Water Supply

Potable water supply will be distributed to from Syarikat Air Johor Sdn Bhd, the city water supplier in Johor.

3.9.7 Support Facilities

As discussed previously, the following support facilities will be constructed and operated by PEC:

- Steam boiler including steam supply and condensate recovery system;
- Cooling water system;
- Demineralized water system;
- Waste water system;
- Fire water system;
- Instrument Air/Plant Air;
- Nitrogen system;
- Potable water; and
- Pipelines from/to Pengerang Deepwater Terminal (PDT).

The following facilities will be developed, operated and managed by third parties:

- Condensate (feed) bulk storage;
- Products bulk storage; and
- Jetty facilities.

The following sections present an overview of the major support facilities to be constructed and operated for information purposes about the general operations of the entire Aromatics Complex.

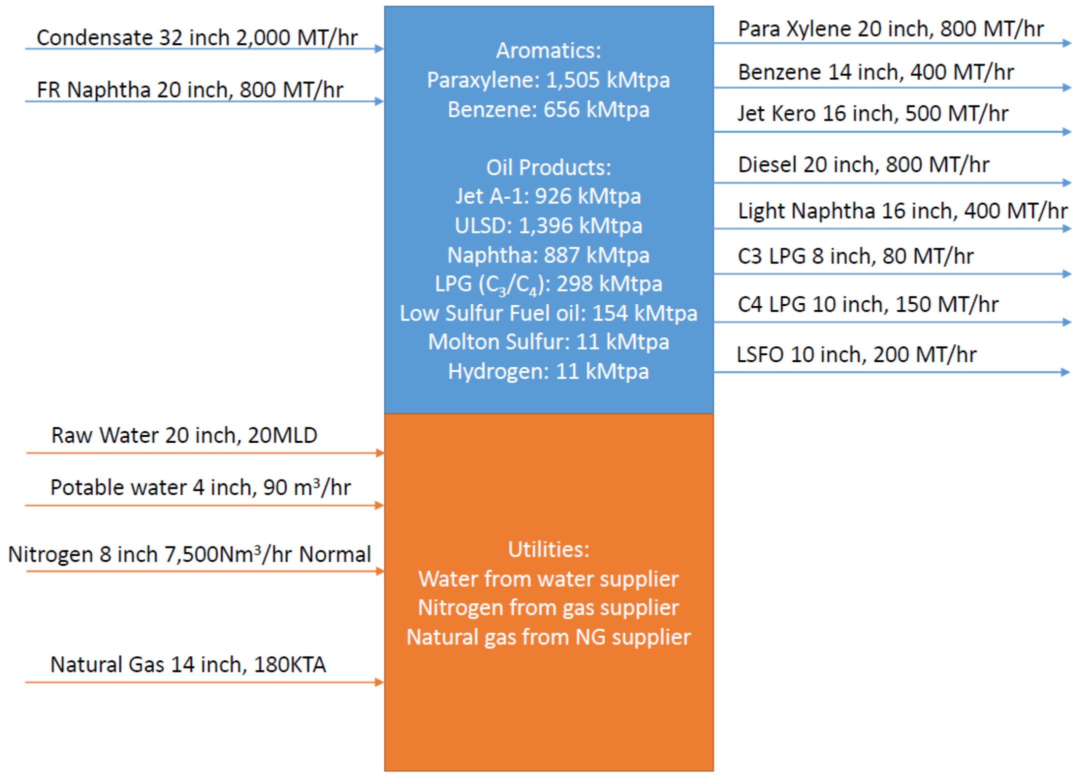
3.9.8 Product Import and Export

Figure 3.27 below provides the figurative layout for all product import and export pipelines for the PEC facility. Incoming pipelines to the jetty include condensate (which is directed on to the third-party bulk storage terminal and sour naphtha (which is directed onto the PEC). Other incoming pipelines to the PEC include condensate from the 3rd party bulk storage terminal and nitrogen (from an external supplier).

The product export is via the same pipelines back to the dedicated PEC jetty of for storage at the third-party bulk storage terminal pending export.

The jetty will be located approximately 5.3 km south of the site at the PDT and the third-party bulk storage terminal located in the PDTs CTF area. The design will be required to meet Malaysian and PEC standards with the jetty topside facilities including for marine receipt and dispatch for PEC facility aromatic products, oil products and LPG.

The jetty including its pipeline from the PEC plant/tank farm and third-party bulk storage terminal will be constructed and operated by the third party.



ESC **Figure 3.27 – Product Import and Export Pipelines**
Source: ChemOne

3.9.9 Product Storage

The on-site bulk storage tanks will be constructed and operated in compliance with Malaysian Standards, whereby:

- Each tank farm bund wall will be sized to contain 110% of the volume of the largest tank, within the same enclosure.
- Rainwater collected within tank bund areas is temporarily stored within the tank bund, each with an inspection pit. Prior to release (via valve) the contained water is inspected and only if it meets requirements for discharge to stormwater drainage is it allowed to be released into the site stormwater drainage system, if not it shall be pumped to the WWTP.
- Loading and unloading pumps shall be dedicated to each product and tank.
- The total storage capacity for the site would be 484,000 m^3 for condensate, intermediate and final products. The specifications of the storage tanks are provided in *Table 3.22*.

All products, except for hydrogen, fuel gas, light ends and tail gas are stored off-site prior to transfer to the jetty via pipeline. Fuel gas, light ends and tail gas produced will have no intermediate storage and will be used onsite internally as feedstock or fuel.

The PEC will have 3 bulk condensate tanks on site, with the bulk of the inventory stored at the third-party bulk storage facility at the PDT. The aboveground condensate tanks, with working capacity of 43,000 metric tonnes each, will receive and store the condensate from the jetty/ third party terminal for daily consumption.

Other raw materials mostly comprise solid or liquid catalysts, in relatively small quantities, that will be stored in the warehouse – with appropriate safety precautions for those that are hazardous, such as containment and segregation.

Table 3.22: Storage Tank Specifications

Tank (Type)	Duty/Material	Volume (MT) & Number	Controls
Condensate	Feed	3 x 43,000	IFR & N_2 Blanketed
Sour Naphtha	Intermediate	2 x 22,000	IFR & N_2 Blanketed
Sweet Naphtha	Intermediate	1 x 22,000	IFR & N_2 Blanketed
Aromatic	Intermediate	1 x 15,000	IFR & N_2 Blanketed
Raw Diesel	Intermediate	1 x 6,900	IFR & N_2 Blanketed
Raw Kero	Intermediate	1 x 4,800	IFR & N_2 Blanketed
Para-Xylene Storage Tanks	Product/Para-Xylene	2 x 17,000	IFR & N_2 Blanketed
Benzene Storage Tanks	Product/Benzene	2 x 7,500	IFR & N_2 Blanketed
Jet/Kero Storage Tanks	Product/Jet/Kero	2 x 10,000	IFR & N_2 Blanketed
Diesel Storage Tanks	Product/Diesel	2 x 14,000	IFR & N_2 Blanketed
Light Naphtha Storage Tanks	Product/Light Naphtha (Blended)	2 x 10,000	IFR & N_2 Blanketed
Fuel Oil Storage Tanks	Product/Fuel Oil	1 x 4,500	IFR & N_2 Blanketed
LPG C_3 Storage Spheres (pressurized sphere)	Product/LPG/C_3	2 x 1,200	Sphere
LPG C_4 Storage Spheres (pressurized sphere)	Product/LPG/C_4	2 x 2,500	Sphere
Molten Sulphur Storage Tank	Molten Sulphur	1 x 1,000	Dome Roof
Slop Tank	-	1 x 6,000	Dome Roof

3.10 Plant Instrumentation, Monitoring and Control Systems

3.10.1 Plant and Equipment Protection

The new plant will be designed with consideration for the highest levels of plant safety and equipment protection systems; provided Instrumented Protective Function systems will include:

- Emergency Shut Down (ESD) and/or Emergency Depressurizing (EDP) systems to protect process units and their related facilities;
- Fire and Gas Detection Systems for early detection and protection from developing hazardous conditions; and
- Fire protection and Alarm Management Systems.

3.11 Safety Systems

Both passive and active safety systems will be provided in the plants, including the following:

- In-place safety management systems (standard operating procedure, permits to work etc.)
- Fire detection, alarms and firefighting systems;
- Automatic sprinkler;
- Fireproofing of critical structures and equipment;
- Fixed and portable gas detectors and smoke/flame detectors;
- Lighting protection;
- Electrical grounding;
- Safety shower and eye bath systems;
- Personal Protective Equipment (PPE);
- Inert gas blanketing; and
- Flare System.

3.12 Fire Detection and Protection Systems

The basic features of fire detection and protection systems are outlined below:

- The plant will be covered by a fire water ring main. Water from the fire water reservoir will be charged and pressurised in the ring main using a combination of motor and diesel driven fire water pumps. Hydrant stand post, water monitors and other appropriate firefighting accessories will be placed in the fire water network as per NFPA design guidelines.
- Storage tanks will be provided with appropriate fire protection measure (e.g. foam, deluge etc.) as per design codes and standards.
- Control room and sub stations will be protected with clean agent flooding systems such as FM 200 etc.
- Automatic sprinkler system and fire hose reel system will be provided for admin building. Fire extinguishers will be placed in strategic location of the buildings as necessary.
- Design scheme for automatic fire alarm system and Manual call point system will be provided in the storage tank areas and in the buildings as necessary.
- The establishment shall be provided with an Automatic Fire Alarm System conforming to Malaysian Standards for Fire safety and Protection, and *Uniform Building By-Laws 1984* requirements.
- For safe storage of flammable liquids, fire protection measures will be provided according to the SDS of the storage liquid. Such systems include but are not limited to:
- Foam protection system
- Deluge System
- Fire hydrant with monitor

- The storage tank will be equipped with heat detectors connected to automatic fire alarm system. The storage area will include manual call points.
- Fire extinguishers will be placed in strategic locations for adequate fire protection as per code requirement of the *Uniform Building By-Laws 1984*.

3.13 Key HSE Design Goals, Objectives and Targets

PEC facility will design, construct and operate a world-scale chemical manufacturing facility that leads the industry in safety, health and environment performance and exceeds the business objectives of the venture.

HSE Goals

- To ensure no accidents, no environmental incidents and no harm to people.

HSE Objectives

- Maximise the utilisation of energy resources to produce clean and safe energy;
- Achieve zero lost time injury through aggressive safety strategies;
- Attain a high level of preparedness to manage emergency incidents;
- Become a leader of sustainable growth; and
- Use high level of good HSE practices.

Targets

- To develop and maintain an HSE management system;
- Hold at all level of management, staff, and contractors accountable for HSE within their areas of responsibility;
- To develop a positive HSE culture throughout the company through effective communication and training;
- To conduct HSE reviews and audit in order to identify shortcomings within the organisation and ensure compliance with local, international and corporate standards and regulations;
- To ensure that contractors demonstrate full compliance with the policy;
- To provide the necessary resources in order to meet company's stated HSE objectives; and
- To ensure optimal security standards are maintained to protect personnel, company assets and information.

3.14 Project Planning Schedule

3.14.1 Construction, Commissioning & Start-up

The PEC facility is currently in the financing stage. Construction will start in Q4 2022 and will stretch up to mid of 2026, with start-up in 2026.

3.14.2 Scheduling and Duration

The current schedule indicates 45 months period with the following breakdown:

- Engineering Procurement Construction (ISBL) - 40 months
- Engineering Procurement Construction (OSBL) - 36 months

- Commissioning and start-up - 5 months

OSBL shall be completed 4 months earlier than ISBL to accommodate feedstock and provide utilities for commissioning and start-up of ISBL.

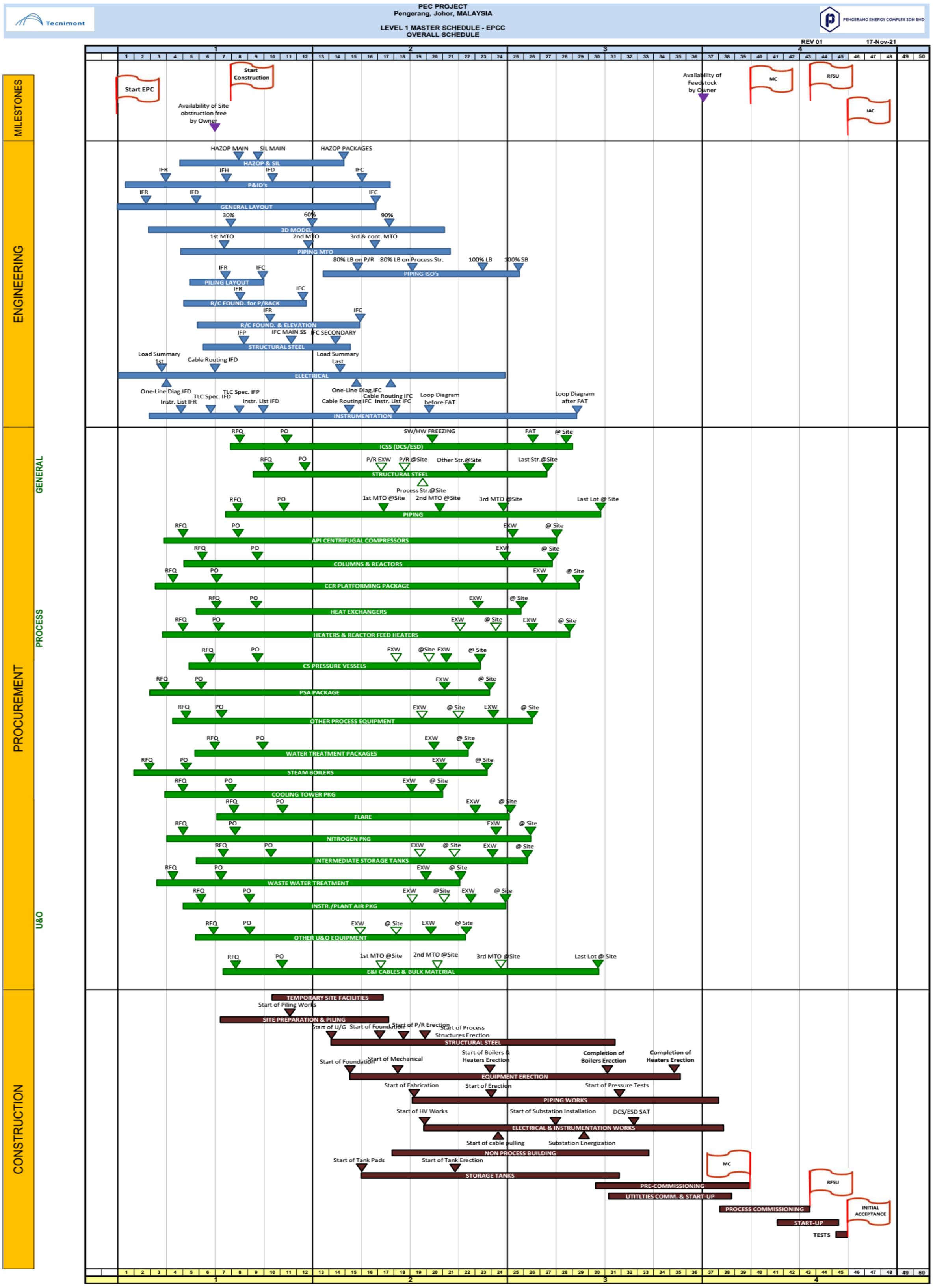


Figure 3.28 – Indicative Project Schedule

Source: ChemOne

3.14.3 Workforce Size

Peak anticipated workforce size is around 7,000 workers. The peak construction period is expected to last about 12 months. A tentative manpower "S" curve for the project is shown below.

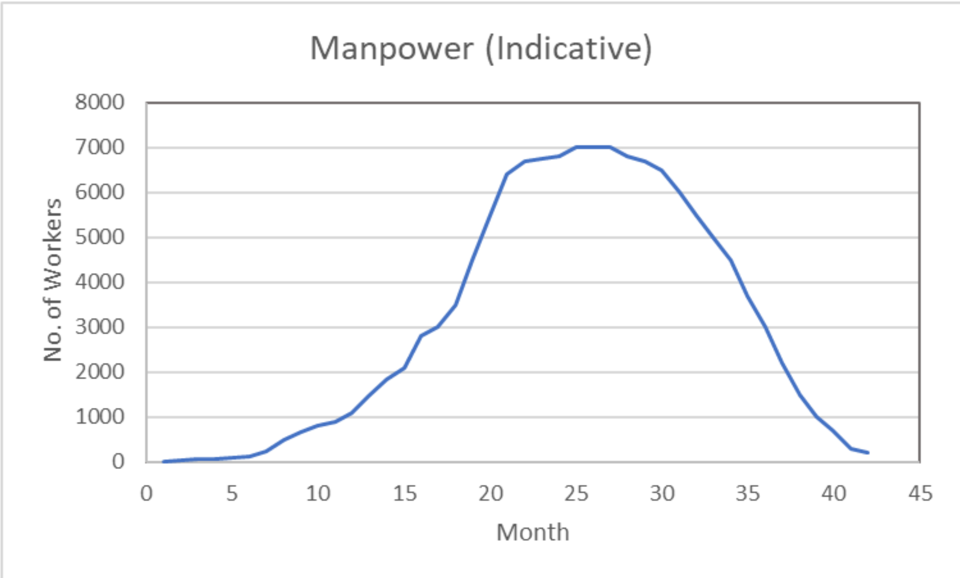


Figure 3.29 – Manpower
Source: ChemOne

3.14.4 Temporary Facilities

Temporary facilities for the PEC facility construction will include temporary offices, laydown areas, offloading and warehousing.

3.14.5 Construction Traffic Generation

Transport arrangements for the workers to be picked up and dropped at the work site.

3.14.6 Construction Equipment Inventory (Indicative)

An indicative construction equipment inventory is presented in *Table 3.23*.

Table 3.23: Construction Equipment Inventory (Indicative)

Equipment	No.
Pile drivers	24
Hydraulic excavators	10
Concrete pumps	14
Cranes (from 10 to 1000 tonnes)	20
Bulldozers	6
Trucks	14-24
Welding Machines	390
Compressors	24
Forklift trucks	14

3.14.7 Sanitation

Temporary toilet facilities will be provided and will be ensured that the toilets and other facilities are kept in hygienic conditions.

3.14.8 Canteens

The project will have its own canteen facilities at the construction site.

3.14.9 Utilities

- Potential water supplier will be Syarikat Air Johor Sdn Bhd.
- Electrical power supply requirements will be supplied from the nearest TNB substation near Kg. Lepau.

4 ANALYSIS OF ALTERNATIVES

4.1 No Project

The ‘no-project option’ would mean that the PEC facility will not materialise and Malaysia would not have gained a USD 3.38 billion investment, besides the other socio-economic benefits spin-off from this investment, as well as the development of new downstream industry.

Without the PEC project, the PIP developer (JCorp) and JPDC will still move ahead to attract other petrochemical industries to occupy the plot. As such, Malaysia, and specifically Johor, will not only lose this substantial investment, but it will also miss an opportunity to attract the state-of-the-art technology and develop talents in the petrochemical sector.

4.2 Site Selection Options

PEC considered the following as critical success factors for its facility:

- Central location;
- Comprehensive logistics support;
- Low cost of production;
- Readily available feedstock;
- Strong product demand; and
- Latest technology.

In brief, PEC had chosen Pengerang, Johor to set up the PEC facility for the following reasons:

- Located near the Petronas’s USD 27 billion RAPID in the PIPC which can provide feedstock and can share the excellent infrastructure, common utilities and supporting services;
- Direct access to international shipping channels via Pengerang Deepwater Terminal (PDT)’s deep water (24m) port facilities with third party bulk storage facilities; and
- Being located strategically close to the markets and outlets for its products.

Three (3) optional sites were considered for the development of the PEC facility, shown in Figure 4.1; the sites are located about 2.5 km apart. Given all three sites are within the PIPC area, there are little differences amongst them in terms of environmental, socio and economic aspects. Of the 3 options, PEC ultimately chose the proposed site in JCorp’s designated PIP.

Based on an appraisal conducted for the EIA of applicable national, Johor State and Kota Tinggi District plans together with the PIPC and PIP masterplans, and in accordance with DoE/ PLAN Malaysia guidance, the proposed site is preliminary assessed as suitable for the PEC project; as it is in a designated industrial zone, the PIP/ PIPC, and is compatible with government planning for the area.

In addition, the PEC is situated a minimum of 500 m from the PIPC border, and hence satisfies the minimum buffer requirement for heavy industry to public settlements.

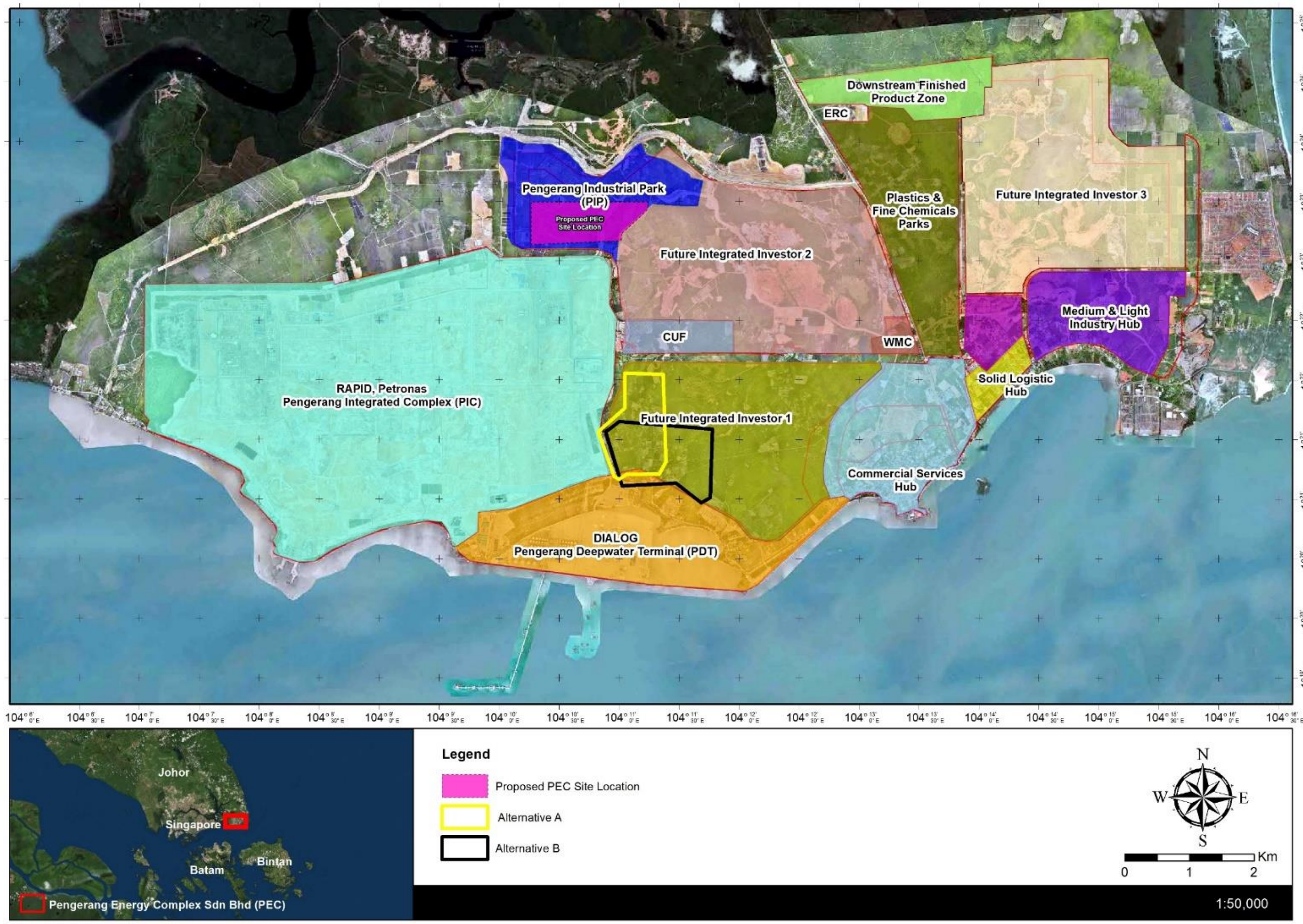


Figure 4.1: Site Options

4.3 Alternative Technology

The PEC products, Benzene and Xylene, can be manufactured via a number of different processes, namely catalytic reforming, toluene hydrodealkylation, toluene disproportionation, transalkylation and steam cracking. Catalytic reforming and steam cracking are the two processes which use more abundant naturally occurring commodities (such as condensate) which are cheaper feedstock than the toluene feedstock required for the alternative manufacturing processes listed above. Considering that there are third party technology suppliers who have been specialising in the development and advancement of all available technologies for decades, PEC desired to obtain such technology to make them more efficient and positioning PEC on the same platform as any other major player in the industry. PEC research has indicated that the third party technology for catalytic reforming is more cost competitive than third party technology for steam cracking, hence a manufacturing process via catalytic reforming was selected as the preferred option.

In catalytic reforming, a mixture of hydrocarbons (heavy naptha from refining condensate) are reacted with some hydrogen gas in the presence of a catalyst at elevated temperature and pressure. Under these conditions, aliphatic/straight chain hydrocarbons form rings and lose hydrogen to become aromatic/ring chain hydrocarbons (BTX; Benzene-Toluene-Xylenes). The aromatic products of the reaction are then separated from the reaction mixture (or reformate) by extraction and distillation.

PEC proposes to convert the lower value by-product of toluene to xylene and benzene. To realise this aim, PEC has the option to use a toluene hydrodealkylation process, toluene transalkylation process, and/or toluene disproportionation process. Toluene hydrodealkylation was discounted because the process converts toluene to benzene by releasing methane gas, which is a greenhouse gas. Furthermore, the hydrodealkylation process was not considered economically feasible under conditions where the price differential between benzene and toluene is small (i.e. toluene is less than 15% cheaper than benzene price).

The toluene disproportionation (TDP) process provides an attractive alternative to the toluene hydrodealkylation process as in the TDP process, two toluene molecules are reacted, and the methyl groups rearranged from one toluene molecule to the other, yielding one benzene molecule and one xylene molecule without the production or emission of methane gas. Transalkylation is a reaction between toluene and C9 aromatics to convert into xylenes.

Given that the demand for para-xylene substantially exceeds the demand for other xylene isomers, a refinement of the TDP process called selective TDP (such as toluene transalkylation) may be used. In this process, the xylene stream exiting the TDP unit is >80% para-xylene. In some current catalytic systems, even the benzene-to-xylenes ratio can be adjusted to produce less benzene and more xylenes when the demand of xylenes is higher.

The technologies detailed above are offered by a number of companies including UOP (Universal Oil Products), Axens, ExxonMobil, Toray, and SK Corporation. UOP of America has been identified as the only supplier who is able to supply the complete package by providing a single integrated advanced technology encompassing condensate splitter process, catalytic cracking, product purification and the conversion of toluene to benzene and xylene, whilst still ensuring economic attractiveness and environmental performance.

UOP is the world's leading licensor of process technologies for aromatics production in addition to being a global technology provider for petroleum refining, gas processing, and petrochemical production. As of 2006, UOP had licensed over 575 separate process units for aromatics production in complexes ranging in size from 21,000 MTPA to 1,400,000 MTPA. JAC has also evaluated Axens, a subsidiary of the French Institute of Petroleum (IFP) as an alternative technology provider. However, UOP was selected by PEC as it is the market leader in the Aromatics Technology and it can offer a complete technology package when compared to Axens which encompasses technologies from other parties (Uhde/ Exxon Mobil) in their package.

Salient advantages/benefits of using UOP are as follows:

- Efficient Integration;
- Simplified Coordination;
- Consistent Basic Design;
- Overall Complex Guarantee;
- Simplified Pre-commissioning & Startup;
- Improved Technical Service Support;
- In overall, the process has the ability to handle wide range of feedstock;
- High Purity Benzene - The benzene produced is typically 99.9 wt-% purity ASTM "Refined Benzene-545." Alternatively, the more stringent ASTM "Benzene for Cyclohexane Feedstock" grade may be produced;
- High Purity Toluene - The toluene produced as an intermediate, is at least TDI grade with less than 1000 wt-ppm non-aromatics;
- High Recoveries - The expected recovery of benzene and toluene is greater than 99.5% of these aromatic components present in the fresh feed;
- High para-xylene purity and recovery – Allow for production of 99.9 wt-% pure para-xylene at 97 wt-% recovery per pass;
- The ability to process C9 aromatic to makes more xylenes (higher value product) than benzene production;
- UOP Tatoray process produce 40% more para-xylene (higher value product) than ortho-xylene;
- The make-up rate for sulfolane solvent extraction is minimal. Solvent used (sulfolane) is the most widely used solvent for aromatics extraction and a readily available commodity chemical. There are no co-solvents or proprietary additives;
- Optimized catalyst and process condition in converting naptha to aromatics – great advances have been made over the last two decades in coupling improved catalyst with operating conditions. Reactor operating pressures is low (3.5 kg/cm2g), which improve reaction selectivities of the more difficult reactions. The lower pressures used to increase the selectivity causes the rate of coke formation on the catalyst to rapidly increase (catalyst deactivation). UOP's CyclemaxTM design easily burns the coke and reconditions the catalyst;
- Environmentally friendly - CCR Platforming has low emissions, minimal environmental impact and high energy efficiency. UOP's latest environmental technology; ChlorsorbTM is used in the CCR section to recycle chloride and reduce atmospheric emissions. ChlorsorbTM technology has been commercialised and is operating successfully;
- A fully integrated aromatic plant based on CCR platforming/Parex in Thailand earned a coveted Five-Star Status Award from British Safety Council, which conducted safety audit;

- A Middle Eastern Aromatic Complex that came on stream in 1992 received its country's Green Industry Award for its environmental performance. They have also had more than 1 period of 1000 straight days of non-stop production;and
- Reliance Industry Limited (RIL), the world largest para-xylene producer (1.4 million tons per year), uses UOP technology and the Jamnagar complex received Shell Safety Award for achieving 10 million man-hours without any lost time accident.

The services provided by UOP to PEC will incorporate the plant design, inspection, commissioning, performance testing and training of operating personnel. UOP will also supply the proprietary process equipment, chemicals and catalysts for the complex. They also provide the product and catalysts guarantees for the plant.

4.4 Alternative Design and Fuel in Environmental Context

The design of the proposed facility takes into account key technical, economic and environmental issues. Key design features of the facility related to the avoidance or minimisation of environmental impacts are summarised in Table *4.1*.

On the basis of the key design features selected for the facility together with the general good practice included within its overall design and layout, fuel and chemical storage facilities and pollution monitoring equipment, the facility offers a range of environmental benefits whilst minimising its potential site-specific impacts on the environment and ensuring safe, secure and efficient operation.

Table 4.1: Summary of Alternatives

Item	Summary of Alternatives	Selected Design
Stack Height	The stacks can be a range of heights. Dispersion is improved by increasing the stack height, but engineering requirements, e.g. structural support and foundations, and associated costs are also increased with stack height.	The stack height will be designed to comply with Malaysia and IFC ambient air quality standards, and optimised with respect to engineering requirements.
Air Pollution Control	There are a range of technologies which may be used to minimise emissions from the facility, which can be divided into three categories: • Fuel selection and combustion controls; • Process selection/alteration for manufacturing process ('source elimination'); • "End-of-pipe" gas cleaning. The best approach for fuel burning equipment is to select a cleaner fuel and control the combustion of the	The facility will utilise 100% gas fuel comprising internal fuel gas plus natural gas. Very low sulphur content. Combustion will be designed and maintained for complete combustion. The fuel burning equipment will be equipped with low-NOx combustors, minimising emissions of NOx which is the key pollutant associated with combustion of gas fuel. H_2S and HCl containing stream will be first scrubbed in a scrubber prior venting or

Item	Summary of Alternatives	Selected Design
	fuel/hydrocarbon such that the production of pollutant emissions is minimised, obviating the need to use gas cleaning equipment (which addresses the results rather than the source of emissions). For process area, process shall be chosen to minimise air pollutant while considering the economic cost. In cases whereby source elimination approach is unrealisable, end-of-pipe solutions shall be applied to process which emit pollutants.	flaring. All hydrocarbons containing streams will be flared prior venting through stack. Air pollution control systems will ensure compliance with the applicable Malaysia and IFC emission standards.
Source of Water Supply	There are 2 potential sources of water supply: • Syarikat Air Johor, the main water supplier in the state of Johor; • Independent water supplier in Pengerang (yet to be identified).	The water supply will be sourced from both potable and industrial water while the amount for each is still under estimation.

4.5 Flare Option

Gas flaring can be defined as the combustion device designed to safely and efficiently destroy waste gases generated in a plant during normal operation. A flare is normally visible and generates both noise and heat. During flaring, the burned gas generates mainly water vapour and CO_2. Efficient combustion in the flame depends on achieving good mixing between the fuel gas and air (or steam), and on the absence of liquids. Low pressure pipe flares are not intended to handle liquids and do not perform efficiently when hydrocarbon liquids are released into the flare system (Emam, 2015).

Many flare systems are currently operated in conjunction with baseload gas recovery systems. These systems recover and compress the waste volatile organic compounds (VOC) for use as a feedstock in other processes or as fuel. When baseload gas recovery systems are applied, the flare is used in a backup capacity and for emergency releases. Depending on the quantity of usable VOC that can be recovered, there can be a considerable economic advantage over operation of a flare alone (USEPA, 2000).

Flares are classified into two common types: elevated and ground flares. Elevated flares are the most widely used flare type in chemical industrial sites. In elevated flares, the gases are combusted using flare headers that are located at a considerable height above the ground. Elevated flares are again classified into several types, depending on the type of gas, the incoming gas pressures, smoking or non-smoking requirements, heat radiation levels and location. Elevated flares have an open flare associated with them. An open flare consists of a visible flame that generates heat and some noise (Vij, 2018).

Ground flares are systems where the combustion of the gases takes place at the ground level. Since these flames are close to the ground, they have to be enclosed in a refractory-lined chamber or enclosure. As combustion takes place at the ground level, gases are released close to the ground, resulting in poor gas dispersion. Due to these limitations, enclosed ground flares are commonly used in situations where the gases to be burned are relatively clean and when reducing noise pollution is critical.

The major factors affecting flare combustion efficiency are vent gas flammability, auto-ignition temperature, heating value (Btu/scf), density, and flame zone mixing.

Enclosed ground flares are suitable for managing low and medium gas flow. However, it has poor dispersion of combustion product because its' stack is near to the ground and may result in severe air pollution or hazard if the combustion products are toxic or in the event of flame-out. Maintenance of ground flares can also be challenging. With ground flares being harder to access, significant maintenance would require a plant wide shut down. An unscheduled break in production could prove incredibly costly for operators. Capital, operating and maintenance cost requirements are high for enclosed ground flares.

Advantages of using the elevated flare are:

- Financially-beneficial way of treating sudden and large volumes of solvent-laden gases;
- Normally extra fuel is not needed to realise good combustion (caloric value of to-be-treated flue gas is sufficient); and
- Good for greatly fluctuating or periodic emissions.

Since the flare at PEC is mainly used for emergency use, the elevated flare is the preferred option.

4.6 No Development Option

The 'no-project option' would mean that the PEC facility will not materialise and Malaysia would not have gained a USD 3.38 billion investment, besides the other socio-economic benefits spin-off from this investment, as well as the development of new downstream industry.

Without the PEC project, the PIP developer (JCorp) and JPDC will still move ahead to attract other petrochemicals industries to occupy the plot. As such, Malaysia, and specifically Johor, will not only lose this substantial investment, but it will also miss an opportunity to attract the state-of-the-art technology and develop talents in the petrochemical sector.

5 RECEIVING ENVIRONMENT - ENVIRONMENTAL AND SOCIAL BASELINE IN 5 KM RADIUS

5.1 Data Sources

The following data sources were used to establish the environmental setting for the Project and to provide inputs for modelling:

- Primary data collection conducted by ESC in 2018 and inputs from PEC;
- Google Earth Pro 7.1.5.1557, Image Year 2016 and DEM - ASTGTM2_N01E104 (updated 28th Feb 2011) from https://gdex.cr.usgs.gov/gdex/ for any required maps;
- The EIA for the Proposed Development of the Pengerang Industrial Park on part of PTD 2083, Mukim Pengerang, Daerah Kota Tinggi, Johor for Johor Corporation by Kualiti Ceria Sdn Bhd (2018);
- Water quality and air quality data from 2015 to 2017, sourced from the Department of Environment Malaysia; and
- Meteorological data from 2015 to 2017 was sourced from the Malaysian Meteorological Department and from Singapore's Changi Airport.

5.2 Site Setting & Land Use (5 km Radius)

This section describes the existing physical environment within and surrounding area of The Project. The limitation coverage of this study is bound to a 5 km radius (25,111.9 ac) from the proposed Project site boundary and concentrate on all required data related to the existing site conditions. Data used in this study derived from primary data based on site survey conducted from February to December 2018 and secondary data that came from existing databases, literature review, geospatial data etc.

Impact to the surrounding environment and the effectiveness of the mitigation measures provided in this report are also supported by the analysis of existing conditions in this section. Therefore, the assessment of the land cover in this study is focussed on the sensitive receptors that are important to study of chemical and biological environment.

In short, the following were appraised in this section:

- Basic information; and
- Current environmental conditions of the site and surrounding areas.

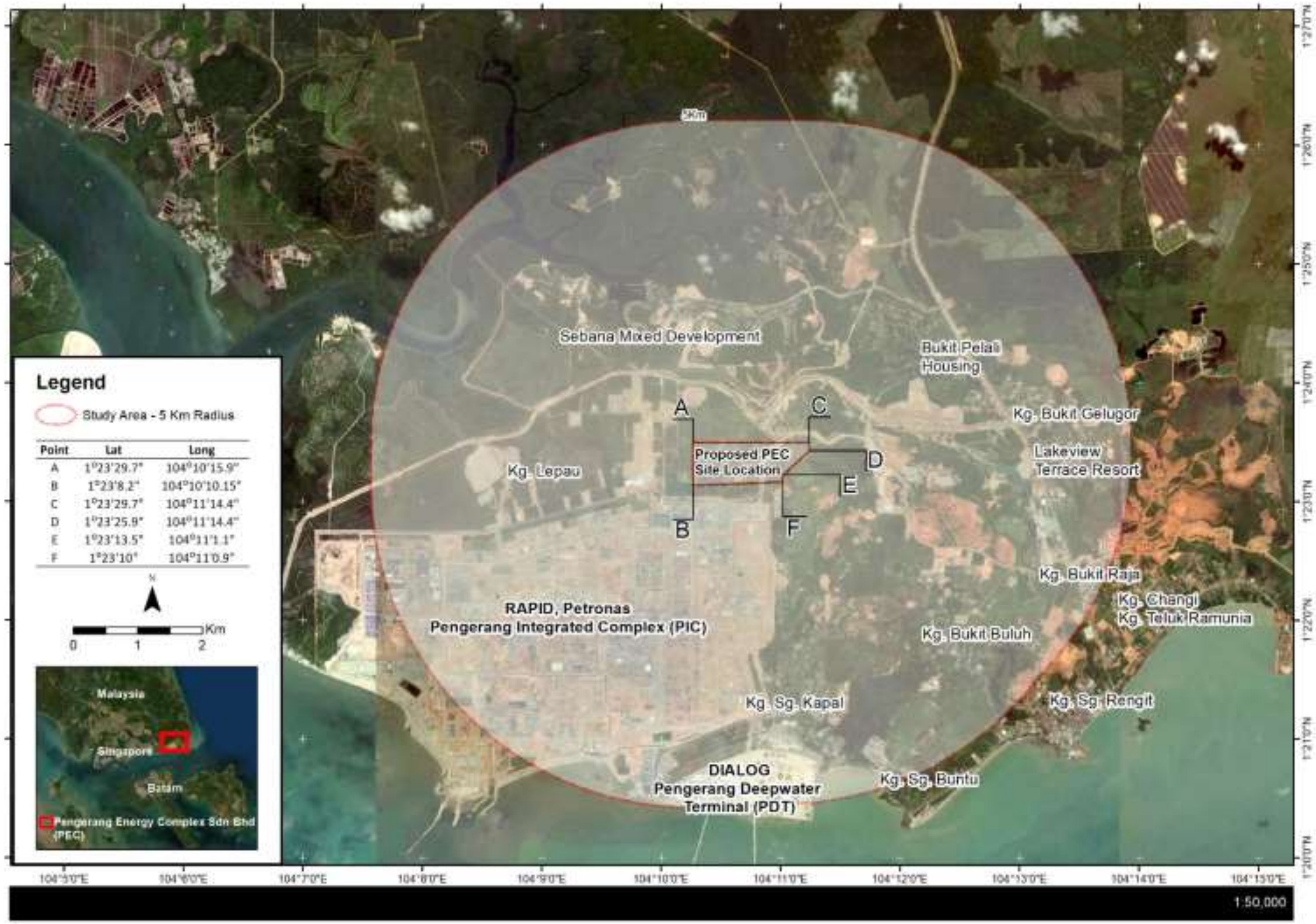


Figure 5.1 – Limit of Study Area for Land Use Analysis

Source: PEC, ESC, ESRI, and Google Earth Image Year 2016

5.2.1 Historical Land Use

Information gathered during the site visits and from desktop studies has been combined with a review of historical Google Earth satellite images of the site and surrounds from 1984 (noting both images and detail are lacking before 2007) and indicate the following:

- **1984 – 1990:** Much of the site and immediate surroundings at higher elevations were covered with vegetation indicative of a logged-over area, with the exceptions being areas around the course of Sg. Lepau, where darker coloured vegetation suggests a riparian reserve around Sg. Lepau was spared from logging. Organised agricultural activity is not visible at the site.
- **1990:** The image shows much of the site, and areas 1 km north and south has been cleared of vegetation.
- **1993 -1994:** Within the site there are indications of organised farming and construction work to the north indicates construction work at the Sebana Cove Resort (now known as Sebana Mixed Development) and its Marina were well underway, with work on the golf course evident in 1994.
- **2004:** Tracks and farmed areas are visible at site. The Sebana Cove Resort (now known as Sebana Mixed Development), its marina and golf course appear operational. Extensive land clearing around Taman Rengit Jaya, proposed for bungalow development (but which reportedly achieved few sales), is visible.
- **2007:** The earliest high-resolution image of the site, shows land use on-site consistent with that observed during the ESI site visit, though at a more concerted level assumed, as currently, for vegetables on about 20% of the site with ponds visible both east and west of the farmed area and tracks entering and exiting the site at four locations. Structures (consistent with chicken farms) are now seen to the south east, but none within the site. Part of the PIC area appears to have been logged over.
- **2012:** Agricultural use continues in the same areas with additional land cleared towards the eastern site boundary. Reclamation of the PDT1 (complete) and PDT2 (incomplete) were observed.
- **2013 - 2015:** Land use at site appears little changed. Site clearance starts and is observed largely completed at both the PIC and Taman Bayu Damai (where resident directly impacted by the PIC were reportedly relocated) is visible. PDT1 appears complete and JPDC access and internal roads, inclusive PIPC ring-road, are seen underway.
- **2016 - 2018:** The last year images are available on Google Earth and used herein. Images show, PIC under construction and new road alignments cleared and under construction for PIPC Phase 1.

The land is currently registered as Lot PTD 2083, Mukim Pengerang, Kota Tinggi, Johor. The current owner of the land is Lembaga Kemajuan Johor Tenggara (KEJORA). The land has now been gazetted under Section 4 of the Land Acquisition Act 1960 by Johor Corporation for industrial development and as such will be re-numbered and sectioned accordingly. Approval for land conversion from agriculture to industrial zoning was successfully obtained from the Pengerang Land Development and Planning Department in March 2019.

5.2.2 Location Suitability

Based on the Local Plan, the proposed site for the PEC is located in the Mukim of Pengerang, District of Kota Tinggi, State of Johor, within Small Planning Block (*Blok Perancangan Kecil, BPK*) 1.1 that has an area coverage of 34,283.4 acres and is located under Planning Block BP 1 which covers 125,601.2 acres or 9.7% of Kota Tinggi District. The Project is approximately 250 acres in size, out of which one third will be left vacant for future expansion. As shown in *Figure* 5.1 and *Figure 5.2*, the Project is located in the vicinity of settlement areas and industrial sites within PIPC that was allocated by Johor State Government's to develop the south-east Johor area into an industrial area for both heavy and light industries.

PEC selected the PIP site as it is already designated as industrial zone and is compatible with government planning for the area in accordance with DOE/ PLAN Malaysia guidance; the proposed site is preliminary assessed as suitable for the PEC project; In addition, the PEC is situated a minimum of 500 m from the PIPC border as shown in Figure *5.2*, and hence satisfies the minimum buffer requirement for heavy industry to public settlements.

The site for the Project that was used as agricultural farm has been vacant and JCorp, with the support of Johor Petroleum Development Corporation (JPDC), has successfully obtained the land conversion approval from agriculture to industrial use in March 2019. This conversion supports the Johor State Structure 2030 Plan and the proposed Pengerang Masterplan (please refer to *Figure 5.3*).

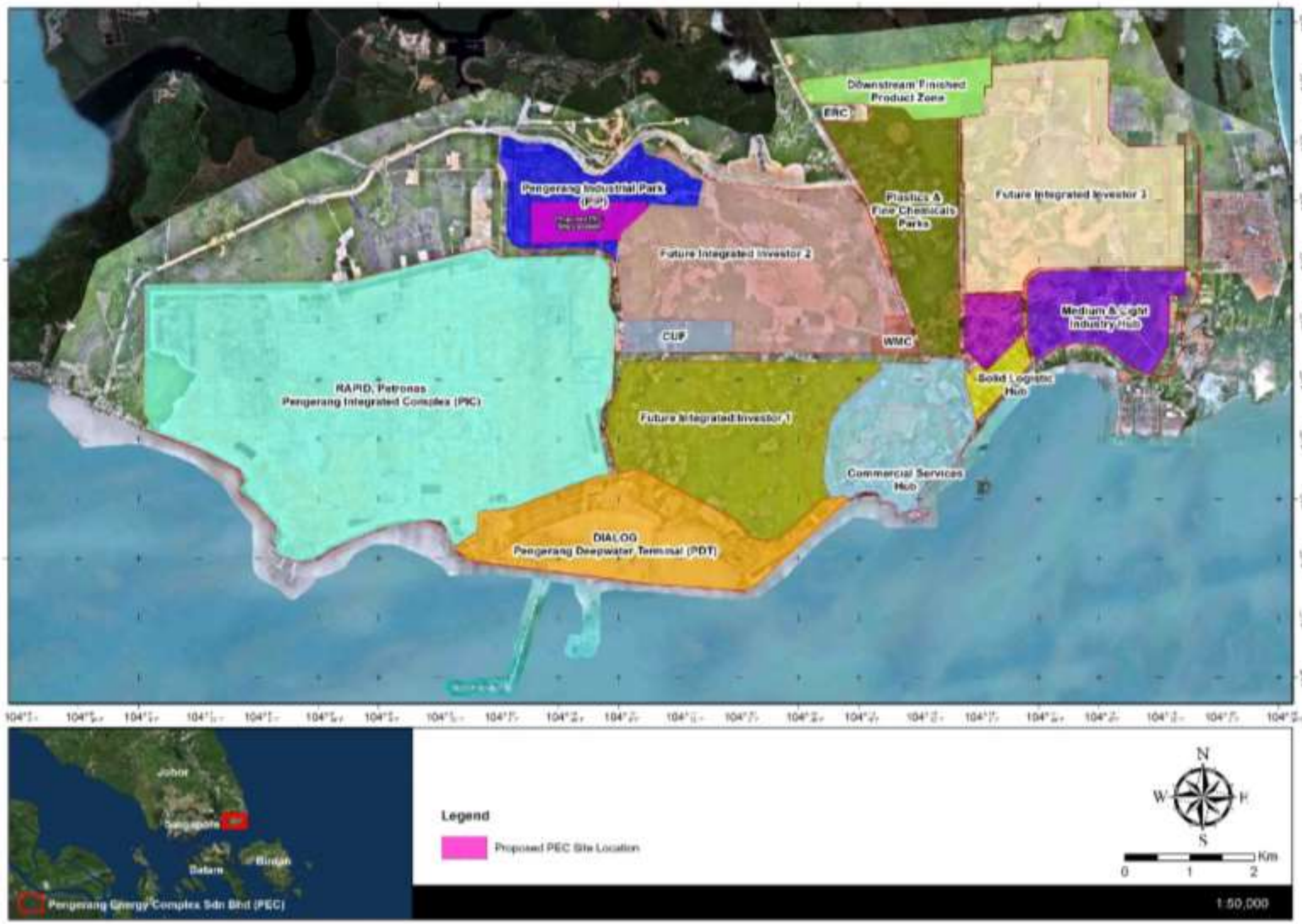


Figure 5.2 – Proposed PEC Site Location within the Pengerang Masterplan

Source: JPDC

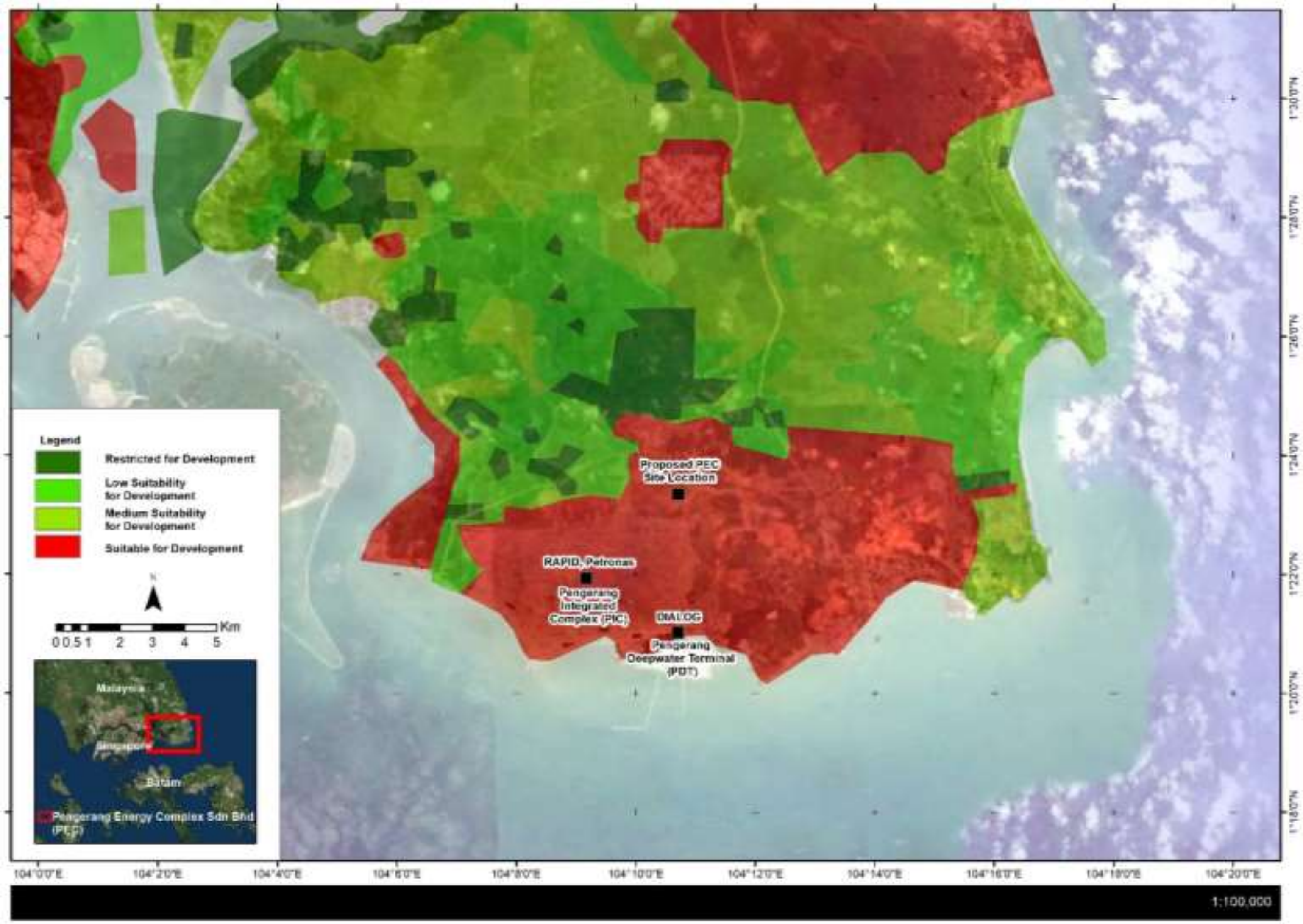


Figure 5.3 – Johor State Structure Plan 2030

Source: Kajian RSN Johor 2030 (Kajian Semula), 2016

5.2.3 Zoning Based on Local Plan

Based on available draft of the Kota Tinggi Local Plan (*Rancangan Tempatan Daerah, RTD)* 2020 the location where the Project is located situated in an agricultural zone in Rancangan Bukit Saga area. Within a 1 km radius to the west is Kg. Lepau settlements zone (< 500 m), the industrial zone on its north (± 500 m) and south (± 200 m) border, and industrial zone to the east (± 800 m). Other than the Kg. Lepau settlement, other settlements zones located within a 3 km radius are observed at the north and north west of the Project, which includes the Sebana Mixed Development (± 1.1 km), and Bukit Pelali Housing (± 2.5 km). Other zones such as utility zone and forest reserve are also present within a 3 km radius. The main zoning in a broader radius (5 km) are agriculture zone in the east side of The Project then followed by the industrial zone in the south-west side.

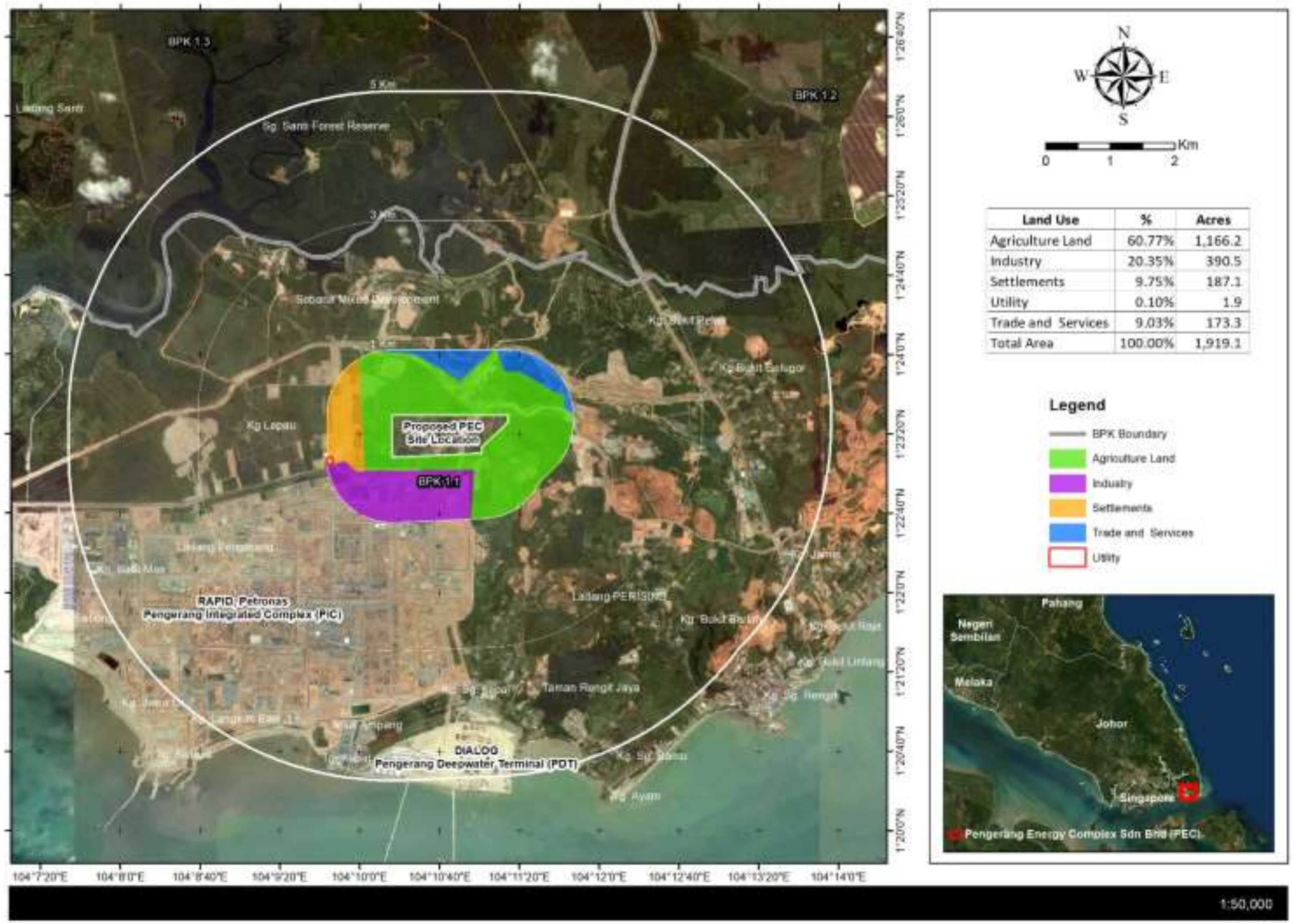
Based on a 1 km radius coverage that has an area of 1,919.1 ac (*Figure 5.4*), the sensitive receptors take up an area of 9.75% of the total area or 187.1 ac to the west of the Project. Significant increase of sensitive receptors area to 17.04 % or 1,816 ac in the 3 km radius (10,654.8 ac) are mainly due to Kg. Lepau settlements zone. However, during the ground truthing exercise in 2018, it was observed that Kg. Lepau settlement zone is populated with less than 100 households and mostly located > 1.5 km west of The Project. Newly built houses in Kg. Lepau settlement zone were also observed during the ground truthing and located sporadically less than 2 Km from The Project site.

Zoning within the Project boundary up to the 5 km Radius (limit of study area) consists of 7 zones (*Figure 5.6*) which are:

- Agriculture Zone
- Industrial Zone
- Forest Reserve Zone
- Trade and Services Zone
- Quarry Zone
- Utility Zone, and
- Settlements Zone

The coverage also includes Sungai Santi that is located within the forest reserve zone, north to west side of The Project. The forest reserve in this area is consisted of mangrove and secondary forest that inhabited by Rare, Threatened, and Endangered (RTE) species.

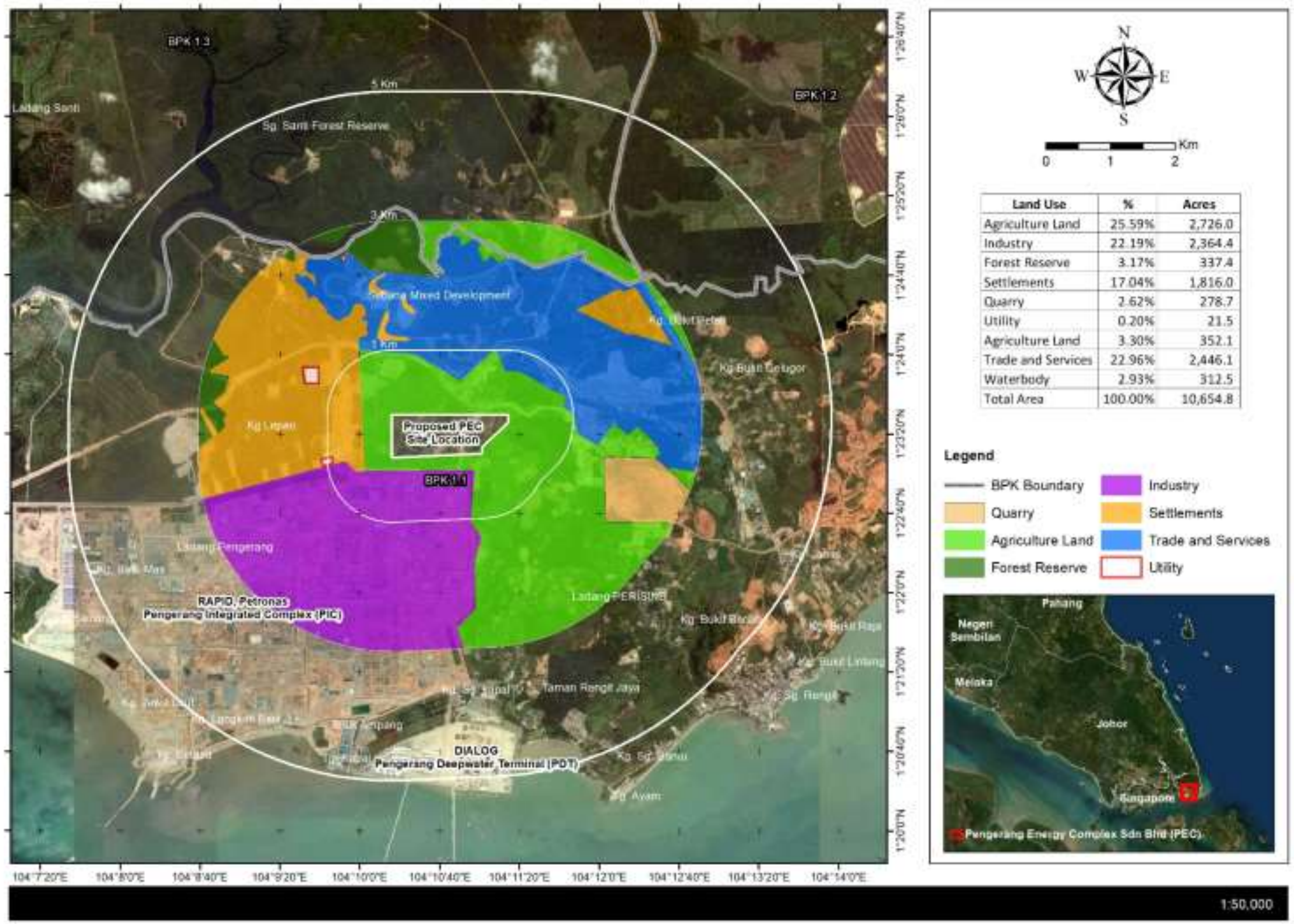
The two most dominant zones within a 5 km radius are agriculture and industry, that includes RAPID and DIALOG which in total comprise ± 60 % of the total area. The second dominant zones are the forest reserve, trade and services, and the settlements zones which covers ± 35 % of the total area. Quarry, water body (Sungai Santi & sea water) and utility zones are covering the rest ± 5 % of the total area of 25,111.9 ac.



Land Use	%	Acres
Agriculture Land	60.77%	1,166.2
Industry	20.35%	390.5
Settlements	9.75%	187.1
Utility	0.10%	1.9
Trade and Services	9.03%	173.3
Total Area	100.00%	1,919.1

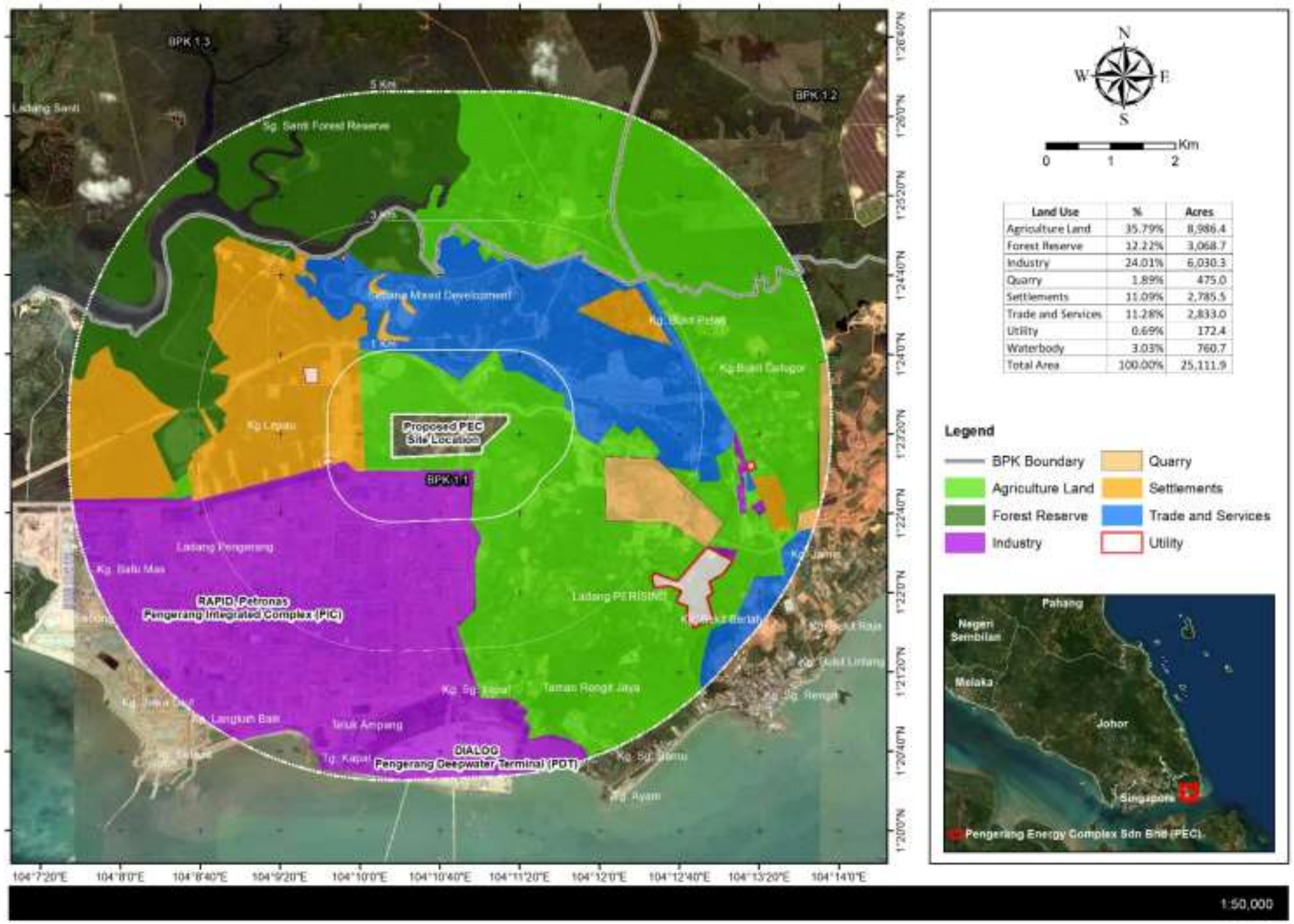
Figure 5.4 – Schematic Land use within 1 Km Radius

Source: Draft of RTD Kota Tinggi 2020; Google Earth Image, 2016



Land Use	%	Acres
Agriculture Land	25.59%	2,726.0
Industry	22.19%	2,364.4
Forest Reserve	3.17%	337.4
Settlements	17.04%	1,816.0
Quarry	2.62%	278.7
Utility	0.20%	21.5
Agriculture Land	3.30%	352.1
Trade and Services	22.96%	2,446.1
Waterbody	2.93%	312.5
Total Area	100.00%	10,654.8

Figure 5.5 – Schematic Land use within 3-km Radius
Source: Draft of RTD Kota Tinggi 2020; Google Earth Image, 2016



Land Use	%	Acres
Agriculture Land	35.79%	8,986.4
Forest Reserve	12.22%	3,068.7
Industry	24.01%	6,030.3
Quarry	1.89%	475.0
Settlements	11.09%	2,785.5
Trade and Services	11.28%	2,833.0
Utility	0.69%	172.4
Waterbody	3.03%	760.7
Total Area	100.00%	25,111.9

Figure 5.6 – Schematic Land use within 5-km Radius

Source: Draft of RTD Kota Tinggi 2020; Google Earth Image, 2016

5.2.4 Existing Land Use within PEC Site

The Proposed Project is located on hilly and flat terrain. However, as per the agreement between Johor Corporation (JCorp) and ChemOne the site will be delivered as a cleared platform. As part of the PIPC site, the proposed site will have supporting infrastructures such as roadways, electricity substation, drainage and a centralised sewage treatment system.

Currently, the PEC proposed project location is covered with secondary vegetation, vegetable plantation and disused ponds (formerly used for fish farming). This land use is based on on-site observation and 2016 Google Earth imagery. The calculated land cover area for the site is as follows:

Table 5.1: Land Use Designation of the PEC Site

No	Land Cover	Land Use Designation (From RTD)	Area (±)	
			(ac)	(%)
1	Secondary Vegetation & Disturbed Land	Agricultural use	175.4	70.17
2	Plantation (Vegetable farms)	Agricultural use	55.5	22.20
3	Disused ponds	Agricultural use	14.3	5.72
4	Road	Agricultural use	4.8	1.91
		Total Area	**250.0**	**100%**

The above land use area is based on the observation during the site visit and the overlay of proposed boundaries as shown in *Figure* 5.7.

Figure 5.7 – Land Use within PEC Site

Source: Site visit 20th - 22nd February 2018, and Google Earth Image Year 2016

The neighbouring land use based on satelite imagery and on-site observations include:

Table 5.2: Neighbouring Land Use of PEC Site

North	Secondary vegetation and PERI Formwork Malaysia Sdn Bhd
South	RAPID, Petronas and existing chicken farm
East	Existing plantation and secondary vegetation
West	Secondary vegetation

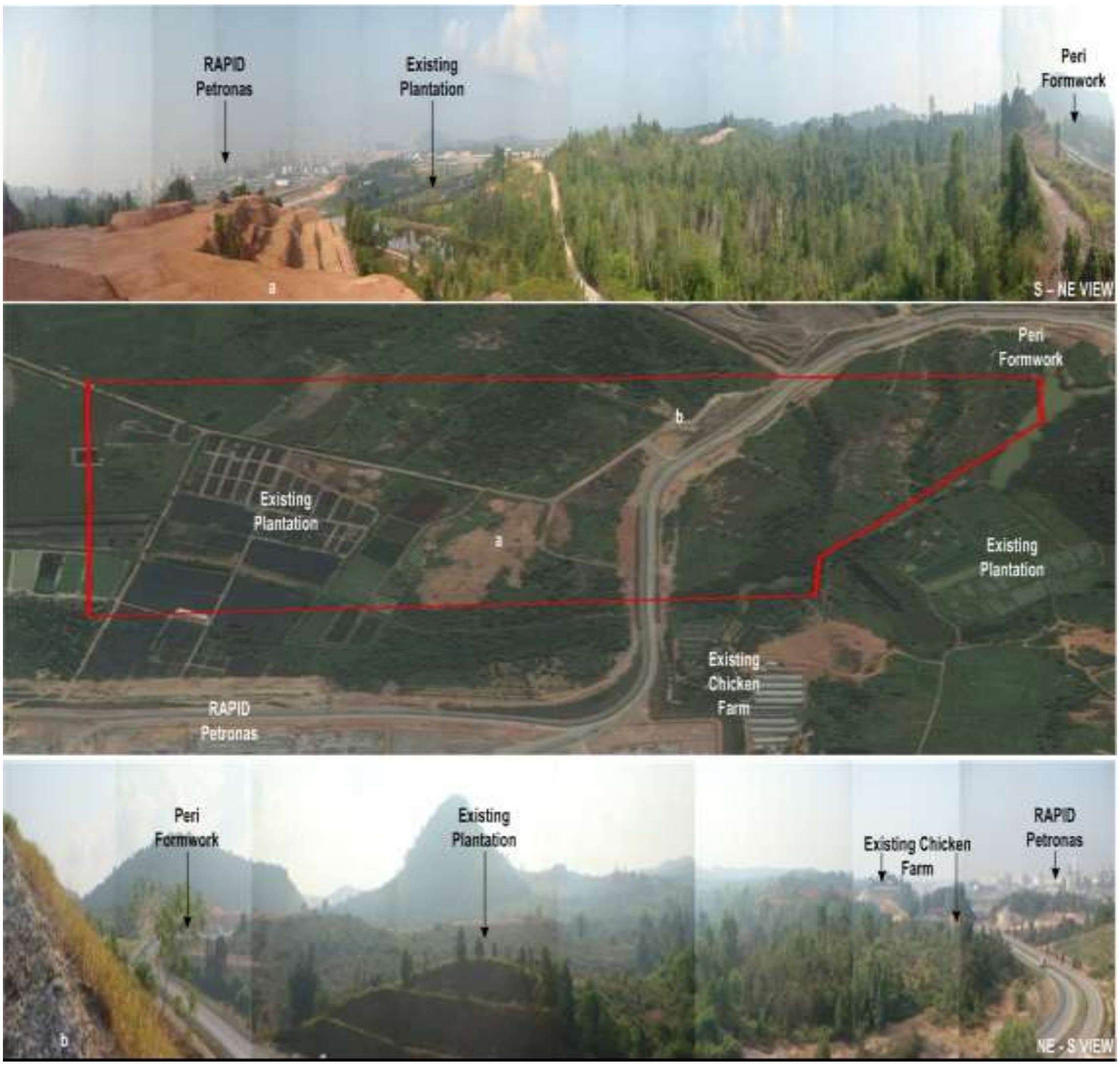


Figure 5.8 – Condition of The Site and its Neighbouring Area
(taken from point a & b)
Source: Site visit 20th - 22nd February 2018

It was noted during the site visit that there are no other sensitive receptors within the site. Sensitive receptors such as settlements, hospitals/clinics, schools, day-care facilities, elderly housing and convalescent facilities were also not found within a 500-m to 1-km radius outside the project boundary. The nearest settlement, Kg. Lepau, is found <2 km to the west of the site.

As the site visit was conducted in February – December 2018, it is reported that land use within the proposed PEC site has been changed. As of January 2019, the existing plantation within the proposed site in western part of the boundary; Peri Formwork in northeast tip; and existing chicken farm in the south are no longer active/ no longer operational. No confirmation on the existing plantation at the far east part off The Site, however closing/ relocation will be made since the plantation is located in PIP area.

5.2.5 Existing Land Use within 0-1 Km Radius from The Site

Based on the observation, the land within a 1 km radius of the site as shown in *Figure 5.9* is mostly covered by:

Table 5.3: Land Use Designation of the PEC Site

Land Cover	Area (±)	
	(ac)	(%)
Pond	42.3	2.21
Plantations	280.1	14.60
Roadway	26.7	1.39
Settlements & Public Amenities	3.4	0.18
Industries & Trades	57.7	3.01
RAPID	389.3	20.28
Disturbed Land & Secondary Vegetation	1,119.5	58.34
Total Area	**1,919.1**	**100.00**

No settlements and public amenities were observed within a 1 km radius except at the southern boundary which is currently being used as a worker's dormitory. There are several industrial activities present in the area and the survey confirmed that RAPID, TLH, Axianergy, Peri Formwork, and SISSPA 1 were operational or under construction. There were also 2 chicken farms located within 1 km radius and the only chicken farm that was observed operational located at the north eastern side of the Project or at the west side of SISSPA 1 complex.

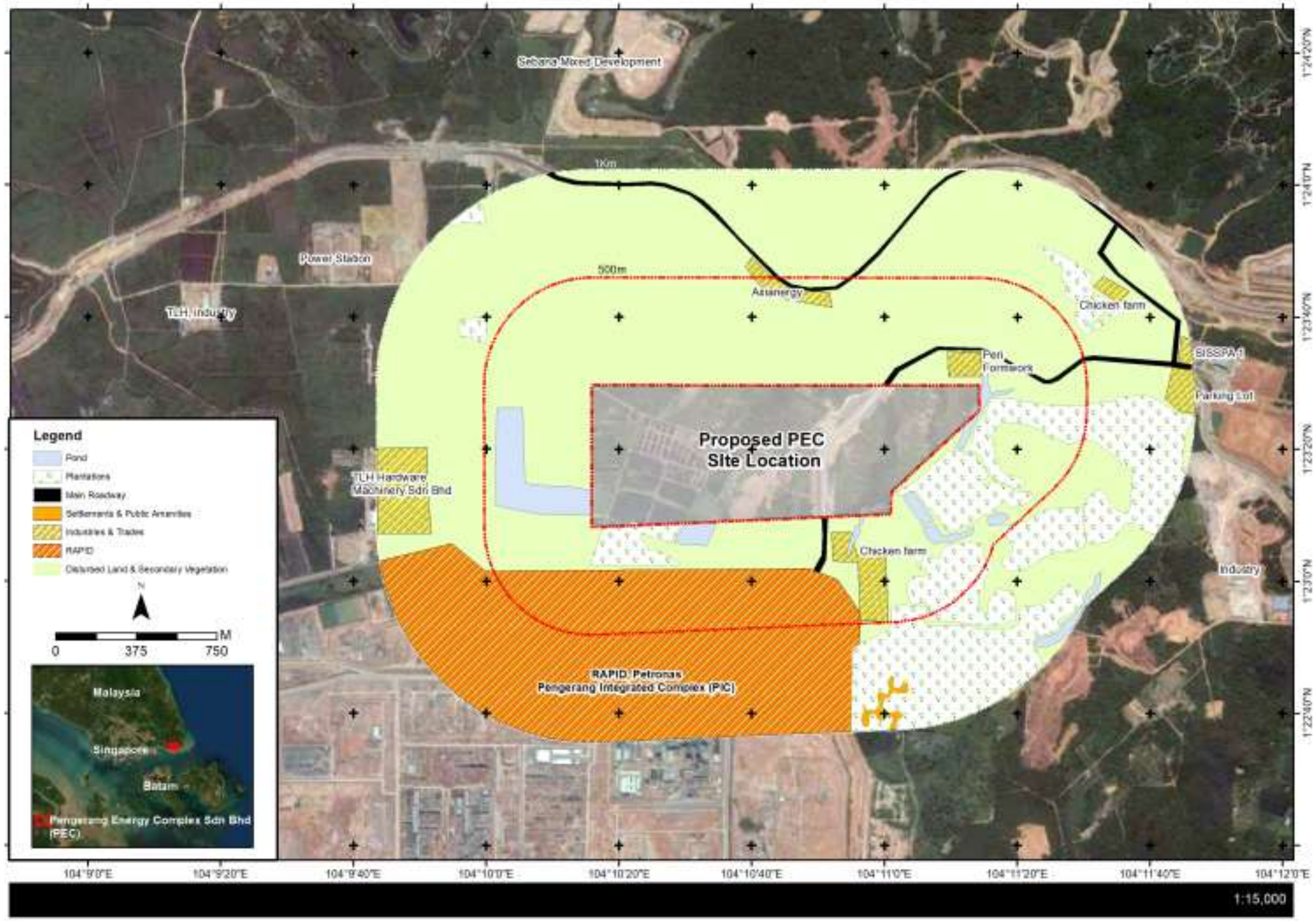


Figure 5.9 – Schematic Land Use within Site Boundary to 0-1 Km Radius

Source: Site visit 20th - 22nd February 2018; Google Earth Image, 2016

5.2.6 Existing Land Use within 1-3 Km Radius from The Site

Based on the observation, the land within 1 – 3 km radius of the site as shown in *Figure 5.10* is mostly covered by:

Table 5.4: Land Use Designation of the PEC Site

Land Cover	Area (±)	
	(ac)	(%)
Disturbed Land, Plantation, & Secondary Vegetations	5,066.3	58.00
RAPID	2,019.9	23.12
Industries & Trades	199.8	2.29
Settlements & Public Amenities	252.4	2.89
Resort	237.8	2.72
Mangrove area	556.9	6.38
Roadway	293.7	3.36
Sg Santi	108.9	1.25
Total Area	**8,735.7**	**100.00**

Several settlements and public amenities were observed within the 1-3 km Radius which include settlements of Kg. Lepau (less than 2 km west of the Project), Sebana Mixed Development (more than 1 km north of the Project), and settlements at Bukit Pelali and Kg Bukit Gelugor (located more than 2 km east of the Project). Settlements that were observed to be used mostly as workers settlements for RAPID and DIALOG are located at the south side of the Project at Kg. Sg. Kapal. Some of the workers were also observed to be living in Kg Lepau area. In general, settlements located in the radius of 3 km radius are as follows:

- Sebana Mixed Development (North side of the Project);
- Bukit Pelali and Kg. Bukit Gelugor (Northeast side of the Project);
- Kg. Sungai Kapal (South side of the Project); and
- Kg. Lepau (West side of the Project).

Several industries and trades that were confirmed operational or under construction in this radius include RAPID, TLH, SISSPA 1, Celcon Solutions Sdn Bhd, and ACE Sepakat. There were also one substation, namely Pengerang Substation located at the west side of the Project, and one quarry operated in the east side of the Project.

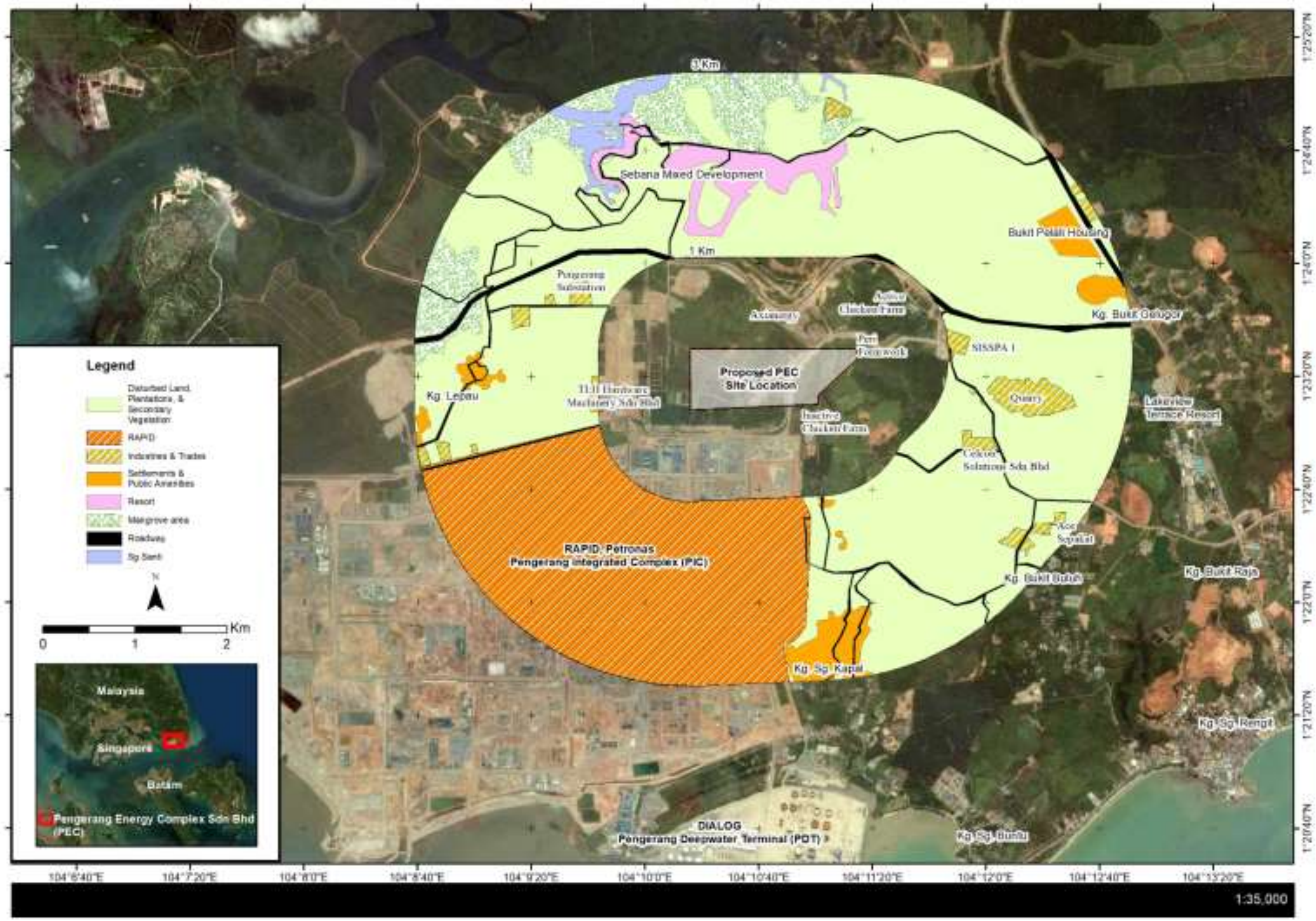


Figure 5.10 – Schematic Land Use within 1-3 Km Radius

Source: Site visit 20th - 22nd February 2018; Google Earth Image, 2016

5.2.7 Existing Land Use within 3-5 km Radius from the Site

Based on the observation, the land within 3-5 km radius of The Site as shown in *Figure 5.11* is mostly covered by:

Table 5.5: Land Use Designation of the PEC Site

Land Cover	Area (±)	
	(ac)	(%)
Disturbed Land, Plantation, & Secondary Vegetations	7,102.77	49.13
RAPID	2,687.57	18.59
DIALOG	776.35	5.37
Industries & Trades	348.42	2.41
Settlements & Public Amenities	323.84	2.24
Resort	11.57	0.08
Mangrove area	2,207.60	15.27
Roadway	231.31	1.60
Sea	224.09	1.55
Sg Santi	536.36	3.71
Temporary Landfill	7.23	0.05
Total Area	**14,457.1**	**100.00**

Observed settlements and public amenities within a 3-5 km radius of the Project were Lakeview Resort, Kg. Bukit Gelugor and Kg. Bukit Raja at the eastern part of The Project, and Kg. Bukit Buluh, Kg. Sungai Kapal, and Kg. Sungai Buntu at the southern part of the Project. RAPID & DIALOG, other industries, trade activities, clinic, temporary landfill, and PMU Teluk Ramunia were also observed. Settlement areas in Kg. Sg. Kapal are now being occupied by workers, mostly for RAPID and DIALOG (Pengerang Integrated Complex (PIC) and Pengerang Deepwater Terminal (PDT) project).

Figure 5.11 – Schematic Land Use within 3-5 km Radius

Source: Site visit 20th - 22nd February 2018; Google Earth Image, 2016

5.2.8 Settlements and Public Amenities within 5 Km Radius from The Site

Settlements

There are no large population centres near (< 5 km) to the PEC other than workers housing at the PIC. The nearest residential settlements/ occupied premises, comprise several small villages (Kg. Lepau being the closest), two resorts, one with residential units under development, and an ongoing residential/ commercial development.

The most sizeable settlements in the immediate area are outside the adopted 5 km EIA study boundary (though they may be close enough to be affected by, say air quality impacts from an industrial area the size of the PIPC); Kg. Sg. Rengit- by a few hundred meters, Pengerang, 7.3 km southwest of the PEC site and Taman Bayu Damai, a constructed settlement built to re-locate those directly impacted by the Phase 1 PIPC/ PIC/ RAPID to the east of the PIPC, near Tanjung Penyusup. Regardless, settlement in the area are not large, and were certainly not so prior to the influx of the tens of thousands of construction workers for the PIC, with the total reported resident population of Pengerang, Pantai Timur and Tanjung Surat sub districts at only 48,600 in 2010.

Some of the villages host temporary workers at the PIC and the resorts accommodate visiting professional staff to the PIC. Both developments actively marketing residential or commercial units are using the PIPC to spur sales and could be said to have been induced by the PIPC to develop or increase its scale.

- **Sebana Mixed Development** is believed to have the closest existing residential units to the PEC, alongside its own golf course situated 1.6 km north of the PEC. On the resort website their property is described as a '*1,200-acre resort township where residential and commercial components are cohesively planned alongside an exclusive private marina and an 18-hole golf course.'* Based on GE imagery, the resort was originally developed in the early 1990s, with all structures then ≥ 2 km from the PEC site location. Land clearance around and to the south of its golf course commenced in 2014 and the first of the first of its 'Golf Villas' completed by 2016 and hence it is likely some are occupied. The extent of land clearance, site preparation indicates the closest housing will be ~130m from the PIPC boundary (1.15 km from the PEC), when all cleared land under development is built on.
- **Kampung Lepau** is the next nearest settlement confirmed settlement, some 2 km to the west of the site and north of the PIC.
- The 363 acres **Bukit Pelali** development, 2.5 km northeast is offering residential units; terraced and cluster homes together with condominiums; as well as commercial shop lots and offices.

Table 5.6 shows the list of settlements within a 5 km radius from the proposed PEC site.

Table 5.6: Identified Settlements Surrounding the Proposed PEC

Settlement	Distance from Proposed Site	Status in 2019
Sebana Mixed Development	± 1,200 m (N)	Populated
Kg. Lepau	± 2,000 m (W)	Populated
Bukit Pelali Housing	± 2,500 m (NE)	Populated
Kg. Bukit Gelugor	± 3,300 m (NE)	Populated
Lakeview Terrace Resort	± 3,500 m (E)	Populated
Kg. Bukit Buluh	± 3,500 m (SE)	Populated
Kg. Sg Buntu	± 4,700 m (SE)	Populated
Kg. Bukit Raja	± 4,800 m (S)	Populated

Figure 5.12 – Settlements and Resorts within 5 Km Radius from Proposed PEC Site

Public Amenities

Table 5.7 shows the list of Public Amenities within a 5 km radius from the proposed PEC site.

Table 5.7: Identified Public Amenities Surrounding the Proposed PEC

Industries	Distance from Proposed Site	Status in 2019
SK Lepau	± 2000 m (W)	Operational
Masjid Kg Lepau	± 2000 m (W)	Operational
Klinik Perunding (H) Sungai Rengit	± 3200 m (E)	Operational
Surau Al Mutasodiqin	± 3700 m (E)	Operational
SMK Tanjung Datuk & Asrama Pusat dan Rumah Guru	± 4100 m (S)	Closed
SJK (C) Yok Poon	± 5000 m (SE)	Operational
SK. Sungai Rengit	± 5000 m (SE)	Operational
Surau Al Jamaliah	± 5000 m (E)	Operational
Surau Kg. Sg. Buntu	± 5000 m (E)	Operational
Chinese Temple	± 5000 m (SE)	Operational
Pengerang Presbyterian Church	> 5000 m (SE)	Operational
Sekolah Agama Sg. Rengit	> 5000 m (SE)	Operational
Sri Muneswaran Temple	> 5000 m (SE)	Operational
Bao An Gong Temple	> 5000 m (SE)	Operational
Ma-Zhu Temple	> 5000 m (SE)	Operational
Masjid Kamat	> 5000 m (SE)	Operational

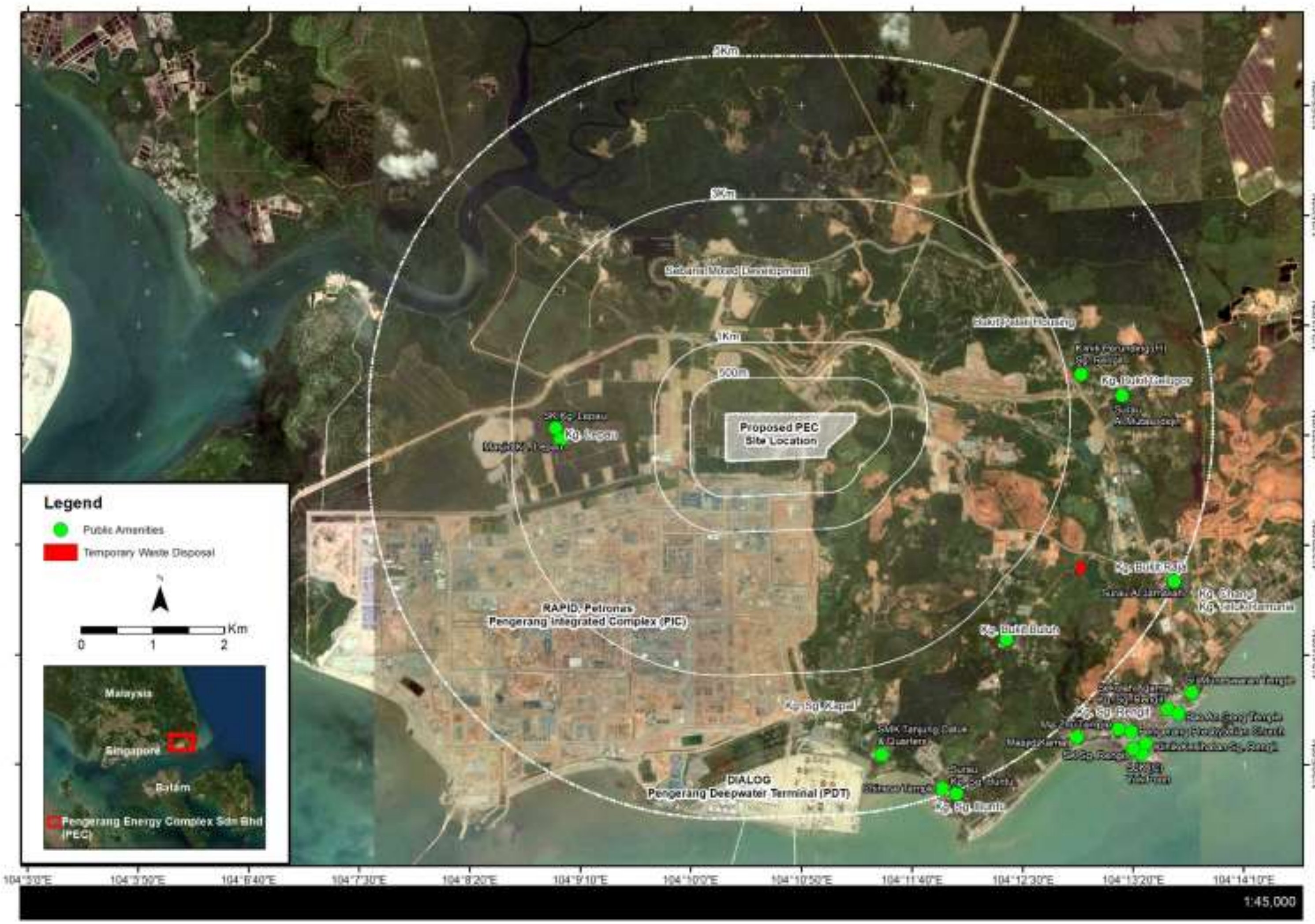


Figure 5.13 – Public Amenities within 5 Km Radius from Proposed PEC Site

5.2.9 Industries and Trades within 5 Km Radius from the Site

Table 5.8 shows the list of industries within a 5 km radius from the proposed PEC site.

Table 5.8: Identified Industries Surrounding the Proposed PEC

Industries	Distance from Proposed Site	Status in 2019
Peri Formwork Malaysia Sdn Bhd	± 100 m (N)	Closed
Inactive Chicken Farms	± 120 m (S)	Closed
Rapid, Petronas	± 270 m (S)	Operational
Axianergy	± 400 m (N)	Operational
Active Chicken Farms	± 750 m (NE)	Operational
TLH Hardware & Machinery Sdn Bhd	± 800 m (W)	Operational
SISSPA 1	± 1000 m (E)	Operational
Pengerang Substation	± 1200 m (NW)	Operational
Celcon Sollutions Sdn Bhd	± 1600 m (E)	Operational
Quarry	± 1700 m (E)	Operational
Industry in front of Bukit Pelali Housing	± 3000 m (NE)	Operational
Ace Sepakat	± 3000 m (SE)	Operational
Industry/ Trade near Kg Bukit Buluh	± 3000 m (SE)	Operational
PMU Teluk Ramunia	± 3800 m (E)	Operational
Industry/ Trade near Kg Bukit Raja	± 4000 m (SE)	Operational

Figure 5.14 – Industries within 5 Km Radius from Proposed PEC Site

Industrial Land Use in PIPC Phase 1 (On-going)

Phase 1 of the PIPC comprises the ongoing 6,277 acre, Pengerang Integrated Complex, a key project under Malaysia's Economic Transformation Programme (ETP) to meet future domestic energy requirements, and the Pengerang Deepwater Terminal, designed to meet the growing need for storage capacity of crude oil and petroleum products in South East Asia (SEA) and the wider Asia region.

From before 2015, soon after the first PIPC facility, the Dialog Terminal at the PDT, commenced operation, JPDC and the Johor Government have been improving infrastructure and public amenities in the area in line with the PIPC masterplan including:

- New roads and upgrades – Upgrading of 27 km of FT92 from Sg. Rengit, construction of 15 km of new PIPC ring road (NRR) as well as the tendering 24 km of internal PIPC roads and 20 km of drainage works with all to be complete in 2019.
- New fire stations have been constructed in Pungai, Sebana and Sg. Rengit, as well as a new police station, schools and medical facilities upgrades.

The land use and activities of the constituent parts of each of the two principal PIPC Phase 1 projects are outlined below, focussing on where the PEC has potential to significantly add to the PIC project's cumulative loadings to the environment:

- **Pengerang Deepwater Terminal (PDT):** The multi-phase, PDT project is being led by Dialog, in a joint venture with Royal Vopak and the Johor Government. It is being developed in several phases with capability to handle, store, blend and distribute crude oil, petroleum products, chemical and petrochemical feedstocks, products and by-products. The PDT can expand to utilise up to four deep water jetties to serve up to 1,355 acres of Centralised Tank Farm (CTF) for PIPC industries and other customers. Currently the PDT includes:
    - **PDT1;** which in 2014 was the first facility to start operations in the PIPC and consists of the Dialog developed, **Pengerang International Terminals Sdn Bhd (PIT);** a 150 acre, 1.3 Mm^3 capacity, liquid hydrocarbon bulk storage terminal situated on reclaimed land and a jetty with 6 deep water berths.
- **Pengerang Integrated Complex (PIC)/ Petronas RAPID Project:** The 6,277-acre PIC houses the USD 27 Billion, 6,242-acre, Petronas RAPID project. Construction of RAPID is nearing completion, with RAPID receiving its first crude oil cargo at Pengerang Deepwater Terminal 2 (PDT2) in September 2019 (PRefChem, 2018). The RAPID project comprises the following:
    - **Oil Refinery;** a 300,000 barrels per day (bpd) oil refinery complex that produces Euro 4M & 5 Mogas, diesels, aviation fuel (Jet A1) and fuel oils for distribution, as well as slurry sulphur by-product, together with LPG and naphtha for its steam cracker complex, that uses pyrolysis cracking to produce up to 3 MMtpa of ethylene/ C2 derivatives, propylene/ C3 derivatives and olefins/ C4/ C6 derivatives.
    - **Integrated Petrochemical Plants;** The cracker products will then directly feed Petronas Chemical's integrated petrochemical plants consisting of polymers, glycols and elastomers segments, with a combined total capacity of about 2.7 MMtpa.

Pengerang Refining and Petrochemical (PRefChem) is a strategic alliance between Petroliam Nasional Berhad (PETRONAS) and Saudi Arabian Oil Company (Saudi Aramco), the national oil company of Saudi Arabia through equal partnership in two joint venture (JV) companies, namely:

- Pengerang Refining Company Sdn. Bhd. (formerly known as PRPC Refinery & Cracker Sdn Bhd); and
- Pengerang Petrochemical Company Sdn. Bhd. (formerly known as PRPC Polymers Sdn Bhd).
- Collectively, the two companies are known as PRefChem.

The main RAPID supporting facilities within the PIC area are:

- **Pengerang Co-generation Plant (PCP):** The PCP is developed as a sophisticated (85% efficient), standalone utilities provider to RAPID. It can generate 1,220 megawatts of electricity (MW), of which 400 MW will be supplied to the national grid via a 51 km transmission line to TNB's substation in Tg. Langsat. In addition, the PCP will also produce up to 1,480 tonnes per hour of steam to meet the demands of the plants within the PIC. Operations, at reduced capacity, commenced in 2017.
- **Air Separation Unit (ASU);** that separates atmospheric air into its primary components, typically nitrogen and oxygen, and delivers various industrial gases to users in the PIC;
- **Raw Water Treatment Plant (RWTP);** treating water supplied by PAMER (see below);
- **Centralised and Shared Utilities and Facilities (UF);** for the PIC users; and
- **Administration buildings and temporary workers housing;** occupy the western part of the PIC, including accommodation for the thousands of construction workers.

Also being developed for RAPID, but outside the PIC area, are:

- **PIPC Raw Water Supply Project (PAMER);** with a first stage capacity to transfer and supply 260 million litres per day (MLD) of raw water in twin pipelines from Sg. Sedili Besar, via the Seluyut Dam and a terminal balancing reservoir at Bukit Panjang, to the PIPC/ PIC and other nearby consumers. The planned second stage can supply a further 260 MLD to the PIPC;
- **Second Pengerang Deepwater Terminal (PDT2);** adjacent to the existing PIT operated PDT1, within the PIPC CTF area; will, when it receives first cargo in August 2018, be a 2.1 Mm^3 capacity, 12 berth facilities to handle/ store RAPID/ PIC imported feedstock (crude oil) and the export of PIC products (petrochemicals & petroleum products); and
- **Re-gasification Terminal 2 (RGT2);** RGT-2, located within the same site as the PDT2, will provide primary gas supply to RAPID, its cogeneration plant, the PCP, and to the Peninsular Gas Utilisation (PGU) grid thereby meeting anticipated domestic gas demand. It will offer Liquefied Natural Gas (LNG) unloading and reloading (at a dedicated jetty suitable for large LNG vessel of sizes of up to $265{,}000m^3$), storage (in 2 x 200,000 m^3 LNG storage tanks), handling and regasification. The plant will have a capacity of 3.5 MMtpa and will be connected to PGU grid via the Pengerang Gas Pipeline (PGP). RGT2 received its first shipment of LNG in October 2017.

All of these large-scale developments are confirmed and some PIC plants/ projects are already operating, with all to be in full operation at proposed PEC commissioning (estimated in 2022). During the PEC EIA environmental baseline studies, some PIC facilities will be in full or partial operation, some may be at the commissioning stage, while others still under construction. As of December 2018, 96% of PIC was completed.

5.3 Atmosphere

5.3.1 Climate

The climate in Pengerang is typical of tropical equatorial climate with abundant rainfall, high and uniform temperatures, and high humidity all year round.

Meteorological data from 2015 to 2017 was sourced from the Malaysian Meteorological Department. The nearest meteorology monitoring station is the Felda Sg. Mas (Station No. 47125). This station is located approximately 26 km from the proposed project site and is the closest station compared to Senai Meteorological Station, which is located approximately 63 km from the proposed project site. The coordinates to the Felda Sungai Mas meteorology monitoring station is 01^{o} 37' N, 104^{o} 09' E. The station monitors parameters such as Temperature, Humidity, Wind and Rainfall as discussed below and summarized as follows:

- The average annual temperature in the area was recorded at 26.7^{o}C with little seasonal variation.
- Rainfall trends for the area show an irregular distribution. High with rainfall was recorded during the months of November, December, February, May and August. There is no particular dry season however the average annual rainfall was recorded to be 59.3 mm.
- The monthly mean relative humidity ranged from 81.3% to 86.6%, with an average of 84%. The highest mean relative humidity was in November and the lowest in March.

Wind was predominantly from northeast and south directions consistent with Malaysia's monsoons (*Figure* 5.15). Wind speeds typically range from 0.3 to 3.3 m/s. Maximum wind speed was recorded at 3.4 to 5.4 m/s.

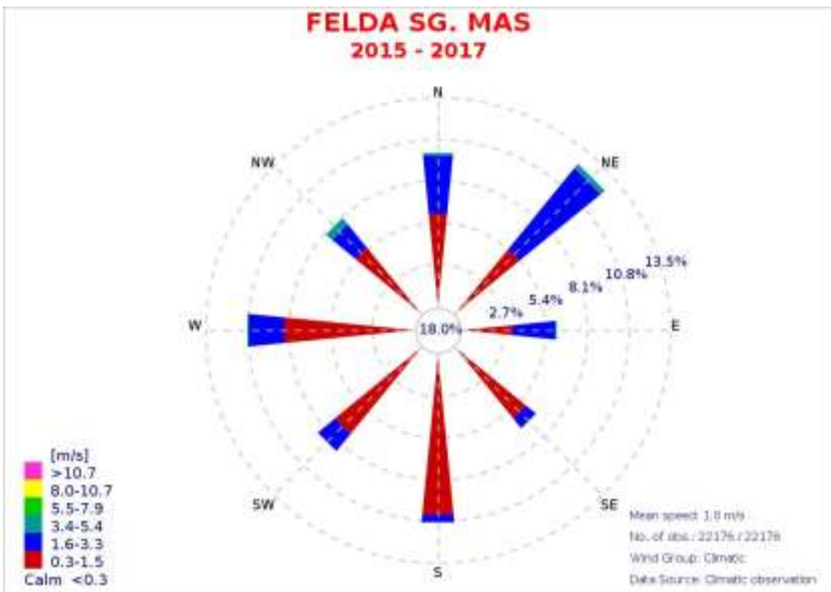


Figure 5.15 – Windrose from Felda Sg. Mas Station

Data was also sourced from Changi meteorology station in Singapore. The PEC site is located 21 km away to the east of Changi, Singapore (1°21'6.93"N; 103°59'18.05"E) The parameters of the data recorded by this station are similar to the data recorded in the Felda Sg. Mas station. The data recorded for the year 2015 to 2017 are summarised and discussed below:

- The average annual temperature in the area was recorded at 28.1^{o}C.
- Rainfall trend in the area is similar to the Felda Sg. Mas area with heavy rainfall recorded during the months of February, May, November, and December. The average annual rainfall was recorded to be at 4.8 mm.
- Wind was predominantly from northeast, southeast and southwest with the speed ranges from 7 to 10km/hr with an average of 8.9 km/hr. Max wind speed ranges from 28 to 38 km/hr with an average of 32.6 km/hr.
- The monthly mean relative humidity ranged from 72.7% to 83.7%, with an average of 78.1%. The highest mean relative humidity was in November and the lowest in March.

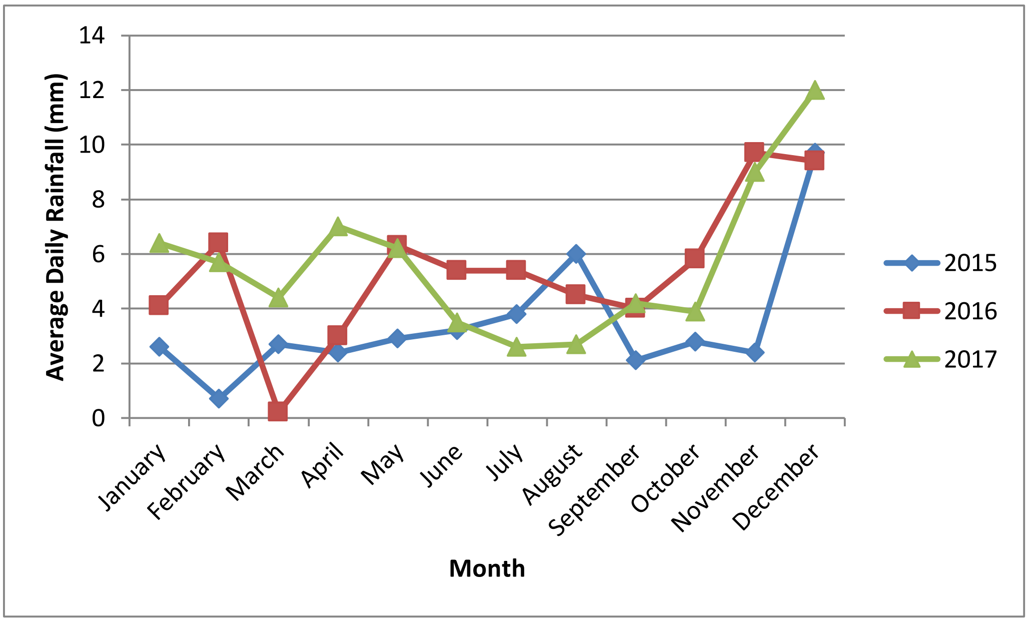


Figure 5.16 – Average Daily Rainfall at Changi Monitoring Station (S24) 2015- 2017

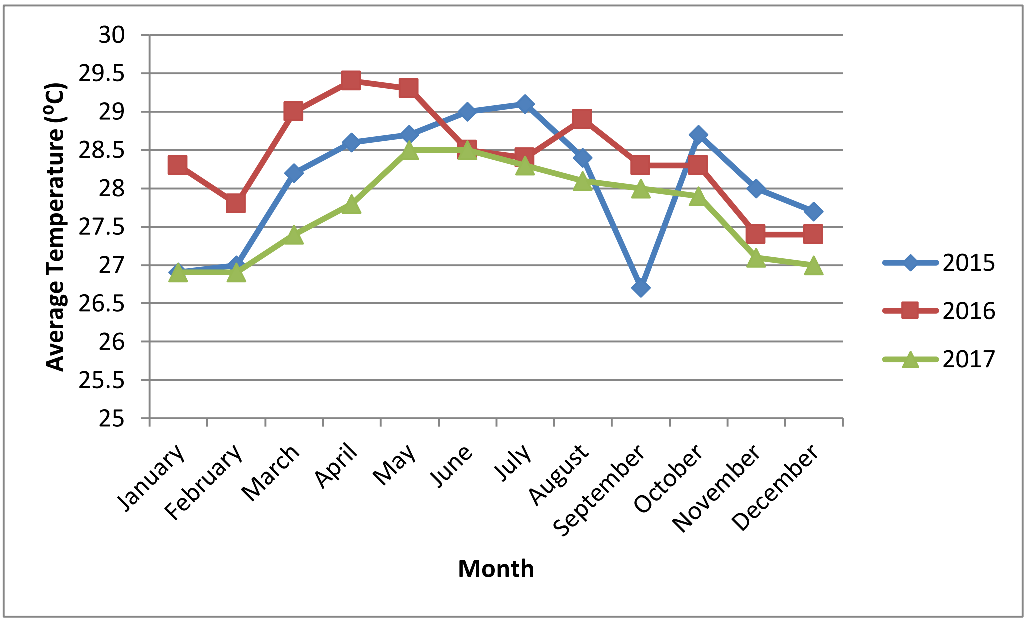


Figure 5.17 – Average Temperature at Changi Monitoring Station (S24) 2015 - 2017

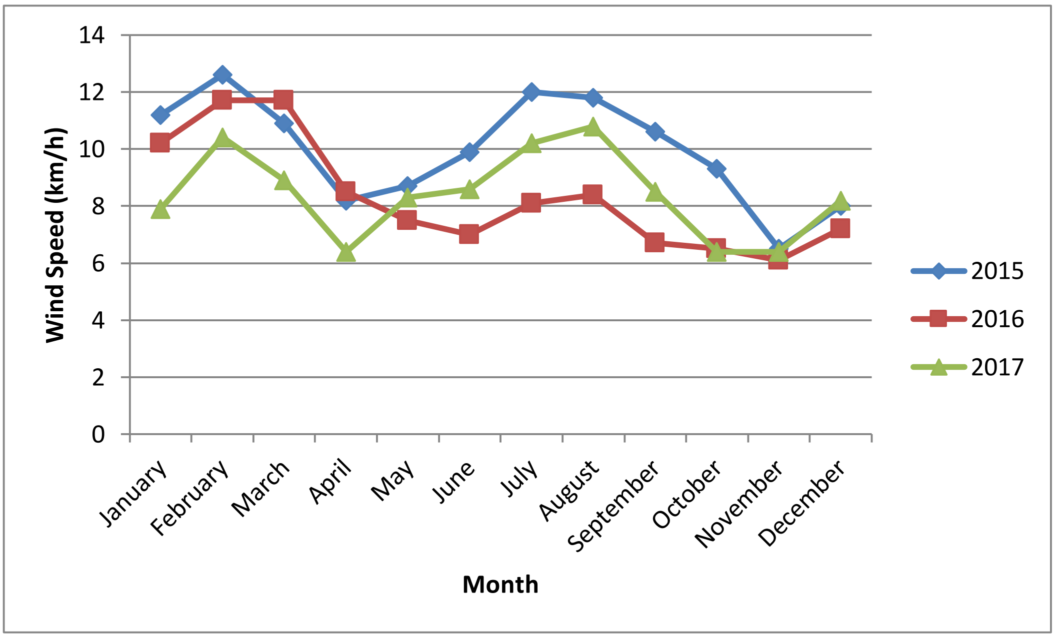


Figure 5.18 – Average Wind Speed at Changi Monitoring Station (S24) 2015 - 2017

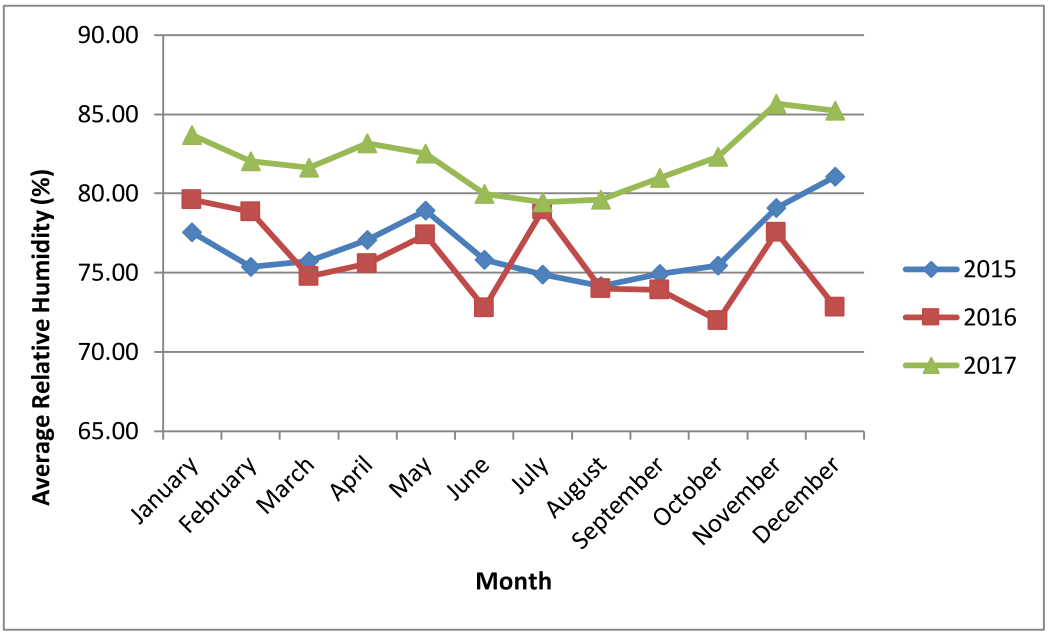


Figure 5.19 – Average Relative Humidity at Changi Monitoring Station (S24) 2015 - 2017

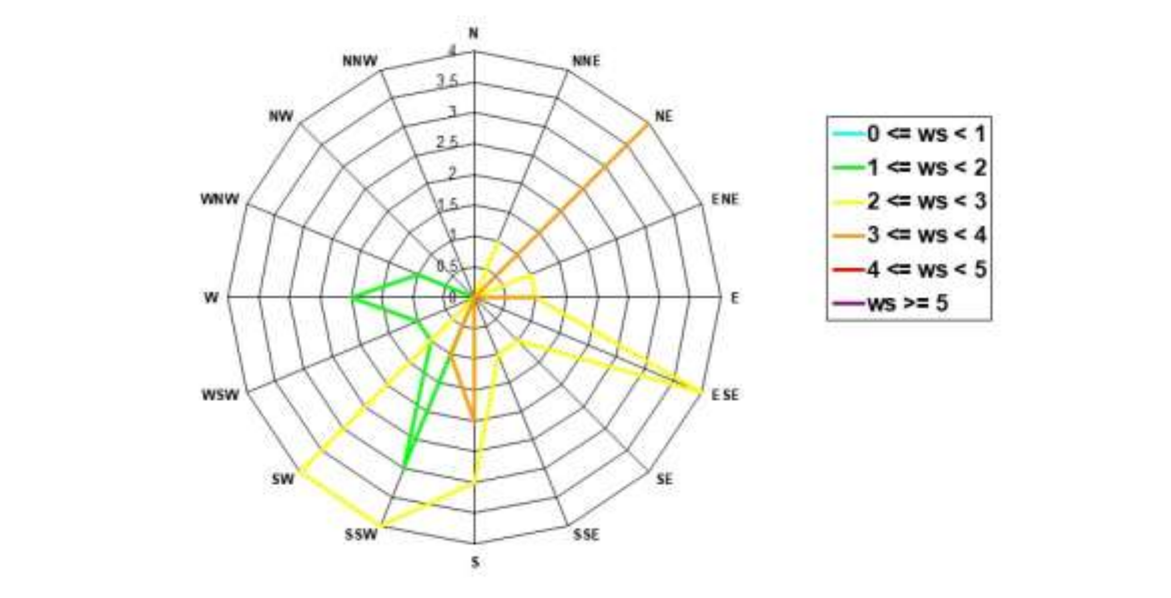


Figure 5.20 – Windrose Diagram of Wind Direction and Speed from Changi Monitoring Station (S24) 2015 - 2017

5.3.2 Air Quality

No major sources of air pollution were identified whilst on site. Air quality status is reported in terms of Air Pollution Index (API) where the API is calculated based on concentration of five major pollutants which are ground level ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter of less than 10 microns in size (PM_{10}). The API is categorised as good, moderate, unhealthy, very unhealthy and hazardous. Based on data from the DOE's Environmental Quality Report 2016, the air quality in Kota Tinggi was considered as "Good" air quality with a reported total of 190 days of "Good" air quality in 2016.

The closest DOE air quality monitoring station is the Pengerang Station located in Kg. Lepau. The station is approximately 2.4 km to the proposed project site and is located within the compound of Sekolah Kebangsaan Lepau. The coordinate of the monitoring station is 1.389973° N, 104.149584° E. The monitoring station continuously monitors parameters such as PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO as listed in the Malaysia Ambient Air Quality Standard (MAAQS).

According to DOE, the monitoring station has only been operating since 2017 and most of the data is still not available to the public. Therefore, DOE can only provide the air quality data for the year of 2017.

The air quality data from the monitoring station for the year of 2017 is shown in Table *5.9* and can be summarised as follows:

- The level of concentration of PM_{10} for the month of December exceeded the Malaysian Ambient Air Quality Standards (MAAQS) of 120 µg/m^3.
- The level of concentration of $PM_{2.5}$ from July until December exceeded the Malaysian Ambient Air Quality Standards (MAAQS) of 50 µg/m^3.
- The level of concentration of NO_2 for the months of July and November exceeded the Malaysian Ambient Air Quality Standards (MAAQS) of 0.040 ppm.
- The air quality data for the parameters O_3 and CO were not available.

Table 5.9: Air Quality Data (2017) from the Monitoring Station in Kg. Lepau

Month	MAAQS Limit IT-2 (2018)	July	August	September	October	November	December
PM_{10} (µg/m^3)	120	104.412	99.881	72.1	118.814	117.417	**189.048**
$PM_{2.5}$ (µg/m^3)	50	**58.624**	**70.075**	**62.131**	**88.71**	**99.626**	**154.285**
SO_2 (ppm)	0.035	0.0067	0.0032	0.0145	0.0212	0.0108	0.0027
NO_2 (ppm)	0.040	**0.0637**	0.038	0.0345	0.0283	**0.0408**	0.0249
O_3 (ppm)	0.060	NA	NA	NA	NA	NA	NA
CO (ppm)	8.75	NA	NA	NA	NA	NA	NA

Note: Results in **BOLD** indicate exceedance to Standard limits.
NA: Not Available

Baseline Ambient Air Quality Sampling

Baseline ambient air sampling was conducted from 24th September to 5th October 2018 at eight (8) locations. The location of the sampling points is shown in *Table 5.10* and *Figure* 5.21 below. Sampling was conducted by a SAMM-accredited laboratory. Samples were sent for laboratory analysis for the following parameters: Particulate Matter (PM_{10}), Particulate Matter ($PM_{2.5}$), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), and Carbon Monoxide (CO). The results showed that PM_{10} and $PM_{2.5}$ levels were over the Malaysian Ambient Air Quality Standards (MAAQS), and hydrogen sulphide (H_2S) levels were abnormally high with no source of the pollution identified (Table *5.11*).

As there were doubts over the results from the first sampling event, additional baseline ambient air sampling was conducted from 10th April to 12th April 2019 at the same 8 sampling locations. A different, SAMM-accredited laboratory, was used for the sampling activities.

The results from the additional sampling were all below the MAAQS except for $PM_{2.5}$ at station A2. The possible sources of the dust pollution observed in the site surrounding are the ongoing construction works and vehicles at PIPC, from the road traffic along unpaved roads and nearby land clearing activities.

Another round of baseline monitoring for the same parameters and locations was conducted from 29th April to 1st May 2019. The results were all below the MAAQS.

Additional sampling for hydrogen sulphide was conducted on 20th June 2019 and 15th – 17th July 2019 (for H_2S & $PM_{2.5}$) at the same locations as the previous monitoring locations. All the results were below the MAAQS. Currently, there is no prescribed limit for H_2S in the ambient air standards. Results from the subsequent samplings are shown in Table *5.11*.

The certificate of analysis is shown in *Appendix D*.

Table 5.10: Location of Baseline Air Quality Sampling Points

Sampling Point	Northing	Easting
A1	1°24'23.4"N	104°10'40"E
A2	1°23'20"N	104°9'00"E
A3	1°23'5"N	104°10'40"E
A4	1°24'0"N	104°12'0"E
A5	1°23'40"N	104°12'40"E
A6	1°23'20"N	104°13'0"E
A7	1°24'30"N	104°9'30"E
A8	1°23'30"N	104°10'50"E

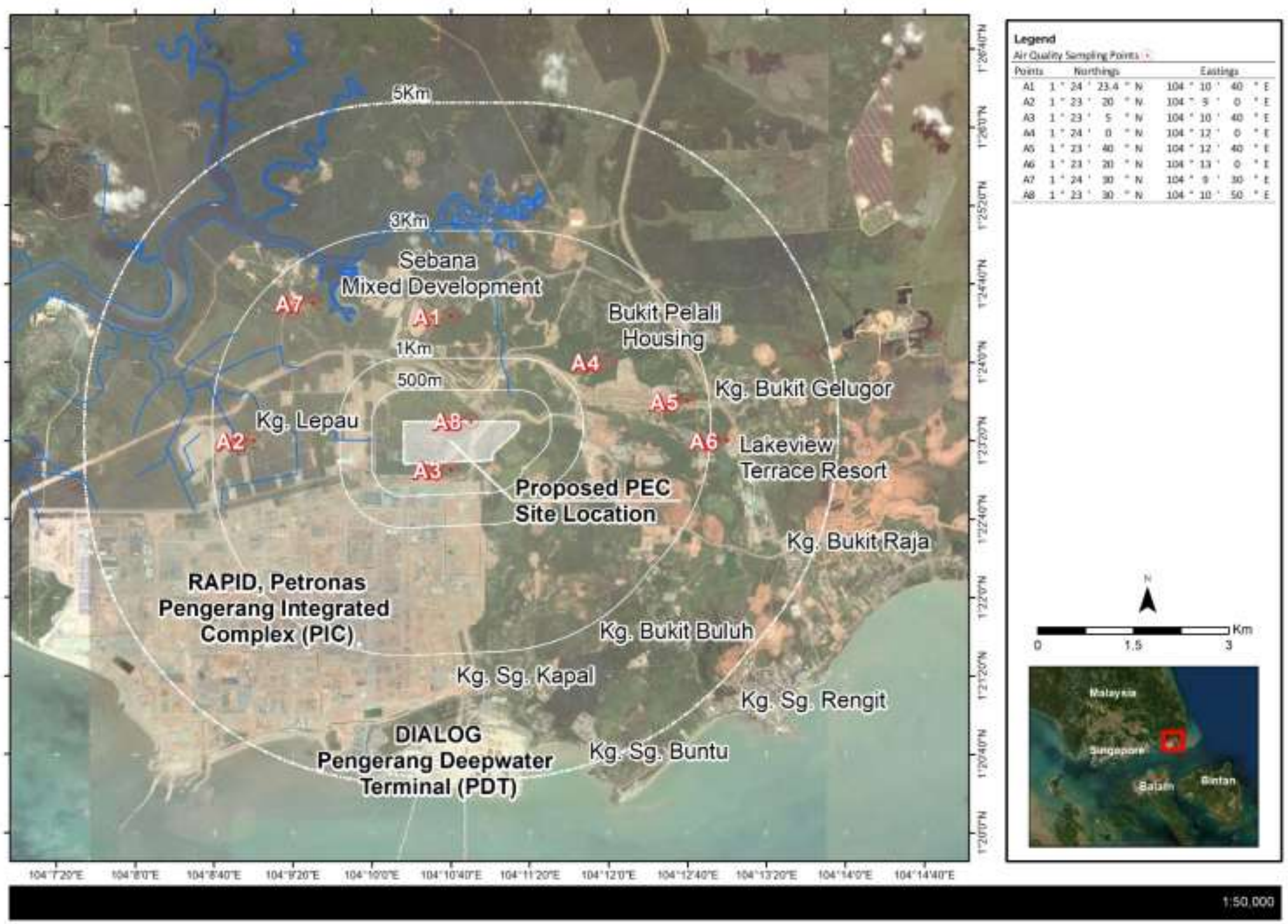


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Figure 5.21 – Baseline Ambient Air Quality Sampling Location

Table 5.11: Ambient Air Quality Sampling Result

Parameter	Duration	Unit	A1	A2	A3	A4	A5	A6	A7	A8	MAAQS*
24th September – 5th October 2018											
Particulate Matter (PM_{10})	24 hrs	µg/m³	**278**	**139**	**125**	97	**153**	97	111	181	120
Particulate Matter ($PM_{2.5}$)	24 hrs	µg/m³	**139**	**97**	**83**	**83**	**111**	**83**	**69**	**83**	50
Nitrogen Dioxide (NO_2)	1 hr	µg/m³	<42	<42	<42	<42	42	42	<42	42	300
Sulphur Dioxide (SO_2)	1 hr	µg/m³	<83	<83	<83	<83	<83	<83	83	<83	300
Carbon Monoxide (CO)	1 hr	mg/m³	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	35
Carbon Monoxide (CO)	8 hrs	mg/m³	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10
Total Hydrocarbon	8 hrs	µg/m³	<104	<104	<104	<104	<104	<104	<104	<104	-
Volatile Organic Compound (VOC)	8 hrs	mg/m³	ND	ND	ND	ND	ND	ND	ND	ND	-
Hydrogen Sulphide (H_2S)	8 hrs	µg/m³	27.1	27.1	25.0	20.8	22.9	22.9	22.9	35.4	-
Ammonia (NH_3)	8 hrs	mg/m³	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Monocylic Aromatics											
Benzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Toluene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Ethylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
m & p-Xylene	8 hrs	µg/m³	< 21	< 21	< 21	< 21	< 21	< 21	< 21	< 21	-
Styrene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
a-Xylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Isopropylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
n-Propylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,3,5-Trimethylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
sec-Butylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2,4-Trimethylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
tert-Butylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
p-Isopropyltoluene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
n-Butylbenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Oxygenated Compounds											
2-Butanone (MEK)	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
4-Methyl-2-pentanone (MIBK)	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-

Parameter	Duration	Unit	A1	A2	A3	A4	A5	A6	A7	A8	MAAQS*
2-Hexanone (MBK)	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
Fumigants											
2 ,2-Dichloropropane	8 hrs	µg/m³	< 10	< 10	< 10	< 10		< 10	< 10	< 10	-
1,2-Dichloropropane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
cis-1,3-Dichloropropylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
trans-1 ,3 Dichloropropylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2-Dibromoethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Halogenated Aliphatics											
Dichlorodifluoromethane	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
Chloromethane	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
Vinyl chloride	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
Bromomethane	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
Chloroethane	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
Trichlorofluoromethane	8 hrs	µg/m³	< 104	< 104	< 104	< 104	< 104	< 104	< 104	< 104	-
1,1-Dichloroethylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
trans-1,2-Dichloroethylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,1-Dichloroethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
cis-1,2- Dichloroethylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1, 1,1-Trichloroethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,1-Dichloropropylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Carbon tetrachloride	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2-Dichloroethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Trichloroethylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Dibromomethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,1,2-Trichloroethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,3- Dichloropropane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Tetrachloroethylene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,1,1,2-Tetrachloroethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,1,2,2-Tetrachloroethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2,3-Trichloropropan e	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2-Dibromo-3-chloropropani	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-

Parameter	Duration	Unit	A1	A2	A3	A4	A5	A6	A7	A8	MAAQS*
Hexachlorobutadiene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Halogenated Aromatics											
Chlorobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Bromobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
2-Chlorotoluene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
4-Chlorotoluene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,3-Dichlorobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,4-Dichlorobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2-Dichlorobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2,4-Trichlorobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
1,2,3-Trichlorobenzene	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Trihalomethanes											
Chloroform	8 hrs	µg/m³	< 42	< 42	< 42	< 42	< 42	< 42	< 42	< 42	-
Bromodichloromethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Dibromochloromethane	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
Bromoform	8 hrs	µg/m³	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-
10th April – 12th April 2019											
Particulate Matter (PM_{10})	24 hrs	µg/m³	78	93	56	14	32	40	41	51	120
Particulate Matter ($PM_{2.5}$)	24 hrs	µg/m³	23	**66**	43	8	27	18	39	6	50
Nitrogen Dioxide (NO_2)	24 hrs	µg/m³	10	9	<5	8	<5	<5	<5	<5	90
Sulphur Dioxide (SO_2)	24 hrs	µg/m³	<5	<5	<5	<5	<5	<5	<5	<5	75
Carbon Monoxide (CO)	8 hrs	mg/m³	0.8	1.4	0.8	0.8	2.6	2.3	1.1	1.1	10
29th April – 1st May 2019											
Particulate Matter (PM_{10})	24 hrs	µg/m³	43	38	62	32	65	42	41	48	120
Particulate Matter ($PM_{2.5}$)	24 hrs	µg/m³	29	21	29	19	37	24	20	18	50
Nitrogen Dioxide (NO_2)	24 hrs	µg/m³	<5	<5	<5	<5	<5	<5	<5	<5	90
Sulphur Dioxide (SO_2)	24 hrs	µg/m³	<5	<5	<5	<5	<5	<5	<5	<5	75
Carbon Monoxide (CO)	8 hrs	mg/m³	0.8	1.1	1.4	2.3	2.6	2.9	0.8	1.1	10
20th June 2019											
Hydrogen Sulphide (H_2S)	8 hrs	µg/m³	<10	<10	<10	<10	<10	<10	<10	<10	-
15th – 17th July 2019											

Parameter	Duration	Unit	A1	A2	A3	A4	A5	A6	A7	A8	MAAQS*
Hydrogen Sulphide (H_2S)	8 hrs	µg/m^3	<10	<10	<10	<10	<10	<10	<10	<10	-
Particulate Matter ($PM_{2.5}$)	24 hrs	µg/m^3	25	16	37	26	38	26	31	33	50

*Note: Results in **BOLD** indicate exceedance to Standard limits.*

**AAQS: Malaysia Ambient Air Quality Standard Interim Tier 2018*

5.3.3 Noise

Baseline environmental noise level sampling was conducted in October 2018. A total of six (6) sampling points were identified. Refer to *Table 5.12* and *Figure* 5.22 for the location. 24-hour sampling was conducted at each location using a Sound Level Meter, Model BSWA308 which was calibrated before the sampling. The results of the sampling are shown in *Table 5.13* and *Table 5.14* for both day time and night time sampling, respectively.

Results were compared with the maximum permissible sound level set in the Planning Guidelines for Environmental Noise Limits and Control. When compared to the permissible sound level for *Schedule 6: Maximum Permissible Sound Levels (Percentile L_N and L_{max}) of Construction, Maintenance and Demolition Works by Receiving Landuse of The Planning Guidelines for Environmental Noise Limits and Control, 2007* 'Noise Sensitive Areas, Low Density Residential, Intuitional, Worship Areas', the existing baseline already exceeded the maximum sound level of 50dB and 40dB for day time and night time, respectively. Based on field observations, the possible high noise sources in the site surrounding are from the construction works and vehicles, road traffic flow and occasional plant noise from the RAPID project site.

Table 5.12: Location of Baseline Noise Sampling Points

Sampling Point	Northing	Easting
N1	1°24'23.4"N	104°10'40"E
N2	1°23'20"N	104°9'00"E
N3	1°23'50"N	104°10'40"E
N4	1°24'00"N	104°12'00"E
N5	1°23'40"N	104°12'40"E
N6	1°23'20"N	104°13'00"E

Table 5.13: Baseline Noise Levels – Day Time (Time: 0700 to 2200)

Sample Marking	Noise Level, dB (A)				
	L_{eq}	L_{min}	L_{max}	L_{10}	L_{90}
N1	63.4	45.9	88.7	66.8	56.5
N2	63.4	55.0	102.7	64.6	56.7
N3	50.0	45.2	63.8	52.6	45.7
N4	58.5	36.7	89.5	60.7	52.9
N5	65.8	43.4	98.5	63.8	61.6
N6	66.8	37.8	92.1	68.5	61.5

Table 5.14: Baseline Noise Levels – Night Time (Time: 2200 to 0700)

Sample Marking	Noise Level, dB (A)				
	L_{eq}	L_{min}	L_{max}	L_{10}	L_{90}
N1	57.6	37.0	89.5	60.0	51.0
N2	58.6	55.1	97.6	57.4	56.3
N3	48.5	45.7	55.5	52.5	46.1
N4	56.0	36.7	89.5	59.1	39.1
N5	57.9	48.5	98.5	59.8	50.7
N6	57.2	36.7	89.5	59.7	47.3

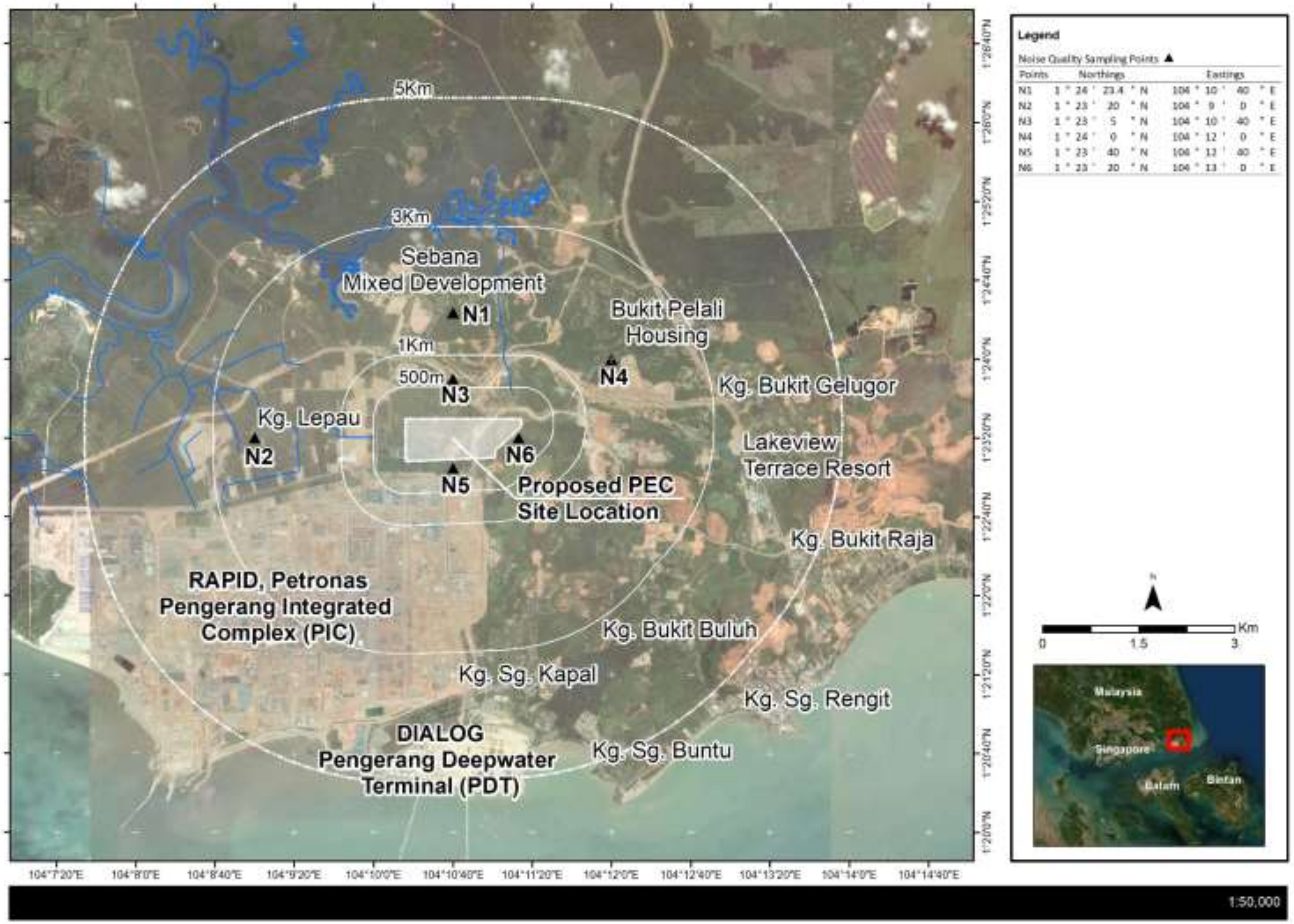


Figure 5.22 – Baseline Noise Quality Sampling Location

5.4 Lithosphere

5.4.1 Vibration

There are no residential areas within the immediate vicinity (1 km Radius) of the proposed PEC site. As such, vibration is not considered to represent a significant issue of concern.

5.4.2 Geology

Based on the 2014 geological map of Peninsular Malaysia by the Department of Mineral and Geoscience, the PEC project area is characterised by Permian Sedimentary Rocks as part of Palaeozoic rocks that are distributed along east Johor (*Figure* 5.23). These sedimentary rocks consist of phylite, slate, and shale with subordinate sandstone and schist. In this area, there is a prominent development of limestone and volcanic characteristics; mainly rhyolitic to andesitic in composition.

As it is situated in Pengerang Tuff (Surjono. SS. *et al*, 2004), the tuff and agglomerate with some lava are also present in this area where tuff and agglomerate are bedded as submarine pyroclastic products. This area may also part of unconformable deposited above the Mersing Formation which are clastic sediment (Murau Conglomerate Formation, Dohol Formation) and volcanic rocks (Sedili, Jasin and Pengerang volcanic). The Pengerang volcanic zone along Tanjung Belungkur shows pyroclastic flows forming thick bed succession. The clasts composed of lapili, lithic and re-sedimented of pyroclastic rocks. However, the Pengerang volcanic along Teluk Ramunia and Pengerang showing that they were produced by several volcanic activities such as intrusions, lava flow as well as pyroclastic flows.

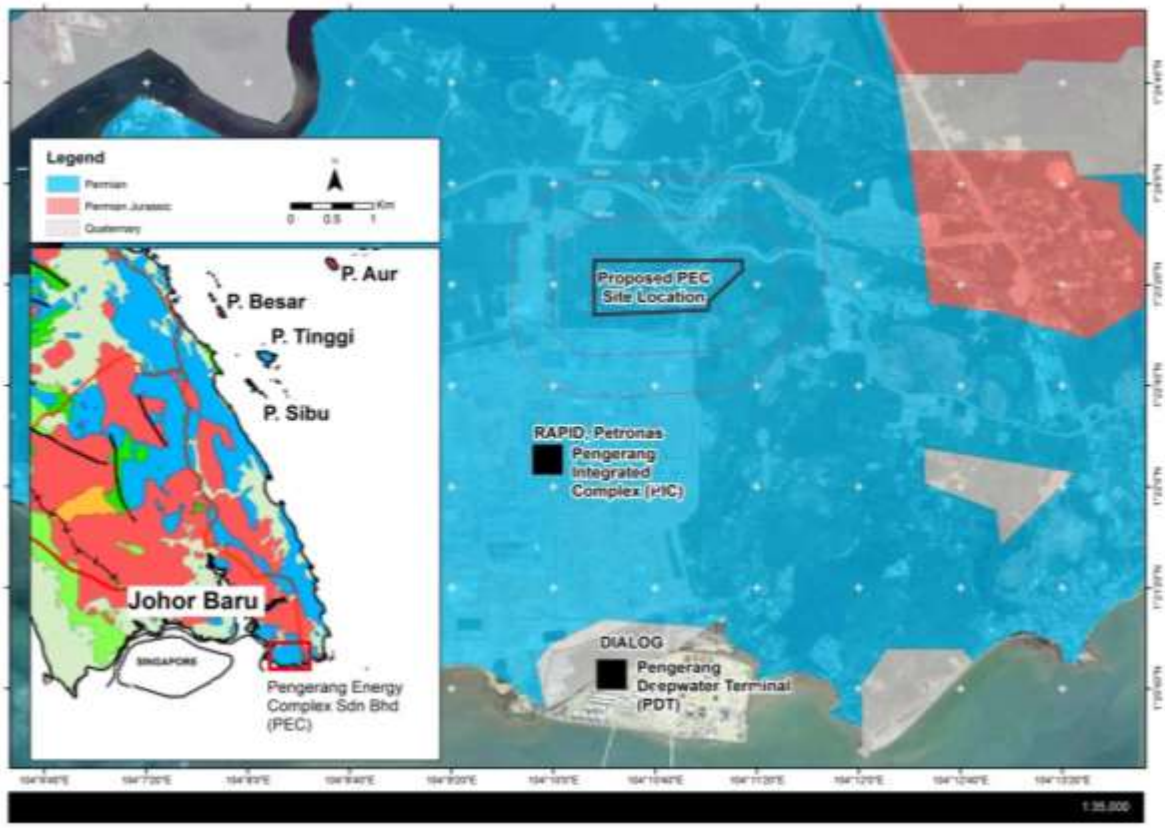


Figure 5.23 – Geological Map within 1 km Radius and in The Vicinity of Proposed PEC

5.4.3 Soil

According to the EIA report for PIP, a soil investigation (SI) study was conducted at the PIP site by Ehwan Bakti Geotechnical & Engineering Service. The SI study was carried out from 16th November 2017 to 10th January 2018. A total of sixty-one (61) boreholes and twenty-eight (28) Mackintosh probes were conducted at the site. However, the EIA report only summarised the data from ten boreholes; no explanation was given on how the ten were chosen and why the rest were not summarised.

The depth of the 10 boreholes ranged from 7 to 21 mbgl. Generally, the top soil was silty sand with organic matter. Between the topsoil to 9 mbgl, the soil was stiff and made up mostly of sand and silt. Between 9 to 21 mbgl, the soil was dense with high plasticity.

Based on the soil map, the proposed site is located on 2 different soils. The western part of the proposed site is located in soils of the alluvial plains and low terraces with organic soils with Gley soils while the eastern part of the proposed site is located on soils o the intermediate and high terraces with red yellow loatosols and Gley soils on subrecent alluvium.

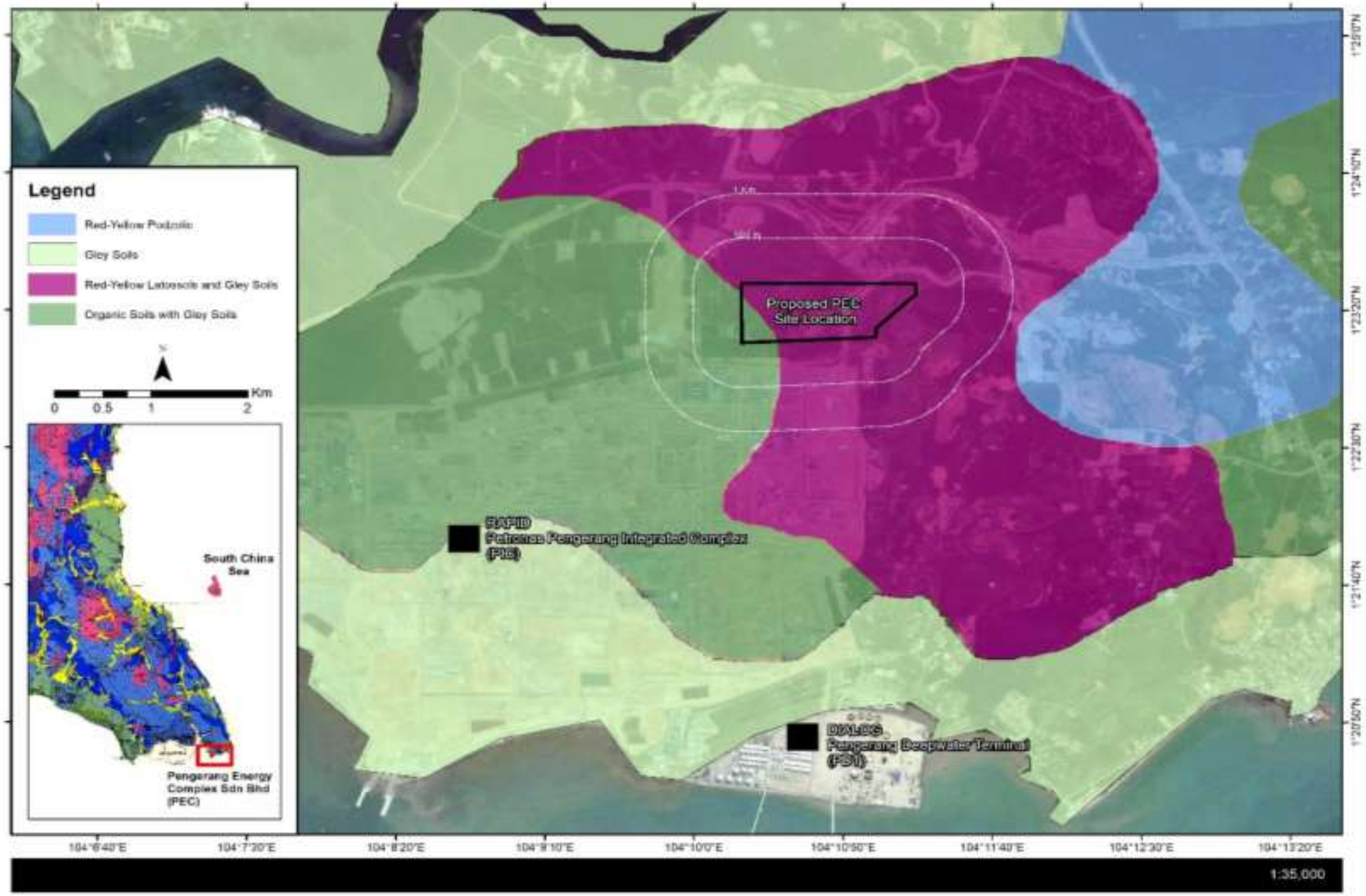


Figure 5.24 – Soil Map

Baseline soil sampling was conducted on 12th and 13th December 2018. Of the proposed fifteen (15) soil sample locations stated in the TOR, only six (6) locations were safely accessible. Due to heavy rains in December and the hilly terrain, many of the proposed borehole locations were inaccessible.

All the borehole drillings were carried out using the percussion drill with hollow stem auger to a maximum depth of 5 meter below ground level (mbgl). At each borehole, soil samples were taken at the first 0.5 mbgl and subsequently every 1 mbgl up to the maximum depth of 5 mbgl. In-situ soil test was then conducted on each soil sample to determine soil characteristics. One soil sample was collected from each borehole; the samples taken were from above the groundwater table, with the exception of BH2 whereby one sample was taken above and below the groundwater level. One duplicate sample was collected from BH3 for quality control. Therefore, a total of eight (8) samples were collected for laboratory analysis.

Laboratory analysis was conducted for the following parameters: 13 heavy metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc), total petroleum hydrocarbons (TPH), volatile organic compounds (VOC) and semi-volatile organic compounds (SVOC).

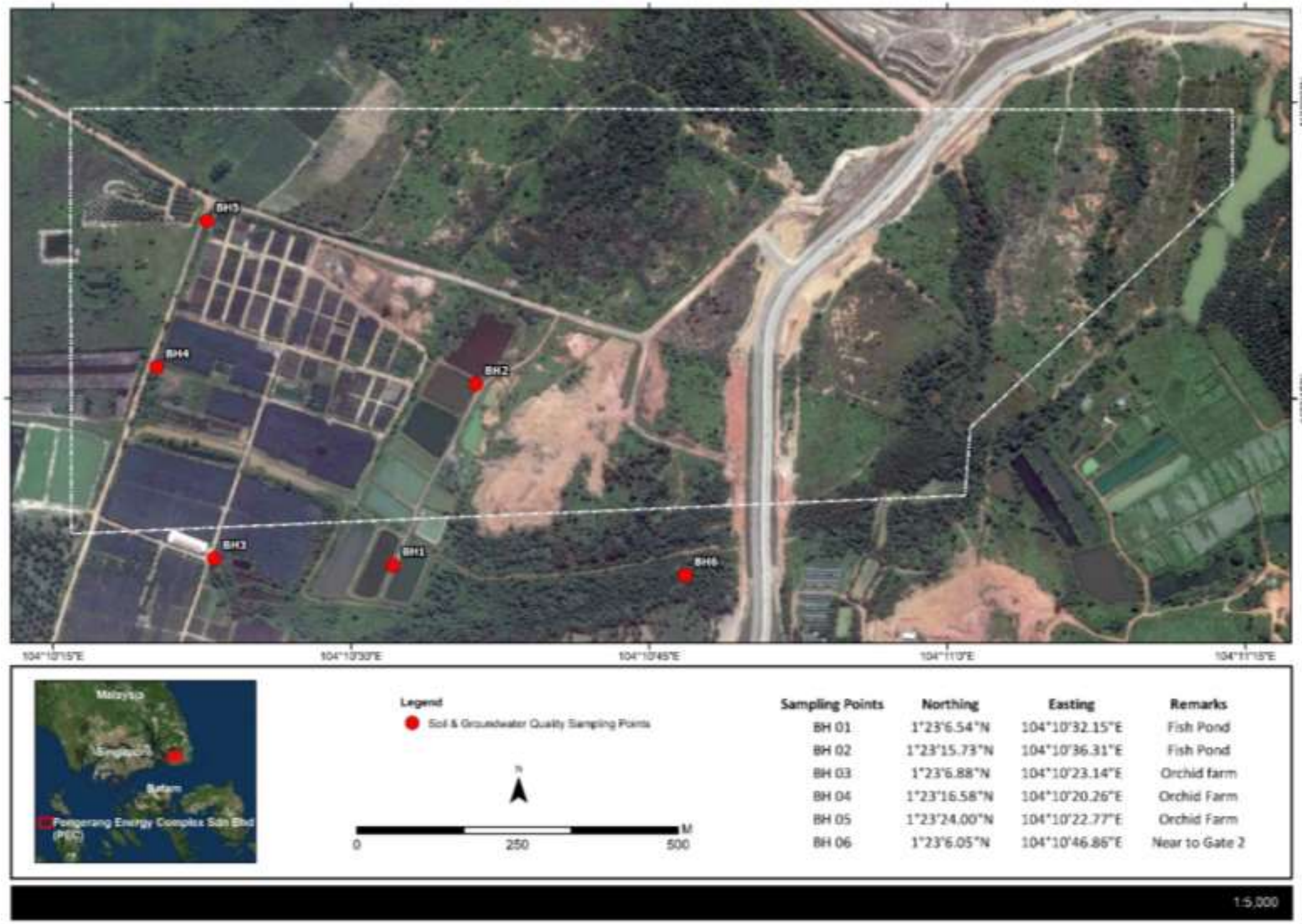
Figure 5.25 show the location of the boreholes, and the coordinates of the soil sampling points is shown in *Table 5.15.* The soil was mainly sand and silt. A layer of topsoil was found at all boreholes. At boreholes BH1, BH 3 and BH6, which was on the southern section of the site, the soil was mainly peat with heavy organic material and shallow groundwater table. The borehole logs are attached in *Appendix D*.

The result from the laboratory analysis is shown in *Table 5.16*. Results from the laboratory analysis were compared against the Site Screening Levels (SSL) for Industrial Soil of the DoE's Contaminated Land Management and Control Guidelines 2009 (DoE-CLM Guidelines). Based on the lab results, the parameters were all below the respective SSL. The Certificate of Analysis is attached in *Appendix D*.

Based on visual observations at the proposed PIP detention pond, the soil was also highly organic.

Table 5.15: Soil Sampling Point Coordinates

Sampling Point	Northing	Easting
BH1	01° 23' 06.54" N	104° 10' 32.15" E
BH2	01° 23' 15.73" N	104° 10' 36.31" E
BH3	01° 23' 06.88" N	104° 10' 23.14" E
BH4	01° 23' 16.58" N	104° 10' 20.26" E
BH5	01° 23' 24.00" N	104° 10' 22.77" E
BH6	01° 23' 06.05" N	104° 10' 46.86" E



Sampling Points	Northing	Easting	Remarks
BH 01	1°23'6.54"N	104°10'32.15"E	Fish Pond
BH 02	1°23'15.73"N	104°10'36.31"E	Fish Pond
BH 03	1°23'6.88"N	104°10'23.14"E	Orchid farm
BH 04	1°23'16.58"N	104°10'20.26"E	Orchid Farm
BH 05	1°23'24.00"N	104°10'22.77"E	Orchid Farm
BH 06	1°23'6.05"N	104°10'46.86"E	Near to Gate 2

Figure 5.25 – Location of Soil & Groundwater Sampling Points

Table 5.16: Soil Sampling Laboratory Results

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
Metals and Major Cations											
Antimony	5	mg/kg	410	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic	1	mg/kg	16	<1	<1	<1	<1	<1	<1	<1	<1
Beryllium	1	mg/kg	2,000	<1	<1	<1	<1	<1	<1	<1	<1
Cadmium	1	mg/kg	810	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	1	mg/kg	2,000	4	2	3	3	4	<1	<1	<1
Copper	1	mg/kg	41,000	6	2	1	1	4	4	<1	<1
Lead	1	mg/kg	800	15	4	4	5	2	3	<1	<1
Mercury	0.10	mg/kg	-	0.32	<0.10	<0.10	0.15	0.25	<0.10	0.27	0.17
Nickel	1	mg/kg	20,000	<1	<1	<1	<1	<1	<1	<1	<1
Selenium	1	mg/kg	5,100	<5	<5	<5	<5	<5	<5	<5	<5
Silver	1	mg/kg	5,100	<1	<1	<1	<1	<1	<1	<1	<1
Thallium	5	mg/kg	66	<5	<5	<5	<5	<5	<5	<5	<5
Zinc	1	mg/kg	310,000	9	8	4	3	9	3	<1	<1
Total Petroleum Hydrocarbon (TPH)											
TPH C6-C9	5	mg/kg	-	<5	<5	<5	<5	<5	<5	<5	<5
TPH C10-C14	50	mg/kg	-	<50	<50	<50	<50	<50	<50	<50	<50
TPH C15-C28	100	mg/kg	-	<100	<100	<100	<100	<100	<100	<100	<100
TPH C29-C36	100	mg/kg	-	<100	<100	<100	<100	<100	<100	<100	<100
VOC: Monocyclic Aromatics											
Benzene	0.5	mg/kg	56	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	0.5	mg/kg	46,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	0.5	mg/kg	290	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Meta- & para-Xylene	1	mg/kg	-	<1	<1	<1	<1	<1	<1	<1	<1
Styrene	0.5	mg/kg	38,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ortho-Xylene	0.5	mg/kg	23,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Isopropylbenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
n-Propylbenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.3.5-Trimethylbenzene	0.5	mg/kg	200	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
sec-Butylbenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2.4-Trimethylbenzene	0.5	mg/kg	280	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
tert-Butylbenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
p-Isopropyltoluene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
n-Butylbenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
VOC: Oxygenated Compounds											
2-Butanone (MEK)	5	mg/kg	190,000	<5	<5	<5	<5	<5	<5	<5	<5
4-methyl-2pentanone (MIBK)	5	mg/kg	52,000	<5	<5	<5	<5	<5	<5	<5	<5
2-Hexanone (MBK)	5	mg/kg	-	<5	<5	<5	<5	<5	<5	<5	<5
VOC: Fumigants											
2.2-Dichloropropane	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2-Dichloropropane	0.5	mg/kg	47	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
cis-1.3-Dichloropropane	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
trans-1.3-Dichloropropylene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2-Dibromoethane (EDB)	0.5	mg/kg	1.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
VOC: Halogenated Aliphatics											
Dichlorodiflouromethane	5	mg/kg	-	<5	<5	<5	<5	<5	<5	<5	<5
Chloromethane	5	mg/kg	84	<5	<5	<5	<5	<5	<5	<5	<5
Vinyl Chloride	5	mg/kg	17	<5	<5	<5	<5	<5	<5	<5	<5
Bromoethane	5	mg/kg	-	<5	<5	<5	<5	<5	<5	<5	<5
Chloroethane	5	mg/kg	-	<5	<5	<5	<5	<5	<5	<5	<5
Trichlorofluoromethane	5	mg/kg	3,400	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Iodomethane	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trans-1.2.-Dichloroethene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.1-Dichloroethane	0.5	mg/kg	170	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cis-1.2-Dichloroethene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
1.1.1-Trichloroethane	0.5	mg/kg	39,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.1-Dichloropropylene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	0.5	mg/kg	13	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2-Dichloroethane	0.5	mg/kg	22	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dibromomethane	0.5	mg/kg	1,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.1.2-Trichloroethane	0.5	mg/kg	55	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.3-Dichloropropane	0.5	mg/kg	2,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Tetrachloroethene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.1.1.2-Tetracholoroethane	0.5	mg/kg	98	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trans-1.4-Dichloro-2-butene	0.5	mg/kg	16	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cis-1.4-Dicholoro-2-butene	0.5	mg/kg	16	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.1.2.2-Tetracholoroethane	0.5	mg/kg	29	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2.3-Tricholoropropane	0.5	mg/kg	4.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pentachloroethane	0.5	mg/kg	190	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2-Dibromo-3-chloropropane	0.5	mg/kg	73	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobutadiene	0.5	mg/kg	220	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
VOC: Halogenated Aromatics											
Chlorobenzene	0.5	mg/kg	1,500	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bromobenzene	0.5	mg/kg	410	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2-Chlorotoluene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Chlorotoluene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.3-Dichlorobenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.4-Dichlorobenzene	0.5	mg/kg	130	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2-Dichlorobenzene	0.5	mg/kg	1,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2.4-Trichlorobenzene	0.5	mg/kg	400	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2.3-Trichlorobenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
VOC: Trihalomethanes											
Chloroform	2	mg/kg	15	<2	<2	<2	<2	<2	<2	<2	<2

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
Bromodichloromethane	0.5	mg/kg	460	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dibromochloromethane	0.5	mg/kg	210	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bromoform	0.5	mg/kg	2200	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SVOC: Phenolic Compounds											
Phenol	0.5	mg/kg	180,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2-Chlorophenol	0.5	mg/kg	5,100	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2-Methylphenol	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3- & 4-Methylphenol	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2-Nitrophenol	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.4-Dimethylphenol	0.5	mg/kg	12,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.4-Dichlorophenol	0.5	mg/kg	1,800	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.6-Dichlorophenol	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Chloro-3-methylphenol	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.4.6-Trichlorophenol	0.5	mg/kg	1,600	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.4.5-Trichlorophenol	0.5	mg/kg	62,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pentachlorophenol	1.0	mg/kg	90	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SVOC: Phthalate Esters											
Dimethyl phthalate	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Diethyl phthalate	0.5	mg/kg	490,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Di-n-butyl phthalate	0.5	mg/kg	62,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Butyl benzyl phthalate	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bis(2-ethylhexyl)phthalate	5.0	mg/kg	1,200	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Di-n-octylphthalate	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SVOC: Nitrosamines											
N-Nitrosomethylethylamine	0.5	mg/kg	78	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-Nitrosodiethylamine	0.5	mg/kg	11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-Nitrosopyrrolidine	1.0	mg/kg	8.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
N-Nitrosomorpholine	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-Nitrosodi-n-propylamine	0.5	mg/kg	2.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
N-Nitrosopiperidine	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-Nitrosodibutylamine	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Diphenylamine & N-Nitrosodiphenylamine	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Diallate	0.5	mg/kg	280	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methapyrilene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SVOC: Nitoaromatics and Ketones											
2-Picoline	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acetophenone	0.5	mg/kg	10,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrobenzene	0.5	mg/kg	280	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Isophorone	0.5	mg/kg	18,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.6-Dinitrotoluene	1.0	mg/kg	620	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2.4-Dinitrotoluene	1.0	mg/kg	1,200	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1-Naphthylamine	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Nitroquinoline-N-oxide	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
5-Nitro-o-toluidine	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Azobenzene	0.5	mg/kg	220	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.3.5-Trinitrobenzene	0.5	mg/kg	27,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phenacetin	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Aminobiphenyl	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pentachloronitrobenzene	0.5	mg/kg	66	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pronamide	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dimethylaminoazobenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorobenzilate	0.5	mg/kg	160	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SVOC: Haloethers											
Bis(2-chloroethyl) ether	0.5	mg/kg	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bis(2-chloroethoxy) methane	0.5	mg/kg	1,800	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Chlorophenyl phenyl ether	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Bromophenyl phenyl ether	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
SVOC: Chlorinated Hydrocarbons											
1.3-Dichlorobenzene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.4-Dichlorobenzene	0.5	mg/kg	130	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2-Dichlorobenzene	0.5	mg/kg	10,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachloroethane	0.5	mg/kg	1,200	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1.2.4-Trichlorobenzene	0.5	mg/kg	400	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachloropropylene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobutadiene	0.5	mg/kg	220	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorocyclopentadiene	2.5	mg/kg	-	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Pentachlorobenzene	0.5	mg/kg	490	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	1.0	mg/kg	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SVOC: Anilines and Benzidines											
Aniline	0.5	mg/kg	300	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Chloroaniline	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2-Nitroaniline	1.0	mg/kg	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Nitroaniline	1.0	mg/kg	820	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenzofuran	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Nitroaniline	0.5	mg/kg	820	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbazole	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3.3`-Dichlorobenzidine	0.5	mg/kg	38	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SVOC: Polycyclic Aromatic Hydrocarbons (PAHs)											
Naphthalene	0.5	mg/kg	20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthylene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthene	0.5	mg/kg	33,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluorene	0.5	mg/kg	22,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phenanthrene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Anthracene	0.5	mg/kg	170,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluoranthene	0.5	mg/kg	22,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pyrene	0.5	mg/kg	17,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Compound	LOR	Unit	DoE-CLM	BH1-2.0	BH2-1.0	BH2-5.0	BH3-4.0	BH4-3.0	BH5-5.0	BH6-3.0	BH-QC
Benz(a)anthracene	0.5	mg/kg	21	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chrysene	0.5	mg/kg	2,100	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(b) & Benzo(k)fluoranthene	1.0	mg/kg	21&210	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	0.5	mg/kg	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	0.5	mg/kg	21	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dibenz(a.h)anthracene	0.5	mg/kg	2.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(g.h.i)perylene	0.5	mg/kg	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

5.4.4 Topography

The PEC site is situated in a generally low-lying area although the site is hilly and undulating. To the east of the temporary RAPID Access Road the site topography varies less from 10 to 40m amsl though the 30m difference is still comparable to a 10-storey building. The elevation on the small eastern part of the site varies considerably more perhaps as much as 80 m from 10 – 90 m amsl. Note however these contours in *Figure* 5.26 dated from 2011 and may have been modified for previous plantation activities and changed due to the construction activities associated with the temporary RAPID Access Road.

For the use of topography analysis, the project location can be divided into 2 areas, which are west side and east side of the unnamed road (that cuts through the Proposed Project site). Based on the Digital Elevation Model (DEM) from ASTGTM2_N01E104 which uses data from 2011, the elevation in the west side of the road ranges from 10 – 40 m amsl, while the east side of the road ranges from 10 – 90 m amsl.

The topography will change when JCorp develops the land for PIP. The site will be prepared as a pre-prepared platform with levels ranging from 10 to 14 m amsl.

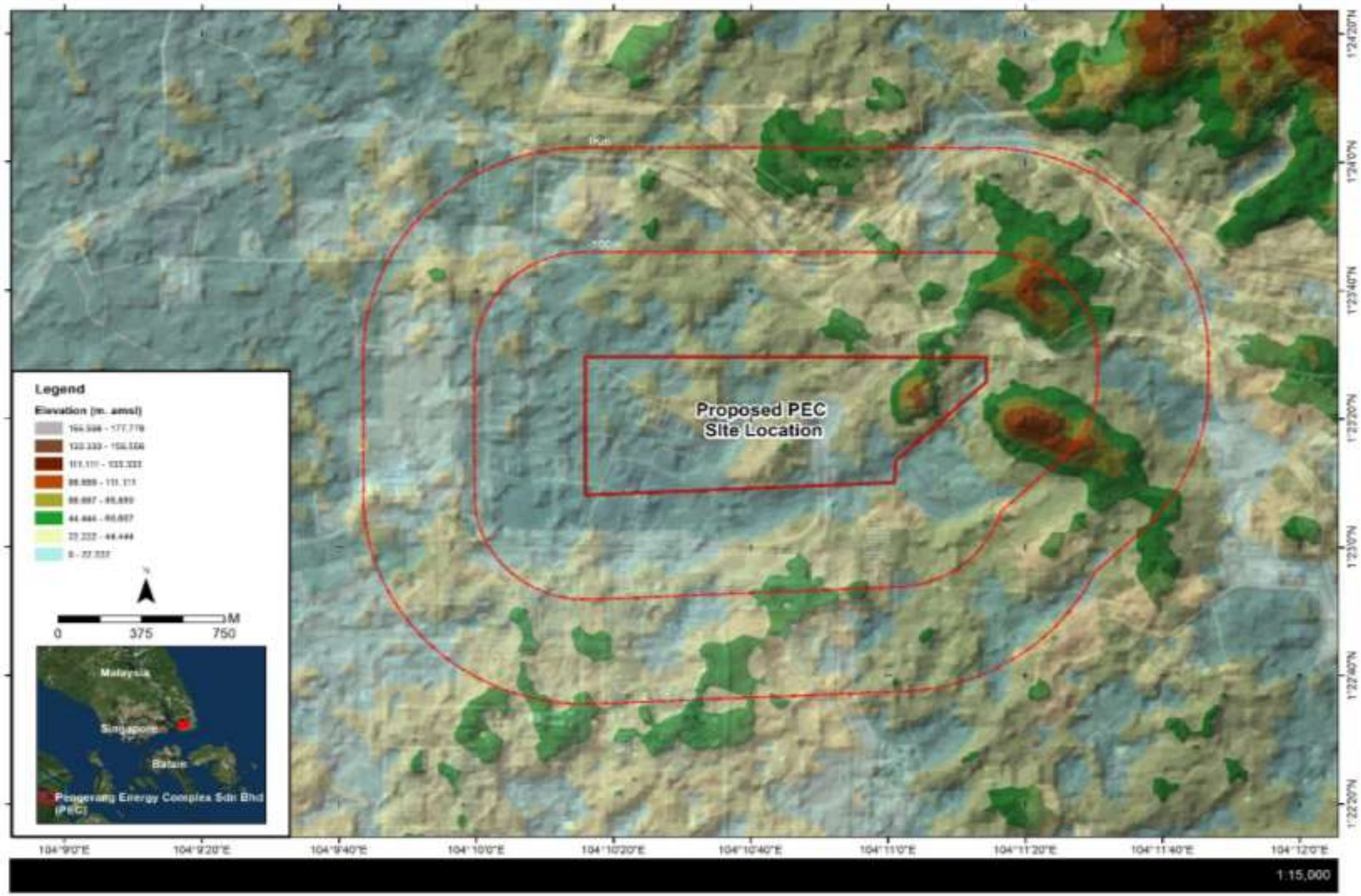


Figure 5.26 – Topography within 1 km Radius from Proposed PEC Site

5.5 Hydrosphere

5.5.1 Hydrology

Based on remote sensing data sourced from the DEIA report for RAPID, the closest river to the proposed project site is Sungai Lepau, located at the southern boundary of the site and flows in the Northeast direction into Sungai Santi (*Figure* 5.27). Sg. Lepau is a tributary of Sg. Santi, which ultimately flows into the Straits of Singapore, to the south. Other tributaries in Sg Santi include Sungai Sebina, Sungai Pelantar, and Sungai Jelutong.

The site is located with the Sg. Lepau sub-catchment, which is approximately 12 km^2 in size. Sg Lepau is part of the Sg. Santi river basin, which comprise a total area of 137 km^2, and flows to the southern boundary of the site and exits west and northwest and flows northwest before draining to mangroves and Sg Santi near its estuary and on to the Singapore Strait. Sg. Santi and Sg. Lepau are influenced by tidal effects.

Kampung Lepau is the nearest residential area, situated approximately 3 km northwest of the site. Based on site observations, locals in Kg. Lepau do not use the river water as a source of potable water as the village is provided with city water supply. According to locals, there are several aquaculture farms along Sg. Santi.

According to a research studied on the conservation of Sungai Santi, the river is covered by mangrove forests along the river bank of Sungai Santi and Sungai Sebana. The same has been reported in the RAPID DEIA report however, the extent of degradation of the mangrove forest has not been assessed past the RAPID and Sebana Mixed Development projects.

There are no water intake points or water treatment plants located along Sg. Lepau or Sg. Santi. The nearest water intake point to the project site is located at the Sungai Lebam water treatment plant (1^o 32' 30''N, 104^{o}12'13''E) approximately 17.3 km northeast of the project site in another river catchment.

As part of the PIP EIA, a total of eleven (11) surface water samples were collected for their baseline water quality conditions. The samples were collected in September 2017. The description of the sampling points is shown in *Table 5.17*. Generally, the river water samples were within Class II of the National Water Quality Standards (NWQS) with the exception of biochemical oxygen demand (BOD), chemical oxygen demand (COD), iron and phosphorus.

Table 5.17: PIP EIA River Water Sampling Points

Sampling Point ID for PIP EIA	Description of Monitoring Station
W1	Sg Rengit, Downstream of project site (East)
W2	Sg Rengit, Downstream of project site (East)
W3	Sg Lepau, Downstream of project site (Southeast)
W4	Sg Lepau, Downstream of project site (South)
W5	Sg Lepau, Downstream of project site (Southwest)
W6	Sg Lepau, Downstream of project site (West)
W7	Sg. Pelantar, Downstream of project site (West)
W8	Sg. Pelantar, Downstream of project site (West)
W9	Tributary of Sg. Sebina, Downstream of project site (North)
W10	Tributary of Sg. Sebina, Downstream of project site (North)
W11	Tributary of Sg. Sebina, Downstream of project site (North)

Historical water quality data of Sg. Santi from 2015 to 2017 was sourced from the Department of Environment (DOE) Water Division and shown in *Table* 5.18. Based on the data, the water quality index (WQI) for Sg. Santi was calculated. The WQI represents water quality on a scale of 0 – 100 is the best water quality. The average yearly WQI from 2015 to 2017 was 82, 80 and 81, respectively, which is Class II status of the National Water Quality Standards.

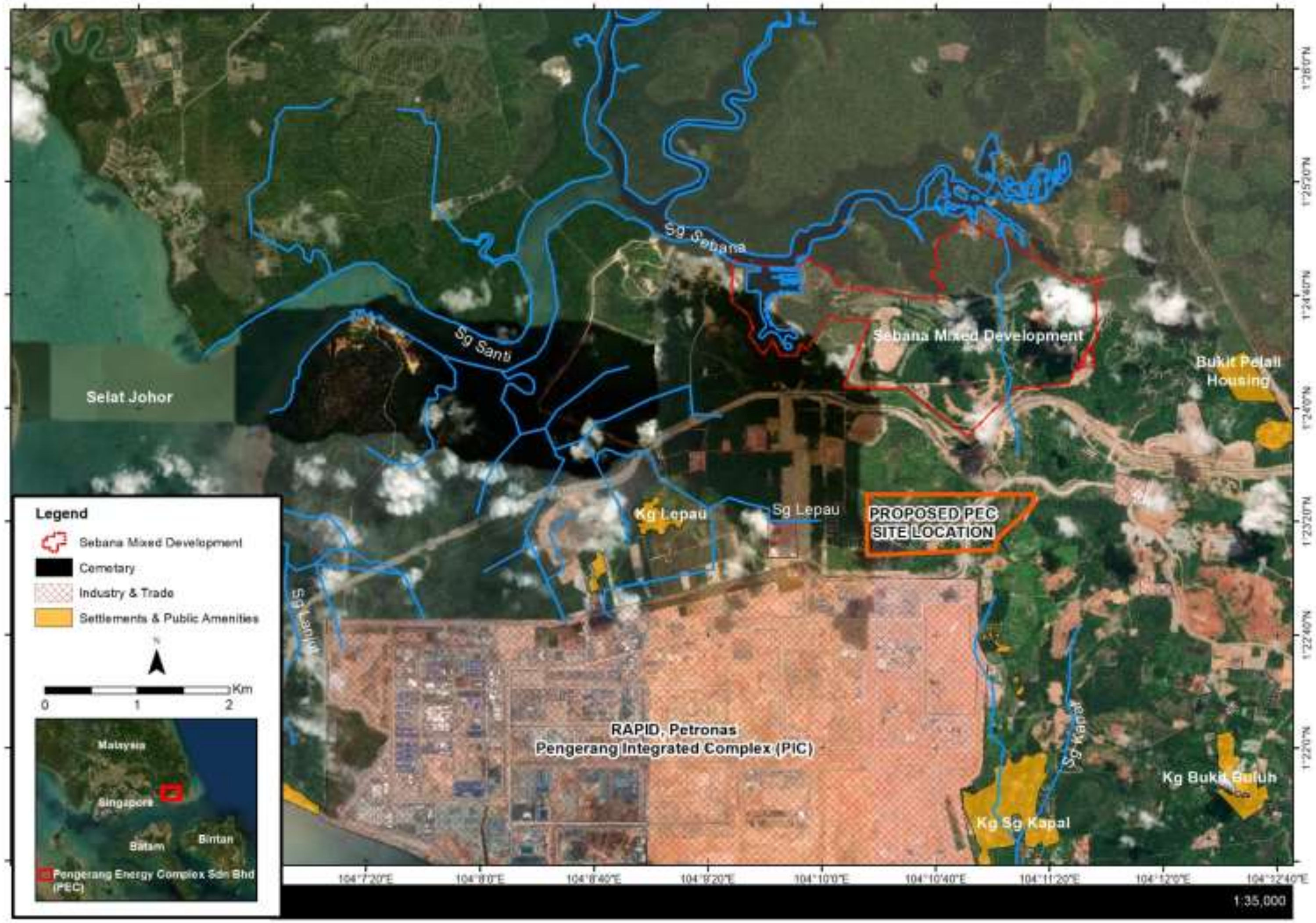


Figure 5.27 – Tributaries in Surrounding PEC Site

Table 5.18: Sg. Santi Historical Water Quality Data

Sampling Date	DO (% Sat)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	pH	NH_3NL (mg/l)	Temp (◦C)	Cond (µS)	Sal (ppt(g/l))	Tur (NTU)	DS (mg/l)	TS (mg/l)
11/02/2015	85.0	5.8	6	24	3	7.3	0.04	27.2	43,507	28.0	7.8	27,300	27,303
13/04/2015	68.7	4.4	9	45	2	7.2	0.03	30.3	45,811	29.5	4.2	28,100	28,102
17/06/2015	81.0	5.3	15	63	11	7.5	0.03	29.8	43,789	28.1	25.2	26,700	26,711
14/08/2015	78.4	5.1	14	41	18	7.5	0.01	30.0	43,604	28.0	16.9	26,200	26,218
12/10/2015	103.4	6.7	2	17	4	7.4	0.12	30.6	42,404	27.1	8.3	27,700	27,704
16/02/2016	71.8	4.7	8	35	11	7.0	0.20	29.6	44,467	28.6	14.5	26,000	26,011
12/04/2016	68.4	4.3	11	43	8	7.3	1.24	30.0	52,638	34.5	8.2	28,000	28,008
14/06/2016	69.4	4.5	5	12	6	7.0	0.06	30.4	42,891	27.4	1.5	32,200	32,206
11/08/2016	76.9	5.0	7	31	9	7.0	0.13	30.0	41,832	26.7	4.6	25,100	25,109
13/10/2016	114.6	7.3	10	38	20	7.4	0.05	30.6	44,901	28.9	2.8	27,200	27,220
15/02/2017	85.2	5.8	7	26	128	7.3	0.11	28.3	40,453	25.8	59.1	24,900	25,028
11/04/2017	70.1	4.6	10	42	83	7.2	0.10	30.2	39,889	25.3	NA	25,400	25,483
27/07/2017	92.4	6.0	5	18	26	7.9	0.09	29.9	48,288	28.4	23.9	27,000	27,000
29/09/2017	73.7	4.9	3	12	59	7.1	0.19	29.8	42,275	24.5	16.4	23,200	23,200
27/11/2017	72.0	4.9	6	24	17	7.6	0.08	28.3	39,605	25.2	5.6	25,100	25,100

Sampling Date	NO_3 (mg/l)	Cl (mg/l)	PO_4 (mg/l)	As (mg/l)	Hg (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Zn (mg/l)	Ca (mg/l)	Fe (mg/l)	K (mg/l)	Mg (mg/l)
11/02/2015	<0.01	13900	<0.01	0.002	<0.0002	<0.001	<0.001	<0.01	<0.01	354.1	<0.01	390.0	1117.7
13/04/2015	<0.01	14200	<0.01	0.002	<0.0002	<0.001	<0.001	<0.01	<0.01	353.6	0.13	395.3	1090.0
17/06/2015	0.06	14600	<0.01	0.002	<0.0002	<0.001	<0.001	<0.01	<0.01	325.9	<0.01	538.4	1020.6
14/08/2015	0.36	14700	<0.01	0.001	<0.0002	<0.001	<0.001	<0.01	<0.01	311.7	0.04	393.3	882.3
12/10/2015	<0.01	17800	<0.01	0.001	<0.0002	<0.001	<0.001	<0.01	<0.01	277.2	<0.01	419.3	1070.0
16/02/2016	0.01	12600	<0.01	<0.001	<0.0002	<0.001	<0.001	<0.01	<0.01	314.0	<0.01	317.0	841.4
12/04/2016	<0.01	8160	<0.01	0.002	<0.0002	<0.001	<0.001	<0.01	<0.01	328.2	<0.01	376.9	807.8
14/06/2016	0.02	16800	<0.01	0.002	<0.0002	<0.001	<0.001	<0.01	<0.01	446.5	<0.01	458.0	1590.0
11/08/2016	0.09	15700	<0.01	0.001	<0.0002	<0.001	<0.001	<0.01	0.03	374.0	0.05	379.0	898.0
13/10/2016	0.01	14300	<0.01	0.002	<0.0002	<0.001	<0.001	<0.01	0.02	272.0	0.03	284.0	772.0

Sampling Date	NO_3 (mg/l)	Cl (mg/l)	PO_4 (mg/l)	As (mg/l)	Hg (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Zn (mg/l)	Ca (mg/l)	Fe (mg/l)	K (mg/l)	Mg (mg/l)
15/02/2017	0.02	17900	<0.01	0.002	<0.0002	<0.001	0.001	<0.01	0.04	324.0	<0.01	328.0	1030.0
11/04/2017	<0.01	13500	<0.01	0.001	<0.0002	<0.001	<0.001	<0.01	0.05	305.0	0.04	377.0	750.0
27/07/2017	<0.010	15400	0.38	0.008	0.001	0.004	<0.001	<0.001	0.005	288	0.01	338	775
29/09/2017	2.05	14200	0.05	0.002	<0.001	<0.001	0.001	<0.001	0.015	241	<0.010	332	695
27/11/2017	<0.010	14600	<0.010	0.002	<0.001	<0.001	0.001	<0.001	0.009	285	<0.010	344	804

Sampling Date	Na (mg/l)	Og (mg/l)	MBAS (mg/l)	E-coli (cfu/100ml)	Coliform (cfu/100ml)
11/02/2015	8,230	<1	<0.05	0	0
13/04/2015	9,470	<1	0.20	0	0
17/06/2015	10,000	<1	0.20	0	500
14/08/2015	8,050	<1	0.15	0	3,700
12/10/2015	9,730	<1	<0.05	0	300
16/02/2016	12,100	<1	<0.05	0	0
12/04/2016	8,380	<1	<0.05	0	0
14/06/2016	12,900	<1	<0.05	100	100
11/08/2016	9,130	<1	<0.05	0	50,000
13/10/2016	6,550	<1	<0.05	50	800
15/02/2017	8,180	<1	<0.05	900	2,700
11/04/2017	7,760	<1	<0.05	400	2,300
27/07/2017	8,050	<1	<0.050	<1.000	700
29/09/2017	7,790	<1	<0.050	<1.000	2,400
27/11/2017	7,820	<1	<0.050	<1.000	3,400

Source: Department of Environment Malaysia

Based on the Aqueduct Water Risk Atlas (2018), the Pengerang area is located in a low water risk area (*Figure* 5.28). Water risk refers to the possibility of an area experiencing a water-related challenge (e.g. water scarcity, water stress, flooding, infrastructure decay, drought).

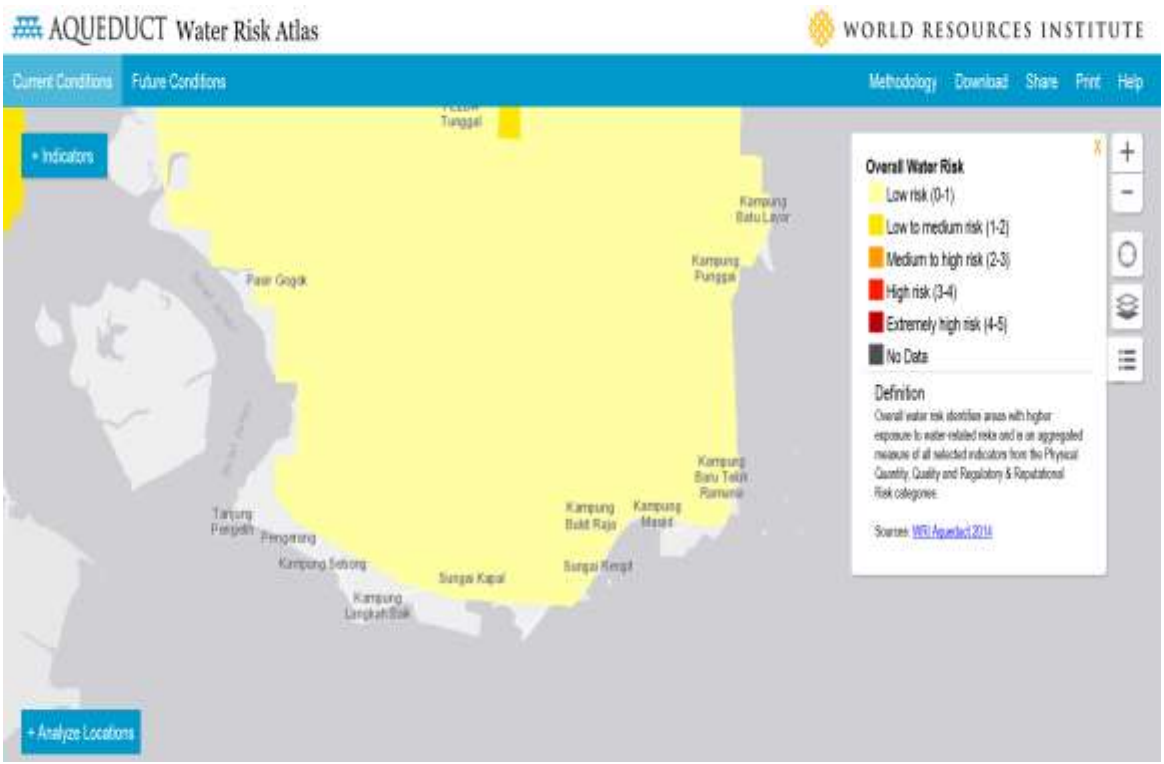


Figure 5.28 – Water Risk Area in Pengerang

5.5.2 Surface Water

The baseline river water sampling was conducted in October 2018. A total of six (6) samples were collected for lab analysis. *Table 5.19* shows the coordinates for the sampling points while *Figure* 5.29 shows the location.

Samples were analysed for Conductivity, pH, Salinity, Temperature, Total Dissolved Solids, Total Suspended Solids, Turbidity, Colour, Biochemical Oxygen Demand, Chemical Oxygen Demand, Ammonia as N, Total Coliform, Dissolved Oxygen and Total Faecal Coliform.

Table 5.19: Water Quality Sampling Point Coordinates

Sampling Point	Northing	Easting	River Catchment
SW1	1° 23’ 25.04” N	104° 9’ 40.78” E	Sg. Lepau
SW2	1° 23’ 33.83” N	104° 9’ 4.76” E	Sg. Lepau
SW3	1° 24’ 12.72” N	104° 8’ 6.80” E	Sg. Lepau
SW4	1° 24’ 37.36” N	104° 7’ 18.36” E	Sg. Santi
SW5	1° 23’ 46.39” N	104° 10’ 54.12” E	Sg. Sebina
SW6	1° 24’ 51.47” N	104° 9’ 69.84” E	Sg. Sebina

Table 5.20 shows the results from the lab analysis. Results were compared against the National Water Quality Standards (NWQS). The results for all sampling points were generally within Class II of the NWQS, except for total coliform count. Possible sources of contamination along Sg. Lepau are runoff from oil palm plantations and from Kg. Lepau. At Sg. Santi, aquaculture farmed were noted along the river which can cause contamination from various pharmaceutical products, anti-

fouling paints, and fish food used in aquaculture farming. The Certificate of Analysis for the samples are attached in *Appendix D*.

Table 5.20: River Water Quality Sampling Result

Parameter	Unit	LOR	SW1	SW2	SW3	SW4	SW5	SW6
Conductivity	µS/cm	1	487	27,700	41,200	42,400	1,100	40,000
Floatables	Yes/No	-	No	No	No	No	No	No
Odour	Yes/No	-	No	No	No	No	No	No
pH Value	pH Unit	0.1	5.8	4.5	6.6	6.8	5.7	6.6
Salinity	Parts/1000	0.1	0.2	16.6	25.8	26.6	0.5	24.9
Temperature	°C	0.1	28.6	28.6	28.6	28.5	28.5	28.5
Total Dissolved Solids	mg/L	1	228	21,300	31,100	32,000	223	30,000
Total Suspended Solids	mg/L	1	11	48	36	46	38	43
Turbidity	NTU	1.0	136	225	14.6	14.6	247	11.9
Colour (True)	TCU	5	40	30	10	10	50	25
Biochemical Oxygen Demand	mg/L	1	6	8	7	6	8	6
Chemical Oxygen Demand	mg/L	10	19	23	23	19	23	19
Ammonia as N	mg/L	0.01	5.77	0.04	1.71	0.16	0.59	0.06
Dissolved Oxygen	mg/L	0.01	8.20	7.27	7.75	7.93	8.59	8.05
Total Coliform Count	CFU/ 100mL	1	2,500	340	3,600	180	1,900	1,300
Total Faecal Coliform Count	CFU/ 100 mL	1	120	140	<1	<1	100	<1

Figure 5.29 – Surface Water Sampling Points

5.5.3 Flood

Based on the flood data provided by Department of Drainage (DID), the only area that is prone to flooding within 5 km radius of the project site is Kg. Lepau. There were records of flood cases in Kg. Lepau in the year of 2014, 2015, 2016, and 2017. The details of the flood cases are as shown in the table below:

Table 5.21: Flood Cases in Kg. Lepau

Date	Duration of flood (day)	Area (km^2)	Depth of Floodwater (m)	No. of People Displaced
26/12/2014	1	2.5	0.3	143
13/12/2015	1	0.3	1	-
3/1/2016	1	0.3	0.5	6
24/1/2017	2	1.5	1.0	5

Source: DID, 2018.

The flood in Kg. Lepau usually occurs between the month of December and January, during the monsoon season. This is due to the significantly heavy rainfall in the area, the tidal condition of the Sungai Lepau, and the drainage infrastructure in Kg. Lepau and Sungai Lepau. Besides that, Kg. Lepau is also located in the lowland area which makes it more likely to be flooded in the event of heavy rainfall.

Reportedly, the tidal gates nearby to Kg. Lepau have not been functioning for some time and occasionally, the access road to Kg. Lepau and the oil palm plantation are flooded. During the site visit in July 2018, river widening project along Sg. Lepau was ongoing, undertaken by DID's contractor. The river appeared to be free flowing without obstruction.

5.5.4 Hydrogeology

Groundwater quality plays a vital part in developing a healthy environment as it is one of the natural sources of fresh water. Almost all areas of Pengerang, including the proposed project site, are overlaid on a high aquifer region (*Figure* 5.30). Based on the Hydrogeological Map of Johor, recorded by the Mineral and Geoscience Department of Malaysia in 2008, no groundwater abstraction or monitoring wells are installed in the areas of Pengerang. Moreover, no groundwater usage was observed in the nearby residential areas during the site visit.

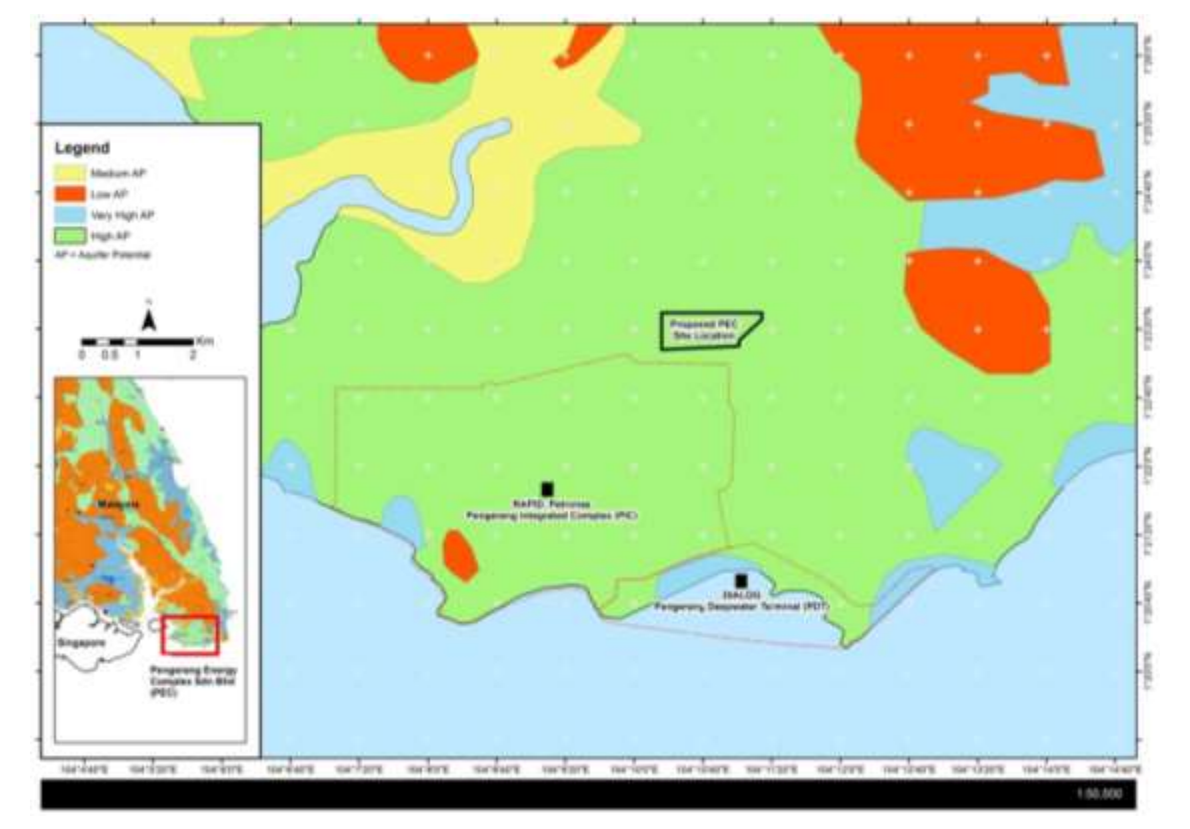


Figure 5.30 – Areas of Aquifer Potential in Pengerang

5.5.5 Groundwater

All soil borings were converted into 50 mm-diameter temporary groundwater monitoring wells for collection of groundwater samples. The well screen consists of 0.05 m diameter; schedule 40 uPVC casing with slot size of 0.001 m. The screen was extended 2m below the encountered groundwater surface and allowed to straddle above the water level, depending on the depth to groundwater. Clean sand was used as the filter pack material. Figure 5.21*Figure* 5.25 show the location of the boreholes and the coordinates of groundwater sampling points is shown in *Table 5.22*.

Following well installation, water levels in all wells were measured to allow for assessment of groundwater flow direction. After purging, a groundwater sample was collected from each of the groundwater monitoring wells, as well as an additional sample for quality assurance/quality control purposes. A total of 7 groundwater samples were collected for laboratory analysis.

Groundwater samples will be collected using a clean disposable Teflon bailer. Field measurements of temperature, pH, conductivity, dissolved oxygen and redox potential were performed immediately following groundwater collection at each well. Samples collected were carefully poured in clean glass containers provided by the laboratory, sealed and labelled in accordance with the standard chain-of-custody protocol. All the groundwater samples will be placed in a cooler and chilled to less than 4°C for laboratory analysis.

Laboratory analysis for groundwater samples were conducted for the following parameters:

- 13 priority heavy metals (Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn);
- Total petroleum hydrocarbons (TPHs);
- Volatile organic compounds (VOC); and

- Semi-volatile organic compounds (SVOC).

Elevation survey was carried out after the sampling.

Table 5.22: Groundwater Quality Sampling Point Coordinates

Sampling Point	Northing	Easting	Relative Level (m)	Description
BH 01	1.385149°	104.175596°	4.660	GROUND_BH 1
			4.273	TOP PIPE_BH 1
BH 02	1.387703°	104.176754°	6.347	GROUND_BH 2
			6.567	TOP PIPE_BH 2
BH 03	1.385245°	104.173094°	4.183	GROUND_BH 3
			4.381	TOP PIPE_BH 3
BH 04	1.387939°	104.172294°	4.638	GROUND_BH 4
			3.893	TOP PIPE_BH 4
BH 05	1.390000°	104.172993°	6.236	GROUND_BH 5
			6.443	TOP PIPE_BH 5
BH 06	1.385013°	104.179684°	6.738	GROUND_BH 6
			7.283	TOP PIPE_BH 6

Table 5.23 below shows the in-situ results from the sampling while *Table 5.24* shows the lab results. The results were compared to SSL in the DoE-CLM Guidelines. The groundwater contour map was generated based on the elevation survey and water level readings. The groundwater contour map is presented in *Figure* 5.31.

Table 5.23: In-situ Groundwater Quality Results

Sampling Point	Date	Time	Water Level (mbgl)	DO (mg/L)	TSS (mg/L)	Turbidity (NTU)	Salinity (PSU)	pH	Temp (°C)
BH1	14/12/18	0900	0.59	8.15	385.1	257.4	0	5.81	26.19
BH2	14/12/18	0940	1.78	4.32	1844.3	1974.0	0.003	5.83	26.85
BH3	14/12/18	1020	0.80	8.38	4.99	4.34	0.00	5.83	24.86
BH4	14/12/18	1035	1.20	4.61	275.2	275.2	0.10	5.81	26.55
BH5	14/12/18	1110	0.30	7.38	17.05	17.05	0.00	5.61	25.65
BH6	14/12/18	1200	1.07	8.16	-	1250.6	0.00	5.39	26.15

Table 5.24: Lab Results for Groundwater Baseline Sampling

Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
Metals and Major Cations									
Antimony	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic	1.0	µg/L	1.9	2.4	<1.0	3.2	<1.0	1.2	3.2
Beryllium	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	1.0	µg/L	<1.0	<1.0	1.1	<1.0	<1.0	<1.0	<1.0
Copper	1.0	µg/L	1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	1.2	<1.0	<1.0
Mercury	1.0	µg/L	<1.0	<1.0	1.3	<1.0	<1.0	<1.0	<1.0
Nickel	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium	10.0	µg/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Silver	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Thallium	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	1.0	µg/L	4.6	2.4	17.2	25.2	44.2	10.9	27.1
Total Petroleum Hydrocarbon (TPH)									
TPH C6-C9	50	µg/L	<50	<50	<50	<50	<50	<50	<50
TPH C10-C14	50	µg/L	<50	<50	<50	<50	<50	<50	<50
TPH C15-C28	100	µg/L	<100	<100	<100	<100	<100	<100	<100
TPH C29-C36	50	µg/L	<50	<50	<50	<50	<50	<50	<50
VOC: Monocyclic Aromatics									
Benzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Toluene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Meta- & para-Xylene	10	µg/L	<10	<10	<10	<10	<10	<10	<10
Styrene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Ortho-Xylene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5

Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
1.2.4-Trimethylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
VOC: Oxygenated Compounds									
2-Butanone (MEK)	50	µg/L	<50	<50	<50	<50	<50	<50	<50
4-methyl-2pentanone (MIBK)	50	µg/L	<50	<50	<50	<50	<50	<50	<50
2-Hexanone	50	µg/L	<50	<50	<50	<50	<50	<50	<50
VOC: Fumigants									
2.2-Dichloropropane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromoethane (EDB)	5	µg/L	<5	<5	<5	<5	<5	<5	<5
VOC: Halogenated Aliphatics									
Dichlorodiflouromethane	50	µg/L	<50	<50	<50	<50	<50	<50	<50
Chloromethane	50	µg/L	<50	<50	<50	<50	<50	<50	<50
Vinyl Chloride	50	µg/L	<50	<50	<50	<50	<50	<50	<50
Bromoethane	50	µg/L	<50	<50	<50	<50	<50	<50	<50
Chloroethane	50	µg/L	<50	<50	<50	<50	<50	<50	<50
Trichlorofluoromethane	50	µg/L	<50	<50	<50	<50	<50	<50	<50
1.1-Dichloroethene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Iodomethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Trans-1.2.-Dichloroethene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Cis-1.2-Dichloroethene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	5	µg/L	<5	<5	<5	<5	<5	<5	<5

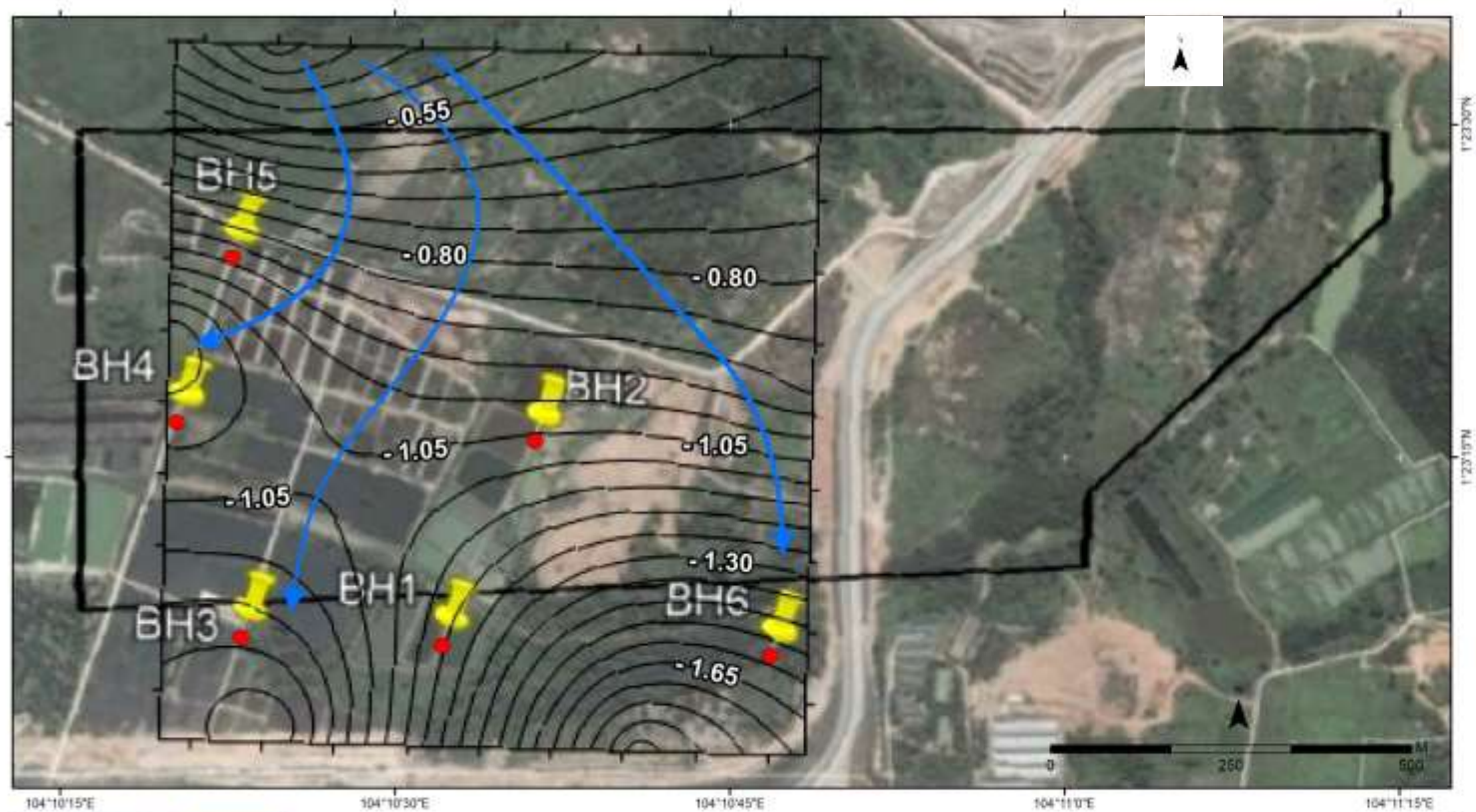
Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
Dibromomethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.1.1.2-Tetracholoroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Trans-1.4-Dichloro-2-butene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Cis-1.4-Dicholoro-2-butene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.1.2.2-Tetracholoroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2.3-Tricholoropropane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
VOC: Halogenated Aromatics									
Chlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
VOC: Trihalomethanes									
Chloroform	20	µg/L	<20	<20	<20	<20	<20	<20	<20
Bromodichloromethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Bromoform	5	µg/L	<5	<5	<5	<5	<5	<5	<5
SVOC: Phenolic Compounds									
Phenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2-Chlorophenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2-Methylphenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5

Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
3- & 4-Methylphenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2-Nitrophenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2.4-Dimethylphenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2.4-Dichlorophenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2.6-Dichlorophenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Chloro-3-methylphenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2.4.6-Trichlorophenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2.4.5-Trichlorophenol	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Pentachlorophenol	10	µg/L	<10	<10	<10	<10	<10	<10	<10
SVOC: Phthalate Esters									
Dimethyl phthalate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Diethyl phthalate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Di-n-butyl phthalate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Butyl benzyl phthalate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Bis(2-ethylhexyl)phthalate	50	µg/L	<50	<50	<50	<50	<50	<50	<50
Di-n-octylphthalate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
SVOC: Nitrosamines									
N-Nitrosomethylethylamine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
N-Nitrosodiethylamine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
N-Nitrosopyrrolidine	10	µg/L	<10	<10	<10	<10	<10	<10	<10
N-Nitrosomorpholine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
N-Nitrosodi-n-propylamine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
N-Nitrosopiperidine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
N-Nitrosodibutylamine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Diphenylamine & N-Nitrosodiphenylamine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Diallate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Methapyrilene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
SVOC: Nitoaromatics and Ketones									
2-Picoline	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Acetophenone	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Nitrobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5

Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
Isophorone	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2.6-Dinitrotoluene	10	µg/L	<10	<10	<10	<10	<10	<10	<10
2.4-Dinitrotoluene	10	µg/L	<10	<10	<10	<10	<10	<10	<10
1-Naphthylamine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Nitroquinoline-N-oxide	5	µg/L	<5	<5	<5	<5	<5	<5	<5
5-Nitro-o-toluidine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Azobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trinitrobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Phenacetin	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Aminobiphenyl	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Pentachloronitrobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Pronamide	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Dimethylaminoazobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Chlorobenzilate	5	µg/L	<5	<5	<5	<5	<5	<5	<5
SVOC: Haloethers									
Bis(2-chloroethyl) ether	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Bis(2-chloroethoxy) methane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Chlorophenyl phenyl ether	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Bromophenyl phenyl ether	5	µg/L	<5	<5	<5	<5	<5	<5	<5
SVOC: Chlorinated Hydrocarbons									
1.3-Dichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Hexachloroethane	5	µg/L	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Hexachloropropylene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Hexachlorocyclopentadiene	25	µg/L	<25	<25	<25	<25	<25	<25	<25
Pentachlorobenzene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Hexachlorobenzene (HCB)	10	µg/L	<10	<10	<10	<10	<10	<10	<10
SVOC: Anilines and Benzidines									

Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
Aniline	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Chloroaniline	5	µg/L	<5	<5	<5	<5	<5	<5	<5
2-Nitroaniline	10	µg/L	<10	<10	<10	<10	<10	<10	<10
3-Nitroaniline	10	µg/L	<10	<10	<10	<10	<10	<10	<10
Dibenzofuran	5	µg/L	<5	<5	<5	<5	<5	<5	<5
4-Nitroaniline	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Carbazole	5	µg/L	<5	<5	<5	<5	<5	<5	<5
3.3`-Dichlorobenzidine	5	µg/L	<5	<5	<5	<5	<5	<5	<5
SVOC: Polycyclic Aromatic Hydrocarbons (PAHs)									
Naphthalene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Acenaphthylene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Acenaphthene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Fluorene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Phenanthrene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Anthracene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Fluoranthene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Pyrene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Benz(a)anthracene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Chrysene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Benzo(b) & Benzo(k)fluoranthene	10	µg/L	<10	<10	<10	<10	<10	<10	<10
Benzo(a)pyrene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Indeno(1.2.3.cd)pyrene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Dibenz(a.h)anthracene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
Benzo(g.h.i)perylene	5	µg/L	<5	<5	<5	<5	<5	<5	<5
VOC: Surrogates									
1.2-Dichloroethane-D4	5	%	96.0	100	105	102	106	96.4	95.2
Toluene-D8	5	%	87.0	92.3	92.0	92.8	87.6	91.6	88.0
4-Bromofluorobenzene	5	%	119	106	102	101	99.1	109	109
Volatile Organic Compound – Surrogates									
Toluene-D8	1	%	88.7	93.4	93.6	94.3	89.3	93.2	89.8
1.2-Dichloroethane-D4	1	%	110	106	103	106	111	102	101

Compound	LOR	Unit	BH1	BH2	BH3	BH4	BH5	BH6	MW-QC
4-Bromofluorobenzene	1	%	112	106	65.6	101	100	110	109
SVOC: Acid Extractable Surrogates									
2-Fluorophenol	0.1	%	38.3	34.0	41.2	38.4	38.4	40.2	34.0
Phenol-d5	0.1	%	36.1	38.3	47.7	36.1	34.1	40.5	32.2
2.4.6-Tribromophenol	0.1	%	54.6	57.2	56.5	78.0	59.6	69.7	64.1
SVOC: Base/Neutral Extractable Surrogates									
Nitrobenzene -d5	0.1	%	58.4	50.9	57.9	52.4	53.0	54.0	52.0
2-Fluorobiphenyl	0.1	%	67.8	68.4	74.5	69.1	67.6	73.5	68.5
4-Terphenyl-d14	0.1	%	59.8	59.6	66.7	61.2	58.3	63.3	58.6



Legend
- Groundwater Quality Sampling Points
- Approximate groundwater flow direction

Sampling Points	Northing	Easting	Remarks
BH 01	1°23'6.54"N	104°10'32.15"E	Fish Pond
BH 02	1°23'15.73"N	104°10'36.31"E	Fish Pond
BH 03	1°23'6.88"N	104°10'23.14"E	Orchid farm
BH 04	1°23'16.58"N	104°10'20.26"E	Orchid Farm
BH 05	1°23'24.00"N	104°10'22.77"E	Orchid Farm
BH 06	1°23'6.05"N	104°10'46.86"E	Near to Gate 2

1:5,000

ESC

Figure 5.31 – Groundwater Contour Map

5.6 Biosphere

JCorp are responsible for site clearance, site formation and to provide a prepared, pre-levelled site with certification the land has been re-zoned for industrial use. Much of the land within the site has been leased out by JCorp for many years for agriculture cultivation (e.g. orchard and flower farming) (approx. 22% of 250 acres) and fish farming (approx. 5.7%). The remaining areas of the site were overgrown with scrubs and belukar forest of low value and low grade. Wildfire was observed at large area in the west portion of PEC had cleared much of the belukar forest (as shown in *Photo 5.1*).

Evidence of forest fires at the northern boundary of the site, facing west

Evidence of forest fires at the northern boundary of the site, facing north

ESC **Photo 5.1: Evidence of Forest Fires at the Northern Boundary of the Site**
Source: Site visit July 2018

The nearby land clearing and construction activities at RAPID site and surrounding infrastructure have changed and would have impacted the presence of fauna on this site. As such, it is concluded that the baseline flora and fauna conditions at the time of site survey are of very little natural ecological resources of conservation value left on-site.

However, the PIP is less than 2.5 km (PEC less than 3 km) from the Sg Santi Forest Reserve, which is predominantly a mangrove forest. With the development of the PIPC, the major natural and biological resources remaining in the vicinity will be housed in this roughly 30 km^2 reserve, in its mangroves and estuarine waters/ intertidal mudflats and fisheries. These mangrove ecosystems are also now known to provide not just environmental but economic protection too:

- They act as barriers to protect against coastal and riverbank erosion, but also against severe storms and coastal flooding;
- They protect and provide breeding areas and habitats for many species of fish, birds, and crustaceans, not to mention being utilised by over 35 mammal species;
- They provide more than 50 commercially viable products; and
- They are also very important for inshore and offshore and aquaculture sites. It is the tidal lowlands, especially in mangrove forests, that are the spawning and nursery grounds for many commercially valuable fish and shrimp species.

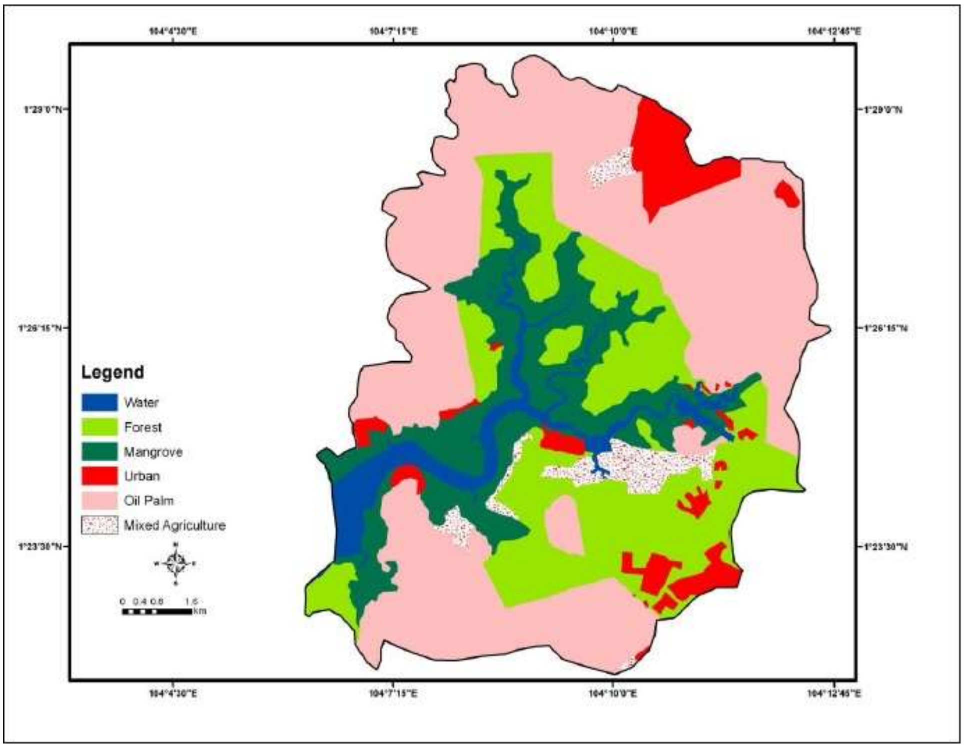
According to a research studied on the conservation of Sungai Santi, the river is covered by mangrove forests along the river bank of Sungai Santi and Sungai Sebina. This research was also reported in the RAPID DEIA report however, the extent of degradation of the mangrove forest has not been assessed since the RAPID and Sebana Mixed Development projects.

The following information on Sungai Santi were obtained from secondary sources.

6.1.1 Sungai Santi Mangrove Forest

Sungai Santi Mangrove Forest covers an area of 3,165 ha. The most commonly found type of vegetation in the area is the estuarine mangrove. The mangrove forest consists of a mosaic of inter-related forest habitats such as, seasonal peat swamp forest, Adinandra forest, and Adinandra scrubland (Norhayati, *et al*., 2012).

According to the research conducted on vegetation density of the mangrove areas in Sungai Santi, the diversity of the mangrove species in Sungai Santi is considerably high with a total of 27 true mangroves (Norhayati, *et al*., 2012) and 13 mangrove-associated species (Akmal, *et al*., 2011). The river bank all along Sungai Santi is densely populated with various types of mangroves with the species *Avicennia spp.,* and *Rhizophora spp.,* predominantly located near the sea (Affendi, *et al.*, 2005). *Bruguiera spp., Rhizophora spp.,* and Piai ferns (*Acrostichum aureum*) also occurs abundantly at the mouth of the main rivers (Norhayati, *et.,* 2012).



Source: Akmal, *et al*., 2011

Figure 5.32 – Land use of Surrounding Area in Sungai Santi 2007

Additionally, all five members of the *Bruguiera*, a plant genus of in the family of Rhizophoraceae, were found in Sungai Santi (Wan Juliana, *et al*., 2014).

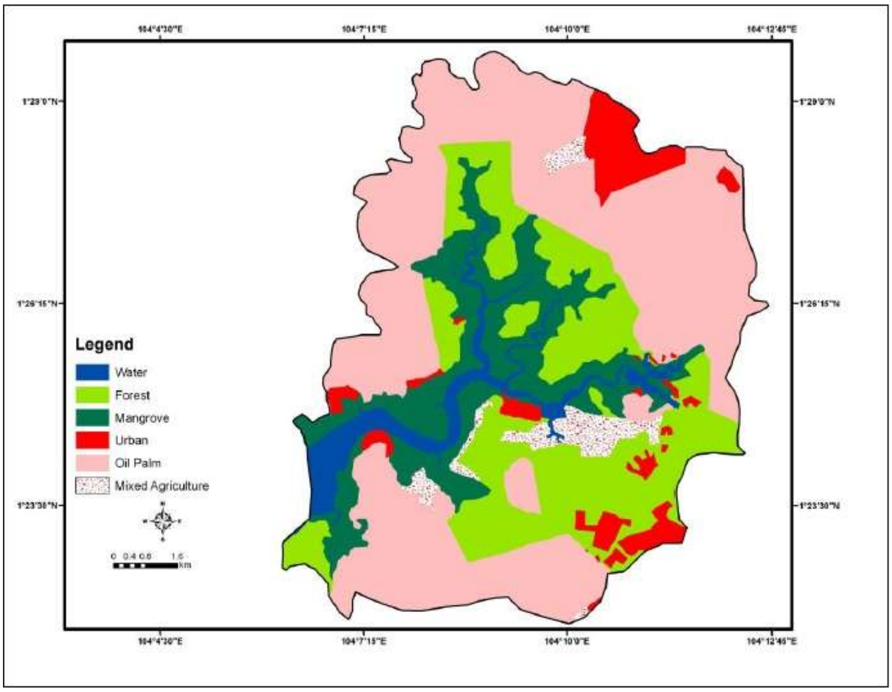
Bruguiera hainessi is the rarest species of Bruguiera and is currently listed as critically endangered under the IUCN Red List. This species is commonly found at relatively dry areas where it is inundated for only a few hours a day. It has very distinctive features with its brown to grey bark and corky yellow to brown lenticels (Lee, *et al.,* 2015). This species has a limited and patchy distribution. There are approximately 200 known mature individuals remaining in the world with 80 of it in Malaysia. Previously in Peninsular Malaysia, it can only be found in Matang Forest Reserve, Perak. However, a research conducted to study the distribution of *Rhizophoraceae* in

Peninsular Malaysia has shown that the species is also presence in Sungai Santi mangrove forest (Wan Juliana, *et al.,* 2014).

Table 5.25: True Mangrove Species in Sungai Santi

Family	Species	IUCN Status
Avicenniaceae	*Avicennia alba*	Least Concern
	A. lanata	Vulnerable
	A. officinalis	Least Concern
Rhizophoraceae	*Rhizophora apiculata*	Least Concern
	R. mucronata	Least Concern
	Ceriops tagal	Least Concern
	C. decandra	Near Threatened
	Bruguiera gymnorhiza	Least Concern
	B. sexangula	Least Concern
	B. hainesii	Critically Endangered
	B. cylindrica	Least Concern
	B. parviflora	Least Concern
Meliaceae	*Xylocarpus granatum*	Least Concern
	X. moluccensis	Least Concern
	X. mekonggensis	Least Concern
Rubiaceae	*Scyphiphora hydrophylacea*	Least Concern
Sonneratiaceae	*Sonneratia alba*	Least Concern
	S. ovata	Near Threatened
Palmae	*Nypa fruticans*	Least Concern
Euphorbiaceae	*Excoecaria agallocha*	Least Concern
Combretaceae	*Lumnitzera littorea*	Least Concern
Sterculiaceae	*Heritiera littoralis*	Least Concern
Pteridaceae	*Acrostichum aureum*	Least Concern
	A. speciosum	Least Concern
Myrsinaceae	*Aegiceras corniculatum*	Least Concern
Malvaceae	*Hibiscus tiliaceus*	Least Concern

Source: Norhayati, et al., 2012



Source: Akmal, et al., 2011

Figure 5.33 – Land use of Sungai Santi Catchment in 2007

6.1.2 Invertebrates of Sungai Santi

The invertebrates play an important role in the process of nutrient cycle in a mangrove ecosystem. Most of the crustaceans and mollusks of Sungai Santi are detritus feeders and feed on the partially decomposed mangrove litters which further break down the mangrove litters and thus, enables it to be further degraded by the fungi and bacteria. This particular process holds a great ecological importance as it formed the basis of the detritus food chains which contributes to the ecological stability of a mangrove system (Norhayati, *et al.,* 2012).

Table 5.26: List of Crustaceans Species in Sungai Santi

Subphylum	Order	Family	Species
Crustacean	Decapoda (Crabs)	Grapsidae	
			Episesarma singaporense
			Episesarma palawanense
			Episesarma sp.
		Ocypodidae	*Dotilla wichmanni*
			Uca annulipes
			Liyoplax sp.
		Calappidae	*Matuta planipes*
		Eriphiidae	*Myomenippe hardwickii*
			Ozious guttatus
	Order Decapoda (Others)	Thalassinidae	*Thalassina* sp.
		Alphiidae	*Alpheus* sp.
		Upogebiidae	*Wolffogebia* sp.
		Penaeidae	*Penaeus merguiensis*
		Palaemonidae	*Macrobrachium* sp.
		Paguridae	*Clibanarius padavensis*

Source: Norhayati, et al., 2012

Table 5.27: List of Bivalves Species in Sungai Santi

Subphylum	Order	Family	Species
Bivalvia	Arcoida	Arciidae	*Anadara granosa*
			Scapharca sp.
			Trachycardium sp.
	Mytiloidea	Mytilidae	Musculista senhousua
			Mytilus sp.
			Modiolus aratus
	Ostreoida	Ostreidae	*Sccostrea cucullata*
			Saccostrea mordax
			Ostrea sp.
		Anomiidae	*Enigmoia aenigmatica*
	Pterioida	Isognomonidae	*Isognomon ephippium*
	Solenoidea	Solenidae	*Solen* sp.
	Tellenoidea	Tellinidae	*Tellina* sp.
	Veneroida	Donacidae	*Donax cuneatus*
		Veneridae	*Anomalocardia squamosal*
			Gafrarium divaricatum
			Gafrarium tumidum
			Meretrix meretrix
		Psammobiidae	*Hiatula diphos*
		Corbiculidae	*Polymesoda erosa*

Source: Norhayati, et al., 2012

Table 5.28: List of Gastropods Species in Sungai Santi

Subphylum	Order	Family	Species
Gastropoda	Caenogastropoda	Assimineidae	*Assiminea miniata*
		Batillariidae	*Batillaria zonalis*
		Cerithiidae	*Cerithium sp.*
			Clypeomorus bifasciatus
		Potamididae	*Telescopium telescopium*
			Terebralia palustris
			Cerithidea obtuse
			Cerithidea decollate
			Cerithidea cingulata
		Cerithiidae	*Cerithium lifuense*
	Cycloneritimorpha	Neritidae	*Nerita articulate*
			Nerita undata
			Nerita histio
	Littorinimorpha	Littorinidae	*Littoraria carinifera*
			Littoria scabra
			Littoria melanostoma
			Littorina irrorata
			Littorina conica
	Neogastropoda	Columbellidae	*Columbella duclosiana*
		Melongenidae	*Pugilina ternatana*

Subphylum	Order	Family	Species
			Volema myristica
		Nassariidae	*Nassarius livescens*
			Nassarius jacksonianus
		Muricidae	*Chicoreus capucinus*
			Thais gradate
			Morula rumphiusu
			Thais javanica
			Thais luteostoma
			Thais clavigera
	Pulmonata	Ellobiidae	*Ellobium aurisjudae*
			Ellobium aurismidae
	Systellommatophora	Onchidiidae	*Platyvindex sp.*
			Onchidium sp.
	Siphonarioidea	Siphonariidae	*Siphonaria normalis*
	Vetigastropoda	Trochidae	*Monodonta labio*

Source: Norhayati, et al., 2012

6.1.3 Avifauna of Sungai Santi

There are total of 18 families of birds comprising of 26 different species have been recorded at Sungai Santi. The most commonly found species in the area are the collared Kingfisher (*Halcyon choris*), the Black-capped Kingfisher (*Halcyon Pileata*) and the Little Heron (*Butroides striatus*). Most of the waterbird species in the area such as the Common redshank (*Tringa tetanus*), Terek Sandpiper (*Xenus cinereus*), Great egret (*Egretta alba*) and the Little egret were frequently observed feeding on the mudflats of Sungai Santi. Besides that, there are also two (2) species of migrant birds, namely the Far Eastern Curlew (*Numenius madagascariensis*) and the Asian Dowitcher (*Limnodromous semipalmatus*), that were spotted in the area specifically in the months of August and April each year. These migrant birds utilized the mangrove area in Sungai Santi as stop-overs during their north to south migrations (Norhayati, *et al*., 2012).

Table 5.29: List of Avifauna Species in Sungai Santi

Common Name	Scientific Name	Local Name	IUCN Status
Brahminy Kite	*Haliastur indus*	Lang Merah	Least Concern
Black-capped Kingfisher	*Halcyon pileata*	Pekaka Kopiah Hitam	Least Concern
White-throated Kingfisher	*Halcyon smyrnensis*	Pekaka Belukar	Least Concern
Collared Kingfisher	*Todiramphus chloris*	Pekaka Sungai	Least Concern
House Swift	*Apus affinis*	Layang-layang Rumah	Least Concern
Little Egret	*Egretta garzetta*	Bangau Kecil	Least Concern
Grey Heron	*Ardea cinerea*	Pucong Seriap	Least Concern
Little Heron	*Butorides striata*	Pucong Keladi	Least Concern
Green-caped Emerald Pigeon	*Chalcophaps indica*	Punai Tanah	Least Concern
Greater Coucal	*Centropus sinensis*	But-But Carik Anak	Least Concern
Great Crested Tern	*Thalasseus bergii*	Cama Besar Berjambul	Least Concern
Chestnut-headed Bee-eater	*Merops leschenaulti*	Berek Berek Senja	Least Concern
Black Oriole	*Oriolus hosii*	N/A	Near Threatened
Grey-faced	*Picus canus*	Belatuk Gunung	Least Concern

Common Name	Scientific Name	Local Name	IUCN Status
Woodpecker			
Maroon Woodpecker	*Blythipicus rubiginosus*	Belatuk Punggor	Least Concern
Common Sandpiper	*Actitis hypoleucos*	Kedidi Pasir	Least Concern
Asian Glossy Starling	*Aplonis panayensis*	Perling Mata Merah	Least Concern
Common Myna	*Acridotheres tristis*	Tiong Gembala Kerbau	Least Concern
Oriental Magpie-robin	*Copsychus saularis*	Murai Kampung	Least Concern
Far Eastern Curlew	*Numenius madagascariensis*	N/A	Endangered
Asian Dowitcher	*Limnodromus semipalmatus*	N/A	Near Threatened

Note: N/A – Not Available

6.1.4 Mammals of Sungai Santi

There are 21 species of mammals recorded at Sungai Santi. The most commonly found small mammals in the area are the Common Palm Civet (*Paradoxurus hermaphrodites*), Plantain Squirrel (*Callosciurus notatus*), Common Treeshrew (Tupaia glis), and Bats (*Macrochiroptera*). There were also a family of Smooth Otters (*Lutra perspicillata*) observed in the mangrove area of Sungai Santi. The most prevalent big mammals in the area are the Wild Boar (*Sus scrofa*) (Norhayati, *et al*., 2012).

Table 5.30: List of Mammals Species in Sungai Santi

Common Name	Scientific Name	Local Name	Status
Asian Small-clawed Otter	*Aonyx cinereus*	Memerang	Vulnerable
Smooth-coated Otter	*Lutrogale perspicillata*	N/A	Vulnerable
Grey-bellied Squirrel	*Callosciurus caniceps*	Tupai teratak	Least Concern
Plantain Squirrel	*Callosciurus notatus*	Tupai pinang	Least Concern
Goat	*Capra hircus*	Kambing	Not Evaluated
Lesser Dog-faced Fruit Bat	*Cynopterus brachyotis*	Cecadu pisang	Least Concern
Horsfield’s Fruit Bat	*Cynopterus horsfieldi*	Cecadu pisang besar	Least Concern
Leopard cat	*Prionailurus bengalensis*	Kucing batu	Least Concern
Long-tailed Macaque	*Macaca fascicularis*	Kera	Least Concern
Pig-tailed monkey	*Macaca nemestrina*	Beruk	Vulnarable
Common palm civet	*Paradoxurus hermaphroditus*	Musang pulut	Least Concern
Large Flying-fox	*Pteropus vampyrus*	Keluang	Near Threatened
Dark-tailed Tree Rat	*Niviventer cremoriventer*	Tikus akar	Least Concern
Müller’s Sundamys	*Sundamys muelleri*	Tikus lembah	Least Concern
House rat	*Rattus rattus*	Tikus rumah	Least Concern
Long-tailed Giant Rat	*Leopoldamys sabanus*	Tikus ekor panjang	Least Concern
Malaysian Field Rat	*Rattus tiomanicus*	Tikus belukar	Least Concern
Whitehead’s Sundaic Maxomys	*Maxomys whiteheadi*	Tikus ekor pendek	Vulnerable
Wild Boar	*Sus scrofa*	Babi hutan	Least Concern
Common Treeshrew	*Tupaia glis*	Kencong	Least Concern
Malay civet	*Viverra tangalunga*	Tenggalung	Least Concern
Large Indian civet	*Viverra zibetha*	Musang	Least Concern

Note: N/A – Not Available

6.1.5 Fishes of Sungai Santi

Sungai Santi consists of a very complex interconnected major and small tributaries rivers. Such a complex ecosystem has been known to harbor a great diversity of fishes that holds a significant importance to both the estuarine ecosystem as well as to the local communities. The list below highlighted several species of fishes that were observed in Sungai Santi (Norhayati, *et al*., 2012).

Table 5.31: List of Fishes Species in Sungai Santi

Common Name	Scientific Name	Local Name	Status
Tigertooth croaker	*Otolithes ruber*	Tengkerong panjang	Not Evaluated
Soldier Croaker	*Nibea soldado*	N/A	Not Evaluated
Toli Shad	*Tenualosa toli*	N/A	Not Evaluated
Gizzard Shad	*Anodontostoma chacunda*	N/A	Not Evaluated
Lattice Monocle Bream	*Scolopsis taenioptera*	N/A	Least Concern
Largescale Terapon	*Terapon theraps*	Kerong batu	Least Concern
Java Rabbifish	*Siganus javus*	Dengkis jawa	Least Concern
Concertina Fish	*Drepane longimana*	N/A	Not Evaluated
Spotted Sicklefish	*Drepane punctata*	Daun-baru bintik	Not Evaluated
Spotted Scat Fish	*Scatophagus argus*	Kitang	Least Concern
Tenpounder	*Elops machnata*	N/A	Least Concern
Sagor Catfish	*Hexanematichthys sagor*	N/A	Not Evaluated
Common Halfbeak	*Hyporhamphus unifasciatus*	N/A	Least Concern
Gold-spotted mudskippers	*Periophthalmus chrysospilos*	N/A	Not Evaluated
Blue-spotted mudskippers	*Boleophthalmus boddarti*	N/A	Least Concern

Note: N/A – Not Available

6.1.6 Reptiles in Sungai Santi

Similar to most mangrove ecosystem, Sungai Santi mangrove forest is home to various species of reptiles. These species of snakes and lizards, though common in the area, are hard to find due to their elusive nature and their tendency to avoid human contact. Listed below are the species of reptiles that were observed in Sungai Santi (Norhayati, *et al*., 2012).

Table 5.32: List of Reptiles Species in Sungai Santi

Common Name	Scientific Name	Local Name	Status
Common Water Monitor Lizard	*Varanus salvator*	Biawak air	Least Concern
Yellow-banded Mangrove Snake	*Cantoria violacea*	Ular cincin emas	Least Concern
Paradise Tree Snake	*Chrysopelea paradisi*	N/A	Least Concern
Dog-faced Water Snake	*Cerberus rynchops*	N/A	Least Concern
King Cobra	*Ophiophagus hannah*	N/A	Vulnerable
Reticulated python	*Phyton reticulatus*	N/A	-

Note: N/A – Not Available

6.1.7 Sighting of Dugongs

The dugong (*Dugong dugon*) is a large herbivorous marine mammal. It can grow up to 3m in length and weight up to 400kg (Affendi, *et al.,* 2005). The dugong has a large population range and has a range spanning waters of 48 countries ranging from the tropical and subtropical shallow coastal habitats of East Africa to the Red Sea and Arabian Gulf, and eastwards to the Indo-Pacific region as far as Australia (Louisa, *et al.,* 2014). In Peninsular Malaysia, dugongs are protected under the Fisheries Act 1985 Part VI and the Fisheries (Control of Endangered Species of Fish) Regulations 1999.

Dugongs are commonly found in coastal areas with its population distribution being the most concentrated in wide shallow protected bays, large inshore island and wide shallow mangrove channels. According to a research on the conservation of Dugongs in Johor, there have been numerous sighting of dugongs within the vicinity of Sungai Santi, specifically to the south of Sungai Santi, in the shallow water bay near the mouth of Sungai Lepau to Tanjung Pengelih. This wide mangrove-lined bay has been known to the locals as the resting place for dugongs (Affendi, *et al.,* 2005). Besides that, dugongs were also known to utilize certain habitats for specific activities. Estuaries and shallow waters have been recorded as sites for calving for dugongs.

The dugongs' diet consists predominantly of seagrass. However, only certain seagrass meadows are suitable to dugong as they have a very specialised diet. It most preferable species of seagrass are the Halophlia, Halodule, and Cymodocea due to its high nitrogen, presumed digestibility and low in fibre content. There are various types of seagrass presence in Sungai Santi including Halophila ovalis, Enhalus acoroides and Ulva reticula with the latter being the most dominant species in the area.

The research conducted on the conservation of dugongs in Johor indicates the presence of extensive seagrass meadow on the tidal flat in Pasir Gogok, which is located on the mouth of Sungai Santi. Significant dugongs' feeding trails were observed here due to the species of seagrass, Halophilia Ovalis, being the most dominant species in the area (Affendi, *et al.,* 2005).

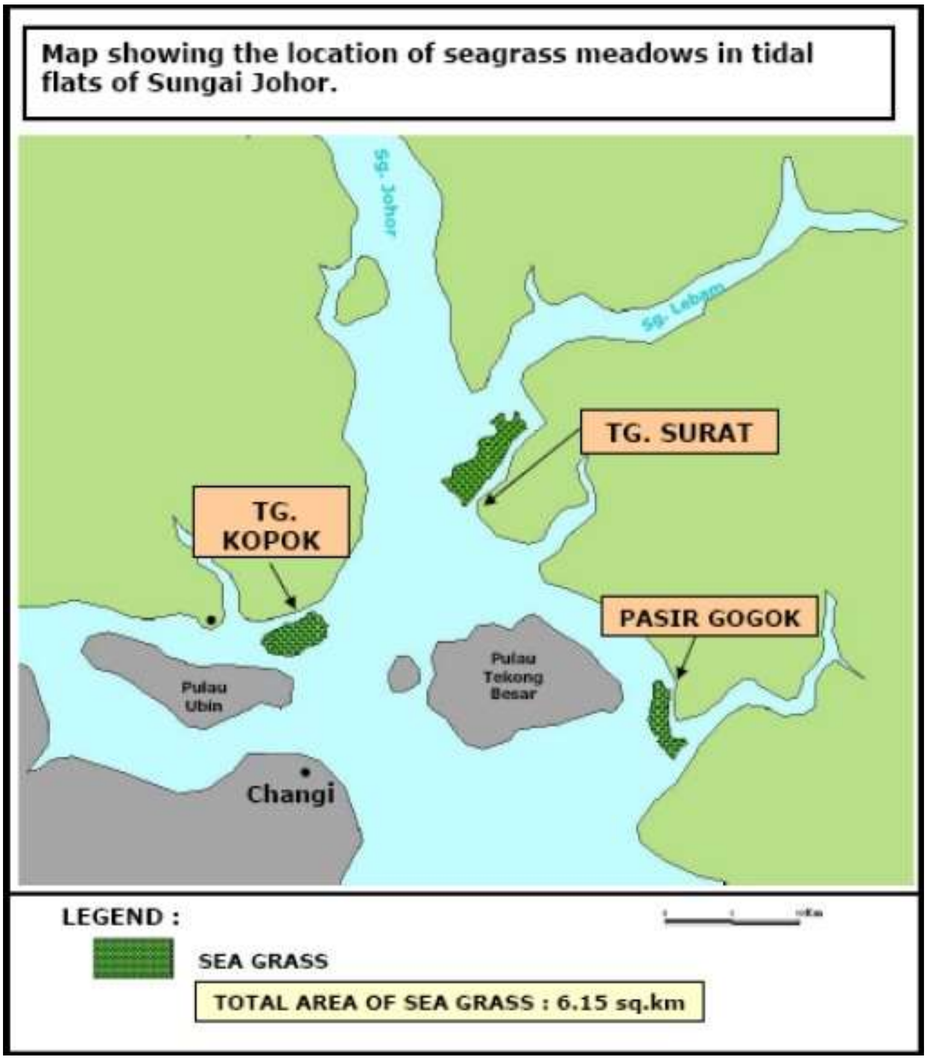


Figure 5.34 – Seagrass Meadows Location

Source: Akmal, *et al.,* 2011

5.7 Social, Economy and Cultural Sphere

5.7.1 Project Affected Communities

The operation of PEC will affect communities nearby the project sites direct or indirectly, mainly from pre-construction, construction and operational stages. The affected communities encompass 8 villages inside the 5 km impact zone and located in Kota Tinggi District, Mukim/ local authority Pengerang. The lists of villages are listed in *Table 5.33* below.

Table 5.33*: Project Affected Communities*

State	District	Sub-District/ Mukim	Village	Location
Johor	Kota Tinggi	Pengerang	Kg Lepau	1-3 km West side of the Project
			Kg Bukit Pelali	1-3 km Est of the Project
			Kg Bukit Buloh	3-5km Southern part of the Project
			Kg Bukit Gelugor	3-5km Eastern part of The Project
			Kg Bukit Raja	3-5km Eastern part of The Project
			Taman Rengit Jaya	3-5 km South of the Project
			Kg Sungai Kapal	1-3 km South side of the Project
			Kg. Sungai Buntu	3-5km Southern part of the Project

5.7.2 Demographics

5.7.2.1 Demographic of Johor State

The data from the Department of Statistics Malaysia shows the total population in Johor is recorded at 3.47 million people in 2013 and slightly increased to 3.65 million people in 2016. The average annual population growth from 2013 to 2016 ranged from 0.7% to 2.4% with the highest average annual population growth occurred in 2014 at a rate of 2.4%. The sex ratio, which is used to compare the composition of male and female population or, in other words, to determine the number of males for every 100 females, ranged from 111 to 112. This figure indicated that there are about 111-112 males for every 100 females in Johor. At the time of preparing this report, no data is available specifically for Kota Tinggi District or local authority Pengerang. Number of birth rate in 2013 – 2017 ranged from 16.3 – 17 and death rate ranged from 5 – 5.5 per 1,000 populations. The data shows that birth rate is higher than death rate. This indicates that the rate of natural increase of population was 11.3 – 11.5 per 1,000 populations.

Table 5.34: Johor Population Data

Population Data	2013	2014	2015	2016	2017
Area (km^2)	19,192	19,016	19,102	19,102	-
Population (million)					
Total	3.47	3.56	3.61	3.65	3.70*
Male	1.83	1.88	1.91	1.93	1.96*
Female	1.64	1.68	1.7	1.72	1.75*
Average Annual Population Growth Rate (%)	0.7	2.4	1.4	1.1	1.3*
Sex Ratio	111.58	111.90	112.35	112.21	112
Birth and Death (per 1,000 population)					
Crude Birth Rate	16.5	17	16.8	16.3	-
Crude Death Rate	5.1	5	5.2	5.5	-
Total Fertility Rate #	2.1	2.2	2.1	2.1	-
Life Expectancy (years)					

Population Data	2013	2014	2015	2016	2017
Male	72	72.1	72.1	72.2p	72.2*
Female	76.8	76.9	77	77.0p	77.2*

Source: Department of Statistic Malaysia, 2017

Notes:

1. 2013 - 2017: Population Estimates based on the adjusted Population and Housing Census of Malaysia 2010.

2. Starting 2011, the labour force statistics are estimated based on the latest current population estimates. Therefore, the annually statistics labour force time series is updated.

3. # Total Fertility Rate: The rate per woman aged 15-49 years.

4. p is Preliminary.

*5. * is an Estimate figure.*

6. The added total may differ due to rounding.

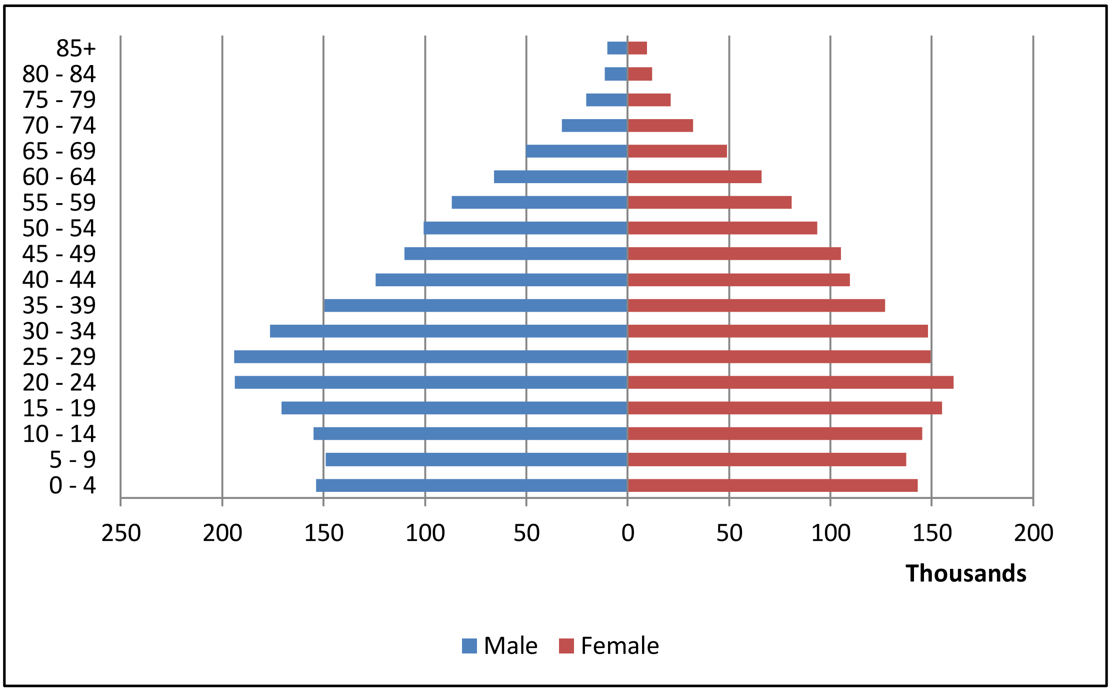


Figure 5.35 – Population Pyramid of Johor mid-year 2017

Source: Department of Statistic Malaysia, 2017.

On the other hand, the population pyramid of Johor is shown in *Figure* 5.35 in the form of "bee-hived pyramid" shape. The shape indicates that large proportion of working population between 15-59 years old and narrow based which indicates low birth rate or slow population group which makes the proportion of younger population shrinks. The shape also indicates the older age population is increasing. The life expectancy for Johor Baharu is quite high which is around 72 years for male and 76-77 years for female.

5.7.2.2 Demographic of 5 km Radius Impact Zone

Although the study area inside the 5km radius impact zone covers an extensive land area, the overall population constitute only 326 households, based on feedback from the former village heads of Kg. Lepau, Kg. Bukit Buloh and Kg. Bukit Raja and the Pejabat Penghulu of Mukim Pengerang and Pantai Timur in September 2018. This is primarily due to the resettlement of more than 3,000 people to Taman Bayu Damai between 2013 and 2016.

Assuming a confidence level of 95% and accepting a margin of error of 8%, the minimum sample size obtained through the Raosoft model is 98. A total of 100 respondents from the six villages were selected using stratified random sampling. Kg. Lepau being the nearest to the Project site (within 1.5km) is regarded the most vulnerable towards any impact from the activities of the proposed Project site. Thus, the largest sample was obtained from Kg. Lepau (Table *5.35*). The second largest sample was obtained from Kg. Bukit Pelali located about 3km from the Project site. Smaller samples were taken from villages located within 4km to 5km radius from the proposed plant. The demographic and social profile as well as the views and perceptions of the respondents from these villagers will serve as a benchmark and representative of the impacted population.

Table 5.35: Distribution of Respondents by Villages

Village	Distance from Project Site (km)	No. of respondents	% of village households
Kg Lepau*	1.5	50	60
Kg Bukit Pelali	3	20	50
Taman Rengit Jaya	3.5	12	12
Kg Bukit Buloh	4	6	10
Kg Bukit Gelugor	4	3	10
Kg Bukit Raja	4.5	9	9

*Note: * The perception survey in Kg. Lepau covered 60% (i.e. 30 respondents) of the 50 households residing there as well as 10% (i.e. 20 respondents) of the 200 non-local residents (Malaysians from other states) who are renting living quarters in the village and working in RAPID and the PIPC. The total population of Kg. Lepau in Sept. 2018 was close to 400 people (i.e. 200 locals and 200 non-locals), based on feedback from the former village head of Kg. Lepau. The 50 respondents who were interviewed in Kg. Lepau represent 12.5% of the population.*

A total of a hundred respondents were interviewed between September and October 2018 and in January 2019 to obtain an understanding of the demographic and socio-economic character of the local community located inside the 5km impact zone as well as the non-local workers who have opted to use these villages as their interim home. Eighty of those interviewed are local residents (i.e. owner occupiers from the six villages) and twenty are non-locals (Malaysians from the other parts of Johor and the other states, namely Sabah, Sarawak, Terengganu, Kelantan, Selangor and Pahang). The non-locals are recent arrivals to Pengerang to work in RAPID or to start their own business or work in businesses and industries that are related to RAPID and the PDT. The majority of the respondents are males (85%) with the rest females (15%).

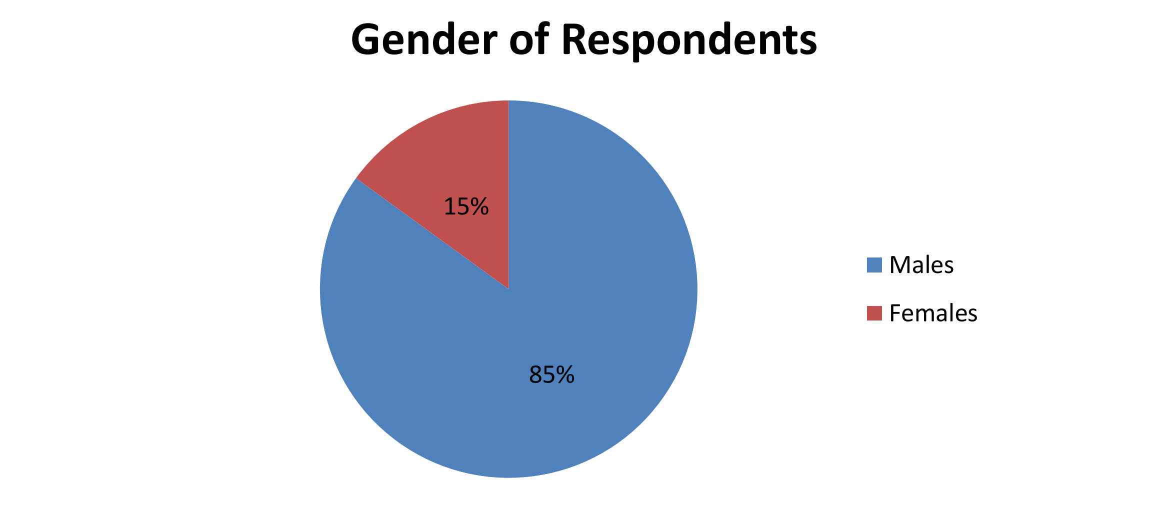


Figure 5.36 – Demographics of Respondents

The breakdown by age group of the local respondents is as follows: between 20 to 39 years (23%), between 41 to 59 years (34%) and 60 years and above (43%). In contrast, the twenty non-locals are aged between 20 to 39 years. When combined, the respondents in the 20 – 39 age group represent the majority group (39%). Those aged 60 years and above (34%) is the second largest.

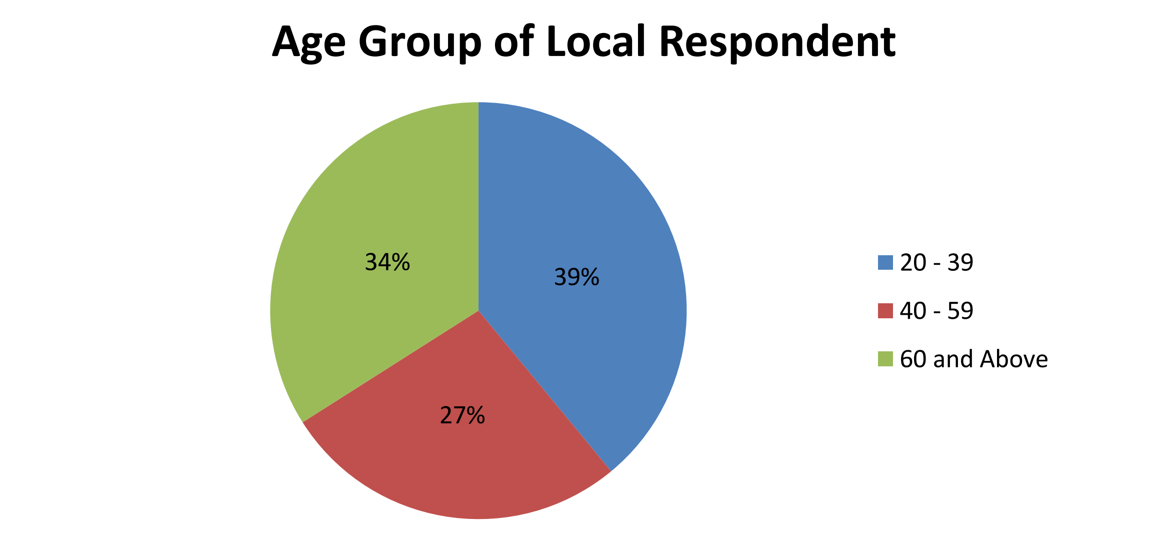


Figure 5.37 – Age Group of Local Respondents

The demographic character of Kg. Lepau, in particular, has changed over the past 5 years. Based on information from its former village head, the village is currently home to 50 families with an estimated population of less than 200 people and an exceptionally high aging population. About 43% of Kg. Lepau's population are aged 60 years and above in comparison to Mukim Pengerang (12%), Daerah Kota Tinggi (8.3%) and Johor state (8.3%). (Malaysia Census 2010). A high aging population is also evident in the five other villages located inside the 5km impact zone. The likely explanation for this pattern is that prior to RAPID and Dialog's deepwater port project in Pengerang, the villages in Pengerang faced outmigration of the younger population to the other parts of Johor, particularly to Pasir Gudang, for employment and economic reasons. On the other hand, the non-locals who have made Kg. Lepau their interim home are primarily younger with an average age of 32 years. They are economically active and constitute about 200 people in number.

5.7.2.3 Education

With respect to the level of education attained amongst the local respondents, a high proportion has a primary school education (43%), secondary school education (56%) and tertiary/diploma (1%). In contrast, the non-local respondents have a better educational level. Those with a primary school education (10%), secondary school education (30%) and tertiary education (60%).

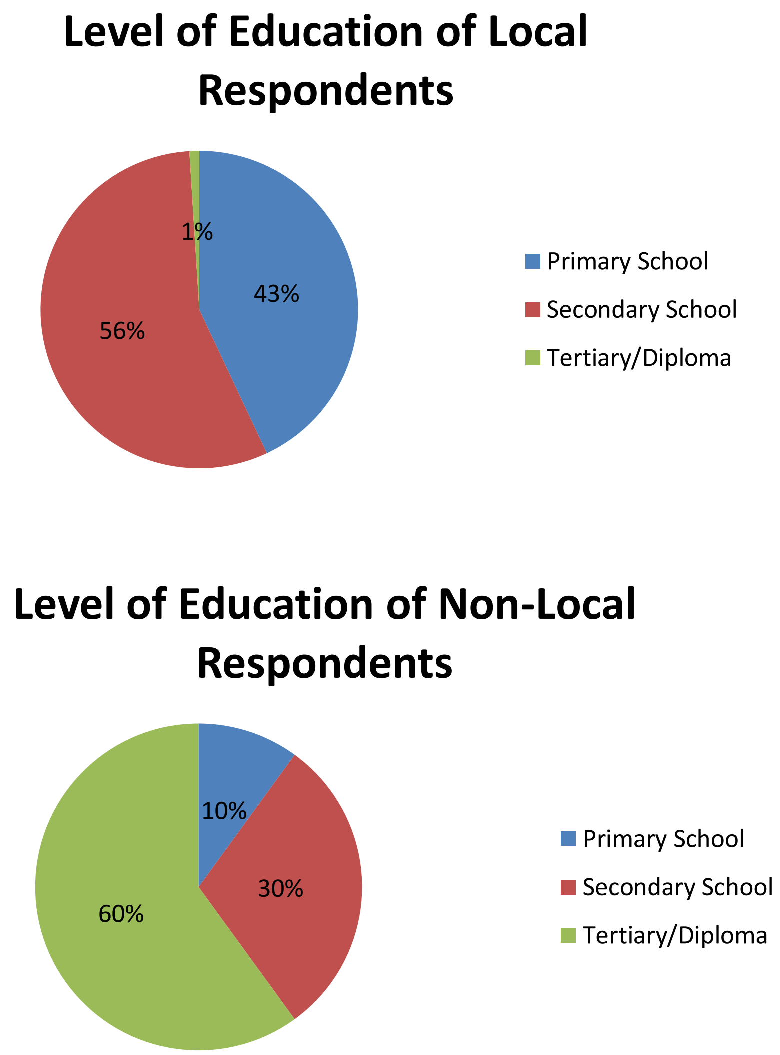


Figure 5.38 – Education Level of Respondents

Based on ground truthing there were only two (2) schools present within a 5 km radius, which are Primary School SK Kg. Lepau and Secondary School SMK Tanjung Datuk. The changing demographic character of Kg. Lepau and the other villages is also reflected in the declining enrolment of students. In 2015, SK Kg. Lepau (the only primary school in Kg. Lepau) recorded an enrolment of 14 students and 13 teachers. In 2018, however, the school had only 6 students and 4 teachers. Secondary School SMK Tg. Datuk has been relocated to SMK Taman Bayu in Taman Bayu Damai in December 2018 east of The Site.

5.7.2.4 Ethnicity

Ethnically, the local respondents from Kg. Lepau, Kg. Bukit Pelali, Kg. Bukit Gelugor, Kg. Bukit Raja and Kg. Bukit Buloh are predominantly Malays (100%). Taman Rengit Jaya, on the other hand, is a mixed community, where those interviewed include the Chinese (40%), Indians (40%) and Malays (20%). The ethnic breakdown of the non-locals comprises Malays (85%), Indians (10%) and Chinese (5%).

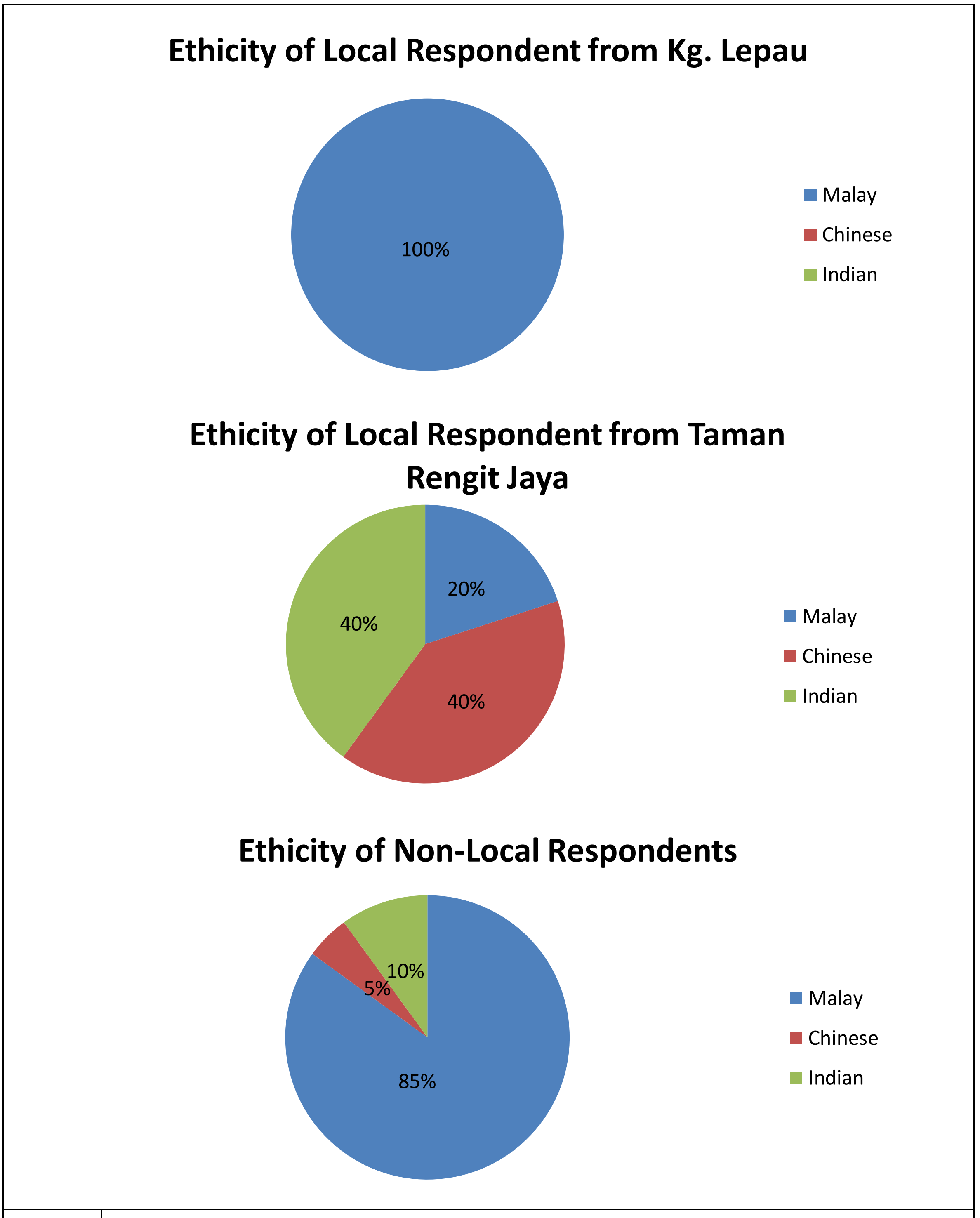


Figure 5.39 – Ethnicity of Respondents

Based on the study, Chinese and Indian ethnicity were observed in Kg. Sg. Buntu and Taman Rengit Jaya while Malay ethnicity was observed as the majority in the study area.

5.7.3 Economics

Gross Domestic Product (GDP) is to measure the total value-added of goods and services produced in a year in a region. It is one of the indicators to measure the economic progress of a region. Table below shows that GDP of Johor was recorded at RM 87,974 million in 2013 and steady increased to RM 104,480 million in 2016. The economic growth of Johor gradually increased with annual growth rate between 4.7% to 6.5%. The highest GDP growth occurred in 2014 with 6.5% of growth.

Table 5.36: Economic Growth of Johor

Gross Domestic Product (GDP)	2013	2014	2015	2016	2017
GDP at constant 2010 prices (RM million)	87,974	93,654	98,889*	104,480^{p}	-
GDP per capita at current prices (RM)	26,308	28,089	29,558*	31,952^{p}	-
GDP Growth (%)	4.7	6.5	5.6*	5.7^{p}	-

Source: Department of Statistics Malaysia, 2018.

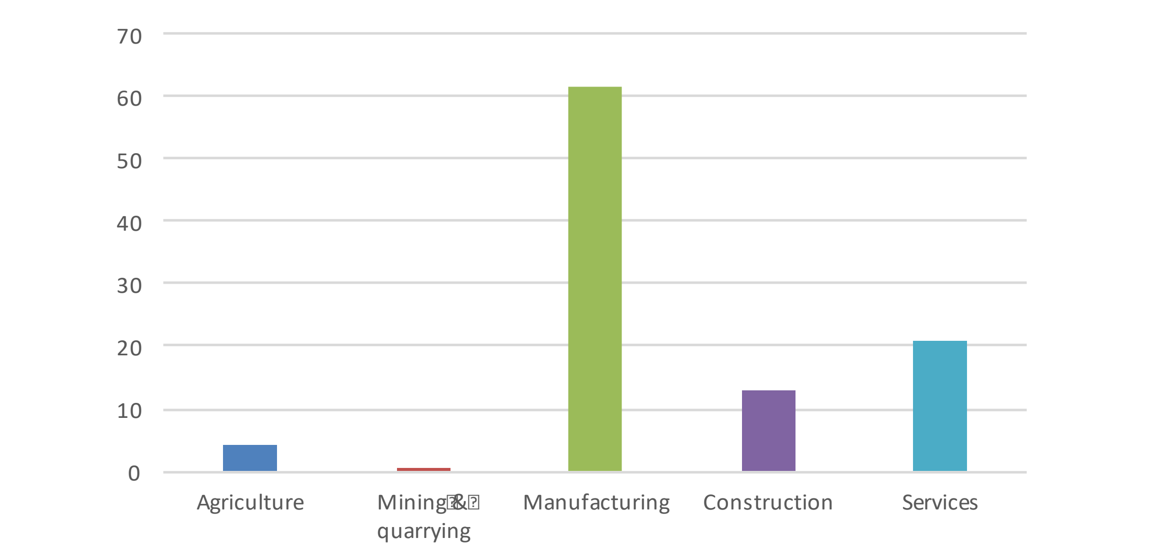


Figure 5.40 – Percentage GDP Share of Major Industry Sectors 2015
Source: Economic Census 2016, Department of Statistics Malaysia, 2017.

In term of percentage GDP share, as presented in *Figure* 5.40 manufacturing sector was the largest industry sector which contributed more than 60% of total GDP in 2015 and then followed by manufacturing sector as second largest contributor with total percentage of about 21%. Third and fourth largest contributor to GDP were construction and agricultural sector, respectively, about 13% and 4%. Mining and quarrying sectors are the least sector with less than 1% contribution.

5.7.4 Employment and Labour Force

Population age of 15-59 years old, which is considered as economically active, is grouped as working age or productive age population. The working age population is made up of the labour force and the non-labour force. The labour Force consists of people working and those seeking work. Meanwhile, the non-labour force is made up of people in school, taking care of households, or those doing other activities besides paid employment.

Table 5.37: Employment and Labour Force of Johor

Employment and Labour Force	2013	2014	2015	2016	2017
Employment					
Labour Force ('000)	1,598.90	1,621.10	1,633.20	1,639.10	-
Employed ('000)	1,553.40	1,579.70	1,582.60	1,580.60	-
Unemployment ('000)	45.4	41.4	50.6	58.5	-
Labour Force Participation Rates, LFPR (%)					
Total	67.5	67.5	67.1	66.6	-
Male	82.2	82.4	81.5	81.4	-
Female	50.7	50.7	50.9	49.9	-
Unemployment Rate (%)	2.8	2.6	3.1	3.6	-

Source: Department of Statistics Malaysia, 2018.

As shown in *Table 5.37*, the labour force for Johor was around 1,598,900 people in 2013 and slightly increased over the year to 1,639,100 people in 2016. There was also a total of 45,400 people who are being unemployed in 2013 and the number slightly rose to 58,500 people in 2016. The table also shows that unemployment rate ranged from 2.6% to 3.6%, where the highest unemployment occurred in 2016 with rate of 3.6%.

5.7.5 Livelihood and Economic Activities

Livelihood is a way of making a living or earning income to fulfil household needs. People can make a living through employment in formal and informal. Department of Statistics Malaysia listed several industrial sectors where people mostly work.

Referring to *t and* required a lot of labour.

Table *5.38*, total number of people employed by industry sector in Johor in 2010 and 2015 was 790,211 and 1,188,511 people respectively. Mainly, the manufacturing sector employed most of people which accounted for about 42% in 2010 and 38% in 2015. Second largest sector that provided the job for Johor people is service sector which contributed about almost 40% in 2010 and 37% in 2015. Construction and agricultural sector was recorded as the third and fourth largest sector contributed to the employment with 11% and 6.4% in 2010 to 20% and 4.8% in 2015. Mining and quarrying engaged the people less than 1% as also presented in *Figure* 5.41. The largest annual growth rate was in the construction sector where many infrastructure projects were under development and required a lot of labour.

Table 5.38: Number of Persons Engaged by Industry Sectors

Sector	2010		2015		Annual Growth
Agriculture	50,802	6.4	57,000	4.8	2.3
Mining & quarrying	2,738	0.3	5,377	0.5	14.5
Manufacturing	332,372	42.1	448,365	37.8	6.2
Construction	90,070	11.4	240,493	20.3	21.7

Sector	2010		2015		Annual Growth
Services	314,229	39.8	435,261	36.7	6.7
Total	**790,211**	**100**	**1,188,511**	**100**	**8.5**

Source: Economic Census 2016, Department of Statistics Malaysia, 2017.

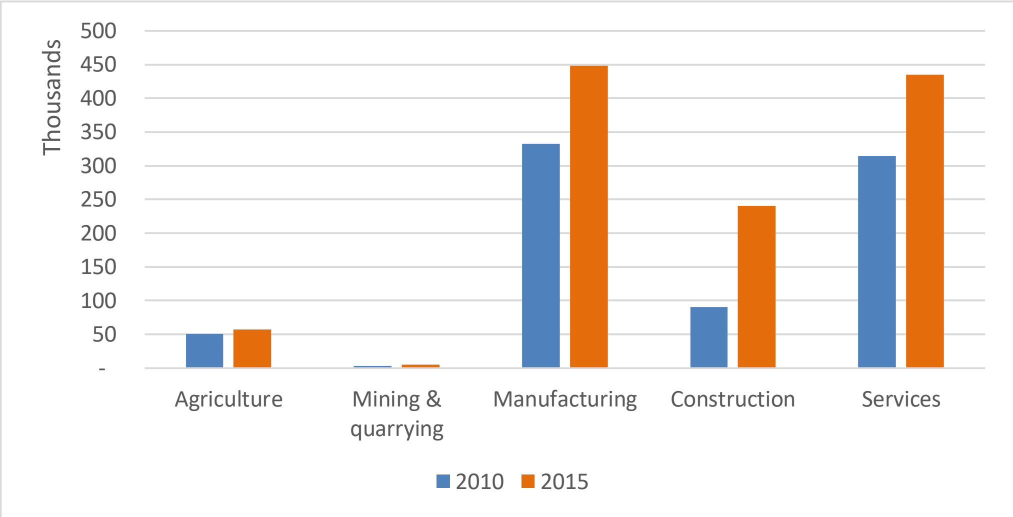


Figure 5.41 – Number of Persons in Johor Engaged in Industry Sectors in 2010 and 2015

Source: Source: Economic Census 2016, Department of Statistics Malaysia, 2017.

In term of number of people employed by type of employment in Johor for 2016, Table 5 38 shows majority of People of Johor, which accounted for about 20.13% of total number, worked as Plant and machine operators and assemblers, and then followed by Service and sales workers and Craft and related trades workers, respectively about 18.77% and 17.65%. The fourth and fifth largest were elementary occupations and technicians and associate professionals account for 12.80% and 11.89%. The remaining percentage of number of people employed, which is less than 6% each, was for professionals, Managers, Skilled agricultural, forestry, livestock and fishery workers.

Table 5.39: Number of People Employed by type of Employment and sex state of Johor, 2016

Type of Employment/ Sex	Male	Female	Total	Percentage
Managers	50.3	11.3	61.6	4.90%
Professionals	58.2	75.9	134.1	5.67%
Technicians and associate professionals	122.0	52.4	174.4	11.89%
Clerical support workers	37.4	100.0	137.4	3.64%
Service and sales workers	192.7	164.4	357.1	18.77%
Skilled agricultural, forestry, livestock and fishery workers	46.6	3.9	50.6	4.54%
Craft and related trades workers	181.2	32.6	213.8	17.65%
Plant and machine operators and assemblers	206.6	66.9	273.5	20.13%
Elementary occupations	131.4	46.7	178.1	12.80%
Grand total	**1,026.5**	**554.2**	**1,580.6**	100.00%

Source: Labour Force Survey Report, Malaysia, 2016, Economic Census 2016, Department of Statistics Malaysia, 2017.

Note: Figure is in thousand

For per capita income, as shown in *Table 5.36* per capita income for Johor was RM 26,308 per capita in 2013 and steadily increased to RM 29,558 and RM 31,952 in 2015 and 2016 respectively. Department of Statistics Malaysia also reported main source of income of household and strata for urban and rural residents in 2014 and 2016. The source of income was categorized from paid employment, self-employment, property and investment and current transfer received. Most of people in Johor obtained their income from paid employment which accounted for between 63% – 65% and then followed by self-employment which was about 15%. People who generated income from property and investment as well as from current transfer received accounted for between 12% to 13% and 7.6% to 7.7% respectively.

Table 5.40: Percentage of income by main source of income of head of household and strata, Johor, 2014 and 2016

Main source of income	2014			2016		
	Total	Urban	Rural	Total	Urban	Rural
Income from paid employment	65.0	67.7	53.2	63.5	65.5	53.8
Income from self-employed	15.4	13.6	23.5	15.4	14.1	21.6
Income from property and investment	12.0	11.9	12.6	13.5	13.5	13.4
Current transfers received	7.6	6.8	10.7	7.7	6.9	11.2

Source: Household Income and Basic Amenities Survey Report By State and Administrative District, Johor 2016, Department of Statistics Malaysia, 2017.

On the other hand, in the survey area, the villagers of Kg. Lepau were once dependent on their oil palm smallholdings (to an extent) as one of the sources of income. Located at the fringe of the village, these smallholdings were previously managed by FELCRA (Federal Land Consolidation and Rehabilitation Authority, a federal agency set up specially to develop the rural areas by assisting the farmers in the management and replanting of their agricultural land). Based on feedback from the respondents during the social and perception survey, it is understood that FELCRA has ceased its management role (for a number of reasons that include declining commodity price). Since then, the smallholdings have remained idle and occasionally inundated due to drainage issues and during the wet season.

Fruit cultivation around the village is pursued, albeit on a small scale and mainly for personal subsistence.

Dependence on fishing as a source of livelihood has declined considerably since work started on the coastal reclamation for a deep water terminal and development of Pengerang as a petroleum processing hub. The fishermen who were interviewed in the social survey reported a drastic plunge in earnings and having to go further out to drop their nets. This could be due to a number of reasons that include reduced water quality along the rivers and near shore areas (thus affecting the mangroves and the fish and prawn spawning areas along the riparian areas) and restrictions placed on traditional fishing grounds to accommodate vessel movement.

The villagers realise that while old livelihoods like fishing and dependence on the land are diminishing, new incomes are available from the new developments in Pengerang.

Regarding the ownership of household assets, *Figure* 5.42 shows the percentage of households in Malaysia and Johor who own the household assets. Above 90% of household owned basic household's equipment such as washing machine, refrigerator, gas/ electric stove, mobile phone, radio/hi-fi, and television. Other household items owned by 50%-90% of people of Johor and Malaysia are cars, motorcycle, laptop, subscription of internet at home, video/ VCD/DVD player, and Paid TV/ Channel. The *Figure* 5.42 also shows that, the ownership of household item for people of Johor is slightly higher than Malaysian in general.

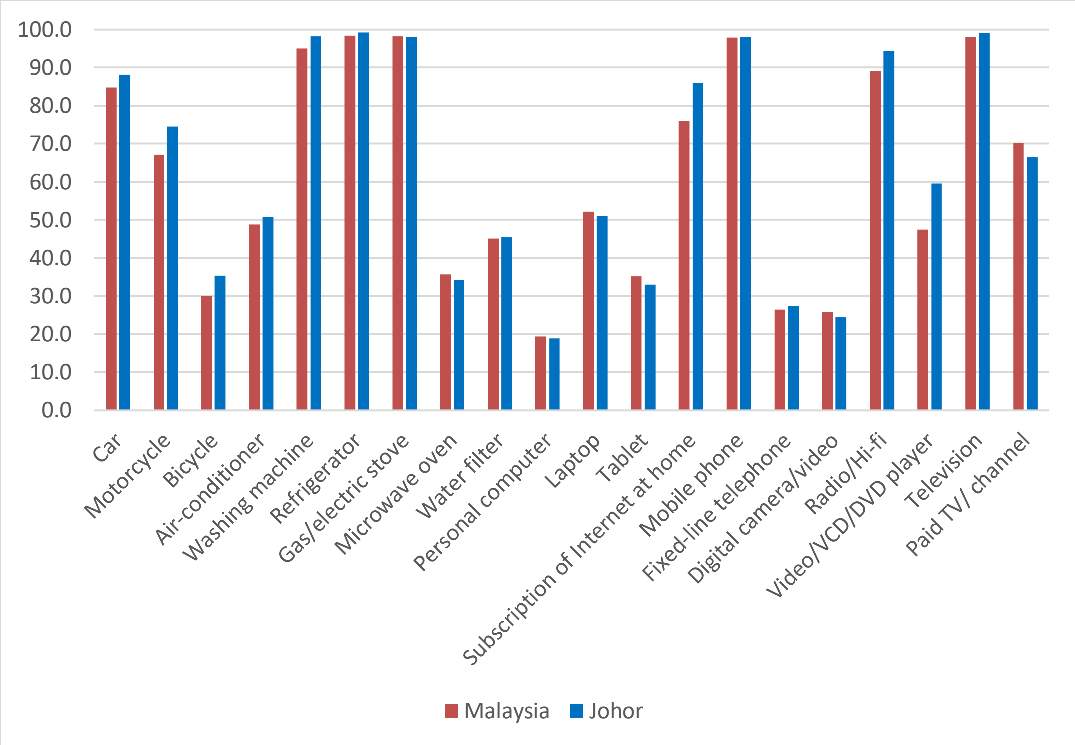


Figure 5.42 – Percentage of Household Owned Household Asset of Malaysia and Johor

Source: Household Income and Basic Amenities Survey Report By State and Administrative District, Johor 2016, Department of Statistics Malaysia, 2017.

Related to the poverty Malaysia, the concept of poverty is based calculation of food poverty line income (PLI) and non-food PLI for each household. Household who fall below PLI is considered poor as they may not be able to meet basic need (food and non-food items). The poverty line for Peninsular Malaysia in 2016 was RM 960, and Sabah/ W.P. Labuan, and Sarawak are RM 1,180 and RM 1,020 respectively as presented in Table *5.42*.

Table 5.41: Poverty Line income, Malaysia, 2016

Region	Total	Urban	Rural
	(RM) per month		
Peninsular Malaysia	960	970	880
Sabah/ W.P. Labuan	1,180	1,170	1,220
Sarawak	1,020	1,070	940

Source: Household Income and Basic Amenities Survey Report By State and Administrative District, Johor 2016, Department of Statistics Malaysia, 2017.

As reported by Department of Statistics Malaysia, 2017 on the household income and basic amenities survey report, there is zero incident of poverty in Johor in 2014 and 2016, as presented in Table *5.42*, compared to Malaysia overall. The zero incident of poverty is in line with high per capita income that reached RM 31,952 per annum as well as high percentage of house owned household asset as shown *Figure* 5.42.

Table 5.42: Incidence of Poverty

Location	Year	Malaysia	Johor
Urban	2014	**0.3**	0.0
Rural		**1.6**	0.0
Total		**0.6**	0.0
Urban	2016	**0.2**	0.0
Rural		**1.0**	0.0
Total		**0.4**	0.0

Source: Household Income and Basic Amenities Survey Report By State and Administrative District, Johor 2016, Department of Statistics Malaysia, 2017.

5.7.6 Education

Table *5.43* shows that number of pre-school in 2016 was 667 units, whereas primary and secondary schools were 906 and 274 across Johor state with total student 602,259 people and teacher 49,572. Student-teacher ratio for pre-school was 22.19 pupils per one teacher. Conversely, the ratio of student teacher for primary and secondary schools were quite low, which were 12.05 an 11.85 students per one teacher. Low student teacher ratio allows learning process more effective and efficient.

Table 5.43: Number of School, Students, Teachers, Student-Teacher Ratio of Johor 2016

Level of Education	Number of School	Students	Teachers	Student Teacher Ratio
Pre School/ Kindergarten	**667**	**20,566**	**927**	22.19
Primary School	**906**	**327,915**	**27,221**	12.05
Academic	894	324,317	26,824	12.09
Religious	8	3,435	281	12.22
Special Education	4	163	112	1.46
Secondary School	**274**	**253,778**	**21,424**	11.85
Academic	241	240,997	19,804	12.17
Religious	24	9,076	911	9.96
Technical	1	589	63	9.35
Vocational	8	3116	642	4.85
	1,847	**602,259**	**49,572**	**12.15**

Source: Department of Statistics Malaysia, 2017.

5.7.7 Culture

5.7.7.1 Worship Facilities

Based on the ground truthing, there were 5 worship facilities within 5 km of the proposed PEC site. 1 among these facilities is a Chinese temple at Kg. Sg. Buntu and the other 3 facilities are 1 Masjid at Kg. Lepau, and 3 Surau at Kg. Bukit Gelugor, Kg. Bukit Raja, and Kg. Surau Buntu. The Muslim community in Malaysia is affiliated with the *Sunni denominations* and has its own traditions in religious life.

Table 5.44: Number of Worship Facilities within 5 km Radius

No.	Village	Mosque	Smaller Mosque	Church	Indian Temple	Chinese Temple
1	Kg.Lepau	1	-	-	-	-
2	Kg. Bukit Gelugor	-	1	-	-	-
3	Kg. Bukit Raja	-	1	-	-	-
4	Kg. Sg. Buntu	-	1	-	-	-
5	Kg. Sg. Buntu	-	-	-	-	1
	Total	**1**	**3**	**0**	**0**	**1**

5.7.7.2 Cultural Heritage

Based on the observation, there were no archaeological sites or cultural heritages present within the study area (5 km radius of the proposed PEC site).

5.7.8 Community Perceptions

A perception survey was conducted in tandem with the household socio-economic survey undertaken in September – October 2018 and January 2019 for the purpose of obtaining the community's views with respect to the proposed Project. Generally, the majority of the residents (60%) were aware that the ownership of a large tract of agricultural land located between Lebuhraya Pengerang and the northern boundary of RAPID is in the process of being transferred from KEJORA to Johor Corporation (JCorp), an investment arm of the Johor state government. Additionally, the residents were also aware of JCorp's intention to convert the land for industrial use.

Awareness of the Project

With respect to the proposed Project in particular, 98% the 100 respondents interviewed reported that they were not aware of the proposal. Only 2% indicated that they heard about the proposed Project from friends, but did not know the details or where the plant would be located.

Support for the Project

The respondents cited increase in the movement of heavy vehicles, poor road conditions, road safety along the public roads coupled with dust and noise from the activities in RAPID as problems that they currently faced. In terms of support for the proposed Project, 86% of the respondents viewed the Project favourably and indicated they were willing to support it as the Project would generate economic benefits. This is possibly because the respondents have seen or experience the spill-over effects and economic growth around them in Pengerang, improved infrastructure and road upgrading works in the region and new mixed housing and township projects under construction as a result of the PIPC project. The respondents concurred that the Project would (1) promote business and other spin-offs opportunities (100%); (2) sustain the increase in house rental and land value (97%); (3) generate new job and employment opportunities (93%); and (4) stimulate further development in Pengerang and the other regions in the Kota Tinggi district (87%).

Those who did not view the Project favourably accounted for 14% of the respondents. The main reasons cited pertain to air pollution (86%), noise and dust nuisance (64%), increase in heavy vehicles and road safety issue (93%), influx of foreign workers and social/health problems that might arise (71%) and declining water quality in the rivers (21%).

5.7.9 Indigenous People

No indigenous people present within and in surrounding area where the proposed PEC site is located.

5.8 Public Health

5.8.1 Characteristic of Population

According to the Department of Statistics Malaysia, Johor had a total population of 3.7 million in 2017 and an estimated 1.2% annual growth rate. The crude birth rate was 16.5 per 1,000 population in 2017 and the crude death rate was 5.6 per 1,000 population. The estimated life expectancy for males was 72 years old and 77 years old for females.

Ischaemic heart disease remains as the principal causes of death for Malaysians in general. In 2017, deaths caused by Ischaemic heart diseases accounted for 13.9% of total deaths, followed by Pneumonia (12.7%), Cerebrovascular diseases (7.1%), Transport accidents (4.6%) and Malignant neoplasm of trachea, bronchus and lung (2.3%).

Specifically, for Johor, there are number of infectious diseases occurred in 2016. Dengue fever was recorded as the highest incidence with total case number of 10,613 and then follower by Hand, Foot and Mouth Disease with case number 4,025. Other high cases of diseases were Gonorrhoea, H.I.V/ A.I.D.S, Hepatitis B and C, measles, and others as shown in Table *5.45*.

Table 5.45: Number of Cases of Infectious Diseases

Disease	Number of Cases
Pertusis	10
Other Tetanus	1
Viral	1
Measles	239
Dengue fever	10,613
Dengue haemorrhagic fever	28
Hepatitis A	6
Hepatitis B	245
Hepatitis C	175
Viral Hepatitis	2
Malaria	41
Syphilis	209
Gonorrhoea	330
H.I.V	321
A.I.D.S	156
Leptospirosis	207
Hand, Foot and Mouth Disease	4,025

Source: Department of Statistics Malaysia, 2017.

Additionally, according to the International Journal of Public Health Research (2019) a total of 593 cases of dengue cases were registered in 2015 by the Kota Tinggi Health Office. A majority of the cases occurred in rural areas with 263 cases (44.3%), followed by urban with 177 cases (29.8%), others with 109 cases (18.4%) and semi-urban with 44 cases (7.4%).

5.8.2 Healthcare Facilities

Johor State had a total of 44 hospitals in 2016. Of which, 12 were public hospitals and 32 were privately owned hospitals with a total of 6,559 inpatient beds. Additionally, there about 399 government clinic in Johor with composition of 98 health clinics, 261 village clinics, 32 1Malaysia clinics, and 8 dental clinics. The private clinics across Johor are 1,105 clinics with composition of 894 health clinics and 211 dental clinics.

Further, in term of health workers, Johor has 4,383 registered doctors and 673 dentists as well as 9,924 nurses and 2,113 community nurses for both government and private.

5.9 Housing Condition

The type of house in Johor in 2016 as reported Department of Statistics Malaysia is presented in *Table 5.45.* Majority of house in Johor was in the form of terrace house which accounted about 50%. Low cost house accounted as the second larger which was about 23% and the third type of house was detached house with was about 12%. The remaining houses consisted of semi-detached, town house, cluster, flat, and apartment/condominium.

Table 5.46: Number of existing Housing Stocks by Type, Johor, 2016

Type of House	Unit	Percentage
Detached	86,346	11.80%
Semi-detached	48,121	6.58%
Terrace	363,470	49.68%
Town house	1,342	0.18%
Cluster	6,163	0.84%
Low cost	171,001	23.37%
Flat	23,191	3.17%
Apartment/ Condominium	31,999	4.37%
Total	731,633	100.00%

Source: Department of Statistics Malaysia, 2017.

Housing ownership status and physical condition as shown Table *5.47* is categorized according to location (urban and rural area). Most of housing in Johor fell under owned status with total of 77.3% of ownership and then followed with rented status with total of 19.6%. There was only 3.1% with quarters ownership status. On the other hand, the physical condition of housing was categorized brick, brick and plank, and plank. Majority of housing (89%) was built with brick, and 10% built with brick and plank. Only less than 1% of housing in Johor was built with only plank. High percentage of owned status and built with brick was due to the residents has medium to high income.

Table 5.47: Housing Ownership Status and Physical Condition, Johor, 2016

Location	Ownership Status	Percentage	Physical Condition	Percentage
Urban		74.7%		93.8%
Rural	*Owned*	86.4%	*Brick*	72.2%
Total		**77.3**%		**89.0**%
Urban		22.9%		5.6%
Rural	*Rented*	7.8%	*Brick and plank*	25.8%
Total		**19.6**%		**10.1**%
Urban		2.4%		0.6%
Rural	*Quarters*	5.8%	*Plank*	2.0%
Total		**3.1**%		**0.9**%
Grand Total		***100.00***%		**100.00**%

Source: Department of Statistics Malaysia, 2017.

Similarly, based on the field visit during household survey, the houses in Kg Lepau and the other five villages are a mix of modern single-story brick structures (30%), brick and wood structures (50%) and traditional wooden kampong houses (20%). With respect to water and electricity supply, the area appears to be well served by SAJ and TNB. Pending the implementation of a central sewerage treatment plant and a solid waste collection and management system for Pengerang, individual septic tanks are largely used for sewerage treatment in Kg Lepau and the other five villages whilst solid waste disposal is still by burning and burying.

Perhaps the most significant change in the character of housing in Kg Lepau and the other five villages is the escalated demand for rental accommodation. The recent influx of workers, both local and foreign, arising from the activities in RAPID and the DIALOG Deepwater Terminal, has led to substantial increase in rental rates (typically, between RM5,000 to RM8,000 per living quarter a month) and land prices. Attractive rental rates have encouraged the upgrading of a number of derelict or underutilized kampong as well as half-timber and brick houses particularly in Kg Lepau, and a general physical improvement was observed during the sites visits.


An upgraded house


A new house under construction


House rented to workers from RAPID


House rented to workers from RAPID

Figure 5.43 – Housing Condition at Kg. Lepau

Source: Household Survey. Photographs of houses in Kg Lepau taken on 18th July and 22nd September 2018.

5.10 Transportation and Accessibility

5.10.1 Road Condition

The road is an infrastructure that enables movements of land-based vehicles and one of the most important aspects in supporting economic activities. Table *5.48* summarizes the length of each road in regard to the level of status (i.e. federal and state), and the types of road (i.e. paved, gravel, earth).

Table 5.48: Road Length in Johor 2016

Federal/ State	Type of Road	Length (KM)
Federal	Paved	2,368.7
Johor	Paved	19,362.8
	Gravel	1,509.3
	Earth	392.2
Total		**23,633.0**

Source: Department of Statistics Malaysia, 2017.

In 2016, according to Department of Statistic 2017, the length of paved federal road in Johor was 2,368.7 km; the length of paved, gravel and earth road at state level was 19,362.8 km, 1,509.3, and 392.2 km respectively, which contributed to total road length of 23,633 km.

Specifically regarding the road access to PEC site, it can be accessed via the North-South Highway and then through Senai-Desaru highway (E22) which will link up to Jalan Kota Tinggi – Sungai Rengit (Route 92). An intersection is located southward along Route 92 which will leads to Jalan Kota Tinggi – Pengerang (J52) to PEC site to the west.

Currently, the only accessible route to PEC site is through the intersection on J52 towards PIC Access Road (Unnamed). However, a new road is currently being constructed to the west of PEC site and can be accessed through the roundabout on J52. Once completed, this road will be the new main route to both PIP as well as PIPC and it will permanently replace the current route to RAPID Gate 2.

Figure 5.44 – Access Route (Land Transportation)

Jalan Kota Tinggi – Pengerang (J52) is situated in a flat area with 4 lanes in total with 14 m width and 3 m road shoulder. This road act is the main route to PIC and PIP and is mainly used by RAPID workers. This road has medium rate of occupancy and local occupancy is observed to be low. General geometric data of this roadway is as follows:

Table 5.49: Geometric Data of Jalan Kota Tinggi – Pengerang

Variables	Measurements
Type	4 lanes (2 ways)
Effective width	14 Meter
Effective lane width	3.5 Meter
Effective shoulder width	3 Meter
Side frictions	Low
Terrain	Flat

The Unnamed road is situated on a flat area with 2 lanes in total with 7 m width and no road shoulder. Currently, this road acts as a secondary road to both PIP and PIC. This road is observed to have high occupancy rate mostly contributed by RAPID. The local occupancy rate on this road is non-existence as the road is designated solely as industrial road and there is no local settlement along the route. The general geometric data of the roadway is as follows:

Table 5.50: Geometric Data of Unnamed Road near Proposed PEC Site

Variables	Measurements
Type	2 lanes (2 ways)
Effective width	7 Meter
Effective lane width	3.5 Meter
Effective shoulder width	0 Meter
Side frictions	Low
Terrain	Flat

Figure 5.45: Jalan Kota Tinggi – Pengerang (left) and Unnamed Road (right)

Source: Site visit 20th - 22nd February 2018

5.10.2 Transportation

In 2016, there were about 3,580,441 units of vehicle registered cumulatively in Johor, comprising of motorcar, motorcycle, public transport, commercial vehicle, and other vehicles. Number of motorcycles reached 1,850,747 units or about 51.69% of total vehicles – the largest composition of vehicles, and then followed with motorcar in second place with 1,492,807 units (41.69%). The number of commercial vehicles was 151,246 units (4.22%), and followed by 65,343 other vehicle and public transport 20,298 units (0.57%).

Overall, the number of vehicles in Johor registered new vehicle as many as 75,887 units in 2016 with the largest composition on motorcycle (70.32%) and motorcar (20.59%). The abundance of motorcycles and motorcar in the area could reflect medium and high-income level of the residents as motorcycles and motorcar are affordable by Johor resident. Additionally, in Johor and Malaysia in general, the residents are quite easy to get approval for vehicle financing where the applicants need to attach salary slip or financial statement.

Table 5.51: Number of Vehicle Registered in Johor 2016

Type of Vehicle	Cumulative Number of Vehicle Registered	Percentage	New Vehicle Registration	Percentage
Motorcar	1,492,807	41.69%	15,624	20.59%
Motorcycle	1,850,747	51.69%	53,367	70.32%
Public Transport	20,298	0.57%	522	0.69%
Commercial	151,246	4.22%	4,604	6.07%
Other vehicles	65,343	1.82%	1,770	2.33%
Total	**3,580,441**	100.00%	**75,887**	100.00%

Source: Department of Statistics Malaysia, 2017.

5.10.3 Sea Transportation

No sea transportation directly connects to the proposed PEC site. The closest harbour is located at industrial area PIC area or harbours at Tg. Pengelih, Kg. Rengit and Sebana Mixed Development.

5.10.4 Air Transportation

No air transportation directly connects to the proposed PEC site. The closest airport in Malaysia is at Senai, Johor, where Senai International Airport is located ± 63 Km northwest of The Site.

5.10.5 Electricity Network

In 2016, Department of Statistics Malaysia reported that access to electricity in Johor was about 100% in urban area and 99% in rural area. Electricity service is provided by Tenaga Nasional Berhad (TNB).

Figure 5.46 – Access Route (Sea and Air Transportation)

6 ENVIRONMENTAL, SOCIAL AND HEALTH IMPACT ASSESSMENT (ESHIA) APPROACH & METHODOLOGY

6.1 ESHIA Procedure

The main objective of the ESHIA is to examine, analyse and assess the planned project activities' effects on the baseline conditions described in Section 5. A detailed description of the proposed project activities and components is presented in Section 3.

An ESHIA should assist in ensuring environmentally and socially sound management of the project during its entire lifetime (construction, operation, decommissioning). The Environmental Social and Health Impact Assessment presented in the following section (Section 7) will be for the construction and operation phases and limited impacts during the decommissioning phase, due to the restricted amount of relevant information on the decommissioning activities. However, a detailed decommissioning phase impact assessment shall be developed at a later stage of the project.

The impact assessment process starts with a focusing procedure to identify the key environmental and social features from the baseline information detailed in Section 5 of this ESHIA report. This focus identifies the key biological, physical and human components of the proposed project area of influence. The potential positive and negative changes resulting from the defined project activities presented in Section 3 are then predicted for the area of influence and for the entire lifecycle of the project. These predicted changes (impacts) are then evaluated using a significance ranking process.

6.2 Scope Boundaries of ESHIA

6.2.1 Area of Influence

This ESHIA is concerned with environmental and social impacts associated with the Pengerang Energy Complex aromatic plant and condensate splitter, and support facilities in the total area of 250 acres.

The onsite facility and support facilities that will be assessed in the ESHIA are as follows:

- Onsite bulk storage
- Steam boiler including steam supply and condensate recovery system;
- Cooling water system;
- Demineralized water system;
- Waste water system;
- Fire water system;
- Instrument Air/Plant Air;
- Nitrogen system;
- Potable water; and

The process plant, inclusive of onsite facilities, is to be located in the western part of the site and will occupy an area of ~67.7 ha or ~167 acres (~67% of the total site area, 250 acres), measuring roughly 1,095m in width and 618m in length. It also includes the surrounding region that is affected and impacted by transportation, air emissions, and other aspects of the Project.

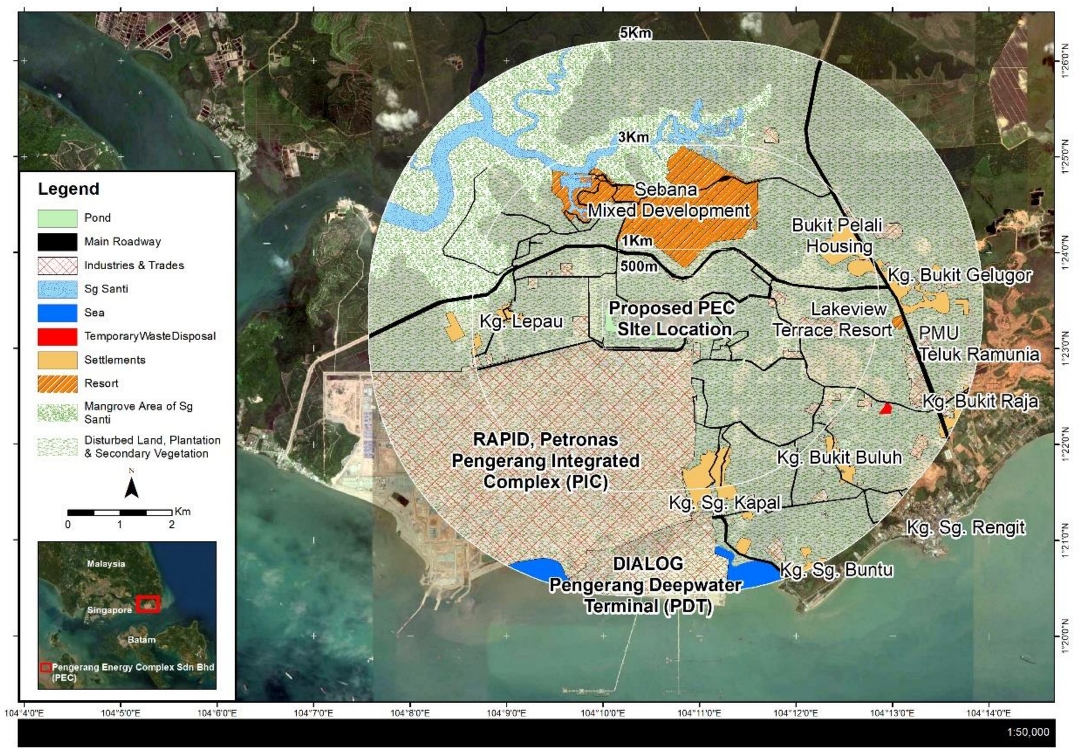
This ESHIA will not be assessing the environmental and social impacts of the associated facilities that are located outside of PEC and are not constructed and managed by PEC. The associated facilities are as follows:

- Pipeline from/to Pengerang Deepwater Terminal (PDT)
- Condensate (feed) bulk storage;
- Product bulk storage; and
- Jetty facilities

These facilities will be constructed and managed by third parties and as such, the environmental and social impacts of these facilities will be addressed by each respective third parties.

6.2.2 Study Boundaries

The study boundary is the combination of Project boundary, ecological boundary, social boundary and administrative boundary. *Figure 6.1* below illustrates a total of 5 km study boundaries based on spatial allocation of local plan for Pengerang to be applied in this environmental assessment.



ESC

Figure 6.1 – PEC 5 km Study Boundary

6.2.3 Scoping Methodology

Data in the ESHIA was obtained from field studies (primary data), and published environmental data and other information from the internet for the related area (secondary data) which will allow for further analysis and to conclude the impact of the proposed project to the environment. Interactions between the project and host environment is commonly described as the impact analysis between project activities on the designated site as the source, the pathway which contributing to distribution/ spreading of impact, and the receptor as the baseline to study the impact of the project.

Screening to determine crucial impacts of the project will endure 3 stages as follows:

- Determining the potential impacts in the form of list of potential impacts.
- Evaluating potential impacts to prioritise based on the significance of the potential impacts, and
- Analysing the significant impact as impact assessment.

6.2.4 Method for Impact Identification and Evaluation

Considered parameters in listing and evaluating the potential impacts were the classification of the impact as natural resources (air, water, soil and biodiversity); waste (general/ hazardous waste); natural hazards (drought, flood etc); noise and vibration; demographic, health and social issues; and public services (transportation, access, utilities, etc).

Consideration for affected people/area; intensity and duration of impact; cumulative impacts; and other environmental components within a 5 km radius of the project was also used to produce the list of potential impacts and its evaluation. Approaches used to evaluate data which comes from primary or secondary data were the modelling, overlay mapping and threshold analysis. Each approach was used only based on the most fitted method for the analysis of each parameters/ impacts.

At the end the prediction is based on analogical method which compared similar activities of existing industries and professional judgement as intrinsic part of environmental assessment suggested result of the analysis. The result was used to determine the significance of impact in the environmental, social, and health impact assessment of the project.

6.2.5 Method for Determining Significance of Impacts

Apart from the result of analysis, the significance of impacts was also determined from the combination of the below:

- The impact capacity to change the natural/ existing environment (loss/ damage/ increase) which commonly expressed in quantitative terms wherever practical;
- The impact to receptor (physical, biological, and human), which respectively focused on its quality, sensitivity to change and importance; its importance (region based) and its sensitivity to impact; and the sensitivity of the community on its ability to adapt and manage the impact;
- The likelihood of the impact which identified the impact from past experienced or previous occurrence evidence.

6.2.6 Impact Mitigation Hierarchy

The mitigation hierarchy is the process whereby a company works towards mitigating impacts by avoiding impacts as much as possible, minimizing those which cannot be avoided, restoring areas where required, and finally offsetting any residual impacts.

With respect to the statement, PEC should implement impact avoidance/ impact reduction strategy and if necessary, to change their standard operating procedure and/or activities whenever found to affect the environment/ biodiversity. This strategy is important during planning/ implementation/ decommissioning as to reduce impacts that cannot be avoided to acceptable levels.

The avoidance should comprise the spatial i.e. site selection; temporal i.e. scheduling; and project design that accommodate sensitivities of biodiversity or ecosystem features. Type of the avoidance in PEC activities is described in *Table 6.1.*

Table 6.1: PEC Avoidance and Key Drivers

Type of Avoidance	Avoidance Strategy	Key Drivers in Avoidance Decisions
Spatial	To select only industry appropriate location in Pengerang	Company policy and financial – PEC; Legislation – Government
	To avoid community's gazetted area, sacred area, and land for livelihood.	
	To avoid any area with waterbody that is consumed by community and to include seasonal stream in waterbody map. Ideally selected location should be situated in area which are not impacted waterbody	
	To avoid any expansion to protected/ sensitive area gazetted by Johor/ Malaysia Government.	
Temporal	To avoid any activities which will disturb surrounding environment/ species.	Company policy and financial – PEC
	To suspend any activities whenever found to be harmful to surrounding environment/ species.	
	To avoid any use of improper chemical/ method/ machinery/ others that can produce more harmful effect to the environment	
	To design proper SOP to each activity that includes the mitigation of impact due to improper procedure application.	
	To avoid inefficient information dissemination by creating clear and simple reporting format and hierarchy.	
Design	To avoid ineffectiveness of plant/ activity design or buffer zone design.	Financial, company policy – PEC Legislation – Government

Based on the avoidance strategy, the mitigation hierarchy is as shown in *Table 6.2.*

Table 6.2: Mitigation Hierarchy

MAXIMISE	AVOID	Any disturbance that can cause potential threats and predicted impact as observed.
	MINIMISE	PEC to minimise effect of plant activities by: - Reviewing and implementing proper site selection/ process method/ reparation/ SOP. - Maintaining process equipment, heavy machinery and means of transport used for the operational so that they can be environmentally friendly and safe to utilise.
	REMEDIATE	PEC to restore any waterbody/ environmental element that has been polluted due to PEC activities and to rehabilitate/ relocate any loss habitat/ species.
MINIMISE	COMPENSATION	PEC to compensate the loss in environmental aspect by; - Conducting environmental recovery/ species enhancements in impacted areas to ensure the recovery and the preservation of biodiversity. - To periodically conduct the environmental/ species/ habitat study within the impacted area to observe the impact of the project to surrounding environment/ habitat.

6.3 Project Categorisation

As part of the review of environmental and social risks and impacts of a proposed investment, IFC uses a process of environmental and social categorisation to reflect the magnitude of risks and impacts. The resulting category determines the level of environmental assessment and disclosure requirement. IFC categorisation follows:

- Category A: Projects expected to have significant adverse social and/or environmental impacts that are diverse, irreversible, or unprecedented;

- Category B: Projects expected to have limited adverse impacts that can be readily addressed through mitigation measures; and
- Category C: Projects expected to have minimal or no adverse impacts.

Based on the nature of the project, the PEC is categorised under IFC Category B Project because it leads to impacts on air quality and human health. However, mitigation measures will reduce the risk.

6.4 ESHIA Approach

Impact of major activities of the project during the construction and operation were first identified based on the project description and various releases into the environment from the project. The resulting impacts are identified by combining information provided in ISO 14004:1996 with the environmental and social sensitivities. Wherever interactions exist between the identified aspects and sensitivities, they are further analysed to determine the potential impacts from the project. The impacts may be beneficial/adverse, direct/indirect, reversible/irreversible and short term/long term. It may also be noted that several activities may contribute to an impact.

The assessment of potential impacts is carried out utilising both qualitative and quantitative assessment techniques. The qualitative assessment is used whereby the impacts are rated as 'low', 'medium', 'high', or 'critical'. This rating is based on two parameters, i.e., the severity of impact (consequence) and the likelihood of occurrence of the aspect. The severity depends on the nature and size of the activity/aspect and the environmental/social sensitivity, while the likelihood depends upon the nature of the activity/aspect and the control measures in place. After considering the control measures, the assessment of the significance of residual environmental impacts has been undertaken by combining the estimates for the severity of the impact and the likelihood of its occurrence.

6.5 ESHIA Methodology

Methodology that has been followed to evaluate the impact assessment was based on severity of potential impacts, likelihood and the significance of residual impacts (*Table 6.4*).

Impact Severity

The severity of an impact is assessed based on the extent, duration, frequency, and reversibility of the impact.

1. Extent
   - Local: Impact is visible locally within 5 km study boundary of the project
   - Regional: Impact is visible beyond 5 km study boundary but are not experienced at the national level.
   - National: Impact is visible at national scale
   - Transboundary: Impact is visible beyond the national boundary of which the project is located at
2. Duration
   - Short Duration: Impact last for the period of less than 6 months
   - Medium Duration: Impact last for the period of more than 6 months but less than 3 years

- Long Duration: Impact last for the period of more than 3 years

3. Occurrence
    - Rare: Impact is predicted to rarely occur over a period of time
    - Periodical: Impact is predicted to occur periodically over a period of time
    - Frequent: Impact is predicted to constantly occur over a period of time
4. Reversibility
    - Reversible: Impact is reversible over time naturally or through the implementation of mitigation measures
    - Irreversible: Impact will cause permanent change to the affected environment or receptor

The severity of an impact is classified if at least three (3) of the criteria fits the description of the classification of respective severity. Positive impacts are classified under a single category. The description of the classification of the impact severity is as shown in *Table 6.3.*

Table 6.3: Impact Severity Classification

Impact Severity	Extent	Duration	Occurrence	Reversibility
Positive	Impact causes positive changes to the receptor			
Negligible	Impact causes negligible changes to the baseline condition			
Low	Local	Short	Rare	Reversible
Medium	Regional	Medium	Periodic or Frequent	Reversible
High	National or Transboundary	Long	Frequent	Irreversible

Receptor Sensitivity

The sensitivity of the receptor is classified in 5 categories i.e. negligible, low, medium and high. The assessment that determine the sensitivity of the receptor is based on two components which are the degree to which a particular receptor is resilient to a change and the value attributed to the receptor by stakeholders or applicable regulations/policies.

Impact Significance

The assessment of the significance of the impact has been undertaken by combining the estimates for the severity of the impact and the sensitivity of the receptor. The interaction of the above criteria is presented in the form of a Significance Assessment Matrix (SAM) which has been used to rank impact significance from Negligible to High. The likelihood has been estimated on the basis of experience and/ or evidence that such an outcome has previously occurred.

Table 6.4: Significance Assessment Matrix

	Receptor Sensitivity			
Impact Severity	**Negligible**	**Low**	**Medium**	**High**
Negligible	Negligible	Negligible	Negligible	Negligible/ Low
Low	Negligible	Low	Low/ Medium	Medium
Medium	Negligible	Low/ Medium	Medium	High
High	Low	Medium	High	High

6.6 Consideration for PEC Impact Assessment

The Environmental, Social and Health Impacts arises as a result of interactions between project related aspects/ hazards and receptors/ sensitivities. The interactions that might occur as a result of construction and operation of the proposed project are identified in *Section 6.7* below. This impact assessment exercise takes into account the following site specific situation and conditions:

- The PEC plant and associate facilities is located in areas which have already been gazetted for heavy industrial/ petrochemicals;
- The nearest sensitive receptor is located 1 km away from proposed project site which is housing area namely Kg. Lepau; and
- Based on UOP technology, the PEC facility is designed to minimise atmospheric emissions, aqueous discharges and wastes generation in line with the relevant local and international standards.

6.7 Identification of Key Activity/ Aspect, Sensitivities and Associated Impact

An interaction matrix with the activities/ aspects (grouped per type with reference to their origin) presented along the Y-axis and the impact severity, likelihood and significance along the X-axis for project activities is presented in *Table 6.5.*

Table 6.5: Activities, Receptors Sensitivity, Impacts Severity and Significance Interaction Matrix

Phase	Activity	Receptor Sensitivity	Impact Severity	Significance
Construction	Air Emission	Low	Low	Low
	Water Emissions	Low	Low	Low
	Soil & Groundwater	Low	Low	Low
	Waste Management	Medium	Low	Medium
	Noise Emissions	Low	Low	Low
	Land Take/ Land Use	N/A	N/A	N/A
	Traffic	Low	Low	Low
	Ecological	-	-	Negligible
	Social	-	-	Positive
	Health & Safety	Low	Low	8Low
Operation	Air Emission	High	Low	Medium
	Water Emissions	Low	Medium	Medium
	Soil & Groundwater	N/A	N/A	N/A
	Waste Management	Medium	Low	Low

Phase	Activity	Receptor Sensitivity	Impact Severity	Significance
	Noise Emissions	Low	Low	Low
	Traffic	Low	Low	Low
	Ecological	-	-	Negligible
	Social	-	-	Positive
	Health & Safety	Low	Low	Low

Note: N/A means Not Applicable

7 PROJECT IMPACTS AND MITIGATION MEASURES

This chapter details the impacts of the PEC project during the different phases of activities and prescribes the applicable and practicable mitigation measures to be implemented.

7.1 Pre-Construction Stage

JCorp will be responsible for the overall site clearing process to prepare a foundation for their tenants including PEC. Therefore, there will be no significant impacts during the pre-construction phase for the Project Proponent. The site will be presented at the correct level for construction. Impacts for site clearing activities is presented in the EIA for the development of the PIP in the report titled "Cadangan Pembangunan Taman Perindustrian Pengerang Di Atas Sebahagian PTD 2083, Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim bagi Tetuan Johor Corporation" which was submitted to the Johor State DOE in November 2018.

7.2 Construction Stage

The construction of the PEC facility is projected to commence in Q1 2020 and will stretch up to the 2022, with start-up in 2023. Impacts during the construction phase will be from activities related to the construction of the facilities onsite which include the production, administrative and utilities structures, internal roads and vehicle parking areas.

Impacts during the construction phase are expected to be:

- Change in existing drainage pattern of the land;
- Clearing of secondary vegetation from large areas and exposing soil may lead to dust generation and sediment run-off;
- Land disturbed due to the construction activities and movement of construction vehicles which will lead to sediment potential sediment run-off;
- Generation of minor scheduled wastes in the form of oil, diesel and paint containers, oil contaminated wastes;
- Generation of solid waste in the form of construction spoils and from the workers;
- Generation of noise due to construction and movement of vehicles;
- Elevated suspended solids and organics content in construction site rainfall run-off and drainage;
- Entrainment of debris and refuse in stormwater run-off from work site areas may result in fouling of receiving water bodies;
- Spillages of liquids such as lubricating oils, diesel and hydraulic fluids that are likely to affect water quality if they enter surrounding water bodies or permeate into the ground;
- Off-site discharge of untreated sewage from the on-site construction workforce has the potential to degrade the quality of receiving water resources
- Fugitive dust emissions from:
  - Minor earthwork and piling activities;
  - Vehicle movements on exposed soil and unpaved roadways;
  - Materials handling;
  - Material tracked out from the site and deposited on local roads within the industrial estate;

- Wind erosion from exposed areas and stockpiled construction materials.
- Construction vehicle/ equipment engine exhaust emissions.
  - Noise generated from construction tools and machineries;
  - The increases of vehicle entering and exiting the Project site may as well increase the noise pollution surrounding the area. Road J52 will be utilised during construction phase of this Project and vehicles particularly heavy vehicles such as lorries and trucks are expected to increase in number and therefore will increase the noise level;
  - Noise pollution may cause hazards to health especially to the workers. Hypertension, hearing loss and sleep disturbances are some of potential health hazards cause by noise pollution
  - Soil erosion and associated off-site siltation/ sedimentation effects as a result of uncontrolled rainfall run-off from exposed site areas;
  - Soil erosion as a result of wind/ mechanical action during dry ambient/ windy conditions; and
  - Contamination of on-site soil and groundwater resources as a result of accidental fuel and oil spillages, lube oil change-outs, inappropriate waste disposal practices etc.
  - Contamination of soil and groundwater resources as a result of inappropriate waste storage, handling and disposal procedures;
  - Fouling of drainage channels and surface water resources as a result of refuse washed off-site in stormwater run-off or as a result of inappropriate waste disposal procedures;
  - General fouling of the environment by windblown refuse;

7.2.1 Site Clearing

The existing Project site is undulating, varying in elevation by over 40 m and the site is mostly covered with secondary vegetation. JCorp will be responsible for the overall site clearing process to prepare a foundation for their tenants including PEC. Although the site preparation will be conducted by JCorp, there will be a minor site clearing e.g. trenching works and temporary drainage works. It is important to identify the impacts of site clearing during construction phase as it is one of the most critical conditions where the cleared land is now left unprotected.

The construction of PEC will be conducted in two (2) phases namely Phase 1 and Phase 2. *Figure* **7.1** shows the project site area for Phase 1 and Phase 2 development. Phase 1 involves the development of the process areas, utilities and administration buildings, while Phase 2 will be reserved for future expansion. No information on future expansion was available during the time of reporting, as such it is not considered/ elaborated further in impact evaluation of this report. Phase 1 covers the western area of PEC site with an area of approximately 172 acres. The construction activities during Phase 1 will involves minimal earthwork as the industrial park developer will deliver the Project Site at the required platform. Phase 2 will cover the eastern area of PEC site with an area of approximately 78 acres. Phase 2 will only involve turfing the exposed ground with grass to prevent surface runoff.

Impact Evaluation

Soil Erosion Risk

The land clearing and earthwork activities during the site preparation phase can lead to the considerable soil erosion and sediment delivery into the receiving water body. This will deteriorate the water quality downstream of the project site. However, as stipulated in JCorp's EIA for the PIP, the site will be handed over as a platformed level land after site clearing and earthworks are conducted by JCorp's contractors.

Nevertheless, soil erosion would still occur at the proposed Project site as it would be left bare without any turfing or paved surfaces. Therefore, the soil erosion rate was estimated for site. As the site is located within the PIP, the parameters used to calculate the soil erosion were mostly obtained from the PIP EIA.

Soil erosion from the proposed development can be estimated by using the Revised Universal Loss Equation (RUSLE). The RUSLE is represented by:

$$A = R \times K \times LS \times C \times P$$

Where,

A	=	Annual soil loss due to erosion (ton/ha/yr)
R	=	Rainfall erosivity factor, MJ/mm.ha.yr
K	=	Soil erodibility factor, t.ha.hr/ (ha.MJ.mm)
LS	=	Topographic factor derived from the slope length and slope gradient
C	=	Cover management factor
P	=	Erosion control practice factor

The estimation of parameters R, K, LS, C and P were based on values from the PIP EIA and the Urban Stormwater Management Manual for Malaysia, 2012 2nd edition by the Department of Irrigation and Drainage.

Table **7.1** below shows the assumptions used to calculate the erosion rate. Three scenarios were used in the calculation of soil erosion rates:

- Pre-construction (bare land without mitigation measures in place);
- Construction (with mitigation measures); and
- Operation (100% paved areas).

Table 7.1: Soil Erosion Factors for RUSLE Calculation

Abbrev.	Factors	Description
R	Rainfall erosivity factor	The rainfall erosivity factor (R) for Pengerang is between 15,000 to 16,000 MJ/mm.ha.yr. For evaluation purposes, the higher limit is used, therefore R value is set at 16, 000 MJ/mm.ha.yr.
K	Soil erodibility factor	The estimated soil erodibility index (K) can be estimated based on the soil texture at site. The K value is 0.015 based on PIP's value which was determined through the soil investigation study for PIP.
LS	Determination of slope length (L) and slope steepness (S) factor	The LS factor for the area depends on the slope length and steepness. Since the project site has been levelled, it is assumed that the slope is flat. The derived LS value is

<table>
<tr><th>Abbrev.</th><th>Factors</th><th>Description</th></tr>
<tr><td></td><td></td><td>0.088.</td></tr>
<tr><td>C</td><td>Cover management factor</td><td>Based on the following scenarios:<table><tr><th>Scenario</th><th>C factor</th></tr><tr><td>Construction without BMPs</td><td>1.0 (bare land)</td></tr><tr><td>Construction with BMPs</td><td>0.3 (turfing 60% cover)</td></tr><tr><td>Operational</td><td>0.005 (impervious)</td></tr></table></td></tr>
<tr><td>P</td><td>Erosion control practice factor</td><td>Based on the following scenarios:<table><tr><th>Scenario</th><th>P factor</th></tr><tr><td>Construction without BMPs</td><td>1 (bare soil)</td></tr><tr><td>Construction with BMPs</td><td>0.8 (check dam)</td></tr><tr><td>Operational</td><td>0.005 (impervious)</td></tr></table></td></tr>
</table>

Based on the factors above, the estimated erosion rates of the project site are as follows:

Pre-Construction (without mitigation) : 21.12 ton/ha/yr

Construction (with mitigation) : 5.06 ton/ha/yr

Operational Phase (impervious surfaces) : 0.11 ton/ha/yr

The results above show that the erosion rate can be significantly reduced with the implementation of mitigation measures.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

The receptor sensitivity is considered as low. This is because site clearing and earthwork activities are expected to be minimal as the site will be handed over to PEC as levelled platform. Besides, the surrounding Project site will be equipped with drainage facilities prior to the construction works as it is included in the overall development of PIP by JCorp. Surface run off from the drain will be channelled to the retention pond next to the site at the western boundary of PIP before being released to Sg. Lepau which subsequently flows to Sg. Santi.

The significance of sewage effluents discharged from the PEC site has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

<u>Mitigation Measures</u>

Surface run-off within the PEC boundary will be diverted into perimeter drains which will be equipped with check dams to ensure all the sediments settle in the drain and only clean water will be channelled through to the PIP retention pond.

Proper site management is essential to minimise/ control site run-off and good housekeeping practice will help to ensure the debris, rubbish and other contaminants are not allowed to enter the surrounding water resources.

The mitigation measures that will be used to reduce the impacts include:

- Exposed site should be kept to a minimum during construction;
- Completed areas should be hard surfaced/ re-vegetated as soon as possible;
- Temporary drainage with appropriate capacity to be provided prior to the site clearing activities;
- Soil stabilisation technique to be implemented where turfing, paving and engineering measures to protect from erosion;
- Temporary measures such as plastic sheets should be used to protect the exposed slopes; and
- Ensure proper housekeeping and cleanliness of the site throughout the construction period.

<u>Pollution and Prevention and Mitigation Measures</u>

Land Development Pollution Prevention and Mitigation Measures (LD-P2M2) details out the mitigation measures that will be implemented during the construction phase of PEC. The objective of the implementation of LD-P2M2 is to minimise the negative impact of erosion and sedimentation during the construction phase of PEC. The mitigation measures that will be implemented on both Phase 1 and Phase 2 are as follows:

- Preparation of Erosion and Sediment Control Plan (ESCP)
  - An ESCP will be prepared by qualified engineer according to the requirements under the Urban Stormwater Management Manual for Malaysia (MSMA) 2nd Edition 2012 and submitted to the Department of Irrigation and Drainage for approval, prior to construction. The design of the drainage system will be designed to achieve the "zero contribution to peak discharge" concept.
- Perimeter Earth Drain
  - Perimeter earth drain will be constructed along the boundary of the site to channel any surface runoff from PEC site into PIP's drainage system.
- Check Dam
  - Two (2) check dams will be constructed before each drainage outlet points to reduce flow velocity of the surface runoff. Check dam is a vertical barrier commonly constructed using stone, gravel-filled sand bags, masonry, logs, woven-wire and brush fills. Check Dam will reduce the flow velocity by disrupting the flow and dissipates the energy of the flowing water.
- Sediment Basin
  - A sediment basin will be constructed at the northwest boundary of the site. Adequate safety precautions must be provided by restricting access to the site or access to the basin with suitable fencing. A stable emergency spillway will be installed to safely convey flows to prevent on-site flooding.
- Drainage Outlet Structure
  - Two (2) drainage outlet structures will be constructed at the northwest and southwest boundary of the site. Drainage Outlet Structure is commonly constructed using rocks, or grouted riprap and will be placed at the end of PEC's

perimeter earth drain. The outlet structure will absorb the flow energy and further reduce the flow velocity of the surface runoff.

- Silt Fence
    - Silt fence will be utilised and placed along the boundary of the site before the perimeter earth drain. Silt fence is a temporary sediment barrier made of porous fabric and commonly attached to supporting wooden or metal post. The silt fence will act as a linear barrier that will ponds surface runoff allowing the sediments to settle and thus, preventing the soil from disturbed land from being washed off into the perimeter earth drain.
- Wash trough for construction vehicles

The location of each proposed LD-P2M2 is shown in *Figure* **7.2** (note that the locations are only approximations. Actual locations will be confirmed during the preparation of the ESCP).

<u>Residual Impact</u>

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, low impact severity and low receptor sensitivity

Figure 7.1 – Proposed PEC Construction Phases
Source: PEC and Google Earth Image, 2016

Figure 7.2 – Proposed LD-2M2

Source: PEC and Google Earth Image, 2016

7.2.2 Air Emission

The construction of PEC facility has the potential to result in adverse impacts on air quality and public health as well as generating significant nuisance effects if uncontrolled not managed properly. Potential sources of impact for this project may include:

- Fugitive dust emissions from:
  - Minor earthwork and piling activities;
  - Vehicle movements on exposed soil and unpaved roadways;
  - Materials handling;
  - Material tracked out from the site and deposited on local roads within the industrial estate; and
  - Wind erosion from exposed areas and stockpiled construction materials.
- Construction vehicle/ equipment engine exhaust emissions.

<u>Fugitive Dust Emissions</u>

All development associated with the PEC Project will be undertaken within a proposed industrial facility (PIP) on land for which major earthworks levelling, cut and fill etc. has already been provided. As a result of the pre-prepared nature of this site, the potential for fugitive dust impacts is considered to be very much lower than would be the case for an unprepared site.

Air quality measurements conducted at the selected monitoring stations during the baseline studies indicated that ambient 24-hour PM2.5 and PM10 concentrations in the project area were in the range of 69 – 139 µg/m3, and 97 – 278 µg/m3, respectively during the sampling period in October 2018. Monitoring undertaken for the PIP EIA Report (September 2017) indicated ambient TSP concentrations in the range of 112 – 154 $\mu g/m^3$.

Ambient particulate monitoring results for the study area are therefore above the respective 24-hour guideline levels of 35 $\mu g/m^3$ and 100 $\mu g/m^3$ for PM2.5 and PM10 specified under the Malaysian Ambient Air Quality Standard (MAAQS) 2020 Standard. These data indicate that ambient air quality in the project area is already above acceptable levels with respect to suspended particulates.

Unlike certain impacts, fugitive dust generation can be effectively controlled by adherence to strict procedural controls and working practices. The adoption of a dust control strategy must therefore be incorporated into the project implementation plan to control fugitive dust to within acceptable levels (i.e. ambient particulates concentrations to be within MAAQS values). Providing such a program is adopted and implemented effectively, then concerns with regard to impacts from fugitive dust generation can be largely allayed. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

The significance of the impacts of fugitive dust emission has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Vehicle/ Equipment Exhaust Emissions

Vehicle/ equipment exhaust emissions will be relatively minor and will be mainly transient in nature over the extent of the works. Emissions from diesel engine vehicles and equipment would not be expected to result in a significant deterioration in local air quality. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

The significance of the impacts of fugitive dust emission has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

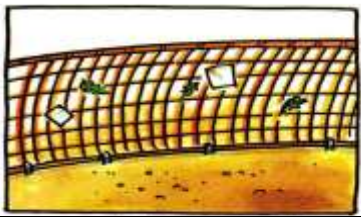
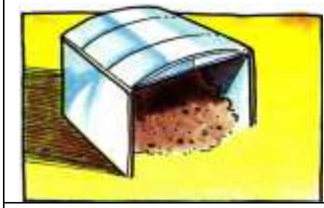
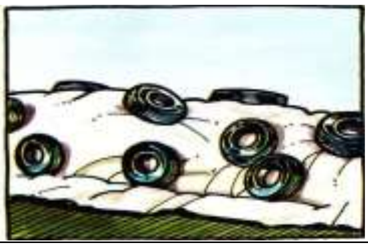
The industrial park developer will deliver the Project Site at the required platform. Hence, for the Project, no major earthwork will be carried out within the Project Site. Nevertheless, in order to minimize the fugitive dust generation during the construction period, where applicable, the following mitigating measures can be adopted by the Project Proponent:

- Fenced construction area to reduce wind-blown dust dispersion and dust clouds;
- The heights from which materials are dropped should be reduced to a practical minimum height to control fugitive dust emissions arising during material handling;
- Ensure construction access or haulage route are kept damp by water browser or equivalent measures on regular basis during the whole construction period. As a rule of thumb, water spraying should be conducted at least every 2 hours during hot and dry conditions when evaporation of water is greatest (Hong Kong Construction Association, 2013). More frequent water spraying should be conducted as when necessary;
- All dusty materials should be sprayed with water prior to any loading, unloading or transfer operation so as to maintain the dusty materials wet;
- The load carried by the vehicle off-site should be covered by clean impervious sheeting to ensure that the dusty materials do not leak from the vehicle;
- Wash trough for wheel washing to be constructed at the entrance of each access road. All construction vehicles shall have their wheels washed before leaving or entering the site onto a public road;
- Areas cleared for open spaces shall be turfed as soon as possible;
- All vehicle within the Project Site to adhere to the speed limit of 25 km/hr;
- All stockpile construction material that could generate fugitive dust during high wind speed such as fine sand and aggregate to be covered when not in used or during high wind speed;

- Fuel-efficient and well-maintained haulage trucks will be used to minimize exhaust emissions. Smoke belching vehicles and equipment shall not be allowed and shall be removed from the Project Site;
- Undertake immediate repairs of any malfunctioning construction vehicles and equipment;
- Idling of engines shall be discouraged;
- To maintain good housekeeping at the Project area, a good housekeeping checklist for managing construction dust can be developed by the Project Proponent as part of its periodic internal environmental auditing for the Project;
- Installation and operation of portable generator set or other fuel burning equipment should comply with the requirements of the *Environmental Quality (Clean Air) Regulations 2014*;
- No open burning of material should be carried out at all times and this activity is strictly prohibited under the *Environmental Quality (Prescribed Activity) (Open Burning) Order 2003*; and
- Where applicable, Project Proponent to adopt Best Management Practices (BMPs) for control of fugitive dust during construction activity as suggested in *Table* **7.2***.*

Table 7.2: Best Management Practices (BMPs) for Control of Fugitive Dust during Construction Activity

Best Management Practice *(where applicable)*	**Description**
Minimize the surface area disturbed 	The less ground disturb, the less dust will rise in every works and less clean up works needed.
Limit dusty work on windy days 	Land clearing activity shall be on hold and stockpiles shall be covered.
Apply dust suppression measures when needed 	Even if the regular schedule is thrown off. It may be a one-time occurrence, or the schedule may need adjusting to more frequent application intervals.

Best Management Practice *(where applicable)*	Description
Clean Up Those Dusty Spills Immediately 	Don't wait for the next scheduled housekeeping - the mess will just get bigger and will take longer.
Grow Vegetative Ground Cover 	Growing grasses or legumes is the most effective, easiest and most economical control because these plants provide a dense, complete cover. Even when the vegetation dries up, the roots will help hold the soil in place.
Use Wind Erosion Controls 	Plant bushes or trees, erect wood or rock walls or earthen banks as permanent wind-breaks, or install porous wind fences as more temporary measures. Using controls with 50% porosity is ideal; the reduced wind velocity provided allows larger particles to settle to the ground.
Pave Haul Roads and Storage Areas 	Heavy vehicles pulverize the surface material and create a constant source of dust. If wholesale paving is too costly, pave just the entrance and exit to minimize carryout, and gravel the remainder to reduce the amount of surface silt.
Enclose Storage, Handling Areas 	If dusty materials are frequently loaded and unloaded. Storage silos, 3-sided bunkers and open-ended buildings are some enclosures used. If handling is less frequent, wind fencing can be used. Conveyor loading may require enclosure or the use of water spray bars both above and below the belt surface to reduce emissions.
Keep Storage Piles Covered 	Piles should be covered with a physical cover or with a dust suppressant spray. Limit the working face of the pile to the downwind side. Most emissions come from loading the pile, load out from the pile, and truck and loader traffic in the immediate area, if the pile is batch loaded. Keep the drop height low to reduce dust, and keep the ground at the base of the pile clear of spills.
Water and/or Sweep Often	Ensure that vehicle traffic is not picking up dust for wind action and carryout. Fewer treatments are necessary in cool, wet weather. "Reasonable dust control measures" are required by some local fugitive dust rules, as are an adequate water supply and keeping

Best Management Practice *(where applicable)*	Description
	dust control equipment in good working order.
Reduce Speed 	Speed Limits on unpaved surfaces to 10 or 15 miles per hour (~15 or ~25 km per hour) for well-travelled areas and heavy vehicles, never to exceed 25 mph (~40 kmph) for any vehicle on any unpaved surface.
Minimize Trips 	Minimize trips by carpooling and grouping jobs and errands. Keep exposed areas adjacent to roads undisturbed by posting, fencing, installing gates or otherwise limiting access to vehicle traffic.
Prevent Transport of Dusty Material Offsite 	Rinsing vehicles before they leave the property and tightly covering loaded trucks.

Source: Modified and adapted from California Environmental Protection Agency (2007)

In addition to the above BMPs, the Project Proponent shall also refer to the DoE Malaysia issued guidance document for mitigation of fugitive emission under the *Environmental Quality (Clean Air) Regulations 2014*. The guidance document is entitled "Guidance Document on Fugitive Emission Control".

<u>Residual Impacts</u>

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on low impact severity and low receptor sensitivity.

7.2.3 Surface Water Quality

Potential impacts on surface water quality during the construction phase may arise as a result of the following:

- Elevated suspended solids and organics content in construction site rainfall run-off and drainage;
- Entrainment of debris and refuse in stormwater run-off from work site areas may result in fouling of receiving water bodies;

- Spillages of liquids such as lubricating oils, diesel and hydraulic fluids that are likely to affect water quality if they enter surrounding water bodies or permeate into the ground; and
- Off-site discharge of untreated sewage from the on-site construction workforce has the potential to degrade the quality of receiving water resources.

Sewage Effluent

Estimations to the effluent and solid waste during the construction is based on the peak number of 7,000 workers. Therefore, the estimated requirement of water for workers is 420,000 L/day (based on 60 L/person/day). With the assumption that 80% of the water requirement volume may be discharged through the sewers i.e. through the use of toilets, the total wastewater generated from daily uses is estimated at 336,000 L/day.

Impact Evaluation

Construction run-off and drainage from exposed site and construction areas will contain increased sediment loads (total suspended solids – TSS) and may have entrained contaminants (e.g. oil, grease etc.). Uncontrolled off-site discharge of stormwater run-off with elevated suspended solids or contaminants will result in impacts to receiving water bodies.

For this Project, site clearing and earthwork activities are expected to be minimal as the site will be handed over to the Client as levelled platform. Besides, the surrounding Project site will be equipped with drainage facilities prior to the construction works as it is included in the overall development of PIP by JCorp. Surface run off from the drain will be channelled to the retention pond next to the site at the western boundary of PIP before being released to Sg. Lepau which subsequently flows to Sg. Santi.

Nevertheless, the potential impacts on water quality from general construction activities are expected to be low and manageable, provided that site drainage is well maintained and good construction practices are observed to ensure that litter, fuels, and solvents are managed, stored and handled properly.

During the construction activities, a sedimentation retention pond will be constructed onsite to ensure that the level of suspended solid discharged into the PIP drains are low.

During the DoE EIA Technical Review Committee meeting, held on 10th July 2019 at DoE Putrajaya, the project proponent was informed that a royal decree was made in Johor in March 2019 which stated that all industries in Johor had to adhere to a stricter treated effluent limit. This has been interpreted by the State DoE as implementing Standard A of the *Environmental Quality (Industrial Effluent) Regulations 2009*. Therefore, any discharge from the Project site shall comply with Standard A. A copy of the royal decree was not provided to ESC or PEC.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the short duration of the construction phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

As previously mentioned, site clearing and earthwork activities are expected to be minimal as the site will be handed over to PEC as levelled platform. Besides, the surrounding Project site will be equipped with drainage facilities prior to the construction works to ensure that construction runoff will be minimal. Therefore, the receptor sensitivity is considered as medium.

The significance of impact to surface water from the PEC construction activities has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Sewage Effluent

For effluents associated with human activity, the principal concern is to ensure that no contamination of surface or groundwater resources occurs. This can be easily achieved by the provision of temporary chemical toilet facilities for the construction workforce.

Mitigation Measures

A proper drainage system will be constructed by JCorp prior to the commencement of construction works for PEC site. A minimal mitigation measures are needed to maintain the existing NWQS Class II water quality which include:

- Regular maintenance of the permanent drainage is required to ensure the discharge water quality;
- Provision of check dams in the drain to help reduce the concentration of the sediments/ silts;
- Temporary toilets and washing facilities shall be equipped with sanitary facilities to ensure that the wastewater will be treated prior to discharging into any drainage system or river;
- Any spillage from fuel storage tank shall be contained within the containment bund of 110% capacity of the largest tank. The storage containers or tanks must be covered at all times; and
- Water quality monitoring shall be conducted upon commencement of construction works and the data shall be compared with the baseline study and also Standard A of the Environmental Quality (Industrial Effluents) Regulation 2009.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on low impact severity and low receptor sensitivity.

7.2.4 Hazardous Material

Scheduled wastes are expected to arise principally as a result of maintenance activities. Waste types may include, but need not be limited to the following:

- Scrap batteries;
- Used engine oil from oil change-outs;
- Spent hydraulic fluids;
- Used air, oil and fuel filters from vehicles and equipment;
- Spent mineral oils and cleaning fluids for vehicle and equipment maintenance;
- Spent solvents from equipment cleaning; and
- Off-specification coating products and paints.

Scheduled wastes can pose serious environmental and health/ safety hazards unless they are handled, stored, transported and disposed of in an appropriate manner. Potential hazards may include:

- Toxic/ adverse health effects on the workforce/ exposed off-site populations;
- Toxic effects on aquatic organisms and adverse impacts on surface water quality, soil and groundwater in the event of materials mismanagement or an accidental release;
- Contamination to soil and groundwater due to leaks or spills on unpaved ground;
- Contamination to surface water bodies due to leaks or spills into drains and waterways; and
- Potential fire hazard.

Impact Evaluation

It is difficult to estimate the likely quantities of these types of wastes generated since they will be highly dependent on the Contractor's on-site maintenance and inspection procedures as well as the number of vehicles/ equipment items used. However, it is expected that generated quantities will be relatively small.

The storage, handling and disposal of these wastes must be conducted in accordance with the 'cradle to grave' management concept outlined in the *Environmental Quality (Scheduled Wastes) Regulations, 2005*.

Based on DoE regulation, the limit for scheduled waste to be stored on site is 20 tonnes or 180 days. Any contaminated waste during the construction and operation stage will be stored in the schedule waste compartment or in sealed drum and to be sent by licensed contractor to the licensed schedule waste premise accordingly.

Providing all wastes generated are handled, stored and disposed of in accordance with appropriate waste management procedures and regulatory requirements, significant environmental contamination would not be anticipated during this phase.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

The sensitive receptors that are located within the 5 km study boundary and could be affected by the mishandling of scheduled waste are the residents of Kg. Lepau and Sebana Mixed Development, and the workers on-site. However, as previously mentioned, the expected generated quantities of the scheduled waste during the construction phase will be relatively small and therefore, the receptor sensitivity is considered as medium.

As such, the significance of generation of hazardous waste during the constructional stage of PEC been identified as **Medium** based on an assessed low impact severity and medium receptor sensitivity.

Mitigation Measures

The generation of waste during the construction period of PEC may have significant impacts on the wellbeing of the personnel on-site as well as to the surrounding area if not managed or controlled properly. Therefore, a good waste management system shall be implemented in order to reduce the impacts of waste generation and ensure good housekeeping protocols.

In general, control measures that can be implemented to reduce the impacts are as follows:

- All wastes will be properly segregated by type to ensure that incompatible wastes are stored separately;
- Recyclable waste will be recovered and recycle on-site.
- Third-party waste management companies will be engaged for recovering and recycling waste that cannot be handled on-site;
- Ensure that the waste storage facilities are capable of containing the predicted waste volume in a manner that is unlikely to cause damage to the environment nor cause any harm on the wellbeing on the personnel on-site;
- Wastes that will be disposed off-site will be fully documented in which the details of the waste, types, quantity, recipient, location of disposal will be recorded prior leaving the site; and
- Wastes that will be disposed off-site will only be handled and transferred by parties that are licensed to transport and/or treat or dispose the waste in accordance to Malaysia Regulations.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on low impact severity and low receptor sensitivity.

7.2.5 Wastes and Co-products

Construction wastes will comprise unwanted materials generated during construction works including rejected structures and materials, surplus materials and materials that have been used and discarded. The materials are generally inert. Construction wastes may also be classified into direct and indirect waste, where direct waste means completely loss materials due to the damage while indirect waste sourced from incorrect works. Waste types may include:

- Equipment and vehicle maintenance parts;
- Material and equipment packaging and wrappings;
- Unusable cement and grouting mixes;
- Broken concrete, wooden forms and wood off-cuts;
- Damaged or contaminated construction materials; and
- Scrap metal.

Wastes generated by the construction activities are likely to generate various non-hazardous wastes such as the following:

- Construction materials such as concrete and broken rocks;
- Excavated materials such as soil; and
- General waste such as food, paper and other packaging materials.

The storage, handling, transport and disposal of these wastes have the potential to result in visual, water, dust and noise impacts in the event of inappropriate management methods. Potential impacts include:

- Contamination of soil and groundwater resources as a result of inappropriate waste storage, handling and disposal procedures;
- Fouling of drainage channels and surface water resources as a result of refuse washed off-site in stormwater run-off or as a result of inappropriate waste disposal procedures; and

- General fouling of the environment by windblown refuse.

General refuse includes food waste, paper wastes, packaging (plastic bags, plastic sheeting etc.), and plastic/ tin cans and containers. Based on a projection of 1.42 kg/ person/day, solid waste generated from the workers' domestic activities, which includes waste from the workers' quarters, is estimated to be 9.94 tonnes/day. The storage and handling of such waste have the potential to give rise to a variety of adverse impacts. These include:

- Odour nuisance, visual impacts and attraction of pests and disease vectors if the waste is not collected regularly (i.e. daily);
- General fouling of the environment by windblown refuse; and
- Fouling of drainage channels and surface water resources as a result of refuse washed off-site in stormwater run-off or inappropriate waste disposal procedures.

The disposal of these types of waste at sites other than approved dumpsites can also lead to similar impacts at the disposal sites.

<u>Impact Evaluation</u>

The disposal of construction wastes is unlikely to raise any long-term concerns due to the inert nature of these types of materials. However, it is good practice to segregate different categories of construction waste at source to facilitate recycling/ disposal. Inert materials (e.g. broken concrete, waste concrete etc.) should be used as structural fill wherever possible. The generation of construction wastes should be minimised through careful control of materials ordering procedures to avoid the purchase of surplus materials. Scrap metals should be sent for recycling.

General industrial, commercial and domestic wastes are controlled under the *Local Government Act 1976* and Refuse Collection, Removal and Disposal By-laws stipulated under the above Act. Deposition of waste in streams, watercourses and public drains is prohibited. Commercial and industrial waste may be collected and disposed of on a fee basis as prescribed by local authorities. Contravention of the by-law is an offence.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km boundary of the study area;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

Although the site will be occupied with construction workers and there are several residential areas located within the 5 km boundary of the study area, general waste is considered as less hazardous due to the inert nature of these types of materials. Therefore, the receptor sensitivity is considered as medium.

The significance of generation of general waste during the constructional stage of PEC has been identified as **Medium** based on an assessed low impact severity and medium receptor sensitivity.

<u>Mitigation Measures</u>

Source of waste in construction activities are mostly from: workmanship; inefficient schedule an over-ordering; excessive offcuts; damage in storage, particularly from water damage; damage when moving materials around site; non-standard sized designs requiring cutting; and workers activities. The following mitigation measures can be applied to both general and schedule waste:

- Considering how the material to be used in construction based on the design to be applied (if possible, conduct change of design based on efficient measurement and shape to avoid unnecessary disposal).
- Design a reuse planning for any possible materials such as cut off bricks and timber as supported data to supply chain.
- Good procurement/ supply chain planning, planning efficient working schedule, and conduct good storing and efficient warehouse management.
- Apply good workmanship with doable and efficient supervision based on efficient working schedule.
- Collecting all solid waste in designated compartment in proper method and timing.
- Disposed seepage in proper manner.
- Constructing proper drainage to flow storm water.
- Place colour coding trash bins in proper places and constructing proper toilets with sufficient septic tank system on site.
- Applying good housekeeping in all activities.

Table **7.3** provides an estimate of waste generated and disposal methods for PEC.

Table 7.3: Construction Waste Management

Waste Description	Approximate Waste Volume	Treatment/ Disposal by PEC	Mitigation by PEC
Timber-based materials	- 5-15% of total volume for construction, however 100% of packaging material and timber used only for scaffolding and supports will be disposed to landfills/ schedule waste.	- To be temporary collected in unused timber compartment at the site. - If possible, to be re-use or recycled for other product. - To be disposed in inert waste landfill. - To be disposed as scheduled waste whenever contaminated with toxic chemicals (paint, oil & grease, etc).	- To calculate timber volume/ requirement; design construction method as to reduce the use of timber; and cutting the timber as to avoid unnecessary disposal. - Timber to be used should come from approved sources (certified).
Metal-based materials	- 5-10% of total volume for construction, however 100% metal used only for scaffolding (if not a rented material) and supports will be disposed as scrap metal/ to landfills/ schedule waste.	- To be temporary collected in unused metal compartment at the site. - Unused metal to be disposed as scrap metal for recycling. - To be disposed in inert waste landfill. - To be disposed as scheduled waste whenever contaminated with toxic chemicals (paint, oil & grease, etc).	- To calculate metal volume/ requirement; design construction method for efficiency; and cutting the metal as to avoid unnecessary disposal.

Waste Description	Approximate Waste Volume	Treatment/ Disposal by PEC	Mitigation by PEC
Soil from earthworks by PEC for trenches, piping, and other similar works that requires excavation and filling, and/or cut and fill.	- 10-15% of total volume for construction if fill is applicable/ 100% of total volume when fill is not applicable.	- To collect unused soil into temporary waste store for filling material. - Excess soil, if any, to be disposed into landfill as waste layer closing/covering material. - To be disposed to inert landfill if mixed with other construction materials. - To be disposed as scheduled waste whenever contaminated with toxic chemicals (paint, oil & grease, etc).	- To carefully plan and apply proper method of excavation and fill.
Bricks	- 10-20% of total volume for construction.	- Broken bricks without mortar to be recycled by crushing down to a very fine material as fill or to produce new bricks. Bricks can be chipped and used in landscapes. - Broken bricks with mortar to be disposed after removal of mortar. - To be disposed in inert waste landfill. - To be disposed as scheduled waste whenever contaminated with toxic chemicals (paint, oil & grease, etc).	- To order and use only good quality bricks. - To calculate bricks volume/ requirement; design construction method for efficiency; and cutting the bricks as to avoid unnecessary disposal.
Asphalt and Concrete/ Mortar and Solvent -based products	- 1-5% of total volume for construction. Unused material to be kept for future works.	- To be temporary collected in unused asphalt/concrete/mortar compartment in The Project Site. - To be disposed in inert waste landfill. - To be disposed as scheduled waste whenever contaminated with toxic chemicals (paint, oil & grease, etc).	- To calculate required volume; design construction method for efficiency; and supervise the usage as to avoid unnecessary disposal.
Drums and cans Plastic -based materials	- 100% of total volume.	- To be temporary collected in waste storage area. - Empty drums and cans to be returned to supplier. - To be disposed in inert	- To calculate required volume; design construction method for

Waste Description	Approximate Waste Volume	Treatment/ Disposal by PEC	Mitigation by PEC
Paper-based materials		waste landfill or to be recycled as scrap metal. - To be disposed as scheduled waste whenever contaminated with toxic chemicals (paint, oil & grease, etc).	efficiency; and supervise the usage as to avoid unnecessary disposal.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on low impact severity and low receptor sensitivity.

7.2.6 Noise

Noise pollution is generally defined as regular exposure to elevated sound levels that may lead to adverse effects in human or other living organisms. Impacts of noise during construction are:

- Noise generated from construction tools and machineries;
- The increases of vehicle entering and exiting the Project site may as well increase the noise pollution surrounding the area. Road J52 will be utilised during construction phase of this Project and vehicles particularly heavy vehicles such as lorries and trucks are expected to increase in number and therefore will increase the noise level; and
- Noise pollution may cause hazards to health especially to the workers. Hypertension, hearing loss and sleep disturbances are some of potential health hazards cause by noise pollution.

Typical plant likely to be used for construction activities will include:

- Piling rig;
- Air compressors;
- Excavator;
- Welding machines;
- Lorries;
- Generators;
- Cranes; and
- Compactors.

The example of noise levels from tools and machineries are as listed in *Table 7.4* below.

Table 7.4: Tools & Machineries for Construction and Noise Level

Tasks/ Tools	Average Noise Level (dBA)	Maximum Noise Level (dBA)
Tasks		
Installing trench conduit	95.8	118.6
Operating work vehicle	98.0	116.7
Welding, burning	98.4	119.7
Operating scraper	99.1	108.6
Demolition	99.3	112.1

Tasks/ Tools	Average Noise Level (dBA)	Maximum Noise Level (dBA)
Laying metal deck	99.6	119.9
Grinding	99.7	118.6
Operating bulldozer	100.2	112.5
Chipping concrete	102.9	120.3
Tools		
Welding, cutting equipment	94.9	122.8
Other hand power tool	95.4	118.3
Hand power saw	97.2	114.0
Screw gun, drill motor	97.7	123.7
Rotohammer	97.8	113.5
Chop saw	98.4	117.7
Rattle gun	98.4	131.1
Stationary power tool	101.8	119.8
Powder actuated tool	103.0	112.8
Chipping gun	103.0	119.2

Source: EHS Today, 2018

All the construction activities shall comply with the noise limit from Schedule 6: Maximum Permissible Sound Levels (Percentile LN and Lmax) of Construction, Maintenance and Demolition Works by Receiving Landuse of The *Planning Guidelines for Environmental Noise Limits and Control, 2007* published by DoE.

Impact Evaluation

The Planning Guidelines for Environmental Noise Limits and Control Volume 1 by DoE define the criteria for the assessment of construction noise impact. The Maximum Permissible Sound Levels (Percentile L_N and L_{Max}) of Construction, Maintenance and Demolition Work by Receiving Land Use for Residential Areas was used. On the basis of the background noise levels discussed in Section 6.10 (reproduced below), the construction noise criteria for the project would be as given in *Table 7.5*.

Table 7.5: Baseline Noise Levels at Sensitive Receptors

Location	Baseline Level (dBA)			Maximum Permissible Noise Limits for Residential Receivers	
	L_{eq}	L_{90}	L_{Max}	L_{90}	L_{Max}
Day-time (0700-2200)					
N1: Sebana Mixed Development	63.4	56.5	88.7	60.0	90.0
N2: Kg. Lepau	63.4	56.7	102.7	60.0	90.0
Night time (2200-0700)					
N1: Sebana Mixed Development	57.6	51.0	89.5	55.0	85.0
N2: Kg. Lepau	58.6	56.3	97.6	55.0	85.0

It should be noted that the existing maximum baseline noise levels frequently exceed the Maximum Permissible Noise Limits; this is not uncommon.

The nearest identified noise sensitive receivers to the proposed PEC are Kg. Lepau and Sebana Mixed Development, which are located 1.5 km and 1.6 km away, respectively. Background noise levels at these locations were found to be on average dBA in the daytime and 51 to 56 dBA at night-time for L_{90} during the baseline noise survey. Noise from construction activities associated with PEC Project would not be expected to be audible at these locations. The adjacent receptors surrounding the Project site are mostly industrial area i.e. RAPID.

Construction noise associated with the project is not therefore expected to be an issue of concern. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km study boundary;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of impacts of elevated noise level on work the environment as well as the local population has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

Noise during construction activities are expected to be generated from equipment usage, piling activities and vehicle movements. The recorded baseline noise level was high, however the nearest receptors, Kg. Lepau is located more than 1 km away from the proposed Project site. Therefore, the 500 m buffer zone is enough to reduce the noise in the area. Good site practices are to be implemented to limit noise emissions at source, for example:

- Only well-maintained equipment should be operated on-site and regular service/ maintenance shall be conducted for each equipment that produce high noise emissions;
- Silencers/ mufflers on construction equipment which produces high noise emissions should be utilised and maintained regularly;
- Hoarding shall be constructed prior to the commencement of construction works and any construction activities that has potential of emitting high noise level shall be limited to daylight hours only (7.00 am – 7.00 pm);
- Reducing speed limits of heavy vehicles and ensure all heavy vehicles e.g. trucks are maintained properly;
- Monitoring for noise level during construction shall be carried out regularly to control the noise emission which may affect the sensitive receptors; and
- Protective equipment such as ear-muff shall be provided to workers handling/ operating the high noise equipment to prevent from hearing impairment.

Residual Impacts

If stipulated control measures are followed, the significance of residual impacts has been identified as **Negligible**.

7.2.7 Soils and Groundwater

Potential impacts on geology, soils and groundwater are broadly similar during construction and operational activities. The principal potential impacts during construction, unless controlled, may include:

- Soil erosion and associated off-site siltation/ sedimentation effects as a result of uncontrolled rainfall run-off from exposed site areas;
- Soil erosion as a result of wind/ mechanical action during dry ambient/ windy conditions; and
- Contamination of on-site soil and groundwater resources as a result of accidental fuel and oil spillages, lube oil change-outs, inappropriate waste disposal practices etc.

<u>Impacts Evaluation</u>

Soil erosion risk and rates are a function of a range of factors including:

- Climatological characteristics (e.g. rainfall, wind speed, etc.)
- Topography (e.g. slope gradient, slope length, area);
- Soil characteristics (composition, structure, moisture content, organic content, permeability etc.);
- Construction activities (e.g. vehicular movements, material excavation and deposit); and
- Exposure (vegetative cover, protective measures, areas exposed etc.).

The project area experiences both heavy and frequent rainfall throughout the year, with an average annual rainfall was recorded to be 59.3 mm; rainfall of this magnitude provides a significant potential for soil erosion.

Exposed soils or stockpiled materials will also be subject to drying which will make them more susceptible to wind erosion. Mechanical effects from vehicle movements etc. on exposed soils will also increase the potential for the entrainment of soil particles.

Given the pre-prepared and flat nature of the sites for the facilities, and providing effective construction site run-off controls and fugitive dust controls are implemented, then significant soil erosion and associated off-site sedimentation would not be expected and therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km boundary of the study area;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of the impact of soil erosion has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Soil & Groundwater Contamination

The groundwater movement across the PEC facility is assumed to be towards the south.

Temporary fuel storage tanks and associated refuelling activities during construction activities poses a risk of soil and groundwater contamination. A leak from a temporary fuel storage tank has the potential to cause significant soil and groundwater contamination. Minor spills during refuelling, lube/ hydraulic oil, oil filter etc. change-outs from construction equipment (e.g. generator sets) and vehicles also have the potential to result in localised contamination.

Risks of soil and groundwater contamination can only be controlled via effective operational controls (i.e. management of activities such as refuelling, fuel loading/ unloading, lube oil change-outs, waste storage and disposal etc., in-place spill clean-up procedures etc.) as well as the provision of hardware control measures for storage facilities (e.g. bunded storage tanks, hard surfaced re-fuelling areas, impermeable barriers, secure materials storage areas etc.). Providing such measures are provided and are implemented in an effective manner, risks of soil and groundwater contamination during construction activities can be minimised.

This study has identified the lack of sensitive environmental receptors in close proximity to the site because the residential areas do not use groundwater wells for potable water and thus, the likelihood of any damage to terrestrial or marine ecological habitats or biodiversity is extremely limited. Therefore, the receptor sensitivity is considered as low

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km boundary of the study area;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of the impacts of soil and groundwater contamination has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

The general construction activities on site may potentially result in adverse impacts on the soil and groundwater quality of the area if not managed properly. Therefore, it is imperative that good operational controls to be considered and implemented during the construction phase in order to prevent any significant contamination of soil and groundwater resources in the proposed Project site.

The risk of soil and groundwater contamination can be controlled via effective operational controls as follows:

- Exposed site areas should be kept to a minimum during the construction of the new facilities and completed areas should be hard surfaced/re-vegetated as soon as practicable;
- Provision of effective construction site run-off controls such as controlled discharge and temporary drains;
- Proper management of refuelling activities, waste storage and disposal;
- Hard surfaced re-fuelling areas;

- Drip collection devices to be readily available for use anywhere in the site in case of a spillage incident;
- In-place spill response and clean-up procedures; and
- Temporary fuel storage tanks constructed with adequate secondary containment.

Residual Impact

The significance of soil & groundwater contamination can be considered **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.2.8 Land Take / Land Use

The land is currently owned by JCorp. The previous tenants that occupied the land have vacated the area since 2018. Therefore, there will be no impacts on the land use of the area.

7.2.9 Transportation / Traffic

The existing road that provides access to PEC site is the State Road J52 that links to Federal Route 92 and transverses northwest to Kota Tinggi. During the construction phase, the only ingress and egress location of the project site is situated at the southern portion of the project site (located near RAPID's Gate 3). Gate 3 will be utilising the same existing road (Unnamed Road) and can be accessed through the roundabout on State Road J52.

All materials or equipment required for construction will be delivered to the PEC site by road. The peak anticipated workforce size during the construction phase is 7,000 workers. It is estimated that about 3,500 workers will be onsite at a time (based on 2 working shifts). 1,000 workers are expected to be travelling in light vehicles and the other 2,500 workers will be travelling in buses prepared by PEC from the worker's quarters to the PEC site. Based on PUSPAKOM maximum limit of 44 passengers per bus, an estimation of 50 buses will be utilised during this period. Additionally, up to 24 numbers of heavy construction vehicles are estimated to be used for the duration of the construction phase.

The potential impacts on traffic during the construction phase of PEC are as follows:

- Increase traffic volume and heavy construction vehicles along State Road J52 and Federal Route 92;
- Increase in delay and congestion at the three-arm junction that links State Road J52 and Federal route 92 due to the additional traffic volume to and from PEC site;
- Movement of heavy construction vehicles may cause damage to the existing road condition and the overall structural integrity; and
- High volume of heavy construction vehicles on the road may affect the safety of road users on Route 92 and Road J52 as well as the residences along the route to the site ingress and egress.

Impact Evaluation

Based on the Traffic Impact Analysis (TIA) conducted by JCorp for the development of PIP, the existing road that provides access to PEC site will be able to adequately accommodate to the increase in traffic during the construction phase therefore the impact would not be significant and therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as **low**. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km of the study boundary;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of transport related impacts to the local population from PEC site has been identified as **Low**, based on assessed low impact severity and low receptor sensitivity.

Mitigation Measures

The construction of PEC may result in the increase of traffic density in the surrounding roads to the site. The influx of heavy construction vehicles and machineries may generate congestion in the surrounding area and increase the potential traffic risk to the frequent motorist that utilises the road. Thus, traffic safety and control measure shall be implemented in order to reduce the potential traffic impacts during the construction period.

The control measures that will be considered are as follows:

- Sufficient warning signs and flagmen shall be provided at the egress and ingress location as well as any identified potential traffic conflict locations to facilitate better control of traffic flow;
- The movement of heavy construction vehicles shall be restricted to off-peak periods in order to minimise congestion on the surrounding traffic;
- Adequate tow-trucks and emergency response teams shall be provided to avoid major congestion in the event of any breakdown; and

Transport vehicle are required to comply with road traffic regulations and Malaysia’s vehicle road worthiness requirements.

Residual Impact

The significance of the residual impacts from the increase in traffic related to the PEC facility are expected to be **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.2.10 Ecological Impacts

The site is a pre-prepared site with potentially only shrub and secondary vegetation left prior to being presented to PEC.

Impact Evaluation

There would be no loss of flora and fauna of value as there the site would be a cleared site with levelled platform.

Mangrove forests along Sg. Santi is not expected to be significantly impacted as runoff from the site will be channelled to the detention pond in PIP before it is released into Sg. Lepau.

The significance of the ecological impacts to the environment during the construction stage has been identified as **Negligible**.

Mitigation Measures

There is no loss of flora and fauna as there the site would be a cleared site with levelled platform. No additional mitigation measures are required for the flora and fauna onsite.

Residual Impact

The residual impacts have been identified as **Negligible**.

7.2.11 Social Impacts

7.2.11.1 Employment and Business

JCorp is responsible for land clearance, cut and fill, installing the main external infrastructure and utilities, and getting the platform to an acceptable level before hand over to the Project Proponent for construction. Most of the new construction related jobs on site would require large numbers of both skilled (including management personnel) and unskilled labour and contract work for construction of the internal infrastructure, buildings and facilities within the 250-acre site. Where feasible and based on skill sets, the proposed Project should maximise local employment.

Besides the employment opportunity, the project is also expected to generate a number of spin-off businesses along the supply value chain related to the Project construction, some of which could be taken up by the local community businessmen or small-scale entrepreneurs. These spin-off business opportunities would include supply of contract workers, supply of diesel, opening up new food and beverage premises and food stalls, catering service to the construction workers, provision of personal services like laundry, barber shops, transportation, accommodation providers, etc. Indeed, this potential project-related employment and livelihood impacts would contribute towards much needed higher income and spending capacity in the region as a result of increase in local employment and local work force, business opportunity, and multiplier effect of the project. Increased business opportunity mainly occurs when large numbers of workers are in the area during construction period. However, the income generation opportunity is not of long-term duration, as it would be mostly limited to the construction period.

On the other hand, employment and business may also involve risk of exploitation of local workers, child labor, social and gender inequality, difficulty to get the job for disable and other vulnerable groups. In regard to the end of construction phase, the company will reduce number of workforce and most of workers will end their contract as project activities declined. This will lead to impact on reduced employment opportunities.

Nevertheless, the significance of the social impacts of PEC on the employment and business of the local population has been identified as **Positive** on an assessed major impact and very likely likelihood.

Mitigation Measures

Employment opportunities will be given priority to local residents. If the job vacancies cannot be filled by local resident, to the extent possible, the opportunity will be given to other parties, including position associated with skilled-labor and management positions. The company will also provide work agreement to all Project-related employment and will be consistent with the Malaysian compliance Labor law, and the Company Regulation relating to worker affairs. The project workers will be provided with the following: Clear and understandable written terms of employment, made available in an accessible manner; Timely payment for Project-related work; Adequate periods of rest; Timely notice of termination of the work relationship; Employment on the basis of equal opportunity, fair treatment, and non-discrimination, and grievance mechanism for employee. Additionally, to incorporate with social development and inclusion, the company promotes equality of opportunity and non-discrimination by improving employment opportunities for poor, disadvantaged, and disabled people as well as removing all barrier to this group. The company will completely avoid child and forced labor by applying the policy standard age of employment which is normally aged above 18 years old.

For business operation, opportunity will be given to local residents to open shop or stall nearby project area to accommodate the need of workers during construction period.

7.2.11.2 Housing the Workforce

No worker camps will be needed for the local workforce from Pengerang and the surrounding region should they be employed as they will return home daily. On the other hand, using foreign workers during the construction phase requires them to be housed, in workers quarters to be located within or outside the project site.

The significance of the social impacts of PEC on the employment and business of the local population has been identified as **Positive** on an assessed major impact and very likely likelihood.

Mitigation Measures

Foreign workers will have to be accommodated in worker camps or purpose-built dormitories to be located near the Project site. This is also to minimise potential social conflict between the locals and the foreigners. Housing foreign workers in purpose-built hostels or dormitories is also be in compliance with the amendments to the *Employment Act 1955 (Act 265)* that the federal government is currently drafting that requires employers to provide workers' accommodation for their foreign workers for all sectors. Renting temporary accommodation in the local villages, as currently practised, is only an interim option. Although its capacity is yet to be confirmed, the worker basecamp for the proposed Project has to be installed with water and electricity supply, toilets and also waste collection and disposal options.

7.2.11.3 Traffic Volume, Movement and Road Safety

Increased traffic movement, especially of heavy vehicles, is potentially a safety concern. During construction, deliveries of heavy equipment and supplies will occur via Lebuhraya Pengerang (Route J52) and the dedicated access (currently under construction) that leads directly to RAPID. Due to the scale of the Project, a significant volume of vehicle movement, traffic congestion and disruption is expected along these main public transport routes. Transport requirements for the Project are estimated as:

- Movements of heavy and wide loads requiring temporary road closures and traffic disruption; and
- Significant truck movements associated with the movement of construction materials and workers to the construction location.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km boundary of the study area;
- The impact is visible only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As previously mentioned, the existing road that provides access to PEC site will be able to adequately accommodate to the increase in traffic during the construction phase therefore the impact would not be significant and therefore, the receptor sensitivity is considered as low

The significance of the impact of traffic congestion due to the increase traffic volume from PEC site has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

Impact of construction traffic loads during the transportation of heavy equipment to site is a potential concern, especially along public roads. One of the measures to address public concern on safety on public roads is to communicate with the community on a regular basis the traffic routing plan and movement schedule of heavy vehicle movement, especially of super and abnormal loads. This needs to be done in advance of the commencement of any construction activity.

7.2.11.4 Health and Safety

Safety and the increasing incidence of disease is one of the concerns local communities have towards the influx of workers, who are mainly single men, though some with families, to fill the project construction-related job vacancies, to RAPID and the surrounding area. Based on their experience in RAPID and DIALOG PDT, the local communities are wary of the incidence of robbery, unhealthy influence of outsiders, unacceptable behaviour by foreign workers, conflicts due to misunderstanding and to a lesser extent sexual harassment and unapproved marriages (ISEAS, 2018). With respect to health, research studies have indicated a high prevalence of parasitic infections and infectious disease observed amongst the foreign worker community in Malaysia (Sahimin, 2016). The prevalence is possibly acquired due to the lack of sanitation and clean water in their home country and compounded with behavioural factor such as poor personal hygiene, sanitation and cleanliness that continues to persist after entry into the country. This is a probable significant concern at the Project site given the scale of the construction activities and the likelihood that the majority of the workers will be foreigners.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km study boundary;
- The impact is only for the duration of the construction phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

Although there are several residential areas located within the 5 km boundary of the study area, it is very unlikely that there will be interaction between the local population and the foreign workers. This is because the workers for the construction phase will not be residing within the project site. As of now, there are no information on where the worker quarters will be located. However, it is very likely that the workers will be housed outside of the 5 km study boundary. Transportation to and from the project site as well as meals will be provided by the project proponent. Furthermore, it is under their working procedure to not go outside of the project site boundary during working hours. Therefore, the receptor sensitivity is considered as low.

As such, the significance of health and safety impacts has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

In addition to health education on the importance of personal hygiene, camps or hostels for foreign workers have to be properly equipped with sanitary facilities to control infections within the community as well as regular medical check-up for the workers.

With respect to safety of workers and the general public, adequate security measures to prevent accidents and injury have to be taken when transporting construction equipment and materials along the main roads. The construction site would need to be fenced and the entrance gates guarded by security staff to prevent any unauthorised access to the site, thus also minimising possible impacts on community health and safety.

Impact Evaluation

These positions created will represent a minor long-term increase in local employment opportunities for both skilled and unskilled jobs.

In terms of housing workers and health and safety, JCorp has earmarked a 22-acre site in their PIP master plan as a 'village' for foreign workers, and this site can be used to accommodate the Project's foreign workers. This will reduce any conflict between foreign workers and local residents.

Residual Impact

The residual impacts have been identified as **Positive**.

7.2.12 Human Health Assessment

A maximum number of 7,000 workers will be employed during construction phase. The workers might be Malaysians and foreigners from Johor and outside of Johor and they will be mostly young males. Though there will be no workers quarters in the proposed project site, the workers may potentially transmit diseases to the local population if they are not properly screened for infectious diseases. A brief summary of the impacts is discussed below.

Impact Evaluation

Infectious diseases may increase if the workers are not properly screen. Sexually-transmitted diseases (STD) which includes human papillomavirus (HPV) infection, trichomoniasis, chlamydia, herpes simplex virus (HSV) infection, gonorrhea, syphilis, human immunodeficiency virus (HIV) infection and hepatitis B. Other diseases that may be brought by foreign workers are malaria, tuberculosis, dengue fever and chikungunya. For dust emission, the impact is expected to be localized within the construction area (usually less than 50 m away). The duration of impact will be short-term to medium term.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km boundary of the study area;
- The impact is only for the duration of the construction phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

Although there are several residential areas located within the 5 km boundary of the study area, it is very unlikely that there will be interaction between the local population and the foreign workers. This is because the workers for the construction phase will not be residing within the project site. As of now, there are no information on where the worker quarters will be located. However, it is very likely that the workers will be housed outside of the 5 km study boundary. Transportation to and from the project site as well as meals will be provided by the project proponent. Furthermore, it is under their working procedure to not go outside of the project site boundary during working hours. Therefore, the receptor sensitivity is considered as low.

The significance of human health impacts during the construction stage has been identified as **Low** based on an assessed low severity and low receptor sensitivity.

Mitigation Measures

- Conduct health screening for all foreign workers;
- Provide adequate sanitation facilities for workers.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.2.13 Occupational Health and Safety

The significant sources of impacts for health and safety during the construction phase of the PEC facility will be:

- Exposure to dust, chemicals, hazardous or flammable materials;
- Slips, trips and falls;
- Over exertion;
- Working at heights;
- Moving machinery;
- Struck by objects;
- Working in confined spaces; and
- Hazard (including failure of building structure, injuries as a consequence of falls or contact with heavy equipment, and dust) posed to the public while accessing PEC facility.

Impact Evaluation

The operational facility will cover an area of 250 ac and will incorporate a wide range of storage containers, pipeline networks, fixed and mobile plant and machinery all of which may pose significant impacts to the health and safety of site staff and visitors. Therefore, the receptor sensitivity is considered as high.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km study boundary;
- The impact is only for the duration of the construction phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

The significance of the occupational health and safety impacts during the construction stage has been identified as **Medium** based on an assessed low impact severity and high receptor sensitivity.

Mitigation Measures

Risks of health & safety impacts can be controlled via effective operational procedures and plans, including but not limited to:

- Ensuring compliance with the *Occupational Safety and Health Act 1994* and Codes of Practice and guidelines as administered by the Department of Occupational Safety and Health (DOSH).
- Carry out comprehensive risk-based job safety/hazard analysis for all tasks;
- Ensuring site design takes into account health & safety considerations;
- Ensure adequate fire detection and response measures are put in place;
- Ensure provision of trained first aid staff on site at all times and appropriate siting of first aid stations and equipment;
- Provision of suitable PPE to protect sight, hearing, skin and respiratory systems etc;
- Provision of adequate lighting and ventilation in all areas;
- Provision of adequate toilet and shower facilities and clean eating area;
- Ensure all staff and visitors are provided with adequate basic OHS training and orientation;
- Inclusion of buffer strips or other methods of physical separation around the facility to protect the public from major hazards associated with incidents, failure, as well as nuisance issues related to noise, dust, or other emissions;
- Application of locally regulated or internationally recognized building codes to ensure structures are designed and constructed in accordance with sound architectural and engineering practice, including aspects of fire prevention and response;

Engineers and architects responsible for designing and constructing facilities, building, plants and other structures should certify the applicability and appropriateness of the structural criteria employed.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Minor**, based on an assessed low impact severity and low receptor sensitivity.

7.2.14 Summary of Impacts During the Construction Stage

Table 7.6 below summarised the impacts and its severity during the construction stage. Based on our assessment, there were no impacts of High significance during the construction stage of the project.

Table 7.6: Summary of Impacts during the Construction Stage

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
Fugitive Dust Emission	• Local Population	Reduction of air quality due to the generation of dust and particulate.			Low		
Vehicle movement	• Local Population	Reduction of air quality due to emission from diesel engine.			Low		
Discharging of sediments from surface runoff	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the increase of sediments discharge.			Low		
Discharging of Sewage Effluent	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the effluent discharge.			Low		
Generation of Hazardous Waste	• Construction Workers • Local Population	Improper handling, storage and management of hazardous waste.				Medium	
Generation of General Waste	• Construction Workers • Local Population	Improper handling, storage and management of general waste.				Medium	
Generation of Excessive Noise	• Construction Workers • Local Population	Noise pollution due to the generation of elevated sound level from construction activities.			Low		
Soil erosion	• Local Population • Sg. Lepau	Offsite sedimentation due to run-off from exposed site.			Low		
Groundwater Contamination	• Local Population • Sg. Lepau	Contamination of groundwater due to the spillage of fuel during construction.			Low		
Traffic Congestion	• Local Population	Increase traffic volume and heavy vehicles due to the construction.			Low		
Flora and Fauna	• Sg. Lepau • Sg. Santi Forest Reserve	Degradation of the ecological value of the surrounding area.		Negligible			
Employment and Business	• Local Population	Generation of spin-off business.	Positive				
Housing the workforce	• Construction Workers	Establishment of worker camps.	Positive				

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
	• Local Population						
Health and Safety of local communities	• Local Population	Increasing incidence of diseases due to the influx of foreign workers .			Low		
Occupational Safety and Health	• Construction Workers	General health and safety risk during the construction phase.				Medium	

7.3 Operational Stage

7.3.1 Air Emissions

7.3.1.1 Sources of Impact from Stationary Point Sources

For this project, during normal operation, the main sources would be mainly from fuel burning equipment. The emitted flue gas consists of combustion gases namely Particulate Matters (PM), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2). The PEC facility and the support facilities will have 10 reboiler and heater stacks, 3 vent stacks, 3 steam boiler stacks and 1 flare stack (listed in *Table 7.7*). All of the stacks will be fired with low sulphur natural gas and the concentration of gaseous emission will meet or be lower than the requirements under the Environmental Quality (Clean Air) Regulations 2014 as per the following:

- Third Schedule (Regulation 13): Limit Values and Technical Standards (By Activity or Industry): E. Oil and Gas Industries: Refineries (All Sizes): Natural Gas processing and Storage and Handling of Petroleum Products; and
- Third Schedule (Regulation 13): Limit Values and Technical Standard (By Activity or Industry): A. Heat and Power Generation: 1. Boilers under Gaseous Fuels.

For this project, project proponent will be adapting the World Bank Group recommended limit of 150 mg/Nm^3 of SO_2 for its SRU process unit emission concentration and also adoption of Ultra-low NOx (Nitrogen Oxides) Burners for its proposed Steam Boilers and Process Heaters with expected emission concentration of 110 mg/Nm^3 for NOx. Minimal fugitive emission of Volatile Organic Compounds (VOCs) is anticipated for the Project as these fugitive gases will be mainly collected and use as waste gas for fuel in its fuel burning equipment. While, negligible residual Mercury (Hg) is anticipated from the NHT stack emission and CRP stack emission as there will be pre-treatment of Hg in the raw material to be processed for the Project.

In the case of Process upset or Emergency situation i.e. abnormal situation, the stream from the Project will be routed to the proposed flare for flaring.

For residual Hydrogen Sulphide (H_2S) emission from SRU Stack and residual Hydrogen Chloride (HCl) emission from CCR RCR Vent, the emission concentrations for these pollutants are expected to comply with the prescribed limit of 7.5 mg/Nm^3 (H_2S) and 200 mg/Nm^3 (HCl) of the *Third Schedule [Regulation 13]: Limit Values and Technical Standards (By Activity or Industry): I. Chemical and Petrochemical Industry in All Sizes of CAR 2014.*

The emission inventory in Chapter 4 already provides information on the emissions of most pollutants from most point sources (stacks).

Table 7.7: PEC Stacks

Source	Main Air Emission	Proposed Abatement Equipment
Flare – Combustion	CO_2, N_2 (Continuous emission of purge gas), negligible residual VOCs	Discharge to flare system STACK 1
Charge Heater – Unit 320-H1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 2
Xylene Splitter Reboiler	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 3
Charge Heater Toluene	Flue gas:	Discharge to STACK 4

Source	Main Air Emission	Proposed Abatement Equipment
Column	O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	
Charge Heater – Unit 200-H1 (NHT)	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs, negligible residual Hg	Discharge to STACK 5
Charge Heater & NO1 Interheater – CCR Unit 300-H1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 6
Charge Heater & NO1 Interheater	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 7
CCR RCR Vent – Unit 312-ME8	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 8
Feed Fractionator Reboiler – 100-H1 and H2 (combined)	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 9
Combined Feed Heater DHT	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 10
KHT Furnaces – Units 120-H1 and H2	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 11
SRU Furnace – Unit 610-H1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 12
CRP Vent – Unit 230-ME1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs, negligible residual Hg	Discharge to STACK 13
SRU tail gas vent – Unit 610-ME1	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs	Discharge to STACK 14
3 X Steam Boiler	Flue gas: O_2, N_2, H_2O, CO_2, SO_2, NO_x, negligible residual VOCs (Continuous)	Discharge to STACKS 15, 16, 17

Impact Evaluation

The contribution of the identified air pollutants from the Project to the surrounding environment was simulated using the AERMOD air quality model. AERMOD is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. Main components of AERMOD comprises of:

- A steady-state model designed for short-range dispersion from stationary industrial sources (up to 50 km);
- A meteorological data pre-processor (AERMET); and

- A terrain pre-processor (AERMAP) to provide a physical relationship between terrain features and the behaviour of air pollution plumes.

The main objective was to assess the air emission dispersion and ground level concentrations (GLC) including the effect at the site boundaries, and surrounding 5 km sensitive receptors. The study was performed on specific scenarios to meet the requirements for EIA approval. Typically, the two emission scenarios considered were:

- Base Scenario: Normal plant operation based on maximum emissions at maximum plant production capacity; and
- Abnormal Scenario: Abnormal plant condition or worst-case emissions whereby emissions are released into the atmosphere without the pollution control equipment in place (i.e. uncontrolled emissions).

A. Source Information

Table 7.8 shows the stack specifications for the Project which were used as the source information for the modelling study while the proposed flare specification is as shown in *Table 7.9.* Inputs to the AERMOD model include emission rates of gaseous pollutants released from the stacks of the Project and other source information such as stack height and internal diameter, source type, exit velocity and temperature, and coordinates of each source with respect to the receptor grid.

Table 7.10 and *Table 7.11* show the emission rates for the criteria air pollutants identified for this modelling exercise.

Table 7.8: Proposed Stacks' Specification

Stack	Stack Numbering	Height (m)	Diameter (m)	Base Elevation (m)	Temperature (^oC)	Exit Velocity (m/s)
Charge Heater 320-H1	Stack 2	50	1.90	12	251	8
Xylene Splitter Reboiler	Stack 3	60	4.50	12	180	8
Charge Heater Toluene Column	Stack 4	52	3.20	12	180	8
Charge Heater 200-H1	Stack 5	53	1.80	12	324	8
Charge Heater & NO1 Interheater	Stack 6	99	3.70	12	162	8
NO_2 Interheater & NO3 Interheater	Stack 7	99	2.90	12	162	8
CCR RCR Vent	Stack 8	80	0.37	12	138	8
FFR + DFFH	Stack 9	55	3.50	12	149	8
Combined Feed Heater/ DHT	Stack 10	31	1.10	12	367	8
KHT Furnaces	Stack 11	31	1.10	12	367	8
SRU Stack	Stack 12	46	1.00	12	205	8
CRP	Stack 13	46	1.00	12	238	8
Steam Boiler	Stack 14	40	2.60	11	166	8
Steam Boiler	Stack 15	40	2.60	11	166	8
Steam Boiler	Stack 16	40	2.60	11	166	8

Source: *PEC (2019)*
Note: *Exit velocity is assumed to meet DOE minimum requirement as recommended in the Guidance Document for Fuel Burning Equipments and Air Pollution Control Systems issued by DOE under the CAR 2014.*

Table 7.9: Proposed Flare Specification

Flare's Parameter	Unit	Value
Ground Elevation	m	10
Flare Height	m	161
Flare Diameter	m	2
Average Molecular Weight	-	66.7
Calculated Lower Heating Value	kcal/kg	10,849
Default Flare Temperature	°C	1,000
Default Flare Exit Velocity	m/s	20
Exit Flowrate	Nm^3/s	Normal Operation: 0.25 Abnormal Situation: 3.40 (Calculated)

Source: *PEC (2019)*
Exit flowrate during abnormal situation was conservatively calculated based on the effective flare height of 20% of the physical flare height

Table 7.10: Stacks' Emission Rates for Identified Criteria Air Pollutants

Stack	Stack Numbering	PM		SO_2		NOx		CO		H_2S		HCl	
		kg/hr	g/s	kg/hr	g/s	kg/hr	g/s	kg/hr	g/s	kg/hr	g/s	kg/hr	g/s
Charge Heater 320-H1	Stack 2	0.78	0.22	-	-	3.72	1.03	54.75	15.21	-	-	-	-
Xylene Splitter Reboiler	Stack 3	3.80	1.06	-	-	22.74	6.32	288.99	80.27	-	-	-	-
Charge Heater Toluene Column	Stack 4	1.92	0.53	-	-	9.98	2.77	126.86	35.24	-	-	-	-
Charge Heater 200-H1	Stack 5	0.80	0.22	-	-	2.41	0.67	40.46	11.24	-	-	-	-
Charge Heater & NO1 Interheater	Stack 6	2.47	0.69	-	-	15.74	4.37	192.08	53.36	-	-	-	-
NO2 Interheater & NO3 Interheater	Stack 7	1.52	0.42	-	-	9.74	2.71	118.90	33.03	-	-	-	-
CCR RCR Vent	Stack 8	-	-	-	-	-	-	-	-	-	-	0.91#	0.25
FFR + DFFH	Stack 9	2.14	0.59	-	-	11.28	3.13	133.57	37.10	-	-	-	-
Combined Feed Heater/ DHT	Stack 10	0.32	0.09	-	-	0.94	0.26	16.95	4.71	-	-	-	-
KHT Furnaces	Stack 11	0.32	0.09	-	-	7.06	1.96	3.21	0.89	-	-	-	-
SRU Stack	Stack 12	0.20	0.06	5.94	1.65	4.36	1.21	1.98*	0.55	0.30#	0.08	-	-
CRP	Stack 13	0.21	0.06	14.01	3.89	2.81	0.78	33.88	9.41	-	-	-	-
Steam Boiler	Stack 14	1.23	0.34	-	-	27.05	7.51	12.29*	3.42	-	-	-	-
Steam Boiler	Stack 15	1.23	0.34	-	-	27.05	7.51	12.29*	3.42	-	-	-	-
Steam Boiler	Stack 16	1.23	0.34	-	-	27.05	7.51	12.29*	3.42	-	-	-	-

Source: PEC (2019)

Note: NOx (Nitrogen Oxides) is conservatively assumed as 100% NO_2 (Nitrogen Dioxide)
Particulate Matters (PM) emission concentration is assumed to meet 5 mg/Nm³ and PM is conservatively assumed as 100% PM10 and PM2.5
**Carbon Monoxide (CO) emission concentration for those indicated is assumed to meet 50 mg/Nm³*
#H_2S and HCl emission concentration is assumed to meet the CAR 2014 prescribed limit of 7.5 mg/Nm³ and 200 mg/Nm³ respectively
Volatile Organic Compounds (VOCs) were assumed to undergo complete combustion, negligible residue

Table 7.11: Flare's Emission Rates for Identified Criteria Air Pollutants

Flare	SO_2		NOx as 100% NO_2		CO		H_2S	
	kg/hr	g/s	kg/hr	g/s	kg/hr	g/s	kg/hr	g/s
Normal	4.39	1.22	1.58	0.44	8.64	2.40	-	-
Abnormal	2,409.0	669.17	-	-	-	-	134.00	37.22

Source: PEC (2019)

Note: PM will be designed to be smokeless, negligible residue

NOx is conservatively assumed as 100% NO_2

VOCs were assumed to undergo complete combustion, negligible residue

NOx and CO during abnormal situation are relatively insignificant in comparison with SO_2 and H_2S, hence not modelled

B. Receptor Grid System

A 5 km x 5 km Cartesian grid with 200 m spacing was used for the impact modelling, the Cartesian grid was gridded from the centre of the study area at the UTM coordinate of 408694.15 m (x-coordinate), 153496.77 m (y-coordinate). The discrete Air Sensitive Receptors (ASRs) identified for this study is as shown in *Table 7.12*.

Table 7.12: Identified Air Sensitive Receptors (ASRs)

Point	Description	UTM Coordinates (x, y)
ASR1	Open Space Near Kg. Lepau	405440.40, 153531.26
ASR2	Sebana Mixed Development	406368.00, 155680.00
ASR3	Sebana Mixed Development	408531.48, 155476.93
ASR4	Bukit Pelali	411003.52, 154757.55
ASR5	Open Space Near Kg. Bukit Gelugor	412239.45, 154143.02
ASR6	Open Space Near Lake View	412857.32, 153528.69

C. Meteorological Data

The site specific AERMET processed from 2015 to 2017 hourly meteorological data was used in the AERMOD modelling. The windrose for this modelling period is as shown in *Figure 7.3*

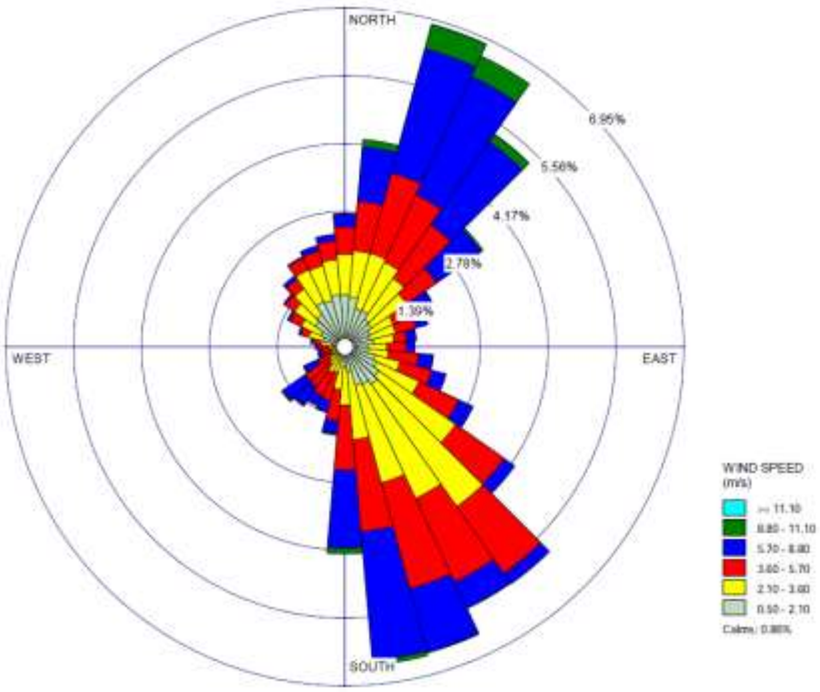


Figure 7.3 – Windrose for the Study Area based on 2015-2017 Meteorological Data

This meteorological data set comprised hourly records mainly wind speed, wind direction, ambient temperature and cloud cover. In addition, AERMET allows entry of three land-use sensitive parameters of the Project Site – the surface roughness length, the Bowen ratio (a measure of the moisture available for evaporation) and the albedo (a measure of how much of the solar radiation is reflected) - to calculate boundary layer scaling parameters (such as surface friction velocity, mixing height and Monin-Obukhov length), reference-height winds and temperature, etc.

D. Topography

Local topography (i.e. ground elevation above MSL) can have a significant influence on the dispersion of air pollutants. Local topography (terrain effects) within the defined receptor grid has therefore been incorporated into the model simulation from the terrain elevation data of the Shuttle Radar Topography Mission (SRTM) obtained from the National Aeronautics and Space Administration (NASA). The rural mode was chosen as roughness parameter in view of the terrain and landuse of the area.

Results from First Air Dispersion Modelling Exercise

First round of air dispersion modelling was conducted in April 2019. Based on the findings of the simulations, during normal operation, the calculated GLCs for identified criteria air pollutants were with the prescribed limits of MAAQS 2013 (Standard [2020]). While during abnormal situation (short-term exposure), as anticipated the contribution of H_2S to the surrounding environment was within the AEGL-1 (Non-disabling) as intended by installation of Flare System as one of air pollution control system except for the contribution of converted SO_2 as earlier highlighted in this Air Quality Modelling exercise. The predicted SO_2 during worst-case scenario was within AEGL-2 at the identified air sensitive receptors.

Results from Second Air Dispersion Modelling Exercise

Additional ambient air quality monitoring was conducted from April to June 2019 to provide a better baseline trend. Therefore, the air dispersion was remodelled. Furthermore, it was noted that there is a 5-storey flat planned in the proposed Sebana Mixed Development project to the north of the PEC site. The model was also revised to include this vertical receptor for abnormal situation.

The following is the summary of the air dispersion modelling from the second modelling exercised. The full modelling report can be found in Appendix C.

The predicted Maximum Average Incremental Concentrations (MAICs) and also the Ground Level Concentrations (GLCs) for all the identified air pollutants are summarized in *Table 7.14* (Normal Operation) and *Table 7.18* (Abnormal Situation) while the iso-contours for the air dispersion modelling exercise for each air pollutants are as shown in its respective sections below.

A. Normal Operation

Particulates Matters as $PM_{10}/PM_{2.5}$

The highest predicted MAICs of $PM_{10}/PM_{2.5}$ for 24-hours averaging time and annual average were at 2.92 $\mu g/m^3$ and 0.47 $\mu g/m^3$ respectively. At the identified ASRs, the predicted MAICs ranged from 0.31 $\mu g/m^3$ to 1.08 $\mu g/m^3$ (24-hours averaging time) and 0.01 $\mu g/m^3$ to 0.14 $\mu g/m^3$ (annual average).

For PM_{10}, the calculated 24-hours averaging time GLCs (i.e. addition of Baseline Level and MAIC) at the identified ASRs ranged from 23.31 $\mu g/m^3$ to 66.06 $\mu g/m^3$, which met the MAAQS, 2013 (Standard [2020]) prescribed limit of 100 $\mu g/m^3$.

While for $PM_{2.5}$, the calculated 24-hours averaging time GLCs at the identified ASRs ranged from 18.01 $\mu g/m^3$ to 34.86 $\mu g/m^3$. Based on the calculated GLC, all the ASRs met the MAAQS, 2013 (Standard [2020]) prescribed limit of 35 $\mu g/m^3$.

The iso-contour for 24-hours averaging time and annual average is shown in Figure *7.4* and Figure *7.5*

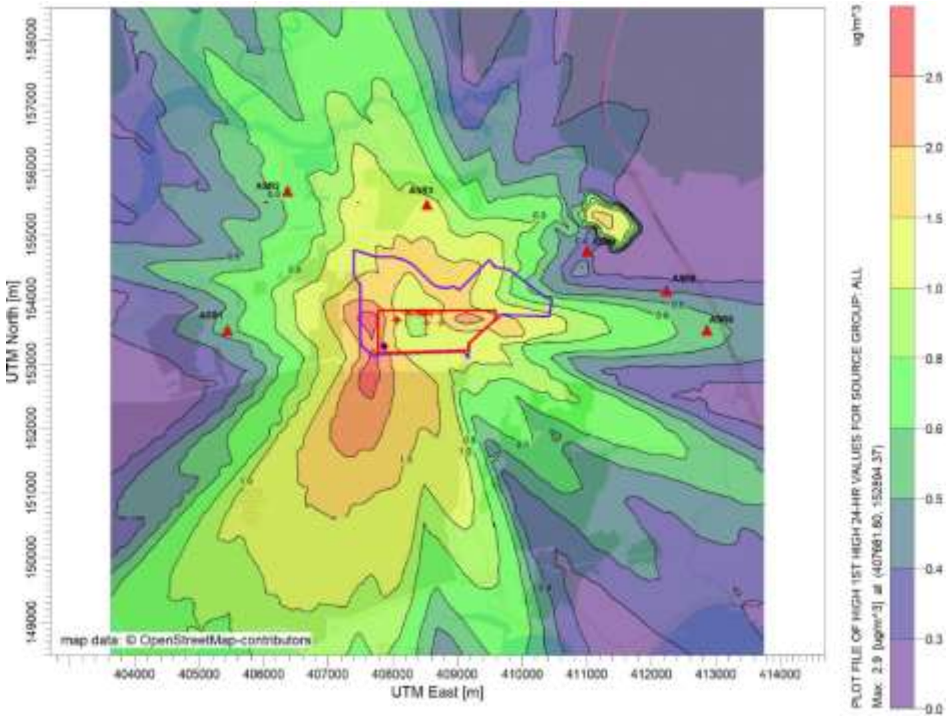


Figure 7.4 – Predicted Maximum 24-hours Average Incremental Concentration of PM10/ PM2.5 during Normal Operation

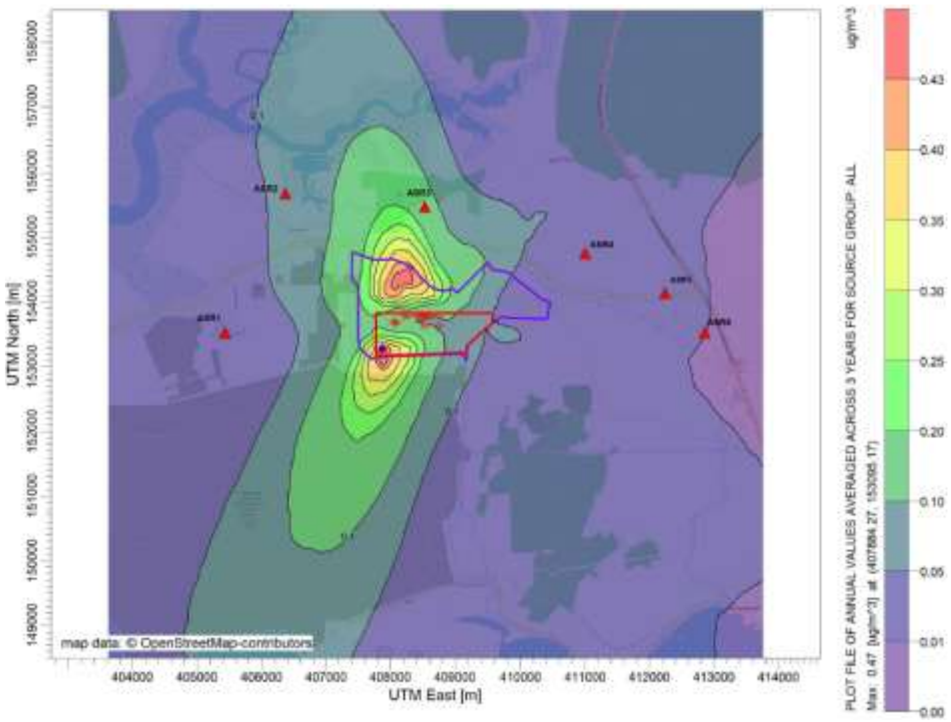


Figure 7.5 – Predicted Maximum Annual Average Incremental Concentration of PM10/ PM2.5 during Normal Operation

<u>Sulphur Dioxide (SO_2)</u>

The highest predicted 1-hour averaging time, 24-hours averaging time and annual average MAICs of SO_2 were predicted at 235.47 µg/m^3, 23.32 µg/m^3 and 1.84 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 11.88 µg/m^3 to 15.93 µg/m^3 (1-hour averaging time), 0.69 µg/m^3 to 3.29 µg/m^3 (24-hour averaging time) and 0.023 µg/m^3 to 0.304 µg/m^3 (annual average).

At the identified ASRs, the calculated 24-hours averaging time GLCs ranged from 0.69 µg/m^3 to 3.29 µg/m^3, which met the MAAQS, 2013 (Standard [2020]) prescribed limit of 80 µg/m^3.

The iso-contour for 1-hour averaging time, 24-hours averaging time and annual average are shown in Figure *7.6,* Figure *7.7* and Figure *7.8.*

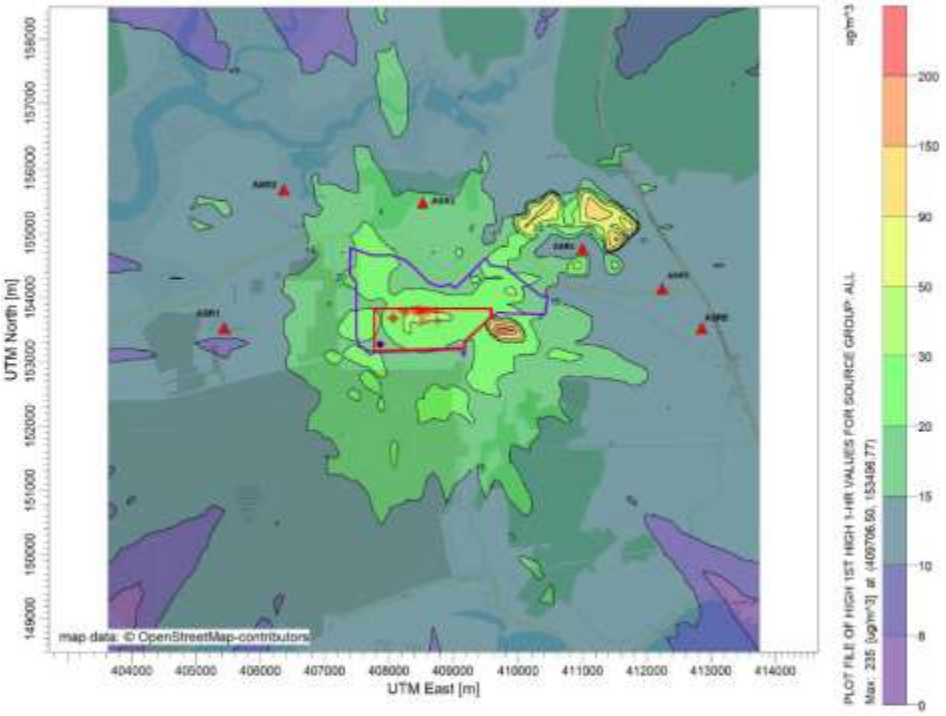


Figure 7.6 – Predicted Maximum 1-hour Average Incremental Concentration of SO_2 during Normal Operation

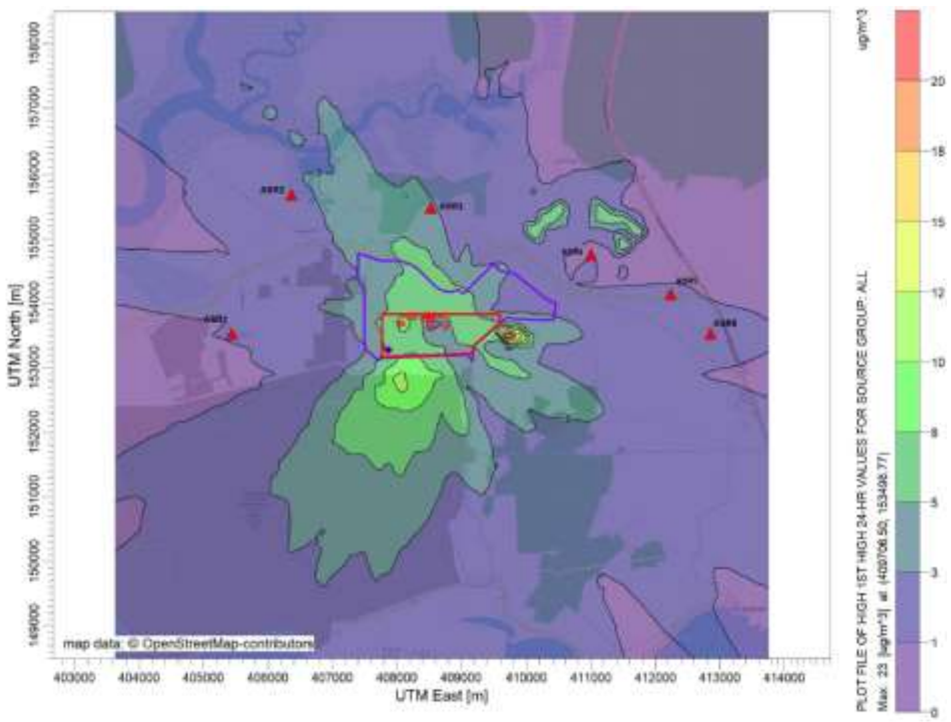


Figure 7.7 – Predicted Maximum 24-hours Average Incremental Concentration of SO_2 during Normal Operation

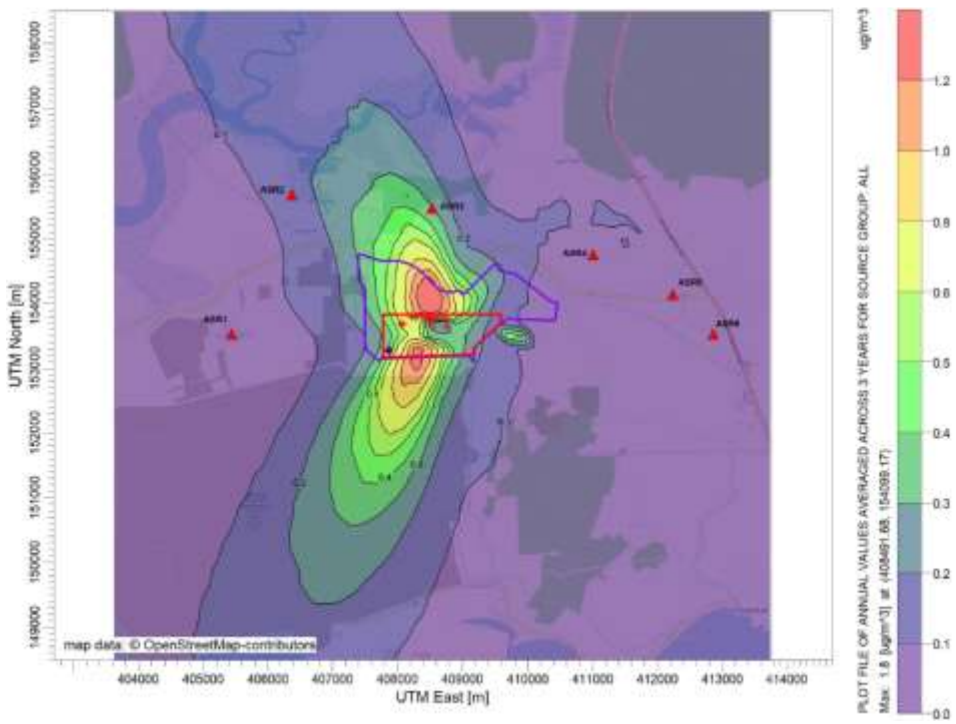


Figure 7.8 – Predicted Maximum Annual Average Incremental Concentration of SO_2 during Normal Operation

Nitrogen Dioxide (NO_X as 100% NO_2)

The highest predicted 1-hour averaging time, 24-hours averaging time and annual average MAIC of NO_2 was 359.34 µg/m^3, 42.26 µg/m^3 and 5.95 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 33.84 µg/m^3 to 42.78 µg/m^3 (1-hour averaging time), 3.22 µg/m^3 to 10.96 µg/m^3 (24-hours averaging time) and 0.104 µg/m^3 to 1.203 µg/m^3 (annual average).

At the identified ASRs, the calculated 24-hours averaging time GLCs ranged from 4.16 µg/m^3 to 15.96 µg/m^3, which comply to the MAAQS 2013 (Standard [2020]) prescribed limit of 70 µg/m^3.

The iso-contour for 1-hour averaging time, 24-hours averaging time and annual average is shown in Figure *7.9,* Figure *7.10* and Figure *7.11.*

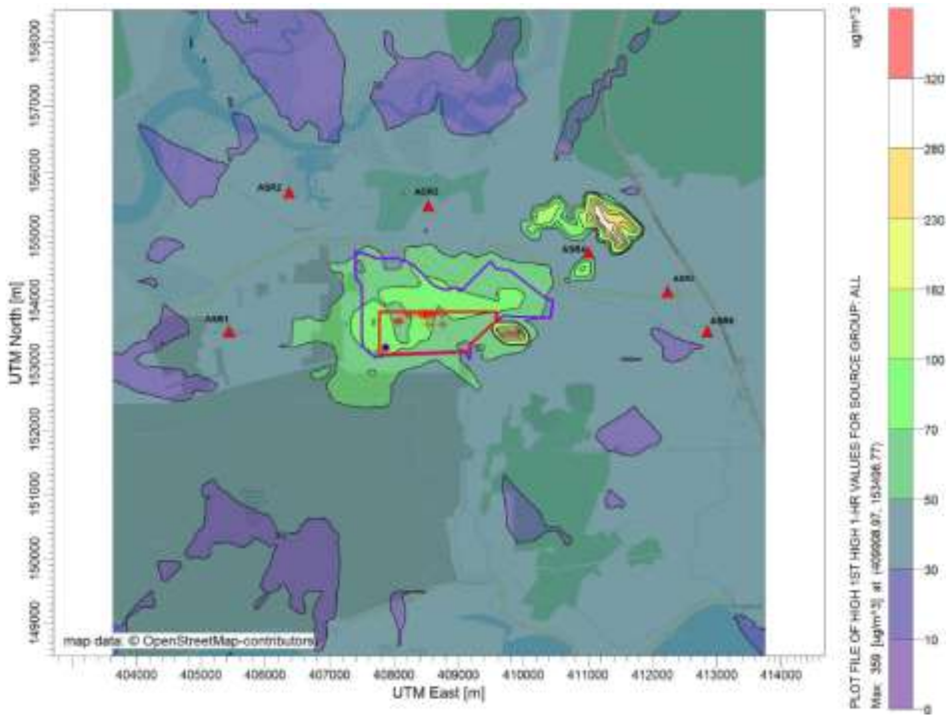


Figure 7.9 – Predicted Maximum 1-hour Average Incremental Concentration of NO_2 during Normal Operation

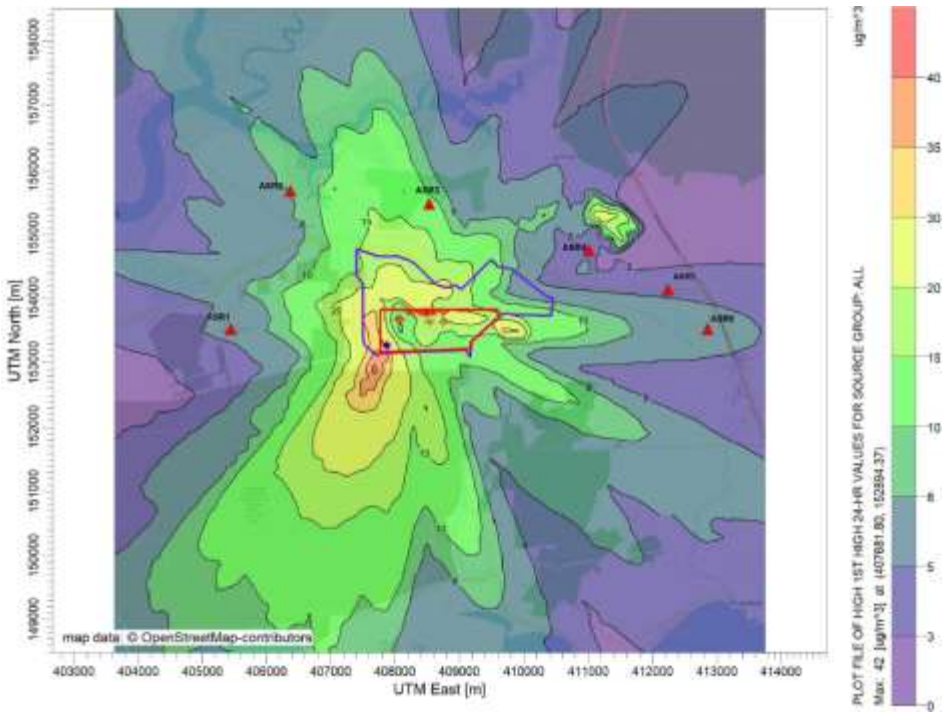


Figure 7.10 – Predicted Maximum 24-hours Average Incremental Concentration of NO_2 during Normal Operation

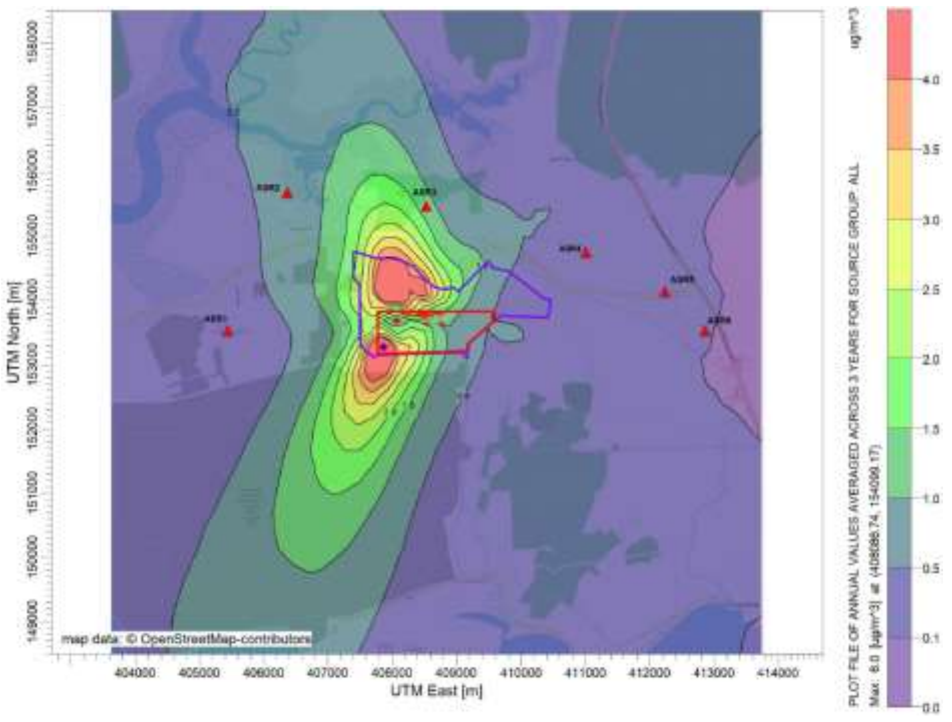


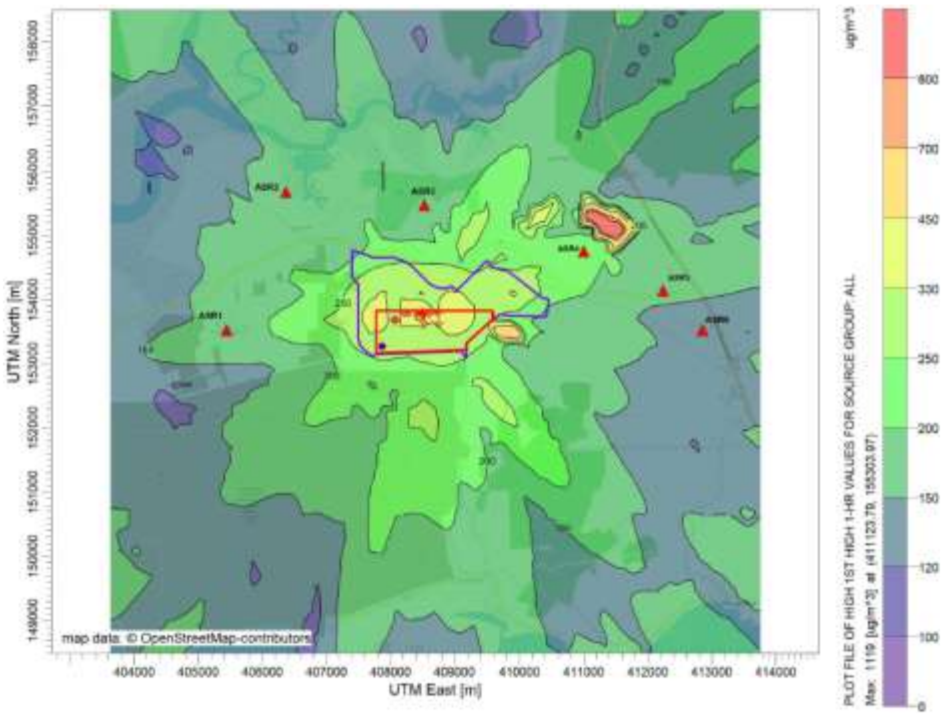
Figure 7.11 – Predicted Maximum Annual Average Incremental Concentration of NO_2 during Normal Operation

Carbon Monoxide (CO)

The highest predicted 1-hour averaging time, 8-hours averaging time and annual average MAIC of CO was 1,118.97 µg/m^3, 323.12 µg/m^3 and 25.52 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 131.14 µg/m^3 to 217.69 µg/m^3 (1-hour averaging time), 27.95 µg/m^3 to 118.29 µg/m^3 (24-hours averaging time) and 0.55 µg/m^3 to 8.17 µg/m^3 (annual average).

At the identified ASRs, the calculated 8-hours averaging time GLCs ranged from 918.29 µg/m^3 to 2,633.00 µg/m^3, which comply to the MAAQS 2013 (Standard [2020]) prescribed limit of 10,000 µg/m^3.

The iso-contour 1-hour averaging time, 8-hours averaging time and annual average is shown in Figure *7.12,* Figure *7.13* and Figure *7.14*.



ESC	**Figure 7.12 – Predicted Maximum 1-hour Average Incremental Concentration of CO during Normal Operation**

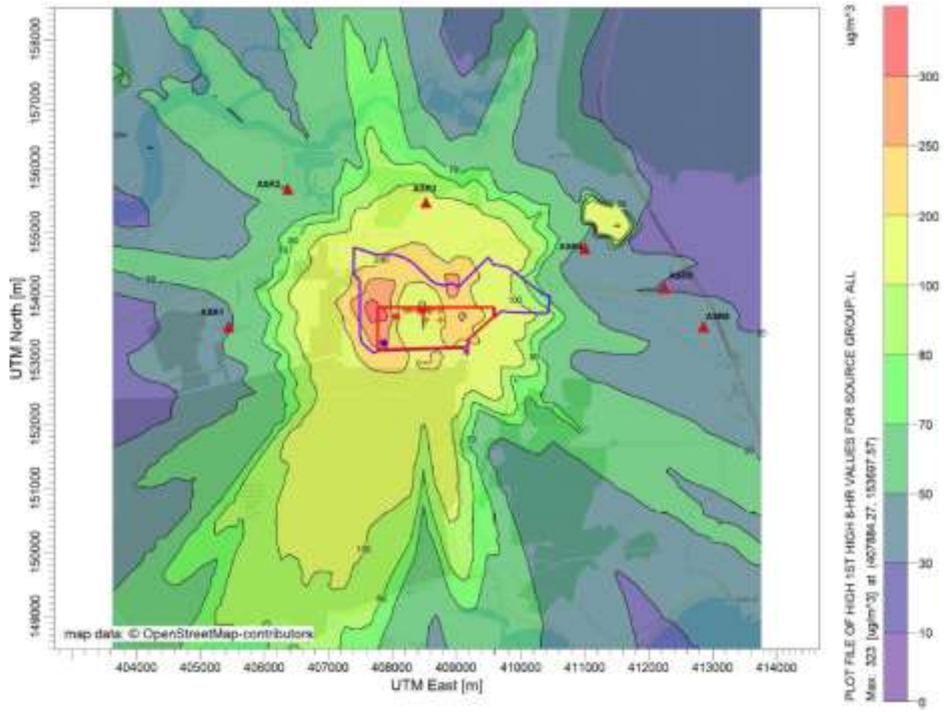


Figure 7.13 – Predicted Maximum 8-hours Average Incremental Concentration of CO during Normal Operation

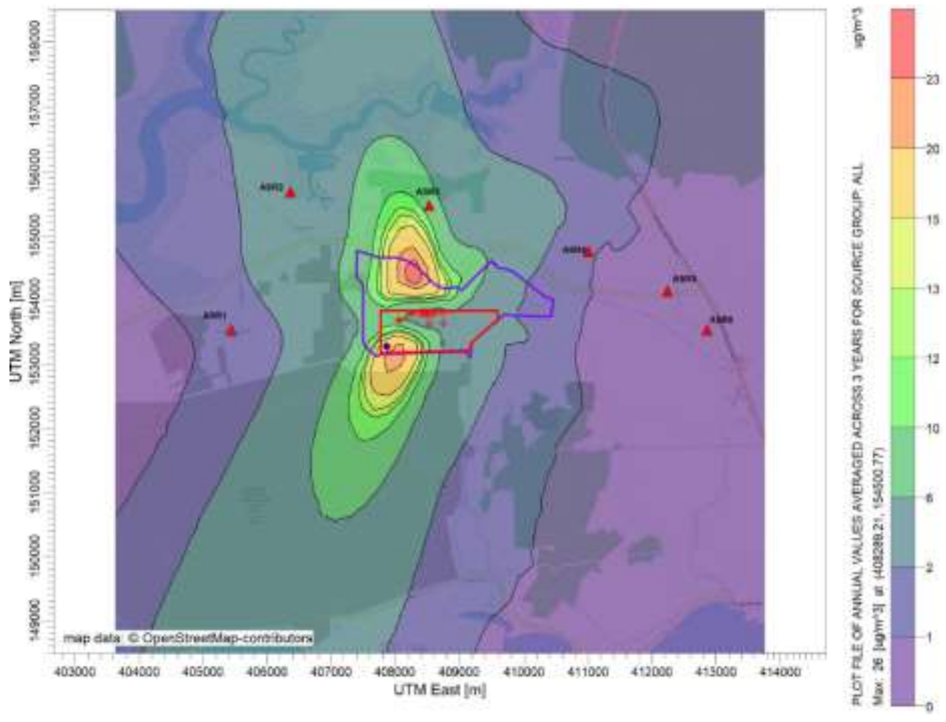


Figure 7.14 – Predicted Maximum Annual Average Incremental Concentration of CO during Normal Operation

Hydrogen Sulphide (H_2S)

The highest predicted 8-hours averaging time, 24-hours averaging time and annual average MAICs for H_2S were at 1.01 µg/m^3, 0.44 µg/m^3 and 0.032 µg/m^3 respectively, while the predicted MAICs for 8-hours averaging time, 24-hours averaging time and annual average were all less than 0.20 µg/m^3 at all identified ASRs. Due to the low baseline value (BL), the Ground Level Concentration (GLC) for 8-hours averaging time ranged from 0.02 µg/m^3 to 0.12 µg/m^3 at the identified ASRs. Currently, this pollutant is not prescribed in the MAAQS 2013.

The iso-contour for 8-hours averaging time and annual average is as shown in Figure *7.15,* Figure *7.20* and Figure *7.17.*

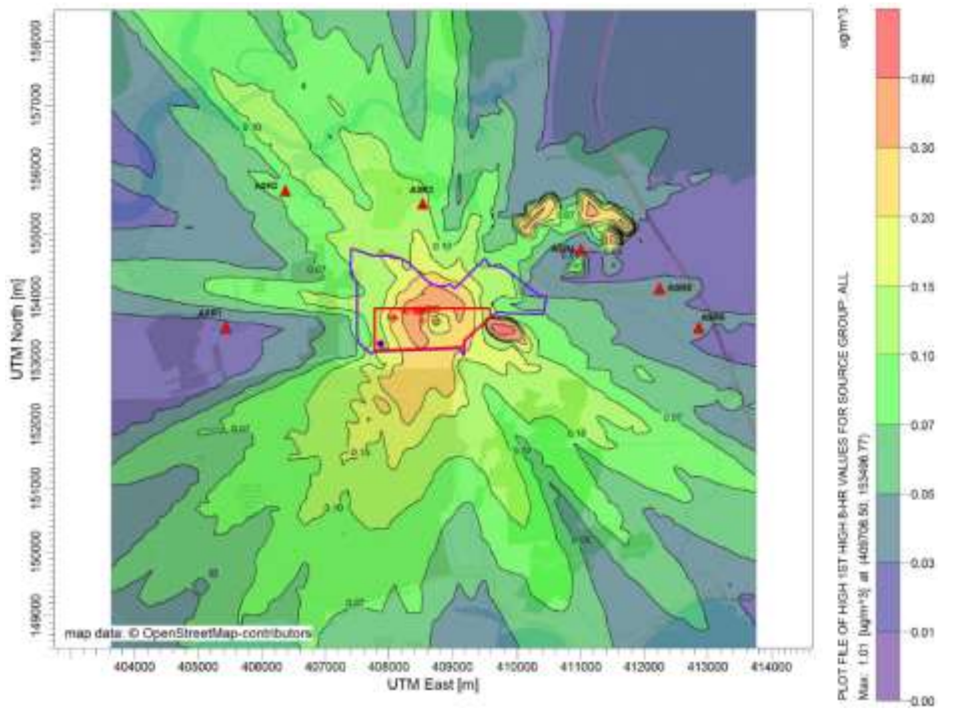


Figure 7.15 – Predicted Maximum 8-hours Average Incremental Concentration of H_2S during Normal Operation

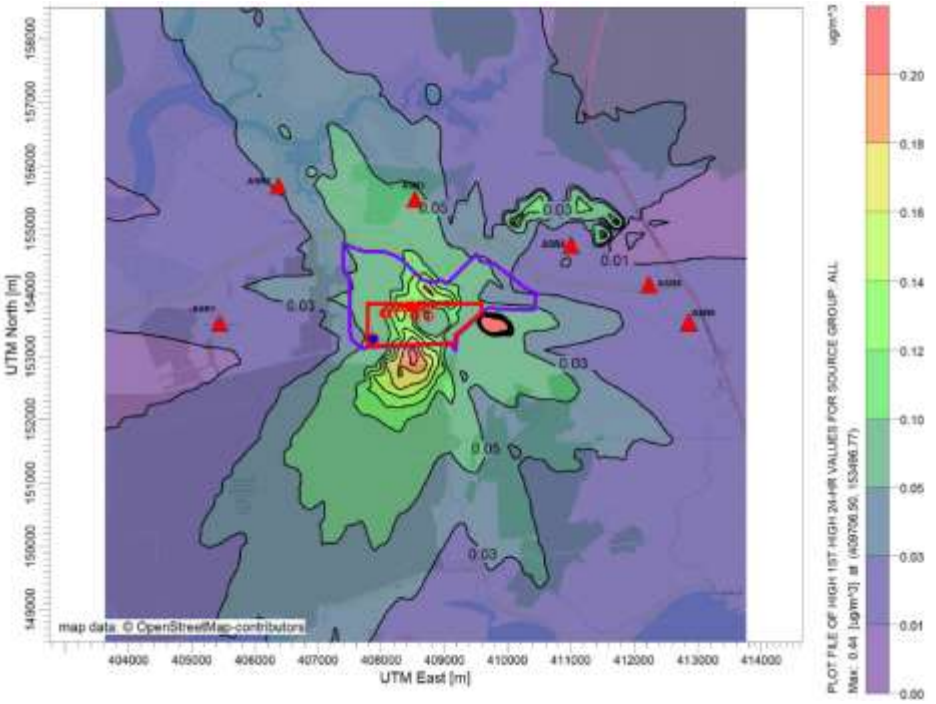


Figure 7.16 – Predicted Maximum 24-hours Average Incremental Concentration of H_2S during Normal Operation

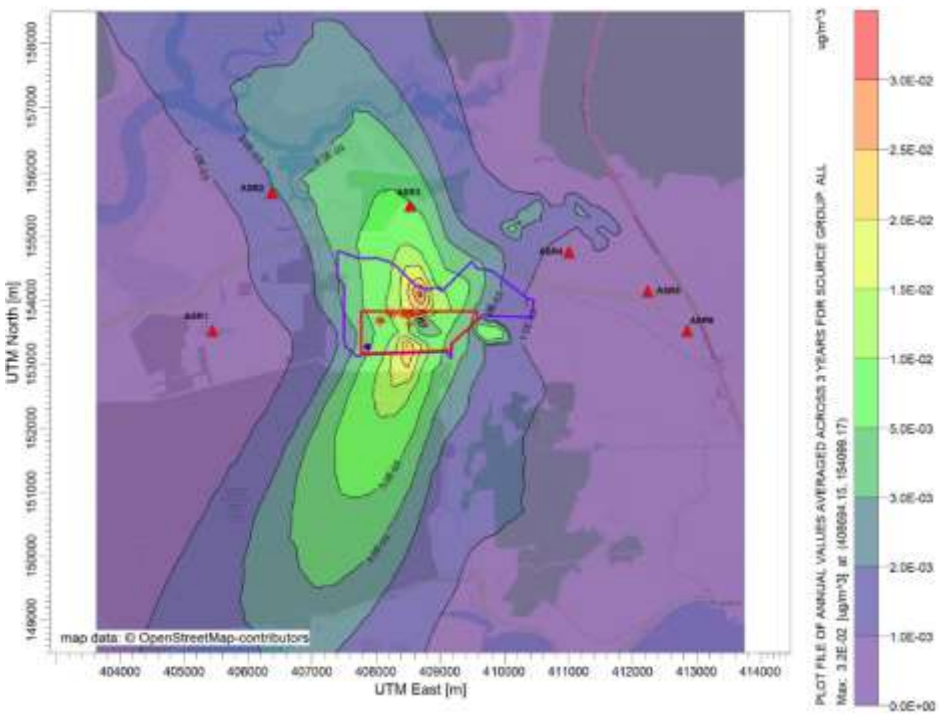


Figure 7.17 – Predicted Maximum Annual Average Incremental Concentration of H_2S during Normal Operation

Hydrogen Chloride (HCl)

The highest predicted 8-hours averaging time,24-hours averaging time and annual average MAICs for HCl was at 2.02 µg/m^3, 0.83 µg/m^3 and 0.054 µg/m^3 respectively, while the predicted MAICs for 8-hours averaging time, 24-hours averaging time and annual average were less than 0.2 µg/m^3, 0.12 µg/m^3 and 0.02 µg/m^3 respectively at all identified ASRs. Currently, this pollutant is not prescribed in the MAAQS 2013.

The iso-contour for 8-hours averaging time and annual average is as shown in Figure *7.18,* Figure *7.19* and Figure *7.20.*

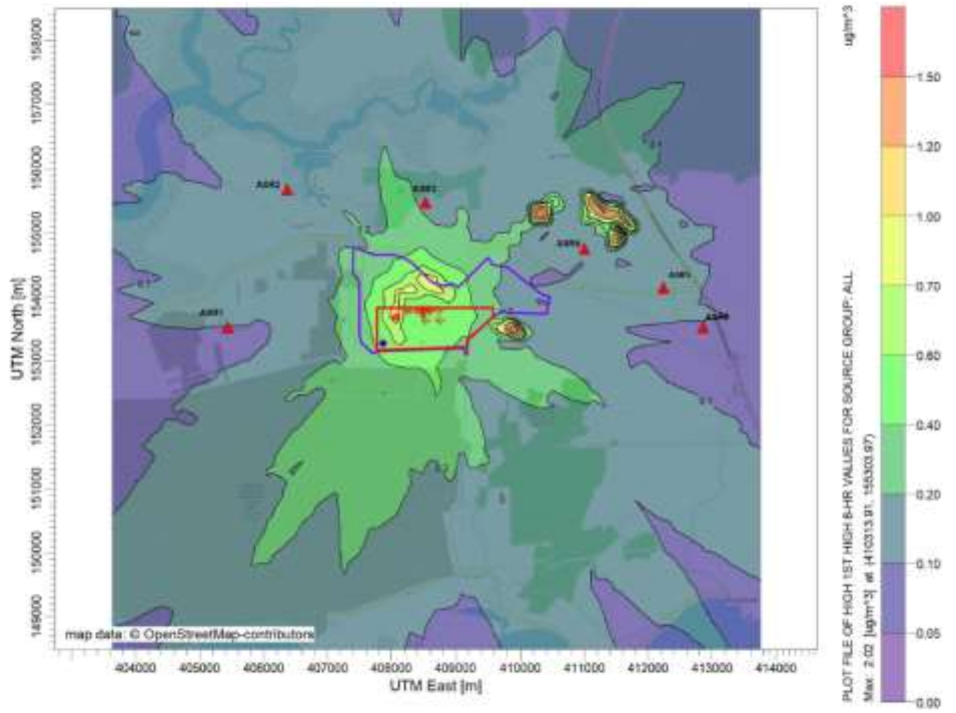


Figure 7.18 – Predicted Maximum 8-hours Average Incremental Concentration of HCl during Normal Operation

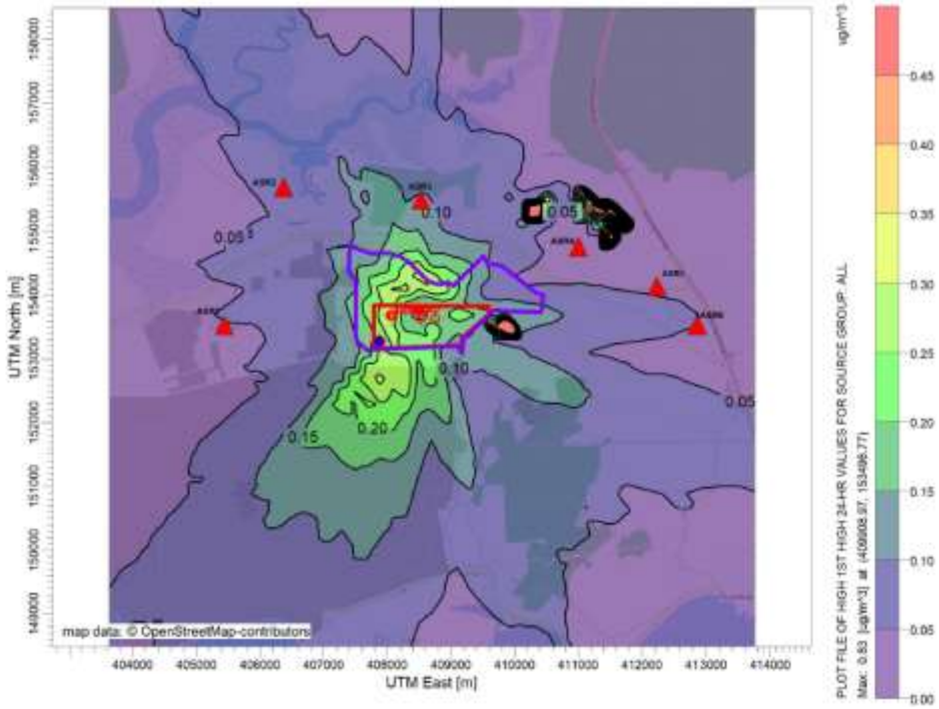


Figure 7.19 – Predicted Maximum 24-hours Average Incremental Concentration of HCl during Normal Operation

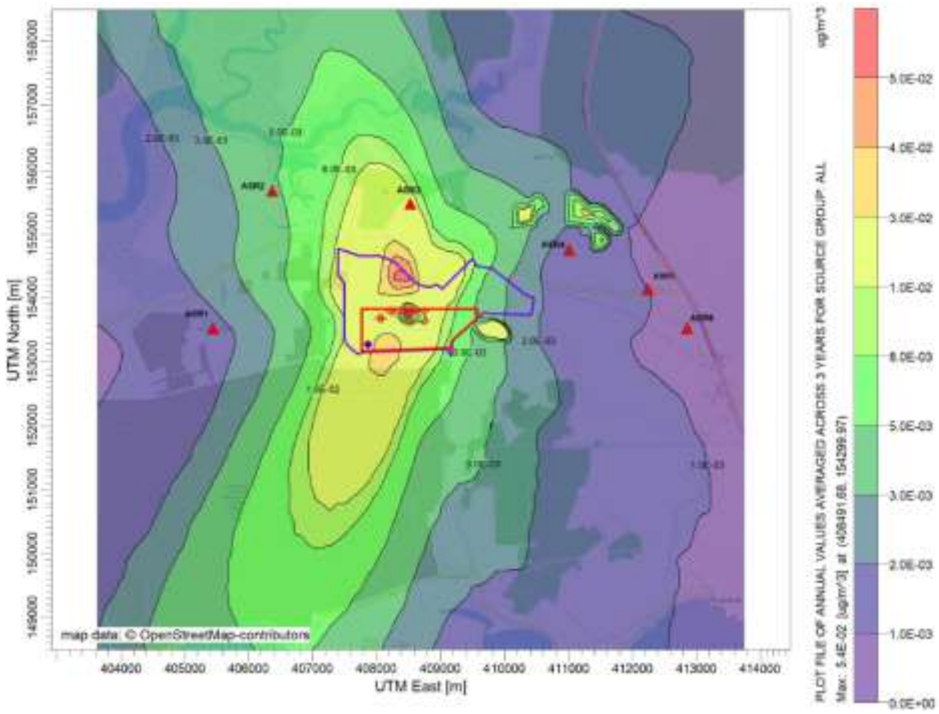


Figure 7.20 – Predicted Maximum Annual Average Incremental Concentration of HCl during Normal Operation

Carrying Capacity

For the Project, in order to assess the Project contribution to the existing airshed, the 25% threshold approach was adopted. The statement as per the International Finance Corporation (IFC) guidelines entitled "Environmental, Health, and Safety Guidelines: General EHS Guidelines: Environmental Air Emissions and Ambient Air Quality (2007)" is reproduced as follows:

- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25% percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.

Based on the 25% threshold, the calculated equivalent ambient concentration for the modelled air pollutant as per the Malaysian Ambient Air Quality Standards 2013 (MAAQS 2013) is shown as shown below:

Table 7.13: Calculated 25% Threshold for Identified Air Pollutants

Pollutant	Average Time	Unit	Standard (2020)	Calculated 25% Threshold
Particulate matter with size less than 10 micron (PM_{10})	Annual	µg/m³	40	10
	24-hours	µg/m³	100	25
Sulphur dioxide (SO_2)	1 Hour	µg/m³	250	62.5
	24 Hours	µg/m³	80	20
Carbon monoxide (CO)	1 Hour	mg/m³	30	7.5
	8 Hours	mg/m³	10	2.5
Nitrogen dioxide (NO_2)	1 Hour	µg/m³	280	70
	24 Hours	µg/m³	70	17.5

It is noted that in the Air Quality Assessment, the Nitrogen Dioxide (NO_2) was conservatively assumed to be 100% of NO_x (Nitrogen Oxides) i.e. 100% NO_x as NO_2 (Tier 1). Hence, further refinement was carried in accordance to the following conservative assumption as tabulated in the following table:

Averaging Time	% of NO_2	Reference
1-hour (In-stack)	10	Conversion ratios for NOx and NO2 as recommended by UK Environment Agency
24-hour (Short-term)	35	

Note: The NOx modelled was for combustion processes for this study

Table 7.15 and Table 7.16 show the summary of compliance to the calculated 25% threshold for the identified air pollutants.

Findings

As shown in the tables, all maximum average incremental concentrations at the identified Air Sensitive Receptors (ASRs) namely ASR1: Open Space Near Kg. Lepau, ASR2: Sebana Mixed Development, ASR3: Sebana Mixed Development, ASR4: Bukit Pelali, ASR5: Open Space Near Kg. Bukit Gelugor and ASR6: Open Space Near Lake View for the prescribed averaging time were in compliance with each calculated 25% threshold.

Conclusion

It can be concluded that the emission from the Project respected the recommended 25% threshold requirement as per the IFC guidelines.

B. Abnormal Situation

For the ambient air criteria during abnormal situation, the Acute Exposure Guidelines Level values for Sulphur Dioxide (SO_2) and Hydrogen Sulphide (H_2S) as shown in Table *7.17* were adopted. The maximum 1-hour averaging time incremental concentration iso-contour for SO_2 and H_2S is as shown in Figure *7.21* and Figure *7.22* (100% Percentile & 98% Percentile) below.

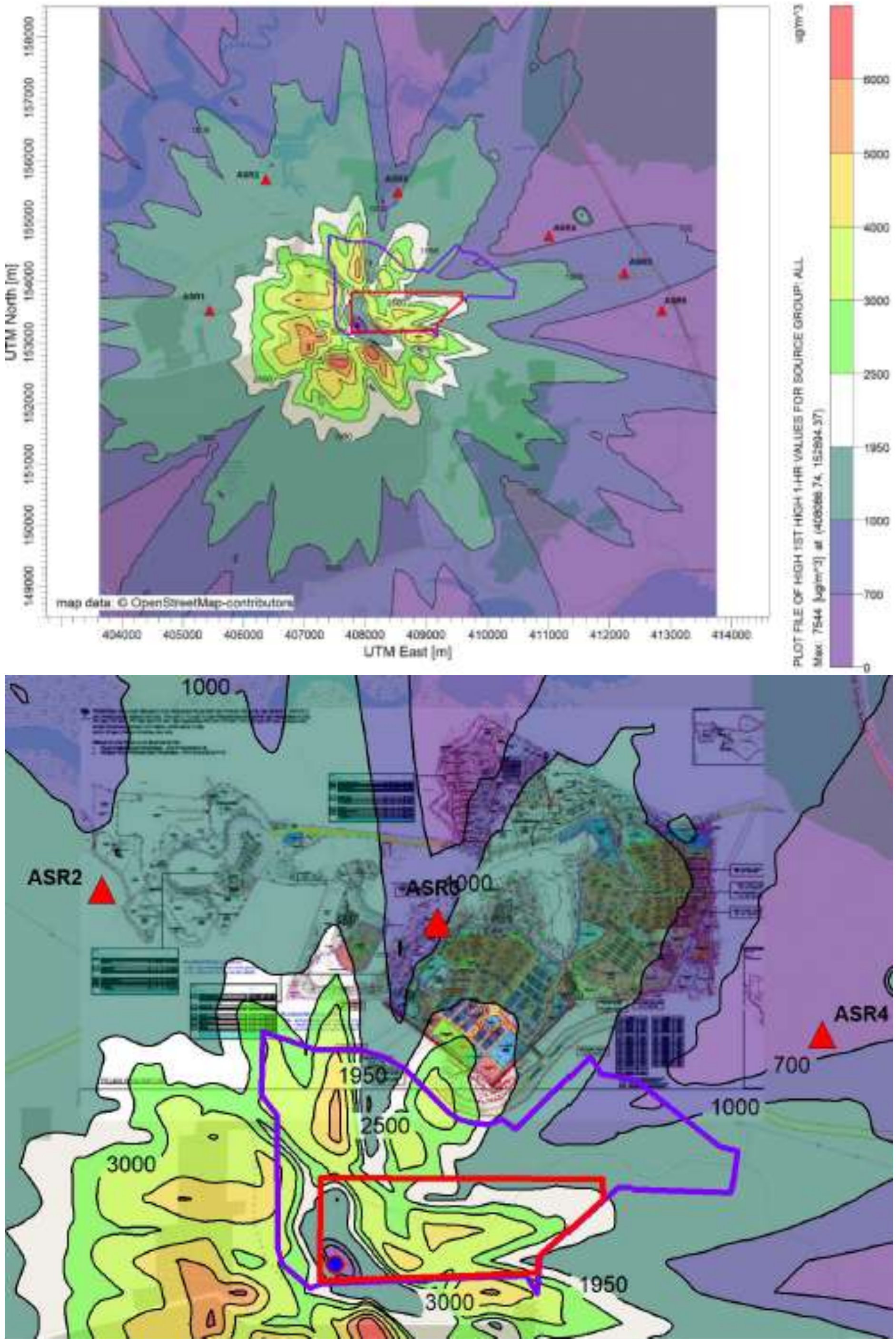


Figure 7.21 – Predicted Maximum 1-hour Average Incremental Concentration of SO_2 during Abnormal Situation (100 Percentile)

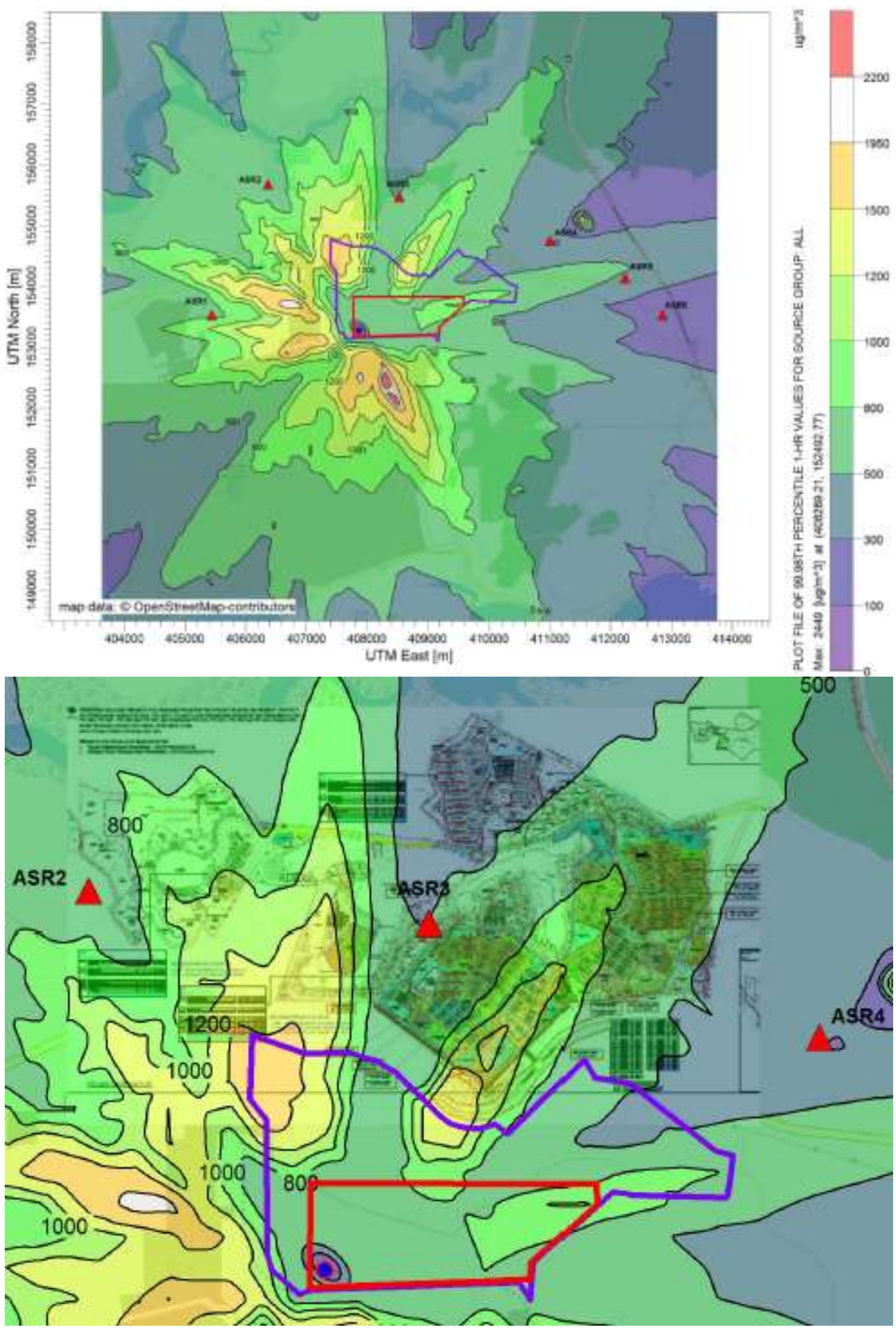


Figure 7.22 – Predicted Maximum 1-hour Average Incremental Concentration of SO_2 during Abnormal Situation (98 Percentile)

Sulphur Dioxide (SO_2)

The highest predicted MAICs of SO_2 for 1-hour averaging time during abnormal situation was at 7,543.9 µg/m3 occurring within Pengerang Industrial Park (PIP).

The predicted MAICs at the identified ASRs ranged from 502.2 µg/m^3 to 1,649.1 µg/m^3, with all ASRs were below the adopted AEGL-2 (Disabling) of 1,950 µg/m^3.

Further analysis of the 3-years of modelling period indicates that the percentile for compliance with AEGL-2 for the overall Sebana Mixed Development was 99.98% i.e. 0.02% (5 hours out of 26,304 modelling hours) of exceedance to AEGL-2.

Additional simulation was carried out for the nearest proposed 5-storey flat (as illustrated in *Figure* **7.24**) within the proposed Sebana Mixed Development, north of the PEC site, which indicates that the predicted MAICs at different levels will be elevated ranging about 2,242 µg/m^3 to 2,247 µg/m^3 and exceeded the AEGL-2. However, at 99.98%, the predicted MAICs at different levels were within the AEGL-2 ranging about 571 µg/m^3 to 600 µg/m^3. The result of this simulation is as shown in Table *7.18* and shown in *Figure* **7.25**.

Hydrogen Sulphide (H_2S)

The highest predicted MAICs of H_2S for 1-hour averaging time during abnormal situation was at 419.6 µg/m^3.

The predicted MAICs at the identified ASRs ranged from 27.9 µg/m^3 to 91.7 µg/m^3 with all ASRs were below the adopted AEGL-1 (Non-disabling) of 710 µg/m^3.

Additional simulation was carried out for the nearest proposed 5-storey flat within the Sebana Mixed Development which indicates that the predicted MAICs at different levels will within AEGL-1. The result of this simulation is as shown in *Table 7.19* and shown in *Figure* **7.26***.*

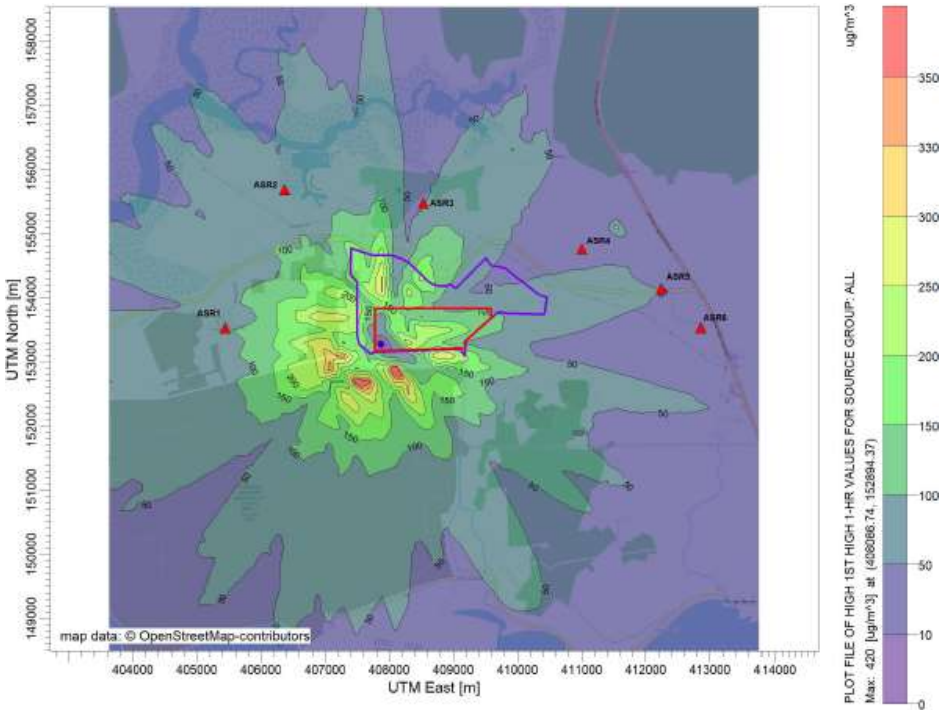


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Figure 7.23 – Predicted Maximum 1-hour Average Incremental Concentration of H_2S during Abnormal Situation

Table 7.14: Predicted MAICs for Identified Criteria Air Pollutants (in µg/m³) during Normal Operation

Parameter	Averaging Time	Baseline Level (µg/m³) [Average]	Concentration (µg/m³)													MAAQS 2013 (Standard [2020]) (µg/m³)
			Highest Predicted MAIC	ASR1 Open Space Near Kampung Lepau		ASR2 Sebana Mixed Development		ASR3 Sebana Mixed Development		ASR4 Bukit Pelali		ASR5 Open Space Near Kampung Bukit Gelugor		ASR6 Open Space Near Lake View		
				MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	
PM_{10}	24-hours	ASR1 = 65.5 ASR2 = 41.0 ASR3 = 60.5 ASR4 = 23.0 ASR5 = 48.5 ASR6 = 41.0	2.92 (Outside PIP; Within PIC)	0.56	66.06	0.68	41.68	1.08	61.58	0.31	23.31	0.38	48.88	0.55	41.55	100
	Annual	-	0.47 (Outside PIP)	0.024	0.024	0.061	0.061	0.138	0.138	0.019	0.019	0.012	0.012	0.010	0.010	40
$PM_{2.5}$	24-hours	ASR1 = 34.3 ASR2 = 30.0 ASR3 = 25.7 ASR4 = 17.7 ASR5 = 34.0 ASR6 = 22.7	2.92 (Outside PIP; Within PIC)	0.56	34.86	0.68	30.68	1.08	26.78	0.31	18.01	0.38	34.38	0.55	23.25	35
	Annual	-	0.47 (Outside PIP)	0.024	0.024	0.061	0.061	0.138	0.138	0.019	0.019	0.012	0.012	0.010	0.010	15

Parameter	Averaging Time	Baseline Level (µg/m^3) [Average]	Concentration (µg/m^3)													MAAQS 2013 (Standard [2020]) (µg/m^3)
			Highest Predicted MAIC	ASR1 Open Space Near Kampung Lepau		ASR2 Sebana Mixed Development		ASR3 Sebana Mixed Development		ASR4 Bukit Pelali		ASR5 Open Space Near Kampung Bukit Gelugor		ASR6 Open Space Near Lake View		
				MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	
SO_2	1-hour	-	235.47 (Outside PIP)	12.11	12.11	13.81	13.81	15.93	15.93	12.75	12.75	11.88	11.88	14.61	14.61	250
	24-hours	ASR1= <5 ASR2= <5 ASR3= <5 ASR4= <5 ASR5= <5 ASR6= <5	23.32 (Outside PIP)	1.11	1.11	2.64	2.64	3.29	3.29	0.69	0.69	1.17	1.17	1.36	1.36	80
	Annual	-	1.84 (Within PIP)	0.048	0.048	0.157	0.157	0.304	0.304	0.043	0.043	0.025	0.025	0.023	0.023	-
NO_X as 100% NO_2	1-hour	-	359.34 (Outside PIP)	33.84	33.84	37.13	37.13	40.56	40.56	42.78	42.78	35.23	35.23	36.52	36.52	280
	24-hours	ASR1 = 4.5 ASR2 = <5 ASR3 = 5.0 ASR4 = 4.0 ASR5 = <5 ASR6 = <5	42.26 (Outside PIP, Within PIC)	6.20	10.70	8.14	8.14	10.96	15.96	3.22	7.22	4.16	4.16	6.01	6.01	70
	Annual	-	5.95 (Within PIP)	0.262	0.262	0.705	0.705	1.203	1.203	0.188	0.188	0.120	0.120	0.104	0.104	-

Parameter	Averaging Time	Baseline Level ($\mu g/m^3$) [Average]	Concentration ($\mu g/m^3$)													MAAQS 2013 (Standard [2020]) ($\mu g/m^3$)
			Highest Predicted MAIC	ASR1 Open Space Near Kampung Lepau		ASR2 Sebana Mixed Development		ASR3 Sebana Mixed Development		ASR4 Bukit Pelali		ASR5 Open Space Near Kampung Bukit Gelugor		ASR6 Open Space Near Lake View		
				MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	
CO	1-hour	-	1,118.97 (Outside PIP; Near ASR 4)	179.43	179.43	171.65	171.65	153.38	153.38	217.69	217.69	180.03	180.03	131.14	131.14	30,000
	8-hour	ASR1 = 1,250 ASR2 = 950 ASR3 = 800 ASR4 = 1,550 ASR5 = 2,600 ASR6 = 2,600	323.12 (Within PIP)	47.94	1,297.94	70.47	1,020.47	118.29	918.29	41.51	1,591 .51	27.95	2,627.95	33.00	2,633.00	10,000
	Annual	-	25.52 (Within PIP)	1.31	1.31	3.09	3.09	8.17	8.17	1.09	1.09	0.64	0.64	0.55	0.55	-
H_2S	8-hour	ASR1= <10 ASR2= <10 ASR3= <10 ASR4= <10 ASR5= <10 ASR6= <10	1.01 (Outside PIP)	0.02	0.02	0.08	0.08	0.12	0.12	0.04	0.04	0.04	0.04	0.03	0.03	-
	24-hour	-	0.44 (Outside PIP)	0.02	0.02	0.03	0.03	0.06	0.06	0.01	0.01	0.02	0.02	0.02	0.02	7 *(Ontario)*
	Annual	-	0.0323 (Within PIP)	0.0005	0.0005	0.0019	0.0019	0.0053	0.0053	0.0007	0.0007	0.0004	0.0004	0.0003	0.0003	-

Parameter	Averaging Time	Baseline Level ($\mu g/m^3$) [Average]	Concentration ($\mu g/m^3$)													MAAQS 2013 (Standard [2020]) ($\mu g/m^3$)
			Highest Predicted MAIC	ASR1 Open Space Near Kampung Lepau		ASR2 Sebana Mixed Development		ASR3 Sebana Mixed Development		ASR4 Bukit Pelali		ASR5 Open Space Near Kampung Bukit Gelugor		ASR6 Open Space Near Lake View		
				MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	MAIC	GLC	
HCl	8-hour	-	2.02 (Outside PIP, Near ASR4)	0.10	0.10	0.16	0.16	0.16	0.16	0.12	0.12	0.11	0.11	0.09	0.09	-
	24-hour	-	0.83 (Outside PIP)	0.05	0.05	0.06	0.06	0.11	0.11	0.04	0.04	0.04	0.04	0.05	0.05	20 *(Ontario)*
	Annual	-	0.0540 (Within PIP)	0.0018	0.0018	0.0046	0.0046	0.0120	0.0120	0.0015	0.0015	0.0010	0.0010	0.0008	0.0008	-

Note: PM is conservatively assumed as 100% PM10 and PM2.5
Ground Level Concentration (GLC) = Baseline Level (BL) + Maximum Average Incremental Concentration (MAIC)
Average Baseline Levels were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
PIP = Pengerang Industrial Park
PIC = Pengerang Integrated Complex (Rapid)
Ontario = Ontario's Ambient Air Quality Criteria (April 2012)

Table 7.15: Predicted MAICs for Identified Criteria Air Pollutants (in µg/m³) during Normal Operation in Compliance of 25% Threshold

No.	Scenario	Identified Air Sensitive Receptor	Maximum Incremental (µg/m³)	Air Sensitive Receptor Incremental (µg/m³)	Compliance with 25% Threshold
1	Pollutant: PM10 24-hours Average Limit: 100 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 25 µg/m³**	ASR1: Open Space Near Kg. Lepau	2.92 (Outside PIP; Within PIC)	0.560	**YES**
		ASR2: Sebana Mixed Development		0.680	**YES**
		ASR3: Sebana Mixed Development		1.080	**YES**
		ASR4: Bukit Pelali		0.310	**YES**
		ASR5: Open Space Near Kg. Bukit Gelugor		0.380	**YES**
		ASR6: Open Space Near Lake View		0.550	**YES**
2	Pollutant: PM10 Annual Average Limit: 40 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 10 µg/m³**	ASR1: Open Space Near Kg. Lepau	0.47 (Outside PIP)	0.024	**YES**
		ASR2: Sebana Mixed Development		0.061	**YES**
		ASR3: Sebana Mixed Development		0.138	**YES**
		ASR4: Bukit Pelali		0.019	**YES**
		ASR5: Open Space Near Kg. Bukit Gelugor		0.012	**YES**
		ASR6: Open Space Near Lake View		0.010	**YES**
3	Pollutant: PM2.5 24-hours Average Limit: 35 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 8.75 µg/m³**	ASR1: Open Space Near Kg. Lepau	2.92 (Outside PIP; Within PIC)	0.560	**YES**
		ASR2: Sebana Mixed Development		0.680	**YES**
		ASR3: Sebana Mixed Development		1.080	**YES**
		ASR4: Bukit Pelali		0.310	**YES**
		ASR5: Open Space Near Kg. Bukit Gelugor		0.380	**YES**
		ASR6: Open Space Near Lake View		0.550	**YES**
4	Pollutant: PM2.5 Annual Average Limit: 15 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 3.75 µg/m³**	ASR1: Open Space Near Kg. Lepau	0.47 (Outside PIP)	0.024	**YES**
		ASR2: Sebana Mixed Development		0.061	**YES**
		ASR3: Sebana Mixed Development		0.138	**YES**
		ASR4: Bukit Pelali		0.019	**YES**
		ASR5: Open Space Near Kg. Bukit Gelugor		0.012	**YES**

No.	Scenario	Identified Air Sensitive Receptor	Maximum Incremental (µg/m³)	Air Sensitive Receptor Incremental (µg/m³)	Compliance with 25% Threshold
		ASR6: Open Space Near Lake View		0.010	**YES**
5	Pollutant: CO 1-hour Average Limit: 30,000 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 7,500 µg/m³**	ASR1: Open Space Near Kg. Lepau ASR2: Sebana Mixed Development ASR3: Sebana Mixed Development ASR4: Bukit Pelali ASR5: Open Space Near Kg. Bukit Gelugor ASR6: Open Space Near Lake View	1118.97 (Outside PIP; Near ASR 4)	179.430 171.650 153.380 217.690 180.030 131.140	**YES** **YES** **YES** **YES** **YES** **YES**
6	Pollutant: CO 8-hours Average Limit: 10,000 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 2,500 µg/m³**	ASR1: Open Space Near Kg. Lepau ASR2: Sebana Mixed Development ASR3: Sebana Mixed Development ASR4: Bukit Pelali ASR5: Open Space Near Kg. Bukit Gelugor ASR6: Open Space Near Lake View	323.12 (Within PIP)	47.940 70.470 118.290 41.510 27.950 33.000	**YES** **YES** **YES** **YES** **YES** **YES**
7	Pollutant: SO2 1-hour Average Limit: 250 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 62.5 µg/m³**	ASR1: Open Space Near Kg. Lepau ASR2: Sebana Mixed Development ASR3: Sebana Mixed Development ASR4: Bukit Pelali ASR5: Open Space Near Kg. Bukit Gelugor ASR6: Open Space Near Lake View	235.47 (Outside PIP)	12.110 13.810 15.930 12.750 11.880 14.610	**YES** **YES** **YES** **YES** **YES** **YES**
8	Pollutant: SO2 24-hours Average Limit: 80 mg/m3 (MAAQS 2013 [Standard 2020]) **25% Threshold: 20 µg/m³**	ASR1: Open Space Near Kg. Lepau ASR2: Sebana Mixed Development ASR3: Sebana Mixed Development ASR4: Bukit Pelali ASR5: Open Space Near Kg. Bukit Gelugor ASR6: Open Space Near Lake View	23.32 (Outside PIP)	1.110 2.640 3.290 0.690 1.170 1.360	**YES** **YES** **YES** **YES** **YES** **YES**

Table 7.16: Predicted MAICs for NO_2 (in µg/m³) during Normal Operation in Compliance of 25% Threshold

No	Scenario	Identified Air Sensitive Receptor	Maximum Incremental (µg/m³)	Air Sensitive Receptor Incremental (µg/m³)- NOx as 100% NO_2	Air Sensitive Receptor Incremental (µg/m³)- NOx as 10% NO_2	Compliance with 25% Threshold	Air Sensitive Receptor Incremental (µg/m³)- NOx as 35% NO_2	Compliance with 25% Threshold
1	1-hour Average Limit: 280 µg/m³ (MAAQS 2013 [Standard 2020]) 25% Threshold: 70 µg/m³	ASR1: Open Space Near Kg. Lepau	359.34 35.93 (10%) (Outside PIP)	33.84	3.38	YES		
		ASR2: Sebana Mixed Development		37.13	3.71	YES		
		ASR3: Sebana Mixed Development		40.56	4.06	YES		
		ASR4: Open Space within Bukit Pelali		42.78	4.28	YES		
		ASR5: Open Space Near Kg. Bukit Gelugor		35.23	3.52	YES		
		ASR6: Open Space Near Lake View		36.52	3.65	YES		
2	24-hours Average Limit: 70 µg/m³ (MAAQS 2013 [Standard 2020]) 25% Threshold: 17.5 µg/m³	ASR1: Open Space Near Kg. Lepau	42.26 14.79 (35%) (Outside PIP, Within PIC)	6.20			2.17	YES
		ASR2: Sebana Mixed Development		8.14			2.85	YES
		ASR3: Sebana Mixed Development		10.96			3.84	YES
		ASR4: Open Space within Bukit Pelali		3.22			1.13	YES
		ASR5: Open Space Near Kg. Bukit Gelugor		4.16			1.46	YES

No	Scenario	Identified Air Sensitive Receptor	Maximum Incremental (µg/m^3)	Air Sensitive Receptor Incremental (µg/m^3)- NOx as 100% NO_2	Air Sensitive Receptor Incremental (µg/m^3)- NOx as 10% NO_2	Compliance with 25% Threshold	Air Sensitive Receptor Incremental (µg/m^3)- NOx as 35% NO_2	Compliance with 25% Threshold
		ASR6: Open Space Near Lake View		6.01			2.10	YES

Table 7.17: Acute Exposure Guidelines Level (AEGL) Values for NO_2 and H_2S

	10-minutes	30-minutes	1-hour	4-hours	8-hours	End Point
Sulphur Dioxide (SO_2)						
AEGL-1 (Non-disabling)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	NOEL for bronchoconstriction in exercising asthmatics
AEGL-2 (Disabling)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	Moderate bronchoconstriction in exercising asthmatics
AEGL-3 (Lethality)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	Calculated BMCLC05 in the rat after a 4-hour exposure
Hydrogen Sulphide (H_2S)						
AEGL-1 (Non-disabling)	0.75 ppm (1.05 mg/m^3)	0.60 ppm (0.84 mg/m^3)	0.51 ppm (0.71 mg/m^3)	0.36 ppm (0.50 mg/m^3)	0.33 ppm (0.46 mg/m^3)	Headache in humans with asthma
AEGL-2 (Disabling)	41 ppm (59 mg/m^3)	32 ppm (45 mg/m^3)	27 ppm (39 mg/m^3)	20 ppm (28 mg/m^3)	17 ppm (24 mg/m^3)	Perivascular edema in rats
AEGL-3 (Lethality)	76 ppm (106 mg/m^3)	59 ppm (85 mg/m^3)	50 ppm (71 mg/m^3)	37 ppm (52 mg/m^3)	31 ppm (44 mg/m^3)	Highest concentration causing no mortality in the rat after a 1-h exposure

Source: *National Academy of Science, United States of America (2010). Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8 and Volume 11.*

Note: *AEGL-1 is the airborne concentration of a substance above which is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptimatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure;*

AEGL-2 is the airborne concentration of a susbtance above which is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape; and

AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

Table 7.18: Predicted MAICs for Identified Pollutants (in µg/m³) during Abnormal Situation

Para-meter	Averaging Time	Baseline Level (µg/m³)	Percentile (%)	Concentration (µg/m³)							AEGL-1 (Non-disabling)	AEGL-2 (Disabling)	AEGL-3 (Lethal)
				Highest Predicted MAIC	ASR1: Open Space Near Kampung Lepau	ASR2: Sebana Mixed Development	ASR3: Sebana Mixed Development	ASR4: Bukit Pelali	ASR5: Open Space Near Kampung Bukit Gelugor	ASR6: Open Space Near Lake View			
SO_2	1-hour	ASR1 = <5 ASR2 = <5 ASR3 = <5 ASR4 = <5 ASR5 = <5 ASR6 = <5 (24-hours averaging time)	100	7,543.9 (Outside PIP, Within PIC)	1,649.1	1,279.3	790.8	502.2	893.0	559.6	520 µg/m³ (0.20 ppm)	1,950 µg/m³ (0.75 ppm)	78,000 µg/m³ (30 ppm)
			99.98	2,449.1 (Outside PIP, Within PIC)	748.2	697.9	506.3	308.6	466.9	274.0			
H_2S	1-hour	ASR1= 27.1 ASR2= 22.9 ASR3= 27.1 ASR4= 20.8 ASR5= 22.9 ASR6= 22.9 (8-hours averaging time)	100	419.6 (Outside PIP, Within PIC)	91.7	71.2	44.0	27.9	49.7	31.1	710 µg/m³ (0.51ppm)	39,000 µg/m³ (27 ppm)	71,000 µg/m³ (50 ppm)

Note: PIP = Pengerang Industry Park
PIC = Pengerang Integrated Complex (RAPID)

AEGL = Acute Exposure Guidelines Level
AEGL-1 is the airborne concentration of a substance above which is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptimatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure;
AEGL-2 is the airborne concentration of a susbtance above which is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape; and
AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

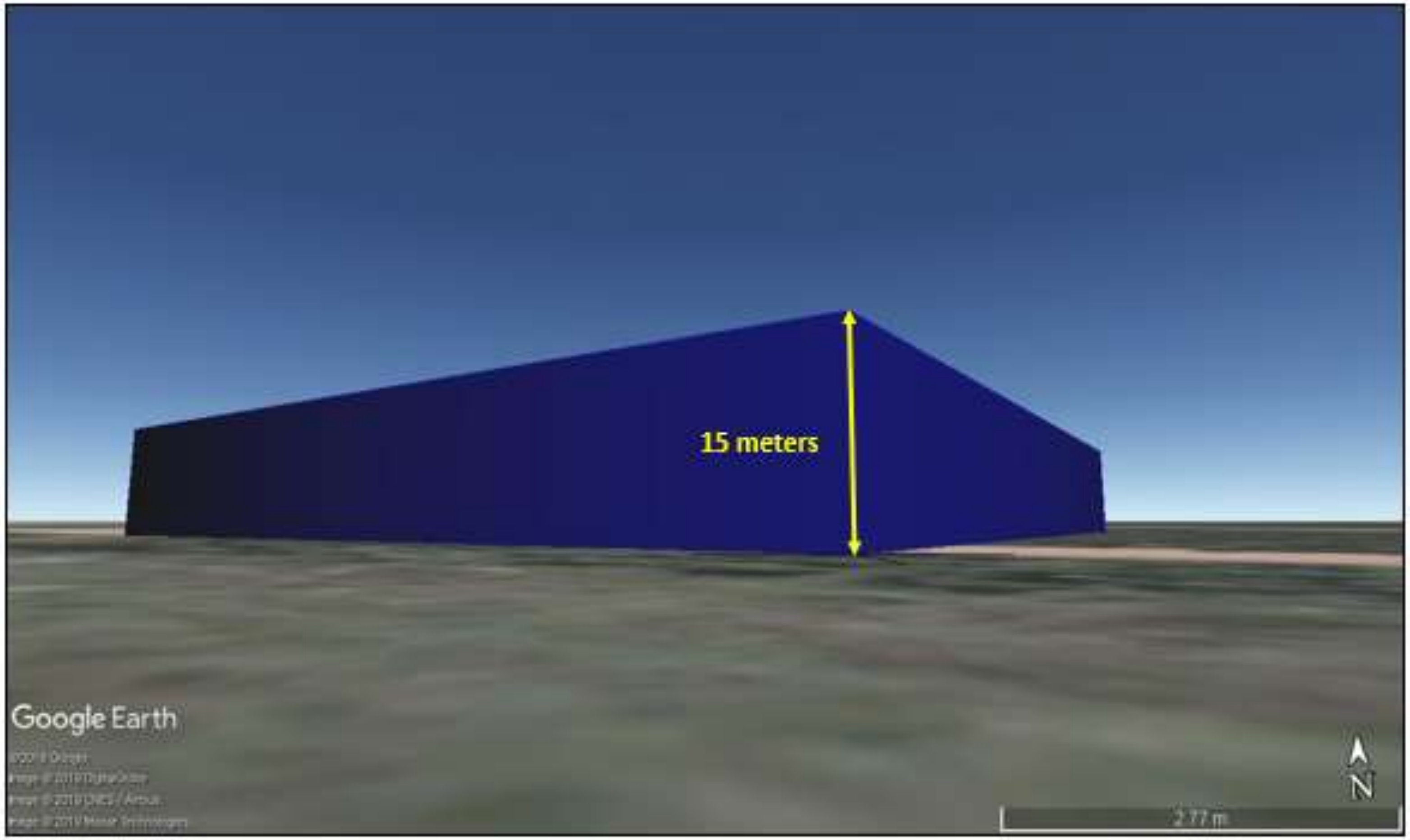
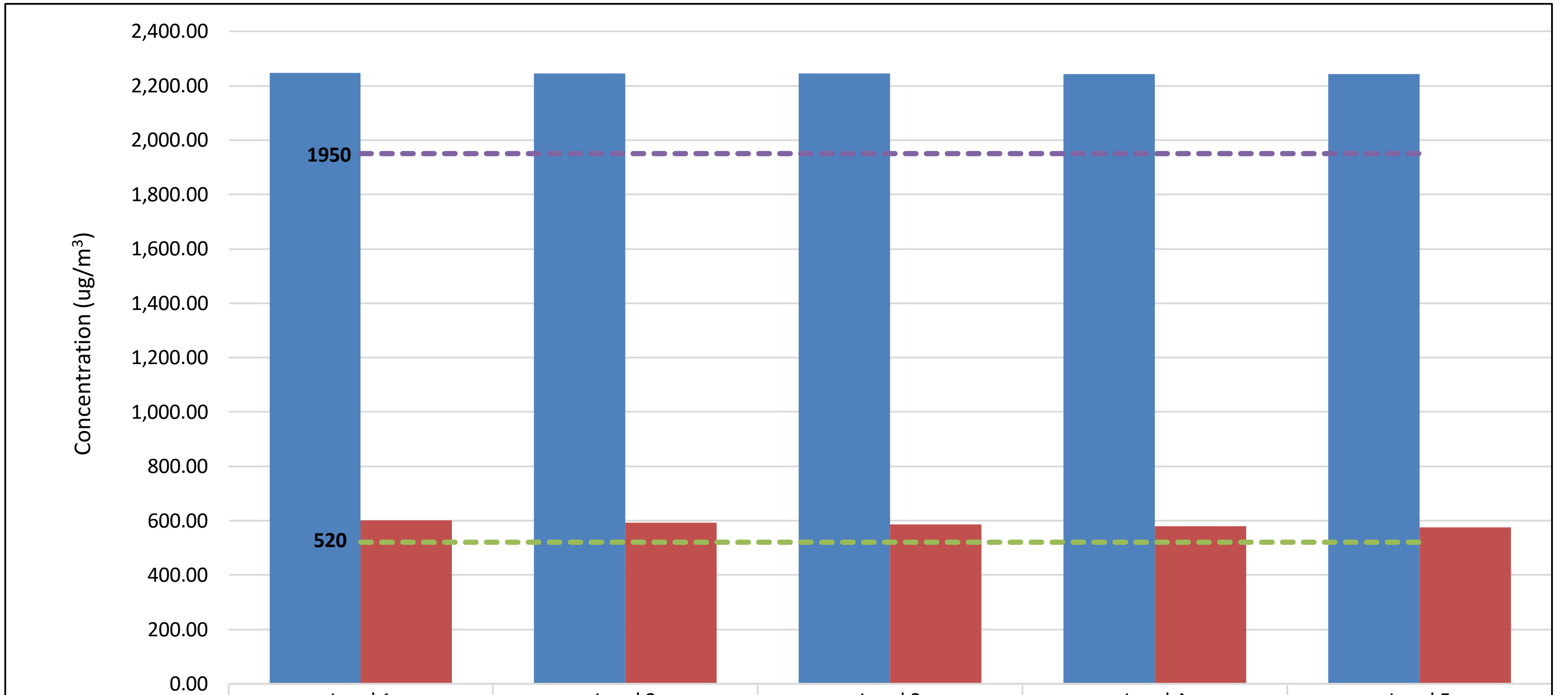


Figure 7.24 – 3D view of the Proposed *Rumah Pangsa* (Package A) at Proposed Sebana Mixed Development

Table 7.19: Predicted MAICs for Identified Pollutants (in µg/m³) at Individual Level of Flagpole Receptors during Abnormal Situation

Parameter	Averaging Time	Baseline Level (µg/m³)	Percentile (%)	Concentration (µg/m³)					AEGL-1 (Non-disabling)	AEGL-2 (Disabling)	AEGL-3 (Lethal)
				Level 1 (1.5 m)	Level 2 (4.5 m)	Level 3 (7.5 m)	Level 4 (10.5 m)	Level 5 (13.5 m)			
SO_2	1 hour	ASR1 = <5 ASR2 = <5 ASR3 = <5 ASR4 = <5 ASR5 = <5 ASR6 = <5 (24-hours averaging time)	100	2,247.05	2,246.40	2,245.25	2,243.62	2,242.57	520 µg/m³ (0.20 ppm)	1,950 µg/m³ (0.75 ppm)	78,000 µg/m³ (30 ppm)
			99.98	600.15	592.22	585.61	579.88	574.94			
H_2S		ASR1= 27.1 ASR2= 22.9 ASR3= 27.1 ASR4= 20.8 ASR5= 22.9 ASR6= 22.9 (8-hours averaging time)	100	124.99	124.95	124.89	124.80	124.74	710 µg/m³ (0.51ppm)	39,000 µg/m³ (27 ppm)	71,000 µg/m³ (50 ppm)

Note: *Each floor is assumed to be 3 m in height and the breathing zone is about 1.5 m from each floors*



	Level 1	Level 2	Level 3	Level 4	Level 5
100 % SO2	2247.05	2246.40	2245.25	2243.62	2242.57
99.98 % SO2	600.15	592.22	585.61	579.88	574.94
AEGL-1	520	520	520	520	520
AEGL-2	1950	1950	1950	1950	1950

Figure 7.25 – Predicted 1-hour Maximum Average Incremental Concentrations for SO_2 at Individual Level of Flagpole Receptors during Abnormal Operation (in µg/m^3)

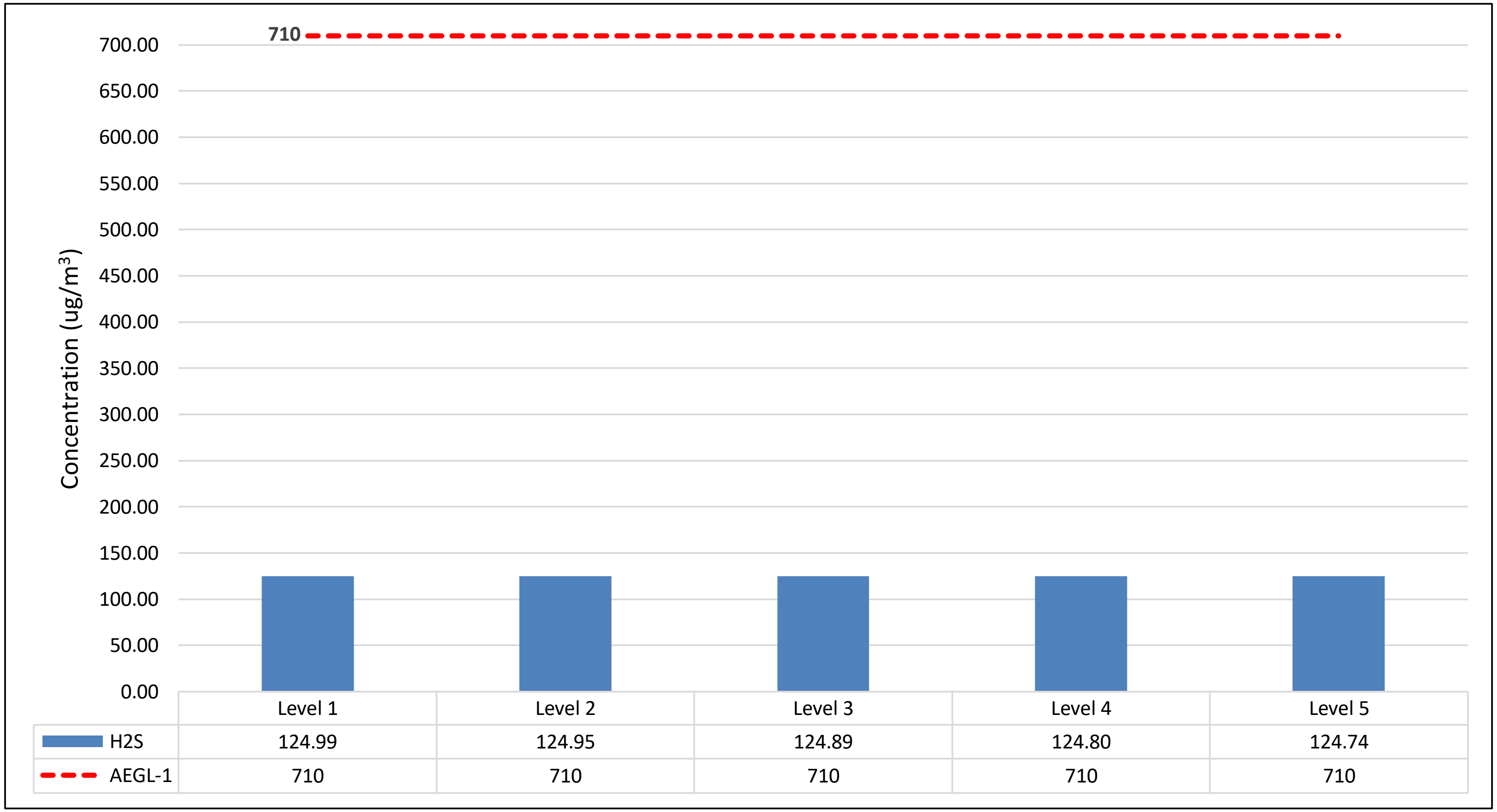


Figure 7.26 – Predicted 1-hour Maximum Average Incremental Concentrations for H_2S at Individual Level of Flagpole Receptors during Abnormal Operation (in μg/m^3)

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is regional;
- The impact is only for the duration of the operational phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

There are several sensitive receptors located within the 5 km study boundary that could be affected by the impact namely the residents of Kg. Lepau and Sebana Mixed Development, and workers on-site. Therefore, the receptor sensitivity is considered as high.

The significance of NO_2, SO_2, CO, PM 2.5, H_2S, and HCl emission during the operational stage on air quality has been identified as **Medium** based on an assessed low impact severity and high receptor sensitivity.

<u>Mitigation Measures</u>

Mitigating measures that should be adopted by the Project Proponent for the Project are as follows:

- The design of all proposed stacks, flare and air pollution control systems should be guided by the Guidance Document on Fuel Burning Equipments and Air Pollution Control Systems issued by DOE Malaysia under the Environmental Quality (Clean Air) Regulations 2014.
- The emission concentrations for the prescribed pollutants shall comply with Environmental Quality (Clean Air) Regulations, 2014 as per the following:
    - Third Schedule [Regulation 13]: Limit Values and Technical Standards (By Activity or Industry): E. Oil and Gas Industries: Refineries (All Sizes): Natural Gas Processing and Storage and Handling of Petroleum Products; and
    - Third Schedule [Regulation 13]: Limit Values and Technical Standards (By Activity or Industry): A. Heat and Power Generation: 1. Boilers under Gaseous Fuels.
- Prior to any installation of fuel burning equipment and air pollution control system, written notification as required under Regulations 5 the above said regulations shall be carried out by submission to the state DOE as per the following:
    - AS/PUB/N-CHIMNEY form: Written Notification on Installation of Exhaust/Vent;
    - AS/PUB/N-APB form: Written Notification on Air Emission Sources (Fuel Burning Equipment);
    - AS/PUB/N-SCRUBBER form: Written Notification on Air Emission Sources (Air Pollution Control System (Scrubber)); and/or
    - Other relevant forms issued by DOE Malaysia.

Upon completion of the installation of these equipment, a written declaration shall be submitted to state DOE under Regulation 7(5).

- Installation of Continuous Emission Monitoring System (CEMS) shall be guided by the following guidelines:
    - Volume I- Guideline for the Installation and Maintenance of Continuous Emission Monitoring Systems (CEMS) for Industrial Premises/Facilities; and

- Volume II-Guideline for the Continuous Emission Monitoring Systems-Data Interface Systems (CEMS-DIS) for Industrial Premises/Facilities.

- Leakage Detection And Repair (LDAR) programme shall be implemented in the facility as required under the Environmental Quality (Clean Air) Regulations 2014 as prescribed in Note 6 of the Third Schedule [Regulation 13]: Limit Values and Technical Standards (By Activity or Industry): E. Oil and Gas Industries: Refineries (All Sizes); Natural Gas Processing and Storage; and Handling of Petroleum Products of the said regulations. Note 6 is read as "For compliance check a "Leakage Detection and Repair Programme" shall be implemented as outlined in the Guidance Document on Leak Detection and Repair in a manner as specified and approved by the Director General.
- The fugitive emissions of volatile organic substances within the facility shall be minimized according to the Best Available Techniques Guidance Document on Storage and Handling of Petroleum Products issued by DOE Malaysia under the CAR 2014.
- As prescribed in Second Schedule [Regulation 13]: Limit Values and Technical Standards (General): (III) Control of fugitive emissions of the Environmental Quality (Clean Air) Regulations 2014, the control of fugitive emissions of non-methane volatile organic compound (NMVOC) shall be minimized in accordance to the Guidance Document on Fugitive Emission Control.
- All internal roads used for the movement of vehicular movements should be paved with suitable material to suppress or minimize dust generation along the roads.

In addition, the Project Proponent will design the Plant in accordance to the World Bank Group's guidelines entitled "Environmental, Health and Safety Guidelines for Petroleum Refining (November 17, 2016)".

Based on the result of the impact assessment of SO_2 to the surrounding air sensitive receptor during abnormal situation i.e. with flaring, attention shall be given to the design of the proposed flare. The following pollution prevention and control measures as recommended in the World Bank Group's guidelines, where appropriate, should be considered for gas flaring:

- Implementing source gas reduction measures to the maximum extent possible;
- Using efficient flare tips (i.e., optimal released gas sonic velocity, in order to avoid malfunctioning of the flare due to its flame off), and optimization of the size and number of burner nozzles (not less than three, which will ensure—acting as pilot burners, positioned 120° from each other—the continuity of flaring);
- Maximising flare combustion efficiency by controlling and optimizing flare fuel/air/steam flow rates to ensure the correct ratio of assist stream to flare stream;
- Minimising flaring from purges and pilots, without compromising safety, through measures including the installation of purge gas reduction devices, flare gas recovery units (mainly for continuous or predictable releases), an upstream knock-out drum (vapour–liquid separator used to avoid entrainment of liquid to the flare stack), soft-seat valve technology (where appropriate), conservation pilots, the use of inert purge gas, and the diversion of flows into the refinery fuel gas distribution network;
- Minimising the risk of pilot blow-out by ensuring sufficient exit tip velocity and providing wind guards;
- Using a reliable pilot auto-ignition system;

- Installing high-integrity instrument pressure protection systems, where appropriate, to reduce over-pressure events and avoid or reduce flaring situations;
- Minimising liquid carry-over and entrainment in the gas flare stream with a suitable liquid separation system;
- Minimising flame lift (flash off) and flame lick (flash back);
- Operating flares to control odour and visible smoke emissions using suitable optical instruments, such as flame detectors, which act on the steam injection in case of black smoke at tip;
- Locating flares at a safe distance from local communities and the workforce, including workers' accommodation units;
- Implementing burner maintenance planning and replacement programs to ensure continuous maximum flare efficiency;
- Metering flare gas on a monthly basis in the interest of pollution evaluation, mainly in terms of CO_2 and SO_2, as well as of released heat (which is an indirect estimation of the greenhouse gas (GHG) emissions);
- Avoiding over-steaming, as too much steam in a flare will reduce flare performance;
- Avoiding a wake-dominated flame. A strong crosswind at high velocity can have a powerful effect on the flare's flame dimensions and shape, causing the flame to be wake-dominated (i.e., the flame is bent over on the downwind side of a flare and imbedded in the wake of the flare tip), reducing flare performance and potentially damaging the flare tip; and
- Avoiding flame lift-off, a condition in which a flame separates from the tip of the flare and there is space between the flare tip and the bottom of the flame due to excessive air induction as a result of the flare gas and center steam exit velocities. This type of flame can reduce flare performance and can progress to a condition where the flame becomes completely extinguished.

Residual Impact

If stipulated control measures are followed the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.2 CO_2 Emissions (Greenhouse Gases)

7.3.2.1 Scope 1

The main sources of carbon dioxide (CO_2) emission from PEC during the operational phase are from the hydrocarbon or fuel-burning equipment such as the boilers, reboilers, heaters, and flare stacks. It is of utmost importance that the emissions from these sources are monitored and recorded as CO_2 are considered as the most common GHG emitted in the energy sector. The estimated total fuel consumption of PEC during the operational phase is shown in *Table 7.20*.

Table 7.20: Estimated Total Fuel Consumption of PEC

Source of Emission	Amount of Fuel (MMBTU)
Condensate Fractionation	313.50
Platforming	865.09
Xylene Fractionation	182.54
Tatoray	47.62

Source of Emission	Amount of Fuel (MMBTU)
Parex	900.81
Isomar	126.99
Naptha Hydrotreating	71.43
Kerosene Unionfining	7.94
Diesel Unionfining	87.30

Based on the estimated annual total fuel consumption of PEC, an estimation of the GHG emission is calculated by utilising GHG Protocol Calculation Tool. The purpose of the conceptual calculation is to estimate the GHG emission of PEC during its operational phase from an estimated total working hours of 8,400 per year. Based on the conceptual calculations, approximately 1,330,200.15 tonnes of CO_2e will be generated in a year during the operational phase of PEC. The estimated total emission of Scope 1 for PEC is shown in *Table 7.21.*

Table 7.21: Estimated Total Emission of Scope 1 Emission of PEC

Source of Emission	Amount of Fuel (MMBTU)	GHG Emissions (tonnes)			
		CO_2	CH_4	N_2O	All GHGs (tonnes CO_2e)
Condensate Fractionation	313.4973	19.052	3.308E-04	3.308E-05	19.070
Platforming	865.0938	52.575	9.128E-04	9.128E-05	52.625
Xylene Fractionation	182.54274	11.094	1.926E-04	1.926E-05	11.104
Tatoray	47.61984	2.894	5.024E-05	5.024E-06	2.897
Parex	900.8087	54.746	9.504E-04	9.504E-05	54.797
Isomar	126.9862	7.717	1.340E-04	1.340E-05	7.725
Naptha hydrotreating	71.4297	4.341	7.537E-05	7.537E-06	4.345
Kerosene Unionfining	7.9366	0.482	8.374E-06	8.374E-07	0.483
Diesel Unionfining	87.30305	5.306	9.211E-05	9.211E-06	5.311
Total Scope 1 GHG Emission (tonnes CO_2e)/hr					**158.357**
Total Scope 1 GHG Emission (tonnes CO_2e)/yr					**1,330,200.15**

Note that the calculations do not take into consideration usage of any GHG emissions minimisation measures.

7.3.2.2 Scope 2

Scope 2 emissions are calculated from purchased or acquired electricity, steam, heat and cooling. For PEC, only 2 sources of energy are utilised, namely electricity and steam. Electricity is purchased from the national grid while steam is generated utilising electricity also from the national grid. Note that the calculations for steam assumes that none is acquired from the PEC processes. This may change during Detailed Design which will significantly reduce the consumption data.

For the assessment of the emissions from usage of electricity, the location-based method was utilised. As such the emission factor for Peninsular Malaysia from the 2017 Clean Development Mechanism (CDM) Electricity Baseline for Malaysia, published by Malaysian Green Technology Corporation for the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) was applied. The emission factors from CDM were previously used for the study of Malaysia's GHG emission and are considered as the national emission factor. However, only the CO_2 values are available and therefore reported. The activity data and the emission factor used for the calculation of scope 2 emission of electricity is as shown in Table *7.22*.

For the calculation of the scope 2 GHG emission, the following formula, based on GHG Protocol Scope 2 Guidance, was applied:

Emission = Activity Data x Emission Factor

Table 7.22: Estimated Total Emission of Scope 2 Emission of PEC

Source of Emission	Activity Data (mWh)	Emission Factor (tonnes CO_2e)	Calculated Emission
Steam	194.04	0.667	129.43
Electricity	80.38	0.667	53.61
Total CO_2e Emission (tonnes CO_2e/hr)			**183.04**
Total CO_2e Emission (tonnes CO_2e/yr)			**1,537,528.78**

Based on the conceptual calculation, PEC will be emitting approximately 1,537,528.78 tonnes CO_2e of scope 2 emission annually. However, as of the writing of this report, only these set of data are available. Additional data will be included once the detail design of PEC has been finalised.

7.3.2.3 Total GHG Emission

The total estimated GHG emission of Scope 1 and Scope 2 of PEC is 2,867,727.93 tonnes CO_2e per year. This corresponds to less than 1.1% of Malaysia's total carbon emission in 2018 (BP Statistical Review of World Energy 2019) which amounted to 250.3 million tonnes. The estimated total GHG emission of PEC is summarised in Table *7.23*

Table 7.23: Estimated Total Emission of Scope 1 and Scope 2 Emission of PEC

Type of Emission	Calculated Emission (tonnes CO_2e)
Scope 1	1,330,200.15
Scope 2	1,537,528.78
Total Emission	**2,867,727.93**

Note that the calculations do not take into consideration usage of any GHG emissions minimisation measures.

Impact Evaluation

The potential impact GHG emission is considered a global issue and could not be assessed by the Significance Assessment Matrix (SAM) that is utilised to assess other environmental impacts of PEC. Therefore, the impact GHG emission of PEC will be assessed by comparing it with Malaysia's total carbon emission as well as the GHG emission of similar industry.

As previously mentioned, the total estimated GHG emission of Scope 1 and Scope 2 of PEC is 2,867,727.93 tonnes CO_2e per year. This corresponds to less than 1.1% of Malaysia's total carbon emission in 2018 (BP Statistical Review of World Energy 2019) which amounted to 250.3 million tonnes.

The emissions above are calculated based on worst-case scenario and do not account for any mitigation or minimisation measures. The volumes of all gases containing the hydrocarbons that are removed through the flare will have to be recorded and reported to ensure that the air pollution control system that will be implemented is functioning at its optimum level and the trend of potential unexpected increment of GHG emission could be mitigated. The impact of GHG emission of PEC will be assessed in further details once the final design has been finalised.

Mitigation Measures

PEC facility shall meet the IFC Performance Standard III in relation to CO_2 emission of more than 100,000 tons per year for the aggregate emission of both facilities within the physical boundary of

PEC (direct sources) as well as its associated facilities (indirect sources). The monitoring and reporting of PEC's GHG emission will be conducted annually in accordance with internationally recognised methodologies such as those provided by the Intergovernmental Panel on Climate Change (IPCC). Besides that, PEC will also continually evaluate the feasibility and the cost-effectiveness of various alternatives from both the technical and financial perspective to further reduce its GHG emission during the design and operation stage of PEC.

The alternative options to reduce the GHG emission that will be, but is not limited to, considered by PEC are as follows:

- Continuous enhancement of energy efficiency and consumption;
- Protection and enhancement of sinks and reservoirs of greenhouse gases;
- Carbon capture and storage technologies;
- Carbon Financing; or
- Adoption of other mitigation measures such as the reduction of fugitive emission and/or the reduction of gas flaring.

PEC will promote the reduction of project-related greenhouse has (GHG) emission in a manner that is appropriate to the nature and scale of the project operations and impacts. Furthermore, as the design of the process units have not been finalised, the fuel required is estimated based on recent similar complexes. The accuracy and detail of this estimate will be improved as the project progresses.

The following aspects will be considered by PEC in finalising the detail design to ensure inclusion of BAT:

- Minimizing energy consumption for the site, as a whole, by using process models and pinch techniques;
- Optimizing the hydrogen network by evaluating the process conditions for the hydrogen sources, hydrogen consumers, and overall hydrogen recovery and reuse;
- Minimizing water consumption by designing the process units, sour water stripping and utilities to maximize water reuse.;
- Optimization of shared process systems such as sour water stripping and amine treating; and
- Reducing CO2 generation by minimizing fired heater duty, electricity consumption and steam usage and maximizing process heat recovery.

<u>Residual Impacts</u>

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

7.3.3 Wastewater

Based on the liquid effluent inventory in *Chapter 3 (Table 3.13)*, wastewater is generated on a continuous basis and intermittently, depending on the process. All wastewater will be sent to the onsite wastewater treatment plant.

The wastewater treatment plant might experience difficulties during start up or equipment malfunction and possible impacts are:

- Chemical hazard and pollution of Sg. Lepau;

- Chemicals from wastewater treatment plant can cause airborne hazards that will affect human health. Inhaling the chemicals may cause respiratory infection, eye irritation, depression, central nervous system damage and poisoning; and
- The airborne hazards will create an unpleasant odour caused by the chemicals from the wastewater treatment plant.

<u>Impact Evaluation</u>

The impacts are considered minor; however, proper mitigation measures and maintenance of the wastewater treatment plant is required to ensure optimum operation of the plant. The effluent discharge from the wastewater treatment plant shall be treated and comply to Standard A of the *Environmental Quality (Industrial Effluents) Regulations 2009*.

Additionally, the effluent from the wastewater treatment plant will be discharged into the retention pond next to the western boundary of the site. JCorp will be responsible for the operational and maintenance of the retention pond. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as medium. The assessment of the severity of the impact is as follows:

- The extent of the impact may be visible outside the 5 km study boundary;
- The impact is only for the duration of the operational phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of the impact of effluent discharge during the operational stage has been identified as **Medium** based on an assessed medium impact severity and low receptor sensitivity.

<u>Mitigation Measures</u>

A wastewater treatment plant will be constructed at the western boundary of the site. The sources of contaminated or potentially contaminated water from PEC facility are as follows:

- Process wastewater/ air emission control equipment/ knock out drums;
- Potentially contaminated water from process areas;
- Domestic sewage; and
- Stormwater.

Other potential effluent sources are unintentional spillages, equipment wash-water, which may contain extraction solvents and aromatics, and rainwater.

Mitigation measures that can be implemented include:

- The site storm and wastewater conveyance system shall be designed to ensure pre-segregation of non-contaminated and contaminated and/or potentially contaminated water;
- The clean water system shall collect clean storm water from areas not normally subjected to contamination, which is directly discharged from the facility via the storm water discharge channel, via an effluent screen pit;
- There will be one slop oil tank which has a storage volume of 6,000m^3 to hold the skimmed oil. The oil will be used for on-site reprocessing;

- All process wastewater and wastewater from the flare and other emission control equipment shall be directed to the dedicated wastewater treatment facility on site;
- Treated wastewater will be discharged to on-site final pond with a holding volume of 10,000m^3; and
- Monitoring of the effluent discharge on quarterly basis shall be conducted to ensure the wastewater treatment plant is operating at optimum level.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.4 General Waste

Operational activities from the plant will result in the generation of a variety of non-hazardous wastes, the most significant of which are:

- Packaging/wrapping/containers (plastic, cardboard, paper, metal, wood etc) for imported operational materials;
- General wastes (food, paper, plastic, metals and other packaging etc) relating to site administration offices and canteens.

Domestic waste was estimated to be 596.4 kg/day (based on an average generation rate of 1.42 kg/day/person and 420 people working in PEC) an estimation of waste will be 214.7 tonnes/yr. Waste parts and packaging materials are estimated at 1,000 kg/day or 360 tonnes/yr.

Other solid wastes are from the process units are estimated to total 2,757 m^3/yr. The spent catalyst for the Distillate Unionfining (KHT) Unit and Distillate Unionfining (DHT) Unit is estimated at 16,677 kg and 56,117 kg respectively.

Impact Evaluation

The potential impact of general waste is expected to be low. General waste should be segregated into recyclable and non-recyclable wastes and stored in the designated containers on-site. Recyclable wastes are expected to be mainly office wastes such as paper and plastic wrapping. Non-recyclable municipal wastes, such as food waste are to be disposed of off-site at an approved disposal site.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the operational phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

Although the site will be occupied with construction workers and there are several residential areas located within the 5 km boundary of the study area, general waste is considered as less hazardous due to the inert nature of these types of materials. Therefore, the receptor sensitivity is considered as medium.

The significance of the impact of generation of general waste during the operational stage has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

All wastes will be managed in accordance with a Solid Waste Management Plan for the site to cover all operational areas. The fundamental principles of the Solid Waste Management Plan are to create and maintain good housekeeping protocols to ensure that:

- The facility will be managed in such a way as to minimise the generation of wastes;
- Where possible wastes will be recovered or recycled on site;
- External companies capable of recovering or recycling wastes, that cannot be handled on site, will be contracted for waste removal whenever practicable;
- All wastes will be segregated by type ensuring that incompatible wastes are stored separately;
- Waste storage facilities should be suitable for the purpose by ensuring that waste containers/storage areas are capable of containing predicted waste volumes in a manner unlikely to cause damage to the environment or harm to human health;
- Waste designated for off-site disposal will be fully documented to include details of waste type, quantity, recipient, final destination and all other relevant information prior to leaving the site; and
- Waste designated for off-site disposal will only be transferred by such party that can demonstrate that they are licensed to transport and/or treat or dispose of the waste in accordance with Malaysian Regulations.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.5 Scheduled Waste

Hazardous wastes are described as scheduled wastes in Malaysia and are regulated under the *Environmental Quality (Scheduled Waste) Regulations 2005*.

The Site is expected to generate the following types of hazardous wastes:

- Spent catalysts from liquid or gas phase hydrogenation of olefins, diolefins and sulphur;
- Clay from olefins removal;
- Absorbents from Xylene separation consisting of alumina or molecular sieves;
- Sludge/solid polymerisation materials recovered from process equipment during maintenance activities;
- Oil contaminated materials or spent chemicals;
- Laboratory wastes;
- Sludges from the wastewater treatment plant;
- Used containers, bags and process equipment contaminated by chemicals from production activities.

It is estimated that the maximum amount of hazardous waste that will be generated during operations is estimated to be <500 tonnes/year.

Storage, handling and transport of the waste may potentially impact the environment resulting in:

- Contamination to soil and groundwater due to leaks or spills on unpaved ground;

- Contamination to surface water bodies due to leaks or spills into drains and waterways; and
- Potential fire hazard.

Impact Evaluation

Hazardous wastes may potentially cause significant environmental and health/safety hazards if it is not handled, stored, transported and disposed properly. Nevertheless, the potential impact of schedule waste generated during operational phase is expected to be low and manageable. All scheduled waste generated will be handled, stored and disposed in accordance to *Environmental Quality (Scheduled Wastes) Regulation 2005* and the DoE *Guidelines for Packaging, Labelling and Storage of Scheduled Wastes in Malaysia, 2014*.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the operational phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

The sensitive receptors that are located within the 5 km study boundary and could be affected by the mishandling of scheduled waste are the residents of Kg. Lepau and Sebana Mixed Development, and the workers on-site. However, during the operational phase, the project site will be platformed. In an event of mishandling of scheduled waste, it its very likely that the contamination will be well contained within the project boundary of PEC and thus, only the workers on-site that will be directly affected by the impact. Therefore, the receptor sensitivity is considered as medium.

As such, the significance of the impact of the generation of hazardous waste during the operational stage has been identified as **Low** based on an assessed low impact severity and medium receptor sensitivity.

Mitigation Measures

All wastes will be managed in accordance with a Solid Waste Management Plan for the site to cover all operational areas. The fundamental principles of the Solid Waste Management Plan are to create and maintain good housekeeping protocols to ensure that:

- Implementing 3R concept to manage waste during operational stage as follows:

Table 7.24: Implementation of the 3R Concept to Manage Waste

3R Concept	Implementation
<u>Reduction of waste</u> Selectively disposed collected waste and reused/ regenerated usable materials for waste management efficiency.	- Reuse spent catalyst after catalyst regeneration by manufacturer - Return used drums and any compartments to supplier - Reduce weight and volume of WWTP sludge via dewatering and drying - Use of recyclable and reusable material in production
<u>Reuse of Waste</u> Reuse any possible component whenever approved by regulation at any possible process. Reprocessed used components to have its commercial value is also highly suggested.	- Reuse of drums for storage of compatible material - Reuse of decontaminated drums for common storage
<u>Recycling of Waste</u> Process of transforming waste that considered as raw material to another type of product by recycling/ recovery facility that has been approved by DOE.	- Reprocess slop oil - Recycle spent oil into low grade oil - Recycle of general waste such as glass bottles, cans and paper - Recycle of e-waste such as batteries, electrical and electronic products - Composting of food waste into soil conditioner - Reprocess spent chemicals and solvent by DOE-approved recovery company

- All wastes will be segregated by type ensuring that incompatible wastes are stored separately;
- Spent catalyst sent to the catalyst vendor or the recyclers for recovery;
- Handling of the scheduled waste by adopting good operational practices that includes the followings:
  - <u>Design of the scheduled waste storage area</u>

    Storage area should be designed with: design and material that can prevent leakage of any form, can cover and allow smooth waste transport, and free of cracks; installation of adequate bunding; installation of pipe/ covered drainage to channel wastewater to treatment plant/ collection chamber; providing 10% extra storage from the actual amount of waste to be stored with storage period not exceeding 180 days; proper signage and fence should be in place; suitable ventilation; compartments based on groups of incompatible wastes; adequate escape route, firefighting system and other emergency response equipment.
  - <u>Transportation of waste</u>

    Trucks and forklift are expected to be the main transport to carry solid and liquid to the scheduled waste storage area. Waste will be properly contained in drums, intermediate bulk containers, cylinders and poly bags. All medium to contained the scheduled waste is made by waterproof material and always in covered during transport and storage.

- <u>Temporary Waste Storage</u>

  To manage the waste movement and storage efficiently and safely, several temporary storages will be located within the complex areas. For unit processes which frequently generate waste, dedicated transit areas will be provided. A proper loading and unloading bay will be part of the transit areas and temporary storage areas. From the collection system, the waste will be sent to the waste pre-treatment and treatment facilities.

<u>Residual Impact</u>

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.6 Noise

Noise sources during operational phase will mostly come from the equipment of the process plant. The primary noise sources within the production facilities will include:

- Flare;
- Pumps;
- Coolers;
- Condensers;
- Compressors and steam turbines.

Apart from the machineries, noise may also generate from moving the raw materials and goods to and from the site. Increase in number of vehicles e.g. workers vehicle may contribute to the noise level in the area. The impacts of noise during the operational phase are most likely to give effect to the workers rather than the residents nearby as the workers will be exposed to noise sources directly and the nearest residential area is located 1 km away from the plant. The potential noise impacts during operational phase according to the Industrial Noise Control Module published by the Department of Occupational, Safety & Health (DOSH) are:

- Tinnitus (ringing, buzzing or whistling in the ears, when there is no external sound);
- Hearing loss whether is temporary, acoustic trauma and permanent hearing loss; and
- Other health problems such as increased heart rate, increased breathing rate, hypertension, sleep disturbance, lack of concentration and fatigue and aggression.

<u>Impacts Evaluation</u>

The potential impact of noise to residential receptors during the operational phase is expected to be Low, based on minor impact and very likely likelihood. The existing baseline noise level in the surrounding area of the site has already exceeded the permissible sound level set in the Planning Guidelines for Environmental Noise Limits and Control and that the nearest residential areas are located at least 1 km away. For RAPID staff, the noise levels are considered to be within the permissible levels. Staff within PEC will be issued with PPE to reduce any exposure to excessive noise. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km study boundary;

- The impact is only for the duration of the operational phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of impacts of elevated noise level on work the environment as well as the local population has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

The operational phase will generate noise disturbance. Major sources of impact are derived from operational equipment at the process plant, pumping, flare and air system. The emphasis for noise pollution control during the operational stage is on the design and placing of the noise generating equipment within the work areas.

Noise emissions control measures may include, but not limited to, the following;

- Best practice procedures (such as turning off equipment when not in use);
- Regular equipment maintenance; and

Noise prevention and mitigation measures such as silencer, relocation of equipment, replacement with lower noise level, and personal protective equipment etc. should be applied where predicted or measured noise impacts from the facility or operation exceed the applicable noise level.

Residual Impacts

If stipulated control measures are followed, the significance of residual impacts from noise onto sensitive receptors has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.7 Human Health Assessment

Health Impact Assessment (HIA) is the process of estimating the potential impact of a chemical, biological, physical or social agent on a specified human population system under a specific set of conditions and for a certain time frame. The main approach to the HIA is to assess the impacts of the proposed activities of the Pengerang Energy Complex on the health of residents of the affected communities within the vicinity of the project. The HIA was prepared based on DoE's Guidance Document on Health Impact Assessment (HIA) in Environmental Impact Assessment (EIA), 2012.

A brief summary of the impacts is discussed below.

7.3.7.1 Identification of Issues

This first step explores the source-pathway-receptor link, the component of each is essential in the expression of risk. Health impacts are mainly secondary impacts upon the human community that emanate from primary impacts upon the physical (air, water and soil); biological (animals and plants) and social environments. In the case of this proposed project, the main health impacts will emanate from human exposure to air pollutants that will be released during the construction and operational phases of the proposed project. The major pathway for human exposure to the released air pollutants during the construction and operational phases will be through direct inhalation. Indirect exposure to air pollutants through the ingestion route is highly unlikely in this case. The proposed project site is adjacent to the Petronas Refinery and Petrochemical Integrated Development (RAPID). There is no food crop grown in the vicinity of the proposed project.

Therefore, there is low probability of human health risk from the consumption of contaminated foods.

7.3.7.2 Hazard Identification

Hazard identification involves the identification of potential environmental hazards and characterization of their innate adverse toxic or health effects. The purpose is to scope for potential environmental and health hazards that may emanate from the operation of the proposed project. The review indicated that the major environmental hazards from the proposed project will be mainly particulate and gaseous air pollutants during the proposed project operational phase.

7.3.7.3 Air Pollutants

During normal project operation, the main point sources would be mainly emissions from fuel burning equipment. Air pollutants emitted by the proposed project during the operational phase include particulate pollutants in the form of respirable particles (PM_{10}) and fine particles ($PM_{2.5}$), as well as gaseous pollutants as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), hydrogen sulphide (H_2S) and hydrogen chloride (HCl). Minimal fugitive emission of volatile organic compounds (VOCs) is anticipated as these fugitive gases will be mainly collected and use as waste gas for fuel in its fuel burning equipment. Residual hydrogen sulphide (H_2S) will also be emitted from the SRU Stack and residual hydrogen chloride (HCl) emission from the CCR RCR Vent.

7.3.7.4 Exposure Assessment

For the project operational phase, two air pollution emission scenarios were simulated. One is the normal emission scenario whereby all air pollution devices are functioning normally. The other is the abnormal emission scenario when there is a process upset or emergency situation, whereby the stream from the project will be routed to the proposed flare for flaring. For each of the emission scenario, two exposure scenarios were simulated. One exposure scenario is the highest predicted ambient air pollutant concentration. The other is the sensitive receptor ambient air pollutant concentration.

Six air sensitive receptor sites were identified and are the same as the receptors identified *Table 7.12* in *Section 7.3.1*.

7.3.7.5 Health Risk Characterisation

Reference is made to the results from the Air Quality Modelling Report. During normal project operation (*Table 7.13*), all the predicted GLCs for $PM_{2.5}$, PM_{10}, SO_2, NO_2 and CO at the 6 ASRs will fall below their MAAQS 2013 (Standard 2020), while the predicted GLCs for H_2S and HCl will not exceed their Ontario' Ambient Air Quality Criteria 2012.

During abnormal project operation (Table *7.17*), the GLCs for SO_2 at the 6 ASRs will be below its AEGL-2 limit, while the GLCs for H_2S will be below its AEGL-1 limit. Therefore, public exposures to the resulting GLCs of either SO_2 or H_2S are not expected to cause any long-lasting adverse health effects.

7.3.7.6 Hazard Quotients for Air Pollutions

The hazard quotient (HQ) is a measure of the possibility of seeing chronic, non-carcinogenic health effects among the exposed population. The HQ due to chronic inhalation exposure to H_2S and HCl at the highest predicted GLC at ASR under normal project operation were calculated. This HQ was obtained by taking the ratio of the ambient air concentration or exposure air concentration to the reference concentration.

The highest predicted GLC for H_2S (0.06 µg/m^3) and HCI (0.11 µg/m^3) at the Sebana Mixed Development (ASR3) during normal project operation gives a HQ of 0.029 and 0.005, respectively. Since the HQ is less than 1, it means that it is likely that a chronic, non-carcinogenic health effect will not be seen among those exposed over a lifetime.

Impact Evaluation

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site within the 5 km study boundary;
- The impact is only for the duration of the operational phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

As previously mentioned, the assessed hazard quotient (HQ) is less than 1. This shows that it is unlikely that a chronic, non-carcinogenic health effect will likely be seen among those exposed over a lifetime. Therefore, the receptor sensitivity is considered as low.

The significance of the impact on human health during PEC operational stage has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

Risks to human health from air emissions from the facility can be controlled via effective procedures shown below:

- Conduct regular monitoring of air pollutant levels close to sensitive receptors as to ensure the security of human health in surrounding PEC area;
- Conduct regular maintenance on all air pollution control equipment to ensure emissions are below the levels stipulated in the *Environmental Quality (Clean Air) Regulations 2005*;
- The continuous emission monitoring systems is recommended to be installed to track the irregularities and the emission trend of the pollutants;
- Accumulation of hazardous ambient levels is necessary to be prevented by automatic shutdown within 30 minutes under the emergency of circumstances whenever pollutants are monitored impacting closest settlements during operational stage.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.8 Health and Safety

The significant sources of impacts for health and safety during the operational phase of the PEC facility will be:

- Exposure to dust, chemicals, hazardous or flammable materials;
- Slips, trips & falls;
- Over exertion;
- Working at heights;
- Moving machinery;

- Struck by objects;
- Working in confined spaces;
- Exposure to noise and vibration.
    - Facility-specific occupational health and safety hazards. These hazards would be identified based on job safety analysis or comprehensive hazard or risk assessment, using established methodologies such as a hazard identification study (HAZID), hazard and operability study (HAZOP), and a quantitative risk assessment (QRA). The most significant occupational health and safety hazards occur during the operational phase of the facility primarily include:
    - Process safety hazard (specific to the facility, the hazards includes; hydrocarbon complex reactions, multistep organic synthesis reactions/units, process integrity failure, process automation system failure, false alarm failure, safety feature failure, damage or leak at pipelines – including those outside the facility battery limit)
    - Chemical hazards (including gas and/or liquid chemical release to the environment, BLEVE, fire, and explosion)
- Chemical hazard during transportation (release of hazardous and flammable chemicals to public facility.

<u>Impact Evaluation</u>

The significance of Health and Safety impacts is expected to be low. The impacts on Health and Safety can be controlled by ensuring that safety work procedures implemented and in compliance with the Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC) which enables hazards to be identified, risk associated to be assessed and suitable control measure can be then implemented and all other requirements under the Occupational Safety and Health Act 1994. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised in the project site;
- The impact is only for the duration of the operational phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

The significance of health and safety impacts has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

<u>Mitigation Measures</u>

Risks of health & safety impacts can be controlled via effective operational procedures and plans, including but not limited to:

- Ensuring compliance with the *Occupational Safety and Health Act 1994* and Codes of Practice and guidelines as administered by DOSH.
- Carry out comprehensive risk-based job safety/hazard analysis for all operational tasks implement risk management measures in accordance to international best practices.
- Implementation and on-going review of OHS management plans to ensure relevance and best practice at all times;

- Ensuring site design takes into account health & safety considerations;
- Ensure adequate fire detection and response measures are put in place including the identification and labelling of suitable exits;
- Ensure provision of trained first aid staff on site at all times and appropriate siting of first aid stations and equipment;
- Equipment to be designed/purchased to minimise risks of accidental human entanglement in moving parts;
- Provision of suitable PPE to protect sight, hearing, skin and respiratory systems etc;
- Provision of adequate lighting and ventilation in all areas;
- Provision of adequate toilet and shower facilities and clean eating area;
- Ensure all staff and visitors are provided with adequate basic OHS training and orientation;
- Noise prevention and mitigation measures such as selection of equipment with lower noise levels, installing silencers for fans/engine exhausts/compressors, noise barriers, relocation of equipment to less sensitive areas, installation of acoustic enclosures for equipment casing radiating noise, installation of vibration isolation measures and personal protective equipment, etc. should be applied where predicted or measured noise impacts from the facility or operations exceed the applicable noise level guideline stipulated in IFC guideline and Malaysia Environmental Noise Limits and Control. In addition, no employee should be exposed to a noise level greater than 85 dB(A) for duration of more than 8 hours per day without hearing protection. For every 3 dB(A) increase in sound levels, the 'allowed' exposure period or duration should be reduced by 5%. Periodic medical hearing checks should be performed on workers exposed to high noise levels;
- Major hazards should be managed according to international regulations and best practices (e.g., OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response, Second Edition (2003), EU Council Directive 96/82/EC, so-called Seveso II Directive, extended by the Directive 2003/105/EC, and USA EPA (EPA, 40 CFR Part 68, 1996 — Chemical accident prevention provisions);
- Emergency Response Plan and Transport Emergency Response Plan will be prepared and followed at all time;
- Facility shall provide information and involve the communities in emergency preparedness and response plans and relevant drills in case of major accident;
- Driver transporting chemicals and plant operators will be trained and/or certified to handle the chemicals and response during emergency;
- Prevention and mitigation measures identified in QRA, HAZOP, HAZID would be reinforced to avoid/eliminate or minimise the risk for hazard to as low as practically possible (ALARP);
- All spills should be avoided and precautions should be taken to control and minimize them;
- Adequate ventilation should be provided in all areas where hazardous and toxic products are handled;

- Air extraction and filtration should be provided in all indoor areas where emissions and dust can be generated;
- Gas detectors should be installed in hazard areas wherever possible;
- Storage tanks should not be located close to installations where there is a risk of fire or explosion;
- Should underground storage be present, special tank design and environmental monitoring shall be considered to manage potential for soil and groundwater contamination;
- Pipelines shall be maintained and the maintenance of pipelines (both inside and outside the facility battery limit) shall be assigned to a party;

Potential exposures to substances and chemicals during routine plant and maintenance operations should then be managed based on the results of a job safety analysis and industrial hygiene survey and according to the occupational health and safety guidance provided in the EHS Guidelines.

Residual Impact

If stipulated control measures are followed, the significance of residual impacts has been identified as **Low**, based on an assessed low impact severity and low receptor sensitivity.

7.3.9 Socio-Economics

7.3.9.1 Employment and Business Opportunities

Usually, economic changes and new employment opportunities marginalise long-term, older local residents. During operation of the proposed Project, most jobs will be for professional and technically skilled workers like engineers and technicians which require specific training. These specific skills may not readily be found in the villages around the Project area or in the surrounding region in Pengerang. These skilled workers are likely to comprise Malaysians from other parts of Johor and other states, including foreign professionals where relevant and a large number of foreign contractors and workers.

The local communities have already questioned the possibility of their residents getting jobs in the proposed Project. By their lack of numbers and the required skill sets, the local population of Kg. Lepau and the other villages located inside the Project's zone of impact and the wider Pengerang area are insufficient to meet the needs and requirements of the proposed Project. However, ancillary jobs business opportunity including and support services (for example supply of food, supply of diesel, housekeeping, barber and laundry services, transportation, homestay, etc.) could be generated by the Project and its activities and would be available for people from the surrounding settlements or villages. This would create additional income for the local community. Other business opportunity during operation phase may be related to waste management and supporting facilities of condensate splitter and aromatics which could likely be sub-contracted to eligible local business entity.

7.3.9.2 Changes in Demographic Character

One of the variables that are often correlated with adverse social impacts of development is demographic changes, such as in the size and composition of the resident population or the influx of a temporary workforce. With the influx of foreign workers, Kg. Sungai Rengit is now derogatively referred to as "Pekan Bangla" (Bangladeshi Town); residents complain that local mosques are overrun with foreigners who have also set up shops and homes there. This is in spite of Temporary Workers' Villages built and already being used within the PIPC. A drive through the edges of Kg. Sungai Rengit reveals a number of workers' quarters fashioned out of refurbished containers and other improvised facilities.

In respect to Kg. Lepau, change in the demographic pattern is already evident through the inflow of Malaysian workers from the other parts of Johor and Malaysia. At the moment, the Malaysian new comers comprise about 50% or more of the total population of Kg. Lepau. The inflow of Malaysian workers into the village is fortuitous as it allows for easier social integration and interface with the local residents. Comprising mainly males in the 20 to 40 age group with a higher level of education and higher disposable income, the arrival of the new residents has favourably changed the demographic pattern of Kg. Lepau, which is trending towards an aging population. It would be considered a positive impact if the proposed Project is able to attract younger, educated and professional/technical people into the region.

7.3.9.3 Housing the Workforce

Increasing cost of living is a significant issue in Pengerang since the construction of RAPID. Cost of food and daily needs are said to be as high as in Johor Bahru town. Added to this is the high house rental for new workers in the area, given the shortage of local rental facilities. The problem is so severe that jobseekers are offered substantial food and housing allowance to encourage them to take up the many available but unfulfilled positions in Pengerang.

While the demand for worker housing has initiated the development of new townships and other associated facilities to address the needs of the new migrant working population, it has also prompted a trend amongst the local communities to upgrade and rehabilitate some of the otherwise abandoned, underutilised or dilapidated kampong houses into rentable living quarters. In Kg. Lepau especially, a number of such houses have been upgraded to take advantage of rentals that range between RM5,000 to RM8,000 a month. Due to shortage of rentable quarters, each living quarter accommodates as many as 20 to 30 workers per living quarter. New housing demand from the proposed Project could sustain or even escalate the rental trend in Kg. Lepau, and consequently, lead to further upgrading of the local community and household income.

With respect to housing the foreign workers, they can be housed in the 22-acre site in PIP that has been earmarked as a 'village' for foreign workers. Located at the junction of Lebuhraya Pengerang and the new dedicated access road that leads to RAPID, the 22-acre site is easily accessible to the Project site.

7.3.9.4 Traffic Volume and Movement

Increased traffic volume and movement of heavy vehicles along the public roads is inevitable due to the transportation of feedstock, petroleum and aromatics products and by-products to and from the proposed Plant. However, some of the feedstock, products and by-products will be piped into or out of the Project site, thereby reducing a considerable amount of land traffic movement.

7.3.9.5 Public Health and Safety

Public health and safety is not anticipated to be an issue to residents and workers living and working inside the 1km to 3km impact zone. The air modelling has indicated that the particulate and gaseous emissions are generally within acceptable limits during normal operation phase of the plant and health impact is minimal.

However, should an abnormal situation, e.g. process upset or emergency situation, occur at the plant, part of the Sebana Mixed Development township that fronts Lebuhraya Pengerang (Route J52) may be subject to an increased concentration for SO_2. The predicted level of seriousness pertaining to health is between AEGL-1 (non-disabling to receptors) and AEGL-2 (disabling to receptors) and exceeding AEGL-2 for medium and high-rise buildings; however, the predicted probability of non-compliance i.e. exceeding AEGL-2, is about 0.02%.

The town centre of Sebana Mixed Development township is an area earmarked primarily for 2 to 3-storey shopoffices and retail premises and supported by a police station, low-rise low-cost walk-up flats, utility facilities and a polyclinic. It is understood that JCorp is in communication with the township developer to relocate the polyclinic to an alternative site that is closer to the residential components. Further, as a town centre, its residential content is likely to be low.

With respect to the safety and health of workers and residents in Sebana Mixed Development town centre, the impact may be slight based on its predicted low likelihood and provided that the stipulated control measures are followed and that only condensate with low sulphur be used in order to reduce the risks.

Overall, impact to health and safety of residents and students of the future Sebana Mixed Development township is not anticipated to be highly significant during abnormal operations as the residential areas and school reserves are located outside the predicted area of concern,

Notwithstanding the low likelihood of an abnormal situation and that the major areas of residential and education are outside the area of concern, it is expedient that an Emergency Response Plan be developed for the Sebana Mixed Development township.

Impact Evaluation

The proposed PEC project is expected to contribute to an improved household disposable income for locals, increase job and business opportunities, and improved infrastructure and facilities.

The significance of the social impacts of PEC on the socio-economic of the local population has been identified as **Positive**.

Mitigation Measures

A. Jobs, Employment and Skills Training for the Local Communities

The proposed Project has positive benefits for the local communities (for example, job creation, up-skilling and enhancement of the local economy by increasing business with local suppliers). Despite that, the local community has questioned the possibility of the local residents getting jobs in new industrial projects as few have the required skill sets.

The Johor Petroleum Development Corporation (JPDC) runs a number of programmes with a variety of entities to train and certify vocational and supervisory staff as well as provide entrepreneurial training assistance and financing. Since its incorporation in 2012, JPDC has worked in tandem with Perbadanan Usahawan Johor Berhad to hold seminars and courses on marketing and entrepreneurship for locals of all ages. Through the collaboration, they have set up cooperatives to provide food catering services to worker camps in PIPC. Working in cooperation with Petronas, both entities have set up KOPEJA (Koperasi Pengerang Jaya Johor Berhad), a cooperative with membership comprising mostly displaced residents from Taman Bayu Damai. The cooperative operates a retail station within the PIPC and members are provided with entrepreneurial and job training. Thus, along similar line, the Project Proponent could consider participating in JPDC's entrepreneurship programme to identify existing or set up new cooperatives that could service the Project's workers and the plant's activities, for example, in the provision of logistics and housing for its non-professional and technical staff.

With respect to skills training, JPDC offers training through IKBN Bandar Penawar, with the cooperation of the Youth and Sports Ministry, Petronas and SIRIM-AWS. The training aims to produce workers within a short period of time and certification that is recognised by O&G

industries. Similarly, the Project Proponent could consider participating in the skill training and certification programme for locals to ensure that they have local workers with the right skill set.

B. Health and Safety in Sebana Mixed Development Town Centre

Overall, impact to health and safety of residents and students of the future Sebana Mixed Development township arising from emergency or abnormal situations is not anticipated to be highly significant as the residential areas and school reserves are located outside the predicted area of concern, i.e. the town centre. However, with respect to the safety and health of workers and residents in the town centre, the impact to their health and safety in the event of an abnormal situation may be slight based on its predicted low likelihood and provided that the stipulated control measures are followed and only condensate with low sulphur must be used to reduce the risks.

Residual Impact

The residual impacts have been identified as **Positive**.

7.3.10 Traffic

During the operational phase, the feedstock condensate and finished products from PEC will be channelled to PDT through a series of pipelines. Other raw materials such as catalysts and chemicals will be transported to PEC on weekly basis by trucks. It is estimated that 25 trucks a week will be transporting the materials to the site.

PEC is estimated to provide 420 new employment opportunities during operational phase. From the number of personnel, 170 personnel are anticipated to be travelling with light vehicles while the other 250 personnel will be travelling by buses provided by PEC. Based on the PUSPAKOM maximum limit of 44 passengers per bus, an estimation of 6 buses will be utilised during the operational phase.

Impact Evaluation

PEC will have working shift as the plant process is continuous. Therefore, the actual number of vehicles on the road will be about 50% of the total forecasted number of vehicles with the estimation of 85 light vehicles and 3 buses per working shift.

Based on the Traffic Impact Analysis (TIA) conducted by JCorp for the development of PIP, the existing road that provides access to PEC site will be able to adequately accommodate to the increase in traffic during the operational phase. Therefore, the receptor sensitivity is considered as low.

The severity of the impact has been identified as low. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project site;
- The impact is only for the duration of the operational phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

The significance of the impact of traffic congestion due to the increase traffic volume from PEC site during the operational stage has been identified as **Low** based on an assessed low impact severity and low receptor sensitivity.

Mitigation Measures

Impacts to traffic during the operational phase are considered to be minimal as the feedstock and products will be shipped via pipeline. Other raw materials will be transported by a total of 25 trucks on weekly basis.

An increase in traffic from workers is expected. Based on the Traffic Impact Analysis conducted by JCorp for the development of PIP, the existing road that provides access to PEC site will be able to adequately accommodate to the increase in traffic during the operational phase.

All vehicles are required to comply with Malaysian road traffic regulations.

Residual Impact

With at least 85 light vehicles and 3 buses expected per working shift, the significance of the residual impacts from the increase in traffic related to the PEC facility are expected to be **Low** based on an assessed low impact severity and low receptor sensitivity.

7.3.11 Summary of Impacts during the Operational Stage

Table 7.25 summarised the impacts during the operational stage and its severity. Based on our assessment, there were no impacts of High significance during the operational stage of the project.

Table 7.25: Summary of Impacts During the Operational Stage

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
Combustion Gas Emission	• PEC Personnel	Reduction of air quality due to the emission of combustion gases.				Medium	
Emission of GHG	• PEC Personnel • Local Population	Reduction of air quality due to the emission of greenhouse gases.			Low		
Discharging of Liquid Effluent	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the discharge of liquid effluent.				Medium	
Generation of Hazardous Waste	• PEC Personnel • Local Population	Improper handling and storage of hazardous waste.			Low		
Generation of General Waste	• PEC Personnel • Local Population	Improper handling and storage of general waste.			Low		
Generation of Excessive Noise	• PEC Personnel • Local Population	Noise pollution due to the generation of elevated sound level from equipment of process plant.			Low		
Traffic Congestion	• Local Population	Increase traffic volume and heavy vehicles due to the project operation.			Low		
Employment and Business	• Local Population	Generation of spin-off business.	Positive				
Housing the workforce	• PEC Personnel • Local Population	Establishment of worker camps.	Positive				
Health and Safety of local communities	• PEC Personnel • Local Population	Increasing incidence of diseases due to the influx of foreign workers.			Low		
Occupational Safety and Health	• PEC Personnel	General health and safety risk during the operational phase.			Low		

8 CUMULATIVE IMPACTS AND MITIGATION MEASURES

This chapter details the cumulative impacts of the PEC project and associated facilities including RAPID during the different phases of its activities and prescribes the applicable and practicable mitigation measures to be implemented.

Cumulative impacts are conducted in line with the IFC Good Practice Handbook Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets and will be based on the updated publicly available data which are:

- Detailed Environmental Impact Assessment Report (DEIA) for Refinery and Petrochemical Integrated Development (RAPID) in Pengerang, Johor, 2012;
- Detailed Environmental Impact Assessment Report (DEIA) for Refinery and Petrochemical Integrated Development (RAPID) in Pengerang, Johor, 2014;
- Addendum to the RAPID Petrochemical Plants Detailed Impact Assessment (DEIA) Report, Refinery and Petrochemical Integrated Development (RAPID) Project, Pengerang, Johor, 2016; and
- Environmental Impact Assessment (EIA) Schedule 1 for *Cadangan Pembangunan Taman Perindustrian Pengerang Di Atas Sebahagian PTD 2083, Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim*, 2018.

8.1 Overview of CIA Approach

Insufficient data was the main study limitation in producing comprehensive cumulative impact study. Therefore, this assessment was done using data gathered from the field studies and readily available secondary data such as published environmental data, scientific research for the related area. With limited data, a cumulative impact study was done by using the following methodology.

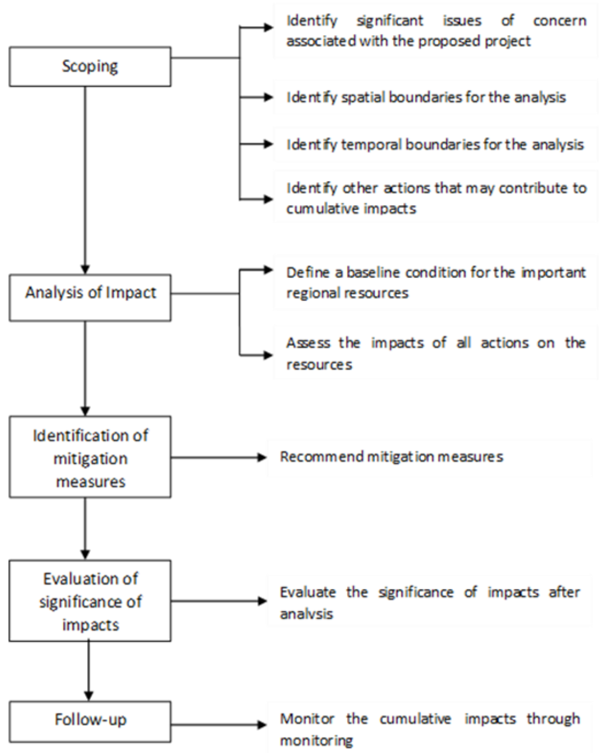


Figure 8.1 - Task Within ESHIA Framework to Address Cumulative Impacts

The scoping exercise identified the plans and projects to be considered cumulatively with the PEC project. Section 8.3 to Section 8.9 of this CIA consider, for all relevant technical topic areas, the potential cumulative impacts which may arise during the construction and operational phases of the Project. Decommissioning effects are not considered herein, because details of the works proposed during this phase are limited and they can be expected to reflect, but be less significant than, the predicted cumulative effects of the construction and operational stage.

The value and sensitivity of each receptor are taken to be the same for the CIA as defined within the relevant topic chapters of the ESHIA. The significance of any cumulative impacts is determined by the predicted change in magnitude of the effect as a result of combined effects.

The emphasis within the CIA was to undertake quantitative assessment using data that has been verified where possible. However, where this is not practicable, professional judgement has been used to determine the significance of a cumulative impact. Where significant cumulative impacts have been identified, mitigation measures and monitoring proposals have been developed where appropriate.

The technical topic areas included in the assessment are:

- Air emission;
- Noise:
- Surface water quality:
- Natural and critical habitat;
- Social – Influx of workers;
- Land traffic; and
- Associated Facilities

For the assessment of the cumulative impacts of PEC project, the identified Valued Environmental and Social Components (VECs) are as follows:

Table 8.1: Valued Environmental and Social Components (VECs)

Environmental Components	Relevant VECs	Justification
Air	• Kg. Lepau • Sebana Mixed Development • Bukit Pelali • Bukit Gelugor (Westside) • Lake View Residence • Tg. Pengelih • Pengelih Naval Base • Kg. Pengerang • Kg. Sg. Kapal • Taman Rengit Jaya • Kg. Sg. Buntu • Kg. Bukit Buloh • Kg. Sg. Rengit • Kg. Bukit Gelugor (Eastside) • Kg. Pasir Gogok • Pulau Tekong (Singapore)	Local populations could be affected by increased dust levels during construction phase and increase air emission from project activities during operational phase.
Noise	• Sebana Mixed Development • Kg. Lepau	Local populations could be affected by the increased noise levels from project

Environmental Components	Relevant VECs	Justification
		activities during both the construction and operational phase.
Surface Water	• Sg. Lepau	The water quality of Sg. Lepau could be affected by the increase of sediments discharge during the construction phase and discharge of liquid effluents during the operational phase.
Flora and Fauna	• Sg. Santi Forest Reserve	The ecological value and critical habitats of flora and fauna species in Sg. Santi Forest Reserve could be affected by the project activities during both construction and operational phase.
Social	• Pengerang	The livelihood and the demographic character of the local population of Pengerang area could be affected by the influx of foreign workers in the area.
Traffic	• Pengerang	The project activities during both construction and operational phase could change the traffic volumes and patterns.

8.1.1 Area of Influence (AoI)

The AoI as defined in the IFC PS 1 are as follows:

- The area likely to be affected by: (i) the project and the client's activities and facilities that are directly owned, operated or managed (including contractors) and that are a component of the project; (ii) impacts from unplanned but predictable developments caused by the project that may occur later or at different location; or (iii) indirect project impacts on biodiversity or on ecosystem services upon which Affected Communities' livelihoods are dependant.
- Associated facilities, which are facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable.
- Cumulative impacts that result from the incremental impacts, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted.

Based on the definition above, the AoI for this project are as listed in the table below.

Table 8.2: Area of Influence

Project Components	Owner/ Developer	AoI Element Determination*
Within PEC Site		
Clearance, levelling and preparation of PEC site	JCORP	Cumulative impacts
PEC process units (ISBL): • Condensate splitter • Aromatic plants	PEC	Funded project
PEC site facilities (OSBL):	PEC	Funded project

Project Components	Owner/ Developer	AoI Element Determination*
• Feed & product intermediate tanks • Steam boilers • Admin building & labs • Fire water, inst/ plant, cooling water • Flare • Warehouses/ maintenance shop • Onsite pipelines • Demineralised water facility • Electricity substations • Onsite roads • Onsite drains		
Offsite facilities used by/ supporting PEC – terminal/ centralised tank farm area		
Development of centralised tank farm area (including land reclamation)	DIALOG	Cumulative impacts
Condensate storage at terminal	DIALOG	Associated facility
Product storage at terminal	DIALOG	Associated facility
Import/ export jetties facilities (at terminal) – bottom sides	DIALOG	Cumulative impacts
Import/ export facilities – top sides loading facilities	DIALOG	Associated facility
Offsite facilities used by/ supporting PEC – Other		
New/ upgraded road from DIALOG tank farm/ jetty area to PIPC/ PEC	State	Cumulative impacts
Access road to west of PIP site (from J52 to west of PIP site)	JCORP (tbc)	Cumulative impacts
Condensate and product pipelines between terminal/ centralised tank farm and PEC		
Pipeline corridor (clearance/ prep/ fencing/ pipe racks)	JCORP	Cumulative impacts
Dedicated pipelines	PEC	Funded project
Supporting Utilities: • Potable water • Waste water • Electric power • Natural gas	JCORP	Cumulative impacts/ supply chain
Worker Accommodation	EPCC/ Contractors	Supply chain
Waste management facilities	TBC	TBC
Other development within PIPC but unrelated to PEC		
Existing facilities – RAPID	Petronas	Cumulative impacts
Existing facilities – wider Pengerang Deep Water Terminal (other than specific elements identified above)	DIALOG	Cumulative impacts

Project Components	Owner/ Developer	AoI Element Determination*
Other planned or reasonably defined future facilities within PIPC (TBC)	TBC	Cumulative impacts

8.2 Project Progress

RAPID

The Pengerang Integrated Petroleum Complex (PIPC) consisted of several parts which are the Pengerang Integrated Complex (PIC) which comprises of RAPID and other ancillary facilities, the Pengerang Deepwater Terminal (PDT), the Pengerang Maritime Industrial Park (PMIP) and the Pengerang Integrated Development Project (PIDP). As reported in an article titled Trends in Southeast Asia: Developing Eastern Johor: the Pengerang Integrated Petroleum Complex, 2018, the development progress within PIPC (as of January 2018) are as follows:

Table 8.3: PIPC Development Progress (as of January 2018)

Aspect	Progress: % Completion
Refinery Complex (RAPID)	94%
Steam Cracker Plant (RAPID)	91%
Petrochemical Complex (RAPID)	74.3% completion as of August 2017
Raw Water Supply Facility (PAMER)	Began operations in July 2016
Cogeneration Plant (PCP)	Began operations in October 2017
Regasification Terminal 2 (RGT2)	Began operations in October 2017
Air Separation Unit (ASU)	74%
Pengerang Deepwater Terminal 2 (PDT2)	83%
Pengerang Maritime Industrial Park (PMIP)	Target: 100 acres of land ready for topside development in mid-2018
Pengerang Integrated Development Project (PIDP)	Target: Construction begins in 2018

Source: Trends in Southeast Asia: Developing Eastern Johor: the Pengerang Integrated Petroleum Complex, 2018

The Edge Financial Daily and Hong Leong Investment Bank (21st February 2019) reported that as of 31st December 2018, PIC which includes RAPID achieved overall progress of 97% and the refinery plant has achieved crude charge-in to crude distillation unit in October 2018. The steam cracker has achieved mechanical completion and the petrochemical plants are at 93% completion and will commence its operation in the second half of 2019.

PIP

PEC will be constructed within the PIP area. JCorp will be responsible in preparing the land and other centralized facilities such as the drainage system and retention pond for PEC and the other future tenants. Overall, the PIP will be utilized for medium and heavy industries.

Based on PIP EIA, the development of the project will be conducted in 4 phases within the period of 4 years starting from 2018 to 2021. The construction will commence in Q3 of 2018. The main activities include:

Table 8.4: Construction Programme

Section/ Activity	Start Date	End Date
Earthwork (Phase 1)	Q3 2018	Q2 2019
Earthwork (Phase 2A)	Q1 2019	Q3 2019
Earthwork (Phase 2B & 3)	Q1 2019	Q1 2020

Section/ Activity	Start Date	End Date
Main Drain & Detention Pond	Q4 2018	Q2 2019
Water Supply – Reservoir, Suction Tank, Pump House & Incoming Main	Q2 2019	Q1 2021
Sewerage	Q1 2020	Q4 2020
STP & Pumping Station	Q2 2019	Q1 2021
Infrastructure Work – Road, Drain, Sewer Line, Water Pipeline	Q2 2019	Q3 2021

Source: EIA for PIP, 2018

PEC

The construction of the PEC facility is projected to commence in Q1 2020 and will stretch up to 2022, with the start-up in 2023. Impacts during the construction phase will be from activities related to the construction of the facilities onsite which include the production, administrative and utility structures, internal roads, and vehicle parking areas. The activities which have the potential to affect the environment and surrounding area during the construction and operational phase are as discussed in Chapter 7.

8.3 Air Emission

This section will only evaluate the cumulative air impact based on the information on the documents listed in section 8 of this chapter as well as the DoE approved PEC EIA. There are no other data regarding the impact of air on Pengerang area resulting from the processes of RAPID and PIP that are available for public review.

For the assessment of the cumulative air impact to the surrounding area of PEC, the air quality modelling conducted during the development of now DoE approved PEC EIA was reassessed with the additional air sensitive receptors (ASRs) from RAPID. The ASRs from RAPID Project were renamed to accommodate the PEC Project. The new identified ASRs are as shown in *Table 8.5*

Table 8.5: Identified Air Sensitive Receptors (ASRs)

Identified Air Monitoring Locations	Point	
	RAPID	PEC
Tg. Pengelih	AQ1	R1
Pengelih Naval Base	AQ2	R2
Kg. Pengerang	AQ3	R3
Kg. Sg. Kapal	AQ4	R4
Taman Rengit Jaya	AQ5	R5
Kg. Sg. Buntu	AQ6	R6
Kg. Bukit Buloh	AQ7	R7
Kg. Sg. Rengit	AQ8	R8
Kg. Bukit Gelugor (Eastside)	AQ9	R9
Kg. Lepau	AQ10	ASR1
Kg. Pasir Gogok	AQ11	R10
Pulau Tekong (Singapore)	-	R11

Other sources of information utilised for the reassessment of the air quality modelling will be the same as the air quality modelling conducted previously during the development of PEC EIA. These include the stack specification, proposed flare specification, and emission rates of gaseous pollutants released *(refer Table 7.8 – Table 7.11 in Chapter 7).*

The reassessment of the air quality modelling will evaluate two (2) emission scenarios as conducted previously during the development of PEC EIA.

The two (2) emission scenarios considered were:

- Base Scenario: Normal plant operation based on maximum emissions at maximum plant production capacity; and
- Abnormal Scenario: Abnormal plant condition or worst-case emissions whereby emissions are released into the atmosphere without the pollution control equipment in place (i.e. uncontrolled emissions).

8.3.1 Impact Evaluation

8.3.1.1 Receptor Grid System

A 23 km x 17 km Cartesian grid with 340 m spacing was used for the impact modelling, the Cartesian grid was gridded from the centre of the study area at the UTM coordinate of 406760.47 m (x-coordinate), 153515.02 m (y-coordinate). The discrete Air Sensitive Receptors identified for this study is as shown in *Table 8.6.*

Table 8.6: Identified Air Sensitive Receptors (ASRs)

Point	Description	UTM Coordinate	
		X	Y
ASR1	Open Space Near Kg. Lepau	405440.40	153531.26
ASR2	Sebana Cove Resort	406368.00	155680.00
ASR3	Sebana Golf Resort	408531.48	155476.93
ASR4	Bukit Pelali	411003.52	154757.55
ASR5	Open Space Near Kg. Bukit Gelugor (Westside)	412239.45	154143.02
ASR6	Open Space Near Lake View	412857.32	153528.69
R1	Tg. Pengelih	398618.46	151307.55
R2	Pengelih Naval Base	399769.33	152080.6
R3	Kg. Pengerang	401124.86	150698.62
R4	Kg. Sg. Kapal	409607.91	150060
R5	Taman Rengit Jaya	409941.5	149513.82
R6	Kg. Sg. Buntu	411013.64	148437.89
R7	Kg. Bukit Buloh	411122.36	150854.29
R8	Kg. Sg. Rengit	413433.1	150189.62
R9	Kg. Bukit Gelugor (Eastside)	413705.74	154218.84
R10	Kg. Pasir Gogok	400529.08	156954.35
R11	Pulau Tekong (Singapore)	397514.00	156405.00

*Note: Sensitive Receptors (R) except R11 modified from Additional Information to the DEIA Refinery and Petrochemical Integrated Development (RAPID) Project, Pengerang, Johor 2012 to include EURO 5 Mogas and Olefin Tank Units (April 2017) prepared by Integrated Envirotech Sdn Bhd for PRPC Refinery Cracker (RC) Sdn Bhd (**RAPID EIA**)*

8.3.1.2 Normal Operation

<u>Particulates Matters as PM_{10}</u>

The highest predicted MAICs of PM_{10} for 24-hours averaging time was at 2.92 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.171 µg/m^3 to 1.079 µg/m^3. For PM_{10}, the calculated 24-hours averaging time GLCs (i.e. addition of Baseline Level and MAIC of PEC) at the identified ASRs ranged from 0.186 µg/m^3 to 66.063 µg/m^3, which meet the MAAQS, 2013 (Standard [2020]) prescribed limit of 100 µg/m^3. However, ASR1 and ASR3 did not meet the WHO Air Quality Guidelines prescribed limit of 50 µg/m^3. At the same time, the calculated 24-hours averaging time Cumulative GLCs (i.e. addition of Baseline Level, MAIC of PEC and RAPID) at the identified ASRs ranged from 0.686 µg/m^3 to 66.813 µg/m^3, in which ASR1 and ASR3 did not meet the WHO Air Quality Guidelines prescribed limit of 50 µg/m^3. The iso-contour for 24-hours averaging time is as shown in *Figure 8.2.*

The highest predicted MAICs of PM_{10} for annual average was at 0.47 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.007 µg/m^3 to 0.138 µg/m^3. For PM_{10}, the calculated annual average GLCs (i.e. addition of Baseline Level and MAIC of PEC) at the identified ASRs ranged from 0.007 µg/m^3 to 0.138 µg/m^3, which meet the MAAQS, 2013 (Standard [2020]) and WHO Air Quality Guidelines prescribed limit of 40 µg/m^3 and 20 µg/m^3 respectively. At the same time, the calculated annual average of Cumulative GLCs (i.e. addition of Baseline Level and MAIC of PEC and RAPID) at the identified ASRs ranged from 0.030 µg/m^3 to 0.288 µg/m^3, which also meet the MAAQS, 2013 (Standard [2020]) and WHO Air Quality Guidelines prescribed limit of 40 µg/m^3 and 20 µg/m^3 respectively. The iso-contour for annual average is as shown in *Figure 8.3.*

The highest predicted MAICs of $PM_{2.5}$ for 24-hours averaging time was at 2.92 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.171 µg/m^3 to 1.079 µg/m^3. For $PM_{2.5}$, the calculated 24-hours averaging time GLCs (i.e. addition of Baseline Level and MAIC of PEC) at the identified ASRs ranged from 0.171 µg/m^3 to 34.863 µg/m^3, which meet the MAAQS, 2013 (Standard [2020]) prescribed limit of 35 µg/m^3. However, ASR1, ASR2, ASR3 and ASR5 did not meet the WHO Air Quality Guidelines prescribed limit of 25 µg/m^3. On the other hand, the calculated 24-hours averaging time of Cumulative GLCs (i.e. addition of Baseline Level and MAIC of PEC and RAPID) at the identified ASRs ranged from 0.415 µg/m^3 to 35.463 µg/m^3, in which ASR1 did not meet both the MAAQS, 2013 (Standard [2020]) as well as WHO Air Quality Guidelines prescribed limit of 35 µg/m^3 and 25 µg/m^3 respectively. At the same time, ASR2, ASR3 and ASR5 did not meet the WHO Air Quality Guidelines prescribed limit of 25 µg/m^3. The iso-contour for 24-hours averaging time is as shown in *Figure 8.2.*

The highest predicted MAICs of $PM_{2.5}$ for annual average was at 0.47 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.007 µg/m^3 to 0.138 µg/m^3. For $PM_{2.5}$, the calculated annual average GLCs (i.e. addition of Baseline Level and MAIC of PEC) at the identified ASRs ranged from 0.007 µg/m^3 to 0.138 µg/m^3, which meet the MAAQS, 2013 (Standard [2020]) and WHO Air Quality Guidelines prescribed limit of 15 µg/m^3 and 10 µg/m^3 respectively. At the same time, the calculated annual average of Cumulative GLCs (i.e. addition of Baseline Level and MAIC of PEC and RAPID) at the identified ASRs ranged from 0.024 µg/m^3 to 0.238 µg/m^3, which meet both the MAAQS, 2013 (Standard [2020]) as well as WHO Air Quality Guidelines prescribed limit of 40 µg/m^3 and 20 µg/m^3 respectively. The iso-contour for annual average is as shown in *Figure 8.3.*

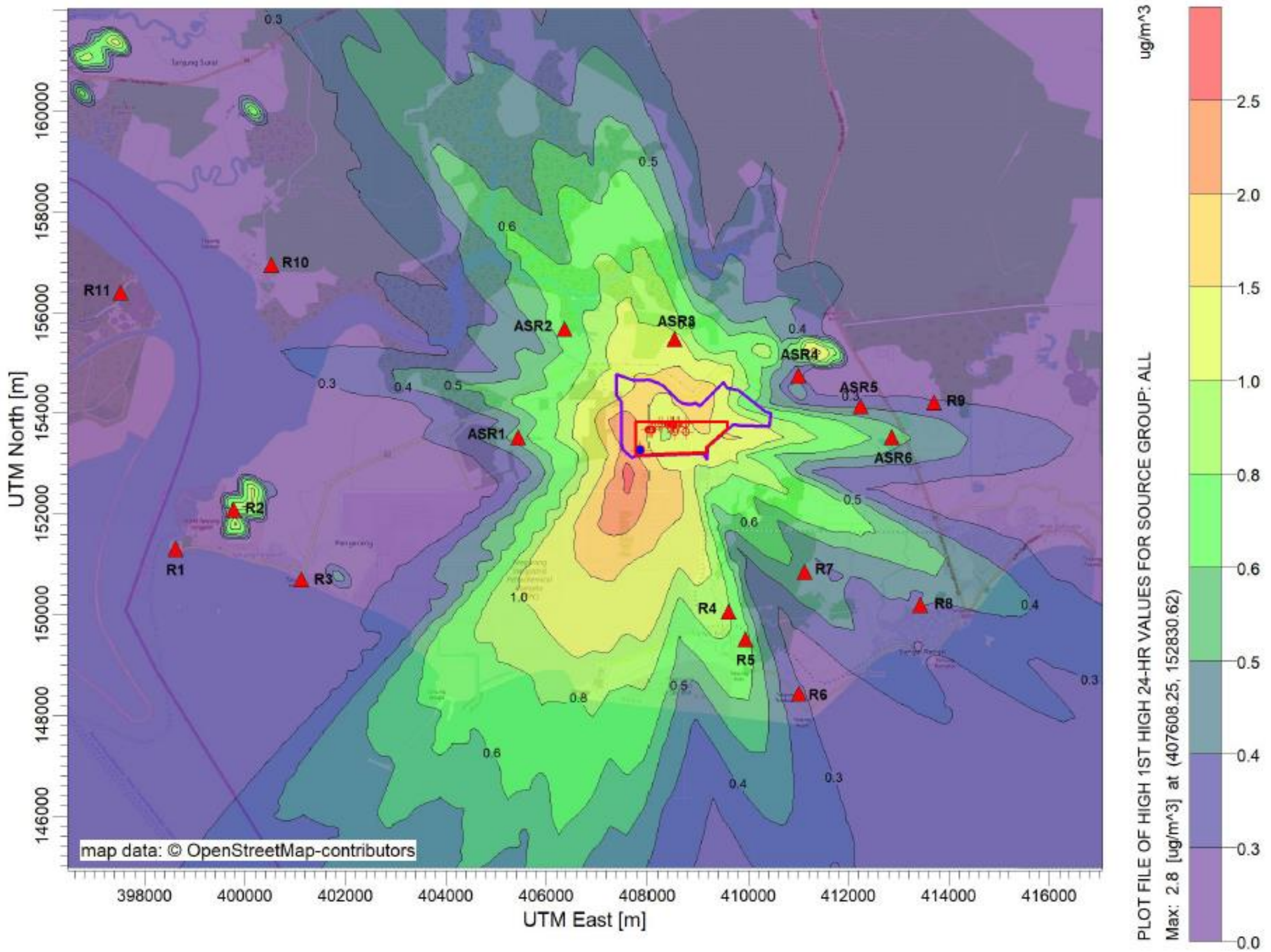


Figure 8.2 – Predicted Maximum 24-hours Average Incremental Concentration of PM_{10}/ $PM_{2.5}$ during Normal Operation

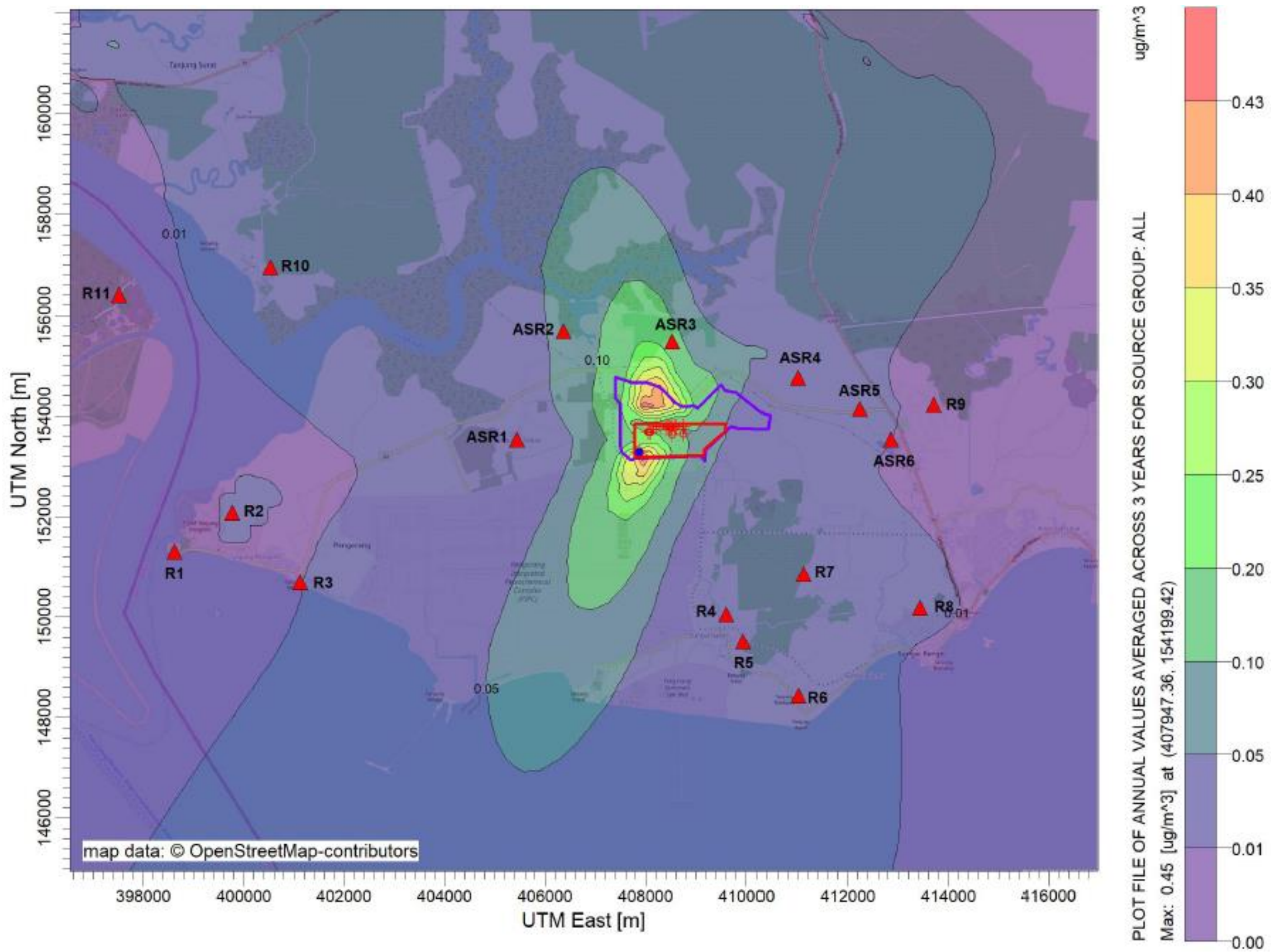


Figure 8.3– Predicted Maximum Annual Average Incremental Concentration of PM_{10}/ $PM_{2.5}$ during Normal Operation

Particulates Matters as PM_{10}

Table 8.7: Predicted 24-Hours MAICs for PM_{10} (in µg/m^3) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m^3)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (100 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines (50 µg/m^3)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC+ RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (100 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines (50 µg/m^3)
PM_{10}	24-Hours	ASR1	Open Space Near Kg. Lepau	65.50	0.563	66.063	Yes	No	0.750*	66.813	Yes	No
		ASR2	Sebana Cove Resort	41.00	0.683	41.683	Yes	Yes	0.750*	42.433	Yes	Yes
		ASR3	Sebana Golf Resort	60.50	1.079	61.579	Yes	No	0.750*	62.329	Yes	No
		ASR4	Bukit Pelali	23.00	0.313	23.313	Yes	Yes	0.750*	24.063	Yes	Yes
		ASR5	Open Space Near Kg. Bukit Gelugor	48.50	0.382	48.882	Yes	Yes	0.500*	49.382	Yes	Yes
		ASR6	Open Space Near Lake View	41.00	0.549	41.549	Yes	Yes	0.500*	42.049	Yes	Yes
		R1	Tg. Pengelih	24.00	0.171	24.171	Yes	Yes	0.339	24.510	Yes	Yes
		R2	Pengelih Naval Base	24.00	0.640	24.640	Yes	Yes	2.500	27.140	Yes	Yes
		R3	Kg. Pengerang	36.00	0.210	36.210	Yes	Yes	0.467	36.677	Yes	Yes
		R4	Kg. Sg. Kapal	25.00	0.829	25.829	Yes	Yes	0.544	26.373	Yes	Yes
		R5	Taman Rengit Jaya	38.00	0.644	38.644	Yes	Yes	0.531	39.175	Yes	Yes
		R6	Kg. Sg. Buntu	28.00	0.336	28.336	Yes	Yes	0.476	28.812	Yes	Yes
		R7	Kg. Bukit Buloh	31.00	0.479	31.479	Yes	Yes	0.513	31.992	Yes	Yes
		R8	Kg. Sg. Rengit	20.00	0.402	20.402	Yes	Yes	0.428	20.830	Yes	Yes
		R9	Kg. Bukit Gelugor	22.00	0.309	22.309	Yes	Yes	0.361	22.670	Yes	Yes
		R10	Kg. Pasir Gogok	20.00	0.190	20.190	Yes	Yes	0.381	20.571	Yes	Yes
		R11	Pulau Tekong (Singapore)	N/M	0.186	0.186	Yes	Yes	0.500*	0.686	Yes	Yes

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.8: Predicted Annual MAICs for PM_{10} (in µg/m^3) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m^3)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (40 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines (20 µg/m^3)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (40 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines (20 µg/m^3)
PM_{10}	Annual	ASR1	Open Space Near Kg. Lepau	N/M	0.024	0.024	**Yes**	**Yes**	0.150*	0.174	**Yes**	**Yes**
		ASR2	Sebana Cove Resort		0.061	0.061	**Yes**	**Yes**	0.150*	0.211	**Yes**	**Yes**
		ASR3	Sebana Golf Resort		0.138	0.138	**Yes**	**Yes**	0.150*	0.288	**Yes**	**Yes**
		ASR4	Bukit Pelali		0.019	0.019	**Yes**	**Yes**	0.100*	0.119	**Yes**	**Yes**
		ASR5	Open Space Near Kg. Bukit Gelugor		0.012	0.012	**Yes**	**Yes**	0.100*	0.112	**Yes**	**Yes**
		ASR6	Open Space Near Lake View		0.010	0.010	**Yes**	**Yes**	0.050*	0.060	**Yes**	**Yes**
		R1	Tg. Pengelih		0.007	0.007	**Yes**	**Yes**	0.023	0.030	**Yes**	**Yes**
		R2	Pengelih Naval Base		0.022	0.022	**Yes**	**Yes**	0.080	0.102	**Yes**	**Yes**
		R3	Kg. Pengerang		0.010	0.010	**Yes**	**Yes**	0.032	0.042	**Yes**	**Yes**
		R4	Kg. Sg. Kapal		0.022	0.022	**Yes**	**Yes**	0.081	0.103	**Yes**	**Yes**
		R5	Taman Rengit Jaya		0.019	0.019	**Yes**	**Yes**	0.077	0.096	**Yes**	**Yes**
		R6	Kg. Sg. Buntu		0.015	0.015	**Yes**	**Yes**	0.064	0.079	**Yes**	**Yes**
		R7	Kg. Bukit Buloh		0.015	0.015	**Yes**	**Yes**	0.063	0.078	**Yes**	**Yes**
		R8	Kg. Sg. Rengit		0.011	0.011	**Yes**	**Yes**	0.047	0.058	**Yes**	**Yes**
		R9	Kg. Bukit Gelugor		0.009	0.009	**Yes**	**Yes**	0.042	0.051	**Yes**	**Yes**
		R10	Kg. Pasir Gogok		0.012	0.012	**Yes**	**Yes**	0.031	0.043	**Yes**	**Yes**
		R11	Pulau Tekong (Singapore)		0.009	0.009	**Yes**	**Yes**	0.050*	0.059	**Yes**	**Yes**

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Particulates Matters as $PM_{2.5}$

Table 8.9: Predicted 24-hours MAICs for $PM_{2.5}$ (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (35 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines (25 µg/m³)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (35 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines (25 µg/m³)
$PM_{2.5}$	24-Hours	ASR1	Open Space Near Kg. Lepau	34.30	0.563	34.863	**Yes**	**No**	0.600*	**35.463**	**No**	**No**
		ASR2	Sebana Cove Resort	30.00	0.683	30.683	**Yes**	**No**	0.400*	**31.083**	**Yes**	**No**
		ASR3	Sebana Golf Resort	25.70	1.079	26.779	**Yes**	**No**	0.600*	**27.379**	**Yes**	**No**
		ASR4	Bukit Pelali	17.70	0.313	18.013	**Yes**	**Yes**	0.400*	**18.413**	**Yes**	**Yes**
		ASR5	Open Space Near Kg. Bukit Gelugor	34.00	0.382	34.382	**Yes**	**No**	0.400*	**34.782**	**Yes**	**No**
		ASR6	Open Space Near Lake View	22.70	0.549	23.249	**Yes**	**Yes**	0.400*	**23.649**	**Yes**	**Yes**
		R1	Tg. Pengelih	N/M	0.171	0.171	**Yes**	**Yes**	0.244	**0.415**	**Yes**	**Yes**
		R2	Pengelih Naval Base		0.640	0.640	**Yes**	**Yes**	1.600	**2.240**	**Yes**	**Yes**
		R3	Kg. Pengerang		0.210	0.210	**Yes**	**Yes**	0.321	**0.531**	**Yes**	**Yes**
		R4	Kg. Sg. Kapal		0.829	0.829	**Yes**	**Yes**	0.361	**1.190**	**Yes**	**Yes**
		R5	Taman Rengit Jaya		0.644	0.644	**Yes**	**Yes**	0.361	**1.005**	**Yes**	**Yes**
		R6	Kg. Sg. Buntu		0.336	0.336	**Yes**	**Yes**	0.314	**0.650**	**Yes**	**Yes**
		R7	Kg. Bukit Buloh		0.479	0.479	**Yes**	**Yes**	0.339	**0.818**	**Yes**	**Yes**
		R8	Kg. Sg. Rengit		0.402	0.402	**Yes**	**Yes**	0.296	**0.698**	**Yes**	**Yes**
		R9	Kg. Bukit Gelugor		0.309	0.309	**Yes**	**Yes**	0.253	**0.562**	**Yes**	**Yes**
		R10	Kg. Pasir Gogok		0.190	0.190	**Yes**	**Yes**	0.267	**0.457**	**Yes**	**Yes**
		R11	Pulau Tekong (Singapore)		0.186	0.186	**Yes**	**Yes**	0.400*	**0.586**	**Yes**	**Yes**

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.10: Predicted Annual MAICs for $PM_{2.5}$ (in μg/m^3) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (μg/m^3)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (15 μg/m^3)	Compliance with WHO Ambient Air Quality Guidelines (10 μg/m^3)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (15 μg/m^3)	Compliance with WHO Ambient Air Quality Guidelines (10 μg/m^3)
$PM_{2.5}$	Annual	ASR1	Open Space Near Kg. Lepau	N/M	0.024	0.024	**Yes**	**Yes**	0.100*	0.124	**Yes**	**Yes**
		ASR2	Sebana Cove Resort		0.061	0.061	**Yes**	**Yes**	0.100*	0.161	**Yes**	**Yes**
		ASR3	Sebana Golf Resort		0.138	0.138	**Yes**	**Yes**	0.100*	0.238	**Yes**	**Yes**
		ASR4	Bukit Pelali		0.019	0.019	**Yes**	**Yes**	0.050*	0.069	**Yes**	**Yes**
		ASR5	Open Space Near Kg. Bukit Gelugor		0.012	0.012	**Yes**	**Yes**	0.050*	0.062	**Yes**	**Yes**
		ASR6	Open Space Near Lake View		0.010	0.010	**Yes**	**Yes**	0.050*	0.060	**Yes**	**Yes**
		R1	Tg. Pengelih		0.007	0.007	**Yes**	**Yes**	0.017	0.024	**Yes**	**Yes**
		R2	Pengelih Naval Base		0.022	0.022	**Yes**	**Yes**	0.052	0.074	**Yes**	**Yes**
		R3	Kg. Pengerang		0.010	0.010	**Yes**	**Yes**	0.023	0.033	**Yes**	**Yes**
		R4	Kg. Sg. Kapal		0.022	0.022	**Yes**	**Yes**	0.054	0.076	**Yes**	**Yes**
		R5	Taman Rengit Jaya		0.019	0.019	**Yes**	**Yes**	0.052	0.071	**Yes**	**Yes**
		R6	Kg. Sg. Buntu		0.015	0.015	**Yes**	**Yes**	0.045	0.060	**Yes**	**Yes**
		R7	Kg. Bukit Buloh		0.015	0.015	**Yes**	**Yes**	0.044	0.059	**Yes**	**Yes**
		R8	Kg. Sg. Rengit		0.011	0.011	**Yes**	**Yes**	0.034	0.045	**Yes**	**Yes**
		R9	Kg. Bukit Gelugor		0.009	0.009	**Yes**	**Yes**	0.031	0.040	**Yes**	**Yes**
		R10	Kg. Pasir Gogok		0.012	0.012	**Yes**	**Yes**	0.023	0.035	**Yes**	**Yes**
		R11	Pulau Tekong (Singapore)		0.009	0.009	**Yes**	**Yes**	0.050*	0.059	**Yes**	**Yes**

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Nitrogen Dioxide (NO_X as 100% NO_2)

The highest predicted MAICs of NOx for 1-hour averaging time was at 359.34 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 24.393 µg/m^3 to 17.061 µg/m^3. For NOx, the calculated 1-hour averaging time GLCs (i.e. addition of Baseline Level and MAIC of PEC) at the identified ASRs ranged from 24.393 µg/m^3 to 170.061 µg/m^3, which meet both the MAAQS, 2013 (Standard [2020]) and WHO Air Quality Guidelines prescribed limit of 280 µg/m^3 and 200 µg/m^3 respectively. On the other hand, the calculated 1-hour averaging time of Cumulative GLCs (i.e. addition of Baseline Level and MAIC of PEC and RAPID) at the identified ASRs ranged from 112.857 µg/m^3 to 451.461 µg/m^3, in which R2 did not meet both the MAAQS, 2013 (Standard [2020]), as well as WHO Air Quality Guidelines prescribed limit of 280 µg/m^3 and 200 µg/m^3 respectively. At the same time, ASR1, ASR2, ASR3, ASR4, ASR5, ASR6, R4 and R7 did not meet the WHO Air Quality Guidelines prescribed limit of 200 µg/m^3. The iso-contour for 1-hour averaging time is as shown in *Figure 8.4.*

The highest predicted MAICs of NOx for 24-hours averaging time was at 42.26 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 1.731 µg/m^3 to 10.962 µg/m^3 (24-hours averaging time). For NOx, the calculated 24-hours averaging time GLCs (i.e. addition of Baseline Level and MAIC of PEC) and Cumulative GLCs (i.e. addition of Baseline Level and MAIC of PEC and RAPID) at the identified ASRs ranged from 1.731 µg/m^3 to 15.962 µg/m^3 and 11.951 µg/m^3 to 52.236 µg/m^3 respectively, which meet the MAAQS, 2013 (Standard [2020]) prescribed limit of 70 µg/m^3. The iso-contour for 24-hours averaging time is as shown in *Figure 8.5.*

The highest predicted annual average MAIC of NO_2 was 5.95 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.072 µg/m^3 to 1.203 µg/m^3. At the identified ASRs, the calculated annual average GLCs ranged from 0.072 µg/m^3 to 1.203 µg/m^3, which comply to the WHO Air Quality Guidelines prescribed limit of 40 µg/m^3. The iso-contour for annual average is as shown in *Figure 8.6.*

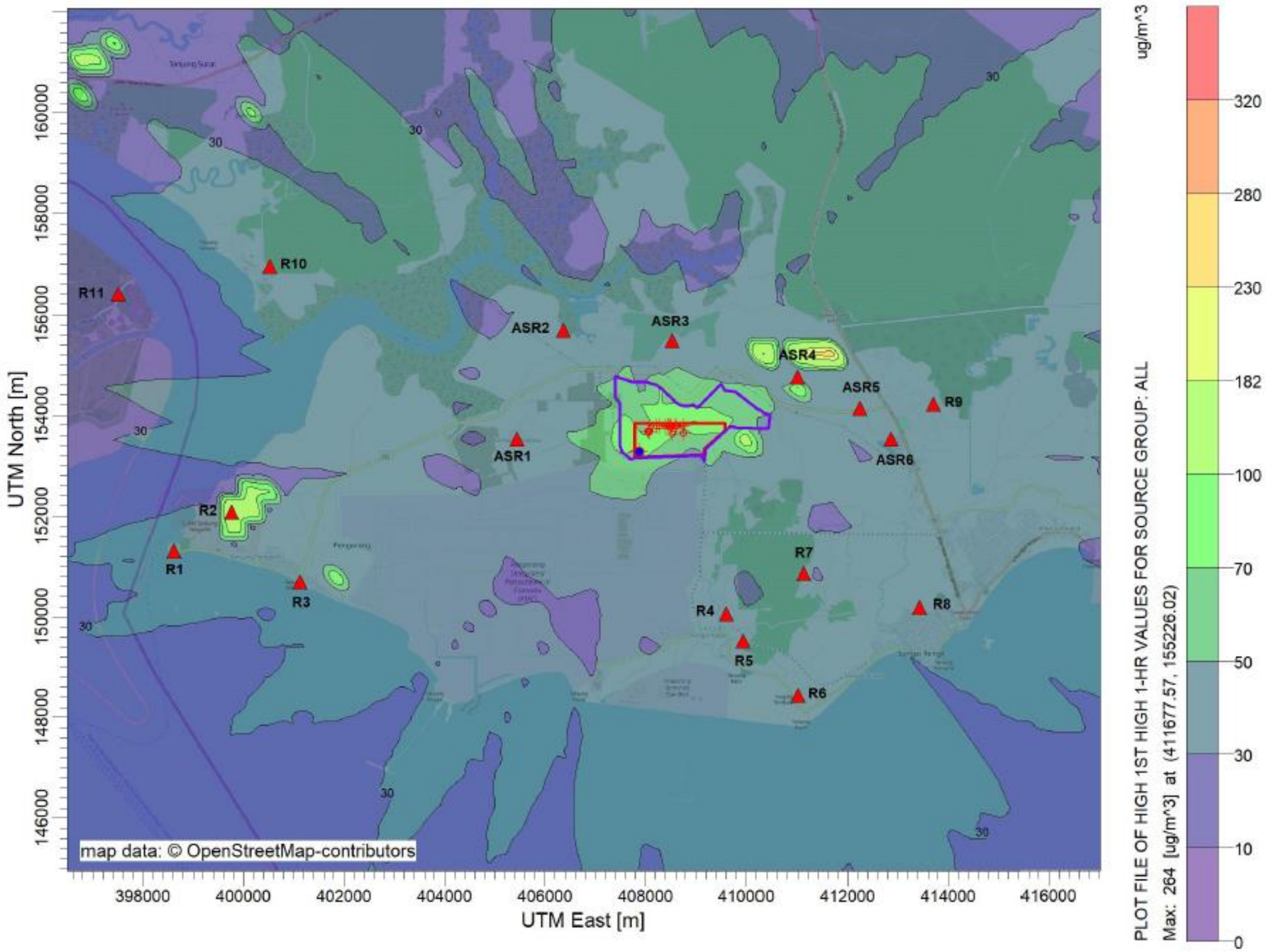


Figure 8.4 – Predicted Maximum 1-hour Average Incremental Concentration of NOx during Normal Operation

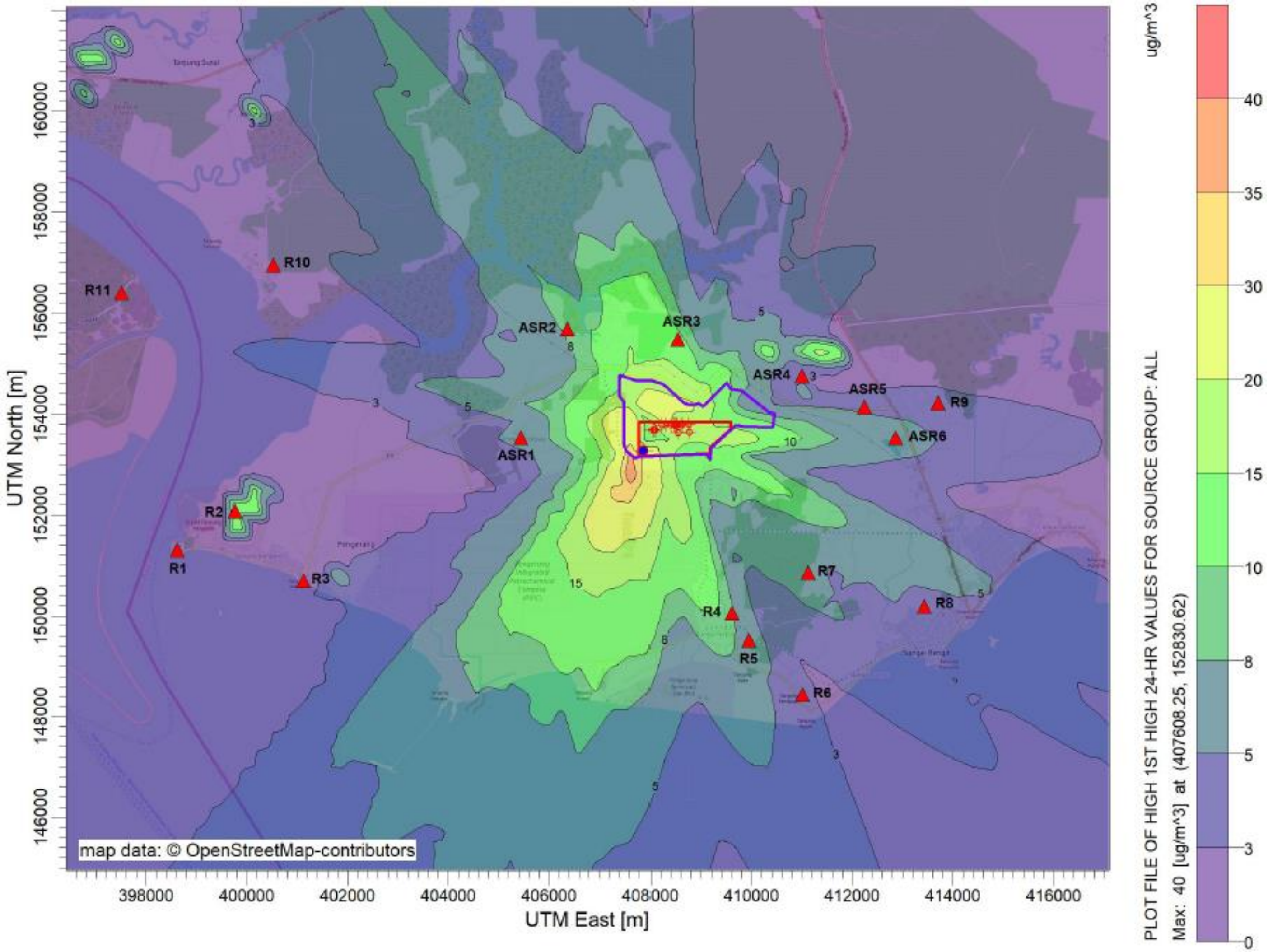


Figure 8.5 – Predicted Maximum 24-Hours Average Incremental Concentration of NOx during Normal Operation

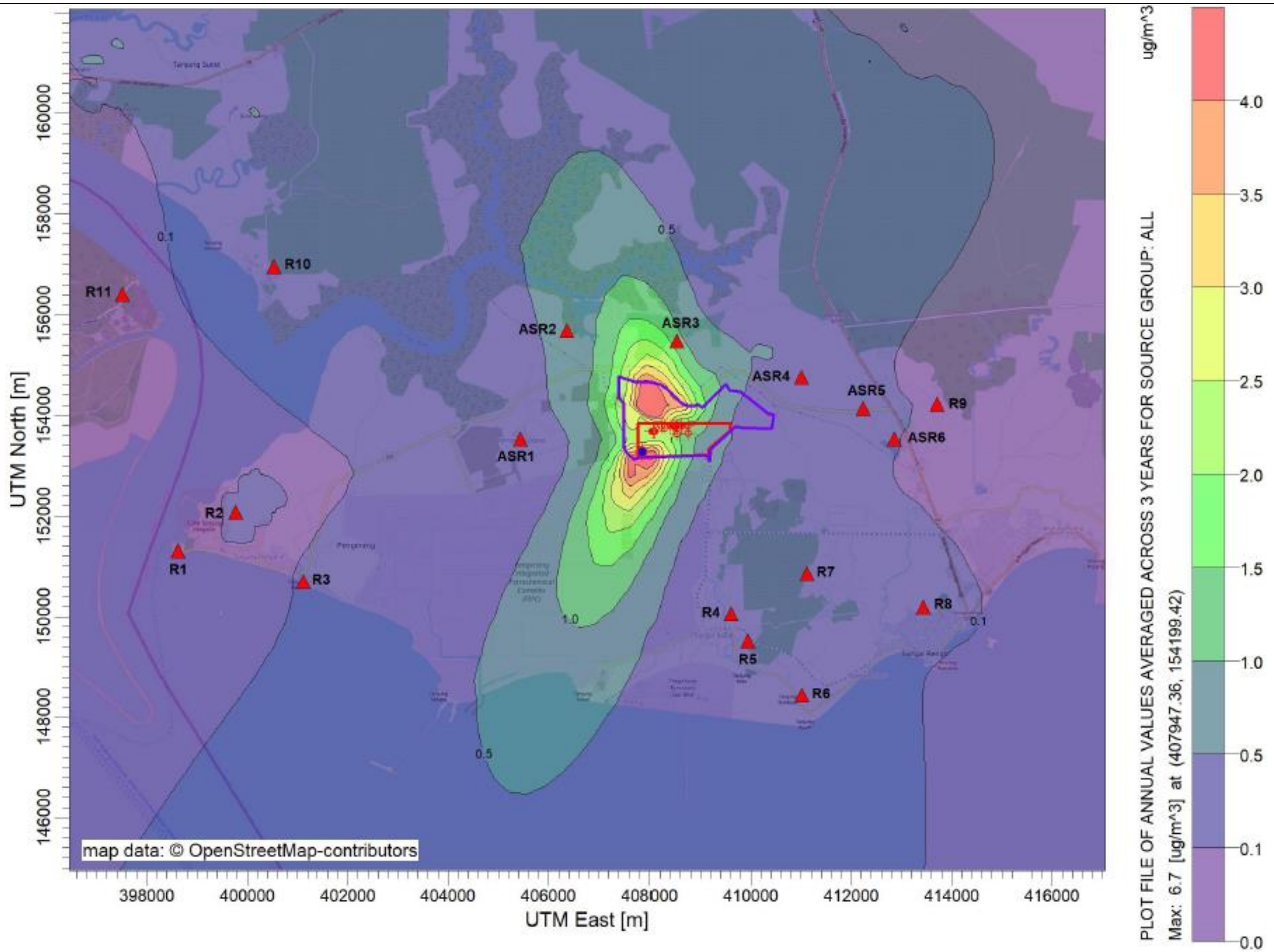


Figure 8.6 – Predicted Maximum Annual Average Incremental Concentration of NOx during Normal Operation

Table 8.11: Predicted 1-Hour MAICs for NOx (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (280 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines (200 µg/m³)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (280 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines (200 µg/m³)
NOx	1-Hour	ASR1	Open Space Near Kg. Lepau	N/M	33.844	33.844	**Yes**	**Yes**	175.000*	208.844	**Yes**	**No**
		ASR2	Sebana Cove Resort		37.128	37.128	**Yes**	**Yes**	175.000*	212.128	**Yes**	**No**
		ASR3	Sebana Golf Resort		40.555	40.555	**Yes**	**Yes**	175.000*	215.555	**Yes**	**No**
		ASR4	Bukit Pelali		42.781	42.781	**Yes**	**Yes**	175.000*	217.781	**Yes**	**No**
		ASR5	Open Space Near Kg. Bukit Gelugor		35.226	35.226	**Yes**	**Yes**	175.000*	210.226	**Yes**	**No**
		ASR6	Open Space Near Lake View		36.520	36.520	**Yes**	**Yes**	175.000*	211.520	**Yes**	**No**
		R1	Tg. Pengelih	<5	31.857	31.857	**Yes**	**Yes**	81.000	112.857	**Yes**	**Yes**
		R2	Pengelih Naval Base	<5	170.061	170.061	**Yes**	**Yes**	281.400	451.461	**No**	**No**
		R3	Kg. Pengerang	<5	35.242	35.242	**Yes**	**Yes**	103.000	138.242	**Yes**	**Yes**
		R4	Kg. Sg. Kapal	<5	36.930	36.930	**Yes**	**Yes**	181.500	218.430	**Yes**	**No**
		R5	Taman Rengit Jaya	<5	31.957	31.957	**Yes**	**Yes**	141.000	172.957	**Yes**	**Yes**
		R6	Kg. Sg. Buntu	<5	38.097	38.097	**Yes**	**Yes**	99.900	137.997	**Yes**	**Yes**
		R7	Kg. Bukit Buloh	<5	32.518	32.518	**Yes**	**Yes**	175.600	208.118	**Yes**	**No**
		R8	Kg. Sg. Rengit	N/D	37.873	37.873	**Yes**	**Yes**	133.300	171.173	**Yes**	**Yes**
		R9	Kg. Bukit Gelugor	<5	37.727	37.727	**Yes**	**Yes**	127.800	165.527	**Yes**	**Yes**
		R10	Kg. Pasir Gogok	N/D	38.359	38.359	**Yes**	**Yes**	92.200	130.559	**Yes**	**Yes**
		R11	Pulau Tekong (Singapore)	N/M	24.393	24.393	**Yes**	**Yes**	105.000*	129.393	**Yes**	**Yes**

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.12: Predicted 24-Hours MAICs for NOx (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (70 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (70 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines
NOx	24-Hours	ASR1	Open Space Near Kg. Lepau	4.5	6.204	10.704	**Yes**	-	20.000*	30.704	**Yes**	-
		ASR2	Sebana Cove Resort	<5	8.140	8.140	**Yes**		20.000*	28.140	**Yes**	
		ASR3	Sebana Golf Resort	5.0	10.962	15.962	**Yes**		30.000*	45.962	**Yes**	
		ASR4	Bukit Pelali	4.0	3.218	7.218	**Yes**		20.000*	27.218	**Yes**	
		ASR5	Open Space Near Kg. Bukit Gelugor	<5	4.161	4.161	**Yes**		20.000*	24.161	**Yes**	
		ASR6	Open Space Near Lake View	<5	6.015	6.015	**Yes**		20.000*	26.015	**Yes**	
		R1	Tg. Pengelih	N/M	1.731	1.731	**Yes**		10.900	12.631	**Yes**	
		R2	Pengelih Naval Base		10.436	10.436	**Yes**		41.800	52.236	**Yes**	
		R3	Kg. Pengerang		2.739	2.739	**Yes**		13.200	15.939	**Yes**	
		R4	Kg. Sg. Kapal		8.330	8.330	**Yes**		21.400	29.730	**Yes**	
		R5	Taman Rengit Jaya		6.228	6.228	**Yes**		21.200	27.428	**Yes**	
		R6	Kg. Sg. Buntu		3.708	3.708	**Yes**		18.900	22.608	**Yes**	
		R7	Kg. Bukit Buloh		5.575	5.575	**Yes**		16.100	21.675	**Yes**	
		R8	Kg. Sg. Rengit		4.752	4.752	**Yes**		12.100	16.852	**Yes**	
		R9	Kg. Bukit Gelugor		3.383	3.383	**Yes**		12.200	15.583	**Yes**	
		R10	Kg. Pasir Gogok		2.112	2.112	**Yes**		12.100	14.212	**Yes**	
		R11	Pulau Tekong (Singapore)		1.951	1.951	**Yes**		10.000*	11.951	**Yes**	

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.13: Predicted Annual MAICs for NOx (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines (40 µg/m³)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines (40 µg/m³)
NOx	Annual	ASR1	Open Space Near Kg. Lepau	N/M	0.262	0.262	-	**Yes**	-	-	-	-
		ASR2	Sebana Cove Resort		0.705	0.705		**Yes**				
		ASR3	Sebana Golf Resort		1.203	1.203		**Yes**				
		ASR4	Bukit Pelali		0.188	0.188		**Yes**				
		ASR5	Open Space Near Kg. Bukit Gelugor		0.120	0.120		**Yes**				
		ASR6	Open Space Near Lake View		0.104	0.104		**Yes**				
		R1	Tg. Pengelih		0.072	0.072		**Yes**				
		R2	Pengelih Naval Base		0.297	0.297		**Yes**				
		R3	Kg. Pengerang		0.103	0.103		**Yes**				
		R4	Kg. Sg. Kapal		0.241	0.241		**Yes**				
		R5	Taman Rengit Jaya		0.207	0.207		**Yes**				
		R6	Kg. Sg. Buntu		0.165	0.165		**Yes**				
		R7	Kg. Bukit Buloh		0.162	0.162		**Yes**				
		R8	Kg. Sg. Rengit		0.115	0.115		**Yes**				
		R9	Kg. Bukit Gelugor		0.090	0.090		**Yes**				
		R10	Kg. Pasir Gogok		0.127	0.127		**Yes**				
		R11	Pulau Tekong (Singapore)		0.090	0.090		**Yes**				

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

<u>Sulphur Dioxide (SO_2)</u>

The highest predicted MAICs of SO_2 for 1-hour averaging time was at 235.47 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 5.658 µg/m^3 to 61.769 µg/m^3. For SO_2, the calculated 1-hour averaging time GLCs (i.e. addition of Baseline Level and MAIC of PEC) and Cumulative GLCs (i.e. addition of Baseline Level and MAIC of PEC and RAPID) at the identified ASRs ranged from 5.658 µg/m^3 to 61.769 µg/m^3 and 25.658 µg/m^3 to 92.069 µg/m^3, which both meet the MAAQS, 2013 (Standard [2020]) prescribed limit of 250 µg/m^3. The iso-contour for 1-hour averaging time is as shown in *Figure 8.7.*

The highest predicted 24-hours averaging time MAICs of SO_2 was predicted at 23.32 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.331 µg/m^3 to 4.459 µg/m^3. At the identified ASRs, the calculated 24-hours averaging time for GLCs and Cumulative GLCs were ranged from 0.331 µg/m^3 to 4.459 µg/m^3 and 2.569 µg/m^3 to 9.286 µg/m^3 respectively, which both meet the MAAQS, 2013 (Standard [2020]) prescribed limit of 80 µg/m^3 and WHO Air Quality Guidelines prescribed limit of 20 µg/m^3. The iso-contour for 24-hours averaging time is as shown in *Figure 8.8.*

The highest predicted annual average time MAICs of SO_2 was predicted at 1.84 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.013 µg/m^3 to 0.304 µg/m^3. At the identified ASRs, the calculated annual average for GLCs was less than 0.4 µg/m^3 at all identified receptors. The iso-contour for annual average is as shown in *Figure 8.9.*

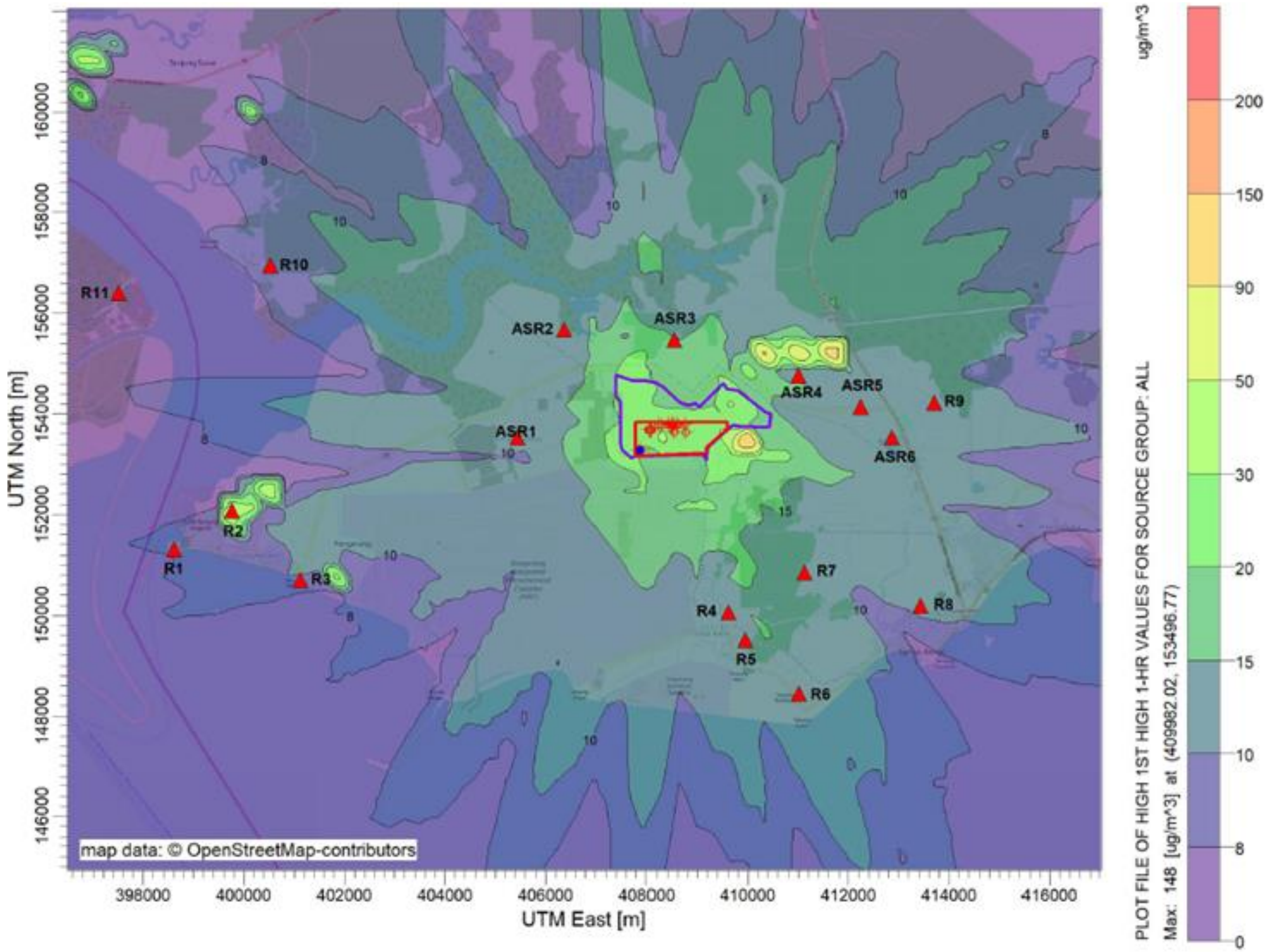


Figure 8.7 – Predicted Maximum 1-hour Average Incremental Concentration of. SO_2 during Normal Operation

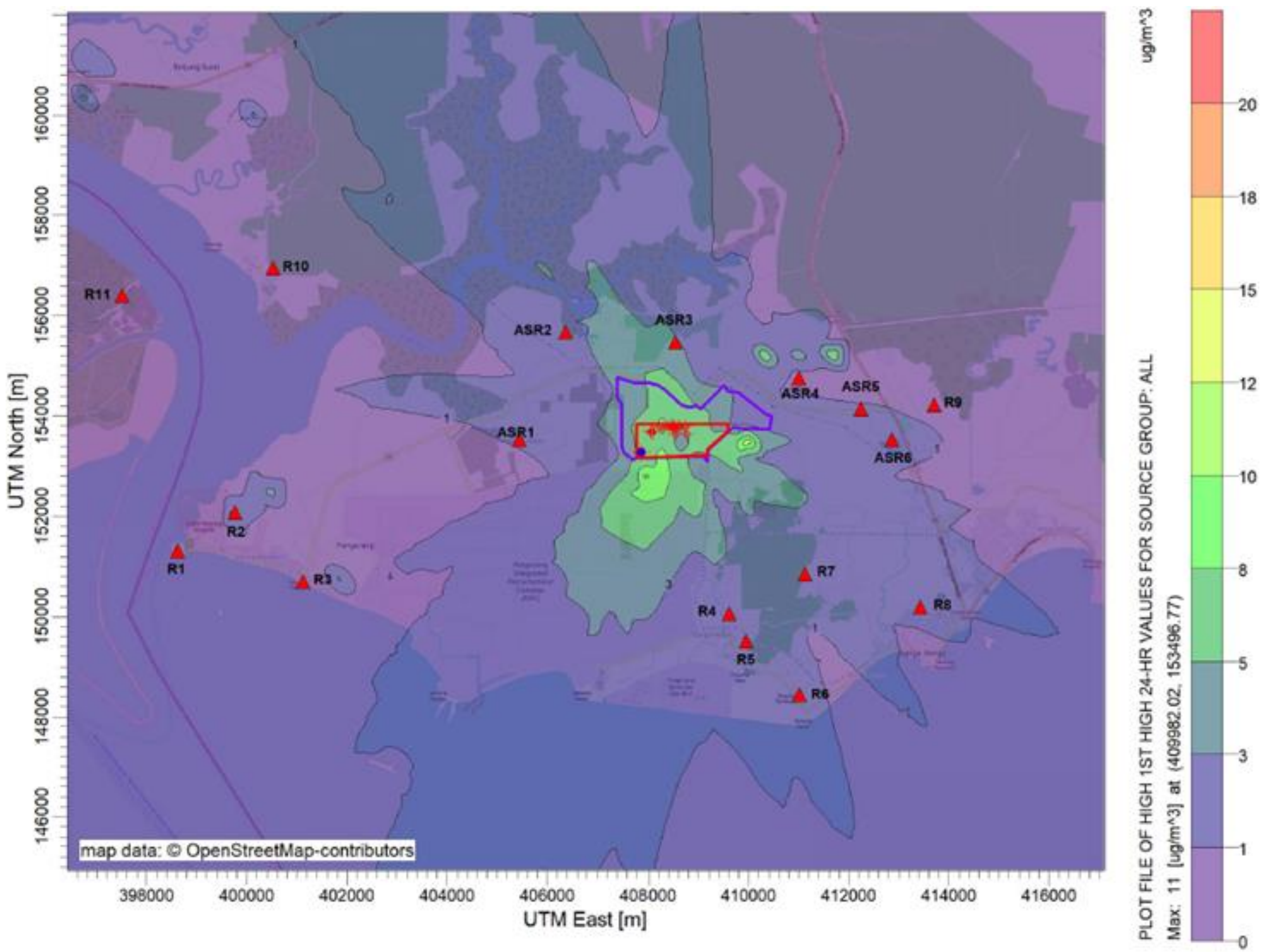


Figure 8.8 – Predicted Maximum 24-Hours Average Incremental Concentration of SO_2 during Normal Operation

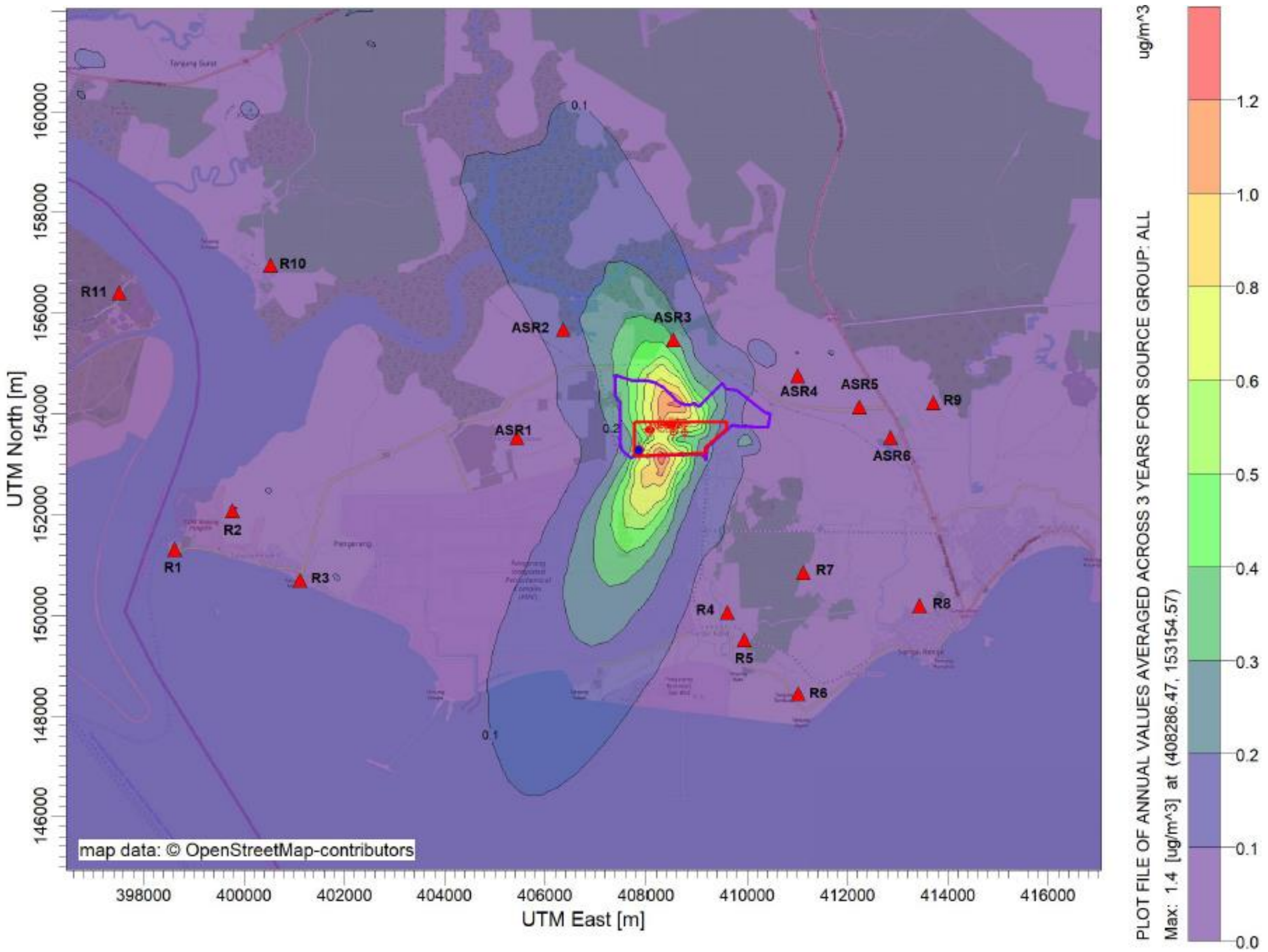


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Figure 8.9 – Predicted Maximum Annual Average Incremental Concentration of SO_2 during Normal Operation

Table 8.14: Predicted 1-Hour MAICs for SO_2 (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (250 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (250 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines
SO_2	1-Hour	ASR1	Open Space Near Kg. Lepau	N/M	12.112	12.112	**Yes**	-	50.000*	62.112	**Yes**	-
		ASR2	Sebana Cove Resort		13.813	13.813	**Yes**		50.000*	63.813	**Yes**	
		ASR3	Sebana Golf Resort		15.926	15.926	**Yes**		50.000*	65.926	**Yes**	
		ASR4	Bukit Pelali		12.746	12.746	**Yes**		40.000*	52.746	**Yes**	
		ASR5	Open Space Near Kg. Bukit Gelugor		11.880	11.880	**Yes**		40.000*	51.880	**Yes**	
		ASR6	Open Space Near Lake View		14.614	14.614	**Yes**		40.000*	54.614	**Yes**	
		R1	Tg. Pengelih	<5	8.407	8.407	**Yes**		19.300	27.707	**Yes**	
		R2	Pengelih Naval Base	<5	61.769	61.769	**Yes**		30.300	92.069	**Yes**	
		R3	Kg. Pengerang	<5	9.624	9.624	**Yes**		20.700	30.324	**Yes**	
		R4	Kg. Sg. Kapal	<5	12.252	12.252	**Yes**		53.600	65.852	**Yes**	
		R5	Taman Rengit Jaya	<5	11.823	11.823	**Yes**		38.000	49.823	**Yes**	
		R6	Kg. Sg. Buntu	<5	13.916	13.916	**Yes**		29.400	43.316	**Yes**	
		R7	Kg. Bukit Buloh	<5	12.300	12.300	**Yes**		51.900	64.200	**Yes**	
		R8	Kg. Sg. Rengit	N/D	10.710	10.710	**Yes**		37.400	48.110	**Yes**	
		R9	Kg. Bukit Gelugor	<5	11.144	11.144	**Yes**		33.900	45.044	**Yes**	
		R10	Kg. Pasir Gogok	N/D	9.212	9.212	**Yes**		24.400	33.612	**Yes**	
		R11	Pulau Tekong (Singapore)	N/M	5.658	5.658	**Yes**		20.000*	25.658	**Yes**	

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

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Table 8.15: Predicted 24-Hours MAICs for SO_2 (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (80 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines (20 µg/m³)	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (80 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines (20 µg/m³)
SO_2	24-Hours	ASR1	Open Space Near Kg. Lepau	<5	1.113	1.113	**Yes**	**Yes**	6.000*	7.113	**Yes**	**Yes**
		ASR2	Sebana Cove Resort	<5	2.643	2.643	**Yes**	**Yes**	6.000*	8.643	**Yes**	**Yes**
		ASR3	Sebana Golf Resort	<5	3.286	3.286	**Yes**	**Yes**	6.000*	9.286	**Yes**	**Yes**
		ASR4	Bukit Pelali	<5	0.693	0.693	**Yes**	**Yes**	4.500*	5.193	**Yes**	**Yes**
		ASR5	Open Space Near Kg. Bukit Gelugor	<5	1.175	1.175	**Yes**	**Yes**	3.000*	4.175	**Yes**	**Yes**
		ASR6	Open Space Near Lake View	<5	1.357	1.357	**Yes**	**Yes**	3.000*	4.357	**Yes**	**Yes**
		R1	Tg. Pengelih	N/M	0.369	0.369	**Yes**	**Yes**	2.200	2.569	**Yes**	**Yes**
		R2	Pengelih Naval Base		4.459	4.459	**Yes**	**Yes**	4.600	9.059	**Yes**	**Yes**
		R3	Kg. Pengerang		0.570	0.570	**Yes**	**Yes**	2.300	2.870	**Yes**	**Yes**
		R4	Kg. Sg. Kapal		2.169	2.169	**Yes**	**Yes**	5.100	7.269	**Yes**	**Yes**
		R5	Taman Rengit Jaya		1.645	1.645	**Yes**	**Yes**	4.900	6.545	**Yes**	**Yes**
		R6	Kg. Sg. Buntu		1.566	1.566	**Yes**	**Yes**	4.300	5.866	**Yes**	**Yes**
		R7	Kg. Bukit Buloh		1.713	1.713	**Yes**	**Yes**	4.200	5.913	**Yes**	**Yes**
		R8	Kg. Sg. Rengit		1.303	1.303	**Yes**	**Yes**	3.000	4.303	**Yes**	**Yes**
		R9	Kg. Bukit Gelugor		0.768	0.768	**Yes**	**Yes**	2.800	3.568	**Yes**	**Yes**
		R10	Kg. Pasir Gogok		0.413	0.413	**Yes**	**Yes**	3.300	3.713	**Yes**	**Yes**
		R11	Pulau Tekong (Singapore)		0.331	0.331	**Yes**	**Yes**	3.000*	3.331	**Yes**	**Yes**

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.16: Predicted Annual MAICs for SO_2 (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines
SO_2	Annual	ASR1	Open Space Near Kg. Lepau	N/M	0.0483	0.048	-	-	-	-	-	-
		ASR2	Sebana Cove Resort		0.157	0.157						
		ASR3	Sebana Golf Resort		0.304	0.304						
		ASR4	Bukit Pelali		0.043	0.043						
		ASR5	Open Space Near Kg. Bukit Gelugor		0.025	0.025						
		ASR6	Open Space Near Lake View		0.023	0.023						
		R1	Tg. Pengelih		0.013	0.013						
		R2	Pengelih Naval Base		0.122	0.122						
		R3	Kg. Pengerang		0.019	0.019						
		R4	Kg. Sg. Kapal		0.066	0.066						
		R5	Taman Rengit Jaya		0.053	0.053						
		R6	Kg. Sg. Buntu		0.043	0.043						
		R7	Kg. Bukit Buloh		0.045	0.045						
		R8	Kg. Sg. Rengit		0.026	0.026						
		R9	Kg. Bukit Gelugor		0.018	0.018						
		R10	Kg. Pasir Gogok		0.023	0.023						
		R11	Pulau Tekong (Singapore)		0.017	0.017						

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Carbon Monoxide (CO)

The highest predicted 1-hour averaging time MAIC of CO was 1,118.97 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 120.058 µg/m^3 to 357.226 µg/m^3. At the identified ASRs, the calculated 1-hours averaging time GLCs and Cumulative GLCs ranged from 120.058 µg/m^3 to 357.226 µg/m^3 and 185.228 µg/m^3 to 927.026 µg/m^3 respectively, which comply to the MAAQS 2013 (Standard [2020]) prescribed limit of 30,000 µg/m^3. Currently, this pollutant is not prescribed in the WHO Ambient Air Quality Guidelines. The iso-contour 1-hour averaging time is as shown in *Figure 8.10.*

The highest predicted 8-hours averaging time MAIC of CO was 323.12 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 19.020 µg/m^3 to 118.289 µg/m^3. At the identified ASRs, the calculated 8-hours averaging time GLCs and Cumulative GLCs ranged from 19.020 µg/m^3 to 2632.999 µg/m^3 and 31.820 µg/m^3 to 2652.999 µg/m^3 respectively, which comply to the MAAQS 2013 (Standard [2020]) prescribed limit of 10,000 µg/m^3. Currently, this pollutant is not prescribed in the WHO Ambient Air Quality Guidelines. The iso-contour 8-hours averaging time is as shown in *Figure 8.11.*

The highest predicted annual average MAIC of CO was 25.52 µg/m^3. At the identified ASRs, the predicted MAICs ranged from 0.388 µg/m^3 to 8.172 µg/m^3. At the identified ASRs, the calculated annual average GLCs ranged from 0.388 µg/m^3 to 8.172 µg/m^3. The iso-contour annual average is as shown in *Figure 8.12.*

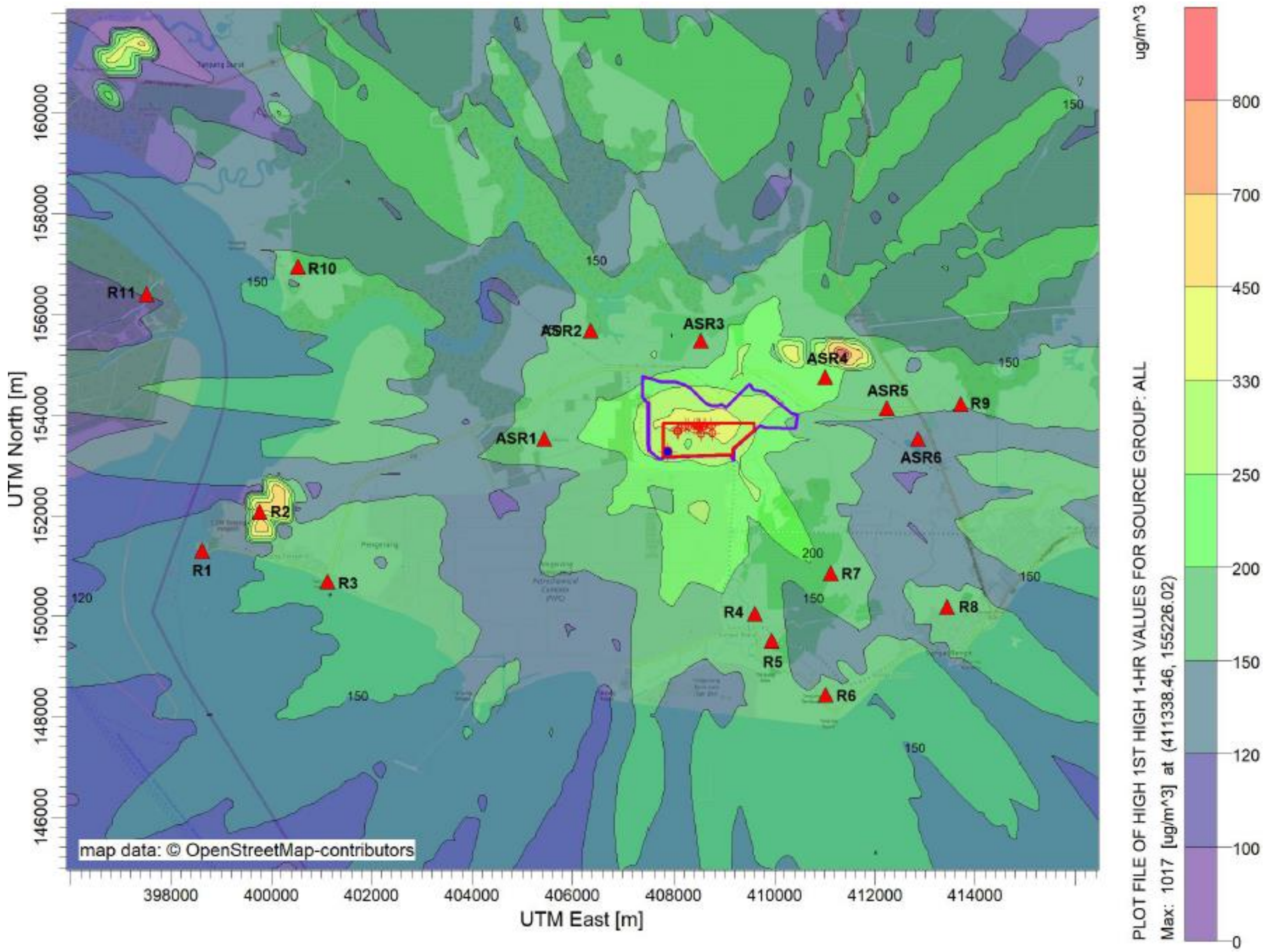

Figure 8.10 – Predicted Maximum 1-hour Average Incremental Concentration of. CO during Normal Operation

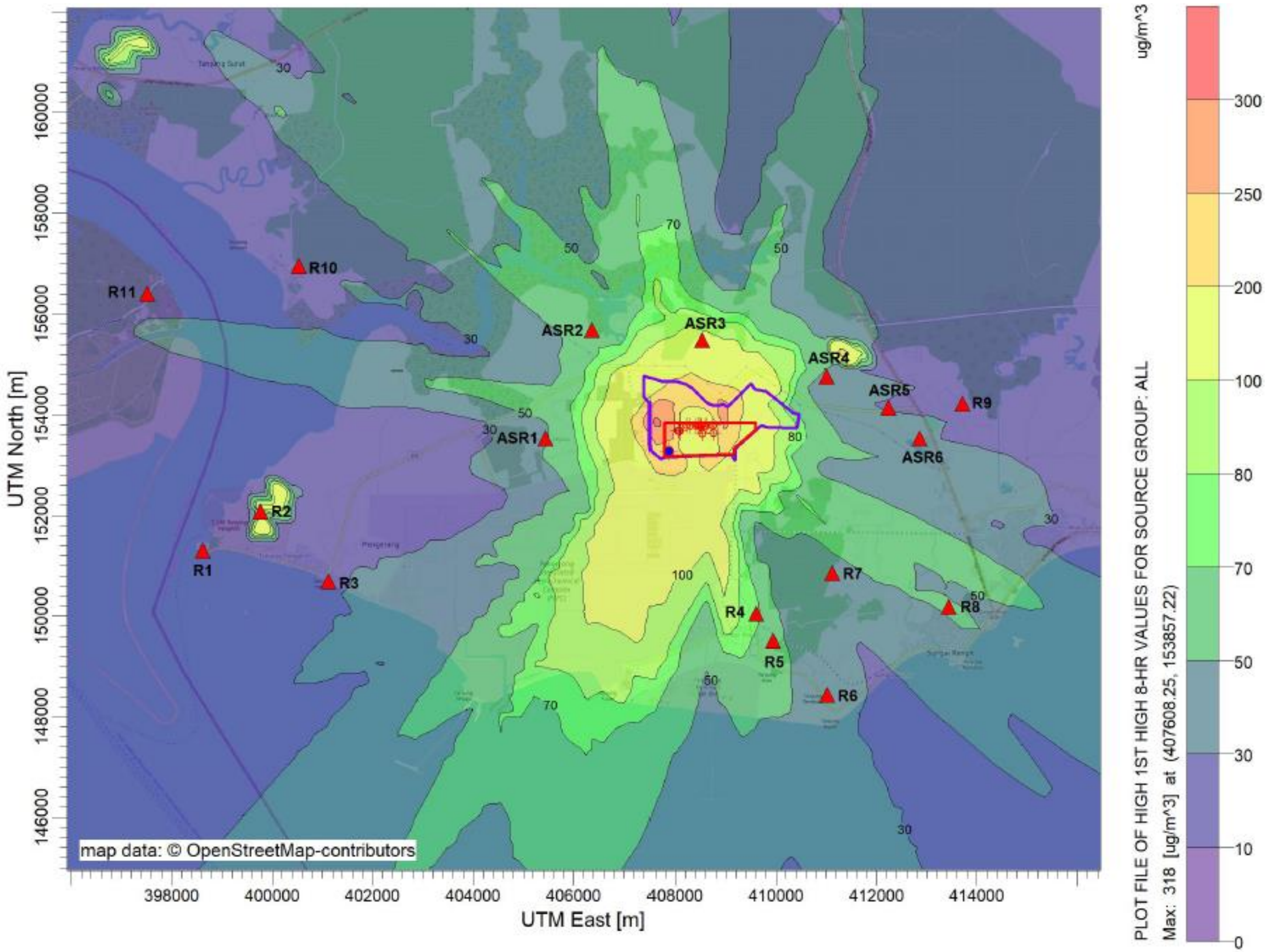

Figure 8.11 – Predicted Maximum 8-Hours Average Incremental Concentration of CO during Normal Operation

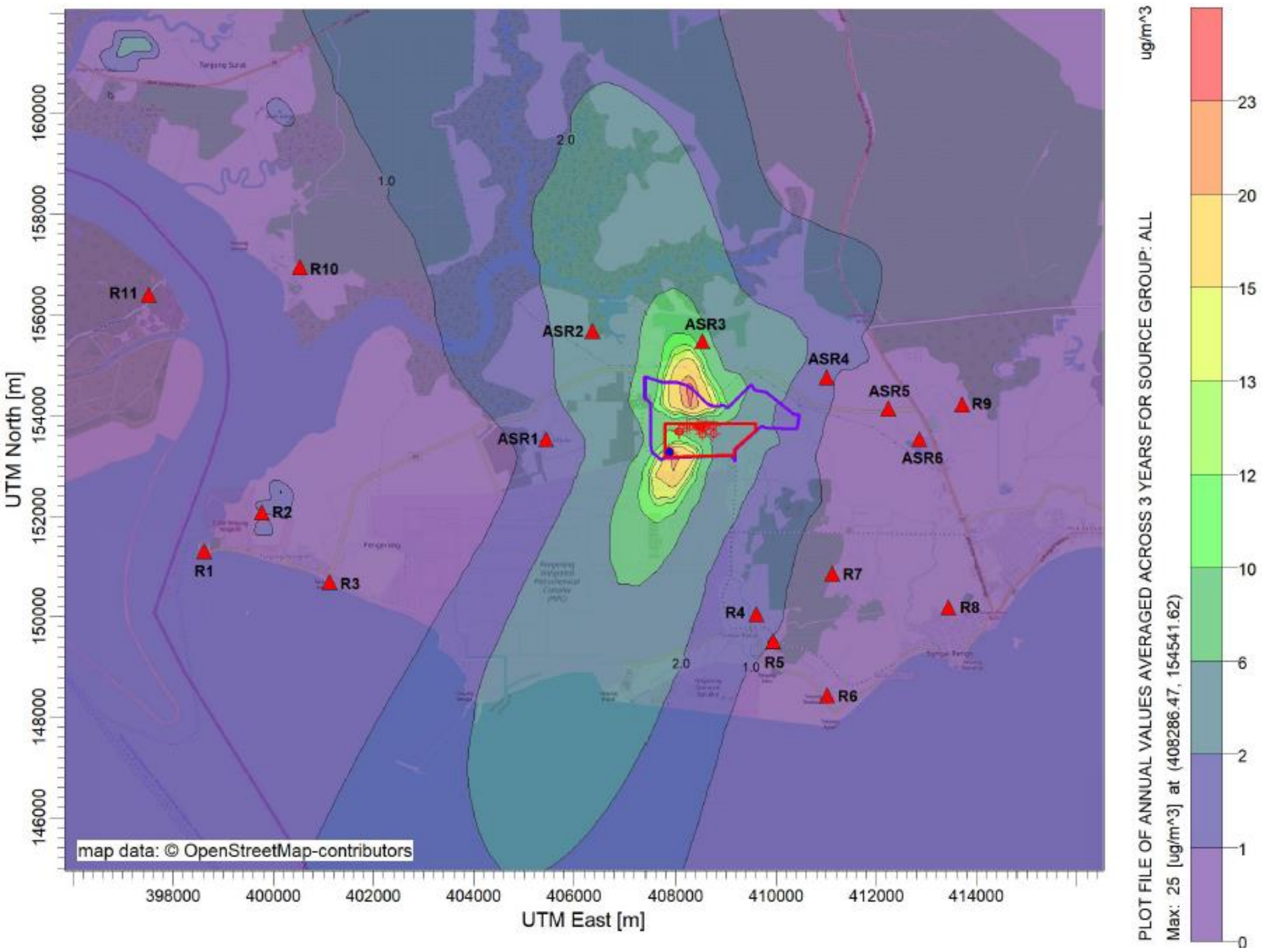

Figure 8.12 – Predicted Maximum Annual Average Incremental Concentration of CO during Normal Operation

Table 8.17: Predicted 1-Hour MAICs for CO (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (30,000 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (30,000 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines
CO	1-Hour	ASR1	Open Space Near Kg. Lepau	N/M	179.429	179.429	**Yes**	-	100.000*	279.429	**Yes**	-
		ASR2	Sebana Cove Resort		171.646	171.646	**Yes**		100.000*	271.646	**Yes**	
		ASR3	Sebana Golf Resort		153.383	153.383	**Yes**		100.000*	253.383	**Yes**	
		ASR4	Bukit Pelali		217.693	217.693	**Yes**		150.000*	367.693	**Yes**	
		ASR5	Open Space Near Kg. Bukit Gelugor		180.033	180.033	**Yes**		100.000*	280.033	**Yes**	
		ASR6	Open Space Near Lake View		131.141	131.141	**Yes**		100.000*	231.141	**Yes**	
		R1	Tg. Pengelih		135.128	135.128	**Yes**		50.100	185.228	**Yes**	
		R2	Pengelih Naval Base		357.226	357.226	**Yes**		569.800	927.026	**Yes**	
		R3	Kg. Pengerang		167.476	167.476	**Yes**		77.700	245.176	**Yes**	
		R4	Kg. Sg. Kapal		186.792	186.792	**Yes**		104.100	290.892	**Yes**	
		R5	Taman Rengit Jaya		174.531	174.531	**Yes**		85.300	259.831	**Yes**	
		R6	Kg. Sg. Buntu		165.079	165.079	**Yes**		64.500	229.579	**Yes**	
		R7	Kg. Bukit Buloh		183.306	183.306	**Yes**		455.400	638.706	**Yes**	
		R8	Kg. Sg. Rengit		168.954	168.954	**Yes**		87.700	256.654	**Yes**	
		R9	Kg. Bukit Gelugor		151.462	151.462	**Yes**		76.400	227.862	**Yes**	
		R10	Kg. Pasir Gogok		158.080	158.080	**Yes**		48.700	206.780	**Yes**	
		R11	Pulau Tekong (Singapore)		120.058	120.058	**Yes**		100.000*	220.058	**Yes**	

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.18: Predicted 8-Hours MAICs for CO (in µg/m^3) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m^3)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020]) (10,000 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020]) (10,000 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines
CO	8-Hours	ASR1	Open Space Near Kg. Lepau	1250.0	47.942	1297.942	**Yes**	-	40.000*	1337.942	**Yes**	-
		ASR2	Sebana Cove Resort	950.0	70.465	1020.465	**Yes**		40.000*	1060.465	**Yes**	
		ASR3	Sebana Golf Resort	800.0	118.289	918.289	**Yes**		40.000*	958.289	**Yes**	
		ASR4	Bukit Pelali	1550.0	41.513	1591.513	**Yes**		40.000*	1631.513	**Yes**	
		ASR5	Open Space Near Kg. Bukit Gelugor	2600.0	27.951	2627.951	**Yes**		20.000*	2647.951	**Yes**	
		ASR6	Open Space Near Lake View	2600.0	32.999	2632.999	**Yes**		20.000*	2652.999	**Yes**	
		R1	Tg. Pengelih	<100	19.020	19.020	**Yes**		12.800	31.820	**Yes**	
		R2	Pengelih Naval Base	<100	67.766	67.766	**Yes**		164.100	231.866	**Yes**	
		R3	Kg. Pengerang	<100	26.176	26.176	**Yes**		16.800	42.976	**Yes**	
		R4	Kg. Sg. Kapal	<100	72.369	72.369	**Yes**		27.900	100.269	**Yes**	
		R5	Taman Rengit Jaya	<100	60.522	60.522	**Yes**		41.500	102.022	**Yes**	
		R6	Kg. Sg. Buntu	<100	39.313	39.313	**Yes**		21.500	60.813	**Yes**	
		R7	Kg. Bukit Buloh	<100	42.613	42.613	**Yes**		205.000	247.613	**Yes**	
		R8	Kg. Sg. Rengit	N/D	53.793	53.793	**Yes**		22.100	75.893	**Yes**	
		R9	Kg. Bukit Gelugor	<100	26.407	26.407	**Yes**		15.800	42.207	**Yes**	
		R10	Kg. Pasir Gogok	N/D	28.568	28.568	**Yes**		17.700	46.268	**Yes**	
		R11	Pulau Tekong (Singapore)	N/M	23.513	23.513	**Yes**		20.000*	43.513	**Yes**	

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.19: Predicted Annual MAICs for CO (in µg/m^3) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m^3)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines
CO	Annual	ASR1	Open Space Near Kg. Lepau	N/M	1.313	1.313	-	-	-	-	-	-
		ASR2	Sebana Cove Resort		3.089	3.089						
		ASR3	Sebana Golf Resort		8.172	8.172						
		ASR4	Bukit Pelali		1.094	1.094						
		ASR5	Open Space Near Kg. Bukit Gelugor		0.644	0.644						
		ASR6	Open Space Near Lake View		0.550	0.550						
		R1	Tg. Pengelih		0.388	0.388						
		R2	Pengelih Naval Base		0.945	0.945						
		R3	Kg. Pengerang		0.544	0.544						
		R4	Kg. Sg. Kapal		1.144	1.144						
		R5	Taman Rengit Jaya		0.976	0.976						
		R6	Kg. Sg. Buntu		0.784	0.784						
		R7	Kg. Bukit Buloh		0.780	0.780						
		R8	Kg. Sg. Rengit		0.570	0.570						
		R9	Kg. Bukit Gelugor		0.479	0.479						
		R10	Kg. Pasir Gogok		0.680	0.680						
		R11	Pulau Tekong (Singapore)		0.475	0.475						

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

<u>Hydrogen Sulphide (H_2S)</u>

The highest predicted 8-hours averaging time MAIC for H_2S was at 1.01 µg/m^3, while the predicted MAICs for 8-hours averaging time was all less than 0.30 µg/m^3 at all identified ASRs. Due to the low baseline value (BL), the Ground Level Concentration (GLC) for 8-hours averaging time ranged from 0.014 µg/m^3 to 0.203 µg/m^3 at the identified ASRs. Currently, this pollutant is not prescribed in the MAAQS 2013 and WHO Ambient Air Quality Guidelines. The iso-contour for 8-hours averaging time is as shown in *Figure 8.13.*

The highest predicted 24-hours averaging time MAICs for H_2S were at 0.44 µg/m^3, while the predicted MAIC was all less than 0.10 µg/m^3 at all identified ASRs. At the identified ASRs, the GLCs and Cumulative GLCs for 24-hours averaging time ranged from 0.005 µg/m^3 to 0.068 µg/m^3 and 0.089 µg/m^3 to 0.310 µg/m^3 respectively which complied to the adopted Ontario Ambient Air Quality Criteria. Currently, this pollutant is not prescribed in the MAAQS 2013 and WHO Ambient Air Quality Guidelines. The iso-contour for 24-hours averaging time is as shown in *Figure 8.14.*

The highest predicted annual average MAICs for H_2S were at 0.032 µg/m^3, while the predicted MAICs for was all less than 0.01 µg/m^3 at all identified ASRs. Due to the low baseline value (BL), the Ground Level Concentration (GLC) ranged from 0.0002 µg/m^3 to 0.0053 µg/m^3 at the identified ASRs. Currently, this pollutant is not prescribed in the MAAQS 2013 and WHO Ambient Air Quality Guidelines. The iso-contour for annual average is as shown in *Figure 8.15.*

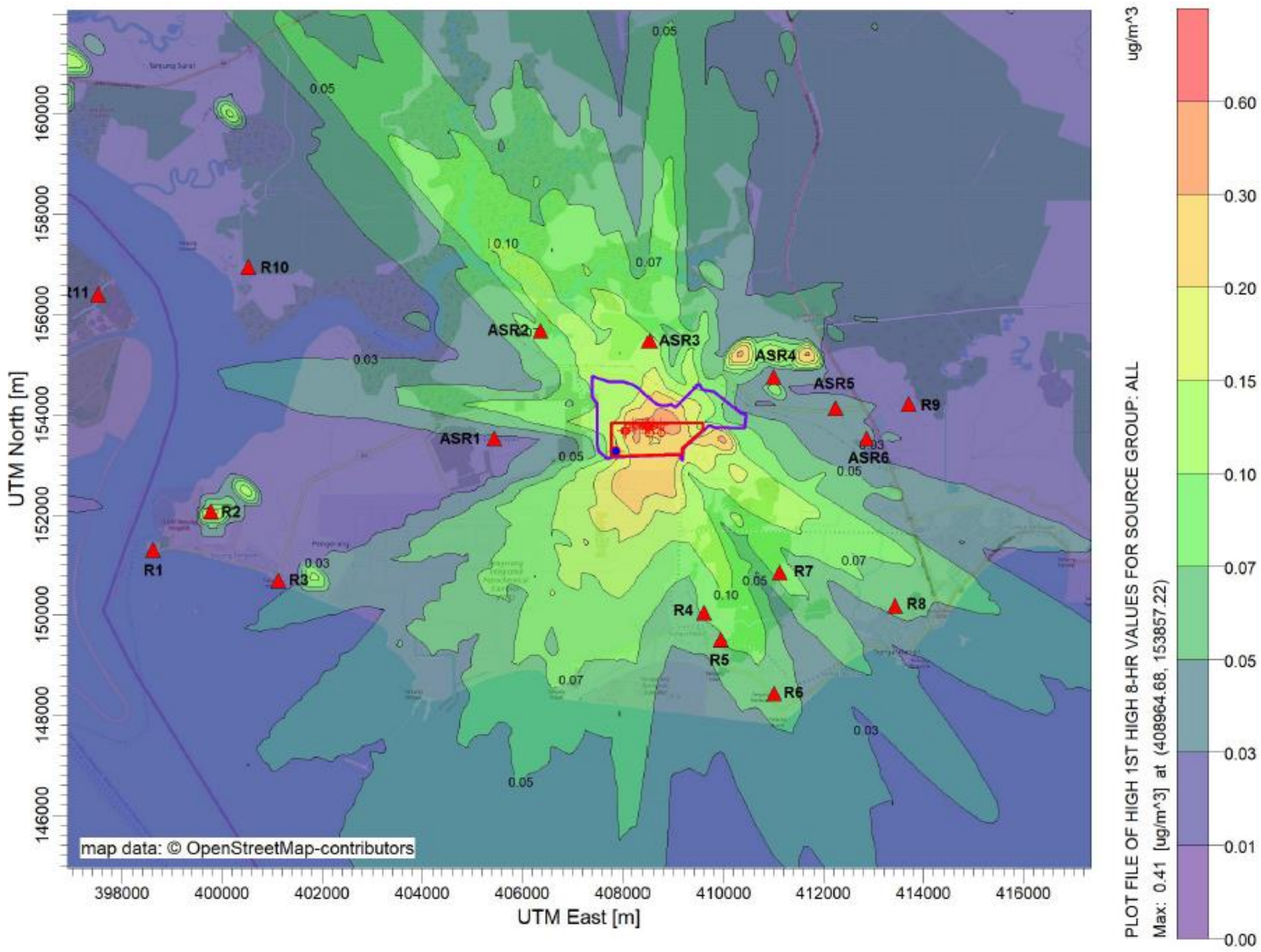

Figure 8.13 – Predicted Maximum 8-hours Average Incremental Concentration of.H_2S during Normal Operation

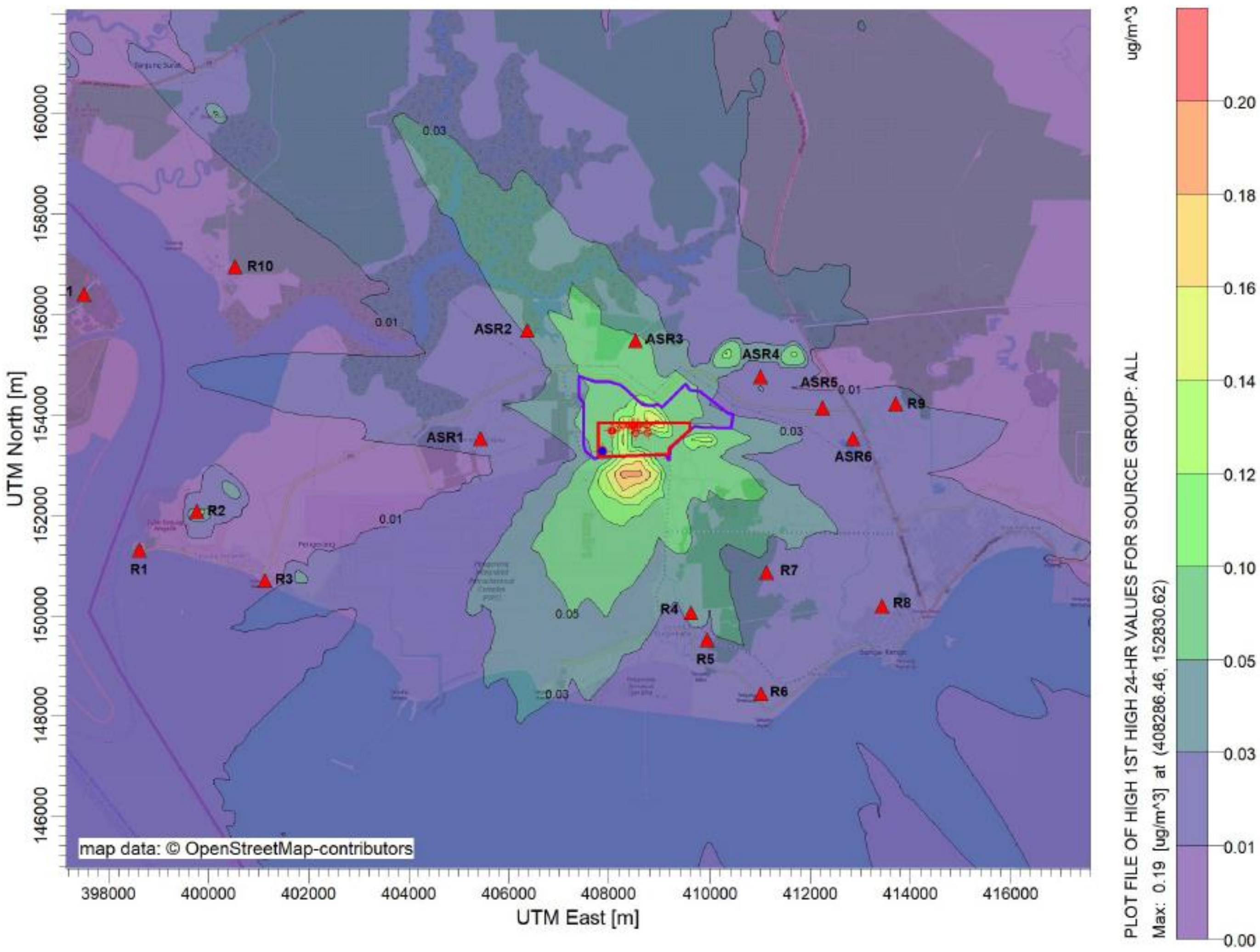

Figure 8.14 – Predicted Maximum 24-Hours Average Incremental Concentration of H_2S during Normal Operation

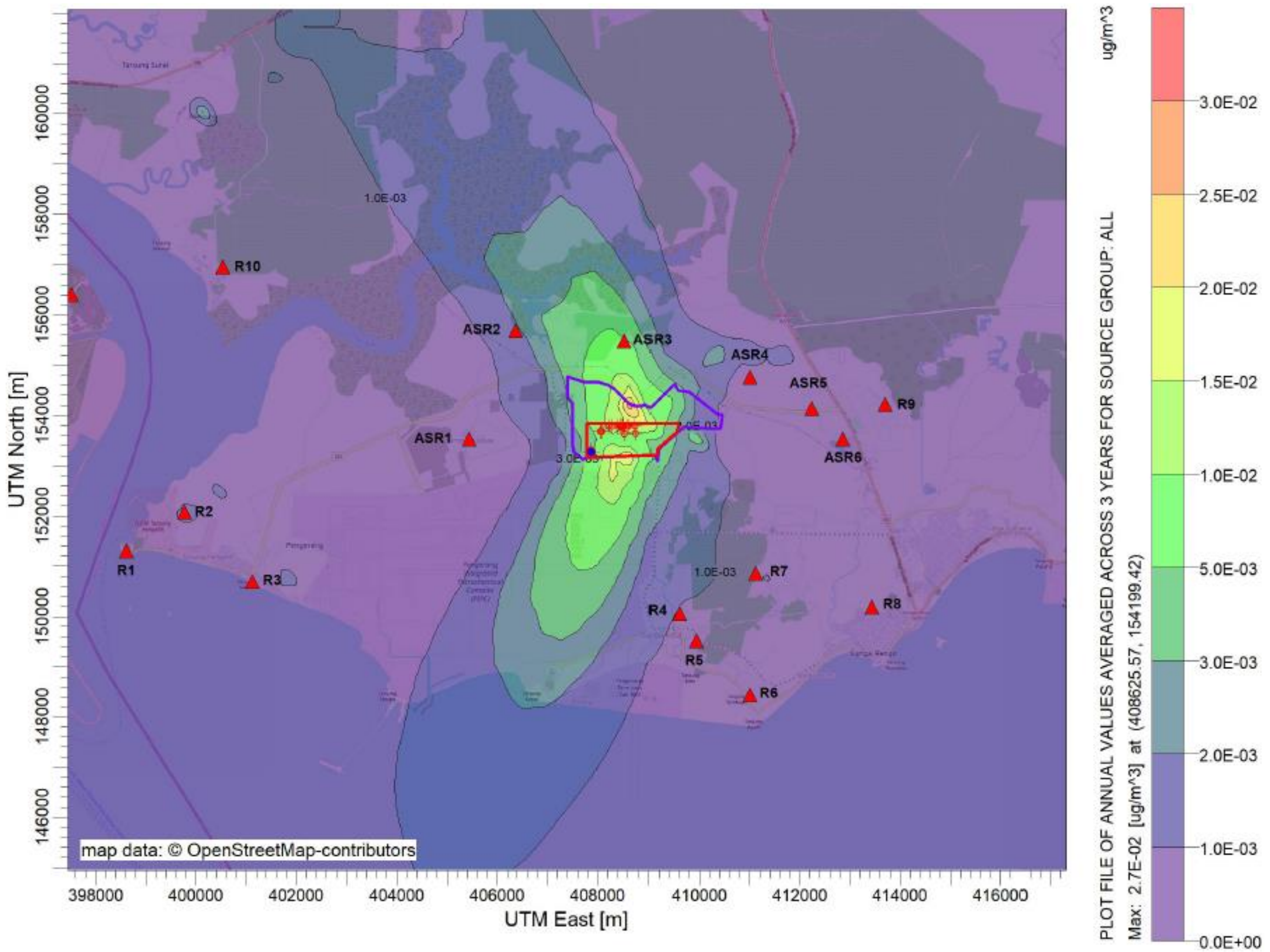

Figure 8.15 – Predicted Maximum Annual Average Incremental Concentration of H_2S during Normal Operation

Table 8.20: Predicted 8-Hours MAICs for H_2S (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines
H2S	8-Hours	ASR1	Open Space Near Kg. Lepau	<10	0.024	0.024	-	-	0.625*	0.649	-	-
		ASR2	Sebana Cove Resort	<10	0.075	0.075			0.625*	0.700		
		ASR3	Sebana Golf Resort	<10	0.123	0.123			0.625*	0.748		
		ASR4	Bukit Pelali	<10	0.036	0.036			0.625*	0.661		
		ASR5	Open Space Near Kg. Bukit Gelugor	<10	0.037	0.037			0.625*	0.662		
		ASR6	Open Space Near Lake View	<10	0.033	0.033			0.625*	0.658		
		R1	Tg. Pengelih	N/M	0.016	0.016			0.155	0.171		
		R2	Pengelih Naval Base		0.203	0.203			0.165	0.368		
		R3	Kg. Pengerang		0.023	0.023			0.134	0.157		
		R4	Kg. Sg. Kapal		0.074	0.074			0.428	0.502		
		R5	Taman Rengit Jaya		0.067	0.067			0.367	0.434		
		R6	Kg. Sg. Buntu		0.062	0.062			0.339	0.401		
		R7	Kg. Bukit Buloh		0.080	0.080			0.384	0.464		
		R8	Kg. Sg. Rengit		0.058	0.058			0.302	0.360		
		R9	Kg. Bukit Gelugor		0.025	0.025			0.216	0.241		
		R10	Kg. Pasir Gogok		0.017	0.017			0.243	0.260		
		R11	Pulau Tekong (Singapore)		0.014	0.014			0.625*	0.639		

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*

Table 8.21: Predicted 24-Hours MAICs for H_2S (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with Ontario Standard (7 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with Ontario Standard (7 µg/m³)	Compliance with WHO Ambient Air Quality Guidelines
H_2S	24-Hours	ASR1	Open Space Near Kg. Lepau	N/M	0.015	0.015	**Yes**	-	0.253*	0.268	**Yes**	-
		ASR2	Sebana Cove Resort		0.035	0.035	**Yes**		0.253*	0.288	**Yes**	
		ASR3	Sebana Golf Resort		0.057	0.057	**Yes**		0.253*	0.310	**Yes**	
		ASR4	Bukit Pelali		0.013	0.013	**Yes**		0.253*	0.266	**Yes**	
		ASR5	Open Space Near Kg. Bukit Gelugor		0.018	0.018	**Yes**		0.253*	0.271	**Yes**	
		ASR6	Open Space Near Lake View		0.021	0.021	**Yes**		0.253*	0.274	**Yes**	
		R1	Tg. Pengelih		0.006	0.006	**Yes**		0.096	0.102	**Yes**	
		R2	Pengelih Naval Base		0.068	0.068	**Yes**		0.094	0.162	**Yes**	
		R3	Kg. Pengerang		0.008	0.008	**Yes**		0.087	0.095	**Yes**	
		R4	Kg. Sg. Kapal		0.033	0.033	**Yes**		0.170	0.203	**Yes**	
		R5	Taman Rengit Jaya		0.028	0.028	**Yes**		0.145	0.173	**Yes**	
		R6	Kg. Sg. Buntu		0.025	0.025	**Yes**		0.136	0.161	**Yes**	
		R7	Kg. Bukit Buloh		0.028	0.028	**Yes**		0.153	0.181	**Yes**	
		R8	Kg. Sg. Rengit		0.020	0.020	**Yes**		0.120	0.140	**Yes**	
		R9	Kg. Bukit Gelugor		0.012	0.012	**Yes**		0.110	0.122	**Yes**	
		R10	Kg. Pasir Gogok		0.006	0.006	**Yes**		0.083	0.089	**Yes**	
		R11	Pulau Tekong (Singapore)		0.005	0.005	**Yes**		0.253*	0.258	**Yes**	

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*
Ontario = Ontario's Ambient Air Quality Criteria (April 2012)

Table 8.22: Predicted Annual MAICs for H_2S (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines
H_2S	Annual	ASR1	Open Space Near Kg. Lepau	N/M	0.0005	0.0005	-	-	-	-	-	-
		ASR2	Sebana Cove Resort		0.0019	0.0019						
		ASR3	Sebana Golf Resort		0.0053	0.0053						
		ASR4	Bukit Pelali		0.0007	0.0007						
		ASR5	Open Space Near Kg. Bukit Gelugor		0.0004	0.0004						
		ASR6	Open Space Near Lake View		0.0003	0.0003						
		R1	Tg. Pengelih		0.0002	0.0002						
		R2	Pengelih Naval Base		0.0018	0.0018						
		R3	Kg. Pengerang		0.0002	0.0002						
		R4	Kg. Sg. Kapal		0.0010	0.0010						
		R5	Taman Rengit Jaya		0.0008	0.0008						
		R6	Kg. Sg. Buntu		0.0006	0.0006						
		R7	Kg. Bukit Buloh		0.0007	0.0007						
		R8	Kg. Sg. Rengit		0.0004	0.0004						
		R9	Kg. Bukit Gelugor		0.0003	0.0003						
		R10	Kg. Pasir Gogok		0.0003	0.0003						
		R11	Pulau Tekong (Singapore)		0.0002	0.0002						

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*
Ontario = Ontario's Ambient Air Quality Criteria (April 2012)

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Hydrogen Chloride (HCl)

The highest predicted 8-hours averaging time MAICs for HCl was at 2.02 µg/m^3, while the predicted MAICs was less than 0.50 µg/m^3 at all identified ASRs. Currently, this pollutant is not prescribed in the MAAQS 2013 and WHO Ambient Air Quality Guidelines. The iso-contour for 8-hours averaging time is as shown in *Figure 8.16.*

The highest predicted 24-hours averaging time MAIC for HCl was 0.83 µg/m^3, while the predicted MAICs was less than 0.20 µg/m^3 at all identified ASRs which complied to the adopted Ontario Ambient Air Quality Criteria. Currently, this pollutant is not prescribed in the MAAQS 2013 and WHO Ambient Air Quality Guidelines. The iso-contour for 24-hours averaging time is as shown in *Figure 8.17.*

The highest predicted annual average MAICs for HCl was at 0.054 µg/m^3, while the predicted MAICs was less than 0.02 µg/m^3 at all identified ASRs. Currently, this pollutant is not prescribed in the MAAQS 2013 and WHO Ambient Air Quality Guidelines. The iso-contour for annual average is as shown in *Figure 8.18.*

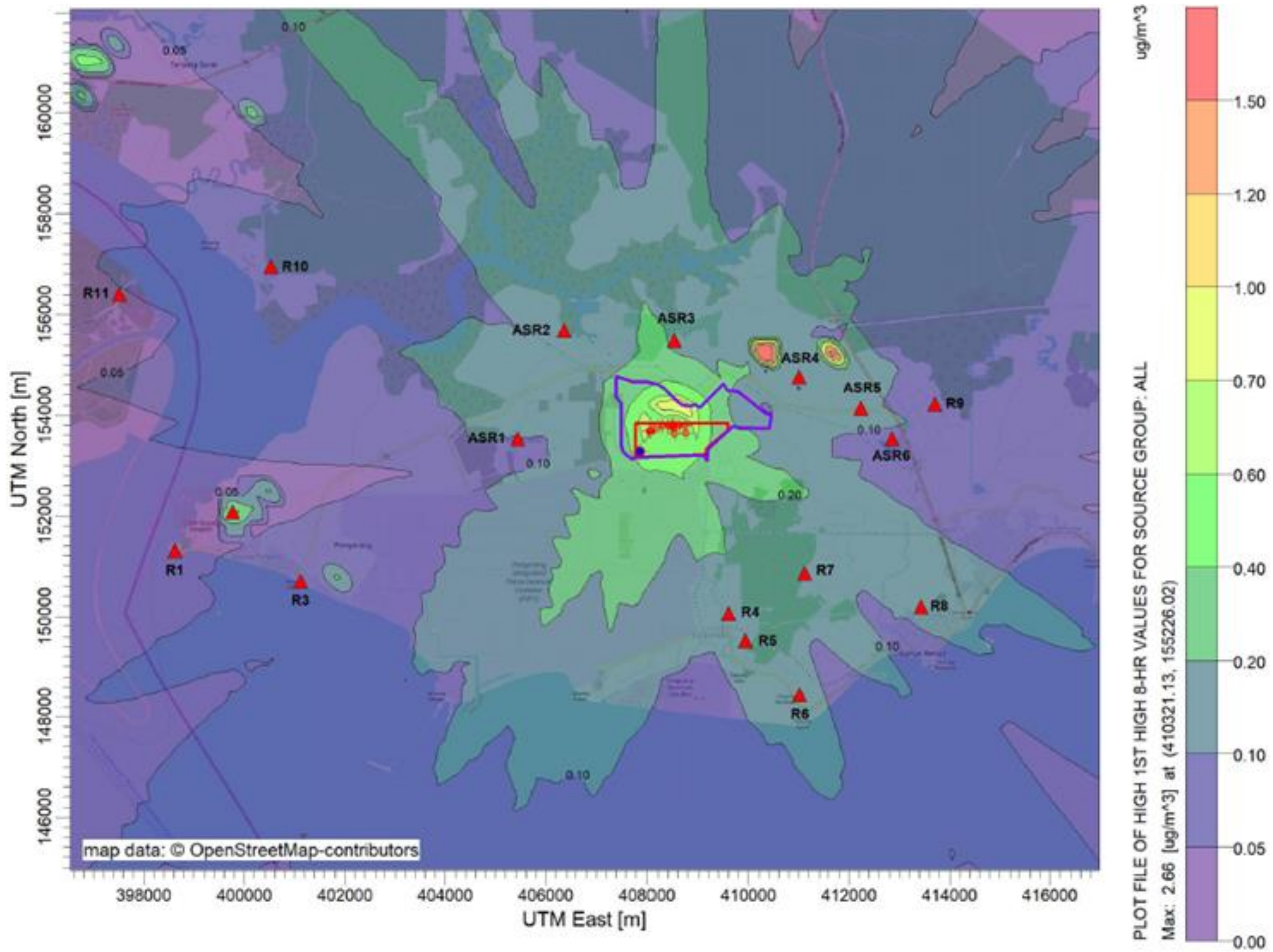


Figure 8.16 – Predicted Maximum 8-hours Average Incremental Concentration of HCl during Normal Operation

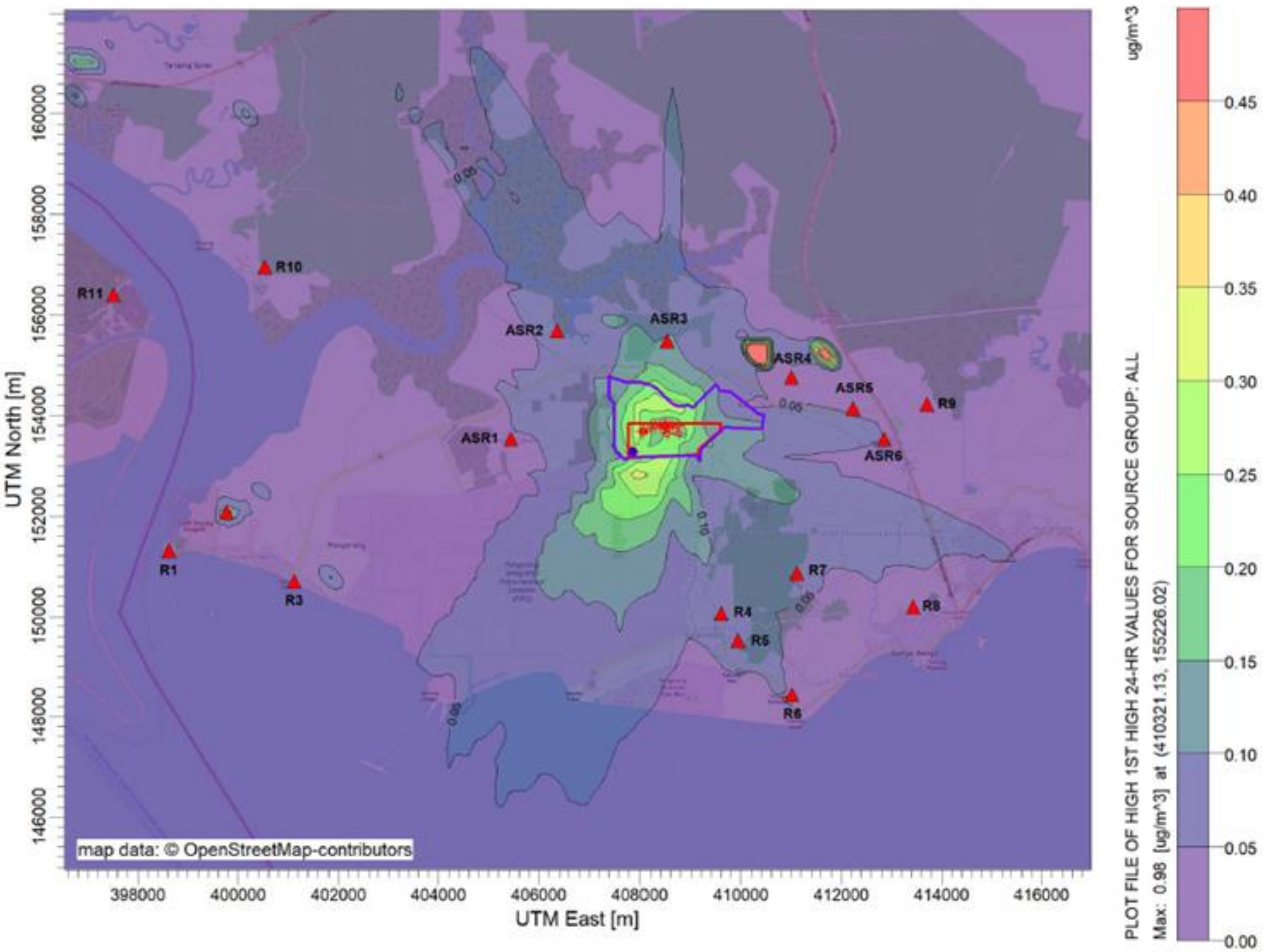


Figure 8.17 – Predicted Maximum 24-Hours Average Incremental Concentration of HCl during Normal Operation

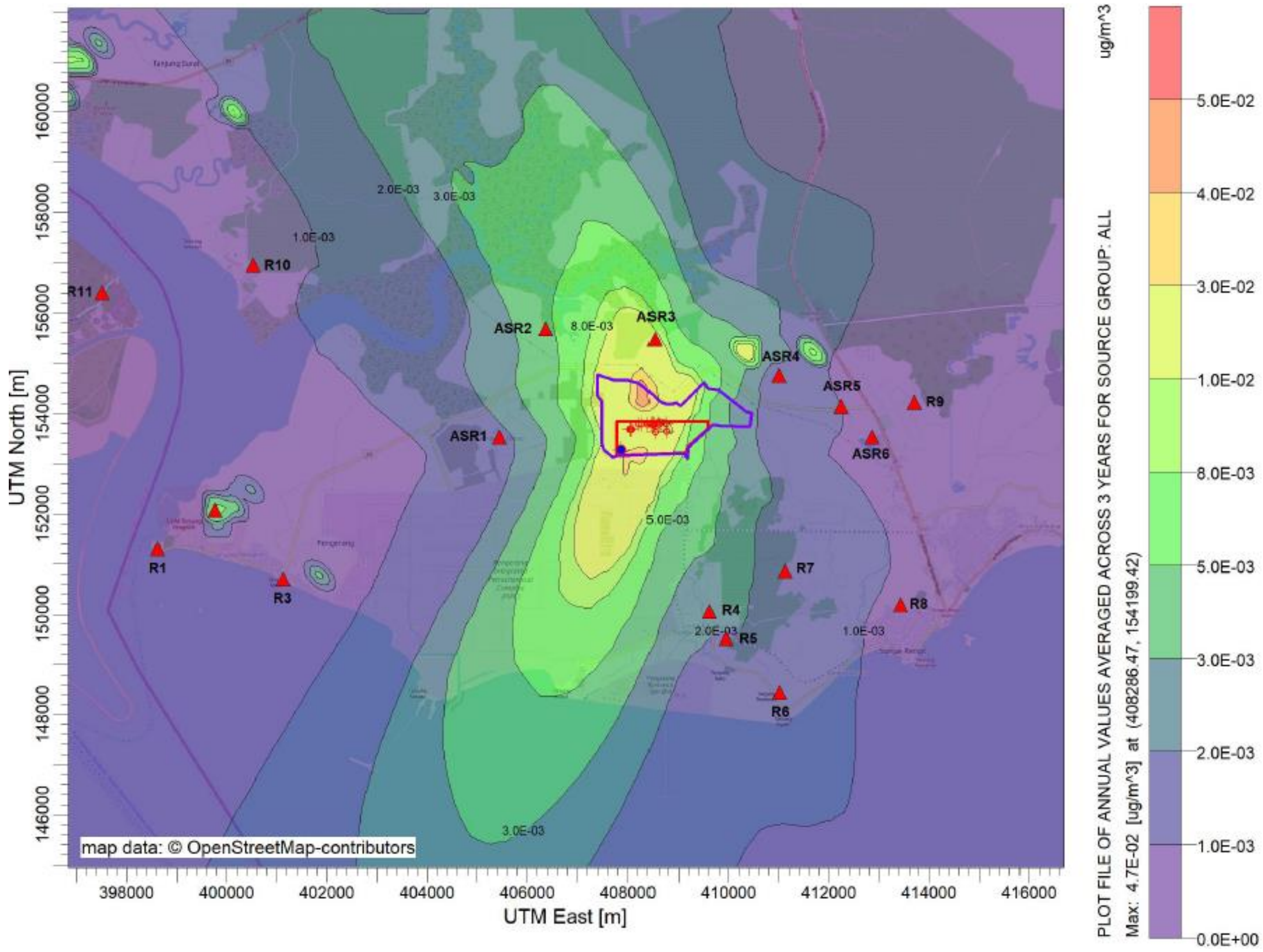


Figure 8.18 – Predicted Maximum Annual Average Incremental Concentration of HCl during Normal Operation

Table 8.23: Predicted 8-Hours MAICs for HCl (in µg/m³) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)									
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines
HCl	8-Hours	ASR1	Open Space Near Kg. Lepau	<10	0.0984	0.098	-	-	-	-	-	-
		ASR2	Sebana Cove Resort	<10	0.1612	0.161						
		ASR3	Sebana Golf Resort	<10	0.1638	0.164						
		ASR4	Bukit Pelali	<10	0.1213	0.121						
		ASR5	Open Space Near Kg. Bukit Gelugor	<10	0.1076	0.108						
		ASR6	Open Space Near Lake View	<10	0.0913	0.091						
		R1	Tg. Pengelih	N/M	0.041	0.041						
		R2	Pengelih Naval Base		0.491	0.491						
		R3	Kg. Pengerang		0.066	0.066						
		R4	Kg. Sg. Kapal		0.137	0.137						
		R5	Taman Rengit Jaya		0.133	0.133						
		R6	Kg. Sg. Buntu		0.139	0.139						
		R7	Kg. Bukit Buloh		0.133	0.133						
		R8	Kg. Sg. Rengit		0.133	0.133						
		R9	Kg. Bukit Gelugor		0.087	0.087						
		R10	Kg. Pasir Gogok		0.066	0.066						
		R11	Pulau Tekong (Singapore)		0.048	0.048						

Note: PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*
Ontario = Ontario's Ambient Air Quality Criteria (April 2012)

Table 8.24: Predicted 24-Hours MAICs for HCl (in µg/m^3) during Normal Operation

Parameter	Scenario	ASR	ASR	Concentration (µg/m^3)								
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with Ontario Standard (20 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with Ontario Standard (20 µg/m^3)	Compliance with WHO Ambient Air Quality Guidelines
HCl	24-Hours	ASR1	Open Space Near Kg. Lepau	N/M	0.0474	0.047	**Yes**	-	-	-	-	-
		ASR2	Sebana Cove Resort		0.0646	0.065	**Yes**					
		ASR3	Sebana Golf Resort		0.1088	0.109	**Yes**					
		ASR4	Bukit Pelali		0.0421	0.042	**Yes**					
		ASR5	Open Space Near Kg. Bukit Gelugor		0.0408	0.041	**Yes**					
		ASR6	Open Space Near Lake View		0.0500	0.050	**Yes**					
		R1	Tg. Pengelih		0.016	0.016	**Yes**					
		R2	Pengelih Naval Base		0.180	0.180	**Yes**					
		R3	Kg. Pengerang		0.022	0.022	**Yes**					
		R4	Kg. Sg. Kapal		0.075	0.075	**Yes**					
		R5	Taman Rengit Jaya		0.059	0.059	**Yes**					
		R6	Kg. Sg. Buntu		0.049	0.049	**Yes**					
		R7	Kg. Bukit Buloh		0.054	0.054	**Yes**					
		R8	Kg. Sg. Rengit		0.045	0.045	**Yes**					
		R9	Kg. Bukit Gelugor		0.030	0.030	**Yes**					
		R10	Kg. Pasir Gogok		0.022	0.022	**Yes**					
		R11	Pulau Tekong (Singapore)		0.016	0.016	**Yes**					

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012 (RAPID EIA)
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*
Ontario = Ontario's Ambient Air Quality Criteria (April 2012)

Table 8.25: Predicted Annual MAICs for HCl (in µg/m³) during Normal Operation in

Parameter	Scenario	ASR	ASR	Concentration (µg/m³)									
				Baseline	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines	Predicted MAIC (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	Compliance with MAAQS 2013 (Standard [2020])	Compliance with WHO Ambient Air Quality Guidelines
HCl	Annual	ASR1	Open Space Near Kg. Lepau	N/M	0.0018	0.002	-	-	-	-	-	-
		ASR2	Sebana Cove Resort		0.0046	0.005						
		ASR3	Sebana Golf Resort		0.0120	0.012						
		ASR4	Bukit Pelali		0.0015	0.002						
		ASR5	Open Space Near Kg. Bukit Gelugor		0.0010	0.001						
		ASR6	Open Space Near Lake View		0.0008	0.001						
		R1	Tg. Pengelih		0.000	0.000						
		R2	Pengelih Naval Base		0.007	0.007						
		R3	Kg. Pengerang		0.001	0.001						
		R4	Kg. Sg. Kapal		0.002	0.002						
		R5	Taman Rengit Jaya		0.002	0.002						
		R6	Kg. Sg. Buntu		0.002	0.002						
		R7	Kg. Bukit Buloh		0.002	0.002						
		R8	Kg. Sg. Rengit		0.001	0.001						
		R9	Kg. Bukit Gelugor		0.001	0.001						
		R10	Kg. Pasir Gogok		0.001	0.001						
		R11	Pulau Tekong (Singapore)		0.0006	0.0006						

Note: *PM is conservatively assumed as 100% PM_{10} and $PM_{2.5}$*
GLC = Ground Level Concentration
MAIC = Maximum Average Incremental Concentration
N/M = Not Monitored
N/D = Not Detected
Average Baseline Levels for ASRs were based on the Ambient Air Quality Monitoring Results carried out on April, May, June and July 2019 while for R was carried out on October 2012
For calculation of average, values of Less than the Minimum Detectable Limit or not detected was assumed to be null
** means extracted from maximum range of iso-contour as per the RAPID EIA*
Ontario = Ontario's Ambient Air Quality Criteria (April 2012)

8.3.1.3 Abnormal Situation

For the ambient air criteria during abnormal situation, the Acute Exposure Guidelines Level values for Sulphur Dioxide (SO_2) and Hydrogen Sulphide (H2S) as shown in *Table 8.26* were adopted.

***Table 8.26*: Acute Exposure Guidelines Level (AEGL) Values for SO_2 and H_2S**

	10-minutes	30-minutes	1-hour	4-hours	8-hours	End Point
Sulphur Dioxide (SO_2)						
AEGL-1 (Non-disabling)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	0.20 ppm (0.52 mg/m^3)	NOEL for bronchoconstriction in exercising asthmatics
AEGL-2 (Disabling)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	0.75 ppm (1.95 mg/m^3)	Moderate bronchoconstriction in exercising asthmatics
AEGL-3 (Lethality)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	30 ppm (78 mg/m^3)	Calculated BMCLC05 in the rat after a 4-hour exposure
Hydrogen Sulphide (H_2S)						
AEGL-1 (Non-disabling)	0.75 ppm (1.05 mg/m^3)	0.60 ppm (0.84 mg/m^3)	0.51 ppm (0.71 mg/m^3)	0.36 ppm (0.50 mg/m^3)	0.33 ppm (0.46 mg/m^3)	Headache in humans with asthma
AEGL-2 (Disabling)	41 ppm (59 mg/m^3)	32 ppm (45 mg/m^3)	27 ppm (39 mg/m^3)	20 ppm (28 mg/m^3)	17 ppm (24 mg/m^3)	Perivascular edema in rats
AEGL-3 (Lethality)	76 ppm (106 mg/m^3)	59 ppm (85 mg/m^3)	50 ppm (71 mg/m^3)	37 ppm (52 mg/m^3)	31 ppm (44 mg/m^3)	Highest concentration causing no mortality in the rat after a 1-h exposure

Source: National Academy of Science, United States of America (2010). Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8 and Volume 11.

Note: AEGL-1 is the airborne concentration of a substance above which is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptimatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure;

AEGL-2 is the airborne concentration of a susbtance above which is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape; and

AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death

The maximum 1-hour averaging time incremental concentration iso-contour for SO_2 is as shown in *Figure 8.19* and *Figure 8.20* (100 % Percentile & 99.98 % Percentile) while and H_2S is as shown in *Figure 8.21* below.

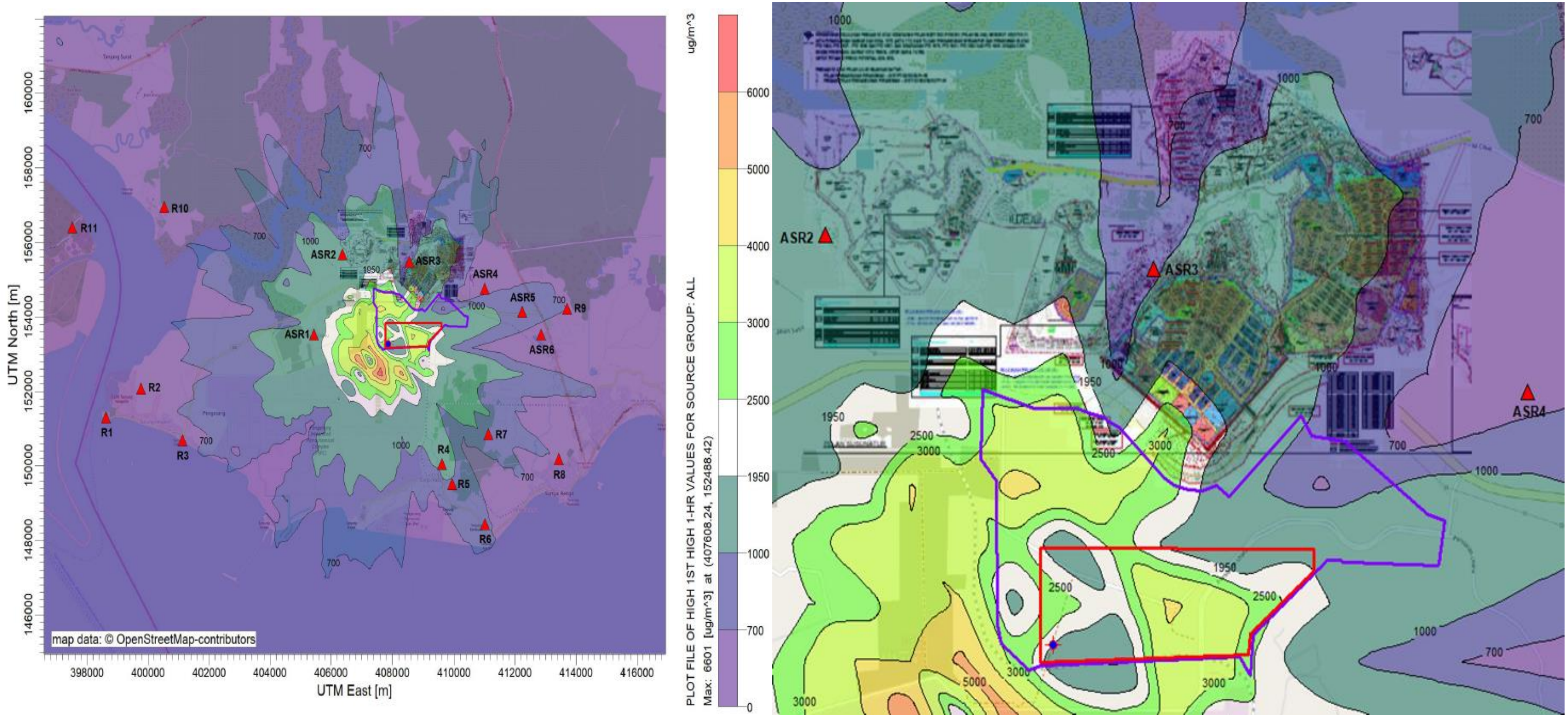


Figure 8.19 – Predicted Maximum 1-hour Average Incremental Concentration of SO_2 during Abnormal Situation (100 Percentile)

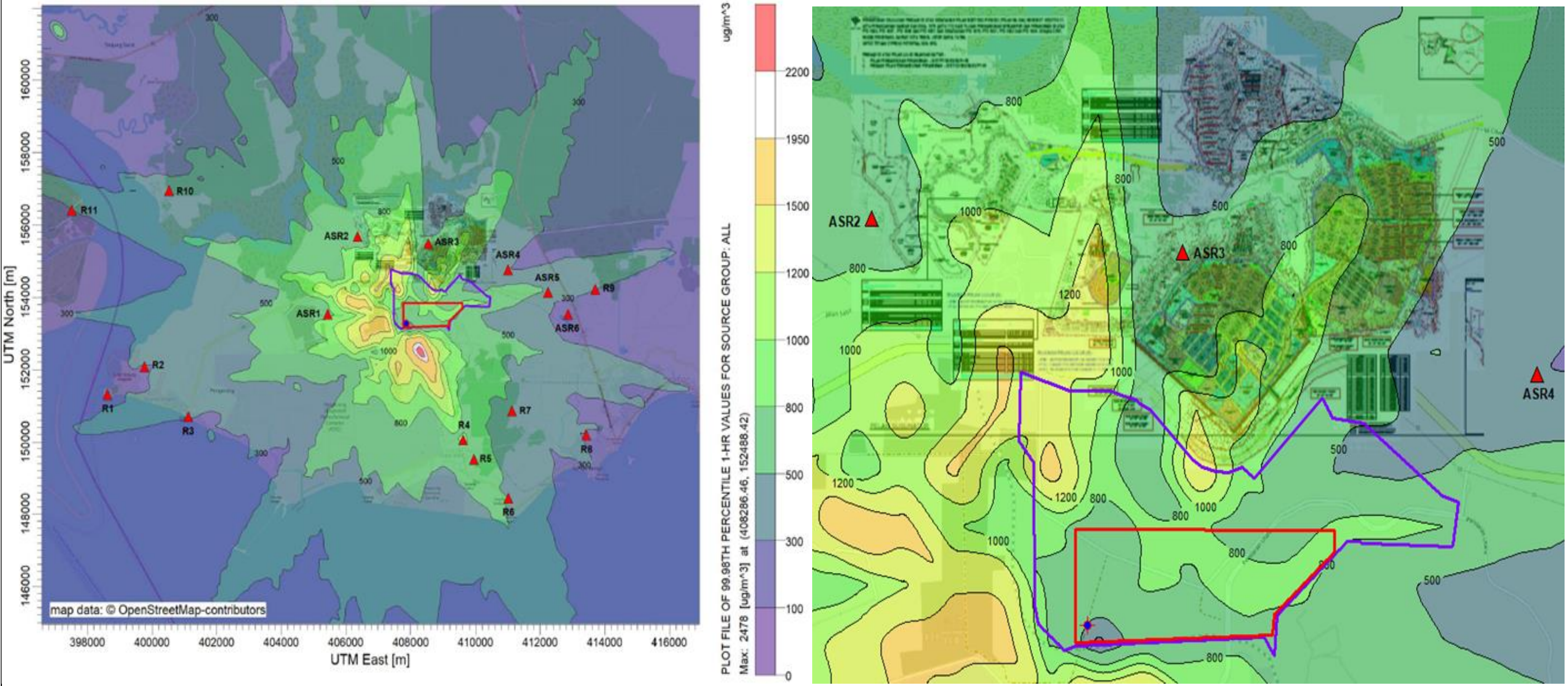


Figure 8.20 – Predicted Maximum 1-hour Average Incremental Concentration of SO_2 during Abnormal Situation (99.98 Percentile)

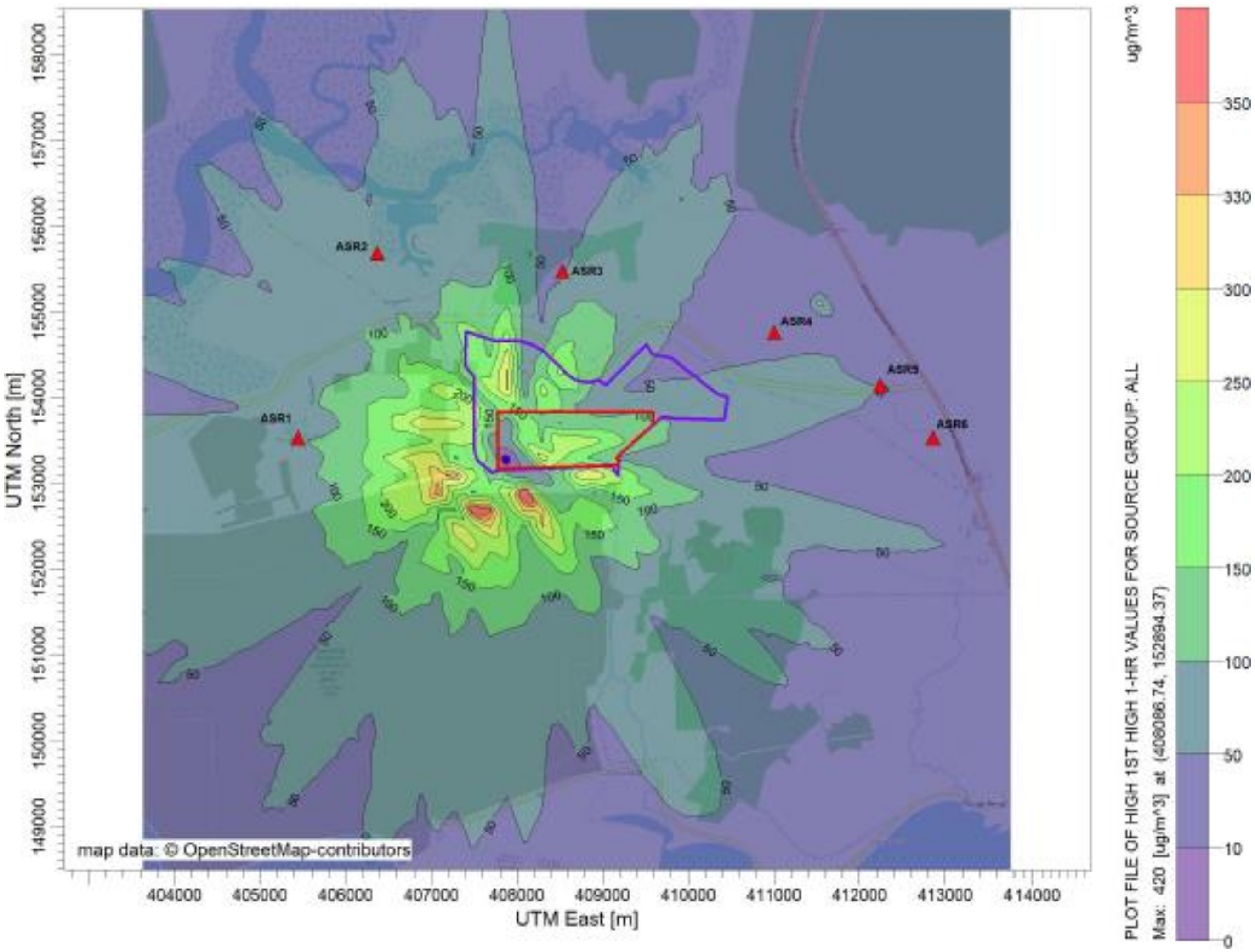


Figure 8.21 – Predicted Maximum 1-hour Average Incremental Concentration of H_2S during Abnormal Situation

<u>Sulphur Dioxide (SO_2)</u>

The highest predicted MAICs of SO_2 for 1-hour averaging time during abnormal situation was at 7,543.94 µg/m^3 occurring within Pengerang Industrial Complex (PIC). The predicted MAICs at the identified ASRs ranged from 469.942 µg/m^3 to 1,649.101 µg/m^3, whereby all ASRs were below the adopted AEGL-2 (Disabling) of 1,950 µg/m^3. At the same time, the Cumulative GLCs at the identifies ASRs ranged from 530.999 µg/m^3 to 1699.101 µg/m^3, which were also below the adopted AEGL-2 (Disabling) of 1,950 µg/m^3.

<u>Hydrogen Sulphide (H_2S)</u>

The highest predicted MAICs of H_2S for 1-hour averaging time during abnormal situation was at 419.63 µg/m^3. The predicted MAICs at the identified ASRs ranged from 26.14 µg/m^3 to 91.73 µg/m^3 with all ASRs were below the adopted AEGL-1 (Non-disabling) of 710 µg/m^3.

At the same time, the Cumulative GLCs at the identifies ASRs ranged from 28.491 µg/m^3 to 94.081 µg/m^3, which were also below the adopted AEGL-1 (Disabling) of 710 µg/m^3.

The summary of the predicted MAICs for identified during the Abnormal situation is as shown in *Table 8.27.*

***Table 8.27*: Predicted MAICs for Identified Pollutants (in $\mu g/m^3$) during Abnormal Situation**

Parameter	Scenario	Percentile (%)	ASR	Location	Concentration ($\mu g/m^3$)								
					Baseline	Highest Predicted MAIC	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Predicted MAIC in Normal Operation (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	AEGL-1 (Non-disabling)	AEGL-2 (Disabling)	AEGL-3 (Lethal)
SO_2	1-Hour	100	ASR1	Open Space Near Kg. Lepau	N/M	7543.94 (Outside PIP, Within PIC)	1,649.101	1,649.101	50.000*	1699.101	**520 $\mu g/m^3$ (0.20 ppm)**	**1,950 $\mu g/m^3$ (0.75 ppm)**	**78,000 $\mu g/m^3$ (50 ppm)**
			ASR2	Sebana Cove Resort			1,279.294	1,279.294	50.000*	1329.294			
			ASR3	Sebana Golf Resort			790.798	790.798	50.000*	840.798			
			ASR4	Bukit Pelali			502.183	502.183	40.000*	542.183			
			ASR5	Open Space Near Kg. Bukit Gelugor			892.945	892.945	40.000*	932.945			
			ASR6	Open Space Near Lake View			559.614	559.614	40.000*	599.614			
			R1	Tg. Pengelih	<5		526.567	526.567	19.300	545.867			
			R2	Pengelih Naval Base	<5		508.112	508.112	30.300	538.412			
			R3	Kg. Pengerang	<5		654.199	654.199	20.700	674.899			
			R4	Kg. Sg. Kapal	<5		1,094.791	1,094.791	53.600	1148.391			
			R5	Taman Rengit Jaya	<5		968.059	968.059	38.000	1006.059			
			R6	Kg. Sg. Buntu	<5		768.817	768.817	29.400	798.217			
			R7	Kg. Bukit Buloh	<5		886.331	886.331	51.900	938.231			
			R8	Kg. Sg. Rengit	N/D		674.852	674.852	37.400	712.252			
			R9	Kg. Bukit Gelugor	<5		700.692	700.692	33.900	734.592			
			R10	Kg. Pasir Gogok	N/D		506.599	506.599	24.400	530.999			
			R11	Pulau Tekong (Singapore)	N/M		469.942	469.942	20.000*	569.942			
		99.98	ASR1	Open Space Near Kg. Lepau	N/M	2449.1 (Outside PIP, Within PIC)	748.23	748.225	50.000*	798.225			
			ASR2	Sebana Cove Resort			697.94	697.940	50.000*	747.940			
			ASR3	Sebana Golf Resort			506.30	506.295	50.000*	556.295			
			ASR4	Bukit Pelali			308.62	308.616	40.000*	348.616			
			ASR5	Open Space Near Kg. Bukit Gelugor			466.85	466.847	40.000*	506.847			
			ASR6	Open Space Near Lake View			273.97	273.966	40.000*	313.966			
			R1	Tg. Pengelih	<5		265.65346	265.653	19.300	284.953			
			R2	Pengelih Naval Base	<5		289.31085	289.311	30.300	319.611			
			R3	Kg. Pengerang	<5		305.17283	305.173	20.700	325.873			
			R4	Kg. Sg. Kapal	<5		835.73934	835.739	53.600	889.339			
			R5	Taman Rengit Jaya	<5		714.58388	714.584	38.000	752.584			
			R6	Kg. Sg. Buntu	<5		499.48793	499.488	29.400	528.888			
			R7	Kg. Bukit Buloh	<5		453.76854	453.769	51.900	505.669			
			R8	Kg. Sg. Rengit	N/D		287.86721	287.867	37.400	325.267			
			R9	Kg. Bukit Gelugor	<5		298.54722	298.547	33.900	332.447			
			R10	Kg. Pasir Gogok	N/D		333.44691	333.447	24.400	357.847			
			R11	Pulau Tekong (Singapore)	N/M		292.37384	292.374	20.000*	392.374			
H_2S	1-Hour	100	ASR1	Open Space Near Kg. Lepau	N/M	419.63 (Outside PIP, Within PIC)	91.73	91.7303	2.351**	94.08128	**710 $\mu g/m^3$ (0.51ppm)**	**39,000 $\mu g/m^3$ (27 ppm)**	**71,000 $\mu g/m^3$ (50 ppm)**
			ASR2	Sebana Cove Resort			71.16	71.1600	2.351**	73.51095			
			ASR3	Sebana Golf Resort			43.99	43.9877	2.351**	46.33866			
			ASR4	Bukit Pelali			27.93	27.9336	2.351**	30.28461			
			ASR5	Open Space Near Kg. Bukit Gelugor			49.67	49.6696	2.351**	52.02055			
			ASR6	Open Space Near Lake View			31.13	31.1282	2.351**	33.47922			

Parameter	Scenario	Percentile (%)	ASR	Location	Concentration (µg/m³)								
					Baseline	Highest Predicted MAIC	Predicted MAIC (PEC)	GLC (Baseline+ Predicted MAIC PEC)	Predicted MAIC in Normal Operation (RAPID)	GLC (Baseline+ Predicted MAIC PEC + RAPID)	AEGL-1 (Non-disabling)	AEGL-2 (Disabling)	AEGL-3 (Lethal)
			R1	Tg. Pengelih			29.290	29.290	1.240	30.530			
			R2	Pengelih Naval Base			28.263	28.263	0.791	29.054			
			R3	Kg. Pengerang			36.389	36.389	1.007	37.396			
			R4	Kg. Sg. Kapal			60.897	60.897	1.430	62.327			
			R5	Taman Rengit Jaya			53.848	53.848	1.266	55.114			
			R6	Kg. Sg. Buntu			42.765	42.765	1.312	44.077			
			R7	Kg. Bukit Buloh			49.302	49.302	1.711	51.013			
			R8	Kg. Sg. Rengit			37.538	37.538	1.281	38.819			
			R9	Kg. Bukit Gelugor			38.976	38.976	1.307	40.283			
			R10	Kg. Pasir Gogok			28.179	28.179	0.972	29.151			
			R11	Pulau Tekong (Singapore)			26.140	26.140	2.351**	28.491			

Note:
PIP = Pengerang Industry Park
PIC = Pengerang Integrated Complex (RAPID)
AEGL = Acute Exposure Guidelines Level
AEGL-1 is the airborne concentration of a substance above which is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptimatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure;
AEGL-2 is the airborne concentration of a susbtance above which is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape; and
AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.
** means extracted from maximum range of iso-contour as per the RAPID EIA*
*** means conservatively extracted from the maximum receptor incremental during the normal operation as per the RAPID EIA*

The severity of the cumulative impact has been identified as medium. The assessment of the severity of the impact is as follows:

- The extent of the impact regional;
- The impact is only for the duration of the construction and operational phase of the PEC and RAPID;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

Based on the assessment, there are several residential areas within close proximity of PEC and RAPID. The local population in these residential areas may potentially be affected by the increase of air pollutant from both PEC and RAPID processes.

Nevertheless, the cumulative contribution in consideration of RAPID overall development may result in elevated NO_2 short term averaging time namely 1-hours averaging time towards the surrounding areas particularly during worst-case meteorological condition. The contribution of Particulate Matters from the RAPID development and PEC is expected to be minimal. Exceedance to the adopted ambient standard/guideline was due to the elevated PM particularly $PM_{2.5}$ in the surrounding areas.

Furthermore, there is expected to be no significant contribution of air pollutants to the nearest receptor at the neighbouring country namely Pulau Tekong is anticipated during normal operation of the proposed plant. Therefore, the receptor sensitivity is considered as low

As such, the significance of NO_2, SO_2, CO, $PM_{2.5}$, H_2S, and HCl emission during the operational stage on air quality due to the Project contribution has been identified as **Medium** based on an assessed medium impact severity and medium receptor sensitivity.

8.3.2 Mitigation Measures

Based on RAPID DEIA 2012, RAPID will be utilising various mitigation measures in order to control its emission during its operational stage. The mitigation measures that will be employed by RAPID during its operational stage are as follows:

- Conduct of ENVID, HAZID and HAZOP at every critical progress of the design stage;
- Provision of adequate buffer zones for the Project site and the design of the plot plan to locate each units of plant processes in a manner that will ensure minimal impact to the surrounding public and receptors;
- Adoption of the best practices based on other PETRONAS Operating Units or other similar plants globally;
- Process Safety Management, Risk based inspection and asset life study;
- Structured maintenance program i.e. scheduled turnaround; and
- Structures training program and competent operator to run the plants.

PEC will employ the various mitigation measures, as stated in Chapter 7 of this report, during its construction and operational phases. Furthermore, the assessment of the cumulative impacts to air at the Pengerang area will also be conducted by the local authority (State DoE) to ensure regulation compliance from the respective facilities in the area. PEC is fully committed in ensuring that its emissions will comply with the regulations and in safeguarding the wellbeing of both the local population as well as the environment. Therefore, PEC will fully cooperate with the local authority if such undertakings were to be conducted in the future.

8.4 Noise

This section will only evaluate the cumulative noise impact based on the information on the documents listed in section 8 of this chapter as well as the DoE approved PEC EIA. There are no other data regarding the impact of noise on Pengerang area resulting from the processes of RAPID and PIP that are available for public review.

The assessment of the cumulative noise impact to the surrounding area of PEC was conducted based on the following scope:

- Current noise level will be based on the baseline noise level from DoE approved PEC EIA;
- The assessment will evaluate the impact on the nearest identified sensitive receptors to PEC namely Kg. Lepau and Sebana Mixed Development; and
- Additional parameters of noise sources will be added in the noise modelling as part of the conservative assumption made to simulate the environment that will be representative to the construction and operational phase of PEC.

8.4.1 Impact Evaluation

8.4.1.1 Noise Impact during Construction Phase of PEC

The nearest identified noise sensitive receivers to the proposed PEC are Kg. Lepau (N2) and Sebana Mixed Development (N1), which are located 1.5 km and 1.6 km away, respectively. Background noise levels at these locations were found to be on average of 63.4 dBA in the daytime and 57.6 dBA to 58.6 dBA and 56.5 to 56.7 dBA at daytime and 51.0 to 56.3 dBA at night-time for L_{90} during the baseline noise survey as shown in *Table 8.28*. The adjacent receptors surrounding the Project site are mostly industrial area i.e. RAPID.

Table 8.28: Baseline Noise Levels at Sensitive Receptors

Location	Baseline Level (dBA)		
	L_{eq}	L_{90}	L_{Max}
Day-time (0700-2200)			
N1: Sebana Mixed Development	63.4	56.5	88.7
N2: Kg. Lepau	63.4	56.7	102.7
Night time (2200-0700)			
N1: Sebana Mixed Development	57.6	51.0	89.5
N2: Kg. Lepau	58.6	56.3	97.6

Noise from construction activities associated with PEC Project would not be expected to be audible at these locations. Nevertheless, a screening exercise using mathematical approach i.e. noise modelling was carried out to confirm this statement.

The sound pressure levels during the construction period were predicted using procedures from the **ISO 9613-2: Acoustic – Attenuation of sound during propagation outdoors – Part 2: General Method of Calculation**. A software package CadnaA (Computer Aided Noise Abatement) developed by Datakustik GmbH which implements the procedures was used to predict the noise levels.

Conservative assumptions were made for the modelling exercise as highlighted below:

- During Construction Period, simulation was carried out for the application of bulldozer along the western side (facing Kampung Lepau) and northern side (facing Sebana Mixed Development) of the Project Site. The conservative sound power level of the dozers of 118 dB(A) as per Schedule 2: Maximum Permissible Sound Power Levels of Excavators, Dozers and Loaders was adopted as documented in The Guidelines for Noise Labelling and Emission Limits of Outdoor Sources (2007) issued by DOE Malaysia;

- The identified Noise Sensitive Receptors (NSRs) as tabulated in *Table 8.29* were used.

Table 8.29: Locations of Identified Noise Sensitive Receptor

Noise Sensitive Receptor	UTM Coordinates (Zone 47 N) (m)			Location
	X	Y		
N1	408531.00	155476.00		Sebana Mixed Development
N2	405440.40	153531.26		Kampung Lepau

- All NSRs were predicted at 1.5 m relative from the ground level. No terrain screening was considered in this assessment.

The Project Site and the identified NSRs for this Project is shown in *Figure 8.22*.

The summary of the predicted noise levels at the identified NSRs during construction period is as shown in *Table 8.32* while, the iso-contour is as shown *Figure 8.23.*

It is predicted that the contribution of noise from the Project Site would be **insignificant** at the identified NSRs with no changes to the baseline level. Hence, it is also anticipated that the recommended limit of 75 dBA for L_{10} and 90 dBA for L_{max} will be met with.

8.4.1.2 Noise Impact during Operation Phase of PEC

The potential impact of noise to residential receptors during the operational phase is expected to be Low as the nearest residential areas are located at least 1 km away. Nevertheless, a screening exercise using CadnaA noise model, similar with the assessment for construction period was carried out to confirm this statement.

As detailed layout of the noise generating equipment and its noise rating were not available at this point of time, it is conservatively assumed that the noise levels from the identified stacks towards the northern part of the Project Site were within 85 dBA at 1 meter with the calculated Sound Power Level of 93 dBA, while, the Sound Power Level at 120 dBA as tabulated in *Table 8.31* and *Table 8.32* respectively. All equipment were at ground level except the Flare at 161 m and were assumed to operate simultaneously. No shielding effect due to the buildings such as storage tanks was considered in the simulation.

As per previous noise assessment (construction period), the same identified Noise Sensitive Receptors (NSRs) were predicted at 1.5 m relative from the ground level. No terrain screening was considered in this assessment.

Table 8.30: Significant Noise Generating Sources for the Project during Operation Period

Noise Source	Calculated Sound Power Level (dBA)	Elevation from Ground Level (m)
Flare	120	161
Charge Heater 320-H1	93	0
Xylene Splitter Reboiler	93	0
Charge Heater Toluene Column	93	0
Charge Heater 200-H1	93	0
Charge Heater & NO1 Interheater	93	0
NO2 Interheater and NO3 Interheater	93	0
CCR RCR Vent	93	0
Feed Fractionator Reboiler & Distillate Fractionator Feed Heater	93	0
Combined Feed Heater / DHT	93	0
KHT Furnaces	93	0
SRU Furnaces	93	0
CRP	93	0
Steam Boiler	93	0
Steam Boiler	93	0
Steam Boiler	93	0

Note: Sound Pressure Levels at 1 m for all equipment are at 85 dBA except for Flare

Table 8.31: Flare Noise Spectrum

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Loudness (dB)	95	101	109	118	115	112	110	107
Total (dBA)	**120**							

*Source: **Table A.1**: Flare Details for General Refinery and Petrochemical Service, ANSI/API Standard 537 (Second Edition, December 2008)*

The summary of the predicted noise levels at the identified NSRs during operation period is as shown in *Table 8.33*. while, the iso-contour is as shown *Figure 8.24.*

It is noted that the existing baseline noise level in the surrounding area of the site has already exceeded the permissible sound level set in the First Schedule: Recommended Permissible Sound Level (L_{Aeq}) By Receiving Land Use for New Development (Low Density Residential – 55 dBA [Daytime] and 50 dBA [Night-time]) and Second Schedule: Recommended Permissible Sound Level (L_{Aeq}) By Receiving Land Use for Existing Land Use for Built Up Areas (Low Density Residential – 60 dBA [Daytime] and 55 dBA [Night-time]) as per the Schedule of Permissible Sound Levels of the Guidelines for Environmental Noise Limits and Control (2019). Hence, the Third Schedule: Recommended Permissible Sound Level (L_{Aeq}) To Be Maintained At The Existing Noise Climate applies where the Recommended Permissible Levels is the **Existing L_{Aeq}**.

Based on the predicted cumulative noise levels both daytime and night-time during the operational period, the existing baseline will be met. Hence, the noise contribution from the Project towards the identified NSRs would be **negligible.**

8.4.2 Mitigation Measures

8.4.2.1 Construction Phase of PEC

Noise during construction activities are expected to be generated from equipment usage, piling activities and vehicle movements. Good site practices are to be implemented to limit noise emissions at source, for example:

- Only well-maintained equipment should be operated on-site and regular service/ maintenance shall be conducted for each equipment that produce high noise emissions;
- Silencers/ mufflers on construction equipment which produces high noise emissions should be utilised and maintained regularly;
- Hoarding shall be constructed prior to the commencement of construction works and any construction activities that has potential of emitting high noise level shall be limited to daylight hours only (7.00 am – 7.00 pm);
- Reducing speed limits of heavy vehicles and ensure all heavy vehicles e.g. trucks are maintained properly;
- Monitoring for noise level during construction shall be carried out regularly to control the noise emission; and
- Protective equipment such as ear-muff shall be provided to workers handling/ operating the high noise equipment to prevent from hearing impairment.

8.4.2.2 Operational Phase of PEC

The operational phase will generate noise disturbance. Major sources of impact are derived from operational equipment at the process plant, pumping, flare and air system. The emphasis for noise pollution control during the operational stage is on the design and placing of the noise generating equipment within the work areas.

Noise emissions control measures may include, but not limited to, the following;

- Best practice procedures (such as turning off equipment when not in use);
- Regular equipment maintenance; and

Noise prevention and mitigation measures such as silencer, relocation of equipment, replacement with lower noise level, and personal protective equipment etc. should be applied where predicted or measured noise impacts from the facility or operation exceed the applicable noise level.

Figure 8.22 – Project Site and Location of Identified Noise Sensitive Receptors

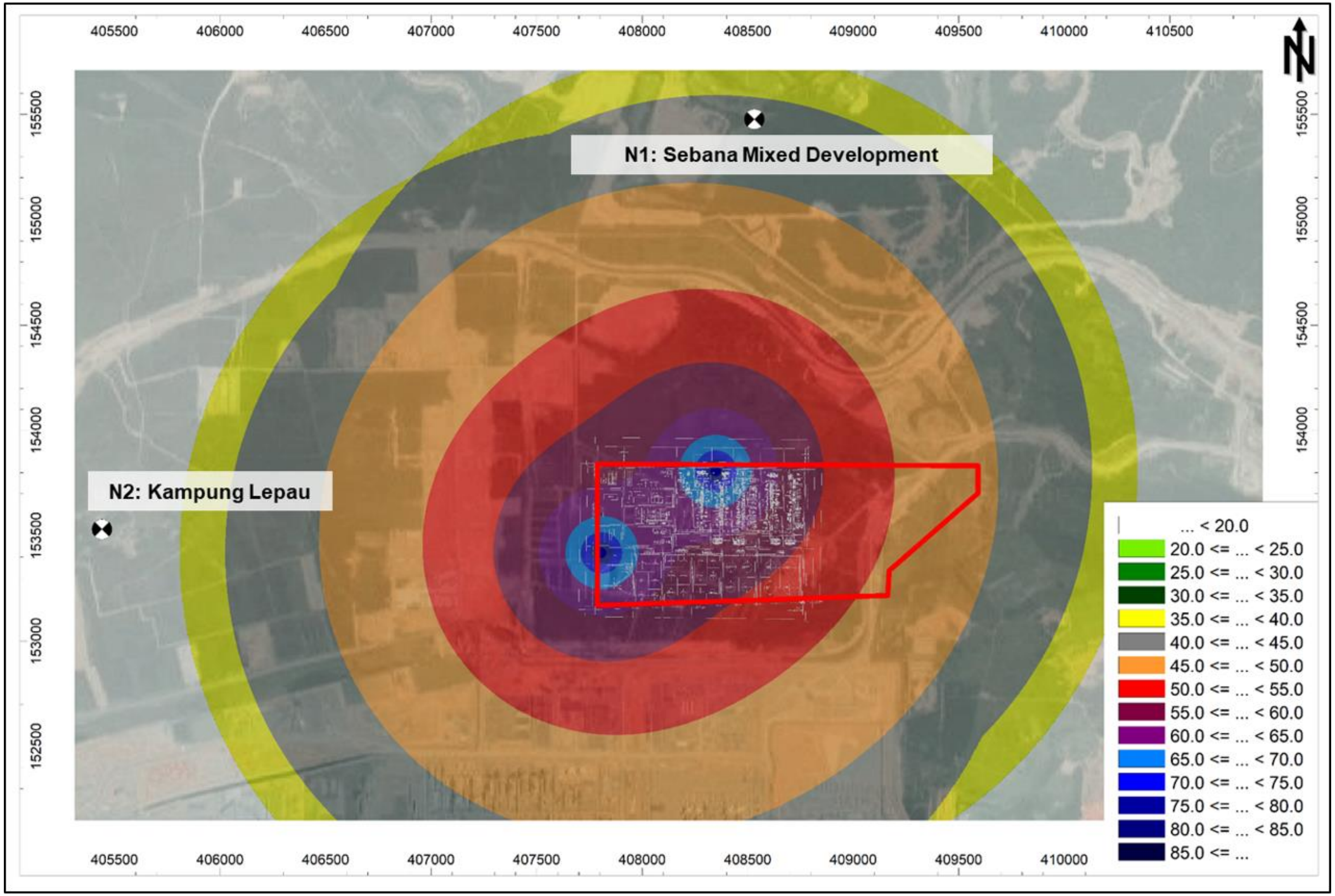


Figure 8.23 – Predicted Noise Iso-contour during Construction Period

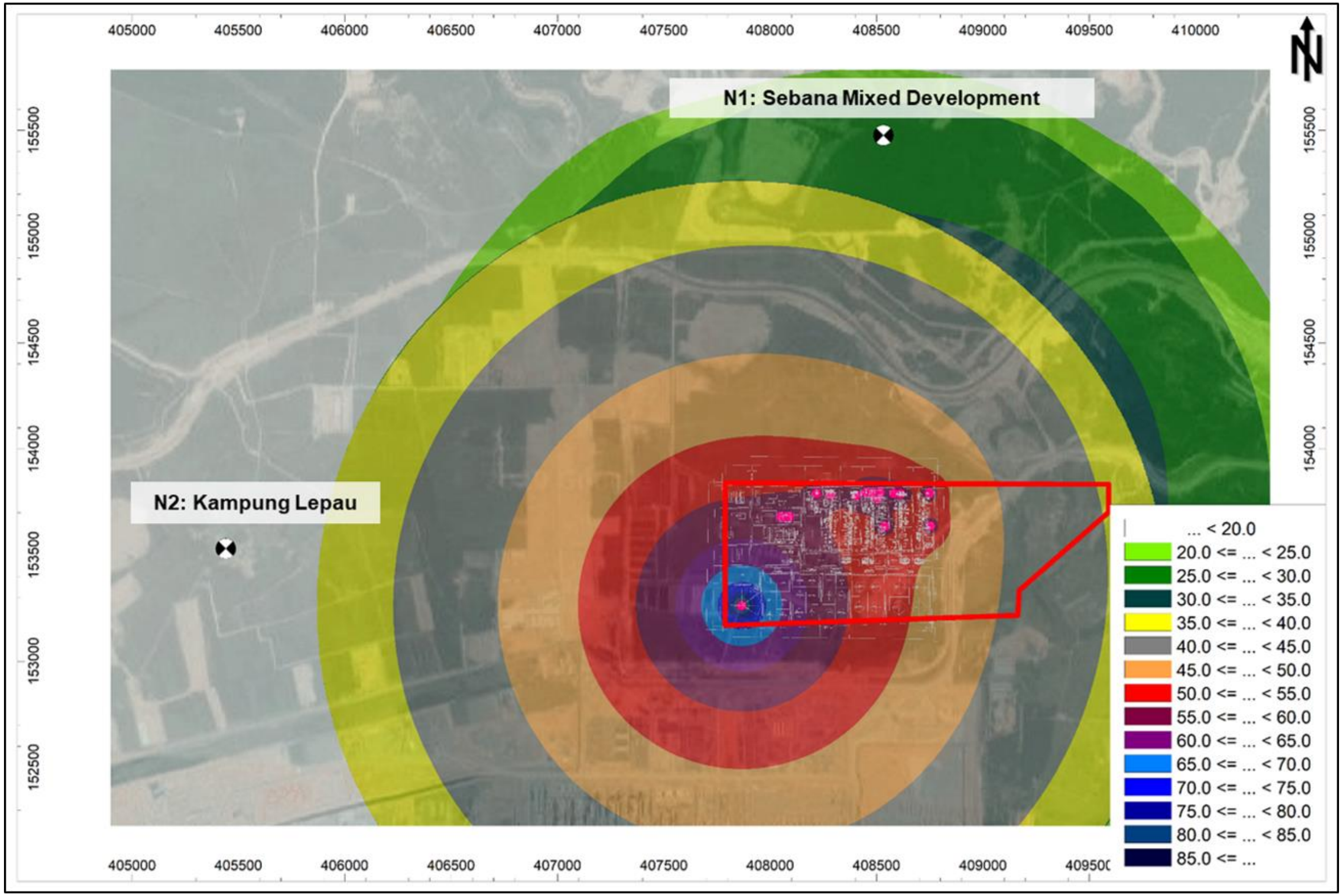


Figure 8.24 – Predicted Noise Iso-contour during Operation Period

Table 8.32: Locations of Identified Noise Sensitive Receptor

Sound Power Level, PWL (dB)*	Conditions	Predicted Noise Levels at NSRs, dB(A)			
		NSR 1 (Sebana Mixed Development)		NSR 2 (Kg. Lepau)	
		Daytime	Night-time		
118 (Bulldozers at the Western and Northern Boundary of the Project Site)	Existing Noise Level (L_{Aeq})	63.4	57.6	63.4	58.6
	Noise Contribution From Construction Activity[#]	<45.0		<20.0	
	Cumulative Noise Level	**63.4 (Comply)**	**57.6 (Comply)**	**63.4 (Comply)**	**58.6 (Comply)**
	Maximum Permissible Sound Level (L_{max})[¥]	**L_{10} – 75, L_{max} - 90**			
	Incremental Noise Level (L_{Aeq})	0	0	0	0
	Anticipated Community Response[@]	**None**	**None**	**None**	**None**

Notes: **Refer to DOE's The Guidelines for Noise Labelling and Emission Limits of Outdoor Sources,* ***Schedule 2: Maximum Permissible Sound Power Levels of Excavators, Dozers and Loaders***

¥Refer to DOE's Guidelines for Environmental Noise Limits and Control (2019), ***Sixth Schedule: Maximum Permissible Sound Levels (Percentile L_{10} and L_{max}) of Construction, Maintenance and Demolition Work by Receiving Land Use***

@Refer to the DOE's Guidelines for Environmental Noise Limits and Control (2019), Table C-1: Human perception of sound and likely environment impact

Table 8.33: Predicted Noise Levels at the Identified NSRs during Operation Period

Sound Power Level, PWL (dB)*	Conditions	Predicted Noise Levels at NSRs, dB(A)			
		NSR 1 (Sebana Mixed Development)		NSR 2 (Kg. Lepau)	
120 (Flare) 93 (Others as per **Table 7.10**)	Existing Noise Level (L_{Aeq})	63.4	57.6	63.4	58.6
	Noise Contribution From Plant Operation	<35.0	<35.0	<20.0	<20.0
	Cumulative Noise Level	**63.4 (Comply)**	**57.6 (Comply)**	**63.4 (Comply)**	**58.6 (Comply)**
	Recommended Permissible Sound Level (L_{Aeq})[¥]	**Existing L_{Aeq} (Third Schedule)**			
	Incremental Noise Level (L_{Aeq})	0			
	Anticipated Community Response[@]	None		None	

Notes: [¥]*Refer to DOE's Guidelines for Environmental Noise Limits and Control (2019), Schedule of Permissible Sound Levels: Third Schedule: Recommended Permissible Sound Levels (L_{Aeq}) To Be Maintained At The Existing Noise Climate*

[@]*Refer to the DOE's The Planning Guidelines for Environmental Noise Limits and Control, Table C-1: Human perception of sound and likely environment impact*

8.5 Surface Water Quality

8.5.1 Assessment of the Surface Water Quality of Sg. Lepau

For the assessment of the cumulative impact on the surface water, only the surface water quality of Sg. Lepau will be assessed as it is the main river in that will be affected by RAPID, PEC and PIP. Note however, that RAPID only discharges into Sg. Lepau during the construction phase only.

The assessment of the potential cumulative impacts on the surface water quality of Sg. Lepau based on PIC/ RAPID and PIP data during their construction and operational phases are described as follows:

<u>PIC/ RAPID</u>

Assessment of the cumulative impact for RAPID as part of PIC is based on the Detailed Environmental Impact Assessment (DEIA) Study for The Proposed Petrochemical Plants in the Refinery and Petrochemical Integrated Development (RAPID) Project, Pengerang 2014 report.

As stated in the report, there are several river catchments within and surrounding the RAPID site. The river catchments of the RAPID site are:

1. Sg. Pengerang – 7.88 km^2 (within RAPID);
2. Sg. Langkah Baik – 4.39 km^2 (within RAPID);
3. Sg. Hj. Ahmad – 4.20 km^2 (within RAPID);
4. Sg. Kapal catchment area – 1.78 km^2 (northern of RAPID); and
5. Sub-catchment of Sg. Santi – 6.24 km^2 (eastern of RAPID).

During construction phase of RAPID, surface runoff from the RAPID site will be drained into five main rivers which are located to the south and north of the site namely Sg. Pengerang, Sg. Langkah Baik, Sg. Teluk Empang, Sg. Hj. Ahmad and Sg. Kapal. The flow of surface runoff is divided into two directions depending on the topography of the site. The northern part of the RAPID site will flow into the tributary of Sg. Lepau, Sg. Lanjut and tributary of Sg. Pengkalan Pinang, which will subsequently flow into Sg. Santi and into Straits of Singapore. As reported in RAPID DEIA 2014, the northern part of the RAPID site has been cleared and the upstream area of Sg. Lanjut and Sg. Pengkalan Pinang, located within the RAPID boundary, have been converted into sediment basins and retention corridors.

The main water body of concern for the purposes of this assessment is Sg. Lepau. Based on the RAPID DEIA 2014, only 190.56 ac of RAPID discharges into Sg. Lepau during the construction period. Prior being discharged into Sg. Lepau, the runoff is contained in a sediment basin to ensure the discharge is as per the regulations and stated in the Approval Conditions for RAPID. The sediment basin and discharge points are decommissioned once construction is completed.

During RAPID operational phase, its main effluent discharge will be from its effluent treatment plant, cooling water discharge, sewage treatment facility and surface water runoff. All effluents from these sources will be channelled into the centralised water treatment plant. The combined effluents will be treated in the centralized water treatment plant prior to being discharged via a common chamber in a single marine outfall located 1.18 km to the south of Tg. Setapa.

<u>PIP</u>

During construction phase of PIP, application of BMPs will be implemented to reduce the adverse impacts on the river and waterways. A total of 22 sediment basins will be constructed to reduce sediment prior to discharging the water into river. Other mitigation measures that will be implemented based on the Erosion Control and Sediment Plan (ESCP) are:

- Silt fences

  Silt fences will be installed at areas fronting the river or waterway.

- Perimeter drain/ earth drain

  Temporary and permanent drainage will be constructed prior to commencement of any earthwork activities. Drainage system will be channelled to sediment basins prior to discharging into the river.

- Check dam

  Check dams will be used along the drainage system to reduce velocity of the surface runoff and sediment/ silt that will enter the sediment basins.

PIP will hand over the clear and levelled land to JCorp for the tenants such as PEC to continue developing the area.

<u>PEC</u>

During PEC construction and operational phase, surface water runoff and wastewater from PEC will be discharged into PIP retention pond. It will then flow into Sg. Lepau and subsequently flows into Sg. Santi and Straits of Johor.

<u>Sg. Lepau Surface Water Quality Assessment</u>

For the assessment of the cumulative surface water quality on Sg. Lepau, the surface water quality data from RAPID surface water sampling conducted in November 2011 will be utilised as the baseline. This data will then be compared to surface water quality data obtained from PEC's surface water sampling which was conducted in October 2018 for the development of its EIA. The purpose of the comparison of these data is to observe any changes that might occurred during RAPID construction phase in 2014 until the commencement of its commissioning phase in 2018. The location of the sampling points for both RAPID and PEC is shown in *Figure 8.25.*

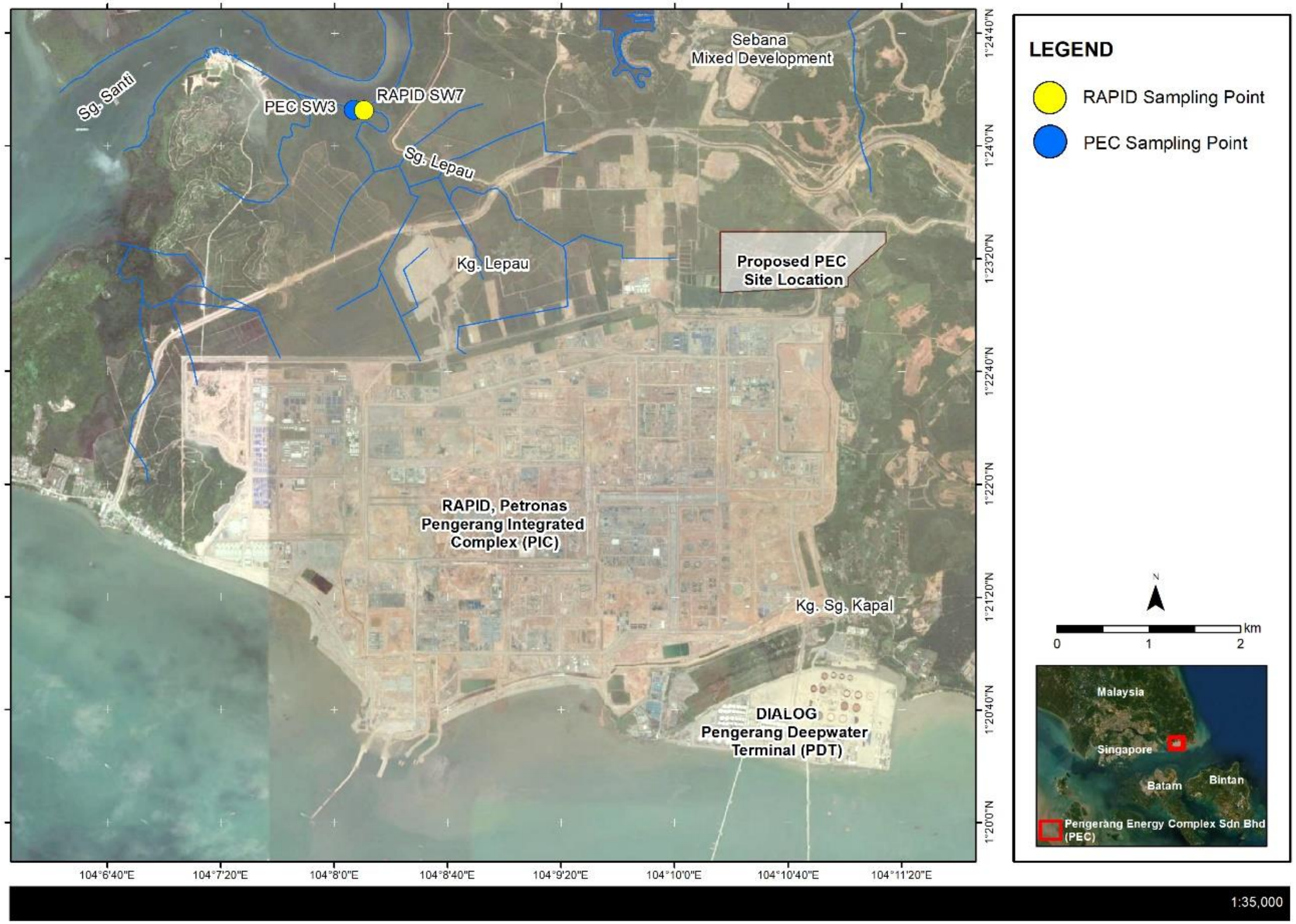


Figure 8.25 – Sampling Points of RAPID and PEC

The surface water sampling result of RAPID and PEC are in *Table 8.34.*

Table 8.34: Surface Water Sampling Result of RAPID and PEC

Parameter	Unit	NWQS Limits	RAPID	PEC
Conductivity	µS/cm	1000	-	41,200
pH Value	pH Unit	6 – 9	6.74 – 8.94	6.6
Salinity	Parts/1000	1	-	25.8
Temperature	°C	Normal + 2°C	26.69 – 29.12	28.6
Total Dissolved Solids	mg/L	1000	-	31,100
Total Suspended Solids	mg/L	50	82	36
Turbidity	NTU	50	-	14.6
Colour (True)	TCU	150	-	10
Biochemical Oxygen Demand	mg/L	3	3	7
Chemical Oxygen Demand	mg/L	25	20	23
Ammonia as N	mg/L	0.3	0.14	1.71
Dissolved Oxygen	mg/L	5 – 7	-	7.75
Total Coliform Count	CFU/ 100mL	5000	-	3,600
Total Faecal Coliform Count	CFU/ 100mL	100	-	<1

Based on the assessment of both RAPID and PEC surface water sampling, there are no significant changes in water quality of Sg. Lepau. This may be due to the mitigation measures applied by RAPID during its construction phase reducing the negative impact of Sg. Lepau and thus, retaining its water quality throughout RAPID construction phase.

<u>Effluent Discharge</u>

Table 8.35 shows the conservative assumption of the water required for PEC processes.

Table 8.35: Water Required fro PEC Processes

Parameter	Unit
Cooling Water Makeup	260 m^3/h
Demineralise Water Plant	100 m^3/h
Process Utility water	~ 50 m^3/h
Plant Tank Farm Area	150 m^3/h
Total Water Required	**~ 600 m^3/h**

The input above will flow to PIP retention pond as shown in the *Figure 8.26.*

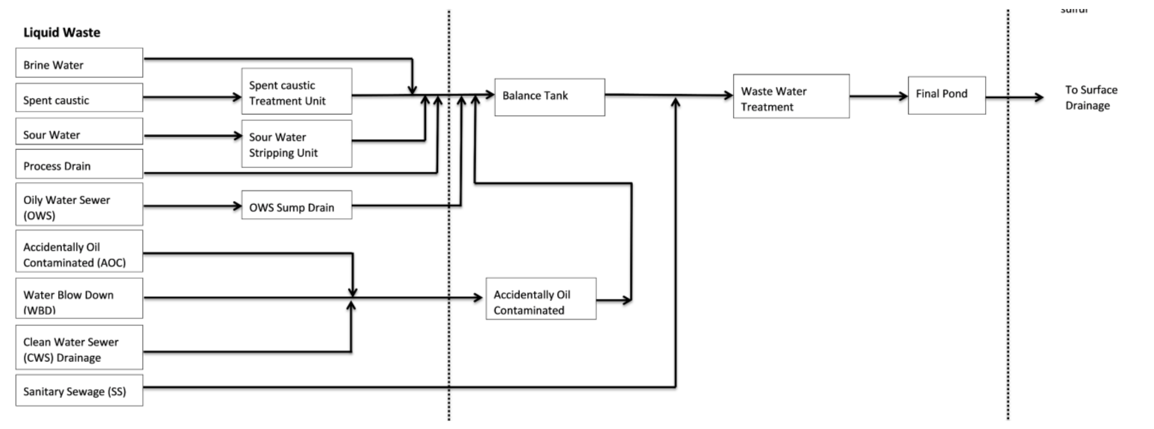


Figure 8.26 – Gas, Liquid, & Solid Waste Treatment Scheme Block Diagram
Source: PEC

The flow of the discharged effluents from PIP retention pond will be regulated by PIP in order to prevent the overflow in Sg. Lepau. Detailed engineering design for the PEC will include the water balance of the overall usage of water and its life cycle in PEC.

<u>RAPID</u>

Based on RAPID DEIA 2012, the amount of water required of the operational phase of RAPID is 50 MGD. There are no other information available for public review regarding the water usage and requirement. However, RAPID will only discharge its effluents through a single marine outfall located 1.18 km to the south of Tg. Setapa. Therefore, the discharge of effluents from RAPID will not impact the quality of Sg. Lepau.

8.5.2 Impact Evaluation

This section will only evaluate the cumulative impact based on the information on the documents listed in section 8 of this chapter as well as the DoE approved PEC EIA. There are no other data regarding the impact of the surface water quality resulting from the processes of RAPID and PIP that are available for public review.

RAPID only discharge into Sg. Lepau during the construction phase of the project. At the commencement of PIP, RAPID's construction had already completed and as such, the discharge outlet into Sg. Lepau had been decommissioned. PIP's ESCP shows that the peak discharge into Sg. Lepau during the construction period is 44 m^3/s for a 50-year ARI.

RAPID's ESCP shows that post-construction peak discharge into Sg. Lepau to be 9.60 and 25.8 m^3/s for 2-year and 100-year ARI respectively.

PIP have constructed a 14.32 ha retention pond for the whole of PIP. All runoffs from tenants of PIP during the construction period will be channelled into this retention pond prior to being discharged into Sg. Lepau. PIP's ESCP estimated the peak runoff into Sg. Lepau post construction period to be 19 m^3/s for a 50-year ARI.

Providing adequate mitigation measures are implemented, the cumulative impacts into Sg. Lepau during PEC's construction activities are expected to be **low**.

Currently, RAPID is entering its commissioning stage and the surface runoff and its effluent will be discharged 1.18 km off the coast of Tg. Setapa. PEC and RAPID will be discharging into a different river system during the operations phase in which PEC will be discharging into PIP's internal drainage system which flows into PIP's retention pond. This retention pond will discharge into Sg. Lepau. *Figure 8.27* shows the flow of both RAPID and PEC. Note that PEC will only be responsible for its internal drainage system. As mentioned in Chapter 5 of this report, all discharge from PEC during construction and operational phase will be drained into PIP drainage then to PIP retention pond before being discharged into Sg. Lepau. To further minimise the impact to SG. Lepau, PEC will utilise various mitigation measures as described in Chapter 7 of this report during both its construction and operational phase. Therefore, the cumulative impact on Sg Lepau due to RAPID and PEC during the operations phase is expected to be **low**.

In consideration of the total cumulative impact of both of construction and operational phase of PEC and RAPID on Sg. Lepau, the severity of the impact has been identified as medium. The assessment of the severity of the impact is as follows:

- The extent of the impact is regional;
- The impact is only for the duration of the construction and operational phase of the PEC and RAPID;
- The frequency of the impact is periodical; and

- The impact is reversible.

The receptor sensitivity is considered as medium. This is because the discharge of construction and runoff and wastewater effluents onto Sg. Lepau may potentially change the water quality of Sg. Lepau. Furthermore, there are several aquaculture activities in Sg. Santi in which Sg, Lepau will eventually flown into. However, all discharge wastewater effluents will be treated to Standard A of the *Environmental Quality (Industrial Effluents) Regulations 2009* prior to discharge.

As such, the significance of the cumulative impact of effluent discharge onto Sg. Lepau has been identified as **Medium** based on an assessed medium impact severity and medium receptor sensitivity.

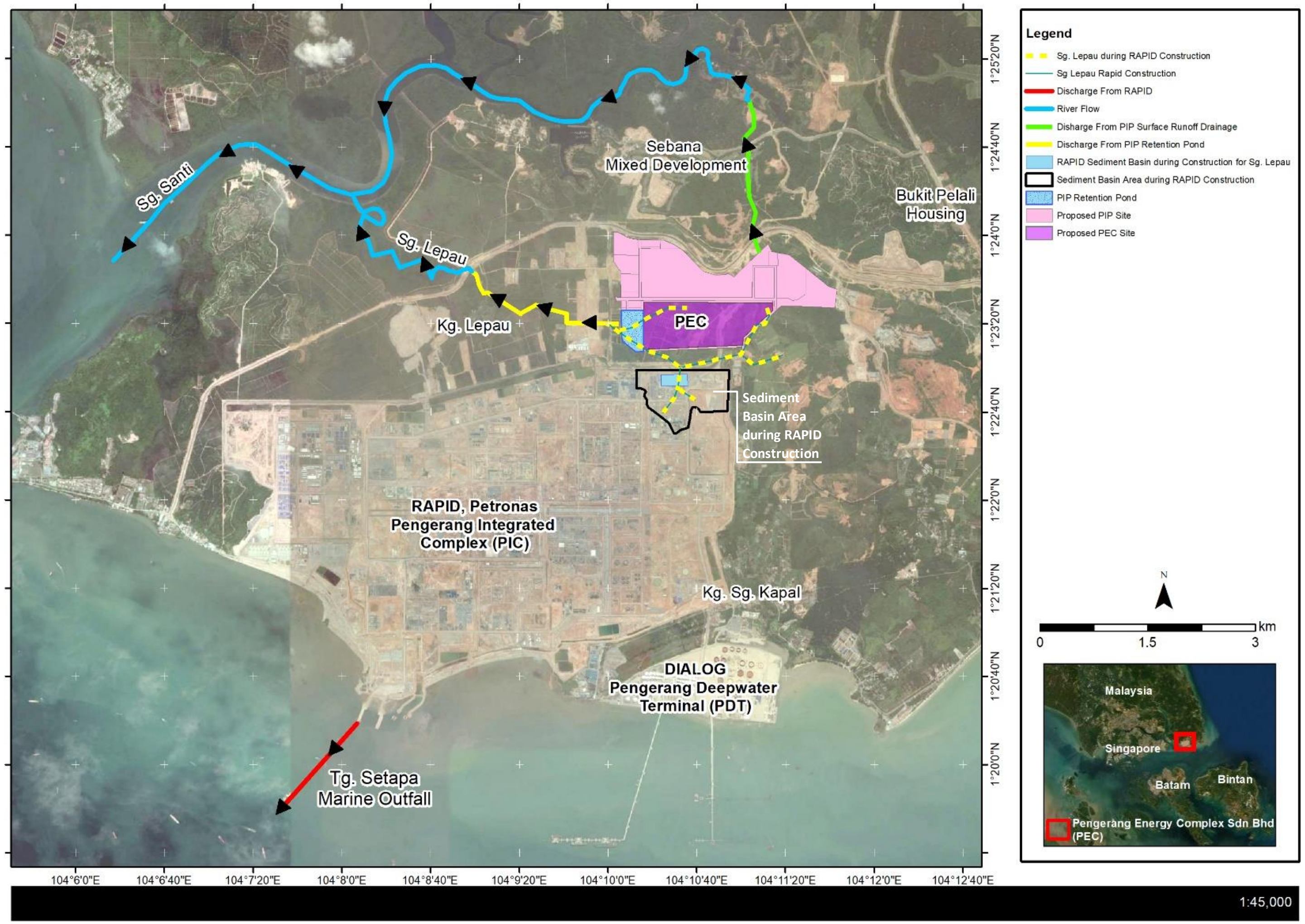


Figure 8.27 – Discharged Flow of RAPID and PEC

8.5.3 Mitigation Measures

Any surface water or effluent discharge needs to be treated to comply with NWQS or Standard A of the *Environmental Quality (Industrial Effluent) Regulations 2009* before entering the waterways. During the construction phase, PEC will construct 2 nos. of sedimentation ponds located at the western boundary of the site prior to discharging the surface runoff into PIP retention pond. Surface water sampling and monitoring will be conducted at the discharge point of the PEC sedimentation pond during the construction phase and at the discharge point of the wastewater treatment plant (WWTP) during the operational phase on a quarterly basis to ensure that the water discharged will be in compliance to the regulation.

8.6 Natural and Critical Habitat

Based on the available data from RAPID, PIP, and PEC, Sungai Santi Forest Reserve is the only designated critical habitat area in Pengerang area and is home to various species of flora and fauna. It is located approximately 3 km from both PEC and RAPID. Although the development of RAPID, PIP and PEC will not directly impact Sungai Santi Forest Reserve, the discharge of effluents into Sg. Lepau from both RAPID and PEC during their respective construction phases and from PIP during the operation phase may influence the river water quality of Sg. Santi which will subsequently affect the flora and fauna species in Sungai Santi Forest Reserve.

8.6.1 Assessment of the Impact on Natural and Critical Habitat

During the construction phase of PIP and PEC, the main source of effluents will be from construction runoff which may contain increased sediment loads (total suspended solids – TSS) as well as entrained contaminants (e.g. oil, grease etc.). However, PIP will utilise various BMPs (Best Management Practices) as part of its LD-P2M2 (Land Disturbing Pollution Prevention Mitigation Measures) plan during its construction phase. This includes the utilisation of check dam, perimeter drain, sedimentation basin as well as silt fence.

As for PEC, site clearing and earthwork activities during the construction phase are expected to be minimal as the site will be handed over to PEC as a levelled platform. During PEC operational phase, all effluents will be treated to Standard A of *Environmental Quality (Industrial Effluent) Regulations 2009*. prior to being discharged to PIP's retention pond. PIP will then have to ensure that the effluents have been treated to Standard A (Industrial Effluent) as per required by DoE prior to discharge into Sg. Lepau to ensure minimum impact to Sg Santi Forest Reserve and its surroundings.

As for RAPID, the potential impact of RAPID on the surrounding marine ecosystem during its operational phase is through the discharge of its effluents to the coastal area located south of RAPID. The three (3) identified sources of effluents based on RAPID DEIA 2012 are as follows:

1. Effluent Treatment Plant and Cooling Water Discharge via Marine Outfall
2. Sewage Treatment Facility
3. Surface Water Runoff

The main source of cooling medium for RAPID, PCP, and RGT2 will be from the seawater intake. After the cooling process, the discharged cooling water from these sources will be combined with the discharged effluent from the centralised effluent treatment plant. The combined effluents will then be discharged via a common chamber in a single marine outfall located 1.18 km to the south of Tg. Setapa.

8.6.2 Impact Evaluation

This section will only evaluate the cumulative impact based on the information on the documents listed in section 8 of this chapter as well as the DoE approved PEC EIA. There are no other data regarding the impact on the critical habitats resulting from the processes of RAPID and PIP that are available for public review.

In consideration of the total cumulative impact of both of construction and operational phase of PEC and RAPID on Sg. Santi Forest Reserve, the severity of the impact has been identified as medium. The assessment of the severity of the impact is as follows:

- The extent of the impact is regional;
- The impact is only for the duration of the construction and operational phase of the PEC and RAPID;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

Although the effluents from both PEC and PIP will be discharged into Sg. Lepau, the potential impacts on water quality are expected to be low and manageable, provided that each responsible party ensures that their effluents are treated in compliance with the regulation prior to discharge and the mitigation measures that will be utilised is properly maintained and working in optimum condition. Furthermore, the discharge of effluents from RAPID to the southern coastal area will not cause a significant impact to the marine coastal ecosystem as there is no critical marine habitat recorded in the area. Therefore, receptor sensitivity is considered as low.

As such, the significance of the cumulative impact on Sg, santi Forest Reserve has been identified as **Low** based on an assessed medium impact severity and low receptor sensitivity.

8.6.3 Mitigation Measure

Any surface water or effluent discharge needs to be treated and complied with NWQS or Standard A of the Environmental Quality (Industrial Effluent) Regulations 2009 before entering the waterways. PEC will construct 2 nos. of sedimentation ponds located at the western boundary of the site prior to discharging the surface runoff into PIP retention pond. Monitoring will be conducted at the discharge point of the PEC sedimentation pond on a quarterly basis.

8.7 Influx of Workers

8.7.1 Assessment of Influx of Non-local workers in Pengerang

RAPID

70,000 workers were employed during the construction phase of the RAPID complex. Some of the workers were foreigners and were provided with a house in the Temporary Workers Accommodation Camp located inside the RAPID complex boundary. The positive impacts expected from the influx of workers were:

a) Improved economic standing due to the increase of demand in general needs and amenities;
b) Provision of vocational support and work training related to the job vacancies and priorities given for local employment will increase jo opportunities from unskilled to skilled workers;
c) Expansion of the hospitality-related industries to cater to the business needs; and

d) Increase demand for local products by foreign workers will help generate additional income for the local residents.

However, the influx of foreign workers may present an increased risk in the transmission of sexually transmitted diseases (STD). Furthermore, immigrants are likely to harbour malarial parasites that have the potential to reintroduce the disease to previously malaria-free areas. Other diseases that may be brought in by foreign workers are tuberculosis and chikungunya.

Other negative impacts of workers influx are:

a) Increased in crime rates and social related concerns such as drug trafficking and etc.;

b) Conflict due to cultural misunderstanding among workers and between local residents; and

c) Stress on existing infrastructure especially health facilities and education.

RAPID is expected to create 4,000 employment opportunities and a further 28,000 direct and indirect employment opportunities during the operational phase. The spillover effect will create more employment opportunities for the locals in other supporting industries such as commercial sectors and services.

<u>PEC</u>

A maximum number of 7,000 workers will be employed during the construction phase. Meanwhile, a total of 420 workers is expected during the operational phase. The workers might be Malaysians and foreigners from Johor and outside of Johor and they will be mostly young males. There will be no workers quarters in the proposed PEC site and therefore, the workers may potentially transmit diseases to the local population if they are not properly screened for infectious diseases. Details of the positive and negative impacts during the construction phase are as described in Chapter 7.

8.7.2 Impact Evaluation

This section will only evaluate the cumulative impact based on the information on the documents listed in section 8 of this chapter as well as the DoE approved PEC EIA. There are no other data regarding the impact of non-local workers on Pengerang resulting from the processes of RAPID and PIP that are available for public review.

Although PEC will be bringing in 7,000 workers during the construction phase, RAPID will be withdrawing a total of 38,000 workers during the same period. Therefore, the total amount of workers in Pengerang area during the construction phase of PEC will be significantly reduced. The number of workers will continue to reduce after completion of the project and during the operational phase.

The cost of living in Pengerang has increased significantly since the construction of RAPID. However, local communities such as Kg. Lepau residents took advantage of the incoming workers to the area by providing rental houses. The rentals range between RM5,000 to RM8,000 a month depending on the type of houses and facilities provided in the house. Furthermore, local communities affected by RAPID project are currently generating income by providing services and other business opportunities in Pengerang area. With the upcoming PEC project, it is expected that the project will contribute to the improvement of household disposable income for the locals, increment in job and business opportunities, as well as improvement of other public infrastructures and facilities.

The significance of the influx of workers has been identified as **Positive**.

8.7.3 Mitigation Measures

The mitigation measures that can be considered by all responsible parties are as follows:

- Conduct health screening for all foreign workers;
- Provide adequate sanitation facilities for workers;
- The priority of employment and business opportunities should be given to the local community; and
- Provide training/ courses and seminars on marketing and entrepreneurship to local communities.

8.8 Assessment of Traffic in Pengerang

RAPID

It is estimated that 4,000 new workers will be employed during operational phase of RAPID and the number of vehicles is expected to increase by 1,000 for light vehicle such as motorcycle and car and the volume of heavy vehicles is expected to increase by 25. In addition, about 3,000 workers will be employed by neighbouring industries which will contribute to the number of vehicles using on Road 92. During operational phase, Road 92, J52 and the three-arms junction of Road 92/ 90/ J52 is expected to affect the existing traffic in Pengerang area. Based on the simulation of traffic conducted by RAPID in 2014, junction of Road 92/ 90/ J52 are likely to experience congestion during peak hours and would not be to accommodate the traffic volumes. This, however, had been remedied as this junction had since been upgraded (refer to *Figure 8.28* - *Figure 8.31*).

PEC

The PEC site can be accessed via the North-South Highway and then through Senai-Desaru Highway (E22) which will link up to Jalan Kota Tinggi – Sungai Rengit (Road 92). An intersection is located southward along Road 92 which will leads to Jalan Kota Tinggi – Pengerang (J52) to PEC site to the west.

Currently, the only accessible route to PEC site is through the intersection on J52 towards PIC Access Road (Unnamed). However, a new road is currently being constructed to the west of PEC site and can be accessed through the roundabout on J52. Once completed, this road will be the new main route to both PIP as well as PIPC and it will permanently replace the current route to RAPID Gate 2.

8.8.1 Impact Evaluation

This section will only evaluate the cumulative impact of traffic based on the information on the documents listed in section 8 of this chapter as well as the DoE approved PEC EIA. There are no other data regarding the impact of traffic on Pengerang resulting from the processes of RAPID and PIP that are available for public review.

RAPID and PEC will be utilizing the Road 92 and J52 during construction and operational phase. Therefore, traffic at both roads will increase and will be affecting the existing road users. The impacts of traffic are:

- Traffic congestion at Road 92 and J52;
- Access from Tg. Pengelih to Kg. Lepau and Kg. Rengit and vice versa will be disrupted by the increase of vehicles utilizing the J52 road;
- Heavy vehicles movement during construction may cause damage to the pavement of existing road;
- Road user safety will be affected due to the increase of heavy vehicles; and

- Generation of fugitive dusts and noise creating nuisance and health problems to residents along the access roads.

This may potentially affect the local population and other road users within the Pengerang area specifically those who reside in Kg. Lepau, Sebana Mixed development and to certain extend, the residents of Sg. Rengit. Therefore, the receptor sensitivity is considered as medium.

In consideration of the total cumulative impact of traffic for both the construction and operational phase of PEC and RAPID on the local population and other road users, the severity of the impact has been identified as medium. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised within the 5 km of respective project boundary;
- The impact is only for the duration of the construction and operational phase of the project;
- The frequency of the impact is periodical; and
- The impact is reversible.

As such, the significance of traffic related impacts to the local population has been identified as **Medium**, based on assessed medium impact severity and medium receptor sensitivity.

2012

2013

Figure 8.28 – Image 2012 and 2013

2014

2015

Figure 8.29 – Image 2014 and 2015

2016

Figure 8.30 – Image 2016

2018

2019

Figure 8.31 – Image 2018 and 2019

8.8.2 Mitigation Measures

The Road 92 has been upgraded into dual lanes carriageways for both directions. Other mitigation measures that can be considered by all responsible parties are as follows:

- Intelligent traffic signals (with cameras as the traffic detectors) shall be installed at the T junction of Road 92/ 90/ 52 to control traffic flow;
- Lamp posts should be installed along Road 92 to prevent from vehicle collision among road users at during night time; and

  Communicate with the community and public users on regular basis the traffic routing plan and movement schedule of heavy vehicle.

8.9 Associated Facilities (Third-party)

This section will assess the cumulative impact of associated facilities of PEC which refers to facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable.

Pipelines

During the operational phase of PEC, feedstock will be supplied by two parties and the final products will be supplied by PEC to six different parties. The transportation of feedstock and final products to and from PEC will be through pipelines. As of the writing of this report, there is no available information regarding the parties involved in the supply and transportation of the feedstock and final products.

PEC will be utilizing pipelines from third-party sources as a medium of import and export of the raw materials and products. The total length of pipelines to be connected between PEC plant and storage terminal for condensate and products are approximately 5.3 km. Details of the pipelines are as shown in *Table 8.36* below.

Table 8.36: Details of Pipelines

Type	Flowrate (MT/hr)	Diameter (Inch)
Feed		
Condensate	2,000	32
FR Naphtha	800	20
Products		
Para Xylene	800	20
Ortho Xylene	150	8
Benzene	400	14
Jet Kerosene	500	16
Diesel	800	20
Light Naphtha	400	16
C3 LPG	80	8 (with vapour return line)
C4 LPG	150	10 (with vapour return line)
LSFO	200	10
Utilities		
Natural Gas	-	14 (pipeline from Petronas gas)
Nitrogen	-	8 (pipeline from Petronas gas)
Industrial Water	-	20 (pipeline tie-in at the plant fence)

Source: PEC, 2019

Storage Tanks

PEC will have 3 bulk condensate tanks onsite to store the fuel gas, light ends and tail gas which will be used onsite internally. Other products will be stored at the third-party bulk storage facility at the PDT area. The aboveground onsite condensate tanks, with working capacity of 43,000 MT each, will receive and store the condensate from the jetty/ third party terminal for daily consumption. The offsite storage terminals information is as shown in *Table 8.37* below.

Table 8.37: Details of Storage Terminals

Feed & Product	Capacity (MT)		Density	Days	Storage Capacity					Loading & Unloading					Remarks
	Yearly	Daily			Total Capacity (MT)	Each Tank (MT)	No. of Tank	Tank Dimension	Type	Parcel Size (MT)	Pump Capacity (MT/hr)	Loading Arm (Inch)	Berth days/parcel	Berth days / year	
Condensate	6,324,000	18,068	0.7426	26	480,000	120,000	4	96.05 x 24.38	DRT or FRT	120,000	4,800	20	1.4	74	<u>Berthing time</u> Total: 26-40 hrs Berth/deberth/billing 6 hrs, allowance 2 hrs <u>Jetty Allocation</u> #1 Condensate, sour naphtha, LSFO crude (future) #2 diesel, PX-1, BZ-1, OX #3 J-Kero, PX-2, BZ-2 #4 C3 LPG, C4 LPG LN #5 reserve for future LSFO tank may not be necessary in case of LSFO to be exported to the neighbour plant
Sour Naphtha	3,725,000	10,642	0.7000	10	32,000	32,000	1	52.39 x 24.38	IFR	30,000	1,500	12	1.2	45	
Para Xylene	1,505,000	4,300	0.8441	23	100,000	50,000	2	58.21 x 24.38	IFR	10,000	800	8	0.9	135	
Ortho Xylene	150,000	428	0.8662	23	10,000	10,000	1	32.01 x 17.06	IFR	5,000	300	6	1.1	33	
Benzene	655,000	1,871	0.8568	23	44,000	22,000	2	40.74 x 21.94	IFR	5,000	500	6	0.8	105	
Jet Kerosene	926,000	2,645	0.7780	30	62,000	31,000	2	49.16 x 24.38	IFR	30,000	1,500	12	1.2	38	
Diesel	1,396,000	3,988	0.7933	22	90,000	45,000	2	58.21 x 24.38	IFR	40,000	2,000	12	1.2	40	
LN Blend	887,000	2,534	0.6330	24	62,000	31,000	2	52.39 x 24.38	IFR	30,000	1,500	12	1.2	38	
LSFO	154,000	440	0.8116	29	13,000	13,000	1	34.92 x 19.50	DR	3,000	200	6	1.0	72	
C3 LPG	38,000	108	0.4710	22	2,400	1,200	2	17.6 ID	Ball	1,000	150	6	0.7	28	
C4 LPG	260,000	742	0.5490	21	16,000	4,000	4	24.8 ID	Ball	2,000	150	6	1.8	130	
Total					**911,400**		**23**								

Source: PEC, 2019

Jetties

4 berths will be constructed at Dialog's jetty 3 to import and export products and feed. 13 nos. of loading and unloading arms will be installed. The operation of loading and unloading will be done within 72 hours. Overall occupancy rate for PEC will be less than 55%. Details of the pipelines are as shown in *Table 8.38* below.

Table 8.38: Details of Jetties

Berth No.	Weight	Purpose
6302	3,000 – 120,000	Unloading condensate and FR naphtha
		Loading LSFO
6307	3,000 – 50,000	Loading diesel
		Loading aromatics products (PX, OX, BZ)
6308	3,000 – 50,000	Loading J-Kero
		Loading aromatics products (PX, BZ)
6305	1,000 – 50,000	Loading light naphtha
		Loading LPG (C3, C4)

Source: PEC, 2019

8.9.1 Impact Assessment

Pipelines will be constructed during the first quarter of year 2 of PEC construction phase. Construction of the pipelines will be handled by a third-party contractor. For operational and maintenance of the pipelines, it will also be handled by a third-party. Details of the contractor and operator of the pipelines will be addressed in the ESMP.

As of the writing of this report, there are no other information regarding the impact of the construction and operation of the jetty, pipeline and storage tanks that are available for public review. The impact listed below are the general impacts that are commonly associated with the construction and operation of facilities of similar nature.

Impact during construction Phase

- Dust pollution due to excavation, backfilling and concreting, hauling and dumping of earth materials and construction spoils;
- Fugitive dust due to the movement of construction vehicles on exposed soil, construction material handling and wind erosion;
- Water pollution due to sediment load in construction water and wastewater from construction camps;
- Impact on the local water source (Sg. Lepau) from runoff;
- Noise generated from construction tools and machineries; and
- Generation of solid waste in the form of construction spoils.

Impact during Operational Phase

- Soil and groundwater contamination due to accidental leakage of underground pipes and storage tanks;
- Water pollution in the coastal area due to increase of marine traffic.

As previously mentioned, there are no other available information regarding the impact of construction of these associated facilities. However, it is expected that the construction of these facilities may potentially affect the environment. For instance, the construction of the jetty may potentially affect the water quality which subsequently may affect the marine species in the area.

Furthermore, the operation of the jetty may potentially affect the marine traffic in the area. However, the severity of the impact can be mitigated provided that proper mitigation measures are implemented by the responsible third parties. Therefore, the receptor sensitivity is expected to be medium.

The severity of the impact has been identified as **low**. The assessment of the severity of the impact is as follows:

- The extent of the impact is localised around the project location within the 5 km of respective project boundary;
- The impact is only for the duration of the construction and operational phase of the project;
- The frequency of occurrence of the impact is periodical; and
- The impact is reversible.

As such, the significance of cumulative impacts of the construction and operational of the associated facilities has been identified as **Low**, based on assessed low impact severity and medium receptor sensitivity.

8.9.2 Mitigation Measures

The mitigation measures that can be considered by all responsible parties are as follows:

Construction Phase

- Exposed soil areas, stockpile of construction materials and on-site roads should be covered and dampened with water to minimise dust generation;
- Implementation of L2-P2M2 such check damns, sedimentation basin and silt fence during the construction phase to reduce the impact of surface water pollution;
- Silencers/ mufflers on construction equipment which produces high noise emissions should be utilised and maintained regularly; and
- All parties shall ensure that any emission emitted during construction phase are in compliance with Malaysia.

Operational Phase

- Regular service/maintenance of the pipeline shall be conducted on the pipeline to ensure that there no leakage;
- Collaborate with local maritime agency to ensure that the flow of the marine traffic is properly coordinated; and
- All parties shall ensure that any emission emitted during operational phase are in compliance with Malaysia.

8.10 Summary of Cumulative Impacts

Table 8.39 below summarised the cumulative impacts on the surrounding area of PEC and its severity. Based on our assessment, there were no impacts of High significance throughout the entirety of the project construction and operational phase.

Table 8.39: Summary of Cumulative Impacts in the Surrounding Area of PEC

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
Combustion Gas Emission	• PEC Personnel	Reduction of air quality due to the emission of combustion gases.				Medium	
Discharging of Liquid Effluent	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the discharge of liquid effluent.				Medium	
Generation of Excessive Noise	• PEC Personnel • Local Population	Noise pollution due to the generation of elevated sound level from equipment of process plant.		Negligible			
Flora and Fauna	• Sg. Santi Forest Reserve	Degradation of the ecological value and critical habitats of flora and fauna species in Sg. Santi Forest Reserve			Low		
Influx of Workers	• PEC Personnel • Local Population	Generation of spin-off business.	Positive				
Traffic Congestion	• Local Population	Increase of traffic volume and heavy vehicles due to the project operation.				Medium	

9 QUANTITATIVE RISK ASSESSMENT

9.1 Introduction

9.1.1 Project Background

Under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 2015 (EIA Order 2015), the construction of the PEC is a Prescribed Activity under the Second Schedule and requires a detailed Environmental Impact Assessment (EIA) be submitted to the Department of Environment (DoE) for approval prior to project implementation.

As part of the Environmental Impact Assessment, a Quantitative Risk Assessment (QRA) needs to be prepared to provide a demonstration that the measures for prevention and mitigation employed by the hazardous installation result in a level of risk that is 'as low as reasonably practicable' (ALARP). The QRA is carried out in accordance with DoE's EIA Guidelines for Risk Assessment.

9.1.2 Objectives of the QRA

The results of this QRA study will be valuable in providing the Malaysian Authorities with relevant information to decide on the acceptability of project on risk grounds. The QRA Report will also provide a demonstration that the measures for prevention and mitigation employed by the hazardous installation result in a level of risk that is 'as low as reasonably practicable' (ALARP). The QRA is carried out in accordance with *DoE's EIA Guidelines for Risk Assessment.*

9.1.3 Scope of Work

The scope of work of the QRA comprises the following:

- **Hazard identification** – a qualitative review of possible accidents that may occur (based on industrial accident records or, as necessary, professional judgement) involving the hazardous substances stored and/or utilised by the project;
- **Scenario identification** – definition of the specific scenarios to be studied in this QRA, with each scenario assigned a unique identification code or isolatable section number;
- **Event tree and frequency analysis** – determination of the frequency or likelihood of occurrence of all identified scenarios;
- **Consequence modelling** – determination of the consequence distances (hazard zones) that would result from realisation of each scenario identified by outcome, e.g. pool fire, jet fire, flash fire, vapour cloud explosion (VCE) and toxic release;
- **Risk Summation**– the summation of consequences and frequencies of all isolatable sections to determine the Individual Risk (IR) and Societal Risk (SR); and
- **Evaluation against Risk Acceptance Criteria** – to determine acceptability of the projects risks to the site surroundings with regards to DoE Individual Risk Acceptance Criteria and, as necessary, to recommend mitigation measures to ensure compliance and that risks are *as low as reasonably practical (ALARP).*

9.2 Hazard Identification and Selection of Scenarios

9.2.1 Introduction

A hazard in this context is defined as a loss of containment (LoC) that has the potential to cause offsite damage to people, property or the surrounding environment. The following section identifies and selects the specific hazardous scenarios to be address in this QRA.

9.2.2 Chemical Inventory and Properties of Hazardous Substances

The substances that will be stored and are subject to a QRA are Condensate, Naphtha, Sour Naphtha, Sweet Naphtha, Pentane, Dodecene, LPG, Butane, Kerosene, Propane, Ethane, Hydrogen, Diesel, Heptane, Sulfolane, Hydrogen Sulfide, Toluene, Xylene, Para-xylene, Hexane, Aromatics, Benzene, Tetramethylbenzene (TTMBZ), Diethylbenzene (DEBZ), and Trimethylbenzene (TMBZ).

The materials are chosen based on high mass percentage in each unit (equipment and pipeline).

Information on the location, hazards, physical properties, physical condition and storage/processing vessels for each hazardous substance is summarised in the tables below. It should be noted that maximum quantities/ inventories and worst case operating/ processing conditions are used in the QRA to ensure conservatism. In particular the QRA was based on preliminary design data whereby inventories in key process vessels were estimated based on the empty volume of the vessels.

Table 9.1: Chemical Inventory On-Site

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
1	Condensate UN ID: 1267	Condensate Tank (800-TK1A~C)	Flammable	Liquid (40˚C @ 0.00barg)	Tank	57,900
2	Naphtha UN ID: 1256	Stripper Receiver (130-V8)	Flammable	Liquid (46˚C @ 6.18barg)	Pressurized vessel	10
		Reactor (200-R1)	Flammable	Liquid (343˚C @ 27.65barg)	Pressurized vessel	100
		Separator (200-V3)	Flammable	Liquid (46°C @ 24.12barg)	Pressurized vessel	300
		Naphtha Splitter (200-V7)	Flammable	Vapour (71°C @ 1.57barg)	Pressurized vessel	600
		Separator (300-V1)	Flammable	Liquid (46°C @ 2.45barg)	Pressurized vessel	85
		Light Naphtha Tank (830-TK1A/B)	Flammable	Liquid (40°C @ 0.00barg)	Tank	15,800
3	Sour Naphtha UN ID: 1255	Sour Naphtha Tank (850-TK1)	Flammable	Liquid (40°C @ 12.672barg)	Tank	31,400
4	Sweet Naphtha	Sweet Naphtha Tank	Flammable	Liquid (40°C @ 0.00barg)	Tank	31,400

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
	UN code: 1268	(851-TK1)				
5	Pentane UN ID: 1265	Feed Surge Drum (100-V18)	Flammable	Liquid (30°C @ 1.18barg)	Pressurized vessel	210
		Feed Fractionator Receiver (100-V5)	Flammable	Liquid (46°C @ 0.49barg)	Pressurized vessel	275
		Feed Fractionator Reflux Coalescer (100-V10)	Flammable	Liquid (47°C @ 12.26barg)	Pressurized vessel	45
		Stabilizer (100-V4)	Flammable	Liquid (56°C @ 6.37barg)	Pressurized vessel	1,100
		Stripper (200-V5)	Flammable	Liquid (99°C @ 11.57barg)	Pressurized vessel	330
		Stripper Receiver (200-V6)	Flammable	Liquid (40°C @ 10.4barg)	Pressurized vessel	20
		Naphtha Splitter (200-V7)	Flammable	Liquid (71°C @ 1.57barg)	Pressurized vessel	600
		Naphtha Splitter Receiver (200-V8)	Flammable	Liquid (58°C @ 1.18barg)	Pressurized vessel	50
		Depentanizer (200-V9)	Flammable	Vapour and Liquid (62°C @ 1.57barg)	Pressurized vessel	140
		Depentanizer Receiver (200-V10)	Flammable	Liquid (53°C @ 1.18barg)	Pressurized vessel	25
		Debutanizer Receiver (300-V7)	Flammable	Liquid (40°C @ 10.98barg)	Pressurized vessel	30
		Debutanizer Receiver (320-V6)	Flammable	Liquid (40°C @ 3.92barg)	Pressurized vessel	10
		C5 Gas Knockout Drum (431-V14)	Flammable	Liquid (85.6°C @ 3.63barg)	Pressurized vessel	6
		Pentane Tanks (843-TK1A,B)	Flammable	Vapour (40°C @ 12.67barg)	Ball Tank	2,500
6	Dodecane UN ID: Not regulated	Desalter (100-V9)	Flammable	Liquid (112°C @ 24.01barg)	Pressurized vessel	110
		Feed Fractionators	Flammable			835

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
		(100-V1)		Liquid (143^{O}C @ 1.18barg)	Pressurized vessel	
		Distillate Fractionator (100-V2)	Flammable	Liquid (243^{O}C @ 1.08barg)	Pressurized vessel	100
		Diesel Stripper (100-V3)	Flammable	Liquid (280^{O}C @ 1.18barg)	Pressurized vessel	40
		Distillate Fractionator Receiver (100-V6)	Flammable	Liquid (108^{O}C @ 0.39barg)	Pressurized vessel	90
		Disulfide Sand Filter (110-V6)	Flammable	Liquid (43^{O}C @ 3.63barg)	Pressurized vessel	1
		Feed Coalescer (130-ME1)	Flammable	Liquid (35^{O}C @ 6.17barg)	Pressurized vessel	30
		Feed Surge Drum (130-V1)	Flammable	Liquid (134^{O}C @ 2.53barg)	Pressurized vessel	25
		Stripper (130-V7)	Flammable	Liquid (260^{O}C @ 6.86barg)	Pressurized vessel	50
		Vacuum Dryer (130-V9)	Flammable	Liquid (173^{O}C @ -0.69barg)	Pressurized vessel	25
		Raw Diesel Storage Tank (100-TK1)	Flammable	Liquid (68^{O}C @ 0.0147barg)	Tank	8,200
		Raw Kerosene Storage Tank (100-TK2)	Flammable	Liquid (68^{O}C @ 0.0147barg)	Tank	6,000
		Distillate Fractionators Reflux Coalescer (100-V11)	Flammable	Liquid (108^{O}C @ 20.59barg)	Pressurized vessel	45
7	LPG UN ID: 1075	Feed Fractionator (100-V1)	Flammable	Vapour (143^{O}C @ 1.18barg)	Pressurized vessel	835
		LPG Tank (841-TK1)	Flammable	Vapour (70^{O}C @ 0.00barg)	Ball Tank	4,500
8	Butane UN ID: 1011	Stabilizer (100-V4)	Flammable	Vapour (56^{O}C @ 6.37barg)	Pressurized vessel	1,100
		Stabilizer Receiver (100-V7)	Flammable	Vapour (38^{O}C @ 5.98barg)	Pressurized vessel	45
		Amine Absorber (110-V8)	Flammable	Vapour (38^{O}C @ 10.095barg)	Pressurized vessel	30

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
		Extractor Plus (110-V1)	Flammable	Vapour (38°C @ 8.83barg)	Pressurized vessel	55
		Deethanizer (115-V1)	Flammable	Liquid (55°C @ 27.95barg)	Pressurized vessel	85
		C3/C4 Splitter (115-V3)	Flammable	Liquid (50°C @ 15.4barg)	Pressurized vessel	75
		Stripper (200-V5)	Flammable	Vapour (99°C @ 11.57barg)	Pressurized vessel	330
		Stripper Receiver (200-V6)	Flammable	Vapour (40°C @ 10.4barg)	Pressurized vessel	20
		Debutanizer (300-V6)	Flammable	Vapour (63°C @ 11.77barg)	Pressurized vessel	270
		Debutanizer Receiver (300-V7)	Flammable	Vapour (40°C @ 10.98barg)	Pressurized vessel	30
		LPG Chloride Treaters (300-V8A/B)	Flammable	Liquid (40°C @ 32.56barg)	Pressurized vessel	7
		Debutanizer (320-V5)	Flammable	Vapour (68°C @ 3.92barg)	Pressurized vessel	80
		Debutanizer Receiver (320-V6)	Flammable	Vapour (40°C @ 3.92barg)	Pressurized vessel	10
		Reformate Splitter (431-V1)	Flammable	Vapour (105°C @ 0.49barg)	Pressurized vessel	750
		Butane LPG Tanks (842-TK1A/B/C/D)	Flammable	Vapour (40°C @ 0.00barg)	Ball Tank	2,500
9	Kerosene UN ID: 1223	Distillate Fractionator (100-V2)	Flammable	Vapour (243°C @ 1.05barg)	Pressurized vessel	605
		Diesel Stripper (100-V3)	Flammable	Vapour (280°C @ 1.18barg)	Pressurized vessel	40
		Coalescer (120-V1)	Flammable	Liquid (40°C @ 12.25barg)	Pressurized vessel	5
		Electrostatic Coalescer Prewash (120-V2)	Flammable	Liquid (40°C @ 12.35barg)	Pressurized vessel	45
		Reactor (120-R1)	Flammable	Liquid (40°C @ 11.57barg)	Pressurized vessel	165
		Caustic Settler (120-V3)	Flammable	Liquid (40°C @ 10.59barg)	Pressurized vessel	75

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
		Water Wash (120-V4)	Flammable	Liquid (40°C @ 10.2barg)	Pressurized vessel	65
		Sand Filter (120-V5A/B)	Flammable	Liquid (40°C @ 9.81barg)	Pressurized vessel	60
		Clay Filter (120-V6A/B)	Flammable	Liquid (40°C @ 8.43barg)	Pressurized vessel	130
		Kerosene Tanks (820-TK1A/B)	Flammable	Liquid (40°C @ 0.00barg)	Tank	12,800
10	Propane UN ID: 1978	C3/C4 Splitter (115-V3)	Flammable	Vapour (50°C @ 15.4barg)	Pressurized vessel	75
		C3/C4 Splitter Receiver (115-V4)	Flammable	Liquid (46°C @ 15.59barg)	Pressurized vessel	20
		Propane LPG Tanks (840-TK1A/B)	Flammable	Vapour (40°C @ 0.00barg)	Ball Tank	2,500
11	Ethane UN ID: 1035	Deethanizer (115-V1)	Flammable	Vapour (55°C @ 27.95barg)	Pressurized vessel	85
		Deethanizer Receiver (115-V2)	Flammable	Vapour and Liquid (38°C @ 27.56barg)	Pressurized vessel	6
		Deheptanizer (320-V2)	Flammable	Vapour (154°C @4.40barg)	Pressurized vessel	640
		Deheptanizer Receiver (320-V3)	Flammable	Vapour (41°C @ 3.70barg)	Pressurized vessel	125
		Deheptanizer Vent Drum (320-V4)	Flammable	Vapour (10°C @ 3.43barg)	Pressurized vessel	2
		Stripper Condenser (380-V4)	Flammable	Vapour (40°C @ 5.20barg)	Pressurized vessel	40
12	Hydrogen UN Code: 1049	Reactor 1 (130-R1)	Flammable	Vapour (380°C @ 75.41barg)	Pressurized vessel	80
		Reactor 2 (130-R2)	Flammable	Vapour (380°C @ 72.57barg)	Pressurized vessel	125
		Separator (130-V3)	Flammable	Vapour (54°C @ 60.31barg)	Pressurized vessel	25
		Flash Drum (130-V4)	Flammable	Vapour (57°C @ 17.60barg)	Pressurized vessel	50
		Recycle Gas Compressor Suction drum	Flammable	Vapour (60°C @ 60.31barg)	Pressurized vessel	3

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
		(130-V5)				
		Make Up Gas Compressor Suction Drum (130-V6)	Flammable	Vapour (40°C @ 31.38barg)	Pressurized vessel	2
		Stripper (130-V7)	Flammable	Vapour (260°C @ 6.86barg)	Pressurized vessel	50
		Off Gas Absorber/Knock Out Drum (130-V11)	Flammable	Vapour (53°C @ 5.88barg)	Pressurized vessel	20
		Treated Off Gas Knock Out Drum (130-V12)	Flammable	Vapour (47°C @ 5.88barg)	Pressurized vessel	2
		Reactor (200-R1)	Flammable	Vapour (343°C @ 27.65barg)	Pressurized vessel	100
		Separator (200-V3)	Flammable	Vapour (46°C @ 24.12barg)	Pressurized vessel	300
		Recycle Compressor Suction Drum (200-V4)	Flammable	Vapour (46°C @ 24.12barg)	Pressurized vessel	5
		Reactor 1 (300-R1)	Flammable	Vapour (549°C @ 5.1barg)	Pressurized vessel	80
		Reactor 2 (300-R2)	Flammable	Vapour (549°C @ 4.61barg)	Pressurized vessel	90
		Reactor 3 (300-R3)	Flammable	Vapour (549°C @ 4.12barg)	Pressurized vessel	105
		Reactor 4 (300-R4)	Flammable	Vapour (549°C @ 3.53barg)	Pressurized vessel	115
		Separator (300-V1)	Flammable	Vapour (46°C @ 2.45barg)	Pressurized vessel	85
		Net Gas Suction Drum (300-V2)	Flammable	Vapour (46°C @ 5.49barg)	Pressurized vessel	20
		Recontact Drum No 1 (300-V3)	Flammable	Vapour (40°C @ 16.57barg)	Pressurized vessel	45
		Recontact Drum No 2 (300-V4)	Flammable	Vapour (40°C @ 33.15barg)	Pressurized vessel	40
		Net Gas Chloride Treaters (300-V5A/B)	Flammable	Vapour (32°C @ 30.2barg)	Pressurized vessel	65

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
		Reactor (320-R1)	Flammable	Vapour (420°C @ 12.41barg)	Pressurized vessel	65
		Separator (320-V1)	Flammable	Vapour (46°C @ 10.98barg)	Pressurized vessel	65
		Reactor (380-R1)	Flammable	Vapour (501°C @ 29.99barg)	Pressurized vessel	60
		Separator (380-V2)	Flammable	Vapour (40°C @ 27.65barg)	Pressurized vessel	40
13	Diesel UN ID: 1203	Reactor 2 (130-R2)	Flammable	Liquid (380°C @ 74.00barg)	Pressurized vessel	125
		Diesel Tanks (825-TK1A/B)	Flammable	Liquid (40°C @ 0.00barg)	Tank	17,600
14	Heptane UN ID: 1206	Separator (130-V3)	Flammable	Liquid (54°C @ 60.31barg)	Pressurized vessel	25
15	Sulfolane UN ID: 3334	Extractive Distillation Column (541-V1)	Flammable	Liquid (174°C @ 1.47barg)	Pressurized vessel	765
		Recovery Column (541-V3)	Flammable	Liquid (174°C @ -0.49barg)	Pressurized vessel	350
		Sulfolane Sump (541-V7)	Flammable	Liquid (180°C @ 0.00barg)	Pressurized vessel	25
16	Hydrogen Sulfide UN ID: 1053	Amine Regenerator Receiver (640-V3)	Flammable and Toxic	Vapour (40°C @ 0.98barg)	Pressurized vessel	1
		Sour Water Stripper Receiver (650-V3)	Flammable and Toxic	Vapour (88°C @ 1.03barg)	Pressurized vessel	10
17	Toluene UN ID: 1294	Debutanizer (300-V6)	Flammable	Liquid (63°C @ 11.77barg)	Pressurized vessel	270
		Debutanizer (320-V5)	Flammable	Liquid (68°C @3.92barg)	Pressurized vessel	80
		Reactor 1/2 (322-R1/R2)	Flammable	Liquid (122°C @ 28.73barg)	Pressurized vessel	50
		Feed Surge Drum (380-V1)	Flammable	Liquid (163°C @ 5.1barg)	Pressurized vessel	315
		Stripper (380-V3)	Flammable	Liquid (209°C @ 6.47barg)	Pressurized vessel	470
		Reformate Splitter (431-V1)	Flammable	Liquid (105°C @ 0.49barg)	Pressurized vessel	755
		Reformate Splitter Receiver	Flammable	Liquid (56°C @ 0.098barg)	Pressurized vessel	120

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m³)
		(431-V2)				
		Toluene Tank (432-TK1)	Flammable	Liquid (38°C @ 0.005barg)	Tank	1,475
		Clay Treaters (432-V1A/B)	Flammable	Liquid (199°C @ 14.22barg)	Pressurized vessel	60
		Benzene Column (432-V2)	Flammable	Liquid (152°C @ 0.7barg)	Pressurized vessel	860
		Toluene Column (432-V4)	Flammable	Vapour and Liquid (232°C @ 4.60barg)	Pressurized vessel	1,340
		Toluene Column Receiver (432-V5)	Flammable	Liquid (168°C @ 0.099barg)	Pressurized vessel	105
		Finishing Column (500-V9)	Flammable	Vapour (117°C @ 0.196barg)	Pressurized vessel	345
		Finishing Column Receiver (500-V10)	Flammable	Liquid (66°C @ 0.098barg)	Pressurized vessel	45
		Recovery Column Receiver (541-V4)	Flammable	Liquid (38°C @-0.686barg)	Pressurized vessel	125
18	Xylene UN ID: 1307	Separator (320-V1)	Flammable	Vapour (46°C @ 10.98barg)	Pressurized vessel	65
		Deheptanizer (320-V2)	Flammable	Liquid (154°C @ 4.21barg)	Pressurized vessel	645
		Clay Treaters (431-V3A/B)	Flammable	Liquid (199°C @ 15.68barg)	Pressurized vessel	160
		Xylene Splitter (431-V4)	Flammable	Vapour and Liquid (237°C @ 0.50barg)	Pressurized vessel	4,645
		Xylene Splitter Receiver (431-V6)	Flammable	Liquid (227°C @ 5.59barg)	Pressurized vessel	315
		Parex Feed Surge Drum (431-V7)	Flammable	Liquid (227°C @ 6.66barg)	Pressurized vessel	2.9456
		Raffinate Column (500-V3)	Flammable	Liquid (148°C @ 0.294barg)	Pressurized vessel	2,225
		Raffinate Column Side Cut Surge Drum (500-V4)	Flammable	Liquid (148°C @0.294barg)	Pressurized vessel	130
		Raffinate Column Receiver	Flammable	Liquid (121°C @ 0.098barg)	Pressurized vessel	140

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Containe r (m^3)
		(500-V5)				
		Raffinate Column Vent Drum (500-V6)	Flammable	Liquid (40^{O}C @ 0.098barg)	Pressurized vessel	2
		Extract Column (500-V7)	Flammable	Vapour (146^{O}C @ 0.196barg)	Pressurized vessel	790
		Extract Column Receiver (500-V8)	Flammable	Liquid (121^{O}C @ 0.098barg)	Pressurized vessel	60
		Finishing Column (500-V9)	Flammable	Liquid (117^{O}C @ 3.43barg)	Pressurized vessel	345
		Xylene Tank (852-TK1)	Flammable	Liquid (40^{O}C @ 0.00barg)	Tank	12,100
19	Para-xylene UN ID: 1307	Para-xylene Tanks (500-TK3A/B)	Flammable	Liquid (40^{O}C @ 0.001barg)	Tank	3,860
		Para-xylene Tanks (810-TK1A/B/C/D/E)	Flammable	Liquid (40^{O}C @ 0.00barg)	Tank	19,200
20	Hexane UN ID: 1208	Extractive Distillation Column (541-V1)	Flammable	Vapour (174^{O}C @ 1.47barg)	Pressurized vessel	765
		Extractive Distillation Column Receiver (541-V2)	Flammable	Liquid (49^{O}C @ 0.49barg)	Pressurized vessel	40
		Stripper (380-V3)	Flammable	Vapour (209^{O}C @ 5.98barg)	Pressurized vessel	470
21	Aromatics UN ID: 1993	Separator (380-V2)	Flammable	Liquid (40^{O}C @ 27.54barg)	Pressurized vessel	40
		Heavy Aromatics Tanks (834-TK1A/B)	Flammable	Liquid (46^{O}C @ 0.00barg)	Tank	1,245
		Aromatics Tank (431-TK1)	Flammable	Liquid (40^{O}C @ 0.00barg)	Tank	17,200
22	Benzene UN ID: 1114	Separator Net Gas Suction Drum (300-V2)	Flammable	Liquid (46^{O}C @ 5.49barg)	Pressurized vessel	20
		Recontact Drum No 1 (300-V3)	Flammable	Liquid (40^{O}C @ 16.57barg)	Pressurized vessel	45
		Recontact Drum No 2	Flammable	Liquid (40^{O}C @ 33.15barg)	Pressurized vessel	40

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Container (m^3)
		(300-V4)				
		Deheptanizer Receiver (320-V3)	Flammable	Liquid (41^{O}C @ 3.63barg)	Pressurized vessel	125
		Deheptanizer Vent Drum (320-V4)	Flammable	Liquid (10^{O}C @ 3.43barg)	Pressurized vessel	2
		Stripper Receiver (380-V4)	Flammable	Liquid (40^{O}C @ 5.2barg)	Pressurized vessel	40
		Benzene Column (432-V2)	Flammable	Vapour (152^{O}C @ 0.7barg)	Pressurized vessel	860
		Benzene Column Receiver (432-V3)	Flammable	Liquid (59^{O}C @ 0.1barg)	Pressurized vessel	285
		Sulfolane Feed Tank (541-TK1)	Flammable	Liquid (40^{O}C @ 0.005barg)	Tank	4,140
		Recovery Column (541-V3)	Flammable	Vapour (174^{O}C @ -0.49barg)	Pressurized vessel	350
		Benzene Tanks (812-TK1A/B/C/D)	Flammable	Liquid (40^{O}C @ 0.00barg)	Tank	8,700
		Benzene Day Tanks (432-TK2A/B)	Flammable	Liquid (40^{O}C @ 0.00barg)	Tank	2,060
23	Diethyl-benzene UN ID: 2049	Adsorber Chamber No 1 (500-V1)	Flammable	Liquid (156^{O}C @ 13.03barg)	Pressurized vessel	720
		Desorber Chamber No 2 (500-V2)	Flammable	Liquid (156^{O}C @ 13.03barg)	Pressurized vessel	720
		Raffinate Column (500-V3)	Flammable	Liquid (148^{O}C @ 0.294barg)	Pressurized vessel	2,225
		Extract Column (500-V7)	Flammable	Liquid (146^{O}C @ 0.196barg)	Pressurized vessel	790
		Desorbent Rerun Column (500-V11)	Flammable	Liquid (204^{O}C @ 0.588barg)	Pressurized vessel	20
		Desorbent Storage Tank (500-TK1)	Flammable	Liquid (35^{O}C @ 0.001barg)	Tank	2,000
		Plant Inventory Storage Tank (500-TK2)	Flammable	Liquid (35^{O}C @ 0.001barg)	Tank	3,860

No.	Chemical	Handling Location	Major Hazards	Physical Form at Operating Condition	Type of Container	Unit Capacity of Containe r (m^3)
		Parex Sump Drum (500-V12)	Flammable	Liquid (40°C @ 0.98barg)	Pressurize d vessel	25
24	Methane UN ID: 1971	Stripper Receiver (130-V8)	Flammable	Vapour (46°C @ 6.30barg)	Pressurize d vessel	10

Table 9.2: Pipeline Information

No.	Chemical	From	To	Pipe Diameter (inch)	Pipe Flowrate (MT/hr)
1	Condensate	Tank Farm	PEC Plant	32	2,000
2	FR Naphtha	Tank Farm	PEC Plant	20	800
3	Para Xylene	PEC Plant	Tank Farm	20	800
4	Benzene	PEC Plant	Tank Farm	14	400
5	Jet Kero	PEC Plant	Tank Farm	16	500
6	Diesel	PEC Plant	Tank Farm	20	800
7	Light Naphtha	PEC Plant	Tank Farm	16	400
8	C3 LPG	PEC Plant	Tank Farm	168	800
9	C4 LPG	PEC Plant	Tank Farm	10	150
10	LSFO	PEC Plant	Tank Farm	10	200

Table 9.3: Nature and Application of PEC Products, Co-products and By-products

Primary Products
Benzene (Primary product): Benzene is an important basic chemical, as the base for many intermediates and polymers. It is the major raw material for the production of the following: • Cumene, from which phenol and bisphenol A, the precursors of epoxy resins and polycarbonates, are made; • Styrene, from which polystyrene is then made; and • Cyclohexane, the precursor of caprolactam and adipic acid, which in turn feed into nylon production. Benzene derived products are themselves raw materials for a vast range of everyday items such as clothing, packaging, paints, adhesives, unbreakable windows, plywood, computer casings, compact discs and many more. Benzene has the chemical formula C_6H_6. It is a clear, colourless, volatile liquid, with a characteristic "aromatic" odour; benzene is highly flammable, vapour/air mixtures are explosive and carcinogenic to humans. Benzene is also very toxic to aquatic organisms.
Para-xylene (Primary product): Paraxylene is an aromatic chemical. It is used as a plasticizer, chemical intermediate and polyester intermediate. Paraxylene is used for polyester fibres for clothing and fabrics, PET soft drink bottles and films for audio and video tapes. Paraxylene is a colourless liquid and has a characteristic odour. Paraxylene is flammable, harmful to humans and toxic to aquatic organisms.
Co-products
Jet Fuel (Co-product): Jet fuel is a mixture of large number of hydrocarbons (usually $C_8 – C_{16}$) and is clear to straw coloured liquid and has fuel oil odour. It is highly flammable and may have some 1% aromatics including BTX (benzene, toluene, and xylene). Jet fuel does not gel at low temperature, hence it is primarily used as aviation fuel.

Diesel (Co-product): It is colourless to yellow-brown saturated hydrocarbon liquid (C_{10}-C_{16}) which has a mild petroleum odour. Diesel may contain many traces elements which are corrosive to aircraft turbines; hence diesel is primarily used as a fuel for on-land vehicles. Diesel is flammable and gives off irritating and toxic fumes/ particulates. It is harmful to aquatic organisms.
C3 and C4 LPG (Co-products): Liquefied Petroleum Gas (LPG) is a mixture of hydrocarbon gases; C3 (propane) and C4 (butane and iso-butane). LPG is extremely flammable/ explosive and is used as fuel in heating appliances and vehicles, and increasingly replaces chlorofluorocarbons as an aerosol propellant. Pressurised LPG containers that are subjected to fire of sufficient duration and intensity can undergo a boiling liquid expanding vapour explosion (BLEVE).
Fuel Oil (Co-product): Fuel oil is another fraction obtained from petroleum distillation/ refining, as with Jet fuel or Diesel, either as a distillate or a residue. It is made of longer hydrocarbon chains, particularly alkanes, cycloalkanes, and aromatics. It has an oil type odour and is black in colour. It is flammable and primarily used as a fuel in various industrial, marine, off-road vehicle and home heating applications, where air regulations permit.
By-products
Light naphtha (By-product): Light naphtha is a hydrocarbon mixture consisting of straight-chained and cyclic aliphatic compounds, generally with 5 to 9 carbon atoms per molecule. Light Naphtha's boiling point ranges from 30-70^{o}C and it has a high paraffin content. It is mainly used as a petrochemical feedstock in olefins production (e.g. ethylene).
Hydrogen rich gas (By-product) *: Hydrogen gas is light, colourless, and a highly flammable/ explosive gas. As a strong reducing agent, hydrogen gas can react easily with other chemical substances. Large quantities of hydrogen are needed in the petroleum and chemical industries for hydrogenation reaction, hydrodealkylation, hydrodesulphurisation, and hydrocracking. It is also used in the production of plastics, polyester, and nylon.
Fuel Gas (By-product): Fuel gas is a mixture of hydrogen, methane (C1), ethane (C2), and propane (C3) gases, (typical composition H_2: 0.13 wt-% CH_4: 1.56 wt% C_2H_6: 58.57 wt% C3+: 39.74 wt-%). Fuel gas is flammable, non-toxic and is used as a combustion fuel.
By-products
Light Ends (C1-C5) (By-product): Light ends (except C5s) are gases at atmospheric pressure and temperature. These are used as fuel in various industrial operations as well as for heating. Light ends can be dangerous when heavier than air as they can settle in a flammable cloud on the ground or in hollows/ drains/ utility trenches etc.
Sulphur (By-product): The production of low sulphur fuels requires the treatment, or desulphurisation, of product oils and this is recovered as elemental sulphur by-product, a yellow solid powder. Almost 70% of world sulphur production originates from refineries. It can be used include in phosphate fertiliser and the chemicals industry, but as world production outstrips demand it is also disposed to landfill.

9.2.3 Hazard Identification

Based on potential loss of containment (LoC) from the storage vessels and ancillary equipment and the process vessels and ancillary equipment, the major flammable hazards identified are releases of dodecane/diesel, hexane, butane, ethane, propane and hydrogen. The potential outcomes are a jet fire, pool fire, flash fire, vapour cloud explosion, fire ball. Toxic hazards identified are releases from hydrogen sulphide.

Leaks can range in size from a pinhole leak to a catastrophic failure. In general smaller leaks have higher accident likelihood but lower consequence distances. On the other hand larger releases have lower accident likelihood but longer consequence distance. The representative scenarios considered in this study are:

- Pipelines;
    - Small leak (10 mm);
    - Large leak (25 mm); and
    - Catastrophic failure (which is represented by inner diameter of the pipe).
- Pressurised Vessels;
    - Small leak (10 mm);
    - Large leak (50 mm);
    - Catastrophic failure; and
- Atmospheric Tanks;
    - Small leak (150 mm);
    - Large leak (500 mm); and
    - Catastrophic failure.

Table 9.4 presents the listing of the release scenarios and outcome events. *Appendix E* presents the release scenarios modelled (isolatable sections) for the PEC operations and the possible events from the respective release scenarios.

Table 9.4: Release Scenarios and Outcome Events

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
1	IS01_COND_PIPE_L	Release of condensate due to leak/catastrophic failure of condensate pipeline (stream 100) and associated fittings/pipings from condensate tank. An immediate and delay outcome of the released condensate will result in fire.	n-Octane	10 mm	4 inch		32 inch	1. 1,133m pipe; Ø0.81288m 2. Free spreading pool	-	Pool Fire
2	IS02_NAPHTHA_PIPE_L	Release of naphtha due to leak/catastrophic failure of naphtha pipeline (stream 500) and associated fittings/pipings from distillate unionfining process unit. An immediate and delay outcome of the released naphtha will result in fire.	n-Hexane	10 mm	25mm		2 inch	1. 132m pipe; Ø0.0508m 2. Free spreading pool	-	Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
3	IS03_PENTANE_CFSD_L	Release of pentane due to leak/catastrophic failure of pentane and associated fittings/pipings from condensate feed surge drum (100-V18). An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel, 1 valve, 1 pump	Area C1 - 28,600m^2	Pool Fire, Flash Fre, VCE
4	IS04_DODEC_DESALT_L	Release of dodecane due to leak/catastrophic failure of desalter (100-V9) and associated fittings/pipings. An immediate and delay outcome of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel, 5 valves		Pool Fire
5	IS05_PENTANE_FFR_L	Release of pentane due to leak/catastrophic failure of feed fractionator receiver (100-V5) and associated	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves; 1 pump1; 1		Jet Fire, Pool Fire, VCE, Flash Fire, BLEVE (Fireball)

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.						heat exchanger		
6	IS06_LPG_FFTP_V	Release of LPG due to leak/catastrophic failure offailure of feed fractionator (100-V1) Top Part and associated fittings/pipings. An immediate and delay outcome of the released LPG will result in fire.	LPG	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves		Jet Fire, Flash Fire, VCE
7	IS06_DODEC_FFBP_L	Release of dodecane due to leak/catastrophic failure of feed fractionator (100-V1) Bottom Part and associated fittings/pipings. An immediate and delay outcome of the	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released dodecane will result in fire.								
8	IS07_PENTANE_FFRCO_L	Release of pentane due to leak/catastrophic failure of feed fractionator reflux coalescer (100-V10) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 3 valves		Jet Fire, Pool Fire, VCE, Flash Fire, BLEVE (Fireball)
9	IS08_BUTANE_STABTP_V	Release of butane due to leak/catastrophic failure of stabilizer (100-V4) Top Part and associated fittings/pipings. An immediate and delay outcome of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Pool Fire, VCE, Flash Fire, BLEVE (Fireball)

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
10	IS08_PENTANE_STABBP_L	Release of pentane due to leak/catastrophic failure of stabilizer (100-V4) bottom part and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 pump; 1 valve		Jet Fire, Pool Fire, VCE, Flash Fire, BLEVE (Fireball)
11	IS09_BUTANE_STABREC_V	Release of butane due to leak/catastrophic failure of stabilizer receiver (100-V7) and associated fittings/pipings. An immediate and delay outcome of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 3 valves; 1 heat exchanger		Jet Fire, Pool Fire, VCE, Flash Fire, BLEVE (Fireball)
12	IS10_KERO_DFTP_V	Release of kerosene due to leak/catastrophic failure of distillate fractionator (100-V2) and associated	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released kerosene will result in fire.								
13	IS10_DODEC_DFBP_L	Release of dodecane due to leak/catastrophic failure ofdistillate fractionator (100-V2) and associated fittings/pipings. An immediate ignition of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 3 valves 3 heat exchangers ; 1 pump		Pool Fire
14	IS11_KERO_DSTP_V	Release of kerosene due to leak/catastrophic failure of diesel stripper (100-V3) top part and associated fittings/pipings. An immidiate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
15	IS11_DODEC_DSBP_L	Release of dodecane due to leak/catastrophic failure of diesel stripper (100-V3) bottom part and associated fittings/pipings. An immidiate ignition of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 1 pump, 2 valves		Pool Fire
16	IS12_DODEC_DFR_L	Release of dodecane due to leak/catastrophic failure of distillate fractionator receiver (100-V6) and associated fittings/pipings. An immidiate and delay outcome of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 4 heat exchangers ; 1 pump		Pool Fire
17	IS13_BUTANE_AMAB_V	Release of butanedue to leak/catastrophic failure of amine absorber (110-V8) and associated	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released butane will result in fire.								
18	IS14_BUTANE_EXPLUS_V	Release of butane due to leak/catastrophic failure of extractor plus (110-V1) and associated fittings/pipings. An immediate ignition of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves; 1 pump		Jet Fire, Flash Fire, VCE
19	IS15_DODEC_SANDF_L	Release of dodecane due to leak/catastrophic failure of disulfide sand filter (110-V6) and associated fittings/pipings. An immediate and delay outcome of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 1 pump; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
20	IS16_PROPANE_PIPELINE_L	Release of propane due to leak/catastrophic failure of LPG pipeline (stream 100) from CCR platforming process unit and associated fittings/pipings. An immediate and delay outcome of the released propane will result in fire.	Propane	10 mm	25 mm		3 inch	168m pipe (Ø0.0762m)		Pool Fire
22	IS18_BUTANE_PIPELINE_L	Release of butane due to leak/catastrophic failure of butane pipeline to storage (stream 220) and associated fittings/pipings. An immediate ignition of the released butane will result in fire.	Butane	10 mm	25 mm		4 inch	776m pipe (Ø0.1016m)		Pool Fire
23	IS19_ETHANE_DETP_V	Release of ethane due to leak/catastrophic failure of deethanizer (115-V1) top part and associated	Ethane	10 mm	50mm	Full vessel		1 pressure vessel	Area C1 - 28,600m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate ignition of the released ethane will result in fire.								
24	IS19_BUTANE_DEBP_L	Release of butane due to leak/catastrophic failure of deethanizer (115-V1) bottom part and associated fittings/pipings. An immediate ignition of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves; 1 heat exchanger		Pool Fire
25	IS20_ETHANE_DERTP_V	Release of ethane due to leak/catastrophic failure of deethanizer receiver top part (115-V2) and associated fittings/pipings. An immediate ignition of the released ethane will result in fire.	Ethane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE
27	IS21_PROPANE_SPLITTP_V	Release of propane due to leak/catastrophic failure of C3/C4 splitter top part (115-V3) and	Propane	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		associated fittings/pipings. An immediate ignition of the released propane will result in fire.								
28	IS21_BUTANE_SPLITBP_L	Release of butane due to leak/catastrophic failure of dC3/C4 splitter bottom part (115-V3) and associated fittings/pipings. An immediate ignition of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel, 2 valves; 1 heat exchanger		Pool Fire
29	IS22_PROPANE_SPLITR_L	Release of propane due to leak/catastrophic failure of C3/C4 splitter receiver (115-V4) and associated fittings/pipings. An immediate ignition of the released propane will result in fire.	Propane	10 mm	50mm	Full vessel		1 pressure vessel, 3 valves; 1 pump, 2 heat exchangers		Pool Fire
30	IS23_PROPANE_PIPELINE_L	Release of propane due to leak/catastrophic failure of C3 LPG	Propane	10 mm	25 mm		3 inch	664m pipe (Ø0.0762m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		pipeline to storage (stream 214) and associated fittings/pipings. An immediate ignition of the released propane will result in fire.								
31	IS24_KERO_COALES_L	Release of kerosene due to leak/catastrophic failure of coalescer (120-V1) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel; 5 valves	Area C1 - 28,600m2	Pool Fire
32	IS25_KERO_ECPW_L	Release of kerosene due to leak/catastrophic failure of electrostatic coalescer prewash (120-V2) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
33	IS26_KERO_REAC_L	Release of kerosene due to leak/catastrophic failure of reactor (120-R1) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire
34	IS27_KERO_CAUSET_L	Release of kerosene due to leak/catastrophic failure of caustic settler (120-V3) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire
35	IS28_KERO_WWASH_L	Release of kerosene due to leak/catastrophic failure of water wash (120-V4) and associated fittings/pipings. An immediate ignition of	n-Nonane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		the released kerosene will result in fire.								
36	IS29_KERO_SANDFIL_L	Release of kerosene due to leak/catastrophic failure of sand filter (120-V5A/B) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		2 pressure vessels; 5 valves		Pool Fire
37	IS30_KERO_CLAYFIL_L	Release of kerosene due to leak/catastrophic failure of clay filter (120-V6A/B) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.	n-Nonane	10 mm	50mm	Full vessel		2 pressure vessels; 7 valves		Pool Fire
38	IS31_KERO_PIPELINE_L	Release of kerosene due to leak/catastrophic failure of kerosene	n-Nonane	10 mm	2 inch		6 inch	146m pipe (Ø0.1524m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		pipeline (stream 38) and associated fittings/pipings. An immediate ignition of the released kerosene will result in fire.								
39	IS32_DODEC_FEEDCO_L	Release of dodecane due to leak/catastrophic failure of feed coalescer (130-ME1) and associated fittings/pipings. An immediate ignition of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 3 valves	Area C2 - 25,800m^2	Pool Fire
40	IS33_DODEC_PIPELINE_L	Release of dodecane due to leak/catastrophic failure of diesel pipeline from condesate fractionation unit (stream 101) and associated fittings/pipings. An immediate ignition of	Dodecane	10 mm	2 inch		6 inch	282m pipe (Ø0.1524m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		the released dodecane will result in fire.								
41	IS34_DODEC_FSD_L	Release of dodecane due to leak/catastrophic failure of feed surge drum (130-V1) and associated fittings/pipings. An immediate ignition of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 valve	Area C2 - 25,800m2	Pool Fire
42	IS35_H2_REAC1_V	Release of hydrogen due to leak/catastrophic failure of reactor 1 (130-R1) and associated fittings/pipings. An immidiate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 3 heat exchanger; 3 valve		Jet Fire, Flash Fire, VCE
43	IS36_H2_REAC2TP_V	Release of hydrogen due to leak/catastrophic	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		failure of reactor 2 (130-R2) top part and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.								
45	IS37_H2_SEPTP_V	Release of hydrogen due to leak/catastrophic failure of separator (130-V3) top part and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 valves		Jet Fire, Flash Fire, VCE
47	IS38_H2_FDTP_V	Release of hydrogen due to leak/catastrophic failure of flash drum (130-V4) top part and associated fittings/pipings. An	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves;		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released hydrogen sulfide will result in fire								
49	IS39_H2_RGCSD_V	Release of hydrogen due to leak/catastrophic failure of recycle gas compressor suction drum (130-V5) bottom part and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 2 compressor, 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE
50	IS40_H2_PIPELINE_V	Release of hydrogen due to leak/catastrophic failure of make up gas pipeline from platforming unit (stream 501) and associated fittings/pipings. An immediate and delay	Hydrogen	10 mm	25 mm		3 inch	230m pipe (Ø0.0762m)		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released hydrogen will result in fire.								
51	IS41_H2_MGCSD_V	Release of hydrogen due to leak/catastrophic failure of make up gas compressors suction drum (130-V6) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 2 compressors, 1 valve		Jet Fire, Flash Fire, VCE
52	IS42_H2_STRIPTP_V	Release of hydrogen due to leak/catastrophic failure of stripper (130-V7) top part and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
53	IS42_DODEC_STRIPBP_L	Release of dodecane due to leak/catastrophic failure of stripper (130-V7) bottom part and associated fittings/pipings. An immediate and delay outcome of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 2 heat exchangers; 1 valve		Pool Fire
54	IS43_MET_SRTP_V	Release of methane due to leak/catastrophic failure of stripper receiver (130-V8) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen sulfide will result in fire.	Methane	10 mm	50 mm			1 valve		Jet Fire, Flash Fire, VCE
55	IS43_NAPHTHA_SRBP_L	Release of naphtha due to leak/catastrophic failure of stripper receiver (130-V8) and	n-Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		associated fittings/pipings. An immediate and delay outcome of the released of naphtha will result in fire.						exchanger; 2 valves		
56	IS44_DODEC_VACDRY_L	Release of dodecane due to leak/catastrophic failure of vacuum dryer (130-V9) and associated fittings/pipings. An immediate and delay outcome of the released dodecane will result in fire.	Dodecane	10 mm	50mm	Full vessel		1 pressure vessel; 3 heat exchangers; 1 pump; 3 valves		Pool Fire
57	IS45_DIESEL_PIPELINE_L	Release of diesel due to leak/catastrophic failure of diesel product pipeline to storage (stream 739) and associated fittings/pipings. An immediate and delay outcome of the	Diesel	10 mm	2 inch		6 inch	780m pipe (Ø0.1524m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released diesel will result in fire.								
59	IS47_H2_PIPELINE_V	Release of hydrogen due to leak/catastrophic failure of off gas pipeline from naphtha hydritreating unit (stream 741) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	25 mm		4 inch	401m pipe (Ø0.1016m)		Jet Fire, Flash Fire, VCE
60	IS48_H2_OGA_V	Release of hydrogen due to leak/catastrophic failure of off gas absorber/knock out drum (130-V11) and associated fittings/pipings. An immediate and delay outcome of the	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve	Area C2 - 25,800m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released hydrogen will result in fire.								
61	IS49_H2_TOGKD_V	Release of hydrogen due to leak/catastrophic failure of treated off gas knock out drum (130-V12) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 2 valves		Jet Fire, Flash Fire, VCE
62	IS50_H2_RETP_V	Release of hydrogen due to leak/catastrophic failure of reactor top part (200-R1) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 3 heat exchangers ; 1 valve	Area R1 - 31,800m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
63	IS50_NAPHTHA_REBP_L	Release of naphtha due to leak/catastrophic failure of reactor bottom part (200-R1) and associated fittings/pipings. An immediate and delay outcome of the released naphtha will result in fire.	n-Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 3 heat exchangers; 1 valve		Pool Fire
64	IS51_H2_SEPTP_V	Release of hydrogen due to leak/catastrophic failure of separator top part (200-V3) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Flash Fire, VCE
65	IS51_HEAVY NAPHTHA_SEPBP_L	Release of x due to leak/catastrophic failure of separator bottom part (200-V3) and associated	n-Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released x will result in fire.								
66	IS52_H2_RCSD_V	Release of hydrogen due to leak/catastrophic failure of recycle compressor suction drum (200-V4) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve; 1 compressor		Jet Fire, Flash Fire, VCE
67	IS53_BUT_STRITP_V	Release of butane due to leak/catastrophic failure of stripper top part (200-V5) and associated fittings/pipings. An immediate and delay outcome of the	Butane	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released hydrogen sulfide will result in fire								
68	IS53_PENTANE_STRIBP_L	Release of pentane due to leak/catastrophic failure of stripper bottom part (200-V5) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 1 valve		Pool Fire
69	IS54_BUTANE_STRTP_V	Release of butane due to leak/catastrophic failure of stripper receiver top part (200-V6) and associated fittings/pipings. An immediate and delay outcome of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
70	IS54_PENTANE_STRBP_L	Release of pentane due to leak/catastrophic failure of stripper	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 2 heat		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		receiver bottom part (200-V6) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.						exchangers ; 2 valves		
71	IS55_LIGHT NAPHTHA_NASTP_V	Release of x due to leak/catastrophic failure of naphtha splitter top part (200-V7) and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	n-Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
72	IS55_PENTANE_NASBP_L	Release of pentane due to leak/catastrophic failure of naphtha splitter bottom part (200-V7) and associated fittings/pipings. An immediate and delay outcome of the	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released pentane will result in fire.								
73	IS56_PENTANE_NASR_L	Release of pentane due to leak/catastrophic failure of naphtha splitter receiver (200-V8) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 3 valves		Pool Fire
74	IS57_PENTANE_DEPTP_V	Release of x due to leak/catastrophic failure of depentanizer top part (200-V9) and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
76	IS58_PENTANE_DEPR_L	Release of pentane due to leak/catastrophic failure of depentanizer receiver (200-V10) and	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 2 heat exchangers		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.						; 2 pumps; 1 valve		
77	IS59_PENTANE_ADSORB_L	Release of pentane due to leak/catastrophic failure of adsorber (230-V1A/B) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		2 pressure vessels; 2 heat exchangers ; 2 valves		Pool Fire
78	IS60_H2_REAC1_V	Release of hydrogen due to leak/catastrophic failure of Reactor 1 (300-R1) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 valves		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
79	IS61_H2_REAC2_V	Release of hydrogen due to leak/catastrophic failure of Reactor 2 (300-R2) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
80	IS62_H2_REAC3_V	Release of hydrogen due to leak/catastrophic failure of Reactor 3 (300-R3) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
81	IS63_H2_REAC4_V	Release of hydrogen due to leak/catastrophic failure of Reactor 4 (300-R4) and associated fittings/pipings. An	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released hydrogen will result in fire.								
82	IS64_H2_SEPTP_V	Release of hydrogen due to leak/catastrophic failure of separator (300-V1) top part and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 compressor ; 2 valves		Jet Fire, Flash Fire, VCE
83	IS64_HEAVY NAPHTHA_SEPBP_L	Release of x due to leak/catastrophic failure of separator (300-V1) bottom part and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	n-Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 2 heat exchangers ; 2 pumps; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
84	IS65_H2_NGSDTP_V	Release of hydrogen due to leak/catastrophic failure of net gas suction drum top part (300-V2) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 compressor ; 1 valve		Jet Fire, Flash Fire, VCE
85	IS65_BENZENE_NGSDBP_L	Release of benzene due to leak/catastrophic failure of separator net gas suction drum bottom part (300-V2) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire
86	IS66_H2_RD1TP_V	Release of hydrogen due to leak/catastrophic failure of recontact	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger;		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		drum no 1 top part (300-V3) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.						1 compressor ; 2 valves		
87	IS66_BENZENE_RD1BP_L	Release of benzene due to leak/catastrophic failure of recontact drum no 1 bottom part (300-V3) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
88	IS67_H2_RD2TP_V	Release of hydrogen due to leak/catastrophic failure of recontact drum no 2 top part (300-V4) and associated fittings/pipings. An immediate and delay	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released hydrogen will result in fire.								
89	IS67_BENZENE_RD2BP_L	Release of benzene due to leak/catastrophic failure of recontact drum no 2 bottom part (300-V4) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire
90	IS68_H2_NGCT_V	Release of hydrogen due to leak/catastrophic failure of net gas chloride treaters (300-V5A/B) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		2 pressure vessels; 5 valves		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
91	IS69_BUTANE_DBTP_V	Release of x due to leak/catastrophic failure of debutanizer top part (300-V6) and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
92	IS69_TOLUENE_DBBP_L	Release of toluene due to leak/catastrophic failure of debutanizer bottom part (300-V6) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve; 1 heat exchanger		Pool Fire
93	IS70_BUTANE_DBRTP_V	Release of butane due to leak/catastrophic failure of debutanizer receiver top part (300-V7) and associated fittings/pipings. An	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 3 heat exchangers; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released butane will result in fire.								
94	IS70_PENTANE_DBRBP_L	Release of pentane due to leak/catastrophic failure of debutanizer receiver bottom part (300-V7) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 2 valves		Pool Fire
95	IS71_BUTANE_LPGCT_L	Release of butane due to leak/catastrophic failure of LPG chloride treaters (300-V8A/B) and associated fittings/pipings. An immediate and delay outcome of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		2 pressure vessels; 6 valves		Pool Fire
96	IS72_H2_REAC_V	Release of hydrogen due to	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 2	Area A3 - 7,500m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		leak/catastrophic failure of reactor (320-R1) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.						valves; 2 heat exchangers		
97	IS73_H2_SEPTP_V	Release of hydrogen due to leak/catastrophic failure of separator top part (320-V1) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 compressor ; 1 valve		Jet Fire, Flash Fire, VCE
98	IS73_XYLENE_SEPBP_L	Release of x due to leak/catastrophic failure of separator bottom part (320-V1) and associated fittings/pipings. An immediate and delay	m-xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve; 1 heat exchanger		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released x will result in fire.								
99	IS74_XYLENE_PIPELINE_L	Release of x due to leak/catastrophic failure of feed pipeline from raffinate side cut surge drum in parex process unit (stream 108) and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	m-xylene	10 mm	3.3 inch		10 inch	410m pipe (Ø0.254m)		Pool Fire
100	IS75_ETHANE_DHTP_V	Release of ethane due to leak/catastrophic failure of deheptanizer top part (320-V2) and associated fittings/pipings. An immediate and delay outcome of the released ethane will result in fire.	Ethane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve	Area A3 - 7,500m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
101	IS75_XYLENE_DHBP_L	Release of xylene due to leak/catastrophic failure of deheptanizer bottom part (320-V2) and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 pump; 1 valve		Pool Fire
102	IS76_ETHANE_DHRTP_V	Release of ethane due to leak/catastrophic failure of deheptanizer receiver top part (320-V3) and associated fittings/pipings. An immediate and delay outcome of the released ethane will result in fire.	Ethane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
103	IS76_BENZENE_DHRBP_L	Release of benzene due to leak/catastrophic failure of deheptanizer receiver bottom part (320-V3) and associated fittings/pipings. An	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 pump; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released benzene will result in fire								
104	IS77_ETHANE_DHVDTP_V	Release of ethane due to leak/catastrophic failure of deheptanizer vent drum top part (320-V4) and associated fittings/pipings. An immediate and delay outcome of the released ethane will result in fire.	Ethane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
105	IS77_BENZENE_DHVDBP_L	Release of benzene due to leak/catastrophic failure of deheptanizer vent drum bottom part (320-V4) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire.	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
106	IS78_BENZENE_PIPELINE_L	Release of benzene due to leak/catastrophic failure of benzene pipeline from stripper overhead at tatoray process unit (stream 602) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire.	Benzene	10 mm	2.6 inch		8 inch	330m pipe (Ø0.2032m)		Jet Fire, Flash Fire, VCE
107	IS79_TOLUENE_PIPELINE_L	Release of toluene due to leak/catastrophic failure of toluene pipeline from reactor outlet at olefin reduction process unit (stream 601) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	2 inch		6 inch	260m pipe (Ø0.1524m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
108	IS80_BUTANE_DBTP_V	Release of butane due to leak/catastrophic failure of debutanizer top part (320-V5) and associated fittings/pipings. An immediate and delay outcome of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve	Area A3 - 7,500m2	Jet Fire, Flash Fire, VCE
109	IS80_TOLUENE_DBBP_L	Release of toluene due to leak/catastrophic failure of debutanizer bottom part (320-V5) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Pool Fire
110	IS81_BUTANE_DBRTP_V	Release of butane due to leak/catastrophic failure of debutanizer receiver top part (320-V6) and associated fittings/pipings. An	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released butane will result in fire.								
111	IS81_PENTANE_DBRBP_L	Release of pentane due to leak/catastrophic failure of debutanizer receiver bottom part (320-V6) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 pump; 1 valve		Pool Fire
112	IS82_TOLUENE_PIPELINE_L	Release of toluene due to leak/catastrophic failure of reformate splitter overhead (toluene pipeline) from xylene fractionation unit (stream 104) and associated fittings/pipings. An immediate and delay outcome of the	Toluene	10 mm	4 inch		12 inch	560m pipe (Ø0.3048m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released toluene will result in fire.								
113	IS83_H2_PIPELINE_V	Release of hyrogen due to leak/catastrophic failure of make up hydrogen pipeline (stream 180) from CCR platforming process unit An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	4 inch		12 inch	170m pipe (Ø0.3048m)		Jet Fire, Flash Fire, VCE
114	IS84_TOLUENE_REAC12_L	Release of toluene due to leak/catastrophic failure of reactor 1/2 (322-R1/R2) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		2 pressure vessels; 1 heat exchanger; 5 valves	Area A3 - 7,500m2	Pool Fire
115	IS85_TMBZ_PIPELINE_L	Release of trimethylbenzene (TMBZ) due to	TMBZ	10 mm	2 inch		6 inch	260m pipe (Ø0.1524m)		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		leak/catastrophic failure of C9+ aromatics (TMBZ pipeline) (stream 102) from xylenes fractionation unit and associated fittings/pipings. An immediate and delay outcome of the released TMBZ will result in fire								
116	IS86_TOLUENE_PIPELINE_L	Release of toluene due to leak/catastrophic failure of toluene pipeline (stream 101) from benzene-toluene fractionation unit and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	3.3 inch		10 inch	110m pipe (Ø0.254m)		Pool Fire
117	IS87_TOLUENE_FSD_L	Release of toluene due to leak/catastrophic failure of feed surge	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat	Area A1 - 24,800 m2	Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		drum (380-V1) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.						exchanger; 2 valves; 1 pump		
118	IS88_H2_REAC_V	Release of hydrogen due to leak/catastrophic failure of reactor (380-R1) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 2 heat exchangers ; 1 valve		Jet Fire, Flash Fire, VCE
119	IS89_H2_PIPELINE_V	Release of hydrogen due to leak/catastrophic failure ofmake up hydrogen pipeline from PSA unit (stream 180) associated fittings/pipings. An immediate and delay	Hydrogen	10 mm	2.6 inch		8 inch	408m pipe (Ø0.2032m)		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released hydrogen will result in fire.								
120	IS90_H2_SEPTP_V	Release of hydrogen due to leak/catastrophic failure of separator (380-V2) top part and associated fittings/pipings. An immediate and delay outcome of the released hydrogen will result in fire.	Hydrogen	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve	Area A1 - 24,800 m2	Jet Fire, Flash Fire, VCE
121	IS90_AROMATICS_SEPBP_L	Release of x due to leak/catastrophic failure of separator (380-V2) bottom part and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	n-Octane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
122	IS91_HEXANE_STP_V	Release of X due to leak/catastrophic failure of stripper (380-V3) top part and associated fittings/pipings. An immediate and delay outcome of the released X will result in fire.	Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
123	IS91_TOLUENE_SBP_L	Release of toluene due to leak/catastrophic failure of stripper (380-V3) bottom part and associated fittings/pipings. An immediate and delay outcome of the released toluenewill result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 2 heat exchangers ; 1 valve		Pool Fire
124	IS92_ETHANE_SRTP_V	Release of ethane due to leak/catastrophic failure of stripper condenser (380-V4) top part and associated fittings/pipings. An	Ethane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released ethane will result in fire.								
125	IS92_BENZENE_SRBP_L	Release of benzene due to leak/catastrophic failure of stripper condenser (380-V4) bottom part and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire.	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 1 valve		Jet Fire, Flash Fire, VCE
126	IS93_BUTANE_RSTP_V	Release of butane due to leak/catastrophic failure of reformate splitter (431-V1) top part and associated fittings/pipings. An immediate and delay outcome of the released butane will result in fire.	Butane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve	Area A2 - 17,500m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
127	IS93_TOLUENE_RSBP_L	Release of toluene due to leak/catastrophic failure of reformate splitter (431-V1) bottom part and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 3 valves		Pool Fire
128	IS94_TOLUENE_RSR_L	Release of toluene due to leak/catastrophic failure of reformate splitter receiver (431-V2) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger, 2 pumps; 3 valves		Pool Fire
129	IS95_XYLENE_CT_L	Release of xylene due to leak/catastrophic failure of clay treaters (431-V3A/B) and associated	Xylene	10 mm	50mm	Full vessel		2 pressure vessels; 4 valves		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.								
130	IS96_XYLENE_PIPELINE_L	Release of xylene due to leak/catastrophic failure of xylene pipeline (deheptanizer bottoms) (stream 203) from isomar process unit and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	3.3 inch		10 inch	100m pipe (Ø0.254m)		Pool Fire
131	IS97_XYLENE_XSTP_V	Release of x due to leak/catastrophic failure of xylene splitter (431-V4) top part and associated fittings/pipings. An immediate and delay outcome of the	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve	Area A2 - 17,500m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released x will result in fire.								
132	IS97_XYLENE_XSBP_L	Release of xylene due to leak/catastrophic failure of xylene splitter (431-V4) bottom part and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 3 pumps; 1 valve		Pool Fire
133	IS98_PENTANE_KOD_L	Release of pentane due to leak/catastrophic failure of C5 gas knockout drum (431-V14) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 3 valves		Pool Fire
134	IS99_XYLENE_XSR_L	Release of xylene due to leak/catastrophic failure of xylene splitter receiver (431-V6)	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		bottom part and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.								
135	IS100_XYLENE_PFSD_L	Release of xylene due to leak/catastrophic failure of parex feed surge drum (431-V7) and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		19 pressure vessel; 1 valve		Pool Fire
144	IS107_TMBZ_PIPELINE_L	Release of trimethylbenzene (TMBZ) due to leak/catastrophic failure of TMBZ pipeline (stream 425) to tatoray process unit and associated fittings/pipings. An	TMBZ	10 mm	2 inch		6 inch	80m pipe (Ø0.1524m)		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released TTMBZ will result in fire								
145	IS108_TMBZ_PIPELINE_L	Release of tetramethylbenzene (TTMBZ) due to leak/catastrophic failure of TTMBZ pipeline (stream 479) to heavy aromatics tank and associated fittings/pipings. An immediate and delay outcome of the released TTMBZ will result in fire	TTMBZ	10 mm	25 mm		2 inch	798m pipe (Ø0.0508m)		Jet Fire, Flash Fire, VCE
146	IS109_TOLUENE_PIPELINE_L	Release of toluene due to leak/catastrophic failure of toluene pipeline (stream 100) to 432-TK1 and associated fittings/pipings. An immediate and delay outcome of the	Toluene	10 mm	2 inch		6 inch	170m pipe (Ø0.1524m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released toluene will result in fire.								
147	IS110_TOLUENE_TANK_L	Release of toluene due to leak/catastrophic failure of toluene tank (432-TK1) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	150 mm	500 mm	Full Vessel		1 tank; 2 pumps; 1 valve	Area A1 - 24,800 m2	Pool Fire
148	IS111_TOLUENE_CT_L	Release of toluene due to leak/catastrophic failure of clay treaters (432-V1A/B) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		2 pressure vessel; 5 valves; 1 heat exchanger		Pool Fire
149	IS112_TOLUENE_PIPELINE_L	Release of toluene due to leak/catastrophic failure of toluene pipeline (stripper	Toluene	10 mm	2.6 inch		8 inch	500m pipe (Ø0.2032m)		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		bottom) (stream 131) from tatoray unit and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.								
150	IS113_TOLUENE_PIPELINE_L	Release of toluene due to leak/catastrophic failure of toluene pipeline (finishing column overhead) (stream 140) from parex unit and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	2 inch		6 inch	440m pipe (Ø0.1524m)		Pool Fire
151	IS114_BENZENE_BCTP_V	Release of benzene due to leak/catastrophic failure of benzene column (432-V2) top part and associated	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger;	Area A1 - 24,800 m2	Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released benzene will result in fire						2 pumps; 1 valve		
152	IS114_TOLUENE_BCBP_L	Release of toluene due to leak/catastrophic failure of benzene column (432-V2) bottom part and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 2 valves		Pool Fire
153	IS115_BENZENE_BCR_L	Release of benzene due to leak/catastrophic failure of benzene column receiver (432-V3) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 valve; 1 heat exchanger		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
154	IS116_TOLUENE_TCTP_V	Release of toluene due to leak/catastrophic failure of toluene column (432-V4) top part and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel		Jet Fire, Flash Fire, VCE
155	IS116_TOLUENE_TCBP_L	Release of toluene due to leak/catastrophic failure of toluene column (432-V4) bottom part and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 valve		Pool Fire
156	IS117_TOLUENE_TCR_L	Release of toluene due to leak/catastrophic failure of toluene column receiver (432-V5) and associated	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 2 valves; 1		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.						heat exchanger		
158	IS119_DEBZ_ADC1_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of adsorber chamber 1 (500-V1) and associated fittings/pipings. An immediate and delay outcome of the released DEBZ will result in fire	DEBZ	10 mm	50mm	Full vessel		1 pressure vessel; 4 valves; 2 pumps	Area A2 - 17,500m2	Jet Fire, Flash Fire, VCE
159	IS120_DEBZ_ADC2_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of adsorber chamber 2 (500-V2) and associated fittings/pipings. An immediate and delay	DEBZ	10 mm	50mm	Full vessel		1 pressure vessel; 4 valves; 2 pumps		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released DEBZ will result in fire								
160	IS121_XYLENE_RCTP_V	Release of xylene due to leak/catastrophic failure of raffinate column (500-V3) top part and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
161	IS121_DEBZ_RCBP_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of raffinate column (500-V3) bottom part and associated fittings/pipings. An immediate and delay outcome of the released DEBZ will result in fire	DEBZ	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
162	IS122_XYLENE_RCSCSD_L	Release of xylene due to leak/catastrophic failure of raffinate column side cut surge drum (500-V4) and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire
163	IS123_XYLENE_RCR_L	Release of xylene due to leak/catastrophic failure of raffinate column receiver (500-V5) and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 2 valves		Pool Fire
164	IS124_XYLENE_RCVD_L	Release of xylene due to leak/catastrophic failure of raffinate column vent drum (500-V6) and associated	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.								
165	IS125_XYLENE_ECTP_V	Release of X due to leak/catastrophic failure of extract column (500-V7) top part and associated fittings/pipings. An immediate and delay outcome of the released X will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
166	IS125_DEBZ_ECBP_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of extract column (500-V7) bottom part and associated fittings/pipings. An immediate and delay outcome of the	DEBZ	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 heat exchanger; 2 valves		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released DEBZ will result in fire.								
167	IS126_XYLENE_ECR_L	Release of xylene due to leak/catastrophic failure of extract column receiver (500-V8) and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve; 1 heat exchanger; 2 pumps		Pool Fire
168	IS127_TOLUENE_FCTP_V	Release of toluene due to leak/catastrophic failure of finishing column (500-V9) top part and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
169	IS127_XYLENE_FCBP_L	Release of xylene due to leak/catastrophic failure of finishing	Xylene	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 2		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		column (500-V9) bottom part and associated fittings/pipings. An immediate and delay outcome of the released xylene will result in fire.						heat exchangers; 1 valve		
170	IS128_TOLUENE_FCR_L	Release of toluene due to leak/catastrophic failure of finishing column receiver (500-V10) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 1 valve		Pool Fire
171	IS129_DEBZ_DRC_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of desorbent rerun column (500-V11) and associated fittings/pipings. An	DEBZ	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		immediate and delay outcome of the released DEBZ will result in fire								
172	IS130_DEBZ_TANK_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of desorbent storage tank (500-TK1) and associated fittings/pipings. An immediate and delay outcome of the released DEBZ will result in fire.	DEBZ	150 mm	500 mm	Full Vessel		1 tank; 1 valve; 2 pumps		Jet Fire, Flash Fire, VCE
173	IS131_DEBZ_TANK_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of plant inventory storage tank (500-TK2) and associated fittings/pipings. An immediate and delay	DEBZ	150 mm	500 mm	Full Vessel		1 tank; 1 heat exchanger ; 2 pumps		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released DEBZ will result in fire								
174	IS132_PXYLENE_TANK_L	Release of paraxylene due to leak/catastrophic failure of paraxylene storage tank (500-TK3A/B) and associated fittings/pipings. An immediate and delay outcome of the released paraxylene will result in fire.	Paraxylene	150 mm	500 mm	Full Vessel		2 tanks; 2 pumps		Pool Fire
175	IS133_DEBZ_PSD_L	Release of p-diethylbenzene (DEBZ) due to leak/catastrophic failure of parex sump drum (500-V12) and associated fittings/pipings. An immediate and delay outcome of the released DEBZ will result in fire	DEBZ	10 mm	50mm	Full vessel		1 pressure vessel; 4 pumps; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
176	IS134_BENZENE_TANK_L	Release of benzene due to leak/catastrophic failure of sulfolane feed tank (541-TK1) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire	Benzene	150 mm	500 mm	Full Vessel		1 tank	Area A1 - 24,800 m2	Jet Fire, Flash Fire, VCE
177	IS135_HEXANE_EDCTP_V	Release of hexane due to leak/catastrophic failure of extractive distillation column (541-V1) top part and associated fittings/pipings. An immediate and delay outcome of the released hexane will result in fire.	Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Jet Fire, Flash Fire, VCE
178	IS135_SULFO_EDCBP_L	Release of sulfolane due to leak/catastrophic failure of extractive distillation column	Sulfolane	10 mm	50mm	Full vessel		1 pressure vessel; 4 pumps; 1 heat		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		(541-V1) bottom part and associated fittings/pipings. An immediate and delay outcome of the released sulfolane will result in fire.						exchanger; 3 valves		
179	IS136_HEXANE_EDCR_L	Release of hexane due to leak/catastrophic failure of extractive distillation column receiver (541-V2) and associated fittings/pipings. An immediate and delay outcome of the released hexane will result in fire.	Hexane	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 2 pumps; 1 valve		Pool Fire
180	IS137_BENZENE_PIPELINE_L	Release of benzene due to leak/catastrophic failure of benzene pipeline to storage (stream 136) and associated fittings/pipings. An immediate and delay	Benzene	10 mm	25 mm		4 inch	230m pipe (Ø0.1016m)		Jet Fire, Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released benzene will result in fire								
181	IS138_BENZENE_RCTP_V	Release of x due to leak/catastrophic failure of recovery column (541-V3) top part and associated fittings/pipings. An immediate and delay outcome of the released x will result in fire.	Benzene	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve	Area A1 - 24,800 m2	Jet Fire, Flash Fire, VCE
182	IS138_SULFO_RCBP_L	Release of sulfolane due to leak/catastrophic failure of recovery column (541-V3) bottom part and associated fittings/pipings. An immediate and delay outcome of the released sulfolane will result in fire.	Sulfolane	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
183	IS139_TOLUENE_RCR_L	Release of toluene due to leak/catastrophic failure of recovery column receiver (541-V4) and associated fittings/pipings. An immediate and delay outcome of the released toluene will result in fire.	Toluene	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 4 pumps; 2 valves)		Pool Fire
184	IS140_SULFO_SS_L	Release of sulfolane due to leak/catastrophic failure of sulfolane sump (541-V7) and associated fittings/pipings. An immediate and delay outcome of the released sulfolane will result in fire.	Sulfolane	10 mm	50mm	Full vessel		1 pressure vessel; 1 valve		Pool Fire
185	IS141_SULFO_TANK_L	Release of sulfolane due to leak/catastrophic failure of plant inventory tank (541-	Sulfolane	10 mm	50mm	Full vessel		1 pressure vessel; 2 pumps; 1 heat		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		TK2) and associated fittings/pipings. An immediate and delay outcome of the released sulfolane will result in fire.						exchanger; 2 valves		
188	IS144_H2S_ARR_V	Release of hydrogen sulfide due to leak/catastrophic failure of amine regenerator receiver (640-V3) and associated fittings/pipings. An immediate and delay outcome of the released hydrogen sulfide will result in toxic release.	Hydrogen Sulfide	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve	Area C2 - 25,800m^2	Jet Fire, Flash Fire, Explosion, Toxic Gas Dispersion
189	IS145_H2S_SWSR_V	Release of hydrogen sulfide due to leak/catastrophic failure of sour water stripper receiver (650-V3) and associated fittings/pipings. An immediate and delay	Hydrogen Sulfide	10 mm	50mm	Full vessel		1 pressure vessel; 1 heat exchanger; 1 valve		Jet Fire, Flash Fire, Explosion, Toxic Gas Dispersion

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		outcome of the released hydrogen sulfide will result in toxic release.								
190	IS146_COND_TANK_L	Release of condensate due to leak/catastrophic failure of condensate tanks (800-TK1A-C) and associated fittings/pipings. An immediate and delay outcome of the released condensate will result in fire.	n-Octane	150 mm	500 mm	Full Vessel		1. 3 tanks (ID: 46.59m, H: 24.38m) 2. bund size 25,550m2	Tank Farm Areas	Pool Fire
191	IS147_PXYLENE_TANK_L	Release of paraxylene due to leak/catastrophic failure of paraxylene tanks (810-TK1A-E) and associated fittings/pipings. An immediate and delay outcome of the released paraxylene will result in fire.	Paraxylene	150 mm	500 mm	Full Vessel		1. 5 tanks (ID: 31.06m, H: 16.45m) 2. Bund size 17,500m2		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
192	IS148_BENZENE_TANK_L	Release of benzene due to leak/catastrophic failure of benzene tanks (812-TK1A-D) and associated fittings/pipings. An immediate and delay outcome of the releasedbenzene will result in fire	Benzene	150 mm	500 mm	Full Vessel		1. 4 tanks (ID: 26.21m, H: 15.24m) 2. Bund size 17,500m2		Jet Fire, Flash Fire, VCE
194	IS150_KEROSENE_TANK_L	Release of kerosene due to leak/catastrophic failure of kerosene tanks (820-TK1A,B) and associated fittings/pipings. An immediate and delay outcome of the released kerosene will result in fire.	n-Nonane	150 mm	500 mm	Full Vessel		1. 2 tanks (ID: 49.5m, H: 24.38m) 2. Bund size 17,500m2		Pool Fire
195	IS151_DIESEL_TANK_L	Release of diesel due to leak/catastrophic failure of diesel tanks (825-TK1A,B) and associated	Dodecane	150 mm	500 mm	Full Vessel		1. 2 tanks (ID: 49.5m, H: 24.38m) 2. Bund		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		fittings/pipings. An immediate and delay outcome of the released diesel will result in fire.						size 17,500m2		
196	IS152_NAPHTHA_TANK_L	Release of light naphtha due to leak/catastrophic failure of light naphtha tanks (830-TK1A,B) and associated fittings/pipings. An immediate and delay outcome of the released light naphtha will result in fire.	Light n-Hexane	150 mm	500 mm	Full Vessel		1. 2 tanks (ID: 43.68m, H: 21.34m) 2. Bund size 17,500m2		Pool Fire
198	IS154_FUEL_TANK_L	Release of fuel oil due to leak/catastrophic failure of fuel oil tanks (833-TK1A,B) and associated fittings/pipings. An immediate and delay outcome of the released fuel oil will result in fire.	Dodecane	150 mm	500 mm	Full Vessel		1. 2 tanks (ID: 31.06m, H: 16.45m) 2. Bund size 17,500m2		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
199	IS155_PROPANE_TANK_V	Release of propane LPG due to leak/catastrophic failure of propane LPG tanks (840-TK1A, B) and associated fittings/pipings. An immediate and delay outcome of the released propane LPG will result in fire.	Propane			Full Vessel		1. 2 tanks (ID: 21m, H: ball tank) 2. Bund size 3,700m2		Bleve (Fireball), Flash Fire, VCE
200	IS156_BUTANE_TANK_V	Release of butane LPG due to leak/catastrophic failure of butane LPG tanks (842-TK1A-D) and associated fittings/pipings. An immediate and delay outcome of the released butane LPG will result in fire.	Butane			Full Vessel		1. 4 tanks (ID: 21m, H: ball tank) 2. Bund size 3,700m2		Bleve (Fireball), Pool Fire, Flash Fire, VCE
201	IS157_LPG_TANK_V	Release of LPG due to leak/catastrophic failure of LPG tank (841-TK1) and	LPG			Full Vessel		1. 1 tank (ID: 15m, H: ball tank)		Flash Fire, VCE

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		associated fittings/pipings. An immediate and delay outcome of the released LPG will result in fire.						2. Bund size 3,700m2		
202	IS158_PENTANE_TANK_V	Release of pentane due to leak/catastrophic failure of pentane tanks (843-TK1A, B) and associated fittings/pipings. An immediate and delay outcome of the released pentane will result in fire.	Pentane			Full Vessel		1. 2 tanks (ID: 21m, H: ball tank) 2. Bund size 3,700m2		Flash Fire, VCE
204	IS160_SONAPHTHA_TANK_L	Release of sour naphtha due to leak/catastrophic failure of sour naphtha tank (850-TK1) and associated fittings/pipings. An immediate and delay outcome of the	Sour n-Hexane	150 mm	500 mm	Full Vessel		1. 1 tank (ID: 34.95m, H: 18.28m) 2. Bund size 21,800m2		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		released sour naphtha will result in fire.								
205	IS161_SWNAPHTHA_TANK_L	Release of sweet naphtha due to leak/catastrophic failure of sweet naphtha tank (851-TK1) and associated fittings/pipings. An immediate and delay outcome of the released sweet naphtha will result in fire.	Sweet n-Hexane	150 mm	500 mm	Full Vessel		1. 1 tank (ID: 37.85m, H: 21.34m) 2. Bund size 21,800m2		Pool Fire
206	IS162_AROMATICS_TANK_L	Release of aromatics due to leak/catastrophic failure of aromatics tank (431-TK1) and associated fittings/pipings. An immediate and delay outcome of the released aromatics will result in fire.	n-Octane	150 mm	500 mm	Full Vessel		1. 1 tank (ID: 37.85m, H: 18.28m) 2. Bund size 21,800m2		Pool Fire
211	IS167_BENZENE_TANK_L	Release of benzene due to leak/catastrophic	Benzene	150 mm	500 mm	Full Vessel		1. 2 tanks (ID: 13.4m,		Pool Fire

No.	Isolatable Sub-section ID	Description	Representative Material	Leak Size				Note	Area	Potential Outcome
				Small	Large	Catastrophic Failure	Full Bore Rupture			
		failure of benzene day tank (432-TK2A/B) and associated fittings/pipings. An immediate and delay outcome of the released benzene will result in fire						H: 14.6m) 2. bund size 21,800m2		

9.3 Frequency Analysis

9.3.1 Base Failure Frequencies

Generic failure rate data for these equipment items have been taken from publications and technical papers and from searches of database sources such as the *UK HSE Failure Rate and Event Database*. The table below summarises the generic equipment failure data used in this study. Please refer to *Appendix E* for the event tree calculations.

Table 9.5: Historical Onshore Equipment Failure Rates

Equipment Item	Failure Size	Base Failure Frequency
Tank	Small	2.5 x 10^{-3} per vessel year
	Large	1 x 10^{-4} per vessel year
	Catastrophic	5 x 10^{-6} per vessel year
LPG Butane Tank	Catastrophic	2 x 10^{-6} per vessel year
Pipe of diameter between 0 – 49mm	10 mm diameter	1 x 10^{-5} per m per year
	25mm diameter	5 x 10^{-6} per m per year
	Guillotine	5 x 10^{-6} per m per year
Pipe of diameter between 50 – 149mm	10mm diameter	1.68 x 10^{-6} per m per year
	25mm diameter	1 x 10^{-6} per m per year
	Guillotine	5 x 10^{-7} per m per year
Pipe of diameter between 150 – 299mm	10mm diameter	9.14x 10^{-7} per m per year
	1/3 pipework diameter	4 x 10^{-7} per m per year
	Guillotine	2 x 10^{-7} per m per year
Pipe of diameter between 300 – 499mm	10mm diameter	7.14 x 10^{-7} per m per year
	1/3 pipework diameter	2 x 10^{-7} per m per year
	Guillotine	7 x 10^{-8} per m per year
Pipe of diameter between 500 - 1000 mm	10mm diameter	6.14 x 10^{-7} per m per year
	1/3 pipework diameter	1 x 10^{-7} per m per year
	Guillotine	4 x 10^{-8} per m per year
Pressurized vessel	Small	1.00 x 10^{-5} per vessel per year
	Large	5.00 x 10^{-6} per vessel per year
	Catastrophic	6.00 x 10^{-6} per vessel per year
Pump	Small	3.50 x 10^{-4} per pump per year
	Large	1.50 x 10^{-4} per pump per year
Heat Exchanger/compressor	Small	2.61 x 10^{-3} per HE per year
	Large	8.07 x 10^{-5} per HE per year
Valve	Small	1.40 x 10^{-4} per valve per year
	Large	6.00 x 10^{-5} per valve per year

9.3.2 Ignition Probabilities

Apart the base failure frequency data, the ignition probability data is a key element for the event frequency calculation. The ignition probabilities were determined from the look-up correlation, *IP Research Report*[1] for onshore scenarios as provided in *Table 9.6*, selected based on the size of PEC plant.

Table 9.6: Look-up Correlation Selection Guide (Onshore Scenarios)

No.[1]	Look-up Release Type	Application
9	Large Plant Liquid (Liquid release from large onshore plant)	Releases of flammable liquid that does not have any significant flash fraction (10% or less) if it is released from large onshore outdoor plants (plant area above 1,200 m^2, site area above 35,000 m^2).
Note 1:	Reference number based on look-up correlation selection guide.	

The ignition probability for each identified scenario was determined based on the release rate and representative release rate as presented in *Table 9.7.*

Table 9.7: Ignition Probability based on Release Area

Release Rate (kg/s)	Ignition Probability at Large Plant Liquid	Immediate Ignition Probability	Delayed Ignition Probability
0.1	0.001	0.001	0
0.2	0.0013	0.001	0.0003
0.5	0.0019	0.001	0.0009
1	0.0025	0.001	0.0015
2	0.0045	0.001	0.0035
5	0.0097	0.001	0.0087
10	0.013	0.001	0.012
20	0.031	0.001	0.03
50	0.067	0.001	0.066
100	0.12	0.001	0.119
200	0.13	0.001	0.129
500	0.13	0.001	0.129
1000	0.13	0.001	0.129

9.3.3 Event Tree Analysis

Using the base failure frequency and ignition probabilities listed above, each event outcome frequency is predicted via the use of event tree analysis as shown generically on *Figure 9.1.*

[1] IP Research Report, Ignition Probability Review, Model Development and Look-up Correlations, January 2006

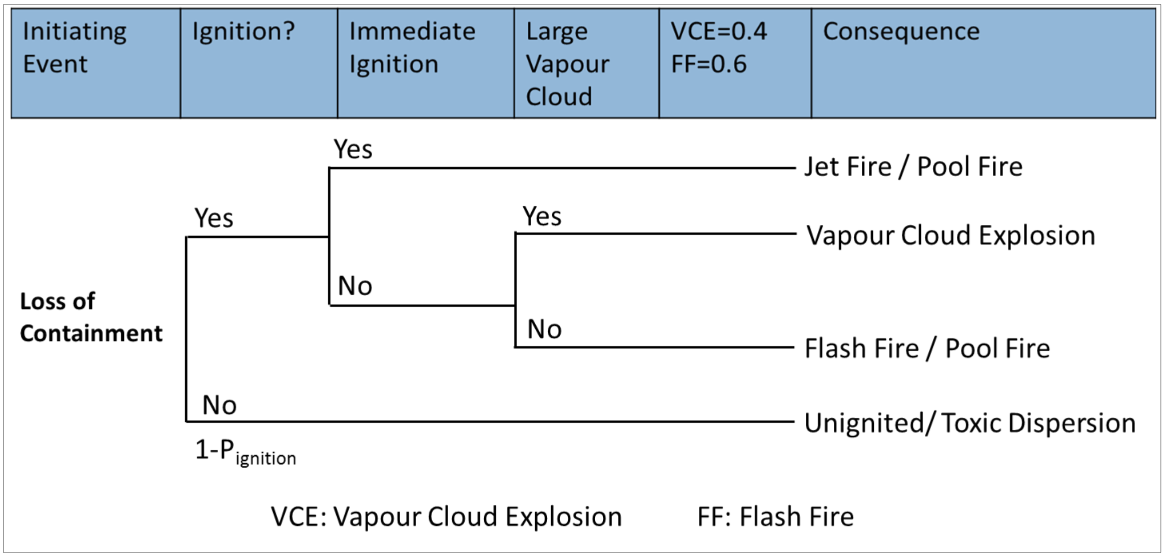


Figure 9.1 – Event Trees for Small, Large Releases and Catastrophic Failures

The event tree analysis is used to assess the final event frequency of all possible outcomes emanating from an initiating event considering various scenarios.

In the event tree analysis, the probability of ignition is multiplied to the base failure frequency to determine the probability of fire/explosion events upon release. The probability of ignition is dependent on the release phase and the mass release rate, as indicated in *Figure 9.1.* For conservatism, the total mass release rate has been taken into account for selection of the ignition probabilities.

In this study, the pool fire is assessed as an immediate liquid phase ignition event as, say, could occur for a transfer pipeline release with the pool forming on the ground beneath the pipe rack.

For delayed gas phase ignition, the consequences are modelled as a vapour cloud explosion or flash fire event. Toxic dispersion hazards may arise if the material is assessed to be toxic and can generate a toxic vapour cloud which poses acute lethal effects to humans.

9.4 Consequence Analysis

9.4.1 Hazard Zones

To estimate the hazard zone distances, consequences analysis/modelling for each outcome event has been conducted as follows:

- *Jet Fires* - based on heat flux causing 90%, 50% and 3% fatalities (to those exposed), corresponding to 34.9, 24.7 and 13 kW/m^2 thermal radiation harm footprints
- *Pool Fires* - based on heat flux causing 90%, 50% and 3% fatalities (to those exposed), corresponding to 34.9, 24.7 and 13 kW/m^2 thermal radiation harm footprints;
- *Flash Fire* - based on 100% fatality assumed within the extent of a flammable cloud to its Lower Flammable Limit (LFL);
- *Vapour Cloud Explosions* - based on overpressures of 0.35, 0.5 bar (exposure to which is assumed to result in 15% and 100% fatality respectively); and
- *Toxic Dispersion* - based on 90%, 50% and 3% fatality for those exposed to toxic concentrations.

9.4.2 Probit Analysis

The QRA uses probit analysis in deriving fire heat radiation levels and toxic concentrations that cause fatalities.

The probit function for fatality due to heat flux is given in *RIVM Reference Manual Bevi Risk Assessments*, consistent with the *DoE Guidelines for Risk Assessment*, as follows:

$Pr = -41.61 + 2.79 \ln (tI^{4/3})$

Where:

Pr	probit corresponding to the probability of death	(-)
t	duration of exposure to the radiation heat flux	(s)
I	heat flux at target	(W/m^2)

The probit function for fatality due to vapour cloud explosion is given by:

$Pr = a + b \ln (P^o)$

Where:

Pr	probit corresponding to the probability of death	(-)
Po	peak overpressure	(Pa)
a, b	constant describing the overpressure	(-)

The probit function for fatality due to toxic effects is given by:

$Pr = a + b \ln (C^n t)$

Where:

Pr	probit corresponding to the probability of death	(-)
C	gas concentration	(ppm)
t	exposure duration	(min)

In this study, the toxic effect of Hydrogen Sulphide was considered and the probit constants are shown in *Table 9.8*. The probit constants were extracted from *RIVM Reference Manual Bevi Risk Assessments*.

Table 9.8: Probit Constants

Material	Probit Constants [ppm]		
	a	b	n
Hydrogen Sulphide	-10.834	1	1.9

9.4.3 Methodology and Consequence Models Used

The software package *TNO Riskcurves version 10.1.9* has been used for calculation of consequence effects. Consequence analysis is carried out for identified outcome events, including release rates, and estimates of heat flux and toxic distances are made. Individual Risk calculations are performed with *TNO Riskcurves Version 10.1.9*.

9.4.4 Consequence Models Inputs

This QRA assesses the risks from the storage vessels and ancillary equipment and the process vessels and ancillary equipment.

9.4.5 Worst Case Scenarios

Table 9.9 presents the worst-case scenarios identified for the PEC facilities.

It should be emphasised that all the hazard zones are confined either within the PEC Site or within the industrial areas and do not encroach to any locations where involuntary recipients of industrial risks might be present such as residential areas, schools, hospitals and places of continuous occupancy, etc. The nearest sensitive receptor is the Kg Lepau, approximately 1.5km to the west of the PEC site.

Table 9.9: Worst Case Scenarios

Isolatable Section	Hazard Type	Fatality Levels-Harm Footprint	Maximum Hazard Zone [m]
003_100V018_C (catastrophic rupture of feed surge drum under weather condition C3)	Pool Fire (Pentane)	90% fatality	170
		50% fatality	205
		3% fatality	258
130_Xylene_pipe_B (large leak of xylene pipeline under weather condition F1)	Jet Fire (Xylene)	90% fatality	181
		50% fatality	190
		3% fatality	206
200_842T001_C (catastrophic rupture of Butane LPG tanks under weather condition F1)	Fireball (BLEVE) (Butane LPG Tanks)	90% fatality	825
		50% fatality	1,083
		3% fatality	1,502
199_840T001_C (catastrophic rupture of propane tank under weather condition F1)	Flash Fire (Propane)	LFL	1,686
201_841T001_C (catastrophic rupture of LPG tank under weather condition F1)	Explosion (LPG)	90% fatality	Not Attained
		50% fatality	560
		3% fatality	561
189_650V003_C (catastrophic rupture of sour water stipper under weather condition F1)	Toxic Dispersion (H_2S)	90% fatality	1
		50% fatality	2
		3% fatality	100

Notes:
1. N/A – not attainable
2. LFL – Lower Flammable Limit

9.5 Risk Summation and Evaluation

9.5.1 Definitions and Risk Acceptance Criteria

Internationally industrial risk is usually judged from one or both of two points of view. The first point of view is that of the individual and the second that of society as a whole or the community around an industrial facility. Published offsite Risk Acceptance Criteria are usually expressed in terms of fatalities.

9.5.1.1 Individual Risk Definition and its Calculation

Location specific Individual Risk (IR) may be defined as the frequency at which an individual may be expected to sustain a given level of harm from the realisation of specified hazards. This is usually expressed as the probability that an individual will be harmed if he stood at a given location for the course of one (1) year:

Individual Risk per year = Number of Fatalities per Individual per year

= Number of Fatalities per year/ Number of People Exposed to the Risk

Location specific Individual Risk (IR) is usually represented by iso-risk contours overlaid on a map of an industrial facility and its surroundings. The IR is the combination of the consequences of an event and the likelihood of the outcome of that event. Producing iso-risk contours, or the combination of these two (2) measures, can be conducted by hand, but is repetitive and more suited to computer software such as the *TNO RiskCurves* software ESC have used for the QRA. Inputs to the software comprise:

- Scenarios detailing all identified hazardous events and their frequencies;
- Release location containing the locations of hazardous events on the site;
- Consequence results including all the calculated consequences of each event under each possible weather condition; and
- Weather frequencies detailing the local meteorological data according to a matrix of weather class (wind speed, stability combinations) and wind directions.

9.5.1.2 DoE Offsite Individual Risk Acceptance Criteria

The offsite Individual Risk Acceptance Criteria adopted in this QRA are those from the DoE's *EIA Guidelines for Risk Assessment*, where by the iso-risk contours generated for the PEC facilities should satisfy the following*:*

- The 1×10^{-6} fatalities/person per year Individual Risk contour should not extend to any areas where involuntary recipients of industrial risks might be located, such as residential areas, schools, hospitals and places of continuous occupancy, etc.; and
- The 1×10^{-5} fatalities/person per year Individual Risk contour should not extend beyond the area of neighbouring industrial developments.

9.5.1.3 Societal Risk Definition and Acceptance Criteria

Societal Risk is often defined as "the relation between frequency and the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards". If the specified level of harm is narrowed down to the loss of life, the Societal Risk may be modelled by the frequency of exceedance curve of the number of deaths, also called the FN-curve.

As the criteria for Societal Risk are not issued by regulatory authorities in Malaysia, the Dutch Guide Value is adopted as provided in *RIVM Reference Manual Bevi Risk Assessments*. These criteria usually divide the log-log FN curve into three areas:

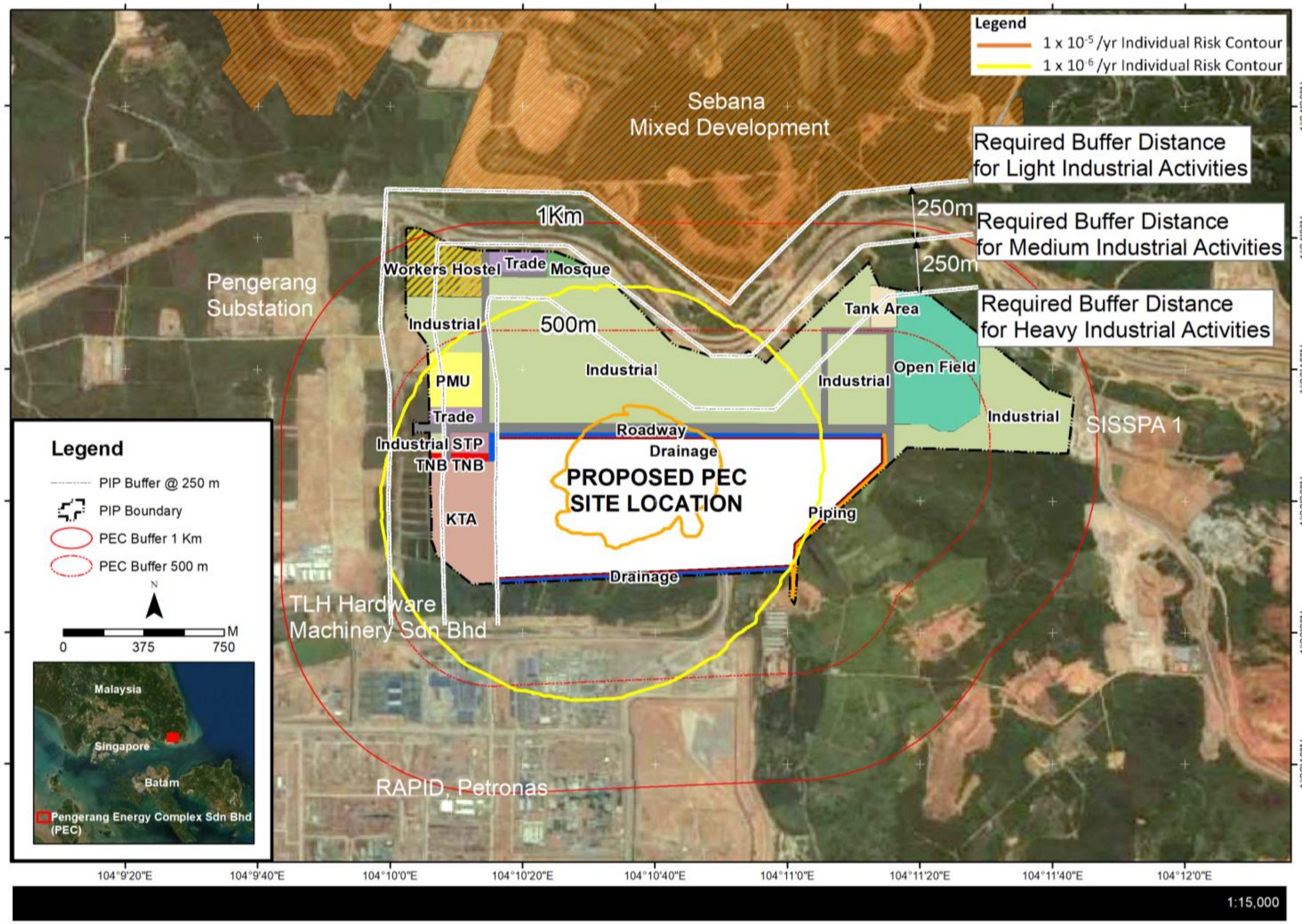
- *An intolerable or unacceptable region* where risks are judged so high that they must be mitigated no matter what the cost or the facility will not be considered for planning permission.
- *A tolerable or acceptable region* where risks are so low that no additional mitigation measures are deemed necessary.

9.5.2 Individual Risk Results

9.5.2.1 PEC Individual Risk Results

Figure 9.2 presents the Individual Risk contours overlain on the satellite image of the Pengerang area, for loss of containment events as assessed in detail in this QRA. The 1 x 10^{-5} and 1 x 10^{-6}/year contours shown include the contributions from jet fires, pool fires, flash fires, explosions, fireballs and toxic dispersion.

As shown in the figure, the Individual Risk (IR) contour for 1x 10^{-5} and 1 x 10^{-6} per year contour are attained, and extends offsite, however is contained within the Industrial Area. The maximum offsite distance is ~75m and ~670m towards the North respectively. The QRA found the major offsite risk contributors from the PEC plant resulted from failures of the Butane Storage Tank (842TK1) and Area A2 (Xylene Splitter Area). The PEC Facilities is in compliance with *DoE's Risk Acceptance Criteria*.



ESC

Figure 9.2 – PEC Individual Risk Contours

9.5.3 Societal Risk Results

Figure 9.3 presents the societal risks for the PEC Plant. The maximum number of offsite fatalities associated with major accidents events (MAEs) arising from within the PEC site was assessed at 22 with a frequency of 7.85 x 10^{-8}/year, which is found to be within the "Tolerable" region. Hence no additional mitigation measures are required to be implemented in accordance with the ALARP (*as low as reasonably practical*) principle.

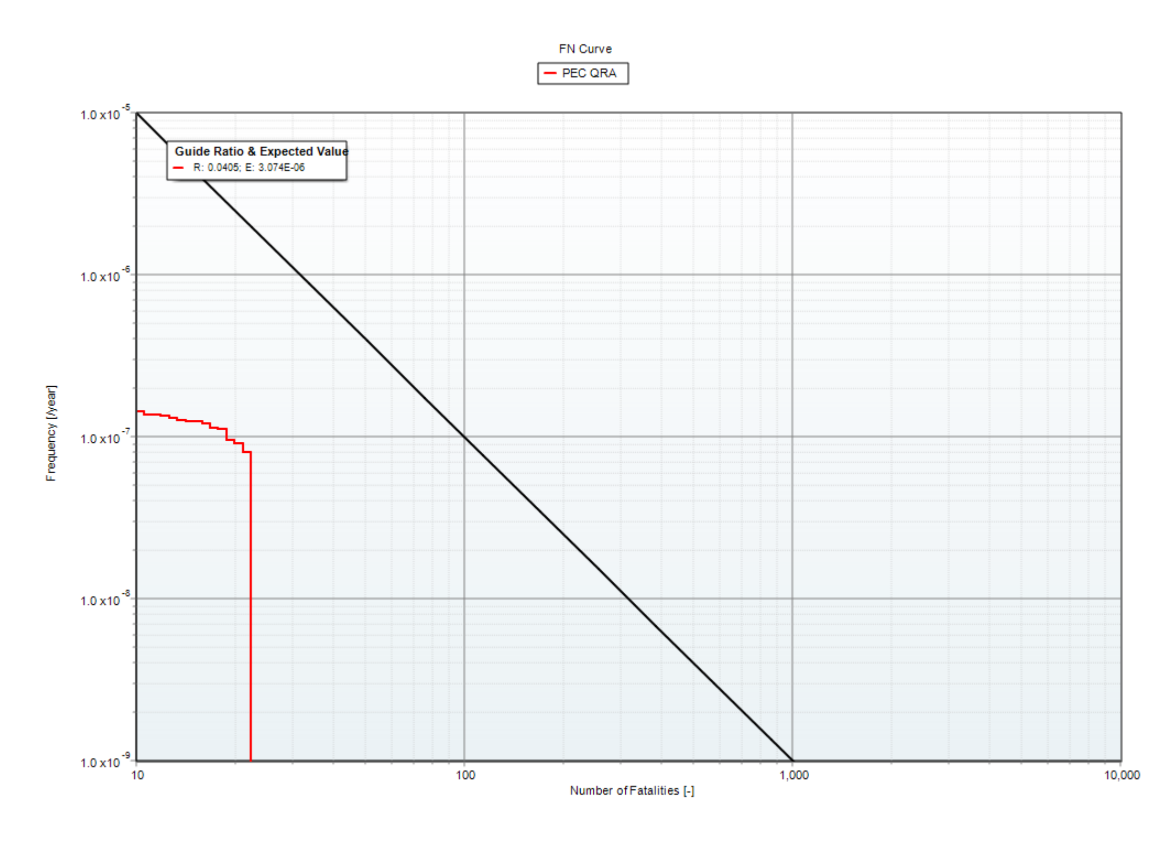


Figure 9.3 – FN Curve

9.6 QRA Conclusions

9.6.1 Frequency Analysis and Consequence Results

The QRA conservatively addresses the failure frequencies of all the facilities at the PEC site and determines the consequences of the hazards identified before performing risk summation and evaluation.

Conservatisms ensure risks are not underestimated and, in this case, include usage of maximum inventories of hazardous substances in vessels and modelling releases based on the worst-case situation, i.e. the isolatable sections are modelled without quantitatively considering the benefits of all safety systems (excepting the tank bunds), procedural or firefighting safety measures onsite.

9.6.2 Risk Summation and Evaluation against Risk Acceptance Criteria

9.6.2.1 Individual Risks

The QRA quantifies its Individual Risk (IR) and found that while the 1 x 10^{-6} per year IR contour extends offsite, it remains confined within the Industrial Area. Hence the risks comply with *DoE Risk Acceptance Criteria*. The QRA found the major offsite risk contributors from the PEC plant resulted from failures of the Butane Storage Tank (842TK1) and Area A2 (Xylene Splitter Area).

Table 9.10: Worst Case Scenarios Result Summary

Isolatable Section	Hazard Type	Fatality Levels- Harm Footprint	Maximum Hazard Zone [m]
003_100V018_C (catastrophic rupture of feed surge drum under weather condition C3)	Pool Fire (Pentane)	90% fatality	170
		50% fatality	205
		3% fatality	258
130_Xylene_pipe_B (large leak of xylene pipeline under weather condition F1)	Jet Fire (Xylene)	90% fatality	181
		50% fatality	190
		3% fatality	206
200_842T001_C (catastrophic rupture of Butane LPG tanks under weather condition F1)	Fireball (BLEVE) (Butane LPG Tanks)	90% fatality	825
		50% fatality	1,083
		3% fatality	1,502
199_840T001_C (catastrophic rupture of propane tank under weather condition F1)	Flash Fire (Propane)	LFL	1,686
201_841T001_C (catastrophic rupture of LPG tank under weather condition F1)	Explosion (LPG)	90% fatality	Not Attained
		50% fatality	560
		3% fatality	561
189_650V003_C (catastrophic rupture of sour water stipper under weather condition F1)	Toxic Dispersion (H_2S)	90% fatality	1
		50% fatality	2
		3% fatality	100

Notes:
1. N/A – not attainable
2. LFL – Lower Flammable Limit

9.6.3 Societal Risks

The Societal Risk (SR) is within the 'Tolerable' region of the adopted Societal Risk Tolerability Criteria, adopted as provided in *RIVM Reference Manual Bevi Risk Assessments*. The maximum number of offsite fatalities associated with major accidents events (MAEs) arising from within the PEC site was assessed at 22 with a frequency of 7.85 x 10^{-8}/year, which is found to be within the "Tolerable" region. Hence no additional mitigation measures are required to be implemented in accordance with the ALARP (*as low as reasonably practical*) principle.

9.7 Conclusions of the QRA

Based on the QRA results summarised above, it is concluded that the PEC Plant satisfies the *DoE Risk Acceptance Criteria* for Individual Risk as:

- The 1 x 10^{-5} fatalities per year contour remains within the industrial development; and
- The 1 x 10^{-6} fatalities per year contour does not encroach to any public areas, such as residential areas, schools, hospitals.

Therefore, no additional mitigation measures are deemed to be mandatory to further reduce the risks associated with the PEC.

The Societal Risk associated with the PEC Plant is found to be within the tolerable region. Therefore, it can be concluded risks are acceptable and no additional mitigation measures are required to reduce risks to a level *as low as reasonably practical (ALARP)*.

10 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

10.1 Introduction

To ensure that PEC's environmental objectives are achieved for the Project an Environmental and Social Management Plan (ESMP) is to be developed to cover the construction phase of the project, to describe how legislative requirements, the findings of this ESHIA and DOE Approval Conditions, will be implemented.

The ESMP is an environmental and social management framework to ensure compliance with the requirements of the *Environmental Quality Act 1974* as well as the IFC's and Equator Principle's general framework relating to prevention, abatement and mitigation of environmental and social impacts resulted from the facility operation.

The ESMP outlines key strategy and programmes to manage the environmental issues and the facility's compliance status related to its operation.

The key objectives of the ESMP are as follow:

- To ensure continuing compliance with legal requirements, environmental policy and social obligations;
- To serve as a basic document for environmental and social control and protection in order to minimise the impacts from the facility operation;
- To provide an integrated action plans for mitigation and abatement of the negative impacts identified in the EIA;
- To describe the roles and responsibility of the facility team in managing the environmental and social aspects; and
- To establish the framework for environmental monitoring and compliance audit programme, grievance mechanism, as well as the environmental and social management performance review framework.

The ESMP framework for PEC is shown in *Table 10.1.* A complete ESMP for both the construction and operational phases will be developed separately and presented as a separate document prior to the start of construction and operations of PEC respectively.

Table 10.1: Matrix of Environmental and Social Management and Monitoring Effort

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
Significant Impacts Being Managed						
Pre-Construction						
Changes in community livelihood pattern	Land Acquisition	Land acquisition and clearing has been completed by PIPC.	-	-	-	Not Applicable
Concern and community grievances	Land acquisition	Concern and grievance for pre-construction period went to PIP as well as handled and solved by PIPC.	-	-	-	Not Applicable
Construction						
Air emission/ Air quality	Emission of fugitive dust from earthwork activities, construction activities and vehicle movement.	The concentration of PM_{10} in the ambient air quality shall comply with Malaysian Ambient Air Quality Standard (2020).	• Activities that produce significant dust emissions will be monitored during periods of high winds and dust control measures implemented as appropriate • Stockpiles of soil and similar materials will be carefully managed to minimise the risk of windblown dust, e.g. water spray dampening of soils and spoil and during delivery and dumping of sand and gravel during periods of dry weather • Where possible, drop heights for material transfer activities, e.g.	Refer to *Figure 10.1*	Construction	Environmental Officer

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
			unloading of friable materials, will be minimised and carefully managed • On-site and access roads will be well maintained through mechanical means (sweeping or vacuuming) or damping with water and access road will be resurfaced • Trucks transporting potentially dusty materials will use secure load covers extending over the tail and side boards • Vehicle speeds on unsurfaced roads will be limited to 30 km/hr			
Water Quality	Decrease in surface water quality in Sg. Lepau due to the construction activities of PEC. However, since the site has mostly been prepared by JCorp for the PIPC, the impacts are considered to be minor.	The concentration of all parameters of the water discharged must not exceed the National Water Quality Standards (Standard A).	• Provision of temporary site drainage and run-off control systems; settlement ponds and silt fences • Work scheduling (to avoid heavy rainfall periods) • Construction materials that block or obstruct drainage channels should be removed; • Removal of debris/garbage accidentally entering drainage channels • Provision of refuse traps on drain channel outfalls	Refer to *Figure 10.2*	Construction	Environmental Officer

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
			• Control of on-site fuel storage, re-fuelling and vehicle maintenance activities; temporary tanks to have impervious base and secondary containment of minimum 110% of tank size, drip trays • Controls on the on-site storage of hazardous materials • Segregation of wastewater streams to ensure compatibility with selected treatment options (e.g. septic system which can only accept domestic sewage) • Segregation and pre-treatment of oil and grease containing effluents (e.g. use of a grease trap) prior to discharge into sewer systems			
Sedimentation	Increase of sediment load into the storm drains from the earthwork and trenching activities. However, since the site has mostly been prepared by JCorp for the	The concentration of total suspended solids (TSP) must not exceed the limit stated in National Water Quality Standards (Standard A).	• An Preparation of Erosion and Sediment Control Plan (ESCP) will be prepared by qualified engineer; • The design of the drainage system will be designed to achieve the "zero contribution to peak discharge" concept • Perimeter earth drain will be constructed along the boundary of the site;	Refer to *Figure 10.2*	Construction	Environmenta l Officer

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
	PIPIC, the impacts are considered to be minor.		• Two (2) drainage outlet structures will be constructed at the northwest and southwest boundary of the site; • Two (2) check dams will be constructed before each drainage outlet points to reduce flow velocity of the surface runoff; • Silt fence will be utilised and placed along the boundary of the site before the perimeter earth drain; • A sediment basin will be constructed at the northwest boundary of the site; • Wash trough for construction vehicles entering and exiting the site.			
Wastes	Construction Wastes and Scheduled Wastes generated by the construction activities and maintenance of the construction vehicles.	Non-schedule waste must be handled, stored and disposed of according to industrial best management practice (refer Chapter 7) Schedule waste must be handled, stored and disposed of in	• A Solid Waste Management Plan will be prepared; • The facility will be managed in such a way as to minimise the generation of wastes; • Where possible wastes will be recovered or recycled on site; • External companies capable of recovering or recycling wastes, that cannot be handled on site, will	Scheduled Waste Storage Area	Construction	Competent Person for SWM

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
		accordance to Environmental Quality (Scheduled Waste) Regulations 2005	be contracted for waste removal whenever practicable; • All wastes will be segregated by type ensuring that incompatible wastes are stored separately; • Waste storage facilities should be suitable for the purpose by ensuring that waste containers/storage areas are capable of containing predicted waste volumes in a manner unlikely to cause damage to the environment or harm to human health; • Waste designated for off-site disposal will be fully documented to include details of waste type, quantity, recipient, final destination and all other relevant information prior to leaving the site; • Waste designated for off-site disposal will only be transferred such party that can demonstrate that they are licensed to transport and/or treat or dispose of the waste in accordance with the requirements under the			

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	**Source**	**Key Performance Indicators**	**Mitigation Measures**	**Locations**	**Periods**	
			Environmental Quality (Scheduled Wastes) Regulations 2005.			
Noise	Noise from heavy machinery and construction activities.	The noise level for LA_{eq}, LA_{max}, LA_{min}, LA_{90} and LA_{10} must not exceed the noise limit from Schedule 6: Maximum Permissible Sound Levels (Percentile LN and Lmax) of Construction, Maintenance and Demolition Works by Receiving Landuse of The Planning Guidelines for Environmental Noise Limits and Control, 2007.	• Exhaust mufflers will be employed on engine-powered construction plant; • Good practice procedures (such as turning off equipment when not in use); • Noise prevention and mitigation measures such as silencer, relocation of equipment, replacement with lower noise level, and personal protective equipment, etc. should be applied where predicted or measured noise impacts from the facility or operations exceed the applicable noise level guideline; • Mobile plant and other vehicles will be driven responsibly and below 30 km/h within the construction site • Night-time construction activities will normally be restricted to relatively quiet activities	Refer to *Figure 10.1*	Construction	Environmental Officer
Greenhouse gas (GHG): Increasing CO_2 emission	Consumption of fuel oil in the mobilisation of	CO_2 emissions in accordance with the estimated amount of planned fuel	• Calculate CO_2 emissions for mobilisation activities of equipment and materials during construction and start-up stages	-	-	Environmental Officer

<table>
<tr><th colspan="2">Environmental Impact</th><th colspan="2">Environmental Management Effort</th><th colspan="2">Environmental Monitoring</th><th rowspan="2">Responsible PEC Department</th></tr>
<tr><th>Type</th><th>Source</th><th>Key Performance Indicators</th><th>Mitigation Measures</th><th>Locations</th><th>Periods</th></tr>
<tr><td></td><td>equipment and materials</td><td>consumption during the construction phase.</td><td>• Conduct regular inspection and maintenance (Preventive Maintenance) of vehicles and heavy or light equipment</td><td></td><td></td><td></td></tr>
<tr><td>Socio-economic: Increasing employment opportunity</td><td>Recruitment and workforce mobilization</td><td>• High percentage of locally employed manpower. The project estimates to employ up to 7,000 workers during construction period

• If workforce (with certain qualifications and skills) is unavailable locally within 1-5 km range from the project site, the employment opportunity will be given to locals Kota Tinggi (district level), state, and national wide, or migrant workers.</td><td>• Consider and prioritize local workers to fulfill position in accordance to project needs and qualification required.
• Disclose information on availability of job opportunities to public periodically or through Village Head, and Department of Labor Johor and and Local Authority Pengerang in an open and transparent manner.
• Assist the selected local people in determining the type of training needed to improve their qualifications and skill therefore they have greater opportunity to be hired as labor by project proponents or contractors.
• Provide training to project personnel according to the project needs.
• Implement labor recruitment in accordance with applicable labor regulations, including if migrant workers are hired.</td><td>Villages around the project site mainly:
• Kg. Lepau
• Kg Bukit Pelali
• Kg Bukit Buloh
• Kg Bukit Gelugor
• Kg Bukit Raja
• Taman Regit Jaya
• Kg Sungai Kapal
• Kg. Sungai Buntu</td><td>Construction</td><td>External Relation and Human Resources</td></tr>
</table>

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
Socio-economic: Decreasing employment and business opportunity	Construction workers demobilization	• Demobilization of workforce is conducted after end of employment contract and the former employees receive their rights in accordance with the agreement and the applicable provisions according to labor regulation • If migrant workers were hired, demobilization of migrant workers will reduce potential of social conflict	• Regularly inform Department of Labor Johor and Local Authority Pengerang about the number of labor who will be demobilized during the construction period and the end of the construction period. Also inform village head regarding this matter. • The demobilization of workforce is conducted in accordance with agreements between the company and employee. • The company follows laws and regulations on employment regarding the worker mobilization	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal • Kg. Sungai Buntu	Construction	External Relation and Human Resources
Socio-economic: Increasing business opportunity	• Canteen and store operation inside the project site as well as demand for food and daily needs from employee • Equipment an d Material	• The absorption of local products mainly from agriculture (fruits) and fishery commodities, including catering service, both primary and secondary needs • Availability of small / medium industries / services that can	• Optimize the absorption of local products from agriculture (fruits), fisheries, and other commodities • Optimizing small and medium business development of local communities to provide service to the project • Open opportunities for local entrepreneurs to take part in project development activities	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal	Construction	External Relation and Procurement

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
	demand for project • Construction of condensate splitter and aromatics plant and supporting facilities and materials	provide services to condensate splitter and aromatics projects and other supporting activities meet the established requirements	including supporting facilities, such as in food and project materials and labor supply, etc. • Provide support and assistance to local entrepreneurs (including training, business plan development, etc.) and helping them to achieve a healthy and profitable business. • For smallholder farmers, fisherman, and small business owner living around the project site, provide farming, fishery, and other livelihood-related training to improve their skills and income	• Kg. Sungai Buntu		
Socio-economic: Changes in the community livelihood pattern	Derivative effect from decreasing employment opportunity due to construction workforce demobilization	Workforce who got demobilized have alternative of livelihood	• Identified the need of skills to be enhanced an alternative to new livelihoods. • Provide agricultural training (fruits cultivation related training), and processing of fishery products, catering enterprise, entrepreneurship, and other identified livelihood-related training for communities living around the project site. • Provide opportunity and support to develop small and medium	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal • Kg. Sungai Buntu	Construction and operation	External Relation

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	**Source**	**Key Performance Indicators**	**Mitigation Measures**	**Locations**	**Periods**	
			enterprise development of local communities. • Open the opportunities for local entrepreneurs to take part in project development activities including supporting project facilities, as contractors or sub-contractors. • Optimize the use of local available products (fruits, fish, etc.) • Potential and talented construction workers are considered to be employed at the operational stage as required and meet company qualifications and requirements • Provide skills training to the workforce from the villages surrounding the project who are recruited for operation stage			
Socio-economic: Changes in the community Income level	Derivative impact from: • Increasing employment opportunity due to workforce recruitment	• The absorption of products from agriculture, fishery, and other commodities and products from the closest villages to the project	Impacts addressed through primary impact management as proposed for improvement of work: • Informed Labor office at state level and Local Authority Pengerang regularly about the number of demobilization workers during the construction period and the end of the construction period and also to	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya	Construction, Operation	External Relation and Human Resources

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
	and mobilization • Decreasing employment opportunity due to construction worker demobilization	• Availability of small / medium industries / services that can provide services to the project	the Head of Village open and transparent • Demobilization of labor is conducted according to work agreement • Labor demobilization according to the applicable laws and regulations on employment, including provision the right of employee	• Kg Sungai Kapal • Kg. Sungai Buntu		
Socio-cultural: Concerns and community grievance	Derivative impact from: • villager's activities disruption due to project activities • Increase noise and traffic due to equipment and material mobilization as well as condensate splitter and aromatics plant its supporting facilities construction	• Minimum/ low concerns and complaints from communities • Consultation with the local community is recorded • Implementation of grievance mechanism.	• Install traffic signs around the activities in accordance with applicable regulations • Conduct socialization and disclose of information on grievance mechanism and construction activities for condensate splitter and aromatics plant which may cause disturbance to communities • Limited construction activities conducted at night. If it causes above allowable noise level, no construction conducted at night • If construction generates high noise, Install soundproofing, if possible • Perform road check and test operation on a regular basis according to manual maintenance and company guidance on all	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal • Sungai Buntu	Construction	External Relation

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
			vehicles / heavy equipment used for project activities. Maintain speed limit for project vehicles under allowable speed • Maintain a communication with stakeholders to discuss social impacts handling programs due to the development and operation of the project • Grievances submitted by the community are recorded, investigate, processed, and solved. • Accommodate and follow up on grievance, if there are complaints, during the construction of the condensate splitter and aromatics and its supporting facilities			
Socio-cultural: Social conflict	Derivative effects of migrant worker mobilization as large number of workforce needed for construction of PEC project	• No potential conflict between migrant workers and local communities • Minimum/ low concerns and complaints from communities • Consultation with the local community is recorded	• Provide accommodation (camp or quarters) inside the project area for migrant workers • Consult with local authority on recruiting migrant workers and minimizing impacts with local communities • Provide orientation and local community awareness program for migrant workers to introduce cultural sensitivity, taboo, custom, and wisdom of local communities.	Project site and villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal	Construction	Human Resources and External Relation

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
		• Implementation of grievance mechanism.		• Sungai Buntu		
Socio-cultural: Influence on local culture	Labor recruitment and mobilization reach a maximum of up to 7,000 people who carry customs from workers	• No disputes arise due to cultural differences among the employee as well as between employee and community • Arts-culture activities will be regularly conducted in local art and cultural arts community	• Introduce local culture (through employee induction) to migrant workers employed by the project • Require project employees to respect local culture and avoid the taboos prevailing in the local community • Support the community and government program • Encourage local cultural promotion activities	Project site and villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal • Sungai Buntu	Construction, Operation	External Relation
Public health: Decrease environmental sanitation	Labor recruitment and mobilization	The management of environmental sanitation conditions at the site; • No community complaints around the project due to decreasing environmental sanitation (liquid waste, solid waste, etc.) • Implementation of the program to improve	• Provision of adequate sanitary, toilets and clean water, and trash boxes facilities for workers and employees. • Carry out induction and counseling about environmental sanitation on a regular basis to the workforce. • Collect and conduct temporary domestic wastewater treatment (WWTP) that is placed on project site. • Provision of adequate domestic solid waste shelters in the appropriate quantities of waste	• Project site • Villages around the project site mainly: ○ Kg. Lepau ○ Kg Bukit Pelali ○ Kg Bukit Buloh ○ Kg Bukit Gelugor ○ Kg Bukit Raja ○ Taman Regit Jaya	Construction	Health, Safety, and Environment

<table>
<tr><th colspan="2">Environmental Impact</th><th colspan="2">Environmental Management Effort</th><th colspan="2">Environmental Monitoring</th><th rowspan="2">Responsible PEC Department</th></tr>
<tr><th>Type</th><th>Source</th><th>Key Performance Indicators</th><th>Mitigation Measures</th><th>Locations</th><th>Periods</th></tr>
<tr><td></td><td></td><td>the health status of the environment around the project area</td><td>(organic / biodegradable and non-organic / non- decomposable). Sorting of the type of waste according to its nature and recycle it.
• For the waste that cannot be recycle, the management of domestic waste (organic and non-organic) conduct coordination with local authority to dispose the waste in local landfill.
• Install information about keeping clean environment and place the trash at designated boxes.</td><td>○ Kg Sungai Kapal
○ Sungai Buntu</td><td></td><td></td></tr>
<tr><td>Public health: Changes in disease prevalence</td><td>Derivative effects of environmental sanitation reduction by labor acceptance and mobilization</td><td>• Control the prevalence of infectious diseases in the villages around the project site
• No complaints from the community around the project due to health problems and changes in the health status.
• The incidence rate and prevalence of disease due to changes in the health status is under control</td><td>• Conduct inductions and counseling on impact of drugs, alcohol, sexually transmitted diseases (STD), and other infectious diseases (e.g. HIV AIDS, TB, etc.) regularly to the workforce
• Implement CSR program on health service and public health affair with local health institutions (health clinic, hospitals and others) to affected communities
• Consult with community regarding public health issue and health program for community.</td><td>Villages around the project site mainly:
• Kg. Lepau
• Kg Bukit Pelali
• Kg Bukit Buloh
• Kg Bukit Gelugor
• Kg Bukit Raja
• Taman Rengit Jaya
• Kg Sungai Kapal
• Sungai Buntu</td><td>Construction</td><td>Health, Safety, and Environment, and External Relation</td></tr>
</table>

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
		• Maintain public health in the villages around the project where migrant workers reside	• Provide construction workers and employee with insurance coverage according to labor regulations requirement			
Transportation: Land traffic disruption	• Acceptance and mobilization of labor • Mobilization of equipment and materials • Construction of condensate splitter and aromatics plant and its supporting facilities and and materials	• Zero accident target during movement of vehicles from/ to project site • Availability of journey plan management	• Labor entry hours during construction is not on peak hour of traffic volume • Workforce is transported with bus or mini bus • Provide multiply the entrance/ exit doors of the project site • Installation signs board related to transportation such as no parking, u turn, no stop, traffic light, etc. • Installation of yellow flashing light in front of the entrance gate. • Provision of adequate parking space for workers' vehicles. • Coordinate with JPJ and police during the mobilization and demobilization activities	None of villages affected. However, villagers may pass the access road to project site	Construction	Project Manager
Operation						
Air Emission	Emission of HCl, SO_2, NO_2, NH_3, Hg, H_2S, Cl and Total PM from PEC's stacks.	The emission concentrations for the prescribed pollutants shall comply with Environmental Quality (Clean Air) Regulations,	• The design of all proposed stacks, flare and air pollution control systems should be guided by the Guidance Document on Fuel Burning Equipment and Air Pollution Control Systems issued by DOE Malaysia	Continuous Emission Monitoring System (CEMS)	Operation	Competent Person for APCS

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
		2014 as per the following: • Third Schedule [Regulation 13]: Limit Values and Technical Standards (By Activity or Industry): E. Oil and Gas Industries: Refineries (All Sizes): Natural Gas Processing and Storage and Handling of Petroleum Products; and • Third Schedule [Regulation 13]: Limit Values and Technical Standards (By Activity or Industry): A. Heat and Power Generation: 1. Boilers under Gaseous Fuels.	under the Environmental Quality (Clean Air) Regulations 2014.			
Ambient Air Quality	Emission of SO_2, NO_2, CO, O_3, $PM_{2.5}$ and PM_{10} from PEC's process and operational activities.	The concentration of SO_2, NO_2, CO, O_3, $PM_{2.5}$, and PM_{10} emitted shall comply with Malaysian Ambient Air Quality Standard (2020).	• Conduct ambient air monitoring on monthly basis.	Refer to *Figure 10.1*	Operation	Consultant/ SAMM Laboratory

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
Boundary Noise	Noise generated from process equipment during operational phase.	The noise level for LA_{eq}, LA_{max}, LA_{min}, LA_{90} and LA_{10} shall comply to the noise limit from Schedule 6: Maximum Permissible Sound Levels (Percentile LN and Lmax) of Construction, Maintenance and Demolition Works by Receiving Landuse of The Planning Guidelines for Environmental Noise Limits and Control, 2007.	• Good practice procedures (such as turning off equipment when not in use); • Regular maintenance of equipment • Noise prevention and mitigation measures such as silencer, relocation of equipment, replacement with lower noise level, and personal protective equipment, etc. should be applied where predicted or measured noise impacts from the facility or operations exceed the applicable noise level guideline;	Refer to *Figure 10.1*	Operation	Consultant/ SAMM Laboratory
Water Quality	Contaminated water generated from process waste water/ air emission control equipment/ knock out drums, process areas, unintentional spillages and equipment wash-water.	The concentration of all parameters of the water discharged shall comply with National Water Quality Standards (Standard A).	• The site storm and wastewater conveyance system shall be designed to ensure pre-segregation of non-contaminated and contaminated and/or potentially contaminated water; • The clean water system shall collect clean storm water from areas not normally subjected to contamination, which is directly discharged from the facility via the storm water discharge channel, via an effluent screen pit;	Refer to *Figure 10.3*	Operation	Consultant/ SAMM Laboratory

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
			• There will be one slop oil tank which has a storage volume of 6,000m3 to hold the skimmed oil. The oil will be used for on-site reprocessing; • All process wastewater and wastewater from the flare and other emission control equipment shall be directed to the dedicated wastewater treatment facility on site; • Treated waste water will be discharged to on-site final pond with a holding volume of 10,000m3; and • Monitoring of the effluent discharge on quarterly basis shall be conducted to ensure the wastewater treatment plant is operating at optimum level.			
General Waste	Waste generated from packaging of materials and general waste relating to site administration offices and canteens.	Non-schedule waste must be handled, stored and disposed of according to industrial best management practice (refer Chapter 7)	• The facility will be managed in such a way as to minimise the generation of wastes; • Where possible wastes will be recovered or recycled on site; • External companies capable of recovering or recycling wastes, that cannot be handled on site, will be	Waste store	Operation	Environmental Officer

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
			contracted for waste removal whenever practicable; • All wastes will be segregated by type ensuring that incompatible wastes are stored separately; • Waste storage facilities should be suitable for the purpose by ensuring that waste containers/storage areas are capable of containing predicted waste volumes in a manner unlikely to cause damage to the environment or harm to human health; • Waste designated for off-site disposal will be fully documented to include details of waste type, quantity, recipient, final destination and all other relevant information prior to leaving the site; and • Waste designated for off-site disposal will only be transferred by such party that can demonstrate that they are licensed to transport and/or treat or dispose of the waste in accordance with Malaysian Regulations.			
Scheduled Waste	Scheduled Waste generated during operation of PEC	Schedule waste must be handled, stored and disposed of in	• Implementing 3R concept to manage waste during operational stage;	Scheduled Waste Store	Operation	Competent Person for SWM

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	

		accordance to Environmental Quality (Scheduled Waste) Regulations 2005	• All wastes will be segregated by type ensuring that incompatible wastes are stored separately;
			• Spent catalyst sent to the catalyst vendor or the recyclers for recovery;
			• Handling of the scheduled waste by adopting good operational practices that includes the followings:
			   • Proper design of the schedule waste storage area that which includes the usage of suitable construction materials, installation of adequate bunding, ventilation, drainage, safety singnages , and compartments based on groups on incompatible wastes.
			   • Waste will be properly contained in drums, intermediate bulk containers, cylinders and poly bags.
			   • Dedicated transit areas for unit processes which frequently generate waste.			

Greenhouse gas (GHG): Increasing CO_2 emission	Fuel	• CO_2 emissions in accordance with the estimated amount of	• Calculate CO_2 emissions PEC process • Perform periodical maintenance of process equipment and its supporting facilities	-	-	Environmenta l Officer

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
		planned fuel consumption • CO_2 emissions in accordance with the estimated amount of gas and fuel oil planned during operation of Petroleum Refinery and its supporting facilities	• Conduct efficiency and efficient use of fuel gas and oil and electricity usage			
Socio-economic: Increasing employment opportunity	Recruitment of labor operations	• The existence of employment recruitment strategy for operation phase • Achieving the target percentage of local manpower employed as planned	• The company and / or contractor consider the workers of the local workforce as required and meet the required qualifications • Number of job opportunities available is periodically informed to the public of through the Department of Labor Johor and village head in an open and transparent manner • Labor recruitment is implemented in accordance with applicable labor laws and regulations	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal • Sungai Buntu	Operation	External Relation and Human Resources
Socio-economic: Increasing business opportunity	• Operation of condensate splitter and aromatics plant	• Absorption of local products, such as agricultural and fishery and other products	• Optimizing the absorption of local products from agriculture (fruits), fisheries, and other products from the village according to project needs	• Project site • Villages around the project site mainly: ○ Kg. Lepau	Operation	External Relation and procurement

Environmental Impact		Environmental Management Effort		Environmental Monitoring		Responsible PEC Department
Type	Source	Key Performance Indicators	Mitigation Measures	Locations	Periods	
	• Handling of non-hazardous solid waste and hazardous waste	from nearby villages by the project. • Availability of small / medium industries / services that can provide services to condensate splitter and aromatics projects and other supporting activities	• Continue to provide training and assistance for agriculture (fruit farmers), fishery sector, and other livelihood sector for communities living in the area around the project site • Optimizing small and medium business development of local communities, providing good support in terms of training and helping to achieve a healthy and profitable business • Opens opportunity for local entrepreneurs to participate in project development activities including their supporting facilities	○ Kg Bukit Pelali ○ Kg Bukit Buloh ○ Kg Bukit Gelugor ○ Kg Bukit Raja ○ Taman Regit Jaya ○ Kg Sungai Kapal ○ Sungai Buntu		
Socio-cultural: Concerns and complaint from community	Derivative Impacts of the Increased noise and air quality from the operation of the condensate splitter and aromatics plant and its supporting facilities	• Minimum/ low concerns and complaints from communities • Consultation with the local community is recorded • Implementation of grievance mechanism.	• Grievance submitted by the community, recorded, processed, and solved during operation phase • From management side, conduct maintenance machinery/ equipment of the condensate splitter and aromatics facilities to ensure facilities are working safely and reliably and thus no complaint from community. • Conduct socialization regarding the operation of condensate splitter and aromatics facilities periodically.	Villages around the project site mainly: • Kg. Lepau • Kg Bukit Pelali • Kg Bukit Buloh • Kg Bukit Gelugor • Kg Bukit Raja • Taman Regit Jaya • Kg Sungai Kapal • Sungai Buntu	Operation	External Relation

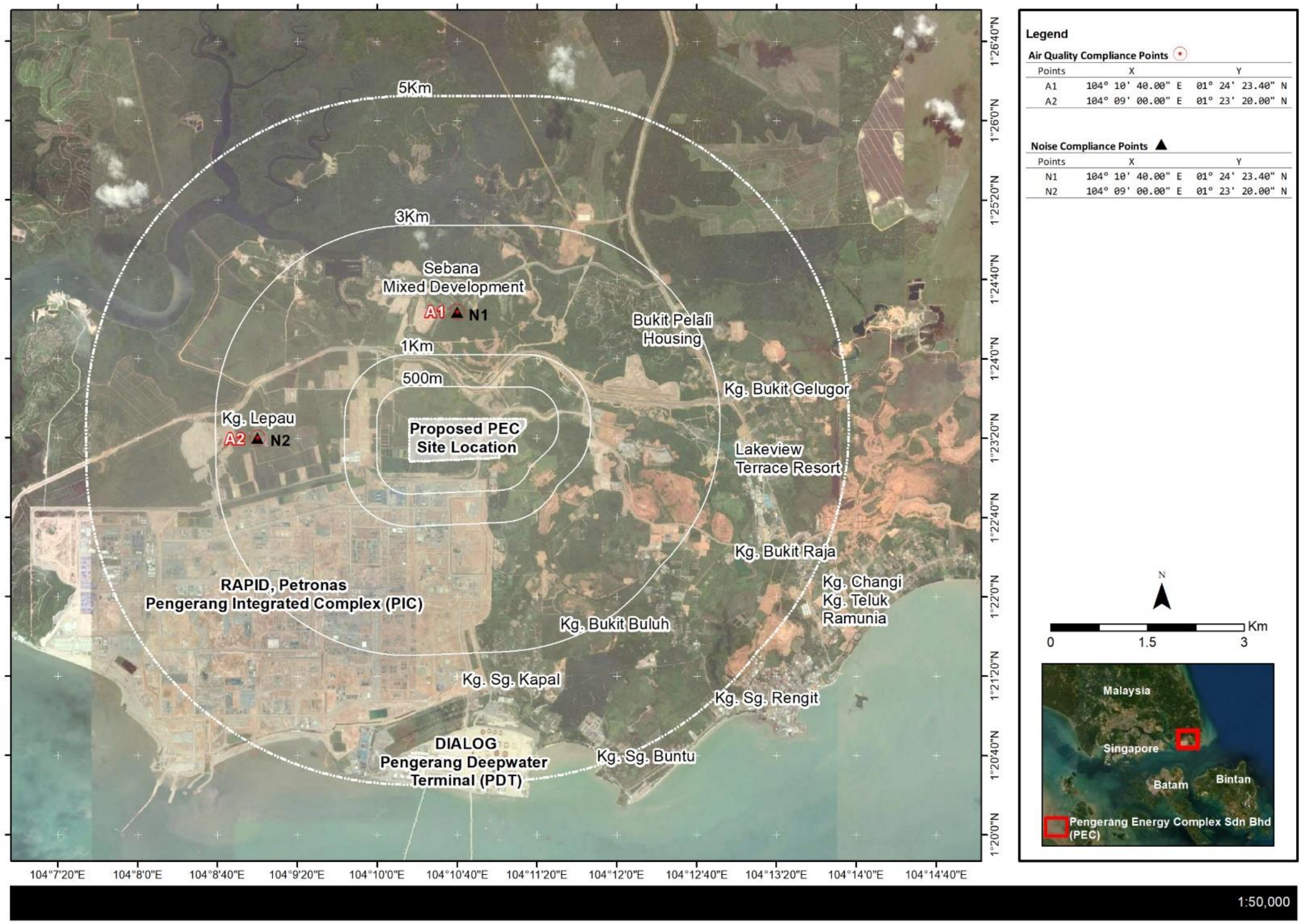
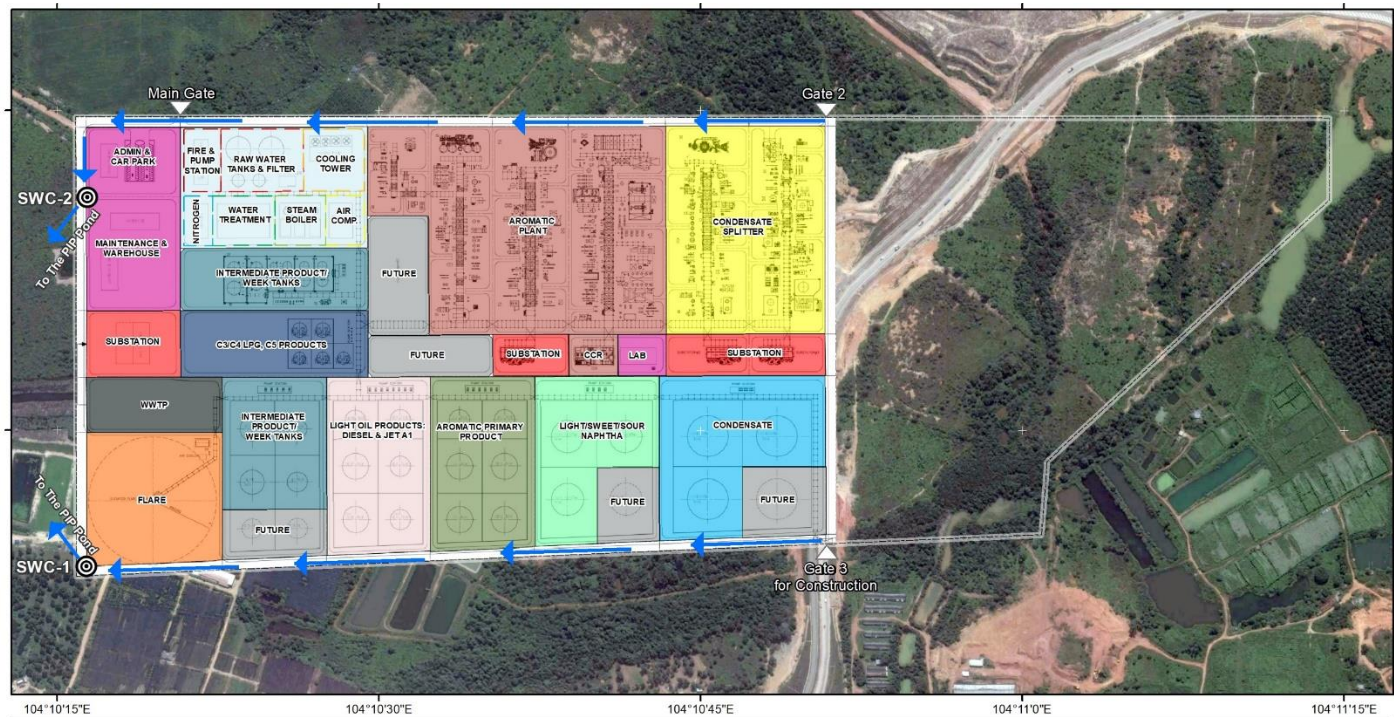


Figure 10.1 – Location of Ambient Air and Noise Sampling Points



Legend

PROPOSED PEC BOUNDARY

SURFACE WATER MONITORING POINTS - CONSTRUCTION PHASE

Surface Water Monitoring Points - Construction Phase

Points	X	Y
SWC-1	104° 10' 16.31" E	01° 23' 08.59" N
SWC-2	104° 10' 16.31" E	01° 23' 25.92" N

N

0 250 500 M

1:5,000

Figure 10.2 – Location of Surface Water Sampling Points During Construction

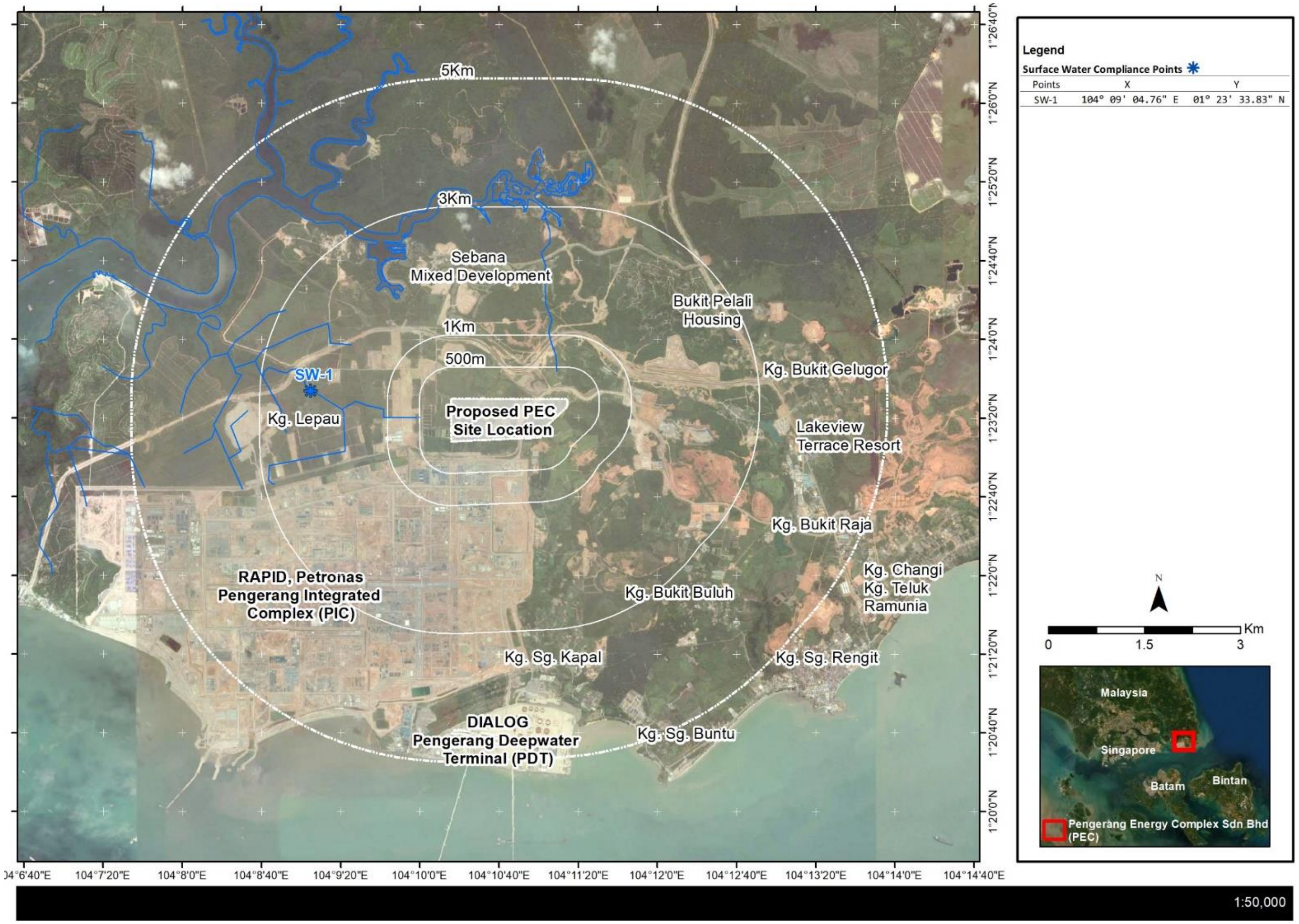


Figure 10.3 – Location of Surface Water Sampling Point During Operation

10.1.1 Contractor's Management Plan

The contractor will ensure that labour standards are respected during the project, by taking into account the capacity of sub-contractors to achieve sound labour management in its assessment of potential sub-contractors.

The contractor will:

- Commit, where requested, to providing a copy of employment registers and records, including details of hours/overtime worked, wages paid and the employment status of workers, both those employed directly and indirectly;
- Assume primary responsibility for day-to-day monitoring of the implementation of labour standards requirements placed by project financiers on the and thereby designate a manager who is responsible for ensuring compliance with labour and health and safety legislation, both in the direct and indirectly-employed workforce (namely, sub-contracted labour);
- Provide or ensure that training is carried out on health and safety issues with regard to all workers, direct and indirectly employed;
- Put in place a mechanism for checking the age of workers;
- Carry out risk assessments in relation to all employees who are under the age of 18;
- Put in place a worker grievance mechanism and details of any complaints lodged under the procedure;
- Undertake to PEC management of all serious accidents that take place in relation to the project.

10.1.1.1 Labour Policies

PEC has set guidelines on Labour Policy for the contractor and sub-contractors to follow in order to ensure compliance to the Malaysian Labour Law. PEC will also implement the IFC Performance Standard 2 on Labour and Working Conditions which will include additional requirements of worker welfare management such as appointment of Welfare Compliance Officer/ Representative and Human Resource (HR) policies. The guidelines include procedures for:

- Terms and Conditions of Employment (e.g. probation, work week/ hours of work and performance of duties);
- Salary and Benefits (e.g. salary period and overtime period); and
- Others (e.g. change in personal particulars and office software);

Other than the HR Policy, PEC has prepared policies related to labour management such as Grievance Management Procedure, Labour Welfare Procedure, Anti-bribery and Corruption Policy, Conflict of Interest Policy, Sanctions and Trade Control Policy, Labour Management Plan, Camp Management Plan and Social Accountability Plan. Contractors will conduct an audit covering all elements above and submit the audit report to PEC on a quarterly basis. The full policies and plans are as attached in *Appendix F*.

10.1.2 Land Acquisition and Resettlement

PEC has selected the optimum location which is in the PIP site. The PIP site is a designated industrial zone and is compatible with government planning. The site (previously KEJORA land) was used as agricultural farms but it has since been vacant to give way to the project. There is no villages or residential area within the 790 acres land. The agricultural land was rented out by KEJORA and there was no permanent structure in the area. The process of land acquisition took 18 months which started from May 2017 until October 2018. Compensations given to 12 tenants and no further objection received from the affected tenants. On March 2019, the land has been successfully converted into an industrial zone and it is now inline with the Johor Structure Plan 2030 and the proposed Pengerang Master Plan.

Although the land is gazetted as industrial zone, PEC has decided to follow the guideline provided by IFC PS 5 on Land Acquisition and Involuntary Resettlement. PEC has set a guideline on the Land Acquisition and Resettlement Framework (refer App*endix F*) to ensure the project-related land acquisition and restriction on the land use does not impact local communities. All the involuntary resettlement which refers to physical displacement and the economic displacement which leads to loss of income sources has been addressed and there will be no direct impact during construction and operational phase.

10.1.3 Health and Safety Management Plan

PEC has prepared the Health, Safety, Security and Environmental Requirements which addressed all Malaysian Standards for Occupational Health and Safety, as well as the Health and Safety guidelines of the international lenders (e.g. IFC Occupational Health & Safety Guidelines 2007), including:

- HSSE Leadership and Commitment;
- Right to Stop Work on HSE Ground;
- Consequence Management for HSE Non-conformances;
- Protection of Workers, Public Assets and Environment;
- HSSE Policies;
- Drugs and Alcohol Policy;
- HSE Mandatory Control Framework;
- Project HSE Plan & Project Security Plan;
- Worksite HSE & Security Procedures
- Contractor’s HSE & Security Organisation;
- Compliance with Legislative and Owner Requirements
- HSSE Responsibility;
- Fatigue Management;
- Permit to Work System; and
- Other guidelines for health, safety and security.

Health and safety management procedures includes internal incident tracking and a corrective action program to prevent recurrence of any such incidents. The Contractor will be responsible and accountable for the actions of its company and employees. These responsibilities will be incorporated into the contract documents consistent with the recommendations of the ESHIA. Workers’ grievance mechanism will be put in place for both construction and operation phases so that workers can raise reasonable workplace concerns as well as for the monitoring and resolving of such concerns. Personnel will be informed of this mechanism at the time of being hired. The full report of HSES Requirements for PEC, Guidelines for Contractor, Interface Management Plan, Environmental Policy Statement, Malaysian Regulatory Permitting Approval Procedure, Preliminary HSE Plan, Preliminary Transportation Plan, Covid-19 Risk Assessment, Environmental Management Plan, Fatigue at Work Place, Fitness to Work, ERP for Construction, Security Management Plan for Construction as well as the ERP for Operations Emergency Handling are as attached in *Appendix F.*

10.1.4 Environmental Auditing

The main objective of the Third-Party Environmental Audit is to provide an independent check on the environmental compliance performance programmes. The audit findings will be used to identify any weaknesses in the ESMP implementation for the purpose of updating the ESMP and to allow for improvement of environmental management practices.

The Environmental Audit is separate and in addition to internal audits; annual, compliance or otherwise; that the HSE Manager shall conduct, inclusive of regular site inspections to monitor and review the environmental practises implemented by workers onsite.

The audit will be conducted covering inspection of several aspects including documentation review, interview with the relevant personnel, site observation and review of environmental quality performance report.

10.1.4.1 Scope of the Audit

The scope of audit proposed during for the construction phase of the Project includes:

- Review of relevant regulatory requirements including relevant permit and licenses, relevant maintenance log sheet, relevant records on environmental audit note, site memo and others;
- Inspection/auditing of mitigation measures implemented onsite in accordance to this ESMP;
- Review the adequacy of the implemented mitigation measures. Additional mitigation/remedial measures, changes in working practices etc. will be recommended as necessary (in the event of non-compliance to performance limits or identification of adverse impacts);
- Analyse and interprets the monitoring results in order to establish the environmental profile of the Project at the time of audit;
- Verify whether the environmental quality monitoring results comply or exceeded the baseline data or the defined environmental performance limits. Any breach of environmental performance limits will be highlighted;
- Assessment of the overall effectiveness of the environmental management system, practices and procedures; Identification of any environmental problems and impacts that may be encountered in the near future, and recommend of potential solutions;
- Investigation of any complaints from residents / sensitive receptors/ neighbouring installations and the actions under taken when complaints are received; and
- Liaison with the responsible parties to review the overall monitoring program in terms of procedures, location of monitoring stations, frequency, parameters measured and test methods to ensure that the environmental objectives are achieved.

10.1.4.2 Frequency of Audit

The audit program proposed for this Project is recommended to be carried out twice a year during the construction phase and once a year during operation.

Besides the compliance audit to be conducted by the Auditor, frequent site inspection will be carried out by the site HSE Officer to monitor best environmental practises implemented by the workers onsite. Frequent inspection by the HSE Officer is crucial to ensure any non-compliance or unfriendly environmental practises are promptly picked-up and corrective action taken in time.

11 INFORMATION DISCLOSURE, CONSULTATION, AND PARTICIPATION

11.1 Stakeholder Analysis and Engagement

Stakeholders as defined by IFC are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively. The project's stakeholder engagement procedures provide a structured, disciplined and integrated process for systematically meeting the engagement objectives.

Stakeholders are proactively engaged before and during construction and operations. Stakeholder engagement is the basis for building strong, constructive and responsive relationships that are essential for successful management of Project's environmental and social impacts. It is an ongoing process that involves varying degrees of the following:

- Stakeholder analysis (influence and interest) and planning;
- Disclosure and dissemination of information;
- Consultation and participation;
- Grievance management and:
- Ongoing reporting to and engagement with affected stakeholders.

The nature, frequency and level of effort of stakeholder engagement for PEC are scaled and commensurate with the limited social and environmental risks and impacts of the Project. PEC is committed to disclosing appropriate information about the Project to enable affected stakeholders to understand the risks, impacts and opportunities of the Project by providing information on the:

- Purpose, nature and scale of the Project;
- Duration of proposed Project activities;
- Risks to and potential impacts on such stakeholders and relevant mitigation measures;
- Stakeholder engagement procedure;
- Grievance mechanism;
- Identification of opportunities for employment and the supply of goods and services, including information about how to apply and access; and
- Community Development Plan

PEC has undertaken consultation in a manner that provides affected stakeholders with opportunities to express their views on Project risks, impacts and mitigation measures, allowing the Project to consider and respond to them. From the start of the Project, engagement has been documented and follows a two-way process that meets the following principles:

- Begins early in the process of identification of environmental and social risks and impacts and continues on an ongoing basis as risks and impacts arise;
- Provides information that is relevant, transparent, objective, meaningful and easily accessible and understandable (e.g. culturally appropriate, local language(s), tailored, simple format);
- Focuses on engagement on those directly affected (as opposed to those not directly affected) and takes special steps to address disadvantaged or vulnerable groups;

- Free of external manipulation, interference, coercion, or intimidation; and
- Enables meaningful participation by those affected.

PEC recognises that informed consultation and participation involving a more in-depth exchange of views and information and an organized and iterative consultation is required if potentially significant adverse impacts are identified. Stakeholder is used in project decision making and also inform the project's mitigation measures and sharing of development benefits and opportunities.

PEC stakeholder engagement procedure provides a structured disciplined and integrated process for systematically meeting the engagement objectives above. External relations are responsible for the execution and resourcing of the procedure, specifically to:

- Prepare for Stakeholder Engagement: Identify stakeholders, consider their issues, assess their influence and interest and document in a Stakeholder Engagement Plan. This exercise is updated continually, based on changing Project conditions and external stakeholder perceptions. Appropriate functions are engaged to conduct stakeholder engagement, including Health, Environment and Safety, Security, Legal, Supply Chain and Operations.
- Conduct Stakeholder Engagements, as part of the EIA process.
- Analyse Stakeholder Results:
  - After engaging stakeholders, analyse stakeholder results and appropriately incorporate stakeholder feedback into Project planning and operations.
  - Provide feedback to the stakeholders on how their views and concerns have been addressed (for example, stakeholder input is considered but not necessarily adopted). The feedback is transparent and timely and stakeholders' responses to the feedback received are monitored and documented.
- Review the Stakeholder Engagement Plan and update as necessary, to improve engagement effectiveness.

11.2 Disclosure of Information and Consultation

Disclosure of information and consultation with the local community were carried out as part of the EIA/ ESHIA process through a limited Social Impact Assessment (SIA). A full SIA was not required as the area had already been cleared and residents relocated during the PETRONAS RAPID project wherein a full SIA was carried out.

Information about the project has been prepared and socialised through the following tools:

- Focus group discussions with affected village;
- Consultation with the public and community leaders;
- Stakeholder interviews;
- Announcements published in local newspapers; and
- PEC Website.

11.2.1 Social Setting

The main towns closest to the PEC project site are Bandar Penawar (located about 10km away to the northeast) and Kg Sungai Rengit (located about 6km away to the south east). Six villages are located inside 5km radius of the Project site boundary: Kg Lepau is the nearest, located 1.5km to the west; Kg Bukit Pelali, located about 3km to the east whilst Kg Bukit Gelugor, Kg Bukit Raja, Kg Bukit Buloh and Taman Rengit Jaya are about 4km to the southeast. These six villages have a total of 326 households (*Table 11.1*). The Sebana Mixed Development is sited about 2km to the north and the new township at Bukit Pelali (under construction) is about 3km to the east.

Table 11.1: Distribution of Households inside 5km Radius of Project Site

Village	Distance from Project Site (km)	Direction from Project Site	Households (frequency)
Kg Lepau	1.5	West	50
Kg Bukit Pelali	3	Northeast	40
Taman Rengit Jaya	3.5	South	60
Kg Bukit Gelugor	4	East	56
Kg Bukit Buloh(1)	4	Southeast	30
Kg Bukit Raja	4.5	East	100
Total			**326**
Kg Sg Rengit(2)	>5km	Southeast	442
Kg Sg Buntu(3)	>5km	South	Not available

Source: Former village heads of Kg Lepau, Kg Bukit Buloh and Kg Bukit Raja, Sept. 2018
Pejabat Penghulu of Mukim Pengerang and Pantai Timur, Sept. 2018

Notes:

(1) Kg Bukit Buloh is currently under land acquisition process and the residents will be resettled to an alternative site once compensation has been paid.

(2) Kg Sg Rengit is more than 5km away from the Project site and is unlikely to be impacted significantly during the construction or operation phase of the Project.

(3) Kg Sg Buntu is not included in the study as all the local residents have been relocated and resettled 20km away in Taman Bayu Damai. The village is currently used as a worker basecamp for PIC.

A major part of the area located to the east and south of the Project site was acquired for PIPC, RAPID and the Pengerang Independent Deepwater Petroleum Terminal in 2013. The exercise involved relocating and resettling more than 3,100 smallholders and fishermen and their families from seven villages to Taman Bayu Permai, about 20km away in Mukim Pantai Timur. Muslim and Chinese graves had to be exhumed and relocated to alternative sites in Mukim Pantai Timur and Tanjung Surat as part of the process.

Prior to the relocation, the area within 5km radius of the Project site was under agriculture, namely, oil palm and rubber smallholdings, fruit orchards, poultry farms and fish ponds. Currently, however, much of the once cultivated areas and poultry farms around Kg Bukit Buloh, Kg Sg Buntu and Taman Rengit Jaya have been unworked or abandoned. A similar observation was made in Kg Lepau where oil palm smallholdings previously under FELCRA's management were found to be abandoned or unworked despite the village not being affected by land acquisition. In fact, large tracts of land inside the 5km zone of impact as well as adjacent to and south of Kg Lepau have being cleared to make way for new industrial facilities that hardware machinery, formwork and fabrications materials storage and warehousing.

11.2.2 Stakeholders Engagement and Consultation

An unstructured interview/dialogue was conducted with the sub-district (mukim) head, village heads, ex-village heads and representatives from two cooperatives, all of whom had interest in Pengerang and the villages located therein. (The setting up of the cooperatives was initiated by the Johor state government with collaboration from PETRONAS to serve as a platform for the resettled residents to be trained and to engage in business and the provision of services and goods to PIC). The dialogue was unstructured to allow for a free discourse between the SIA study team and the EIA coordination team to introduce the Project and for the stakeholders to raise and discuss matters that they consider to be relevant to the community.

A focus group engagement (*Figure 11.1*) was held with the community that is located nearest to the Project site, and therefore, most likely to be impacted by the Project, that is, Kg Lepau. It was also attended by the Penghulu of Mukim Pengerang and Pantai Timur and representatives from Kg Bukit Raja and Kg Bukit Buloh. The engagement session served as a platform for information disclosure to the villagers, addressed stakeholder concerns as well as built community consensus over certain issues. Additionally, the engagement also allowed the study team to cross-check information with stakeholders including obtaining reactions to the proposed Project.

Source: Site visit 20th - 22nd February 2018

Figure 11.1: Focus Group Discussion at Kampung Lepau

A household and perception survey was conducted over a four (4) week period in September and October 2018 and from 8th to 21st January 2019. The aim was to collect socio-economic data of the households as well as to obtain feedback and views of the residents on the proposed Project. A total of 100 respondents were interviewed, of whom 80 are local residents (owner occupiers) and 20 were non-locals (Malaysians) who are renting houses in Kg Lepau and working either in RAPID or on other projects in PIPC. The survey covered villages located within the 5k zone of impact from the Project site, namely, include Kg Lepau, Kg Bukit Buloh, Kg Bukit Pelali, Kg Bukit Gelugor, Kg Bukit Raja and Taman Rengit Jaya.

One-to-one meetings were also convened with institutional and other stakeholders. These meetings allowed the individual stakeholders to share and verify information, as well as to voice their views, preferences and aspirations.

Identification of issues and concerns raised by the stakeholders and evaluation of the significance of issues were undertaken to determine which should be evaluated further in the SIA study. The focus is to decide whether the Project is likely to cause significant adverse impact resulting from construction and operation.

Table 11.2 below summarises the approach method used with respect to engagement with the various stakeholders.

Table 11.2: Approach Method used in Stakeholder Engagement

Date	Approach Method Used	Stakeholders
18 July 2018	Direct one-to-one interview	• Officer, Planning and Development Officer, PBT Pengerang, Bandar Penawar • Manager, Project Planning, Bukit Pelali Properties Sdn Bhd • Sales Manager, Cypress Potential Sdn Bhd, Sebana Mixed Development
22 Sept 2018	Direct one-to-one interview	• Manager, Sebana Mixed Development
22 Sept 2018	Unstructured interview Use of printed handouts of the Project	• Penghulu of Mukim Pengerang & Pantai Timur • Ex-village head of Kg Lepau • Ex-village head of Kg Bukit Buloh • Village head of Kg Bukit Raja, Kg Bukit Gelugor and Kg Bukit Pelali • Chairman of Koperasi Pengerang Jaya Johor Berhad (KOPEJA) • Representative from Koperasi Pengerang Jaya Johor Berhad (KOPEJA • Chairman of Koperasi Jaya Teluk Ramunia (KOJAYA) • Representative from Koperasi Jaya Teluk Ramunia (KOJAYA)
27 Oct 2018	Focus Group Engagement (briefing using slide presentation, printed material and Q&A session)	• Residents of Kg Lepau (nearest receptors) • Penghulu of Mukim Pengerang and Pantai Timur • Former village head of Kg Lepau • Former village head of Kg Bukit Buloh • Village head of Kg Bukit Raja, Kg Bukit Gelugor and Kg Bukit Pelali • Fishermen of Kg Lepau
28 Oct 2018	Meeting	• Johor Corporation
9 January 2019	Direct one-to-one interview	• Owner, fish cage farm, Sg Santi
13th Sept to 9th Oct 2018 8th to 21st January 2019	Household and Perception Survey (questionnaire survey)	• 70 respondents randomly selected from the villages located inside the 5km zone of impact from the Project site. Villages include Kg Lepau, Kg Bukit Pelali, Kg Bukit Gelugor, Kg Bukit Raja and Kg Bukit Buloh. • 10 respondents randomly selected from Taman Rengit Jaya and 20 respondents (Malaysians from outside the Pengerang region, living and working in Pengerang) randomly selected from Kg Lepau.

The results of the limited SIA are described in Chapter 5 and its predicted impacts and mitigation measures discussed in Chapter 7.

11.3 On-going Community Feedback

PEC proactively communicates with external stakeholders, which are carried out primarily by the External Relations function. Tactical plans and approaches will be contained in the Stakeholders Engagement Plan which will be developed prior to commencement of project. PEC will also implement and maintain a grievance mechanism external communication to:

- Receive and register external communications from the public;
- Screen and assess the issues raised and determine how to address them;
- Provide, track and document responses; and
- Adjust the Stakeholders Engagement Plan and Project itself,

11.4 Grievance Mechanism

The intent of the grievance mechanism is to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate and readily accessible and at no cost and without retribution to the party that originated the issue or concern. The mechanism does not impede access to judicial or administrative remedies. *Figure 11.2* outlines the workflow for managing grievances.

Anyone will be able to submit a grievance to the Project if they believe a practice is having a detrimental impact on the community, the environment, or on their quality of life. They may also submit comments and suggestions. Grievances could include:

- Negative impacts on a person or a community (e.g. financial loss, physical harm, nuisance)
- Dangers to health and safety or the environment
- Failure of PEC, its Contractors and sub-contractors and their workers or drivers to comply with standards or legal obligations
- Harassment of any nature
- Criminal activity
- Improper conduct or unethical behaviour
- Financial malpractice or impropriety or fraud
- Attempts to conceal any of the above.

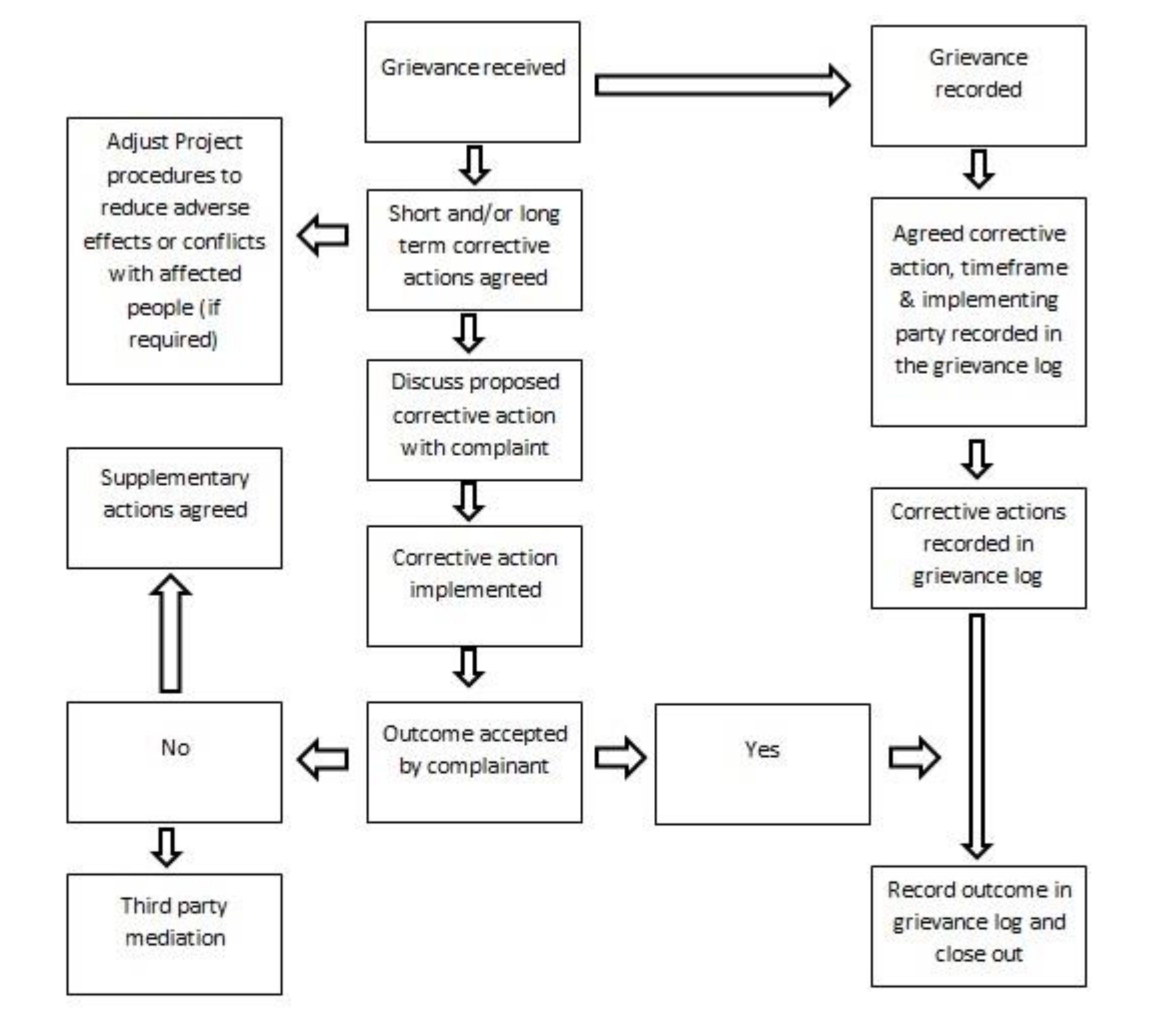


Figure 11.2: Grievance Mechanism Workflow

Affected stakeholders are made aware of the grievance mechanism through sustained external communications and in the course of the stakeholder engagement.

Prior to the actual approval of the project, a form of Grievance Mechanism had already been initiated as part of the formal EIA review process in Malaysia. The PEC EIA report had been advertised from 27th May 2019 to 25th June 2019 and put on public display at DoE Johor State office, DOE headquarters in Putrajaya, and Pengerang Local Authority office for a period of 1 month to allow for comments or any grievances to be formally recorded. The comments and grievances will be recorded and discussed during the EIA Technical Review meeting which will be held on 10th July 2019.

During the construction period, prior to commencement of works, the PEC contact details and information material about the grievance redress mechanism will be disclosed in the local communities at group meetings, on the Project website and in any written information given to stakeholders. Grievances during construction will be investigated by PEC to review the validity and responsibility of each grievance.

As a general policy, PEC will work proactively towards preventing grievances through the implementation of impact mitigation measures and community liaison. The project performance grievance mechanism that will be established prior to the commencement of construction activities will be maintained through construction and operation by the PEC management.

11.5 Stakeholder Outreach for Abandonment

In the event of site closure and decommissioning at PEC, stakeholder outreach aims to create greater understanding of the site closure and decommissioning process, provide updates, and obtain feedback on ongoing site closure efforts.

Stakeholder consultation will be carried out with stakeholders identified in this report and other stakeholders to be identified throughout the project lifespan. The aims for stakeholder consultation in relation to closure are to:

- Provide stakeholders with accurate, timely and comprehensive information about the closure process and closure related issues.
- Identify areas of concern for stakeholders, and allow them to provide input to the closure process and in assessing relevant closure related issues.
- Reduce the potential for misunderstanding and subsequent stakeholders’ dissatisfaction due to the real or perceived exclusion from the closure planning process.
- Ensure that the necessary regulatory requirements are fulfilled.
- Generate a framework for ongoing consultation through operation, closure and post closure.

12 CONCLUSION

This ESHIA has been prepared for the project entitled **Proposed Pengerang Energy Complex (PEC), Mukim Pengerang, Daerah Kota Tinggi, Johor Darul Takzim**. The proposed Pengerang Energy Complex is planned as a world-scale condensate splitter and aromatics complex, on a 250-acre site in the Pengerang Industrial Park that is situated within the Pengerang Integrated Petroleum Complex. The production capacity of the PEC is about 5.8344 Million metric tonnes per annum (MMtpa), or 16.7 kilometric tonnes per day (kMtpd), of aromatic petrochemicals and oil products, which will be processed from 6.324 MMtpa of condensate feedstock.

The Condensate Splitting and Aromatics Complex will require a variety of support facilities which will be constructed and operated by third parties. These support facilities are excluded from the scope of this ESHIA report.

The PEC site is situated 7.5 km northeast of Pengerang and 6 km northwest of Sungai Rengit. Singapore's Pulau Tekong and Changi Airport lie 9 km and 17 km east of the site. Highways connect the PIPC to Johor Bahru, the state capital, and its airport, Senai. To the south is PETRONAS's RAPID development.

The ESHIA has evaluated the potential impacts of the construction and operation of the PEC facility. In particular, the assessment has included dispersion modelling for potential air emissions from the PEC facility and its impact upon ambient air quality in receptor locations. Also conducted was the health impact assessment, social impact assessment and quantitative risk assessment.

Table 12.1 and *Table 12.2* summarises the impacts during the construction stage and operational stage, respectively and its severity. The study assessment found that the majority of the impacts were considered to be "Low". Additionally, based on the QRA results, it was concluded that the PEC facility satisfies the DoE Risk Acceptance Criteria for Individual Risk.

The assessment indicates that, with the adoption of the mitigation measures, the overall impacts of construction and operation of the PEC facility is not expected to be significant as long as the controls described within this report are implemented.

Table 12.1: Summary of Impacts During the Construction Stage

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
Fugitive Dust Emission	• Local Population	Reduction of air quality due to the generation of dust and particulate.			Low		
Vehicle movement	• Local Population	Reduction of air quality due to emission from diesel engine.			Low		
Discharging of sediments from surface runoff	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the increase of sediments discharge.			Low		
Discharging of Sewage Effluent	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the effluent discharge.				Medium	
Generation of Hazardous Waste	• Construction Workers • Local Population	Improper handling, storage and management of hazardous waste.				Medium	
Generation of General Waste	• Construction Workers • Local Population	Improper handling, storage and management of general waste.				Medium	
Generation of Excessive Noise	• Construction Workers • Local Population	Noise pollution due to the generation of elevated sound level from construction activities.			Low		
Soil erosion	• Local Population • Sg. Lepau	Offsite sedimentation due to run-off from exposed site.			Low		
Groundwater Contamination	• Local Population • Sg. Lepau	Contamination of groundwater due to the spillage of fuel during construction.			Low		
Traffic Congestion	• Local Population	Increase traffic volume and heavy vehicles due to the construction.			Low		
Flora and Fauna	• Sg. Lepau • Sg. Santi Forest Reserve	Degradation of the ecological value of the surrounding area.		Negligible			
Employment and Business	• Local Population	Generation of spin-off business.	Positive				
Housing the workforce	• Construction Workers	Establishment of worker camps.	Positive				

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
	• Local Population						
Health and Safety of local communities	• Local Population	Increasing incidence of diseases due to the influx of foreign workers.				Medium	
Occupational Safety and Health	• Construction Workers	General health and safety risk during the construction phase.				Medium	

Table 12.2: Summary of Impacts During the Operational Stage

Aspect	Receptor	Impact Description	Significance				
			Positive	Negligible	Low	Medium	High
Combustion Gas Emission	• PEC Personnel	Reduction of air quality due to the emission of combustion gases.				Medium	
Discharging of Liquid Effluent	• Sg. Lepau	Reduction of water quality in Sg. Lepau due to the discharge of liquid effluent.			Low		
Generation of Hazardous Waste	• PEC Personnel • Local Population	Improper handling and storage of hazardous waste.			Low		
Generation of General Waste	• PEC Personnel • Local Population	Improper handling and storage of general waste.			Low		
Generation of Excessive Noise	• PEC Personnel • Local Population	Noise pollution due to the generation of elevated sound level from equipment of process plant.			Low		
Traffic Congestion	• Local Population	Increase traffic volume and heavy vehicles due to the construction			Low		
Employment and Business	• Local Population	Generation of spin-off business.	Positive				
Housing the workforce	• PEC Personnel • Local Population	Establishment of worker camps.	Positive				
Health and Safety of local communities	• PEC Personnel • Local Population	Increasing incidence of diseases due to the influx of foreign workers.				Medium	
Occupational Safety and Health	• PEC Personnel	General health and safety risk during the construction phase.				Medium	

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