DRAFT Environmental and Social Impact Assessment Report

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Riau 275 MW Gas Combined Cycle Power Plant IPP - ESIA

Medco Ratch Power Riau

ESIA Volume 2: Environmental Impact Assessment

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Important note about your report

The sole purpose of this report and the associated services performed by Jacobs New Zealand Limited (Jacobs) is to describe the Environmental and Social Impact Assessment (ESIA) for the Riau IPP Project, in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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Glossary

Acronym	Term	Definition
ESIA	Environmental and Social Impact Assessment	The ESIA is a comprehensive document of a Project's potential environmental and social risks and impacts. An ESIA is usually prepared for greenfield developments or large expansions with specifically identified physical elements, aspects, and facilities that are likely to generate significant environmental or social impacts.
ESMP	Environmental and Social Management Plan	Summarises the client's commitments to address and mitigate risks and impacts identified as part of the Assessment, through avoidance, minimisation, and compensation/offset. This may range from a brief description of routine mitigation measures to a series of more comprehensive management plans (e.g. water management plan, waste management plan, resettlement action plan, indigenous peoples plan, emergency preparedness and response plan, decommissioning plan).
ESMS	Environmental and Social Management System	The ESMS is the overarching environmental, social, health and safety management system which may be applicable at a corporate or Project level. The system is designed to identify, assess and manage risks and impacts in respect to the Project on an ongoing basis.
	Legal and regulatory framework	The national legal and institutional framework applicable to the project should be defined. This should also include any additional lender requirements and any international agreements or conventions that may also apply.
	Project Description	A project description considers all project phases from pre-construction, construction, operation and decommissioning and is as detailed as possible in order to identify the environmental aspects resulting from project activities. A summary of the project description is provided in ESIA Volume 1: Introduction.

List of Abbreviations

Abbreviation	Description
AoI	Area of Influence
aMSL	Above mean sea level
ADB	Asian Development Bank
AEP	Annual exceedance probability
ALARP	As low as reasonably practicable
AMDAL	Analisis Mengenai Dampak Lingkungan
ASTER	Advanced Spaceborne Thermal Emissions and Reflection Radiometer
BGL	Below Ground Level
BOD	Biochemical Oxygen Demand
CEMS	Continuous Emissions Monitoring System
CCPP	Combined Cycle Power Plant
CFPP	Coal Fired Power Plant
COD	Chemical Oxygen Demand
dBA	Decibel A-weighting
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
ENSO	El Niño Southern Oscillation
EPC	Engineering, Procurement and Construction
EPFI	Equator Principle Financial Institutions
ESCP	Erosion and Sediment Control Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
GEV	Generalised Extreme Value
GHG	Greenhouse Gas
GIIP	Good International Industry Practice
GWP	Global Warming Potential
Ha	Hectares
HFCs	Hydrofluoro Carbons
HRSG	Heat Recovery Steam Generator
HSE	Health, Safety and Environment
IFC	International Finance Corporation
ILO	International Labour Organisation
IPCC	Intergovernmental Panel on Climate Change

Abbreviation	Description
IUCN	International Union for Conservation of Nature
km	Kilometres
m	Metres
MfE	Ministry for the Environment
MGLC	Maximum ground level concentrations
MoE	Ministry of Environment
MRPR	Medco Ratch Power Riau
MW	Megawatt
NBC	Nusa Buana Cipta
NCA	Noise Catchment Areas
NTS	Non-Technical Summary
OCP	Organochlorine Pesticides
OPP	Organophosphorus Pesticides
OHS	Occupational Health and Safety
PFCs	Perfluoro carbons
PLN	PT Perusahaan Listrik Negara (Persero)
PM_{10}	Particulate Matter less than ten microns
$PM_{2.5}$	Particulate Matter less than 2.5 microns
PPE	Personal Protective Equipment
QRA	Qualitative Risk Assessment
RoW	Right of Way
RSL	Regional Screening Levels
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SWL	Sound power level
T	Tonnes
TJ	Terrajoule
ToR	Terms of Reference
TSP	Total Suspended Particulate
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
VPH	Vehicles per hour
VSR	Visually Sensitive Receptor
WBG	World Bank Group
WHO	World Health Organisation
ZTVI	Zone of Theoretical Visual Impact

1. Introduction

1.1 Overview

The Environmental and Social Impact Assessment (ESIA) Volume 2: Environmental Impact Assessment (EIA) provides an assessment of the potential impacts of the Project on environmental receptors, makes mitigation and monitoring recommendations and provides an assessment of residual impacts. This introduction section provides an overview of the ESIA process.

The ESIA process and how related environmental and social assessments are applied is summarised in Figure 1.1. For social impacts, reference should be made to the ESIA Volume 3: Social Impact Assessment.

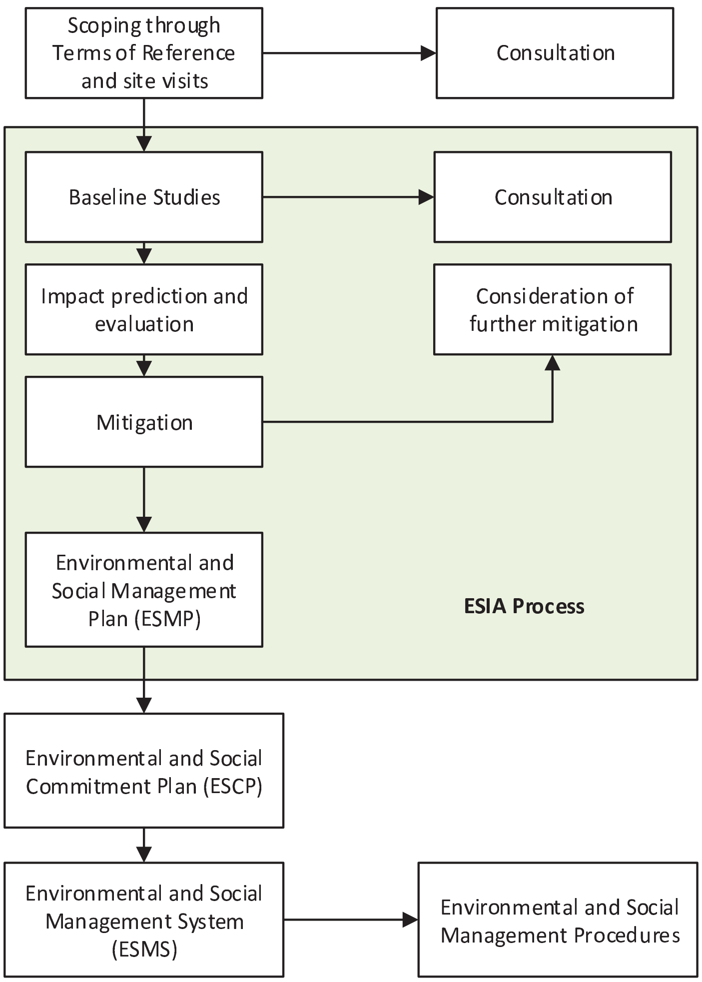


Figure 1.1 : General Overview of the ESIA Process

1.2 Spatial and Temporal Scope

The area of influence (AoI) constitutes the spatial extent of the ESIA as outlined in Figure 1.2 below. The AoI encompasses all areas directly and indirectly affected by Project components, which are primarily contained within the power plant site, along the transmission line route and along the gas pipeline route. For each environmental topic, the spatial and temporal scope will vary and this will be discussed in detail in the methodologies for each.

The study period is a time limit that will be used in predicting and undertaking an impact evaluation as part of the impact assessment. The period is used as a basis to determine if there are any changes to the environmental baseline resulting from the Project activities.

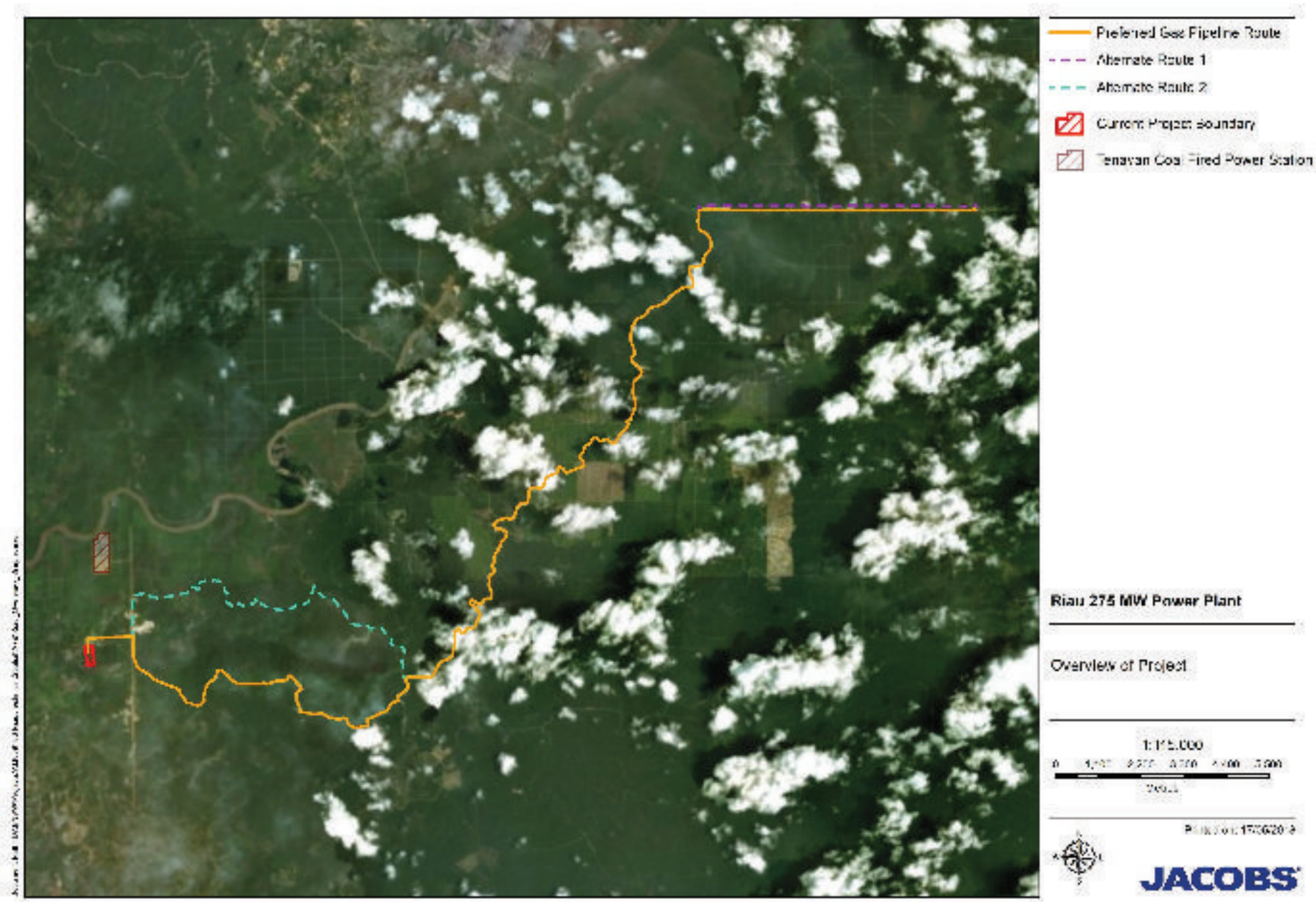


Figure 1.2 : Spatial Scope of the Project

1.3 Baseline Environmental Conditions

Environmental scoping was completed at an early stage to identify development activities that would require attention in the ESIA. The Scoping Report includes the Terms of Reference (ToR) for the ESIA and the ToR for the baseline sampling, the report is located in the ESIA Volume 5: Technical Appendices.

Baseline data collection refers to the collection of background data in support of the environmental assessment. Ideally baseline data should be collected prior to development of a project, but often this is not possible. Baseline data collection can also occur throughout the life of a project as part of ongoing monitoring of environmental and social conditions.

ADB Environmental Safeguards guidance on identification of environmental baseline data states that it "*…describes relevant physical, biological, and socioeconomic conditions within the study area. It also looks at current and proposed development activities within the project's area of influence, including those not directly connected to the project. It indicates the accuracy, reliability, and sources of the data.*"

Baseline information used for this ESIA has utilised primary data collected through on-site surveys by Jacobs environmental and social sub-consultant Nusa Buana Cipta (NBC), between June and September 2017 (dry season) and January to February 2018 (wet season).

In addition, the Project benefits from having environmental studies collected for environmental assessments associated with the Analisis Mengenai Dampak Lingkungan (AMDAL) for PT Perusahaan Listrik Negara (Persero) (PLN) existing 2 x 110 MW Tenayan Coal Fired Power Plant (CFPP). Other publically available studies and data sources have been used as secondary supporting information in this volume.

It should be noted that at the time of baseline surveys being conducted the preferred gas pipeline route was the 'Alternate Route 1 and Alternate Route 2 as shown in Figure 1.2 above. Following completion of baseline surveys two sections of the gas pipeline route was changed by MRPR and is now referred to as the 'Preferred Gas Pipeline Route'. The 10 km section of gas pipeline route that has replaced Alternate Route 2 predominantly consists of palm oil plantation. The 7 km section of gas pipeline that has replaced Alternate Route 1 is 6 m south of an existing oil pipeline which runs adjacent to existing road reserve. The two routes have similar environment and landscape characteristics and therefore the baseline sampling undertaken to date is considered to be representative of the preferred gas pipeline route.

1.4 Structure of Volume 2

This ESIA Volume 2: EIA is structured in the following way:

- Section 2 – Methodology
- Section 3 – Environmental Baseline
- Section 4 – Air Quality (Impact Assessment)
- Section 5 – Greenhouse Gas Emissions (Impact Assessment)
- Section 6 – Soils, Geology and Groundwater (Impact Assessment)
- Section 7 – Hydrology (Impact Assessment)
- Section 8 – Water Quality and Freshwater Ecology (Impact Assessment)
- Section 9 – Landscape and Visual (Impact Assessment)
- Section 10 – Natural Hazards and Vulnerability to Climate Change (Impact Assessment)
- Section 11 – Noise (Impact Assessment)
- Section 12 – Terrestrial Ecology (Impact Assessment)
- Section 13 – Traffic (Impact Assessment)
- Section 14 – Hazardous Substances and Waste (Impact Assessment)

- Section 15 – Working Conditions and Occupational Health and Safety
- Section 16 – Gas Pipeline Qualitative Risk Assessment
- Section 17 – Assessment of Cumulative Impacts
- Section 18 – Summary of Environmental Impact Assessment
- Section 19 – References

2. Methodology

2.1 Introduction

The impact assessment methodology applies to the assessment of potential environmental impacts arising from the Project. The impact assessment methodology has been developed in accordance with good industry practice and the potential impacts have been identified in the context of the Project's AoI, in accordance with International Finance Corporation (IFC) Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts) and Asian Development Bank (ADB) Environmental Safeguards.

2.2 Impact Assessment

The impact assessment predicts and assesses the Project's likely positive and negative impacts, in quantitative terms to the extent possible. For each of the environmental aspects, the assessment determined the sensitivity of the receiving environment and identifies impacts and assesses the magnitude and overall significance of environmental impacts. An ESIA will always contain a degree of subjectivity, as it is based on the value judgment of various specialists and ESIA practitioners. The evaluation of significance is thus contingent upon values, professional judgement, and dependent upon the environmental context. Ultimately, impact significance involves a process of determining the acceptability of a predicted impact.

2.2.1 Defining Impact

There are a number of ways that impacts may be described and quantified. An impact is essentially any change to a resource or receptor brought about by the presence of the proposed project component, project discharge or by the execution of a proposed project related activity. The assessment of the significance of impacts and determination of residual impacts takes account of any inherent mitigation measures incorporated into the Project by the nature of its design.

In broad terms, impact significance can be characterised as the product of the degree of change predicted (the magnitude of impact) and the value of the receptor/resource that is subjected to that change (sensitivity of receptor). For each impact the likely magnitude of the impact and the sensitivity of the receptor are defined. Generic criteria for the definition of magnitude and sensitivity are summarised below.

2.2.2 Direct vs Indirect Impacts

A direct impact, or first order impact, is any change to the environment, whether adverse or beneficial, wholly or partially, resulting directly from an environmental aspect related to the project. An indirect impact may affect an environmental, social or economic component through a second order impact resulting from a direct impact. For example, removal of vegetation may lead to increased soil erosion (direct impact) which causes an indirect impact on aquatic ecosystems through sedimentation (indirect impact).

2.2.3 Magnitude Criteria

The assessment of impact magnitude is undertaken by categorising identified impacts of the Project as beneficial or adverse. Then impacts are categorised as 'Major', 'Moderate', 'Minor' or 'Negligible' based on consideration of parameters such as:

- Duration of the impact – ranging from 'well into operation' to 'temporary with no detectable impact'.
- Spatial extent of the impact – for instance, within the site boundary, within district, regionally, nationally, and internationally.
- Reversibility – ranging from 'permanent thus requiring significant intervention to return to baseline' to 'no change'.
- Likelihood – ranging from 'occurring regularly under typical conditions' to 'unlikely to occur'.

- Compliance with legal standards and established professional criteria – ranging from 'substantially exceeds national standards or international guidance' to 'meets the standards' (i.e. impacts are not predicted to exceed the relevant standards) presents generic criteria for determining impact magnitude (for adverse impacts). Each detailed assessment will define impact magnitude in relation to its environmental or social aspect.
- Any other impact characteristics of relevance.

Table 2.1 below presents generic criteria for determining impact magnitude (for adverse impacts). Each detailed assessment will define impact magnitude in relation to its environmental or social aspect.

Table 2.1 : General Criteria for Determining Impact Magnitude

Category	Description
Major	Fundamental change to the specific conditions assessed resulting in long term or permanent change, typically widespread in nature and requiring significant intervention to return to baseline; would violate national standards or Good International Industry Practice (GIIP) without mitigation.
Moderate	Detectable change to the specific conditions assessed resulting in non-fundamental temporary or permanent change.
Minor	Detectable but small change to the specific conditions assessed.
Negligible	No perceptible change to the specific conditions assessed.

2.2.4 Sensitivity Criteria

Sensitivity is specific to each aspect and the environmental resource or population affected, with criteria developed from baseline information. Using the baseline information, the sensitivity of the receptor is determined factoring in proximity, number exposed, vulnerability and the presence of receptors on site or the surrounding area. Generic criteria for determining sensitivity of receptors are outlined in Table 2.2 below. Each detailed assessment will define sensitivity in relation to its environmental or social aspect.

Table 2.2 : General Criteria for Determining Impact Sensitivity

Category	Description
High	Receptor (human, physical or biological) with little or no capacity to absorb proposed changes
Medium	Receptor with little capacity to absorb proposed changes
Low	Receptor with some capacity to absorb proposed changes
Negligible	Receptor with good capacity to absorb proposed changes

2.2.5 Impact Evaluation

The determination of impact significance involves making a judgment about the importance of project impacts. This is typically done at two levels:

- The significance of project impacts factoring in the mitigation inherently within the design of the project; and
- The significance of project impacts following the implementation of additional mitigation measures.

The impacts are evaluated taking into account the interaction between the magnitude and sensitivity criteria as presented in the impact evaluation matrix in Table 2.3 below.

Table 2.3 : Impact Matrix

		Magnitude			
		Major	Moderate	Minor	Negligible
Sensitivity	High	Major	Major	Moderate	Negligible
	Medium	Major	Moderate	Minor	Negligible
	Low	Moderate	Minor	Negligible	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

The objective of the ESIA is to identify the likely significant impacts on the environment and people of the project. In this impact assessment, impacts determined to be 'Moderate' or 'Major' are deemed significant. Consequently, impacts determined to be 'Minor' or 'Negligible' are not significant.

2.3 Mitigation

Mitigation measures are actions taken to avoid or minimise negative environmental or social impacts. Mitigation includes those embedded within the design (as already considered as part of the impact evaluation) and any additional mitigation required thereafter. Additional mitigation will be implemented to reduce significant impacts to an acceptable level, this is referred to as the residual impact. The mitigation hierarchy should be followed: avoid, minimise, restore or remedy, offset, compensate. Mitigation measures should be clearly identified and linked to environmental and social management plans.

2.4 Monitoring

Monitoring is not linked to the impact evaluation but is an important component of the ESIA. Monitoring and follow-up actions should be completed to:

- Continue the collection of environmental and social data throughout construction, operation and later decommissioning;
- Evaluate the success of mitigation measures, or compliance with project standards or requirements;
- Assess whether there are impacts occurring that were not previously predicted; and
- In some cases, it may be appropriate to involve local communities in monitoring efforts through participatory monitoring. In all cases, the collection of monitoring data and the dissemination of monitoring results should be transparent and made available to interested project stakeholders.

2.5 Residual Impacts

Those impacts that remain once mitigation has been put in place will be described as residual impacts, using Table 2.3 set out above.

2.6 Cumulative Impacts

The assessment of cumulative impacts will consider the combination of multiple impacts that may result when:

- The Project is considered alongside other existing facilities within similar discharges;
- The Project is alongside other existing or proposed projects in the same geographic area or similar development timetable; and
- Impacts identified in different environmental and social aspects of the ESIA combine to affect a specific receptor.

The assessment of cumulative impacts will identify where particular resources or receptors would experience significant adverse or beneficial impacts as a result of a combination of projects (inter-project cumulative impacts). In order to determine the full combined impact of the development, potential impacts during construction and operation phases have been assessed where relevant.

3. Environmental Baseline

3.1 Introduction

This section provides a summary of baseline information known to date for the existing physical and biological environment, using available information and the methodology outlined in Section 2 above. This data will be used to quantify the sensitivity of the receiving environment to the proposed Project.

3.2 Climate

An assessment of 33 years of rainfall data from 1980-2013 was undertaken by NBC. The average annual rainfall over the last five years was ~2,472 mm/year. The greatest rainfall depth occurs through the months of October to December and March/April (>200 mm/month). Rainfall during these months can effectively double the monthly total when compared to 'dry' months, such as June to September.

From 2000 to 2013, the average rainy days per month ranges from 5-10, with wetter months having a greater amount of wet (rainy) days. This fluctuates widely each year, with some of the wetter months experiencing up to 25 rainy days on occasion.

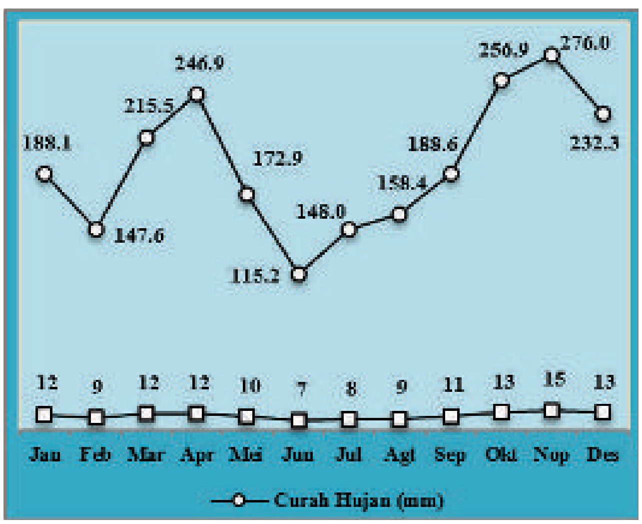


Figure 3.1 : Average Monthly Rainfall (mm) and Rainy Days at the Public Work Office in Senapelan District (Pekanbaru City) between 1980-2013

Temperature remains relatively constant throughout the year, with monthly minimums between 20-24°C and maximums up to 35°C. The average temperature from the most recent data (2015) ranges between 31.7 to 33.6°C, with a mean of 32.6°C.

3.2.1 Meteorology

The air quality assessment (ESIA Volume 5, Appendix E – Air Quality Technical Assessment) has identified meteorological conditions typically associated with the proposed location of the Project. The prevailing weather patterns affect how noise propagates from the source to the receiver locations and provide potential for noise enhancing conditions to be present. Similarly, local weather conditions can also reduce noise impacts where wind directions are generally directed from receiver to the source (i.e. sound propagation towards sensitive receivers is hindered).

Wind is generally light, but the area is subject to monsoonal weather with high winds during the wet months. The predominant wind direction varies throughout the year, with southerly winds occurring primarily during the dry season and northerly winds during the rainy season. The average wind speed is less than 3 m/s.

The wind rose shown in Figure 3.2 has been generated from data collected at an ambient air monitoring site in Pekanbaru for 2010 to 2015. A photograph of the monitoring station, provided as Figure 3.6, indicates that the site is in close vicinity to one or more tall buildings which may influence the winds measured at the site. The meteorological data shows winds predominantly from the north-western and north-eastern sectors, and from the south-southeast. Calm conditions, which are a wind speed of less than 0.5 m/s, are predicted to occur for 27% of the time and the average wind speed for the data period is 0.54 m/s. The very low wind speeds as well as the absence of winds from the north suggest that that winds are measured at a low height above ground level, and are affected by local structures, trees, etc.

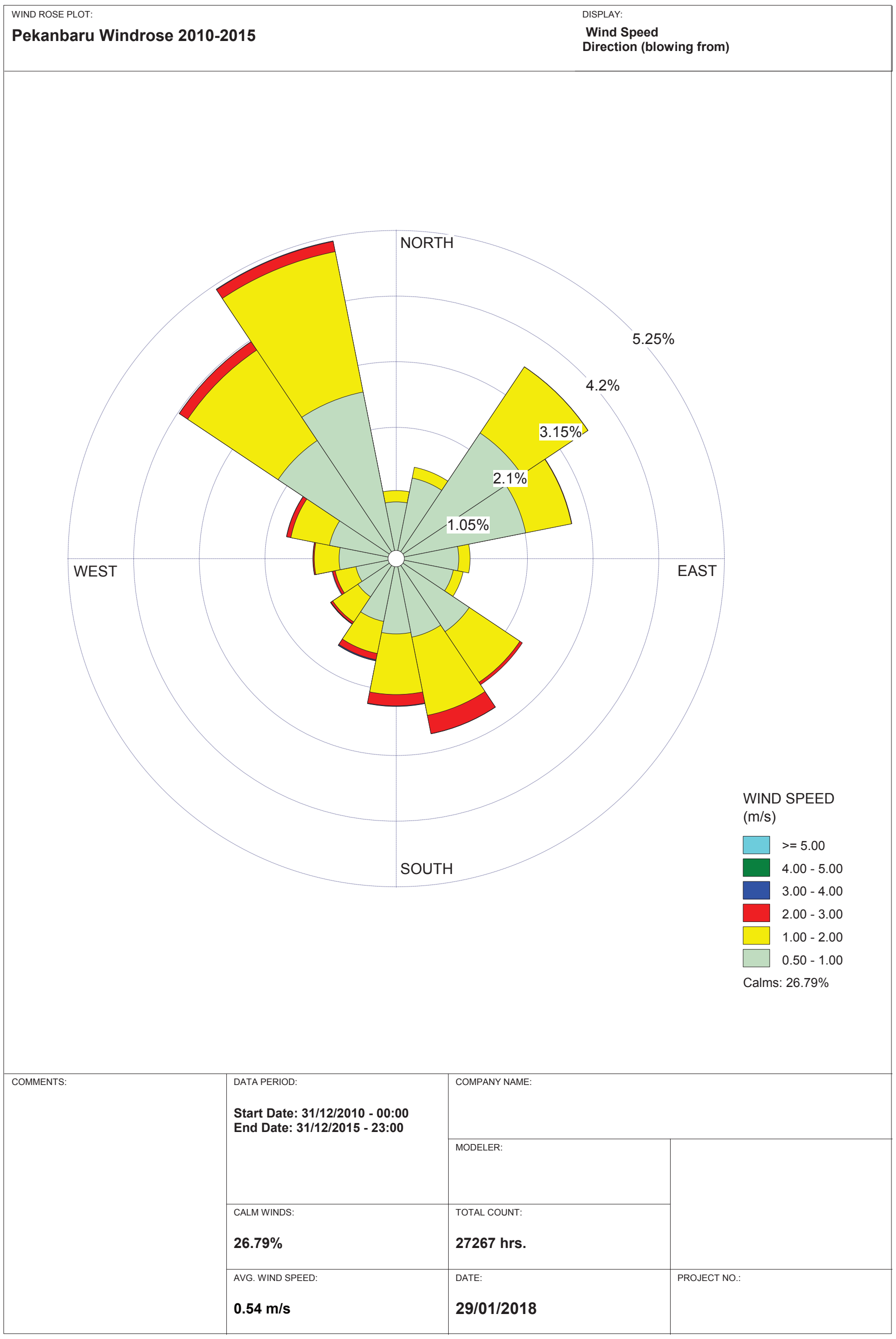


Figure 3.2 : Windrose of Data Collected at Pekanbaru (Years 2010 – 2015)

3.3 Air Quality

Energy production, industrial and household discharges from fuel combustion, and vehicular traffic are the primary anthropogenic contributors to air pollution in the Project area. The main pollutants identified of interest are particulate matter (as Total Suspended Particulate (TSP), PM_{10} and $PM_{2.5}$), CO, NO_2, and SO_2.

The Project area primarily consists of palm oil plantations for several kilometres in all directions, with limited residential land use. The main population centre in the area is Pekanbaru City, the nearest residential areas to the power plant site are located more than 3 km to the west of the plant site. The main source of industrial pollution in the local area is therefore the Tenayan CFPP located 2 km to the north of the site.

The scale of residential and industrial activity in the Project area is relatively low.

3.3.1 Ambient Air Monitoring Data

Ambient air quality monitoring has been undertaken by Jacobs at locations representing the existing air quality around the power plant and the pipeline route. Monitoring data has also been sourced to represent the existing air quality in the city of Pekanbaru.

Baseline Monitoring for the Project Area (Power Plant)

Baseline ambient monitoring data has been collected in association with the Projects at six monitoring sites near the Project area. Two rounds of sampling have been undertaken, one during July 2017 for the dry season, and one during January-February 2018 for the wet season. A map showing the sampling locations is provided as Figure 3.2. The parameters monitored and sampling times conducted at the four sites included:

- Total suspended particulate using high volume sampler (24-hour sampling period per monitoring event) in accordance with Indonesian Standard Method SNI 19-7119.3-2005;
- PM_{10} using low volume sampler fitted with a PM_{10} sampling head (24-hour sampling period per monitoring event) in accordance with Indonesian Standard Method SNI 19-7119.15 (2016);
- $PM_{2.5}$ using low volume sampler fitted with a PM_{10} sampling head (24-hour sampling period per monitoring event) in accordance with Indonesian Standard Method SNI 19-7119.14 (2016);
- Nitrogen dioxide (NO_2) by active sampling (1-hour sampling period) in accordance with Indonesian Standard Method SNI 19-7119.2-2005, and passive sampling (14-day sampling period per monitoring event) in accordance with NIOSH Standard 6700 (1998);
- Sulphur dioxide (SO_2) by active sampling (1-hour sampling period per monitoring event) in accordance with Indonesian Standard Method SNI 19-7119.7-2005;
- Ozone (O_3) by active sampling (1-hour sampling period per monitoring event) in accordance with Indonesian Standard Method SNI 19-7119.8-2005;
- Total non-methane hydrocarbons (TNMHC) by active sampling (30-minute sampling period) in accordance with Indonesian Standard Method SNI 19-7119.13-2005; and
- Lead (Pb) by active sampling (1-hour average) in accordance with Indonesian Standard Method SNI 19-7119.4-2005.

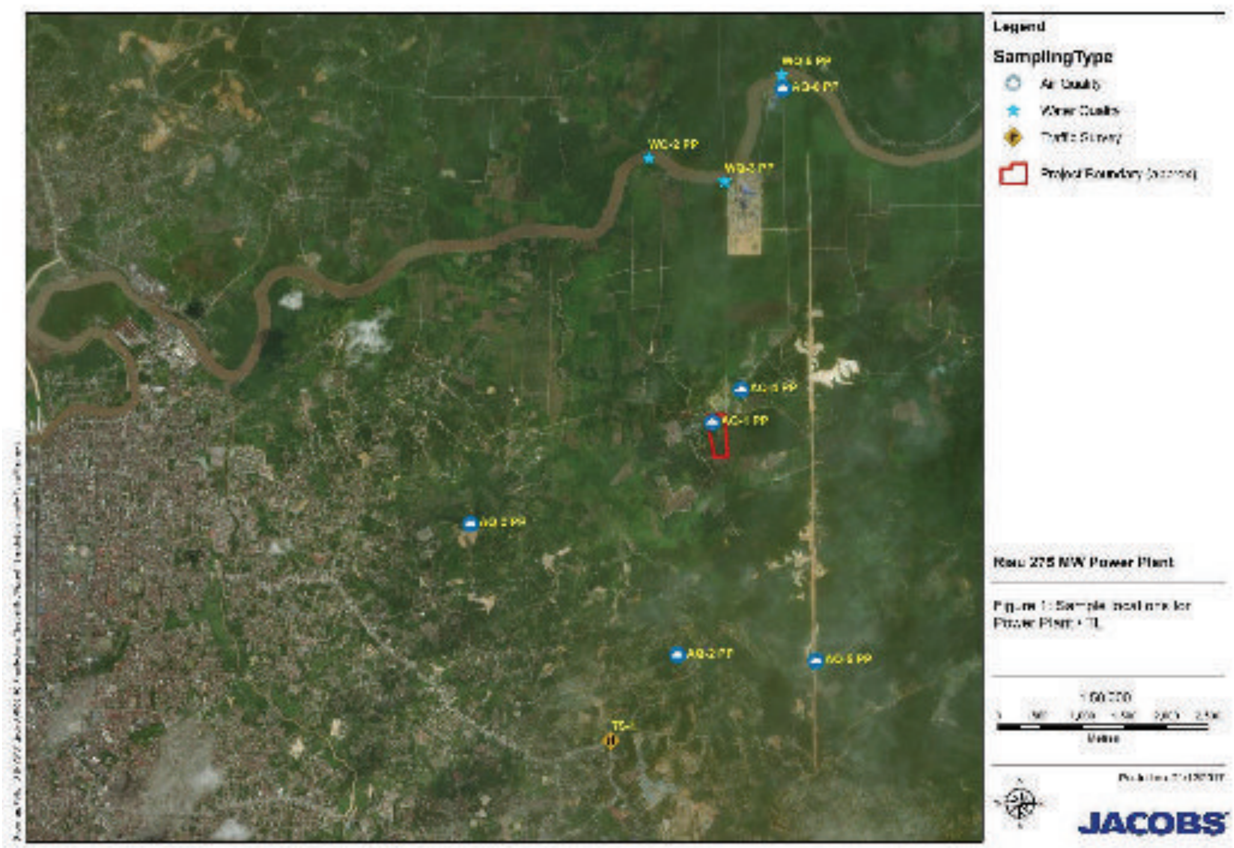


Figure 3.3 : Baseline Sampling Locations for Riau CCPP Power Plant

A summary of the baseline air quality monitoring results for the dry and wet season are provided respectively in Table 3.1 and Table 3.2 below.

Table 3.1 : Baseline Ambient Air Monitoring Results, July 2017 (Dry Season)

Contaminant	Range of Measured Concentrations (µg/m^3)						Overall Average (µg/m^3)	Indonesian Air Quality Standard (µg/m^3)	WHO Air Quality Guidelines (µg/m^3)
	AQ-1	AQ-2	AQ-3	AQ-4	AQ-5	AQ-6			
SO_2 (1-hr avg)	<34	<34	<34	<34	<34	<34	<34	*900*	*500*
O_3 (1-hr avg)	<30	<30	<30	<30	<30	<30	<30	*235*	*n/a*
NO_2 (1-hr avg)	<17	<17	<17	<17	<17	<17	<17	*400*	*200*
NO_2 (14 day average)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	*n/a*	*n/a*
CO (1-hr avg)	0	1200	0	0	0	0	200	*30000*	*n/a*
TNMHC (30-minute avg)	1.0	1.0	0.7	1.6	1.6	1.3	1.2	*160*	*n/a*
TSP (1-hr avg)	49	92	54	6	55-317 (avg 136)	36-141 (avg 69)	95	*230*	*n/a*
PM_{10} (24-hr avg)	n/a	n/a	n/a	n/a	20-66 (avg 45)	9-42 (avg 25)	38	*150*	*50*

Contaminant	Range of Measured Concentrations (µg/m^3)						Overall Average (µg/m^3)	Indonesian Air Quality Standard (µg/m^3)	WHO Air Quality Guidelines (µg/m^3)
	AQ-1	AQ-2	AQ-3	AQ-4	AQ-5	AQ-6			
$PM_{2.5}$ (24-hr avg)	n/a	n/a	n/a	n/a	11-31 (avg 21)	<2-22 (avg 11)	*16*	*65*	*25*
Pb (1-hr avg)	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	*2*	*n/a*

Note: < refers to the detection limit of the sampling method

Table 3.2 : Baseline Ambient Air Monitoring Results, January-February 2018 (Wet Season)

Contaminant	Range of Measured Concentrations (µg/m^3)						Overall Average (µg/m^3)	Indonesian Air Quality Standard (µg/m^3)	WHO Air Quality Guidelines (µg/m^3)
	AQ-1	AQ-2	AQ-3	AQ-4	AQ-5	AQ-6			
NO_2 (1-hr avg)	<17	<17	<17	<17	n/a	<17	*<17*	*400*	*200*
PM_{10} (24-hr avg)	n/a	n/a	n/a	n/a	10-53	13-43	30	*150*	*50*
$PM_{2.5}$ (24-hr avg)	n/a	n/a	n/a	n/a	5-20	17-23	*16*	*65*	*25*

Note: < refers to the detection limit of the sampling method

The ambient monitoring undertaken shows that the ambient air concentrations measured are influenced to some degree by human activity, with concentrations being above what would be typically observed in a rural area. Generally ambient air quality in the project area is good, with ambient air concentrations of contaminants being consistently below the national and international guidelines.

With the exception of particulate matter, the air quality at the sites was determined to be of good quality, with SO_2, NO_2, CO and ozone ambient air concentrations being relatively low, and well below the Indonesian Ambient Air Standards and the World Health Organisation (WHO) Ambient Air Guidelines. Particulate matter concentrations are higher and at times exceeding the WHO 24-hour guideline value of 50 µg/m^3 for PM_{10} and 25 µg/m^3 for $PM_{2.5}$, though are consistently below the Indonesian ambient air standards. It is likely that the occasionally high TSP measurements are a result of the monitors being placed in locations of cleared and unsealed land where dust can be easily mobilised by wind or vehicular traffic. This is demonstrated in the photograph of air quality sampling site AQ-5, shown as in Figure 3.4, which had the highest TSP reading of 317 µg/m^3 as a 24-hour average. Measurements of particulate matter taken elsewhere in the area were generally lower, and likely to be more representative of actual conditions during the plant operation. However, the dusty nature of the disturbed soil does indicate the need for good practice dust management procedures during the construction phase of the Project.

Figure 3.4 : Air Quality Sampling Location AQ-5

Passive sampling for NO_2 was also undertaken at four of the baseline monitoring sites (AQ-1, AQ-2, AQ-3 and AQ-4). Passive samplers were deployed for a 14-day sampling duration at each site for three months over the dry season and for six weeks over the wet season. As with the manual sampling, concentrations of NO_2 at each of the sites were also determined to be below the method detection limit (equivalent to an ambient air concentration of around 0.01 μg/m^3).

<u>Ambient Air Quality Monitoring Along the Gas Pipeline Route</u>

Ambient monitoring data has also been collected along the gas pipeline route, at four locations. A map of these locations is provided as Figure 3.5, and the results are provided in Table 3.3 below. Since sampling was undertaken a section of the gas pipeline route has changed and this is also shown in Figure 3.5 below. Monitoring results along the pipeline route were similar to those in the main Project area, with all contaminants measured below Indonesian Ambient Air Standards and WHO Ambient Air Guidelines.

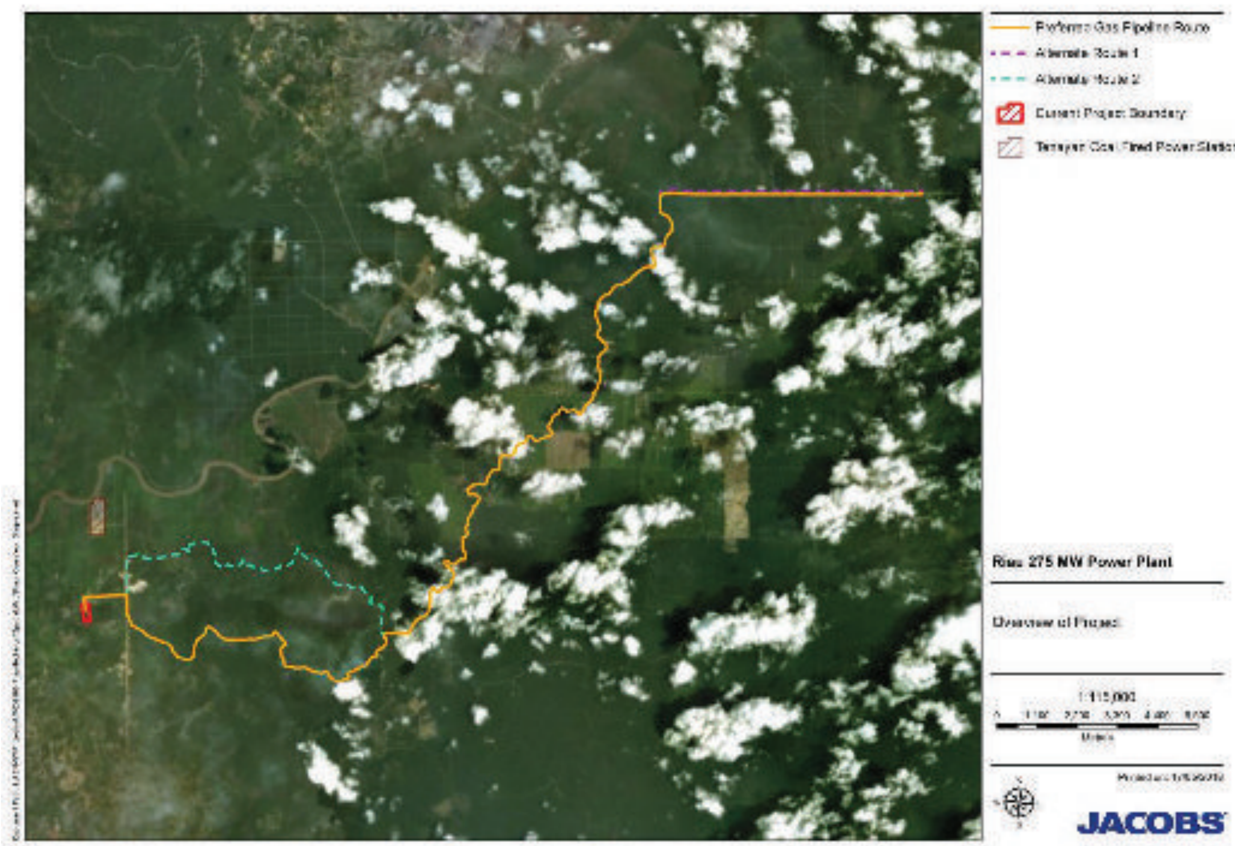


Figure 3.5 : Baseline Sampling Locations for Riau CCPP Gas Pipeline Route

Table 3.3 :Baseline Ambient Air Monitoring Results Along Gas Pipeline Route, January-February 2018 (Wet Season)

Contaminant	Measured Concentrations (µg/m^3)			Overall Average (µg/m^3)	Indonesian Air Quality Standard (µg/m^3)	WHO Air Quality Guidelines (µg/m^3)
	AQ-1	AQ-2	AQ-3			
SO_2 (1-hr avg)	<33	<33	<33	<33	*900*	*500*
O_3 (1-hr avg)	<34	<34	69	<46	*235*	*n/a*
NO_2 (1-hr avg)	<17	<17	<17	<17	*400*	*200*
CO (1-hr avg)	<114	<114	<114	<114	*30000*	*n/a*
TNMHC (30-minute avg)	<1.6	<1.6	<1.6	<1.6	*160*	*n/a*
TSP (1-hr avg)	88	81	71	80	*230*	*n/a*
PM_{10} (24-hr avg)	12-34	56	26-38	26	*150*	*50*
$PM_{2.5}$ (24-hr avg)	10-23	24	14-21	*16*	*65*	*25*
Pb (1-hr avg)	<0.06	<0.06	<0.06	<0.06	*2*	*n/a*

Note: < refers to the detection limit of the sampling method

Pekanbaru City Continuous Ambient Monitoring

To supplement the manual and passive ambient air sampling undertaken for the Project, Jacobs has sourced continuous ambient air monitoring data from the city of Pekanbaru, which maintains an ambient monitoring station approximately 9 km west of the Project. This data is reproduced in Table 3.4.

A photograph of the Pekanbaru monitoring site is shown as Figure 3.6, with Figure 3.7 showing the location of this station (labelled as PEF2) in relation to the Project. Data collected at this site consists of half-hourly measurements of NO, NO_2, O_3, SO_2 and PM_{10}, measured from 2011 to 2015. This data provides a good indication of existing ambient air quality in the Pekanbaru airshed, including any short-term and seasonal variations that could be expected to occur at the power plant site.

It is expected that contaminant concentrations at the urban Pekanbaru City monitoring location would be higher than that in the Project area, due to higher levels of traffic in the City as compared to the Project site which will result in elevated levels of NO_X. This assumption is supported by the baseline monitoring undertaken as part of the air quality assessment described above, which measured lower concentrations of contaminants in the Project area compared to those measured in Pekanbaru.

Figure 3.6 : Photograph of PEF-2 Ambient Air Monitoring Site in Pekanbaru

Figure 3.7 : Location Map of PEF-2 Ambient Monitoring Site in Pekanbaru in Relation to the Project

Table 3.4 : Summary of Ambient Monitoring Data Collected at Pekanbaru, 2011 - 2015

Statistic	NO_2 (µg/m³)		Ozone (µg/m³)	PM_{10} (µg/m³)	SO_2 (µg/m³)	
	1-hour avg	24-hour avg	1-hr avg	24-hr avg	1-hour avg	24-hour avg
average	10		59	48	67	
median	6.8	6.9	45	25	59	61
70th	14	12	88	37	84	85
95th	30	24	166	174	176	153
99th	45	30	233	424	259	254
99.9th	115	46	312	562	341	305
Indonesian Air Quality Standards	400	150	235	150	900	364
WHO Ambient Air Guidelines	200	n/a	n/a	50	n/a	20

The continuous monitoring data in Pekanbaru indicates that the ambient air quality is relatively good with respect to NO_2. The concentrations measured over the 2011-2015 period are generally (excluding outliers) less than 25% of the Indonesian 1-hour average ambient air standard of 400 ug/m³, and less than 15% of the 24-hour average standard of 150 µg/m³. Concentrations of PM_{10} and SO_2 are significantly higher than those observed in the Project area during the baseline air quality monitoring. This is in part due to the more urban nature of the Pekanbaru site, which includes discharges from traffic (including road dust and fuel combustion) and domestic fires etc. It may also be attributed to the longer, continuous nature of the monitoring which is able to capture high pollution events such as that caused by regional-scale agricultural burning and forest fires.

Analysis of PM_{10} concentrations measured during the 2011-2015 period, as shown in Figure 3.8below, shows the concentrations to be highly variable over the course of a year, with significantly elevated concentrations occurring during the June to October dry season when open agricultural burning and forest fires are common throughout the region. These sources contribute to a regional haze which is not attributable to individual industrial sources. The 2015 fire season has been noted as being the worst year for haze on record in Pekanbaru, resulting in widespread mobilisation of the population to combat brush fires. Since then government intervention has greatly reduced the incidence of these fires, and the regional haze problem has been less of a problem.

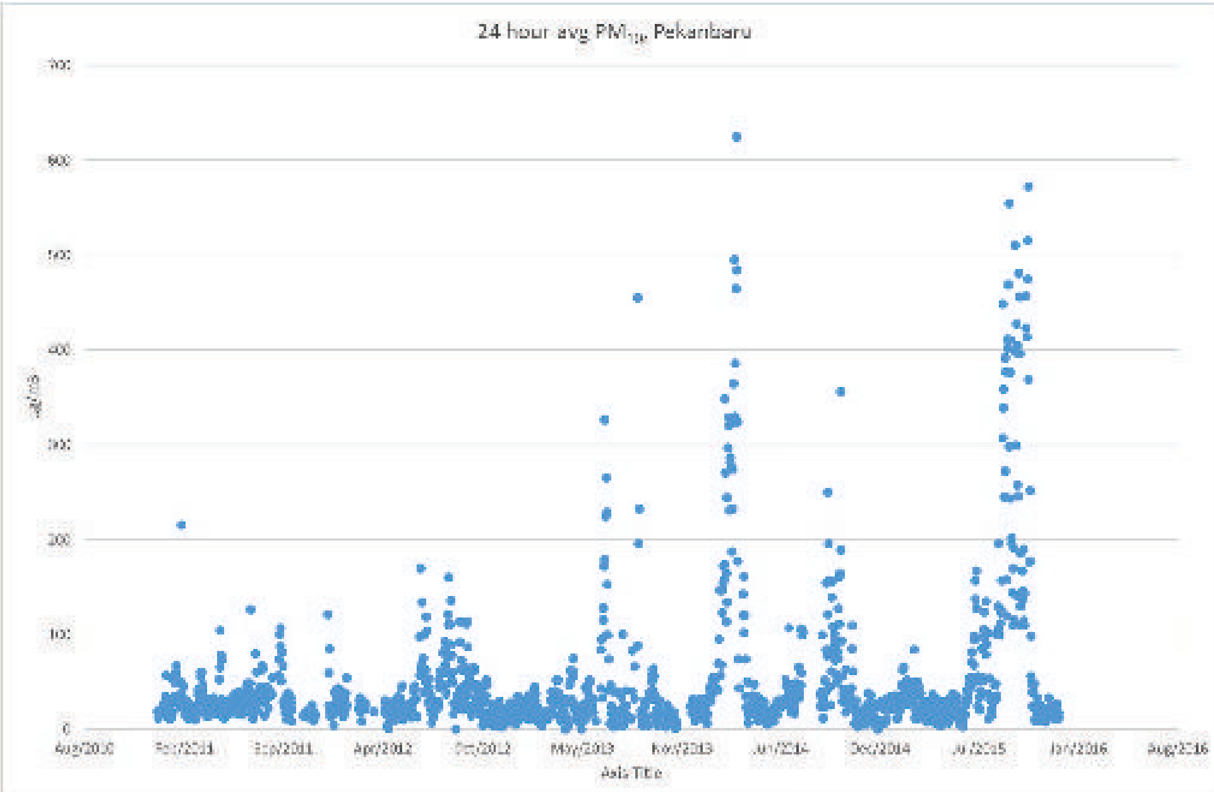


Figure 3.8 : 24-hour Average PM_{10} Concentrations as Measured at Pekanbaru, 2011-2015

Elevated concentrations of SO_2 are assumed to be the result of elevated sulphur content of fuels used for transportation and other industrial sources burning fuels containing sulphur in the area where the continuous ambient air monitoring was undertaken. Given the low level of traffic and other industrial sources in the Project area, the concentrations of SO_2 are also expected to be much lower.

3.4 Soils, Geology and Groundwater

3.4.1 Geology and Soils

The following description of the geology and soils at the power plant site and along the proposed gas pipeline route is based on a detailed geotechnical study (refer to ESIA Volume 5, Appendix B – Process Description) and a document describing the hydrogeology of the power plant. It is noted that the aforementioned documents focus on the power plant site. Therefore, there is limited information describing the geology and soils along the proposed gas pipeline route, though geological and hydrogeological maps indicate that the geology and soils are likely to be similar to those observed at the power plant.

Regional scale geological maps indicate that the geological unit beneath the power plant and gas pipeline route is part of the Minas formation (Rihardika, 2017). The Minas formation is comprised of very fine sandy siltstone that is well sorted, brittle, and poorly cemented. Borehole records obtained from the general vicinity of the power plant are generally consistent with the above description near the ground surface.

The general area that the power plant and proposed gas pipeline route is located in is undulating land that is prone to landslides and general surface erosion. The erosion is primarily due to heavy rainfall events and poorly consolidated soils, typically silt and clay.

At the site, the geology has been interpreted from boreholes and resistivity survey collected as part of baseline studies for the proposed plant. Three boreholes were drilled to a depth of 30 m below ground level (BGL) within the proposed footprint of the site and the logs are summarised below in Table 3.5.

Table 3.5 : Summary of Lithology Identified in Boreholes Within the Power Plant

Borehole	Depth (m)	Lithology
BH-01	0 – 0.40	Clayey SILT
	0.40 – 1.00	Silty CLAY
	1.00 – 27.00	CLAY
	27.00 – 30.00	CLAY
BH-02	0 – 0.60	Clayey SILT
	0.60 – 3.45	Silty CLAY
	3.45 – 30.00	CLAY
BH-03	0 -1.20	Clayey SILT
	1.20 – 5.60	Clayey SILT
	5.60 – 30.00	CLAY

The location of each borehole is shown in Figure 3.9 below.

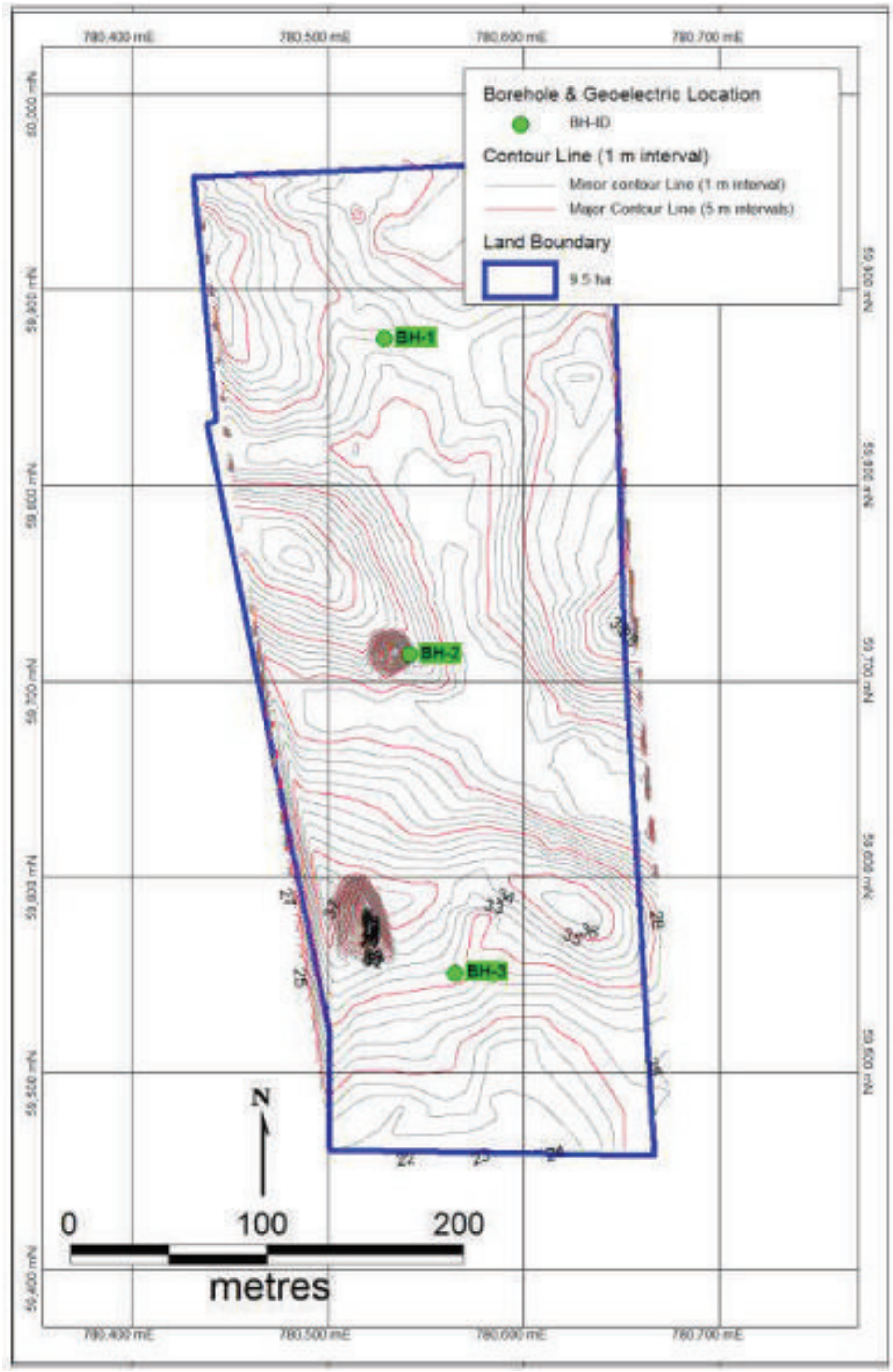


Figure 3.9 : Location of Boreholes Drilled Within the Power Plant Site

The logs presented above indicate the presence of clay layer of considerable thickness between 1 and 5 m below the ground surface. Results from a resistivity survey undertaken as part of a geotechnical study (ESIA Volume 5, Appendix B – Process Description) are consistent with these observations. The results of the resistivity survey identified four geological units that are as follows:

- First layer comprised of topsoil ranging in thickness from 0.64 to 1.53 m;
- Second layer comprised of silty clay ranging in thickness from 2.17 to 4.39 m;

- Third layer comprised of clay ranging in thickness from 27.63 to 30.00 m; and
- Fourth layer comprised clayey sand with a thickness of greater than 66.00 m.

A cross-section showing the results of the resistivity survey is also shown below in Figure 3.10.

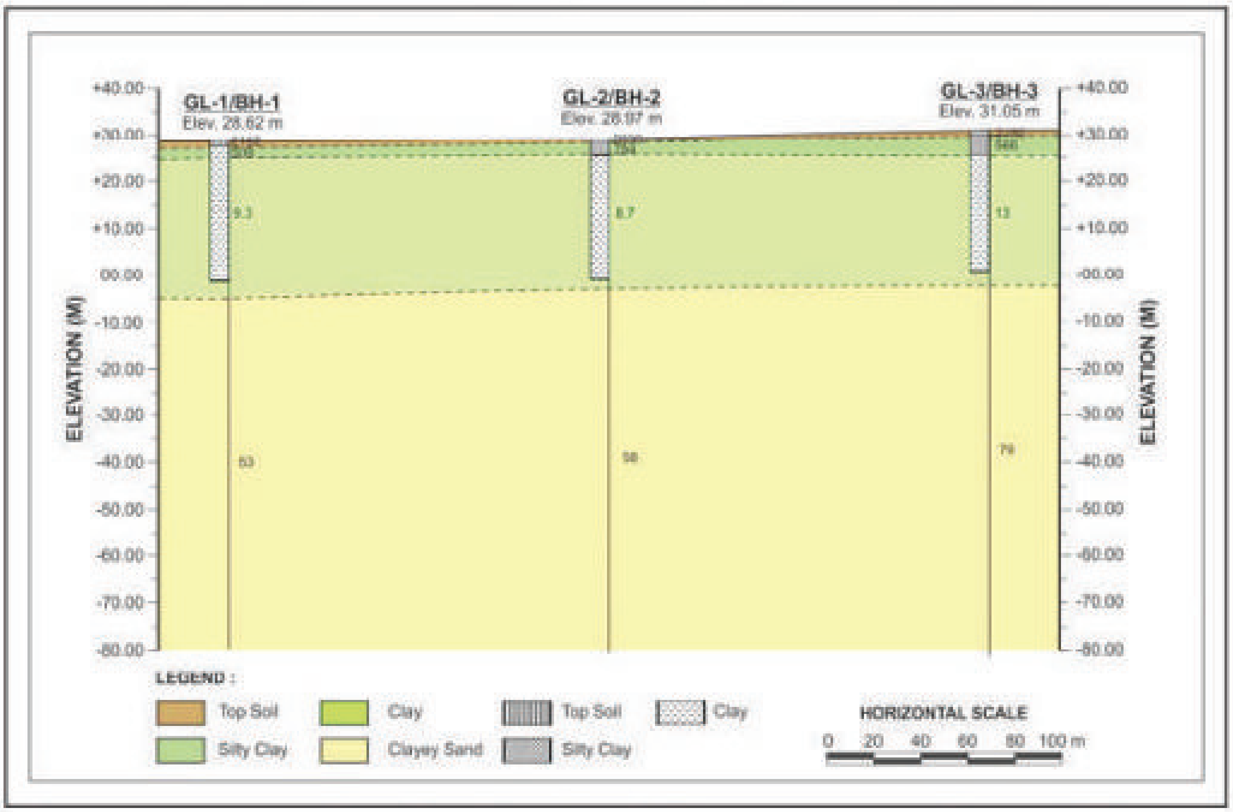


Figure 3.10 : Cross-Section Showing Results of Resistivity Survey

In summary, site-specific information collected at the power plant is generally consistent with regional geological maps near the ground surface and a significant clay layer was identified via site-specific studies between one and five metres below the ground surface.

3.4.2 Groundwater

Groundwater is defined by Freeze and Cherry (1979) as water found beneath the water table in soils and geological formations that are fully saturated.

Based on the above data the site appears to have two distinct aquifers, or water bearing horizons. The first, which is shown on the regional hydrogeological map is a shallow unconfined aquifer system that is perched on top of the regional extensive clay layer described above. This aquifer is shallow, and typically less than 5 m from the ground surface. Groundwater flow in this shallow aquifer will be controlled by topography (i.e. follows the fall of the land) but in general is to the west. According to the hydrogeological map (Rihardika, 2017) this sandstone has a hydraulic conductivity of between 10^{-6} and 10^{-8} cm/s which is consistent with literature values of sand and silty sand.

Based on the water level measured in local wells around the plant there appears to also be a deep aquifer unit located beneath the clay layer around 30 m below ground level. No further information on the hydraulic parameters of this unit is available.

Due to the undulating nature of the site, the shallow groundwater table is likely to be highly variable, with the shallowest levels encountered in the depressions or lower lying areas, and deeper groundwater levels on the slopes of the small hillocks on site.

3.4.3 Local boreholes and wells

Surveys undertaken for the ESIA identified a number of wells in close proximity to the proposed plant and pipeline. There are 20 wells within 1.5 km of the power plant and a further 18 wells within 100 m of the proposed gas pipeline route (see Figure 3.11 and Figure 3.12).

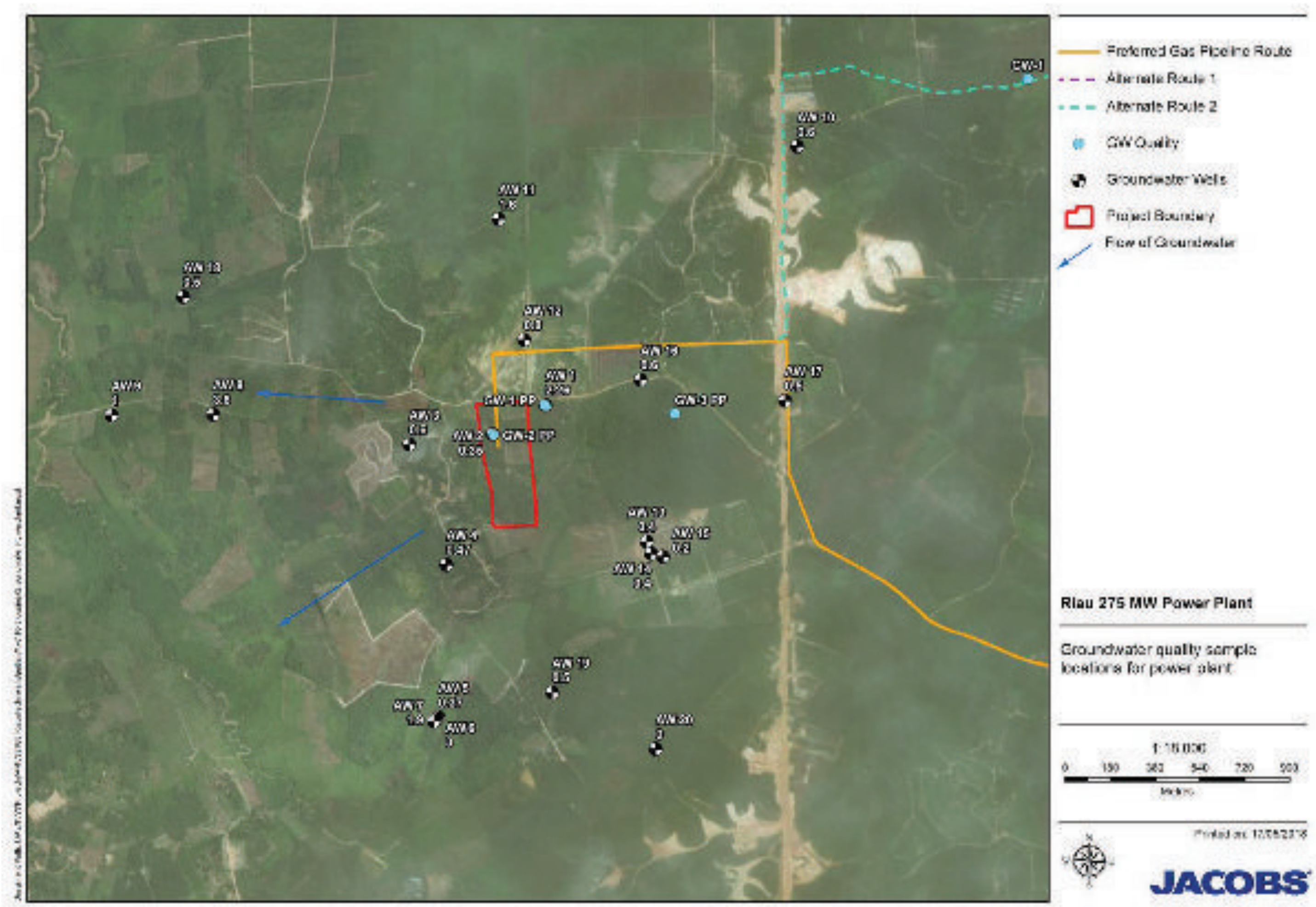


Figure 3.11 : Location of Groundwater Sampling Wells and Neighbouring Wells Within 1.5 km of the Power Plant

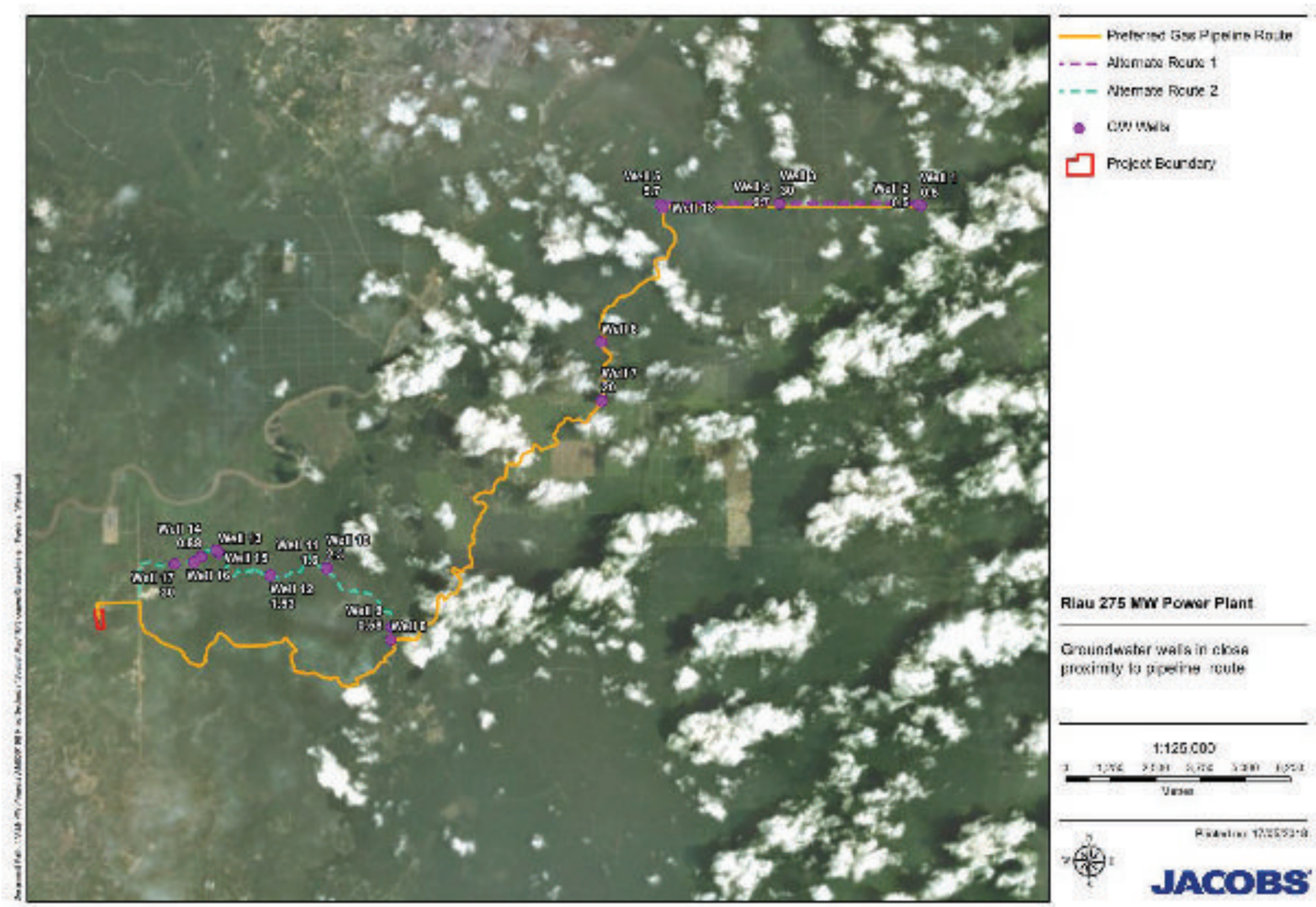


Figure 3.12 : Location of Wells Within Close Proximity to the Proposed Gas Pipeline Route

Groundwater levels range from close to ground surface to 3.8 m BGL as shown in Table 3.6.

Table 3.6 : Summary of Water Levels in Wells in Close Proximity to the Power Plant

Well	Well elevation (m aMSL)	Water level (m aMSL)	Water level (m BGL)	Approx. distance to project boundary (m)
AW1	20	17.74	2.26	70
AW2	27	26.65	0.35	Within project boundary
AW3	19	18.4	0.6	285
AW4	29	28.53	0.47	245
AW5	18	17.63	0.37	795
AW6	18	15	3	805
AW7	17	15.1	1.9	815
AW8	10	6.2	3.8	1,060
AW9	7	6	1	1,465
AW10	23	22.4	0.6	1,500
AW11	14	12.4	1.6	735
AW12	13	12.2	0.8	250
AW13	19	18.6	0.4	445
AW14	20	19.6	0.4	475
AW15	21	20.8	0.2	525
AW16	32	31.4	0.6	465
AW17	25	24.5	0.5	1,035
AW18	6	5.5	0.5	1,255
AW19	21	20.5	0.5	670
AW20	25	25	0	1,015

Notes:
Well depths have not been provided
m aMSL = metres above mean sea level
m BGL = metres below ground level
It is assumed that the well within the project boundary will be decommissioned in accordance with appropriate regulatory standards

Based on the baseline field observations, these wells are likely to be used for domestic purposes and/or irrigation of palm oil plantations. In relation to groundwater quality, visual, olfactory and taste observations have been made on the 20 wells within 1.5 km of the power plant. Unfortunately, the depths of these wells were not recorded during the survey however based on the water levels observed it is assumed that they are all screened in the shallow unconfined aquifer. The observations noted the following:

- The majority of wells produced clear water, though some wells had muddy water;
- The majority of wells had water that tasted like acid; and
- No odour was identified at the majority of wells.

With regard to the 18 wells within 100 m of the gas pipeline (Figure 3.12), well depths range from 0.5 to 60 m, as shown in Table 3.7 below. Unfortunately, groundwater levels for these wells were not recorded. These wells are also likely to be used for domestic purposes and/or irrigation of palm oil plantations. No visual, olfactory or taste observations have been made on these wells.

Table 3.7 : Summary of Water Levels in Wells in Close Proximity to the Gas Pipeline

Well	Depth (m)	Approx. distance to proposed gas pipeline route (m)
1	5	10
2	38	20
3	20	70
4	10	90
5	80	30
6	60	35
7	53	30
8	30	15
9	80	70
20	24	40
11	3	45
12	2	10
13	20	15
14	15	10
15	1,2	75
16	1	100
17	0.50	15
18	7	100

A limited number of groundwater quality analyses have been completed on the 20 wells within 1.5 km of the power plant and the 18 wells with 100 m of the proposed gas pipeline route.

3.4.4 Soil Sampling

Ten soil samples were collected at the power plant during baseline surveys. The locations of the soil samples are shown in Figure 3.13.

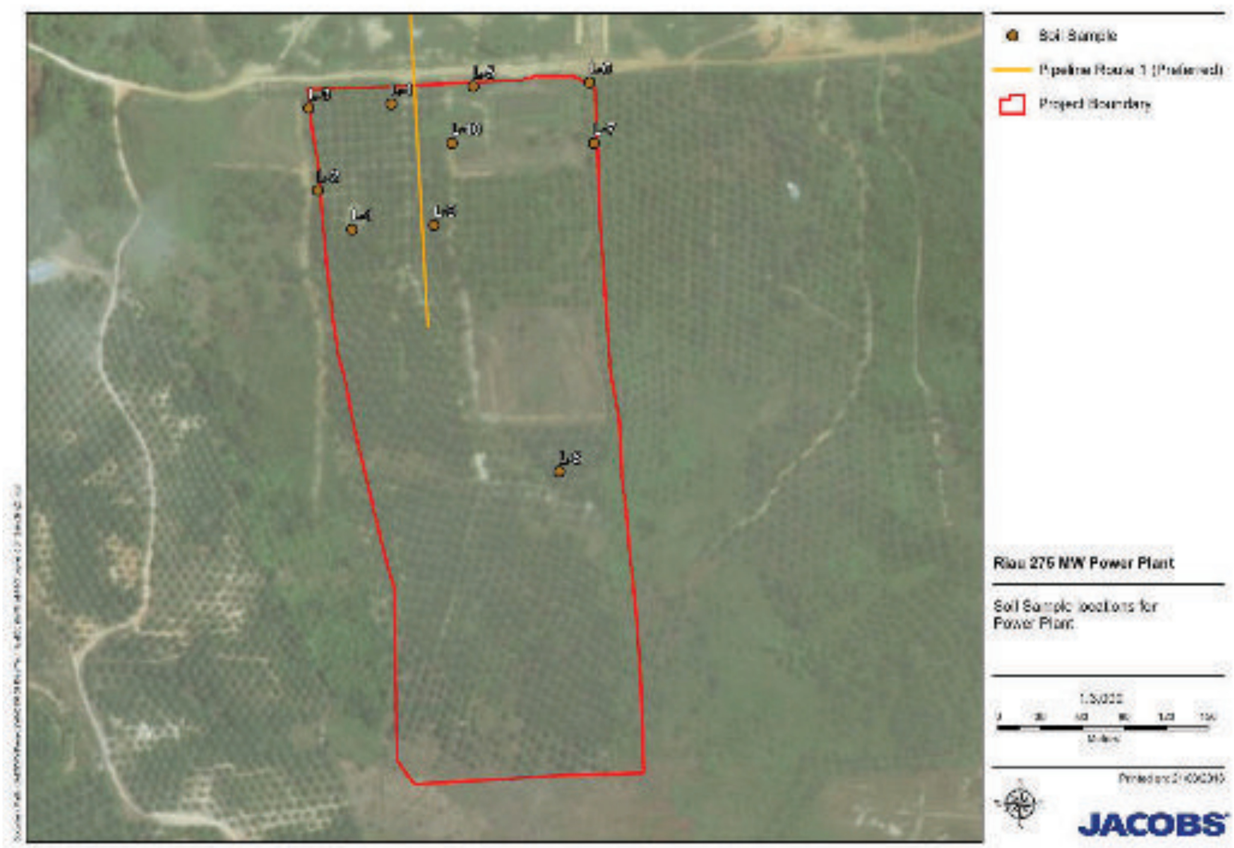


Figure 3.13 : Location of Soil Samples at the Power Plant

These soils samples were analysed for organochlorine pesticides (OCP), organophosphorus pesticides (OPP), carbaryl (sevin) and carbofuran (furadan). This analytical suite was chosen because of the current use of the land as a palm oil plantation.

Results of the soil sampling are shown in Table 3.8. In summary, all soil samples were below detection limits for all analyses, indicating that the soils in the vicinity of the power plant are not contaminated from the use of pesticides.

Table 3.8 : Soil Sampling Results

Sample	Organochlorine Pesticides (OPPs) (mg/kg)	Organochlorine Pesticides (OCPs) (mg/kg)	Carbaryl (Sevin) (mg/kg)	Carbofuran (Furada) (mg/kg)
Detection Limit	0.2	2	0.01	0.02
Regulation Limit	NA	NA	-	-
L-1 PP	< 0.2	< 2	< 0.01	< 0.02
L-2 PP	< 0.2	< 2	< 0.01	< 0.02
L-3 PP	< 0.2	< 2	< 0.01	< 0.02
L-4 PP	< 0.2	< 2	< 0.01	< 0.02
L-5 PP	< 0.2	< 2	< 0.01	< 0.02
L-6 PP	< 0.2	< 2	< 0.01	< 0.02

Sample	Organochlorine Pesticides (OPPs) (mg/kg)	Organochlorine Pesticides (OCPs) (mg/kg)	Carbaryl (Sevin) (mg/kg)	Carbofuran (Furada) (mg/kg)
L-7 PP	< 0.2	< 2	< 0.01	< 0.02
L-8 PP	< 0.2	< 2	< 0.01	< 0.02
L-9 PP	< 0.2	< 2	< 0.01	< 0.02
L-10 PP	< 0.2	< 2	< 0.01	< 0.02

3.4.5 Groundwater Quality Sampling

Groundwater quality samples were collected from three groundwater monitoring wells, one of which is within the boundary of the power plant (GW-2 PP), while the remaining two (GW-1 PP and GW-3 PP) were located immediately to the east of the power plant. The location of the groundwater samples and neighbouring wells are shown above in Figure 3.11.

Samples collected from the three groundwater wells were analysed for a range in chemical, bacterial and organic parameters. Results from the groundwater samples are shown in Table 3.9. The results show that with the exception of pH at GW-2 PP and GW-3 PP and total coliforms at GW-1 PP, groundwater quality is compliant with Indonesian Regulation PP 82/2001 Class II. In addition, it is noted that the groundwater quality is compliant with World Health Organisation (WHO) drinking water guidelines. This indicates that groundwater is generally of good quality and subjected to limited contamination apart from bacterial contamination in one of the sampled wells (GW-1PP), and therefore activities in the area that may impact groundwater quality should be carefully managed.

Table 3.9 : Groundwater Quality Results

Analytes	Unit	Detection Limit	Regulation Limit[1]	WHO Drinking Water Guidelines[2]	GW-1 PP	GW-2 PP	GW-3 PP
Physical							
Temperature	℃	-	±3	NA	27	27.8	28.1
Total Dissolved Solids (TDS)	mg/L	4	1000	NA	39	< 4	60
Total Suspended Solids (TSS)	mg/L	1	50	NA	7	< 1	< 1
Conductivity	µs/cm	1	NA[3]	NA	46	< 1	90
Turbidity	NTU	0.5	NA[3]	NA	9.71	3.07	2.43
Chemical							
pH	-	-	6 – 9	NA	6.67	**4.58**	**4.66**
Biochemical Oxygen Demand (BOD)	mg/L	2	3	NA	< 2	< 2	< 2
Chemical Oxygen Demand (COD)	mg/L	3	25	NA	< 3	< 3	< 3
Ammonia (as NH_3-N)	mg/L	0.07	(-)	NA	0.10	0.19	< 0.07
Nitrate (NO_3)	mg/L	0.003	10	11.3	0.034	0.060	0.822
Nitrite (NO_2)	mg/L	0.005	0.06	1.9	< 0.005	< 0.005	< 0.005
Total Nitrogen	mg/L	0.06	NA	NA	0.10	0.25	1.81
Fluoride (F)	mg/L	0.1	1.5	1.5	< 0.1	0.2	0.2
Phophorus (P)	mg/L	0.03	0.2	NA	< 0.03	< 0.03	< 0.03
Oil and Grease	µg/L	1000	1000	NA	< 1,000	< 1,000	< 1,000

Analytes	Unit	Detection Limit	Regulation Limit[1]	WHO Drinking Water Guidelines[2]	GW-1 PP	GW-2 PP	GW-3 PP
Total Boron (B)	mg/L	0.04	NA	NA	0.62	0.65	0.86
Total Mercury (Hg)	mg/L	0.0005	NA	NA	< 0.0005	< 0.0005	< 0.0005
Total Arsenic (As)	mg/L	0.005	NA	NA	< 0.005	< 0.005	< 0.005
Total Cadmium (Cd)[2]	mg/L	0.002	NA	NA	< 0.002	0.012	0.002
Total Chromium Hexavalent (Cr^{6+})	mg/L	0.004	NA	NA	< 0.004	< 0.004	< 0.004
Total Chromium (Cr)	mg/L	0.02	NA	0.05	< 0.02	< 0.02	< 0.02
Total Copper (Cu)	mg/L	0.01	NA	NA	< 0.01	< 0.01	< 0.01
Total Iron (Fe)	mg/L	0.09	NA	NA	0.30	0.10	<0 .09
Total Lead (Pb)[2]	mg/L	0.005	NA	NA	< 0.005	< 0.005	< 0.005
Total Manganese (Mn)	mg/L	0.01	NA	NA	< 0.01	< 0.01	< 0.01
Total Nickel (Ni)	mg/L	0.01	NA	NA	< 0.01	< 0.01	< 0.01
Total Zinc (Zn)	mg/L	0.02	NA	NA	< 0.02	< 0.02	< 0.02
Dissolved Boron (B)	mg/L	0.04	1	0.5	< 0.04	0.31	0.51
Dissolved Mercury (Hg)	mg/L	0.0005	0.002	0.006	< 0.0005	< 0.0005	< 0.0005
Dissolved Arsenic (As)	mg/L	0.005	1	0.01	< 0.005	< 0.005	< 0.005
Dissolved Cadmium (Cd)[2]	mg/L	0.002	0.01	0.003	< 0.002	< 0.002	< 0.002
Dissolved Chromium Hexavalent (Cr^{6+})	mg/L	0.004	0.05	NA	< 0.004	< 0.004	< 0.004
Dissolved Chromium	mg/L	0.02	NA[3]	NA	< 0.02	< 0.02	< 0.02
Dissolved Copper (Cu)	mg/L	0.01	0.02	2	< 0.01	< 0.01	< 0.01
Dissolved Iron (Fe)	mg/L	0.09	(-)	NA	0.24	<0.09	<0.09
Dissolved Lead (Pb)[3]	mg/L	0.005	0.03	0.01	< 0.005	< 0.005	< 0.005
Dissolved Manganese (Mn)	mg/L	0.01	(-)	0.4	< 0.01	< 0.01	< 0.01
Dissolved Nickel (Ni)	mg/L	0.01	NA	0.07	< 0.01	< 0.01	< 0.01
Dissolved Zinc (Zn)	mg/L	0.02	0.05	NA	< 0.02	< 0.02	< 0.02
Microbiology							
Total Coliforms	colony/100mL	-	5,000	NA	**20,000**	740	12
Organics							
Organochlorine Pesticides (OCP)	µg/L	0.4	NA	NA	< 0.4	< 0.4	< 0.4
Polychlorinated Biphenyils (PCB)	µg/L	0.005	NA	NA	< 0.005	< 0.005	< 0.005
Polycyclic Aromatic Hydrocarbon (PAHs)	µg/L	0.04	NA	NA	< 0.04	< 0.04	< 0.04

Notes:

Bold text indicates exceedance of Indonesian Regulation PP 82/2001 Class II

[1] Indonesian Regulation PP 82/2001 Class II

[2] WHO Drinking Water Guidelines (2017)

[3] Parameter in the described matrix has not been accredited by KAN

3.4.6 Sampling – Gas Pipeline

Four soil samples were collected along the length of the gas pipeline route. The locations of the soil samples are shown in Figure 3.14.

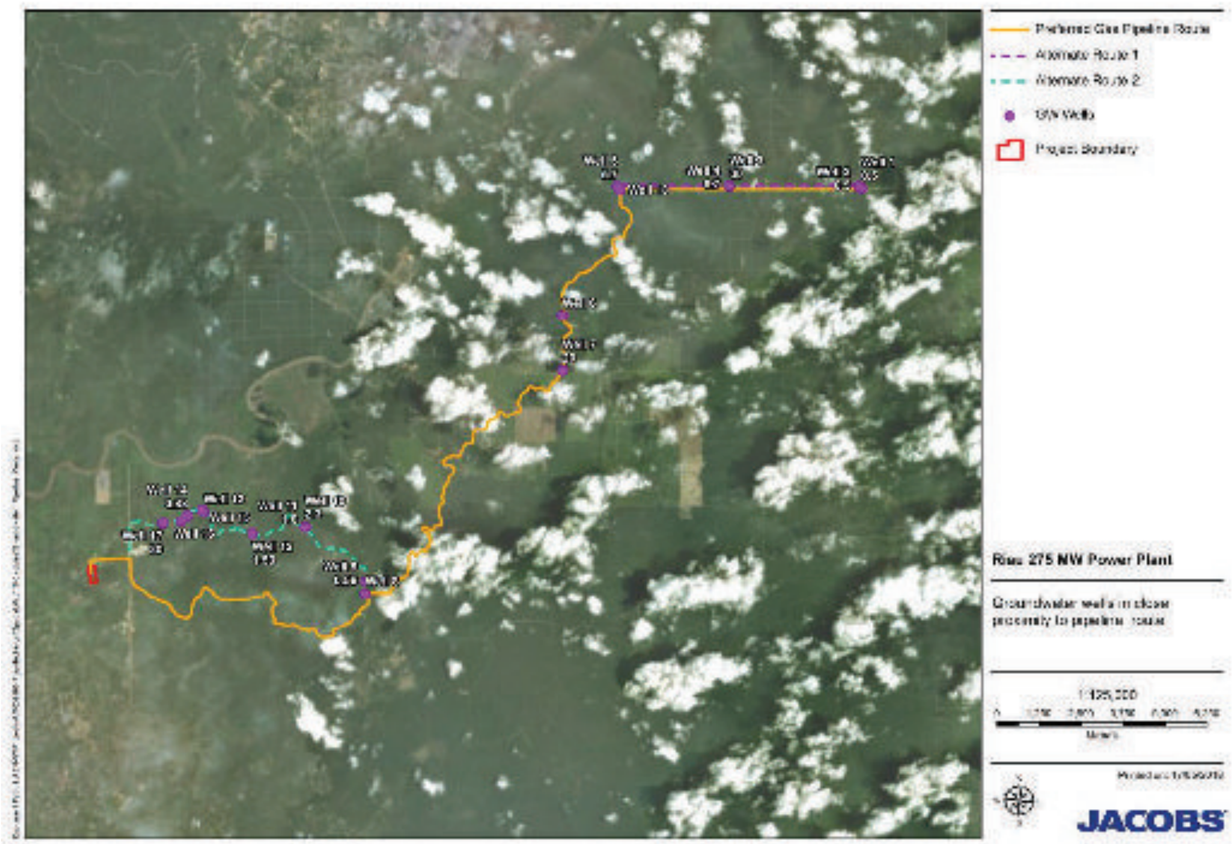


Figure 3.14 : Location of Soil Samples Along the Gas Pipeline

The collected soils samples were analysed and results listed in Table 3.10. The results were compared against the Regional Screening Levels (RSLs) for the Protection of Human Health at Industrial Sites to identify the risk to human health as a result of excavation of the soil. It is noted that these guidelines contain both carcinogenic and non-carcinogenic values in relation to particular contaminants, of which values may be different (e.g., carcinogenic screen level value for Mirex in relation to ingestion (0.018 mg/kg) is different to the non-carcinogenic screen value for Mirex in relation to ingestion (2,300 mg/kg). Where multiple values were potentially relevant for a particular contaminant, the lowest value was taken as exceeding that value may result in adverse impacts on human health it not managed appropriately.

In summary, while contaminants were observed in the soil samples, they were generally at low levels and there were no exceedances of RSLs in relation to the protection of human health. This indicates that no measures are required to protect human health during construction works along the pipeline.

Table 3.10 : Soil Sampling Results

Parameter	Unit	Limit of Reporting	Regional Screening Levels (Protection of Human Health)[1]	Soil 1 PL	Soil 2 PL	Soil 3 PL	Soil 4 PL
Metals & Cations							
Mercury	mg/kg	0.05	46[2]	0.06	0.07	0.08	0.06
Arsenic	mg/kg	1.00	3	< 1.00	2.27	1.63	2.79
Boron	mg/kg	5.00	230,000[3]	< 5.00	< 5.00	< 5.00	< 5.00
Cadmium	mg/kg	1.00	NA	< 1.00	< 1.00	< 1.00	< 1.00

Parameter	Unit	Limit of Reporting	Regional Screening Levels (Protection of Human Health)[1]	Soil 1 PL	Soil 2 PL	Soil 3 PL	Soil 4 PL
Chromium	mg/kg	1.00	NA	12.8	17.000	14.0	14.5
Copper	mg/kg	1.00	47,000	1.1	1.13	< 1.00	< 1.00
Iron	mg/kg	5.00	820,000	7,930	15,000	7,630	6,810
Lead	mg/kg	1.00	270[4]	2.55	4.59	2.34	2.02
Manganese	mg/kg	1.00	26,000	8.84	6.38	8.46	4.10
Nickel	mg/kg	1.00	13,000[5]	1.4	1.21	1.08	< 1.00
Zinc	mg/kg	5.00	350,000	5.96	< 5.00	< 5.00	< 5.00
Polyaromatics Aromatic Hydrocarbons (PAHs)							
Total PAHs	mg/kg	1.0	6,000[6]	< 1.0	< 1.0	< 1.0	< 1.0
Polychlorinated Biphenyls (PCBs)							
Total Polychlorinated Biphenyls	mg/kg	0.25	NA	< 0.25	< 0.25	< 0.25	< 0.25
Organochlorine Pesticides (OCPs)							
Trans-Chlordane	mg/kg	0.5	NA NA	< 0.5	< 0.5	< 0.5	< 0.5
Cis-Chlordane	mg/kg	0.5	NA NA	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan 1	mg/kg	0.5	NA NA	< 0.5	< 0.5	< 0.5	< 0.5
Dieldrin	mg/kg	0.5	2 0.000071	< 0.5	< 0.5	< 0.5	< 0.5
Endosulfan 2	mg/kg	0.5	NA NA	< 0.5	< 0.5	< 0.5	< 0.5
4.4'-DDT	mg/kg	1.0	8.5 0.0077	< 1.0	< 1.0	< 1.0	< 1.0
Mirex	mg/kg	0.001	0.17 0.00063	< 0.001	< 0.001	< 0.001	< 0.001

Notes:
[1] Sourced from Regional Screening Level for Chemical Contaminants at Industrial Sites (May 2018)
[2] Mercury (elemental)
[3] Boron & Borates only
[4] Lead Acetate
[5] Nickel Acetate
[6] Total Petroleum Hydrocarbons (Aromatic (Medium)

3.4.7 Groundwater Sampling

Groundwater samples were collected from seven groundwater monitoring wells along the length of the gas pipeline route. The location of the groundwater samples and neighbouring wells are shown in Figure 3.15 and detailed in Table 3.11.

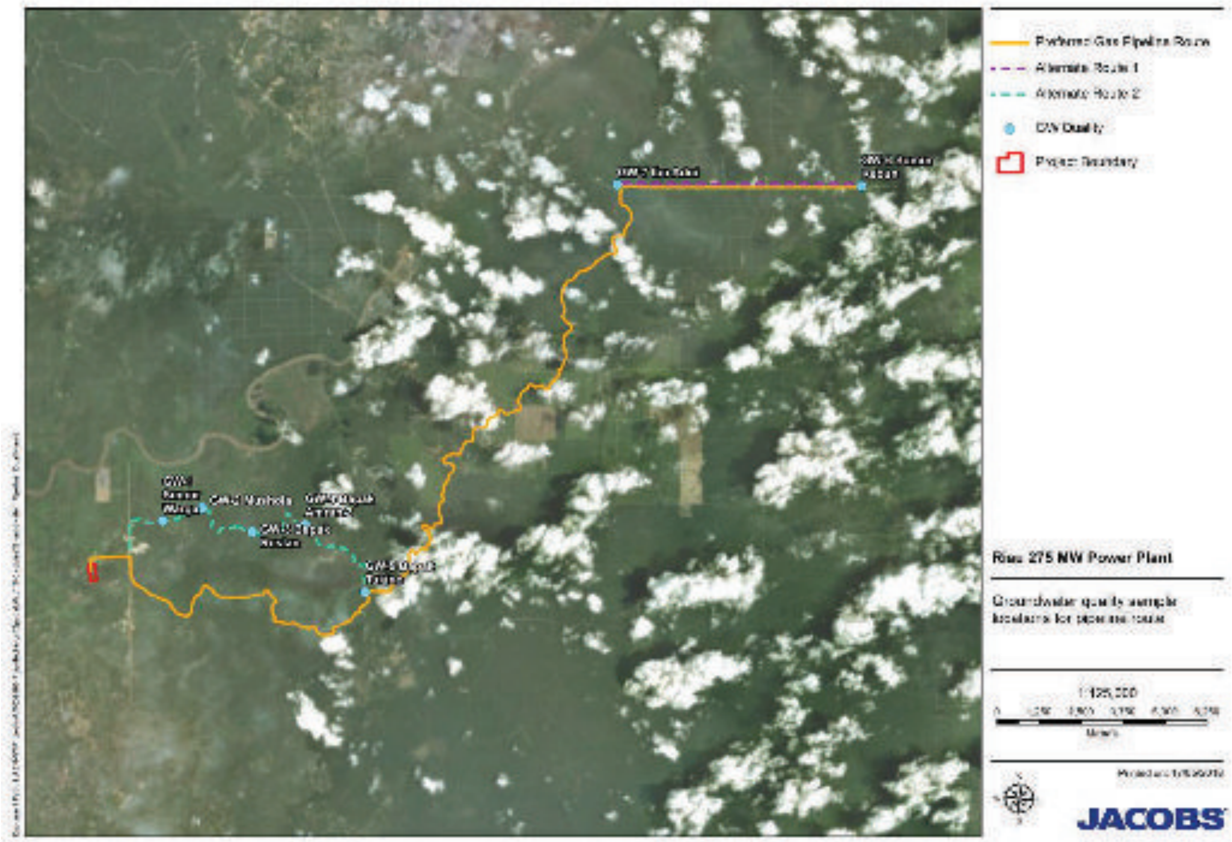


Figure 3.15 : Location of Groundwater Sampling Wells Along the Gas Pipeline Route

Samples collected from the seven groundwater wells were analysed for a range of analytes and results from the groundwater samples are shown in Table 3.11. The results show that these were a small number of exceedances of the relevant regulations. These exceedances are as follows:

- Acceptable range for pH in Indonesian Regulation PP 82/2001 Class II is 6 to 9. pH at GW-1 Sumur Warga, GW-5 Bapak Tukino, and GW-7 Ibu Adui all fell outside the acceptable range;
- Biochemical oxygen demand and chemical oxygen demand concentrations were 4.7 and 141 mg/L at GW-6 Sumur Kebun, respectively, thus exceeding Indonesian Regulation PP 82/2001 Class II of 3 and 25 mg/L, respectively;
- Dissolved boron concentrations of 0.68 mg/L and GW-2 Mushola which exceeded WHO Drinking Water Guidelines of 0.5 mg/L; and
- Total coliform counts in GW-6 Sumur Kebun and GW-7 Ibu Adui were 49 and 5 cfu/100 mL, respectively. These counts did not exceed Indonesian Regulation PP 82/2001 Class II but do indicate localised sources of contamination or inadequate well protection.

The limited contamination is potentially a result of localised activities impacting groundwater in specific wells or site-specific hydrogeological conditions.

Table 3.11 : Groundwater Quality Results

Analytes	Unit	Detection Limit	Regulation Limit[1]	WHO Drinking Water Guidelines[2]	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7
pH	-	-	6 – 9	NA	**4.21**	7.0	6.26	6.8	**4.44**	6.27	**4.97**
Total Suspended Solids (TSS)	mg/L	1	50	NA	1	< 1	< 1	< 1	6	26	< 1
Biochemical Oxygen Demand (BOD)	mg/L	2	3	NA	< 2	< 2	< 2	< 2	< 2	**4.7**	< 2
Chemical Oxygen Demand (COD)	mg/L	5	25	NA	< 5	< 5	< 5	8	< 5	**141**	< 5
Oil & Grease	mg/L	1	NA	NA	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	9	< 1,000
Arsenic (As)	mg/L	0.02	NA	NA	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Boron (B)	mg/L	0.04	NA	NA	< 0.04	4.87	< 0.04	2.22	2.08	0.38	0.36
Cadmium (Cd)	mg/L	0.002	NA	NA	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.02
Chromium (Cr)	mg/L	0.02	NA	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Chromium Hexavalent (Cr^{6+})	mg/L	0.004	NA	NA	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.006	< 0.004
Copper (Cu)	mg/L	0.02	NA	NA	< 0.02	0.06	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron (Fe)	mg/L	0.02	NA	NA	0.05	< 0.02	< 0.02	0.03	0.03	0.43	< 0.02
Lead (Pb)	mg/L	0.02	NA	NA	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Mercury (Hg)	mg/L	0.00005	NA	NA	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Manganese (Mn)	mg/L	0.02	NA	NA	< 0.02	0.04	< 0.02	0.02	< 0.02	< 0.02	< 0.02
Nickel (Ni)	mg/L	0.02	NA	NA	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc (Zn)	mg/L	-	NA	NA	0.08	0.36	0.09	0.10	0.13	0.05	0.07
Ammonia (as NH_3-N)	mg/L	0.07	NA	NA	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07
Fluoride (F)	mg/L	0.1	1.5	1.5	< 0.1	< 0.1	0.2	0.2	< 0.1	0.4	0.1
Total Nitrogen	mg/L	-	NA	NA	1.35	1.19	1.94	1.33	1.04	0.89	1.21
Nitrate (NO_3)	mg/L	0.003	10	11.3	< 0.003	0.136	0.540	0.28	0.206	< 0.003	0.604
Nitrite (NO_2)	mg/L	0.005	0.06	1.9	< 0.005	0.008	0.007	0.012	< 0.005	0.017	0.007
Phophorus (P)	mg/L	0.03	0.2	NA	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.04

Analytes	Unit	Detection Limit	Regulation Limit[1]	WHO Drinking Water Guidelines[2]	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7
Temperature	℃	-	±3	NA	27.5	28.4	26.5	27.1	26.7	27.5	27.4
Conductivity	µs/cm	-	NA	NA	11.3	109	119	76.2	16.6	67.1	65.5
Turbidity	NTU	0.5	NA	NA	2.94	< 0.5	1.78	3.12	0.46	12.2	0.25
Dissolved Arsenic (As)	mg/L	0.02	1	0.01	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Boron (B)	mg/L	0.04	1	0.5	< 0.04	**0.68**	< 0.04	< 0.04	< 0.04	0.29	0.19
Dissolved Cadmium (Cd)	mg/L	0.002	0.01	0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Dissolved Chromium	mg/L	0.02	NA	NA	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Chromium Hexavalent (Cr^{6+})	mg/L	0.004	0.05	NA	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Dissolved Copper (Cu)	mg/L	0.02	0.02	2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Iron (Fe)	mg/L	0.02	NA	NA	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.03	< 0.02
Dissolved Lead (Pb)	mg/L	0.02	0.03	0.01	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Mercury	mg/L	0.00005	0.002	NA	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Manganese (Mn)	mg/L	0.02	NA	0.4	< 0.02	0.04	< 0.02	0.04	< 0.02	< 0.02	< 0.02
Dissolved Nickel (Ni)	mg/L	0.02	NA	0.07	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved Zinc (Zn)	mg/L	0.02	0.05	NA	< 0.02	0.29	0.03	< 0.02	< 0.02	< 0.02	0.02
Total Dissolved Solids (TDS)[3]	mg/L	-	1000	NA	105	11	33	12	41	9	15
Total Coliform	Cfu/100 mL	1	5000	NA	< 1	< 1	< 1	< 1	<1	49	5

Notes:

GW-1 = GW-1 Sumur Warga

GW-2 = GW-2 Mushola

GW-3 = GW-3 Bapak Ruslan

GW-4 = Bapak Amran 2

GW-5 = Bapak Tukino

GW-6 = GW-6 Sumur Kebun

GW-7 = GW-7 Ibu Adui

Analytes	Unit	Detection Limit	Regulation Limit[1]	WHO Drinking Water Guidelines[2]	GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7

Bold text indicates exceedance of Indonesian Regulation PP 82/2001 Class II

Bold text indicates exceedance of WHO Drinking Water Guidelines

[1] Indonesian Regulation PP 82/2001 Class II

[2] WHO Drinking Water Guidelines (2017)

[3] Parameter in the described matrix has not been accredited by KAN

3.5 Hydrology

3.5.1 Siak River Field Surveys

Field surveys were taken on the Siak River in 2017 as part of the baseline studies. Three cross sections were taken 1) upstream, 2) midstream and 3) downstream of the Project location, these indicated that the river width ranged from 121-125 m, and had a maximum depth of 12.8 m. River flow velocities during these assessments ranged from 0.8–1.0 m/s. The temperature of the river varied between 27.9 and 32.1°C.

3.5.2 Tidal Influences

The Riau CCPP intake and discharge point is ~136 km from the coast. Examination of the Siak River (see Section 7.1.1) daily flow time series is not useful for the purposes of identifying sub-daily tidal variations. Local reports from Pekanbaru City upstream of the project site indicate the Siak River is tidal in regards to water level fluctuations, but there is no tidal current at the site. The average tidal range is ~2.2 m at spring tide and 0.6 m at neap tide. Water level fluctuation within the river channel has the range of 1.5–2.2 m at Pekanbaru and maintains a semi-diurnal characteristic (JICA, 2018).

Examination of a global digital elevation model (version 2) and contours developed from an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) dataset indicate the river bank is ~ 10 m aMSL while the planned Riau CCPP location ranges from 20-30 m aMSL. This is further confirmed in Figure 3.16, although there is no datum or surveying reference for this topographic map to indicate how the elevations were defined.

The ASTER dataset has a vertical accuracy of ~17 m at the 95% confidence level, meaning the flat nature of this location makes it difficult to infer contours and topographic changes without local LIDAR or ground surveying, and therefore should be used cautiously.

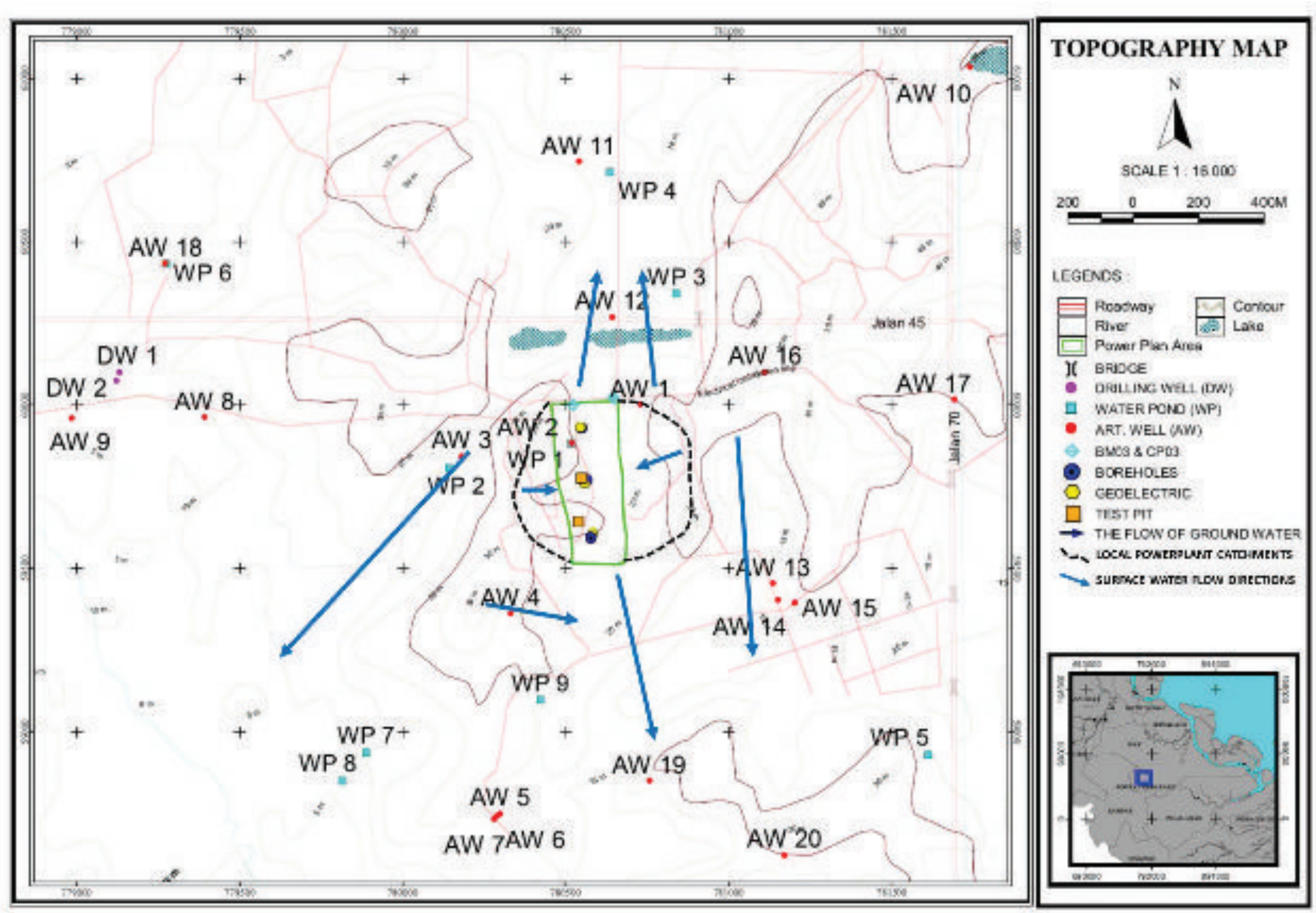


Figure 3.16 : Topographic Map of the Power Plant Location (1:16000 scale). The Power Plant is Indicated by the Green Line, Dashed Black Lines Indicate Local Surface Water Catchments

3.6 Water Quality and Freshwater Ecology

The project area contains the Siak River as the main watercourse. This is a large river draining north-east from the project area. In the general project vicinity, the river is approximately 125 m wide. The river at this location is over 100 km from the sea at an elevation of 10 m aMSL. Based on available monitoring and ecology data and published data in Yuliati (2017) the river would be freshwater at this location and well above any saline water intrusion through tidal influence. The river water level within the project area has however been observed to fluctuate due to tidal influences but is anticipated to be a result of freshwater backing up above the saline reach of the tide.

The Siak River is located approximately 3 km north of the power plant location. The water supply for the power plant will be sourced from this river and cooling water blowdown and other effluents will be discharged back to the river. A temporary jetty for the unloading of equipment for the construction of the power plant will also be constructed in the Siak River. Baseline data has been gathered to characterise the quality of the Siak River in both wet and dry season conditions. The Tenayan River is a tributary of the Siak River and is located to the west of the project location. No other permanent watercourses occur within the power plant (including transmission line, new road, water supply/discharge pipeline) project area.

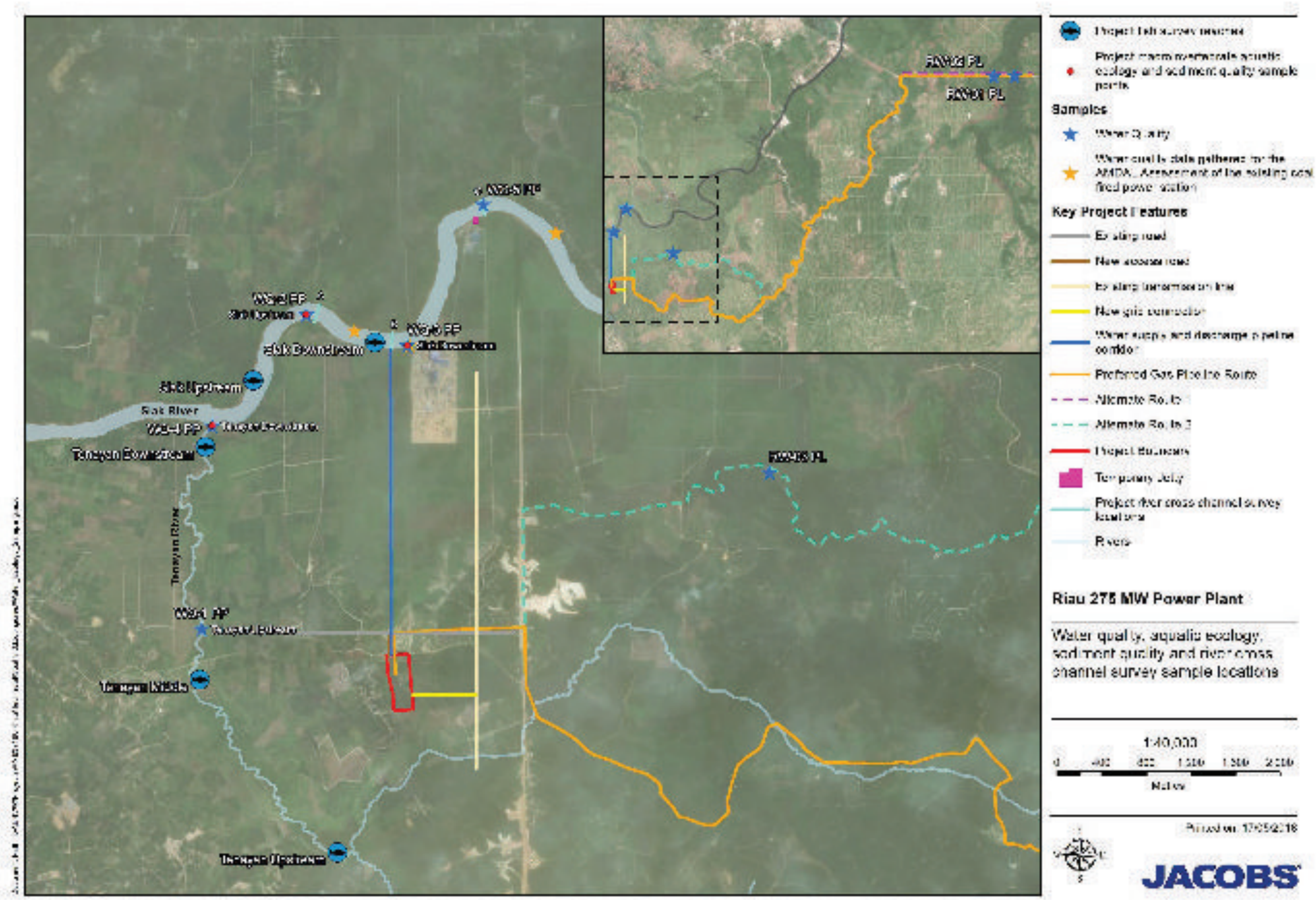


Figure 3.17 : Water Quality, Freshwater Ecology, Sediment Quality and River Cross Channel Survey Sample Locations

3.6.1 River Morphology and Use

The Siak River is a large river approximately 125 m wide and at the proposed location of the intake and temporary jetty is at an elevation of approximately 10 m aMSL. Yuliati *et. al.* (2017) note that it is one of the four main rivers in Riau Province and it is the deepest river in Indonesia. It is characterised as a blackwater river that contains humic acid compounds from the leaching of surrounding peat soils. The river is over 100 km from the sea so is not expected to be tidally influenced at this location especially with no saltwater ingress. Yuliati *et. al.* (2017) studied the tidal influence on water quality in the river and concluded that the maximum point of saline impact on the water was located well downstream (over 80 km) from the power plant and over 40 km from the end of the pipeline route This is also reflected in the fish species that have been found which are mostly freshwater only species. There is evidence of tidal influence on the water levels in proximity to the project area with the freshwater backing up in the river and this impact was observed by Yuliati *et. al.* (2017) as far upstream as Pekanbaru above the project area. Both the Siak River and Tenayan River are used as a source of fish for food by locals.

Yuliati *et. al.* (2017) note that the Siak River is a national strategic river used for navigation, transportation, fishing and a source of raw water for industries. The river is frequently used for transportation by a range of commercial boats and tankers. These boats carry people and cargo up and down the river using various jetties and structures along the river to load and offload people and products. In proximity to the Project there is a jetty associated with the existing Tenayan CFPP and then upstream in Pekanbaru, the largest town on the river, there are a large number of wharfs, jetties and terminals which demonstrate the frequency and regular use of the river for transport.

The Siak River has a gentle grade and is a wide deep channel. The banks contain a range of mud banks and trees/shrubby vegetation (see Figure 3.18, Figure3.19 and Figure 3.20). The water is visually turbid and brown. Three cross sections have been taken across the river with widths ranging from 121 to 125 m and maximum depths from 10.8 to 12.8 m. Therefore, the river is similar upstream and downstream of the proposed Project area.

Figure 3.18 : Siak River in Proximity to Water Quality Sample Sites

Figure 3.19 : Siak River at Location of Cross Section C-C1

Figure 3.20 : Siak River at Location of Proposed Temporary Jetty

The Tenayan River is smaller than the Siak River being approximately 10 m wide in the vicinity of the upstream sample point and 15 m at the downstream point near its confluence with the Siak River. The river is generally brown and turbid (Figure 3.21) with some bankside tree/shrubby vegetation in a thin strip along the river. The wider area beyond the river bank is generally palm oil plantation.

Figure 3.21 : Tenayan River at Downstream Sample Point

The main watercourse that will be crossed by the pipeline route is the Gasib River. Monitoring site RW-02 is located on the main stem of this at the proposed crossing point (Figure 3.22). At this location the river was measured in February 2018 as being 18 m wide and 2.6 m deep at high tide during a cross sectional survey. The river is generally flat and slow flowing.

Monitoring site RW-01 is located on a tributary of the Gasib River close to RW-01 (Figure 3.23). This is a similarly flat and slow flowing area and was measured at high tide as being 9 m wide and 1.9 m deep.

Figure 3.22 : Gasib River at RW-02 Sample Point and Location of Proposed Gas Pipeline Crossing

Figure 3.23 : Gasib River at RW-02 Sample Point and Location of Proposed Gas Pipeline Crossing

3.6.2 Physical and Chemical Properties - Power Plant Vicinity, Siak and Tenayan Rivers

Yuliati *et. al.* (2017) noted concerns about the decline in the water quality of the Siak River due to inputs of domestic and industrial waste and reports of health effects on domestic users of the water and decreases in fish populations. Putri (2011) also noted the polluted nature of the river and concerns over its health that have resulted in the government initiating a policy to control pollution in the river with a resulting suite of programmes aiming to improve the water quality.

Yuliati *et. al.* (2017) assessed the quality of water in the lower Siak River (Palas Village in Pekanbaru City for 180 km downstream to the mouth) This data was gathered over 2015 and 2016 with a focus on understanding the differences in water quality at high and low tide. The Siak River is characterised as a blackwater river (Baun *et. al.* 2007) with high levels of dissolved organic carbon and low dissolved oxygen levels controlled in part by the influence of the tides. Their study compared the water quality to an index that identifies the pollution status of waterbodies by comparison to an established range of water quality in other relevant rivers. The following was concluded from their analysis of the water quality data:

- The pH of the black water was low in line with that found by other researchers;
- Total suspended solids were variable and elevated but generally below guidelines;
- Salinity levels in the lower river were influenced by the tide but this saline impact was not observed further upstream;
- Dissolved oxygen was low due to the high dissolved organic carbon;
- BOD and COD were observed to be elevated and likely to be sourced from industrial and other discharges;
- For nutrients, ammonia and nitrite concentrations were generally above guidelines and nitrate and phosphorous within guidelines;
- Total coliforms and oil and grease were generally within the guidelines; and
- For metals, cadmium and mercury were within guidelines and lead often elevated above the guidelines.

The overall conclusion of Yuliati *et. al.* (2017) was that the Siak River water quality was heavily polluted at all states of the tide. The data gathered for this project indicates the following:

- The water is warm, with generally elevated suspended solids and high turbidity in both wet and dry season with suspended solid concentrations higher in dry season;
- pH and DO were low in accordance with the results discussed above;
- Where guideline values exist concentrations of most parameters were within guideline values;
- Many parameters were below detection limits including most metals and organic parameters indicating reasonable water quality;
- Iron concentrations were elevated above guidelines and it is noted that in the dry season data only boron concentrations were elevated above what may be typical in rivers;
- The chemical oxygen demand was often elevated indicated organic enrichment of the water. BOD was not generally elevated in this data in contrast to published results. Faecal contamination was evident but not always above guidelines and higher in dry season conditions;
- Nutrient concentrations were generally below guidelines where they existed with some elevation of nitrogen observed above what may be expected in good quality rivers; and
- Oil and grease were elevated in the Siak River but not the Tenayan River in data gathered for this project. This may result from the regular boat traffic on the river.

Data gathered in 2010 presents a broadly similar picture with elevated suspended solids, iron, high oxygen demand and elevated microbial contaminants. Therefore, the data gathered for this project is broadly in accordance with that gathered for other projects and discussed in published reports. Overall the rivers appear to have a high sediment load and turbidity, low dissolved oxygen and pH and some elevated metals and nutrients and a higher oxygen demand. The physical and chemical results from baseline sampling was compared to the guidelines outlined in the Government Regulation No. 82 Year 2001 regarding Water Quality Management and Pollution Control Class II. For the tabulated results please refer to the Technical Report - Water Quality and Freshwater Ecology contained in Volume 5: Technical Appendices.

3.6.3 Macroinvertebrates

For the dry season sampling, three surface sediment samples were taken from three separate locations, two on the Siak River and one on the downstream end of the Tenayan River. No differentiation between sites can be made. The results indicate that there was a limited number of taxa with mainly worms, snails and clams being found (Figure 3.24 and Figure 3.25). These are more tolerant of degraded conditions and disturbance.

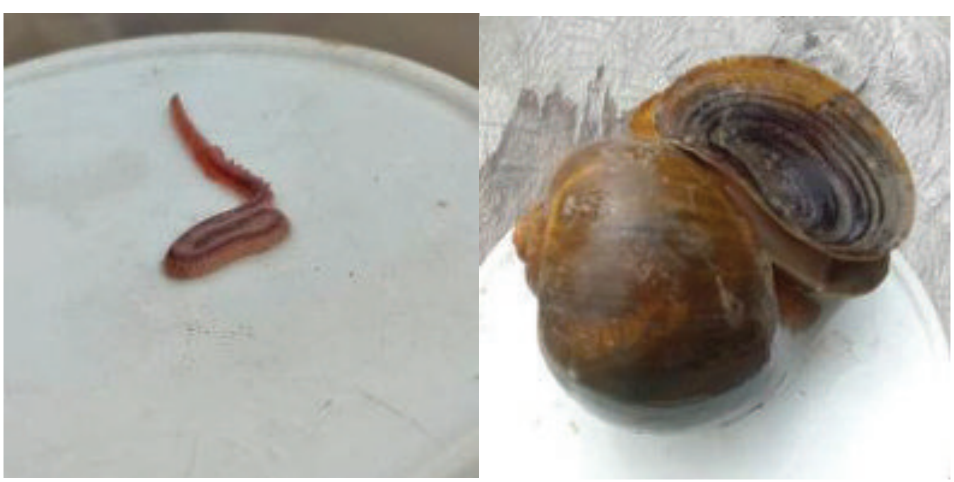


Figure 3.24 : Example of Benthic Macroinvertebrate Species Identified

Figure 3.25 : Example of Benthic Macroinvertebrate Species Identified

Samples were taken from the Siak River and the three rivers along the pipeline route in the wet season. These sites were analysed independently without compositing. Results indicate that:

- The macroinvertebrate populations in the Siak River are impoverished with low numbers of taxa and low diversity (WQ 02, 03 and 05). All three sites are impoverished with the site in proximity to the proposed jetty having the poorest macroinvertebrate ecology.
- The results indicate slightly fewer taxa than in the composite sample previously analysed however in general both indicated poor macroinvertebrate ecology.
- The two sites on the Gasib River (RW-01 and RW-02) and the results from the Pasir River (RW-03B) have greater number of taxa and better diversity than the Siak River. The tributary of the Gasib River (RW-01) and the Pasir River RW-03B have the best macroinvertebrate ecology with examples of pollution tolerant species such as mayflies and the largest diversity of any sites.
- The unnamed creek located along the gas pipeline route in an area of palm plantations had a very poor diversity with mostly midge larvae present. These are indicative of a very disturbed poor habitat areas and/or of poor water quality.

3.6.4 Fish

Fish species have been identified in both the Siak and Tenayan for dry season surveys and for wet season surveys. Overall 9 types of fish were identified in the dry season and 25 in wet season surveys.

The dry season results show that the Siak River had a greater diversity of fish species than the Tenayan River and in greater numbers. There was little difference between the upstream and downstream sites on the Siak River in terms of either species or density. On the Tenayan River there were few fish identified with none in the middle reach. The fish identified to species level were generally species that are found in freshwater systems only and were all native to this area and other areas throughout Asia.

In the wet season there was a greater number of species identified with a similar pattern of distribution with the greatest diversity of species being found in the Siak River. The smaller watercourses including the Tenayan River and Gasib River had lower numbers of fish species.

Aryani (2015) reports on fish populations within the Kampar Kanan River in Riau Province. The study identified the occurrence of 36 fish species belonging to 7 orders, 15 families and 23 genera. Among the collected species, order Cypriniformes was most dominant which is similar to the data gathered for this project. Iskandar and Dahiyat (2012) assessed potential fish populations in the Siak River based on interview methods. This identified 36 species in the Siak River with many thought to be becoming less frequently found than in the past.

These papers indicate that the fishing methods used in this study have provided results broadly in line with published information in terms of numbers of species potentially in the area.

The threat status of the fish identified has been identified with reference to the International Union for Conservation of Nature (IUCN) Red list of threatened species status. This is only possible where fish were identified to species level. One species is identified as near threatened and was found within the Siak River upstream of the proposed water intake and discharge. This is Kryptopterus minor (Siamese Glass Catfish) which is native to Indonesia, Cambodia, Malaysia, Thailand and Vietnam. It was classed as Near Threatened due to inferred population declines arising from the impact of harvesting for the ornamental fish trade and the loss and degradation of suitable habitat, especially peatland and lowland forest covered streams. The remaining species were mostly classed as of least concern or not evaluated. For the tabulated results please refer to the Technical Report - Water Quality and Freshwater Ecology contained in Volume 5: Technical Appendices.

3.6.5 Sediment Quality

Sediment quality results include samples from Siak, Tenayan and Gasib Rivers and include one sample that is a composite across the Tenayan and Siak Rivers. No relevant Indonesian sediment quality guidelines exist for comparison. Therefore, the ANZECC (2000) Guidelines were used to establish relevant sediment guidelines to characterise the environmental quality of the river sediments. The individual sample results had no parameters above guidelines indicating generally good sediment quality. The composite sample represents the general quality of the lower Tenayan River and the Siak River upstream and downstream of the project. Due to the process of compositing samples, results have been multiplied by the number of samples contributing to the composite (3). This therefore allows for a scenario where any one of the contributing composite samples could exceed the guidelines but have been diluted ay the remaining clean samples. This indicates that the surface sediments of the river contain elevated metals, specifically arsenic, cadmium, chromium, lead, mercury and nickel. Water quality data analysed above has indicated from available literature that lead, iron and boron could be in elevated concentrations with other metals below guideline concentrations. Therefore, the individual sample appear to be more representative of the overall water quality as they do not show notable elevation of metals. The results for organic contaminants were below the laboratory detection limits, however it should be noted that the detection limits were generally above the trigger levels therefore it cannot be concluded that organic contaminants are not present in concentrations that may impact on the ecological values of the waterways. For the tabulated results please refer to the Technical Report - Water Quality and Freshwater Ecology contained in Volume 5: Technical Appendices.

3.6.6 Baseline Water Quality and Freshwater Ecology Summary

Overall water quality is average from an ecological perspective with many parameters within environmental guidelines. However, there was low dissolved oxygen, low pH and high suspended sediment, turbidity levels and iron and some impacts of oil and grease and high oxygen demand. Sediment quality indicates little enrichment by metals or hydrocarbons. All river studies had broadly similar water quality. Macroinvertebrate populations in the Siak and Tenayan Rivers were generally fairly impoverished with a reasonably small range of taxa present and those that were are considered to be pollution/disturbance tolerant. A range of fish species were present, especially in the Siak River which are broadly in line with the expected numbers of species for the region. One near threatened species was present at the site upstream of the proposed intake and discharge. The data did not identify any clear differences between the upstream and downstream Siak River sample locations in dry or wet season sampling. The main difference observed between the Siak and Tenayan Rivers was the greater number of fish species observed in the Siak River. The Siak River is the primary watercourse that would be potentially impacted by project activities.

The Gasib and Pasir Rivers at the location of the proposed pipeline crossings had broadly similar water quality to the Siak and Tenayan Rivers and generally a more diverse macroinvertebrate ecology but more impoverished fishery population.

In general, this data indicates that the receiving environments are not pristine and are likely to be degraded to some extent by existing surrounding and upstream land uses and use of the rivers. Utilising the criteria within the ESIA methodology it is considered that overall the water quality and ecology of the Siak River, Gasib River, Pasir River and unnamed creek that the pipeline crosses are of low sensitivity as receptors have some capacity to absorb the project changes. This is due to the existing water quality having some capacity for change and the existing ecology already being degraded and comprising mainly more tolerant species. The presence of one near threatened fish species could indicate that the upstream site on the Siak River may be of medium sensitivity as the fish population has little capacity to absorb changes. This location is upstream of the Project area so less likely to be impacted. For the tabulated results please refer to the Technical Report - Water Quality and Freshwater Ecology contained in Volume 5: Technical Appendices.

3.7 Landscape and Visual

3.7.1 Visual Context

The following section provides a summary of the visual setting for the Project in order to determine the likely visual impacts of the development, aided by the use of 3-D modelling techniques, to provide a comparison of the existing environment and impression of the site post power plant construction.

3.7.2 The Power Plant

The Project site is located approximately 10 km east of Pekanbaru city, approximately 5 km south of the Siak River. The power plant and switchyard will be located within a 9.1 ha area of land being procured for the development by the Project sponsor Medco Ratch Power Riau (MRPR).

The habitat types present at the power plant location include; mixed garden species; palm plantation; open areas; former cultivation areas; small rubber plantations and areas of secondary growth. There are no dwellings located on the site. The project location within a wider geographical context is shown in Figure 3.26 below.

Figure 3.26 : Project Location

Figure 3.27 : Palm Oil Plantation Within Project Site (Source: Tenayan Environmental and Social Baseline Study Report)

3.8 Natural Hazards and Vulnerability to Climate Change

3.8.1 Earthquakes

Indonesia is located in a tectonically active area being surrounded by three major tectonic plates. Indonesia overall is therefore considered an earthquake prone region. Seismic history in Indonesia, including Riau Province, is shown in Figure 3.28 below. Figure 3.28 shows the occurrence of past significant earthquakes around Sumatra that have been recorded between 1650 – 2018. The majority of these earthquakes are concentrated along the southern and western edge Indonesia and not in the vicinity of the project site. There is no submarine trench north of the Island of Sumatra and very few significant earthquakes are expected north or immediately east of Riau Province. The main hazards associated with earthquakes are shaking and liquefaction.

Figure 3.28 : Seismic History in Indonesia (NGD/WDS, 2018)

3.8.2 Tsunami

Due to being located in a seismically active area Indonesia has a history of Tsunami's. Most notably, the 20 December 2004 tsunami caused as a result of a large earthquake within the Indian Ocean and resulting in 150,000+ casualties most on the western side of Sumatra. Tsunami observations from 1650 – 2018 in the vicinity of Sumatra are shown in Figure 3.29 below which indicates tsunamis are concentrated along the western and southern trenches in the areas of high seismic activity. There are no recorded observations of a tsunami to the north of Riau.

Figure 3.29 : Tsunami History in Indonesia (NGD/WDS, 2018)

Due to being a tectonically active region Indonesia contains a number of active volcanoes. The volcanos are concentrated along plate subduction zones to the south and west of Indonesia. Figure 3.30 below shows the location of significant volcanic eruptions in Indonesia from 1650 – 2018, noting that there has been no volcanic activity in the immediate vicinity of the project site. The main hazards associated with volcanic eruptions are lahar, lava and airfall deposits.

The nearest active volcano to the Riau CCPP site is Marapi being approximately 165 km to the south-west of the project site. Marapi is a stratovolcano rising 2,000 m above the Bukittinggi plain in the Padang Highlands and more than 50 eruptions, of small to moderate explosive activity, have been recorded since the end of the 18th century (SIGVP, 2018). No lava flows have been reported outside the summit crater.

Figure 3.30 : Volcanic Eruption History in Indonesia (NGD/WDS, 2018)

3.8.3 Forest Fires

Sumatra and the Riau Province are generally vulnerable to forest fires. Rather than being naturally caused, the forest fires are often caused by people undertaking clearance of vegetation via the slash and burn technique to create productive land, despite it being illegal. When this occurs during dry weather conditions, the blazes often become out of control and threaten villages and public health from smoke inhalation and require evacuations. El Niño Southern Oscillation (ENSO) climate conditions causes dryer weather and increases the risk of uncontrolled forest fires and burning peatlands.

3.8.4 Flooding

Heavy rainfall and associated flood events are a common natural hazard within Indonesia. Settlements built in low lying areas and in close proximity to rivers are particularly at risk of flood water inundation. As recently as December 2017 the Siak River flooded parts of Pekanbaru affecting in 3,567 households or 10,887 people (The Jakarta Post, 2018). See Hydrology baseline in Section 3.5 for further information on flood risk.

3.8.5 Landslides

Landslides are a common natural hazard throughout Indonesia with landslides occurring every year and causing loss of life, damage to property and productive land. The risk of a landslide occurring generally increases in steeper areas that receive high rainfall, with the risk exacerbated by forest clearance and the monsoon season between October and April. The landslide risk in the Riau region is classified as Low to Very Low in the vicinity of Pekanbaru (refer to Figure 3.31).

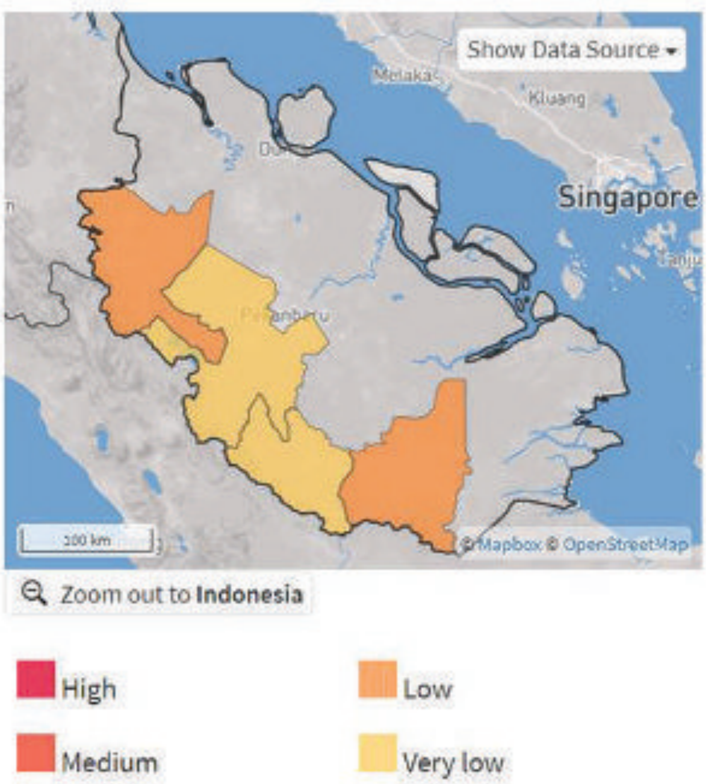


Figure 3.31 : Landslide Hazard Risk (Source: ThinkHazard, 2018(a))

3.8.6 Vulnerability to Climate Change

Climate change, namely sea level rise, has the potential to have widespread impacts on island nations such as Indonesia in the future, with low lying coastal areas to be most affected. The power plant site is located approximately 125 km inland and is approximately 17 m aMSL. As such, sea level rise will not pose a risk to the project site.

3.8.7 Tropical Cyclones

Indonesia is often subject to tropical cyclones which form over the warm oceanic waters near the equator. Tropical cyclones can result in high winds, storm surges, heavy rainfall, flooding and landslides. Coastal regions are most vulnerable to the impacts from tropical cyclones due to them deriving their energy from warm water, and weakening relatively quickly when they track over land. The risk of a tropical cyclone impacting the Riau region is identified as being 'Very Low' (refer to Figure 3.32) with the majority of cyclones impacting the southern and eastern areas of Indonesia (ThinkHazard, 2018). Indonesia experiences tropical cyclones ranging in intensity from category 1 to the largest category 5 cyclones.

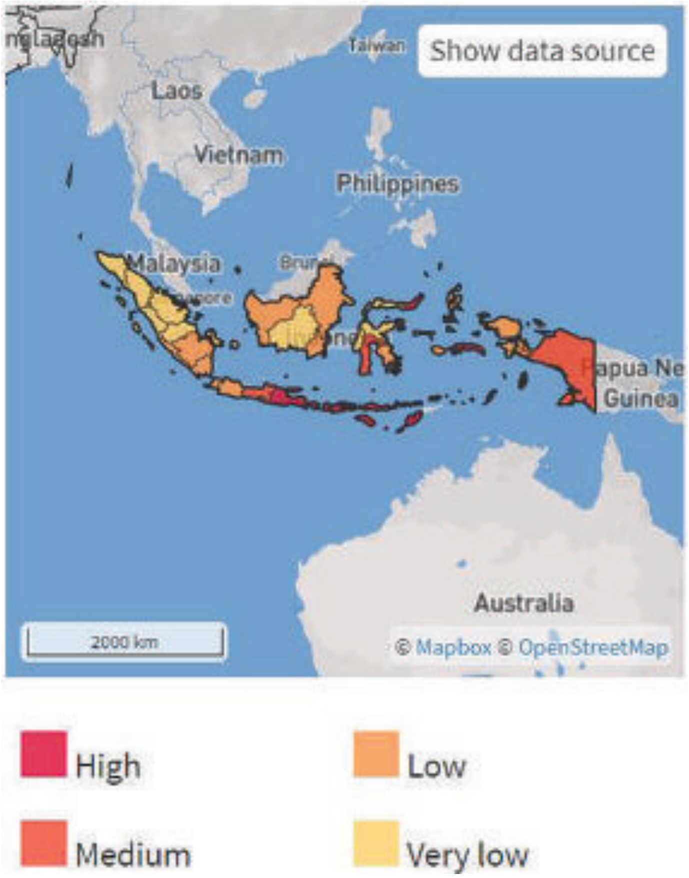


Figure 3.32 : Tropical Cyclone Risk Indonesia (Source: ThinkHazard, 2018(b))

3.9 Noise

3.9.1 Acoustic Character of Surrounding Area

Noise levels were measured at locations representative of the nearest built up areas over several days during September and October 2017 and January (dry season) to February 2018 (wet season). Noise monitoring was conducted in accordance with Indonesian Standards (State Minister of Environment Decree No 48) and the monitoring period was extended to a minimum of 48 hours continuously at the power plant site in accordance with WBG EHS Guidelines. The ambient noise levels were recorded continuously for a one-hour period during representative time intervals and comments against identifiable noise influences were noted during the noise survey. Typically, the noise sources in the area were as follows:

Day time – Residential Areas

- Noise from traffic activity;
- Residential noise (children, talking, televisions, radios);
- Birds; and
- Dogs.

Night time – Residential Areas

- Noise from traffic activity;
- Dominant noise from crickets and other nocturnal insects;

- Generators;
- Crickets; and
- Occasional birds.

Monitoring locations are presented visually in Figure 3.33 below and the results are provided in Table 3.13.

3.9.2 Noise Catchment Areas

The area surrounding the proposed Riau CCPP has been divided into Noise Catchment Areas (NCAs). These areas have been presented in Table 3.20 and graphically in Figure 3.33 and have been defined according to the likely noise environment in the area.

Table 3.12 : Description of NCAs

Noise Catchment Area	Description
NCA 1	The immediate vicinity of the Riau CCPP
NCA 2	Semi-rural receivers on the eastern outskirts of Pekanbaru
NCA 3	Suburban receivers in eastern Pekanbaru
NCA 4	Palm oil plantations
NCA 5	Township near the intersection of Jl Baru Bakal and Jl Pemda
NCA 6	Properties along Jl Ferry Pinang Sebatang

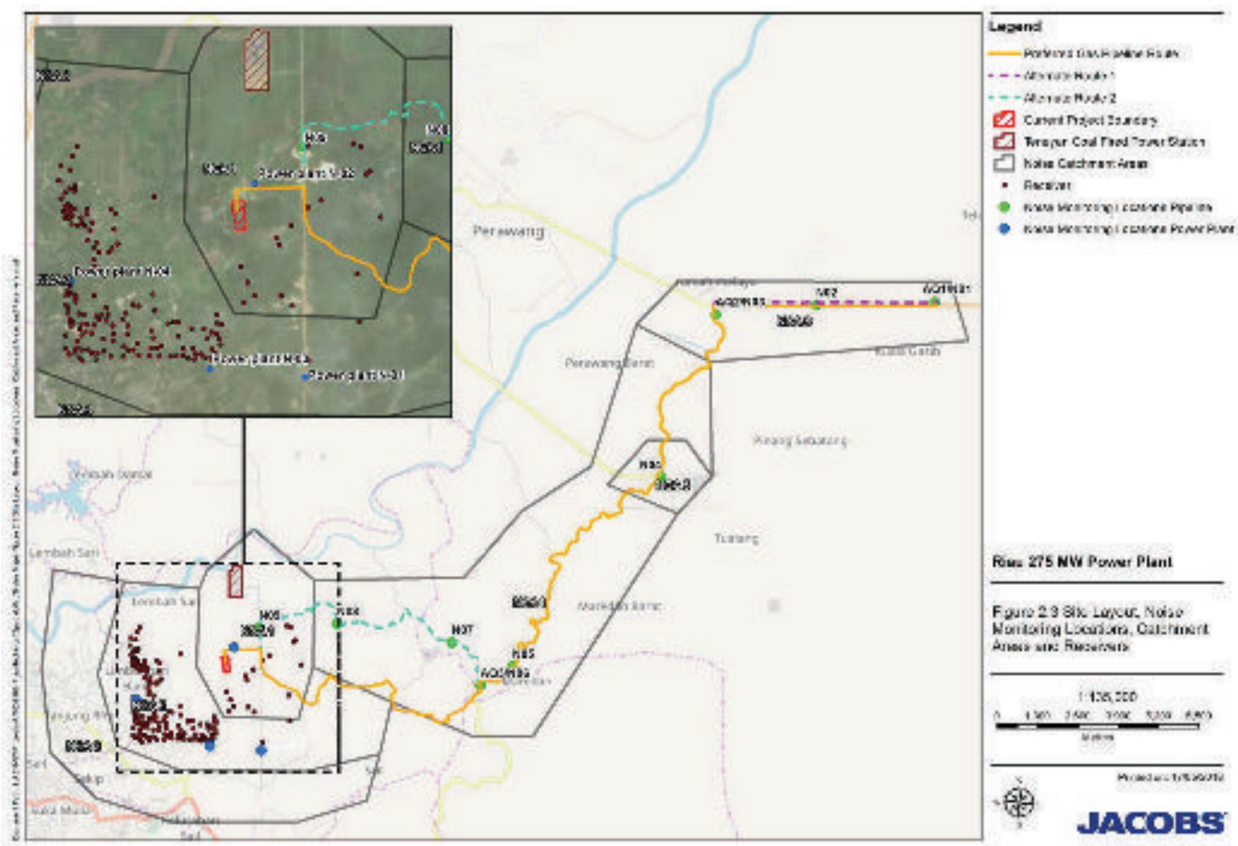


Figure 3.33 : Site Layout Noise Monitoring Locations and Catchment Areas and Receivers

3.9.3 Monitoring Results

The results of monitoring at each location are summarised in Table 3.13 below. Noise monitoring was carried out at each site during periods where noise impacts may be experienced. For the gas pipeline route, noise impacts may be associated with daytime construction work only, while at for receivers potentially affected by power station noise, results are presented for each time interval of the 24-hour monitoring period and for the overall Ls (Daytime), Lm (Night time) and Lsm (24 hour) periods.

Table 3.13 : Noise Monitoring Results

Study area	Location	NCA	Monitored noise level (LAeq period)							Overall noise level			World Bank Parameters	
			L1	L2	L3	L4	L5	L6	L7	Ls	Lm	Lsm	Day	Night
			6am-9am	9am-11am	2pm-5pm	5pm-10pm	10pm-12am	12am-3am	3am-6am				(7:00 to 22:00)	(22:00 to 7:00)
Pipeline	PL01	6	-	57	-	-	-	-	-	-	-	-	-	-
	PL 02	6	-	62	-	-	-	-	-	-	-	-	-	-
	PL03	6	-	71	-	-	-	-	-	-	-	-	-	-
	PL 04	5	-	67	-	-	-	-	-	-	-	-	-	-
	PL 05	4	-	72*	-	-	-	-	-	-	-	-	-	-
	PL06	4	-	62	-	-	-	-	-	-	-	-	-	-

Study area	Location	NCA	Monitored noise level (LAeq period)							Overall noise level			World Bank Parameters	
			L1	L2	L3	L4	L5	L6	L7	Ls	Lm	Lsm	Day	Night
	PL 07	4	-	53	-	-	-	-	-	-	-	-	-	-
	PL 08	4	-	37	-	-	-	-	-	-	-	-	-	-
	PL 09	1	-	45	-	-	-	-	-	-	-	-	-	-
Power station	PS 01	2	61	50	58	49	52	47	44	56	49	55	54	55
	PS 02	1	61	53	62	57	59	62	61	59	61*	59	60	59
	PS 03	2	58	57	60	62	59	56	51	59	56	58	58	58
	PS 04	2	54	57	56	43	46	41	46	53	45	51	49	51

* These results appear to be unrealistically high and may indicate interference from a localised noise source

Audio recording at proposed power plant sites indicated that existing background noise levels were influenced by birds, local traffic and residential noise (including diesel generators) during daytime and evening hours and crickets during night time hours. Background noise levels along the pipeline route are controlled by the proximity of the monitoring site to local roads and the local density of residential properties.

3.9.4 Topography

The local topography and terrain is important in the consideration of noise propagation to other locations adjacent to the site. In the area of interest around the proposed power plant, the land is generally flat, with regular, low rolling hills.

The terrain is typically thickly vegetated with palm oil plantations and interspersed with small dirt roads. Over these large distances, acoustic absorption through these plantations may be significant and land usage has been accounted for in the modelling of noise impacts for the proposal.

3.10 Terrestrial Ecology

3.10.1 Introduction

The terrestrial ecology data was collected on two occasions to encompass the dry and wet seasons to allow an objective assessment of the value of the habitat within the project area for terrestrial ecology.

3.10.2 Dry Season Survey

Habitats

Three survey plots (20 x 100 m) were set up adjacent to the power plant site. The surveys could not be conducted on the actual site because the Project sponsors, MRPR, could not gain access to that land prior to completion of the land acquisition process. The actual areas surveyed were selected as they are determined to be representative of the receiving environment within the power plant site. The plots were located to provide a representation of the ecosystems present within the construction site area as set out in Table 3.14. Within each survey plot data was collected as follows:

- 20 10 x 10 m sub plots were surveyed for trees; and
- 20 5 x 5 m sub plots surveyed for saplings.

In each sub plot the trees and saplings were identified, a voucher specimen was taken and the relative frequency (FN), relative dominance (DN), relative density (KN), and important value index (INP) were calculated by using Curtis (1959) method (Dombois-Ellenberg 1974). Trees and Saplings INP were obtained from the sum of FN, DN, and KN. The species diversity index (H ') and the species evenness index (E) in the plot were calculated by Shannon method (Magurran, 1988).

Table 3.14 : Locations, Co-ordinates, Administrative areas, and Land Coverage of Each Sample Plot

Location	Co-ordinate	Village	District	Regency	Land Use
TR1	00°32'28" LU; 101°31'11" BT	Industri Tenayan	Tenayan Raya	Pekanbaru	Palm Plantation
TR2	00°32'07 LU; 101°31'31" BT	Industri Tenayan	Tenayan Raya	Pekanbaru	Palm Plantation
TR3	00°32'25,2" LU; 101°31'10,1" BT	Industri Tenayan	Tenayan Raya	Pekanbaru	Palm Plantation Shrubs

Note: Co-ordinate used is an approximation for TR2

Fauna

The transmission line and area to the north of the proposed Riau CCPP site were surveyed between 19th July and 1st August 2017 by recording the birds, herpetofauna and mammals observed while walking three transects. The location of the transects is set out in Table 3.15 and shown in Figure 3.34 below.

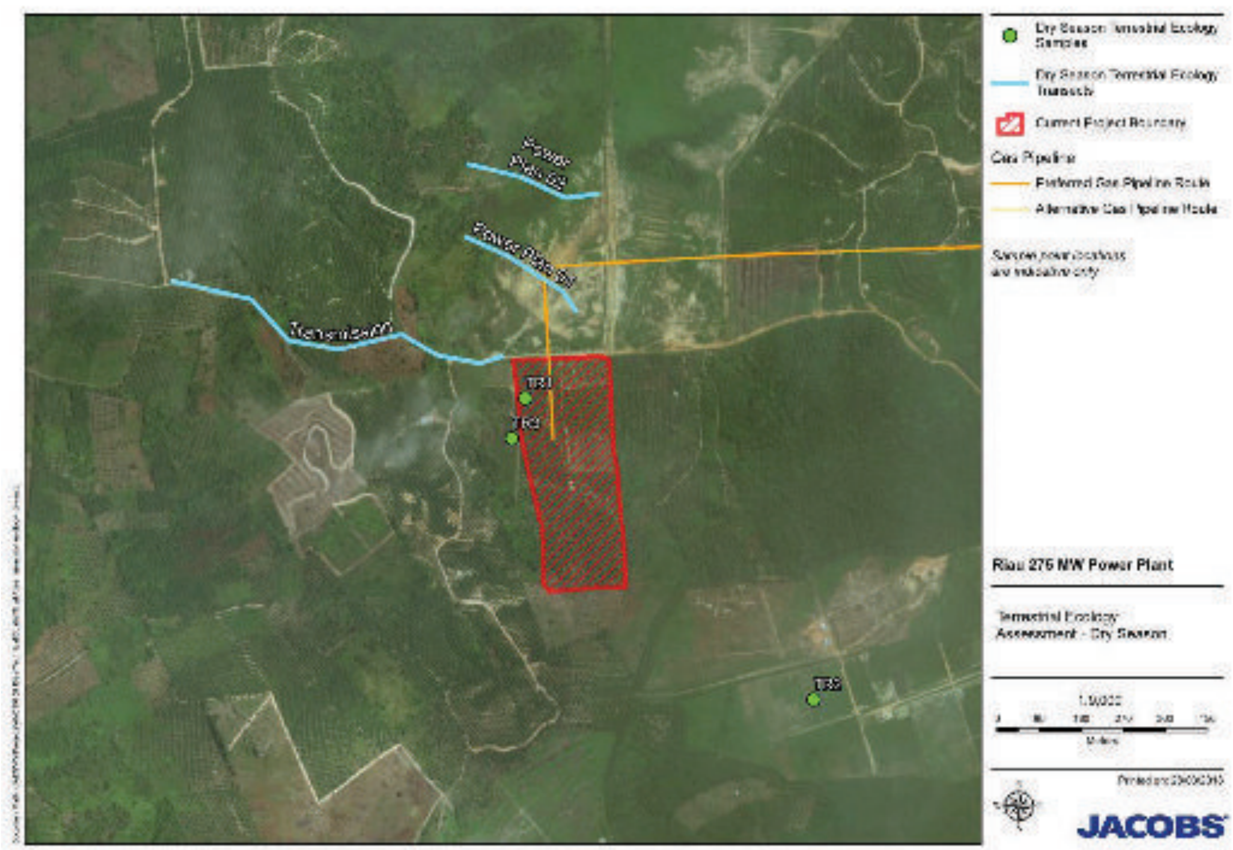


Figure 3.34 : Location of Transects

The bird surveys were carried out within four hours of sunrise and included census points along the transect line. At each census point a 20-minute survey to count all bird species visible and heard within a 50 m radius was carried out. The surveys for herpetofauna and mammals were conducted by recording any species or evidence of species observed long the transect.

Table 3.15 : Line Transect Co-ordinates

No.	Transect ID.	Co-ordinate Start		Co-ordinate End		Length of Transect (m)
		Latitude	Longitude	Latitude	Longitude	
1	Transmission Line	0°32'30.98” U	101°31'9.52” T	0°32'36.22” U	101°30'46.44” T	700
1	Power Plan 01	0°32'34.00” U	101°31'14.61” T	0°32'39.32” U	101°31'6.79” T	300
2	Power Plan 02	0°32'42.28” U	101°31'16.20” T	0°32'44.37” U	101°31'6.98” T	300

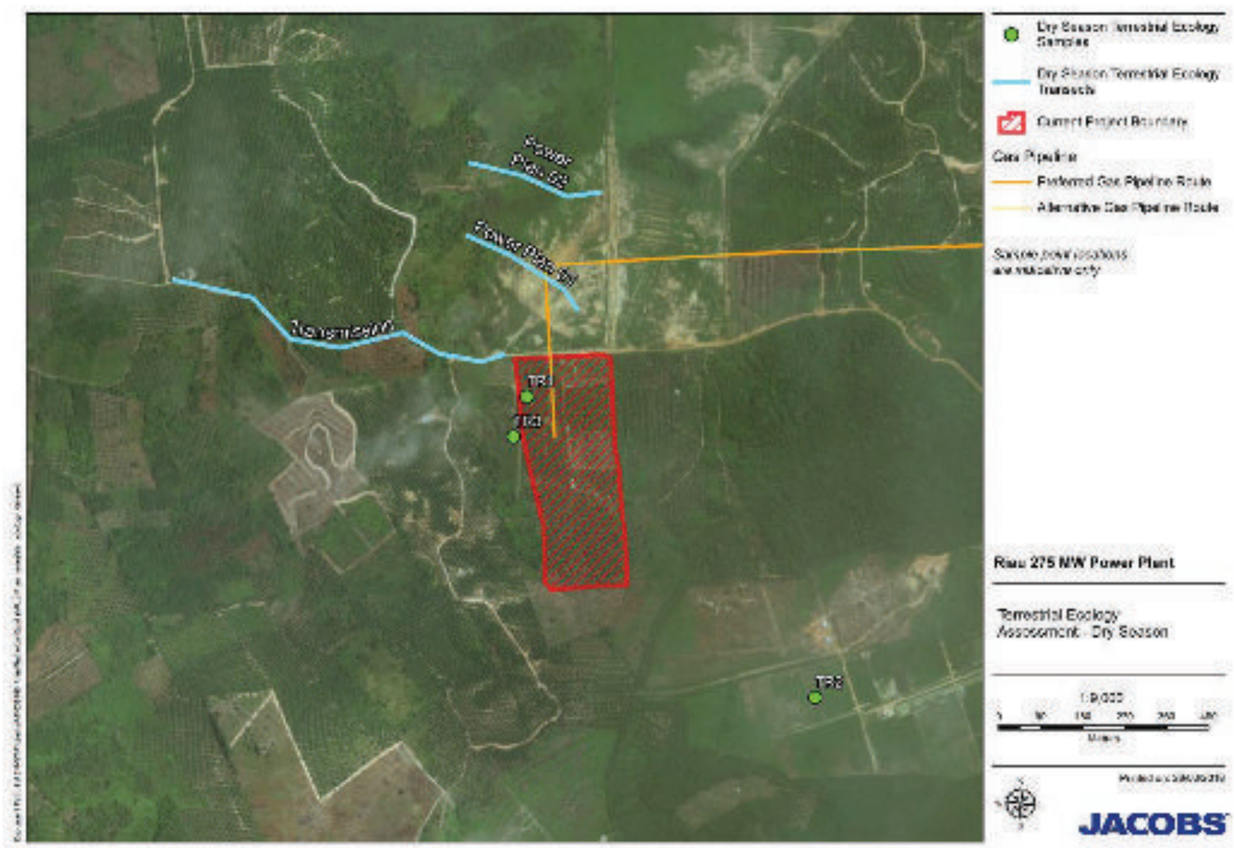


Figure 3.35 : Location of Dry Season Transects

3.10.3 Wet Season Survey

The Project area was surveyed at the locations shown in Table 3.16, Table 3.17 and Figure 3.36 between the 22nd and 31st January 2018.

Table 3.16 : Location of Wet Season Vegetation Survey Transects

Location	Code/ref	Administration area
1. Gas Pipeline Route		
1.1 side of paved highway		
Section 1 (1-5 km)	1.1.1a	Ds. Kuala Gasib, Kec. Koto Gasib, Siak Regency
	1.1.1b	Ds. Kuala Gasib, Kec. Koto Gasib, Siak Regency
Section 2 (6-10 km)	1.1.2a	Ds. Pinang Sebatang, Kec. Tualang, Siak Regency

Location	Code/ref	Administration area
	1.1.2b	Ds. Pinang Sebatang, Kec. Tualang, Siak Regency
Section 3 (11-15 km)	1.1.3	Ds. Tualang Timur, Kec. Tualang, Siak Regency
Section 4 (16-20 km)	1.1.4	Ds. Tualang Timur, Kec. Tualang, Siak Regency
Section 5 (21-25 km)	1.1.5	Ds. Meredan, Kec. Tualang, Siak Regency
1.2 side of unpaved highway		
Section1 (1-5 km)	1.2.1a	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
	1.2.1b	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
Section 2 (6-10 km)	1.2.2a	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
	1.2.2b	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
Section 3 (11-15 km)	1.2.3a	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
	1.2.3b	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
2 CCPP site and water pipe footprint		
2.1 CCPP site footprint		
Power plant	2.1a	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
Power plant	2.1b	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
Power plant	2.1c	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
Transmission line	2.2	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
3. Water pipeline		
Sample site 1	3.1	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City
Sample site 2	3.2	Kelurahan Mlebung, Kec. Tenayan Raya, Pekanbaru City

Table 3.17 : Location of Wet Season Fauna Survey Transects

Location	Code / ref	Data collected (direct and indirect evidence)
Transects on gas pipeline route at road section	TR1 - TR5	Birds, Reptiles, Mammals
Transect on gas pipeline route at unpaved section	UP1 - UP3	Birds, Reptiles, Mammals
Transect on CCPP site and surrounding area	PS1 - PS3	Birds, Reptiles, Mammals
Transect on water pipeline route	WI1 - WI2	Birds, Reptiles, Mammals
Listening point 1 to 8 at gas pipeline route	LP1 - LP8	Amphibians
Listening point at CCPP and surrounding area	LQ1 - LQ2	Amphibians
Listening points at water pipeline route	WL1 - WL2	Amphibians

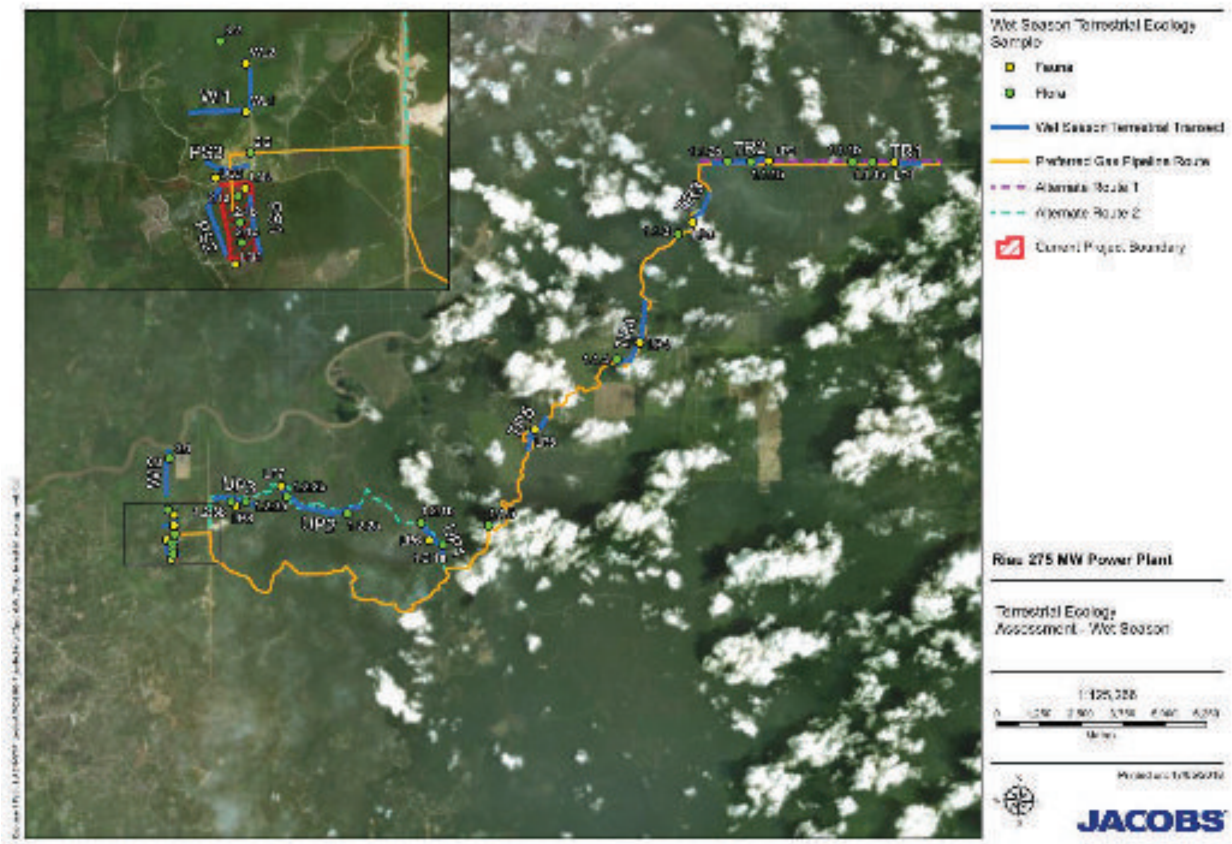


Figure 3.36 : Location of wet season transects

Results

There are no legally protected areas of conservation concern or areas of conservation interest within a 5 km radius of the Project area. Sumatra is listed as one of the WWF Critical Regions of the World (World Wide Fund for Nature (WWF), n.d.). The nearest Important Bird Areas (Birdlife International, 2018) are between 50 and 100 km north, south and east of the project area. The Tesso Nilo National Park is approximately 75 km south of the project area.

Detailed results of the wet season survey work completed at the Riau CCPP site and along the proposed gas pipeline are set out within the results section below. Figure 3.37 below provides an overview of the land use in the Project area.

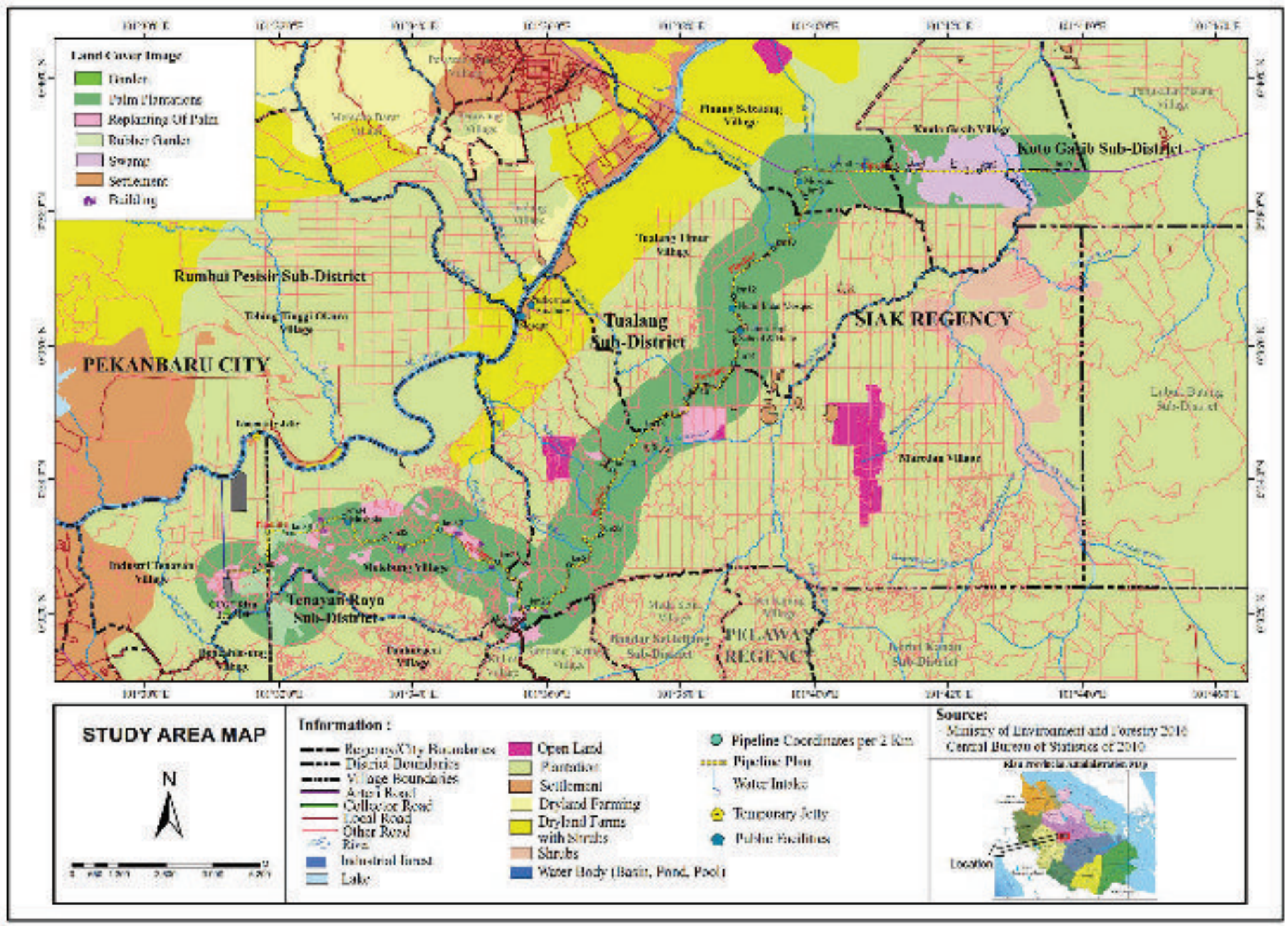


Figure 3.37 : Land Uses within the Project Area

3.10.4 Habitats

3.10.4.1 Dry Season Sampling

The habitat covering the Riau CCPP site was primarily palm oil plantation. TR1 and TR2 were well maintained African oil palm (*Elaeis guineensis*) plantations (Figure 3.38), while TR3 was unmaintained and included a greater proportion of other species (Figure 3.39). Table 3.18 provides a summary of the species recorded in each of the plots and illustrates the dominance of the African oil palm in all three plots.

Table 3.18 : Important Values Index (INP ≥10%) the Main Types of Trees and Saplings for Each Plot on the Riau CCPP Site

No.	Species Name	Tree			Sapling		
		TR-1	TR-2	TR-3	TR-1	TR-2	TR-3
1	*Acacia mangium*	-	8.0	40.6	-	-	17.0
2	*Alstonia angustiloba*	-	-	16.2	-	-	26.6
3	*Aporosa arborea*	-	-	-	-	-	11.6
4	*Archidendron ellipticum*	-	-	-	-	-	21.4
5	*Archidendron jiringa*	-	13.2	-	-	-	-
6	*Artocarpus dadak*	-	-	-	-	-	15.1
7	*Artocarpus elasticus*	-	-	16.5	-	-	31.6
8	*Artocarpus integer*	-	-	-	-	-	26.9
9	*Elaeis guineensis*	292.5	278.8	210.5	-	-	10.1
10	*Ficus variegata*	-	-	-	-	-	14.8
11	*Nephelium rubescens*	-	-	-	-	-	13.5
12	*Paropsia vareciformis*	-	-	-	-	-	21.3
Total number of species recorded in plot		**1**	**3**	**4**	**0**	**0**	**11**

Figure 3.38 : Oil Palm Plantation Within TR1

Figure 3.39 : Unmaintained Oil Palm Plantation Within TR3

3.10.4.2 Wet Season Sampling

The detailed list of species recorded at each of the sample sites as set out in Table 3.19 provides a summary of the numbers of species recorded at each sample site and an indication of the predominant habitat type.

Table 3.19 : Summary of the Wet Season Flora Survey

Code/ref	Habitat type	No. of Sapling species recorded	No of mature tree species recorded	Species with IUCN status recorded
1. Gas pipeline route				
1.1.1a	Secondary swamp forest	7	3	*Alstonia spatulata Blume* (Least concern)
1.1.1b	Secondary swamp forest	10	19	*Maranthes corymbosa Blume* (Least concern)
1.1.2a	Swamps adjacent to Lake Abdullah	25	10	*Elaeis guineensis Jack. (Least concern)* *Nephelium lappaceum L* (Least concern)
1.1.2b	Rubber and palm oil plantations, mixed with natural species	22	13	*Elaeis guineensis Jack. (Least concern)*
1.1.3	Secondary forest	32	21	*Afzelia rhomboidea (Blanco) S. Vidal* (Vulnerable)
1.1.4	Rubber plantation	15	22	*Afzelia rhomboidea (Blanco) S. Vidal* (Vulnerable) *Nephelium lappaceum L* (Least concern)
1.1.5	Oil palm and secondary forest	30	19	Anisoptera marginata Korth. (Endangered) *Anisophyllea disticha (Jack) Baill*. (Least concern) *Elaeis guineensis Jack. (Least concern)*
1.2.1a	Rubber plantation	2	1	
1.2.1b	Jabon plantation (burrflower tree)	3	2	
1.2.2a	Palm oil plantation	0	1	*Elaeis guineensis Jack. (Least concern)*
1.2.2b	Palm oil plantation	0	1	*Elaeis guineensis Jack. (Least concern)*
1.2.3a	Palm oil and Jabon plantation	0	2	*Elaeis guineensis Jack. (Least concern)*
1.2.3b	Palm oil plantation	0	1	*Elaeis guineensis Jack. (Least concern)*
2.1 CCPP site footprint				
2.1a	Palm oil plantation	0	4	*Elaeis guineensis Jack. (Least concern)*
2.1b	Palm oil plantation	0	1	*Elaeis guineensis Jack. (Least concern)*
2.1c	Palm oil plantation	0	1	*Elaeis guineensis Jack. (Least concern)*
2.2 Transmission line				
2.2	Bush/scrub	18	8	*Afzelia rhomboidea (Blanco) S. Vidal* (Vulnerable)
3. Water pipeline				
3.1	Rubber plantation and scrub	30	13	*Nephelium lappaceum L* (Least concern) Santiria apiculata A.W. Benn (Least concern)
3.2	*Acacia mangium* (forest mangrove) stands	15	1	*Afzelia rhomboidea (Blanco) S. Vidal* (Vulnerable)

The sample results indicated that the majority of the species recorded are not included within the IUCN conservation status framework. The sample transect that included species that have been assessed by IUCN are highlighted in Table 3.19 along with the species and conservation status.

The areas that appear to have the greatest species diversity were alongside the gas pipeline route (Transects 1.1.1 to 1.1.5) and the water pipeline route (3.1 and 3.2). These areas appear to provide a more natural habitat, although are considered likely to be modified (IFC, 2012) given the presence of oil palm, rubber and timber/lumber species. The sample sites within Riau CCPP site and along the gas pipeline route adjacent to the unpaved roads were either oil palm or jabon plantation and had very limited species diversity.

The wet season data was collected over the wider project area and based on a comparison of what was collected within the Riau CCPP site during the wet and dry season is considered to provide an appropriate representation of the habitats present.

3.10.5 Fauna

3.10.5.1 Dry Season Sampling (Power Plant)

The species observed during the survey visits are set out in Table 3.20, Table 3.21 and Table 3.22. The majority of species recorded had an IUCN conservation status of Least Concern. Two species with Near Threatened conservation status were recorded, a long tailed parakeet (*Psittacula longicauda)* and a silvery lutung (*Trachypithecus cristatus).* Both of these species are considered by IUCN as Near Threatened because of the extensive habitat loss (deforestation) that has occurred within their range.

The species recorded reflect the habitat type, freshwater swamp forest, that was naturally occurring in the locality and has now been cleared to establish oil palm plantations. It is considered likely that these species have shown some resilience to this habitat change and have managed to adapt to some extent to the modified environment, possibly exploiting any fragments of more natural habitat present.

The following key applies to all of the following results tables:

Conservation Status IUCN

LC Least Concern

NT Near Threatened

VU Vulnerable

EN Endangered

CR Critically Endangered

Protection: PP No. 7 Tahun 1999

DL Protected

Abundance

1 One encounter

J Seldom found (2-5 times encounter)

TU Not common (6-10 times encounter)

U Commonly found (11-20 times encounter)

M Abundance (> 20 times encounter)

Table 3.20 : Bird Species Recorded During the Transect Visits

Scientific name	Common name	IUCN conservation status	PP-7/1999	Abundance
Spilopelia chinensis	Spotted dove	LC		M
Geopelia striata	Zebra dove	LC		M
Pycnonotus goiavier	Yellow-vented bulbul	LC		M
Pycnonotus aurigaster	Sooty-headed bulbul	LC		M
Parus major	Great tit	LC		U
Orthotomus atrogularis	Dark-necked tailorbird	LC		U
Prinia flaviventris	Yellow-bellied prinia	LC		U
Dicaeum trochileum	Scarlet-headed flowerpecker	LC		U
Lonchura striata	White-rumped munia	LC		U
Lonchura leucogastra	White-bellied munia	LC		U
Lonchura malacca	Tricoloured munia	LC		U
Spilornis cheela	Crested serpent eagle	LC	DL	TU
Amaurornis phoenicurus	White-breasted waterhen	LC		TU
Centropus sinensis	Greater coucal	LC		TU
Centropus bengalensis	Lesser coucal	LC		TU
Caprimulgus affinis	Savanna nightjar	LC		TU
Halcyon smyrnensis	White-throated kingfisher	LC	DL	TU

Scientific name	Common name	IUCN conservation status	PP-7/1999	Abundance
Todiramphus chloris	Collared kingfisher	LC	DL	TU
Orthotomus ruficeps	Ashy tailorbird	LC		TU
Prinia familiaris	Bar-winged prinia	LC		TU
Rhipidura perlata	Spotted fantail	LC		TU
Cinnyris jugularis	Olive-backed sunbird	LC	DL	TU
Lonchura maja	White-headed munia	LC		TU
Nisaetus cirrhatus	Changeable hawk-eagle	LC	DL	J
Treron vernans	Pink-necked green pigeon	LC		J
Psittacula longicauda	Long-tailed parakeet	NT	DL	J
Cacomantis merulinus	Plaintive cuckoo	LC		J
Cacomantis sepulcralis	Rusty-breasted cuckoo	LC		J
Surniculus lugubris	Square-tailed drongo cuckoo	LC		J
Caprimulgus macrurus	Large-tailed nightjar	LC		J
Collocalia fuciphaga	Edible-nest swiftlet	LC		J
Collocalia esculenta	Glossy swiftlet	LC		J
Alcedo atthis	Common kingfisher	LC	DL	J
Dendrocopos moluccensis	Sunda pygmy woodpecker	LC		J
Hirundo tahitica	Pacific swallow	LC		J
Lalage nigra	Pied triller	LC		J
Corvus enca	Slender-billed crow	LC		J
Gerygone sulphurea	Golden-bellied gerygone	LC		J
Rhipidura javanica	Malaysian pied fantail	LC		J
Anthreptes malacensis	Brown-throated sunbird	LC	DL	J
Dicaeum trigonostigma	Orange-bellied flowerpecker	LC		J
Zosterops palpebrosus	Oriental white-eye	LC		J

The bird species encountered included a number of species listed on PP No. 7 Tahun 1999. All of the species were considered to have a conservation status of least concern (IUCN, n.d.) except the long-tailed parakeet which is near threatened (IUCN, n.d.) but was seldom recorded during the survey.

Table 3.21 : Herpetofauna Recorded Along the Transects and Known in Surrounding Area

Scientific name	Common name	IUCN conservation status	Abundance
Amphibians			
Pulchrana glandulosa	Rough-sided frog	LC	M
Fejervarya limnocharis	Indian cricket frog	LC	U
Fejervarya cancrivora	Crab eating frog	LC	U
Hylarana erythraea	Common green frog	LC	U
Ingerophrynus melanostictus	Crested toad	LC	TU

Scientific name	Common name	IUCN conservation status	Abundance
Reptiles			
Varanus salvator	Asian water monitor	LC	Commonly encountered in the Siak River
Eutropis multifasciata	Many-striped skink	-	Commonly
Naja sumatrana	Equatorial spitting cobra	LC	Rarely
Dendrelaphis haasi	Haas's bronzeback tree snake	LC	Rarely
Dendragama boulengeri	Boulenger's tree agama	-	Rarely

All of the herpetofauna species encountered during the survey work where considered to be of least concern (IUCN, n.d.) and generally associated with the wetter parts of the survey area, particularly closer to the Siak River.

Table 3.22 : Mammals Recorded Along the Transects and Known in the Surrounding Area

Scientific name	Common name	IUCN conservation status	Abundance
Callosciurus notatus	Plantain Squirrel	LC	U
Trachypithecus cristatus	Silvery Lutung	NT	TU

The power station site and transmission line survey transects only recorded two mammal species. The silvery lutung is considered to be near threatened by IUCN because of extensive habitat loss within its range although it does appear to be able to adapt to some extent to living within modified areas. The plantain squirrel was commonly recorded within survey area and is considered to be adaptable and in some areas an agricultural pest (IUCN, n.d.).

3.10.5.2 Wet Season Sampling (Power Plant, Water Pipeline and Gas Pipeline)

Table 3.23, Table 3.24, Table 3.25 and Table 3.26 provide a summary of the fauna recorded at each sample site.

Birds

Table 3.23 : Summary of the Abundance, Diversity and Conservation Status of Bird Species Recorded During the Wet Season Sampling

Location	Number of bird species recorded (species diversity)	Total number of individuals recorded (abundance)	IUCN status – number of species			No. of species listed on PP-7/1999
			Least concern	Near Threatened	Vulnerable	
Gas Pipeline Route						
TR1	78	572	74	2	2	12
TR2	80	604	75	4	1	12
TR3	72	411	67	3	2	12
TR4	73	487	68	3	2	10
TR5	64	189	61	2	1	10
UP1	47	86	46	1	-	7

Location	Number of bird species recorded (species diversity)	Total number of individuals recorded (abundance)	IUCN status – number of species			No. of species listed on PP-7/1999
			Least concern	Near Threatened	Vulnerable	
UP2	32	218	31	1	-	8
UP3	54	218	52	1	1	8
Riau CCPP site						
PS1	48	160	48	-	-	9
PS2	37	108	37	-	-	7
PS3	44	125	41	3	-	7
Water pipeline route						
WI1	70	289	67	2	1	11
WI2	60	181	57	2	1	10

The diversity of bird species was greatest along the transects covering the gas pipeline and water pipeline routes and this coincides with the areas of habitat that are not dominated by oil palm plantation. The IUCN vulnerable species recorded were black partridge (*Melanoperdix niger)* and Sunda-blue flycatcher (*Cyornis caerulatus*). The IUCN list that key threats to both these species is rapid habitat loss through de-forestation.

Within the Riau CCPP site, the dry and wet season data for birds recorded was relatively similar in terms of the number and types of species recorded.

Herpetofauna

Table 3.24 : Summary of the Amphibian Species Recorded During the Wet Season Sampling

SCIENTIFIC NAME	COMMON NAME	IUCN	Listening Point												
			Gas pipeline route								Riau CCPP site			Water pipeline	
			LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LQ1	LQ2	LQ3	WL1	WL2
Fejervarya limnocharis	*Indian cricket frog*	LC	23	19	7	18	14	10	19	15	5	2	4	8	5
Fejervarya cancrivora	*Crab-eating frog*	LC	15	17	5	8	7	11	6	8	1	1	1	2	1
Pulchrana glandulosa	*Rough sided frog*	LC	37	25	11	12	16	16	4	8	3	2	2	5	6
Hylarana erythraea	*Common green frog*	LC	18	10	12	9	14	26	21	21	9	6	12	13	11
Ingerophrynus melanostictus	*Crested toad*	LC	9	5	2	7	5	5	6	5	1	1	1	2	1
Number of individuals recorded (abundance)			**102**	**76**	**37**	**54**	**56**	**68**	**56**	**57**	**19**	**12**	**20**	**30**	**24**
Number of species recorded (diversity)			**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**

The amphibian species recorded were common to all of the sample sites and the same species were recorded in both the wet and dry season surveys. The abundance of individuals is likely to be linked to the habitat types present close to the listening point and therefore indicates that the areas with a greater abundance of species are likely to have more wet habitats present.

Table 3.25 : Summary of the Reptile Species Recorded During the Wet Season Sampling

SCIENTIFIC NAME	COMMON NAME	IUCN	Location												
			Gas pipeline route								Riau CCPP site			Water pipeline	
			TR1	TR2	TR3	TR4	TR5	UP1	UP2	UP3	PS1	PS2	PS3	WI1	WI2
Aphaniotis fusca	*Earless agamid*	LC	1	1	1	2	1						1	1	
Bronchocela cristatella	*Green crested lizard*	LC	2	3	1	2	1			1				1	1
Dendragama boulengeri	*Boulenger's tree agama*			1	1	1	1							1	
Dendrelaphis haasi	*Haas's bronzeback tree snake*	LC		1	1										
Eutropis multifasciata	*Many-striped skink*	LC	3	2	2	1	2	1	1	1	1	1			
Eutropis novemcarinata	*Nine-keeled skink*	LC		1	1	1	1		1		1	1	1	1	
Lygosoma (quadrupes) sp.	*Writhing skinks*			1	1	1	1						1	1	
Naja sumatrana	Equitorial spitting cobra	LC				1			1						
Tytthoscincus temmincki	*Temmincki lizard*		1	1	1	2	1	1						1	
Varanus bengalensis	*Bengal monitor*	LC		1	1	1	1		1					1	
Varanus salvator	*Asian water monitor*	LC	2	2	1						1		1	2	3
Number of individuals recorded (abundance)			**9**	**14**	**11**	**12**	**9**	**2**	**4**	**2**	**3**	**2**	**4**	**9**	**4**
Number of species recorded (diversity)			**5**	**10**	**10**	**9**	**8**	**2**	**4**	**2**	**3**	**2**	**4**	**8**	**2**

The reptile species recorded all had a least concern conservation status or had not been assessed by the IUCN (IUCN, n.d.). The species diversity varied across the sample sites with the lower values generally associated with the areas of plantation. The wet season survey data for the Riau CCPP site was similar to that recorded during the dry season.

Mammals

Table 3.26 : Summary of the Mammal Species Recorded During the Wet Season Sampling

Scientific name	Common name	IUCN	Location												
			Gas pipeline route								Riau CCPP site			Water pipeline	
			TR1	TR2	TR3	TR4	TR5	UP1	UP2	UP3	PS1	PS2	PS3	WI1	WI2
Callosciurus notatus	*Plantain squirrel*	LC	1	2	3	3	1	1			1				
Helarctos malayanus	*Sun bear*	VU			1										
Hylobates agilis	*Agile gibbon***	EN			5										
Macaca fascicularis	*Crab eating macaque*	LC	17	5	12									10	27
Macaca nemestrina	*Southern pig-tailed macaque*	VU			15	12	1							21	9
Manis javanica	*Sunda pangolin**	CR			1	1	1								
Rusa unicolor	*Sambar deer*	VU			1										
Sus scrofa	*Wild boar*	LC		3	1	1	1	1	1	1			1	1	
Trachypithecus cristatus	*Silvery lutung*	NT			17	8								12	8
Tragulus kanchil	*Lesser mouse-deer*	LC			1	1	1								

Scientific name	Common name	IUCN	Location												
			Gas pipeline route								Riau CCPP site			Water pipeline	
			TR1	TR2	TR3	TR4	TR5	UP1	UP2	UP3	PS1	PS2	PS3	WI1	WI2
Number of individuals recorded (abundance)			18	10	57	26	5	2	1	1	1	0	1	44	44
Number of species recorded (diversity)			2	3	10	6	5	2	1	1	1	0	1	4	3

*Note: All three records were indirect evidence identified as leftovers

**Note: Records were comprised of direct evidence (three visual sightings) and indirect evidence (two calls)

The survey results included both direct and indirect evidence for the species. The mammal species most abundant through the study area were the two macaque species and the silvery lutung. The diversity of species was highest at site TR3 which appears to coincide with an area of secondary forest that also had a relatively diverse number of mature and sapling trees.

Three IUCN vulnerable species, one IUCN endangered and one IUCN critically endangered species were recorded. The sunda pangolin is considered critically endangered by the IUCN (IUCN, n.d.) due to high levels of hunting and poaching for its meat and scales. The key threats to the aigle gibbon are habitat loss, primarily as a result of deforestation (IUCN, n.d.). The three vulnerable species recorded are all considered to have decreasing populations across their range as a result of habitat loss and hunting (IUCN, n.d.).

The Riau CCPP site itself recorded limited mammal interest during the wet season sampling and the this the same as recorded in the dry season.

3.10.6 Baseline Summary

The power station site was dominated by oil palm plantation and the data collected did not include any IUCN Red Listed Threatened species (Vulnerable, Threatened, Endangered or Critically Endangered).

The transmission line was dominated by bush and scrub and included the IUCN Red Listed Threatened species *Afzelia rhomboidea* (legume/tree species).

The water pipeline route passes through *Acacia mangium* (forest mangrove) stands and rubber plantation with scrub and direct evidence of a number of IUCN Red Listed Threatened species were recorded: Afzelia rhomboidea, Black partridge (*Melanoperdix niger*), Sunda blue flycatcher (*Cyornis caerulatus)* and Southern pig-tailed macaque.

The gas pipeline route could be classified in to two main types:

- the route along unpaved roads (26-40 km) was dominated by oil palm plantation with a record of the IUCN Red Listed (Vulnerable) Black partridge in transect UP3.
- the route along the paved roads 0-26 km had more varied habitats recorded including secondary forest, secondary swamp forest and rubber/ oil palm plantations with records (direct and indirect evidence) of a number of IUCN Red Listed Threatened species, *Afzelia rhomboidea, Anisoptera marginata (swamp tree species)*, Black partridge, Sunda blue flycatcher, sunda pangolin, sambar deer, sun bear, southern pig-tailed macaque and aigle gibbon,

3.10.7 Habitat Assessment

Habitats can be defined as Modified, Natural or Critical under the ADB Safeguard Policy Statement and IFC Performance Standard 6. The definitions of these habitats are detailed below.

ADB Safeguard Policy Statement

Under the ADB Safeguard Policy Statement habitats can be defined as:

- Modified Habitat: Areas where natural habitat has been altered, often through the introduction of alien species of plants and animals, such as in agricultural areas;
- Natural Habitat: Land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area's primary ecological functions.
- Critical Habitat: Critical habitat includes areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations of numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities. Critical habitats include those areas either legally protected or officially proposed for protection, such as areas that meet the criteria of the World Conservation Union classification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's world natural heritage sites.

IFC Performance Standard 6

Under the IFC Performance Standard 6 habitats can be defined as:

- Modified Habitat: Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological function and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.
- Natural Habitat: Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition; and
- Critical Habitat: Critical habitats are areas with high biodiversity value, including:
  - (i) habitat of significant importance to Critically Endangered and/or Endangered species;
  - (ii) habitat of significant importance to endemic and/or restricted-range species;
  - (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species;
  - (iv) highly threatened and/or unique ecosystems; and/or
  - (v) areas associated with key evolutionary processes.

Based on the terrestrial ecology surveys undertaken to date and as shown in Figure 3.37, the Project area comprises predominantly oil palm plantations along with lumber and rubber. On this basis and in accordance with ADB and IFC definitions set out above the Project area can be considered to be Modified Habitat. In some very discrete areas there is a mix of oil palms and native regrowth and this is also considered to be Modified Habitat. The survey results show that the area surrounding the Project contains a range of species including IUCN Red Listed Threatened species (Vulnerable, Threatened, Endangered or Critically Endangered). However, the occurrence of these species is not determined to be indicative of natural habitat that would typically support these species and therefore the overall project habitat can be considered to be Modified Habitat.

3.11 Traffic

3.11.1 Main Road

The main north-south highway extending along the spine of Sumatra (named Jl. Lintas Timur Sumatra) runs approximately 5 km south-west of the site and through the city of Pekanbaru (Figure 3.40).

Figure 3.40 : Map Showing Sumatra Highway Network and the Route from the Ports of Belawan and Dumai to the Site

It extends 2,500 km along the length of the eastern side of Sumatra from Pelabuhan Bakauheni in the far south to Banda Aceh in the north connecting the cities of Palembang, Jambi, Pekanbaru and Medan. In rural areas, the highway typically has a six-metre-wide two lane paved carriageway with no passing lanes, roadside barriers, sealed shoulders or median barriers. There is significant ribbon development scattered along the highway including retailing, residential and commercial activity. This route will be used to transport material and equipment from Belawan Port and Dumai Port to the site.

3.11.2 Local Roads

The existing road network immediately surrounding the site is shown in Figure 3.41 below.

Figure 3.41 : Map Showing Road Network Around the Power Plant Site

Immediately surrounding the site there is a network of dirt roads accessing palm oil plantations, many of which would be unsuitable for construction traffic as they are of poor quality and are too narrow. There are currently no useable road links for trucks to the east and west of the site.

A wide and straight dirt road runs from the settlement in the south to the existing coal fired power station on the Siak River to the north. For the proposed power plant, this road provides access for land transport to the Main Road (Jl. Lintas Timur Sumatra). To the north, it extends to the site of the proposed jetty, potentially allowing access for materials transported via river barges. Sections of this road are currently being paved in asphalt.

Between the dirt road to the power plant and the Main Road are narrow sealed roads Jl. Hangtuah and Jl. Badak Ujung which run through a residential area. Parts of Jl Badak Ujung have recently been sealed. The seal is approximately 5.5 m wide.

There are two significant intersections which road transport would pass through when travelling between the proposed power plant and the Main Road. They are the Jl Hantuah / Jl Badak Ujung intersection and the intersection of Jl. Hangtauh with the Main Road.

The layout of both intersections are typical of designs commonly found on arterial roads within Indonesia. The intersection of Jl Hantuah and Jl Badak Ujung is an uncontrolled T-intersection with an unpaved triangular shaped island in the middle of the intersection. The intersection between Jl. Hangtauh and Jl. Lintas Timur Sumatra (the Main Road) is a wide unmarked T-intersection.

The wide open design of these intersections with little signage or road marking provides little guidance to drivers on how the designer intended they should be used. Potentially this could lead to safety issues.

3.11.3 Pedestrian Network

On roads in the vicinity of the proposed power plant and the propose gas pipeline, there is no pedestrian infrastructure including footpaths. As in much of Indonesia, people typically walk along the road shoulder.

3.11.4 Cycling Network

There is no cycling infrastructure around the site or in the settlement to the south of the power plant.

3.11.5 Public Transport

There is little information available on public transport services in the settlement to the south of the power plant due to the informal nature of the public transport sector in Indonesia. However, it is likely that privately owned minibuses (Angkot) and motor cycle taxi's (Ojek) serve the settlement.

3.11.6 Road Traffic Counts

Traffic counts were undertaken on the 25th of January, 27th of January and 1st of February 2018 (all work days). The locations where the counts were taken are shown in the map below (Figure 3.42).

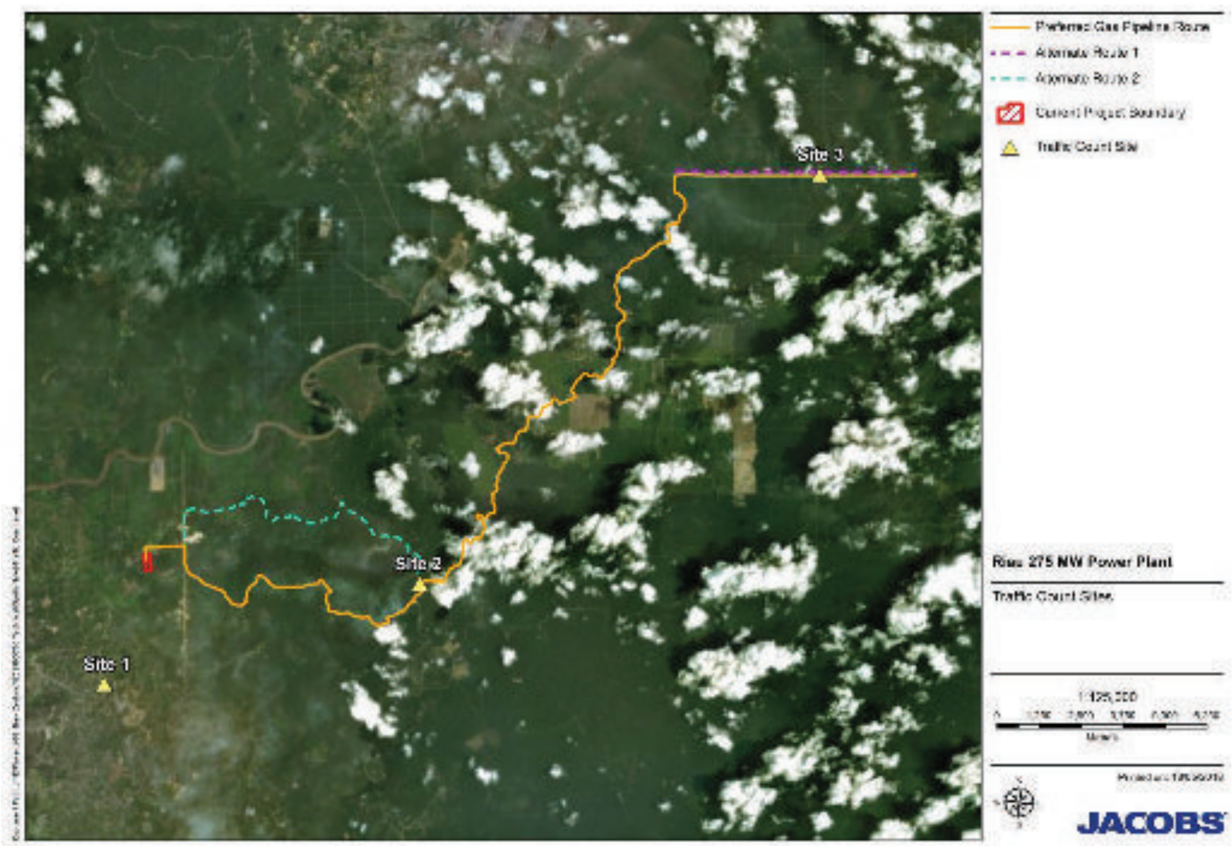


Figure 3.42 : Map Showing Location of Traffic Counts

Traffic counts were undertaken over the following periods:

- Morning Period – 7-9 am (two hours);
- Midday Period – 11 am-1 pm (two hours); and

- Afternoon Period – 2 pm-7 pm (five hours);

Both directions of flow were counted. The counts were classified into car, taxi / minivan, large bus, light truck, heavy truck, motorbike, bicycle, and Tuk tuk.

The first location where traffic counts were undertaken is the intersection of Jl. Hangtuah and Jl. Badak Ujung roads. This road will be used by construction traffic travelling from the Main Road to the power plant site. The results of the survey are shown in Figure 3.43.

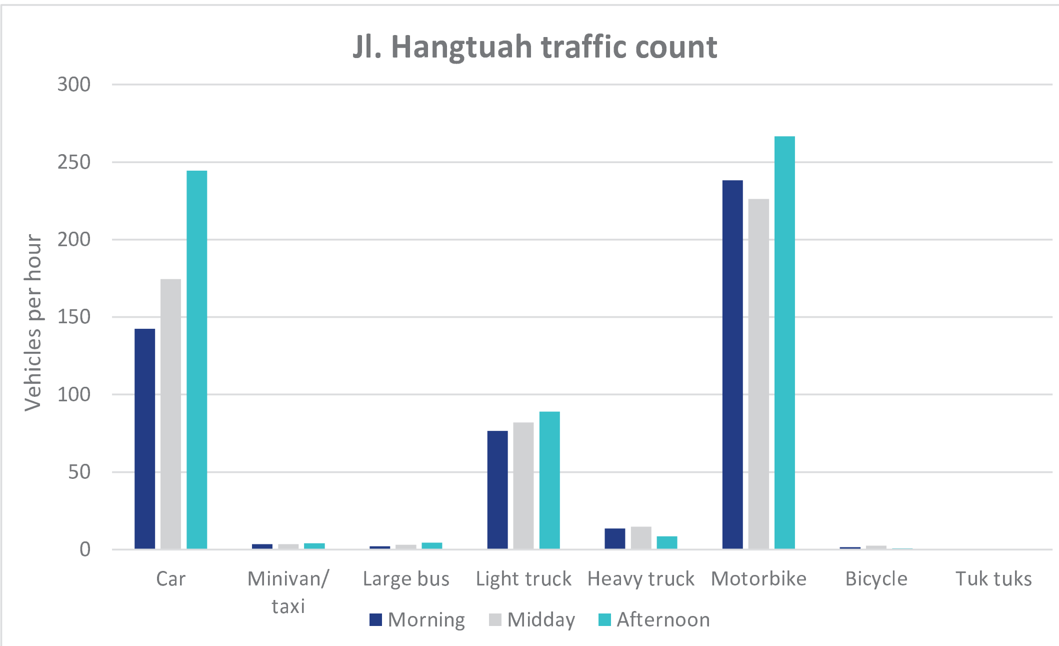


Figure 3.43 : Graph Showing Traffic Counts for Location One: Jl. Hangtuah

The figure shows motorbikes were the most common vehicle counted on Jl Hangtuah with cars being the second most common and light trucks coming in third. The number of minivans/ taxi's, large buses, bicycles and tuk tuks observed was very low and light trucks greatly outnumbered large trucks.

Counts were highest in the afternoon when flows were around 619 vehicles per hour (vph). The second location that traffic counts were undertaken is half way along Jl. Lintas Maredan – Simpang Beringin at the intersection with an unnamed palm oil plantation road (Figure 3.44). This road will be used by traffic travelling to the pipeline construction site. Movement on this road will also need to be managed through temporary traffic controls during the construction of the 40 km long gas pipeline.

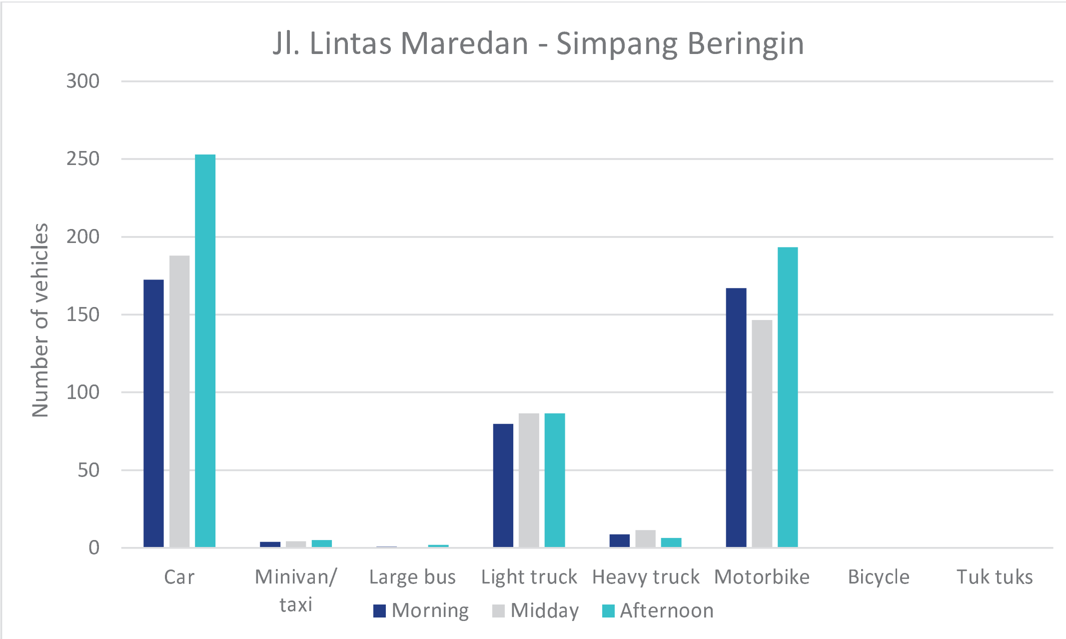


Figure 3.44 : Graph Showing Traffic Counts for Location Two: Jl. Lintas Maredan – Simpang Beringin

The figure shows cars and motorbikes are the most common vehicles at this location with a mode split of roughly 40% cars, 40% motorbikes and 20% trucks. Counts were highest in the afternoon when flows were around 433 vph.

The third location that traffic counts were undertaken is half way along Jl. Perawang – Siak (Figure 3.45). This road will also be used by traffic travelling to the pipeline construction site. Movement on this road will also need to be managed through tempoary traffic management during the construction of the 40 km long gas pipeline.

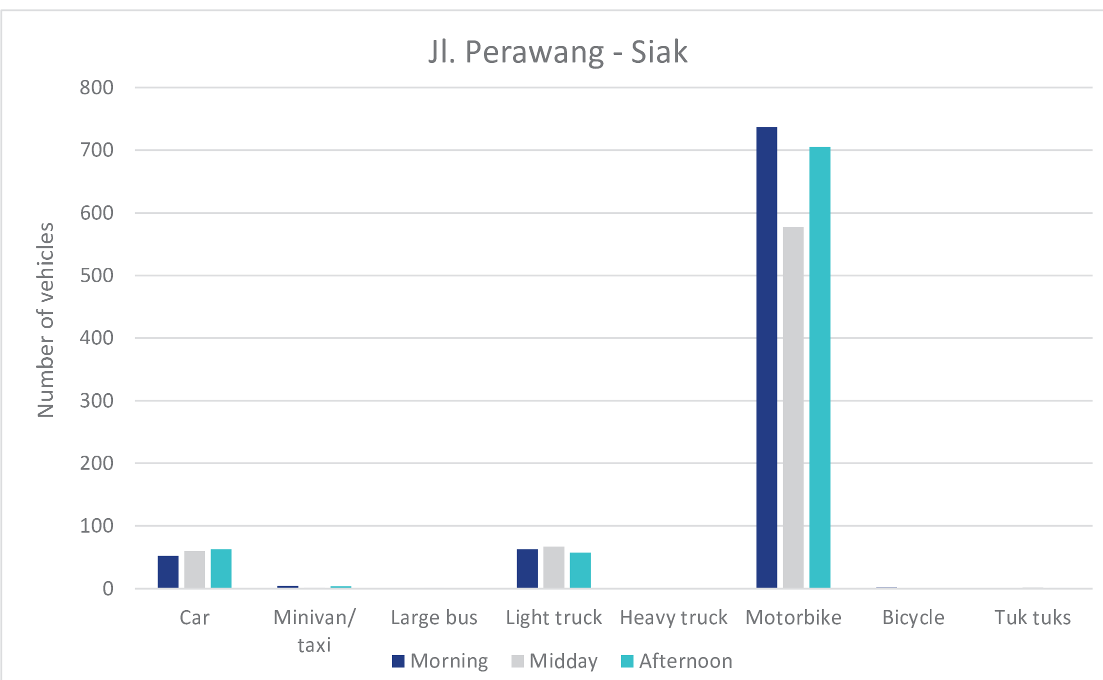


Figure 3.45 : Graph Showing Traffic Counts for Location Three: Jl. Perwang – Siak

At this location motorbikes, are by far the most common vehicle with flows of around 740 vph compared with only 60 vph for cars and 60 vph for light trucks. The highest flow was 858 vph, and unlike the other sites where flows were slightly higher in the afternoon, at this site the highest flow occurred in the morning.

3.11.7 River Traffic Count

A count of the boats using the Siak River was undertaken on the 24th of February 2018 between 8am and 6pm at the location of the proposed temporary jetty. This count was undertaken to gain an understanding of how much traffic was using the river and whether there was likely to be an impact from using the river to transport overweight loads to the site. The results of the survey are shown in Figure 3.46.

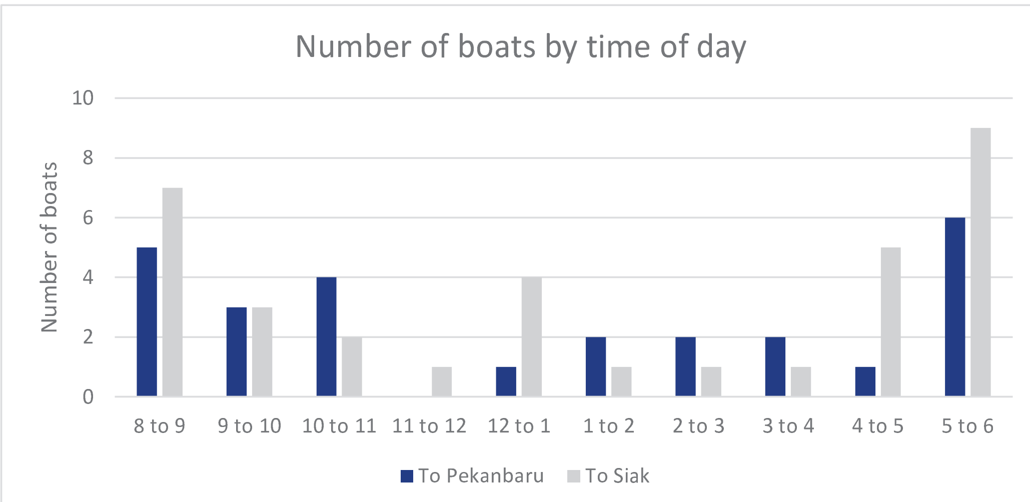


Figure 3.46 : Graph Showing the Number of Boats by Time of Day that were Counted on the Siak River

The figure shows the early morning and late afternoon were the busiest times for river traffic, with flows at these times being more than twice as flows during the middle of the day. The peak flow was 14 boats per hour, which occurred between 4:00pm and 6:00pm. Overall there were 26 boats that went up river to Pekanbaru and 34 boats that went down river to Siak during the 10-hour survey period. Figure 3.47 shows the category of boat survey.

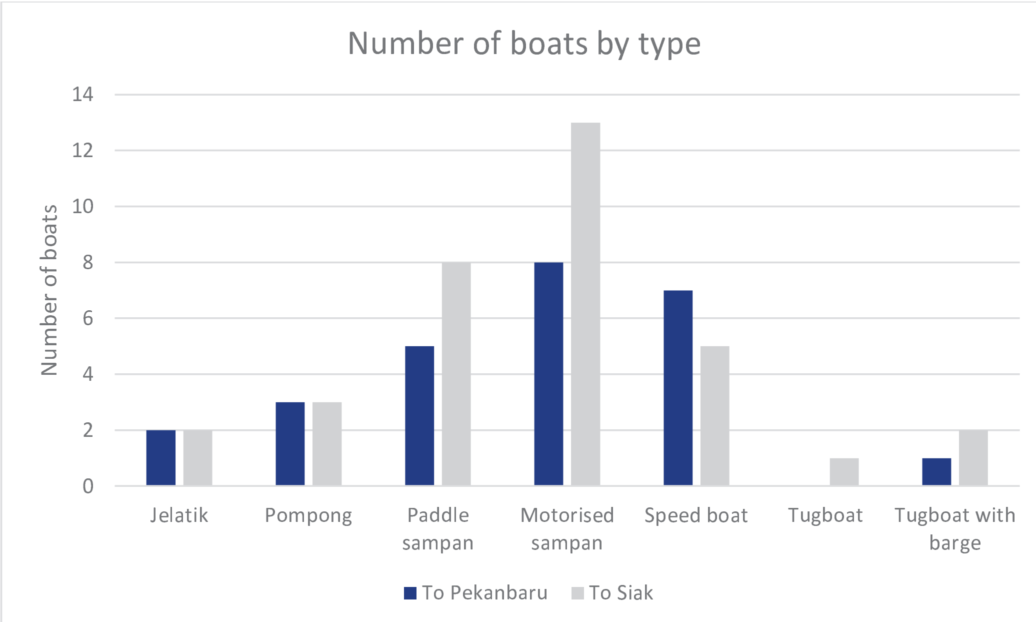


Figure 3.47 : Graph Showing the Number of Boats by Type that was Counted on the Siak River

Boats were grouped into seven categorises which are jelatik (medium sized wooden boat), pompong (small wooden boat with v shape haul), paddle sampan (small flat bottom wooden boat which is moved by paddling), motorised sampan (small flat bottom wooden boat with a motor), speed boat, tugboat and tugboat with barge.

Small boats (pompon, sampan and speed boats) were the most common type of boats on the Siak River making up 52 out of 60 boats counted (Figure 3.46). There was one tugboat and three tugboats with barges that would likely be going to and from the port of Pekanbaru.

3.11.8 Crash Analysis

No specific crash data is available for the roads around the proposed power plant or in the city of Pekanbaru as this information is not collected in a comprehensive manner.

For this reason, consideration has been given to road safety in Indonesia as a whole as it would seem likely that crash patterns in the local area would be similar to those for Indonesia as a whole.

It is estimated that there are 32,000 road crash fatalities in Indonesia per year, or around 90 fatalities per day (Australian Aid). This puts the fatality rate per capita at about 14 fatalities per 100,000 people. By comparison, Sweden, which is one of safest countries in the world, has a fatality rate of below 3 (Australian Aid).

Motorcyclists and pedestrians make up the substantial majority of road fatalities in Indonesia with 50-60% of fatalities being motorcyclists and 20-30% being pedestrians.

The fatality rate in Indonesia is possibly attributable to a mixture of factors including:

- The interaction of motorbikes, trucks and pedestrians within the carriageway;
- Overloading of trucks and motorbikes;
- Ribbon development along main roads;
- The overall standard and condition of roading infrastructure; and
- Road user behaviour.

The roads in the vicinity of the proposed power plant are typical of those within Indonesia and so it is expected that their safety, and the factors associated with road safety are likely to be similar to other roads within the country.

4. Air Quality

This section describes the potential impacts to air quality associated with the construction and operation phases of the Project. Mitigation has been identified where necessary to reduce the scale and nature of potential impacts and monitoring has been proposed. More detailed analysis is provided in the Technical Report- Air Quality Assessment which can be found in Volume 5 – Technical Appendices.

4.1 Specific Methodology

4.1.1 Assessment Criteria

Ambient air quality standards and guidelines have been developed with the primary aim to provide a basis for protecting public health from the adverse effects of air pollution and for eliminating, or reducing to a minimum, those pollutants in air that are known or likely to be hazardous to human health and wellbeing. The ambient air quality standards and guidelines provide values for evaluating the potential impact of contaminants that are commonly discharged from industrial sources.

The Indonesian Ministry of the Environment and Forestry has legislated National Ambient Air Standards that are used as one set of the evaluation criteria in determining the level of impact of the proposed power station emissions to air. The World Bank Group Environmental Health and Safety (EHS) General Guidelines (WBG, 2007) and the EHS Guidelines for New Thermal Power Plants (WBG, 2008) also provide ambient air guidelines and emission limits based on those recommended by the World Health Organisation. The national and international ambient air guidelines and emission limits along with the principle of the development meeting Good International Industrial Practice (GIIP) are used to assess the potential environmental impacts on air quality from the proposed power station.

The following section sets out the emission standards and ambient air standards and guidelines applicable to this air dispersion modelling assessment.

Indonesian Ambient Air Quality Standards

The Indonesian government has promulgated the Indonesia Air Quality Standards - Government Regulation No. 41 of 1999 regarding air pollution control. This regulation sets out the ambient air quality standards for Indonesia which all developments must meet. The ambient air quality standards relevant to this assessment are presented in Table 4.1.

Table 4.1 : Indonesia Ambient Air Quality Standards, 25ºC, 1 Atmosphere

Parameter	Exposure Period	Threshold Limit (25°C)
SO_2 (Sulphur dioxide)	1 hour	900 µg/Nm^3
	24 hours	365 µg/Nm^3
	1 year	60 µg/Nm^3
NO_2 (Nitrogen dioxide)	1 hour	400 µg/Nm^3
	24 hours	150 µg/Nm^3
	1 year	100 µg/Nm^3
PM_{10} (Particulate Matter <10µm)	24 hours	150 µg/Nm^3
$PM_{2.5}$ (Particulate Matter <2.5µm)*	24 hours	65 µg/Nm^3
CO (Carbon monoxide)	1 hour	30,000 µg/Nm^3
	24 hours	10,000 µg/Nm^3
O_3 (Oxidant)	1 hour	235 µg/Nm^3
	1 year	50 µg/Nm^3

Parameter	Exposure Period	Threshold Limit (25°C)
HC (Hydrocarbon)	3 hours	160 µg/Nm^3
Pb (Lead)	24 hours	2 µg/Nm^3
	1 year	1 µg/Nm^3
Dust fall	30 days	10 tonnes/km^2/month (for residential area)
		20 tonnes/km^2/month (for industrial area)

It should be noted that the local environmental agency (Badan Pengelolaan Lingkungan Hidup Daerah or BPLHD), through the AMDAL approval process, can also set stricter ambient air quality standards.

WHO Ambient Air Quality Guidelines

The World Health Organisation has published recommended ambient air quality guidelines for a range of pollutants found in ambient air which have the potential to adversely affect human health (WHO, 2006). These guidelines are often adopted by countries outright or are modified to reflect the countries' national requirements as legislated national ambient air quality standards. In 2005 the WHO updated their published ambient air quality guidelines and this has resulted in a significant reduction in the ambient air quality guidelines recommended for particulate matter (PM_{10} and $PM_{2.5}$) and sulphur dioxide. Interim targets have been provided by the WHO in recognition of the need for a staged approach to achieving the recommended guidelines. The updated guidelines and interim targets are presented in Table 4.2. The WHO ambient air quality guidelines are contained in the World Bank Group Environmental, Health and Safety General Guidelines (WGB, 2007).

The WHO ambient air quality guidelines need to be considered in assessing the impacts of the emissions from the proposed power plant in respect to demonstrating that GIIP is being achieved, and that the more stringent WHO guidelines are being achieved when compared to the Indonesian Ambient Air Standards.

Table 4.2 : Relevant WHO Ambient Air Quality Guidelines, 0°C, 1 Atmosphere

Parameter	Exposure Period	Threshold Limit
Sulphur Dioxide (SO_2)	10 minutes	500 µg/Nm^3 not to be exceeded over an averaging period of 10 minutes
	1 hour	No guideline
	24 hours	125 µg/Nm^3 (Interim target 1) 50 µg/Nm^3 (Interim target 2) 20 µg/Nm^3 (guideline)
Nitrogen Dioxide (NO_2)	1 hour	200 µg/Nm^3
	24 hours	No guideline
	1 year	40 µg/Nm^3
Particulate matter less than 10 microns (PM_{10})	24 hour	150 µg/Nm^3 (Interim target 1) 100 µg/Nm^3 (Interim target 2) 75 µg/Nm^3 (Interim target 3) 50 µg/Nm^3 (guideline)
	annual	70 µg/Nm^3 (Interim target 1) 50 µg/Nm^3 (Interim target 2) 30 µg/Nm^3 (Interim target 3) 20 µg/Nm^3 (guideline)
Particulate matter less than 2.5 microns ($PM_{2.5}$)	24 hour	75 µg/Nm^3 (Interim target 1) 50 µg/Nm^3 (Interim target 2) 37.5 µg/Nm^3 (Interim target 3) 25 µg/Nm^3 (guideline)

Parameter	Exposure Period	Threshold Limit
	annual	35 μg/Nm^3 (Interim target 1) 25 μg/Nm^3 (Interim target 2) 15 μg/Nm^3 (Interim target 3) 10 μg/Nm^3 (guideline)
Ozone (O_3)	8 hour	100 μg/Nm^3

The WHO has no ambient air guideline values for 1-hour average SO_2 and 24-hour average NO_2. New Zealand (NZ) ambient air guidelines (MfE, 2002) have been used to provide an international benchmark to assess modelling predictions for these averaging periods in this report. The NZ ambient air guideline for SO_2 is 350 μg/Nm^3 as a 1-hour average and for SO_2 is 100 μg/Nm^3 as a 24-hour average.

4.1.2 Assessment Methodology – Construction Phase

The air quality impacts during construction of the Project have been assessed in a qualitative manner following WBG EHS Guidelines and based on available information.

The production of dust from construction works such as the formation of roads and preparation of lay-down and building sites is inevitable. Modelling for dust is generally not considered appropriate for assessing construction impacts, as emission rates vary depending on a combination of the construction activity being undertaken and the meteorological conditions, which cannot be reliably predicted. For this assessment *Guidance on the Assessment of Dust from Demolition and Construction, Version 1.1* developed by the Institute of Air Quality Management (IAQM) (2014) has been referenced.

Activities on Site and along the gas pipeline route have been divided into four types to reflect their different potential impacts. These are:

- Demolition;
- Earthworks;
- Construction; and
- Track out.

Of these four types of activities, only earthworks, construction and track out are relevant to the Project as very limited demolition may be required for the gas pipeline.

The IAQM method uses a five step process for assessing dust impacts from construction activities:

Step 1. Screening based on distance to nearest receptor. No further assessment is required if there are no receptors within a certain distance of the works;

Step 2. Assess the risk of dust effects from activities using:

- the scale and nature of the works, which determines the potential magnitude of dust emissions; and
- the sensitivity of the area.

Step 3. Determine site specific mitigation for remaining activities with greater than negligible effects.

Step 4. Assess significance of remaining activities after mitigation has been considered.

Step 5. Reporting.

The Step 1 screening criteria provided by the IAQM guidance suggests screening out assessment of impacts from activities where sensitive 'human receptors' will be more than 350 m from the boundary of the site, 50 m of the route used by construction vehicles, or up to 500 m from the Site entrance. Sensitive 'ecological receptors' can be screened out if they are greater than 50 m from the boundary of the site, 50 m of the route used by construction vehicles, or 500 m from the site entrance.

The Step 2 assessment determines the Dust Emission Magnitude for each of four dust generating activities; demolition, earthworks, construction, and track out. The classes are; Large, Medium, or Small, with suggested definitions for each category.

The class of activity is then considered in relation to the distance of the nearest receptor and a risk category determined through an assessment matrix for each of three categories:

- Sensitivity to dust soiling effects;
- Sensitivity of people to health effects from PM_{10}; and,
- Sensitivity of ecological effects.

4.1.3 Assessment Methodology – Operational Phase

Stack emissions of the power plant have been identified as key source of air pollution during operation of the Project. The Project consists of two sets of gas turbine generating unit, two sets of heat recovery steam generator (HRSG) and one steam turbine generating unit with associated auxiliary equipment. The cooling towers associated with the Project will also discharge particulate matter, though at very low levels, to air, though at very low levels. The Project will be designed to operate continuously throughout the year.

The Black Start Diesel Generators will supply black power in case of a station black out and emergency power for the safe shutdown of the power plant in the event of the loss of mains supply. During combined cycle operation, the heat of exhaust gas will be admitted to the HRSG where superheated steam will be produced which will then drive the steam turbine to generate additional electrical power. Use of the HSRG will not result in additional contaminants to the air discharges.

During combined cycle operation, the heat of exhaust gas will be admitted to the HRSG where superheated steam will be produced which will then drive the steam turbine to generate additional electrical power. Use of the HSRG will not result in additional contaminants to the air discharges.

A two stage modelling approach was taken, first using the TAPM prognostic meteorological model to provide meteorological data for the modelling period. The AERMOD dispersion model (Version 14134) was then used to predict the ground level concentrations of the pollutants discharged from the proposed site.

Modelling was conducted for the following scenarios.

- Emissions of combustion gases and particulate matter from the proposed 275 MW power plant; and
- Emissions of combustion gases and particulate matter from the proposed power plant in addition to the existing Tenayan CFPP.

Both scenarios were modelled assuming continuous operation at maximum continuous rating for the years 2015-2016.

The prognostic meteorological model TAPM was used to develop a meteorological dataset for use with the dispersion model. TAPM was developed by the CSIRO in Australia and predicts all meteorological parameters based on large-scale synoptic information. A wind rose of the meteorological dataset developed by TAPM is provided as Figure 4.1 below. This meteorological data differs from the baseline monitoring data described in Section 3.2 due to the fact that the Pekanbaru meteorological station is influenced by local building effects.

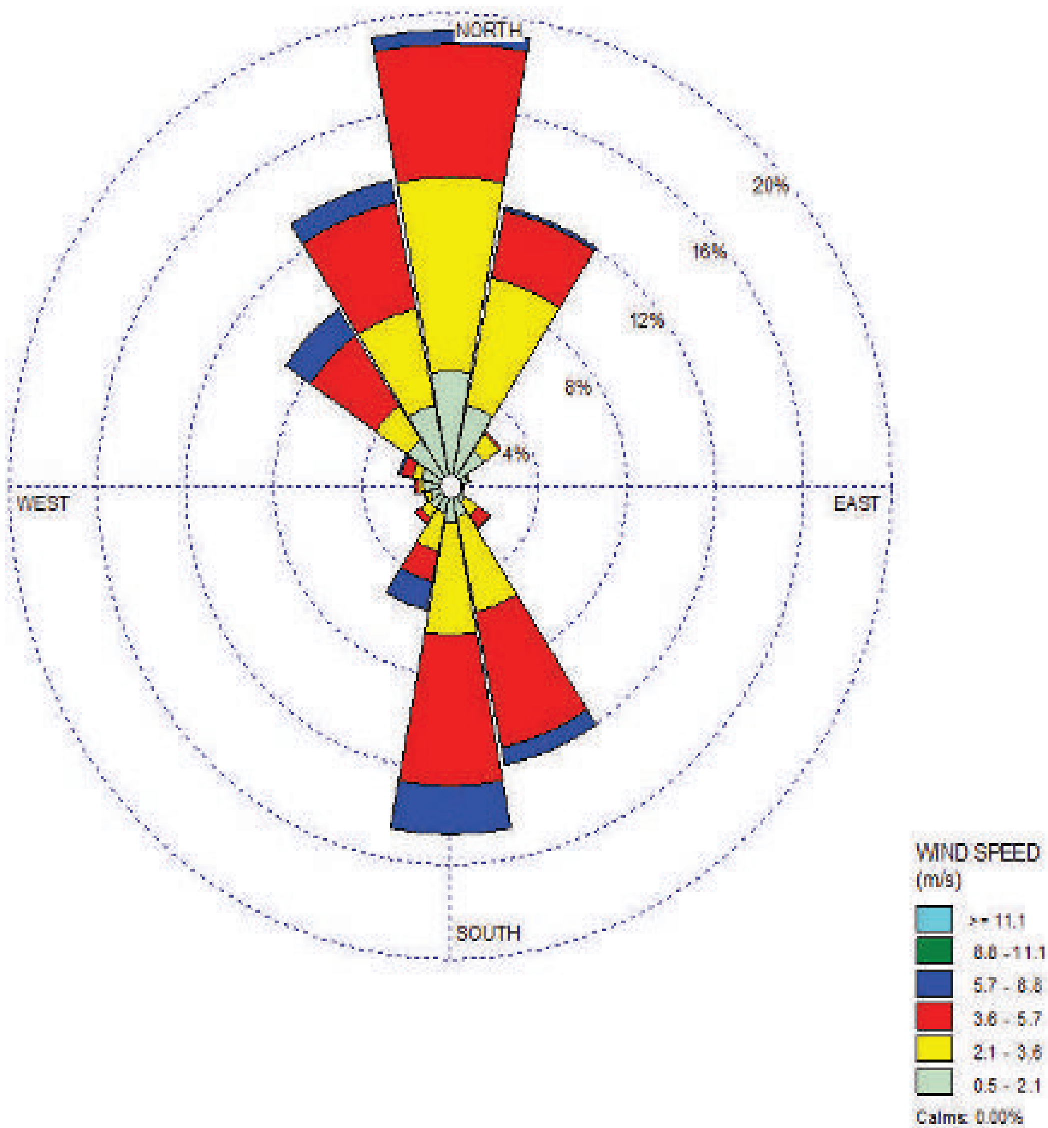


Figure 4.1 : Windrose of Modelled Meteorological Data at Proposed CCPP Site

The AERMOD model was run with a 10 km x 10 km (100 km^2) digital terrain file with 50 m grid spacing. The AERMAP module of AERMOD was run to calculate the ground elevations and representative terrain height scale for all receptors, stacks and buildings in the model from digital terrain elevation data. The effects of building downwash was considered in the modelling.

A number of sources have been identified as potentially discharging pollutants to the atmosphere. They include two point sources corresponding to the locations of the CCPP stacks as shown in design drawings. Locations of stacks at the existing Tenayan CFPP obtained from aerial imagery. Contaminant discharge rates have been derived from design criteria where available, as well as US EPA AP-42 emission factors[1]. Table 4.3 presents the physical parameters of the discharge sources as used in the dispersion model. All PM_{10} has been assumed to be $PM_{2.5}$. Cooling tower particulate emissions were also assessed as part of the total particulate emissions from the power plant.

[1] https://www3.epa.gov/ttnchie1/ap42/ch03/final/c03s01.pdf

Table 4.3 : Source Characteristics and Discharge Rates used in Dispersion Model

Source ID	Stack Height (m)	Stack Diameter (m)	Efflux Velocity (m/s)	Exit Temperature (°C)	Discharge Rate (g/s)			
					NO_X	PM_{10}	SO_2	CO
Riau CCPP (Stack 1)	45	3.8	20	82	12.1*	1.56	0.47*	1.95
Riau CCPP (Stack 2)	45	3.8	20	82	12.1*	1.56	0.47*	1.95
Tenayan CFPP	150	5	10	120	70	11.2	1283	3.1

Note: *guaranteed emission rates

4.2 Assessment of Potential Impacts

4.2.1 Construction Phase

4.2.1.1 Dust

The construction phase of the project will involve land preparation including site clearance, backfilling and land drainage followed by construction of the power plant and associated gas pipeline and transmission line. Potential dust discharges will be associated principally with the site clearance and levelling activities, which will involve movement of earth.

Power Plant

The site area for the power plant and switchyard will need to be cleared of vegetation and any debris prior to levelling. Site clearance works will include felling, trimming, and cutting trees, and disposing of vegetation and debris off-site. Voids and water ponds will be dried and filled with suitable material.

Topsoil will be stripped from the surface. Excavated topsoil will be transported to and stockpiled in designated topsoil storage areas. Prior to being filled, any sub-grade surfaces will be freed of standing water and unsatisfactory soil materials will be removed. All unnecessary excavated materials will be transported and deposited off-site at an approved facility.

The site will then be levelled. Ideally, the cut and fill will be balanced, to minimise the need to import or export material from the site area. Based on the site topography, preliminary estimates show that if the site elevation is set at 28 m, then the cut and fill / backfilling volumes will be reasonably well balanced at approximately 165,000 m^3 each.

Notwithstanding this, it is likely that approximately 45,000 m^3 of soil will need to be disposed of offsite. At 20 m^3 per truck, this will require 2,250 truck movements over approximately 3 months. Access roads will be used to convey soil and other material for offsite disposal.

Due to the volume of earth movement required (165,000 m^3 of cut and fill), the dust emission magnitude of earthworks activities which may be associated with the power plant would be classified as Large, following the IAQM assessment definition in Appendix A:

> *'Total site area <10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), >10 heavy earth moving vehicles active and any one time, formation of bunds >8 m in height, total material moved >100,000 tonnes;'*

The dust emission magnitude of construction activities, which includes on site concrete batching, associated with the power plant would be classified as Medium, following the IAQM assessment definition:

> *'Total building volume 25,000 m^3 – 100,000 m^3, potentially dusty construction material (e.g. concrete), on site concrete batching;'*

The dust emission magnitude of trackout activities associated with the power plant, which includes a range of 50-60 heavy vehicles per day, would fall under the Large classification following the IAQM assessment definition:

> *'Large: >50 HDV (>3.5t) outward movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length >100 m'*

While the potential magnitude of dust emissions is classified as Medium to Large, based on the nature or scale of the power plant construction activities, a survey of aerial imagery and review of baseline site assessment information indicates that there are no residential or other sensitive receptors within 350 m of the construction works associated with the power plant site.

Gas Pipeline

Construction of the gas pipeline involves clearing of vegetation and grading of the immediate area, transporting the pipe sections to the relevant area, digging and preparation of trenches, backfilling the trenches using the excavated material and compaction of trench material.

It is understood that the open gas pipeline trenches will be a maximum of 500 m at any one time and will be no more than 2 m deep by 1 m width. The time that each section of trench is excavated and open is likely to be for around one week therefore gas pipeline construction activities are expected to be limited in terms of spatial extent and therefore in terms of the potential exposure period to dust. On this basis the dust emission magnitude of the pipeline earthworks activities is expected to fall into the 'Small' classification, following the IAQM assessment definition in Appendix A of the Technical Report – Air Quality Assessment (Volume 5 – Technical Appendices).

Based on the variety of construction equipment required for the pipeline excavators (bulldozers, dump trucks, cranes, welding machines and water pumps), the dust emission magnitude of the pipeline trackout activities has been conservatively assigned to the 'Medium' classification, following the IAQM assessment definition in Volume 5 – Technical Appendices.

The construction of the gas pipeline will also occur through largely uninhabited areas, with the land use consisting primarily of palm oil plantations. There are a few residential properties which are located within 350 m of the pipeline route and therefore within a distance to be impacted by construction dust. Due to the nature of the works area (i.e. a maximum of 500 m of open trench at any one time), with reference to the IAQM assessment definitions in Volume 5 – Technical Appendices, there are:

- approximately 1-10 highly sensitive receptors anticipated to be within 50 m of the pipeline construction activities, on a worst-case basis; and
- located in an area with an annual mean PM_{10} above 32 $\mu g/m^3$ (background PM_{10} has been understood to be 48 $\mu g/m^3$).

This would therefore classify the sensitivity of the area to dust soiling effects on people and property as Low, and the sensitivity of the area to human health impacts as Medium with reference to the IAQM definitions in Volume 5 – Technical Appendices.

Summary

Table 4.4 summarises the dust emission magnitude of the Project construction phase of the power plant and pipeline, determined with reference to the IAQM guidance. With reference to the magnitude criteria for the ESIA in Section 2, this would be categorised as Moderate to Major magnitude of impact for the power plant, and Minor to Moderate for the pipeline.

Table 4.4 : Construction Dust Emission Magnitude

Activity	Dust Emission Magnitude	
	As per IAQM (2014) Guidance	ESIA Classification
Power Plant		
Earthworks	Large	Major
Construction	Medium	Moderate
Trackout	Large	Major
Gas Pipeline		
Earthworks	Small	Minor
Construction	N/A	N/A
Trackout	Medium	Moderate

The impact assessment results using the dust emission magnitude classification, and the sensitivity of the area is presented in Table 4.5.

Given the absence of sensitive receptors within 350 m of the power plant, in combination with the relatively short duration of the construction period it is considered that there will be a '**Negligible'** impact from the power plant construction.

As the magnitude classification of dust emissions from the pipeline construction activities is Small to Medium, when this is considered with the Low sensitivity to dust soiling, and Medium sensitivity to human health, a Low risk of impact from dust emissions is concluded, with reference to the IAQM assessment definitions in Appendix A. This translates to a **Minor** impact as per the ESIA impact matrix in Section 2.

Table 4.5 : Risk of Dust Impacts and Significance

Activity	Impact Classification	Significant
Power Plant		
Earthworks	Negligible	Not significant
Construction	Negligible	Not significant
Trackout	Negligible	Not significant
Pipeline		
Earthworks	Minor	Not significant
Construction	N/A	N/A
Trackout	Minor	Not significant

The objective of the ESIA is to identify the likely significant impacts on the environment and people of the project. In this impact assessment, impacts determined to be 'moderate' or 'major' are deemed significant. Consequently, impacts determined to be 'Minor' or 'Negligible' are not significant. On this basis, the construction dust effects of the power plant and gas pipeline are considered to be not significant.

4.2.1.2 Combustion Gases

Ambient air monitoring undertaken during the baseline monitoring undertaken indicates that overall air quality is good with respect to combustion gases, although there is the potential for cumulative impacts of SO_2 and particulate matter. However, combustion emissions associated with construction activities will be more than 350 m from the main residential areas and emissions from the main source will occur over a relatively short duration. As such, it is considered that the potential impact on people living and working in the surrounding area from construction phase combustion gas emissions will be **Negligible**.

4.2.2 Operational Phase

Discharges to Air

Atmospheric dispersion modelling was undertaken to predict the likely impact emissions from the power station on air quality of the surrounding area and to assess the potential impacts on the environment. For more information on model inputs and set up data please refer to Technical Report - Air Quality Assessment, Volume 5: Technical Appendices.

Atmospheric dispersion modelling was used to predict the highest one-hour (99.9th percentile) and 24-hour and annual average maximum ground level concentrations (MGLCs) for NO_2 and SO_2, 24-hour and annual average MGLCs for PM_{10}, and 1-hour averages for CO. The modelling assumes that the CCPP plant was operating simultaneously on a continuous basis over the course of the 2-year modelling period.

Relevant isopleth diagrams are presented in the following sections. The location of the highest concentration predicted by the modelling is indicated by an arrow on each isopleth diagram.

4.2.3 Proposed CCGT Plant Model Results

The highest maximum ground level concentrations (MGLCs) predicted by the AERMOD dispersion model for the proposed power plant are presented in Table 4.6 below. The relevant international air quality standards and guidelines are provided for comparison. Maximum predicted concentrations including the existing background concentrations as derived from the Pekanbaru monitoring data are also provided. As discussed previously the background data is obtained in a more urban environment than the Project area, where ambient air concentrations are likely to be higher. Using this data to represent existing baseline conditions for the assessment of the effects of discharges from the proposed CCPP plant will therefore provide a conservative assessment.

Table 4.6 : Highest MGLCs Proposed Power Plant at for Comparison with International and Indonesian Guidelines

Pollutant and Averaging Period	Highest Predicted MGLCs (µg/m^3)		International Guidelines (µg/m^3)	Indonesian Ambient Air Standard (µg/m^3)
	Excluding Background	Including Background		
CO (1-hour highest 99.9th percentile)	10.2	1210.2	30,000 (NZ)	30,000
CO (24-hour)	2.5	602.5	10,000 (WHO)	10,000
NO_2 (1-hour highest 99.9th percentile)	41.4	55.4	200 (WHO)	400
NO_2 (as NO_2, 24-hour average)	12.8	24.8	100 (NZ)	150
NO_2 (as NO_2, annual average)	3.2	13.2	40 (WHO)	100
PM_{10} (24-hour average)	2	39	150 (WHO Interim target 1); 100 (WHO Interim target 2); 75 (WHO Interim target 3); 50 (WHO)	150
PM_{10} (annual average)	0.6	48.6	70 (WHO Interim target 1); 50 (WHO Interim target 2); 30 (WHO Interim target 3); 20 (WHO)	n/a

Pollutant and Averaging Period	Highest Predicted MGLCs (µg/m³)		International Guidelines (µg/m³)	Indonesian Ambient Air Standard (µg/m³)
	Excluding Background	Including Background		
$PM_{2.5}$ (24-hour average)	2	21	75 (WHO Interim target 1); 50(WHO Interim target 2); 37.5 (WHO Interim target 3); 25 (WHO)	65
$PM_{2.5}$ (annual average)	0.6	24.6	35 (WHO Interim target 1); 25 (WHO Interim target 2); 15 (WHO Interim target 3); 10 (WHO)	n/a
SO_2 (1-hour highest 99.9th percentile)	2.5	85.5	350 (NZ)	900
SO_2 (24-hour average)	0.6	83.6	125 (WHO Interim target 1); 50 (WHO Interim target 2): 20	365
SO_2 (annual average)	0.2	66.2	10 – 30 (NZ)	60

Isopleth diagrams of predicted NO_2 from the Project are provided as Figure 4.2, Figure 4.3 and Figure 4.4 below.

The highest predicted MGLC of NO_2 as a 1-hour average (99.9 percentile) from the Project is 41.4 µg/m³, which is approximately 21% of the WHO guideline, and 18% of the Indonesian Standard value. This concentration is predicted to occur very close to the proposed power plant, just beyond the western boundary of the plant. If the assumed background value of 14 µg/m³ is added, the WHO and Indonesian guidelines and standards for NO_2 are still met. The highest predicted concentrations occur at the site boundary, and decrease with distance from the source.

Predicted MGLCs of NO_2 as 24-hour averages are similarly well below the Indonesian and international guidelines and standards, being less than 13% of the 100 µg/m³ International Guideline value, and 9% of the 150 µg/m³ Indonesian Standard. The highest predicted 24-hour average MGLCs are shown to occur approximately 1.5 km to the southwest of the power plant site boundary. As the airshed is shown to be relatively non-degraded with respect to NO_2, with the assumed background concentration assumed as being 12 µg/m³, both the International Guideline and Indonesian Standard values are predicted to be complied with.

Predicted MGLCs of NO_2 as annual averages (including background) is well below the 40 µg/m³ WHO Guideline, and the 100 µg/m³ Indonesian Standard.

The airshed in Pekanbaru has been shown to be degraded with respect to particulate matter and SO_2, with exceedances being observed at the Pekanbaru monitoring station. This is primarily due to the large scale agricultural burning and forest fires (for PM_{10}) and the use of high sulphur fuel for transport (for SO_2). These sources of air pollution are expected to decrease in the coming years as government regulations limit the spread of fires for agricultural land clearing, and the implementation of lower sulphur content of fuels. Regardless, the incremental increase in ambient concentrations of CO, PM_{10} and SO_2 resulting from the Project's air discharges are predicted to be at a very low level as shown in Table 4.6 above, with respect to the ambient air guidelines. Considering the low emission rates of these contaminants, the incremental effect on the airshed may be assumed to be minor and will not significantly contribute to further airshed degradation.

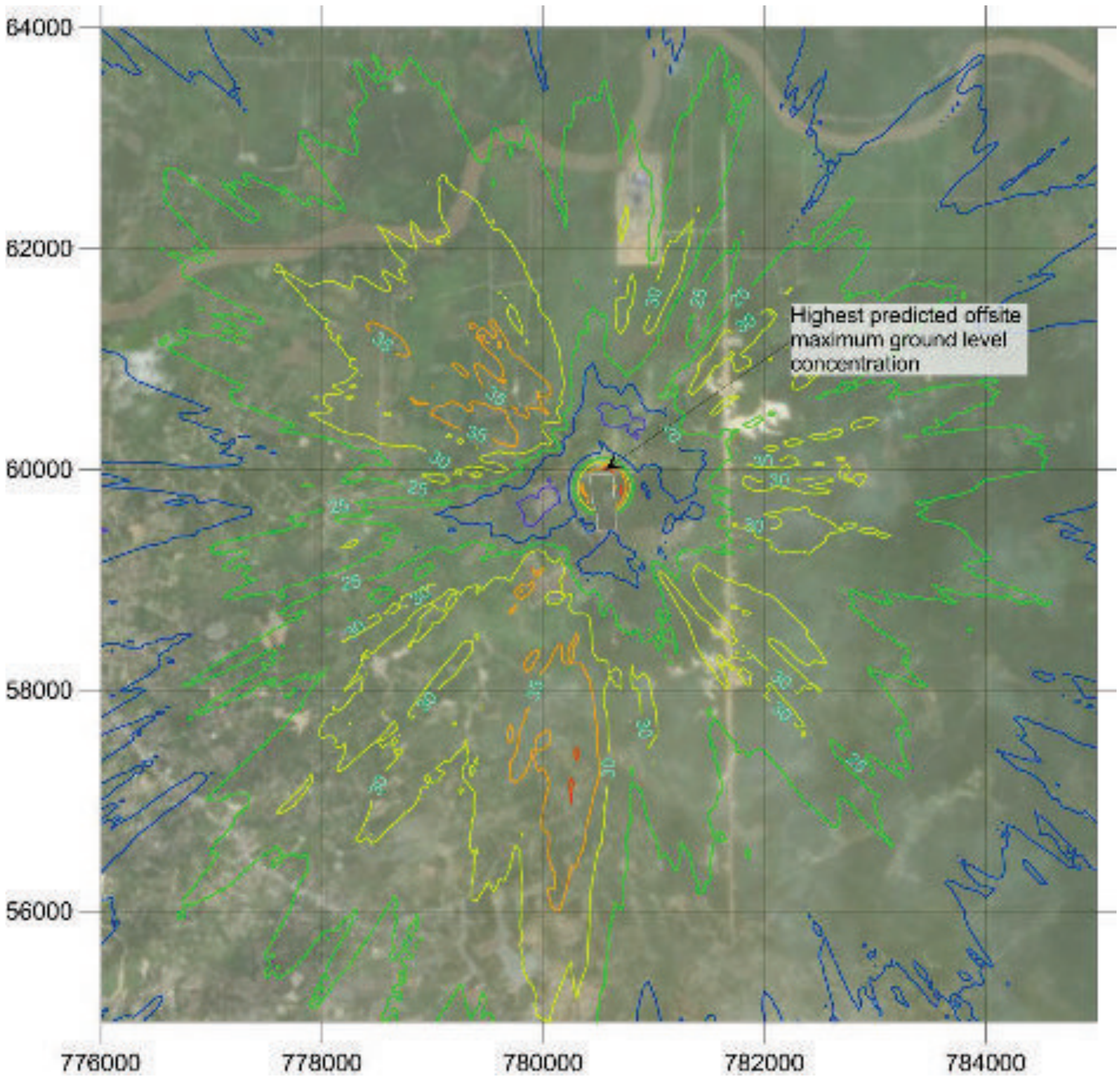


Figure 4.2 : Highest Predicted Maximum Ground Level Concentrations (1-Hour Average, 99.9th Percentile) of NO_2 (µg/m^3) from Discharges from the Proposed Power Plant (Excluding Background)

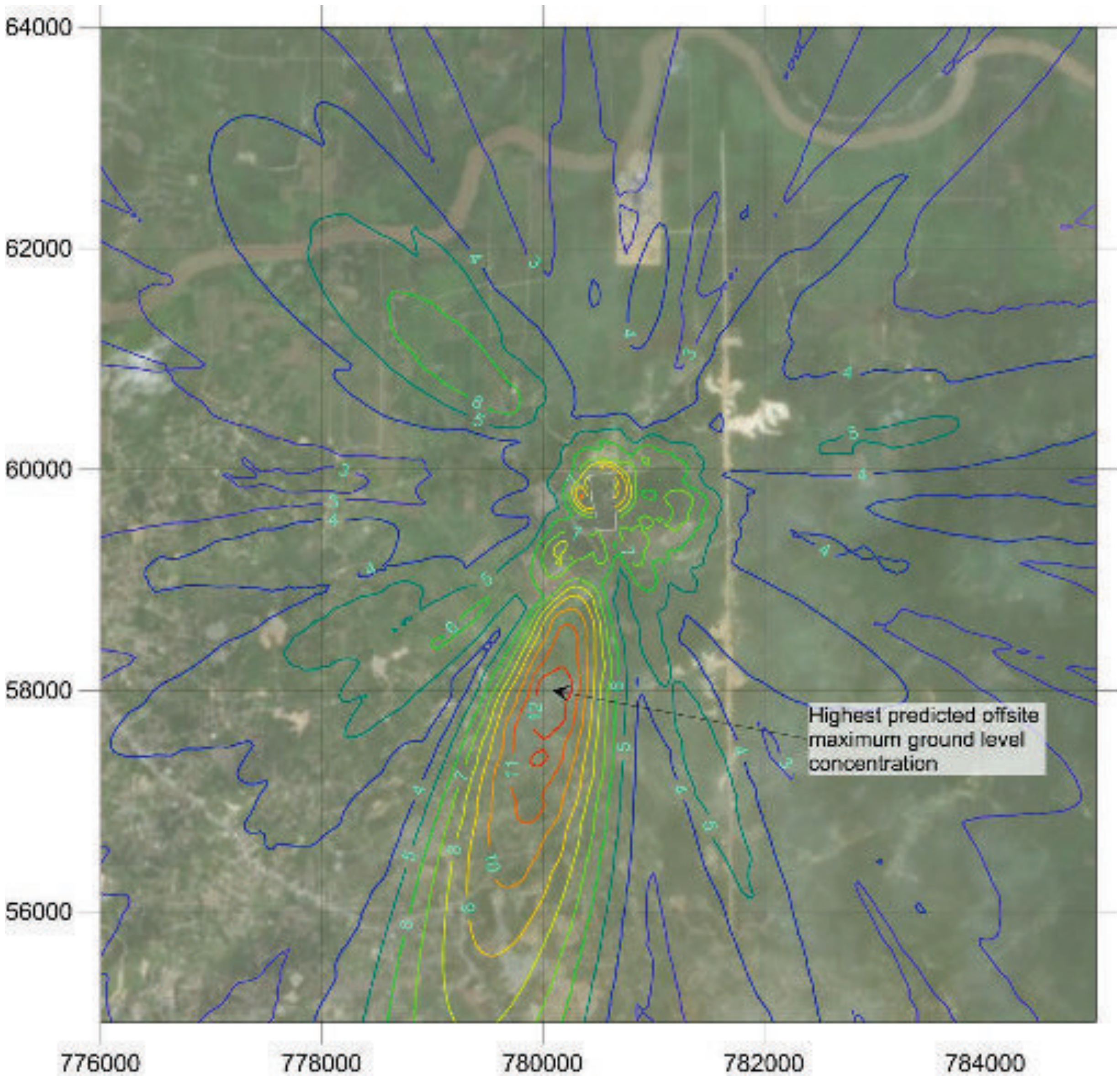


Figure 4.3 : Highest Predicted Maximum Ground Level Concentrations (24-Hour Average) of NO_2 (µg/m³) from Discharges from the Proposed Power Plant (Excluding Background)

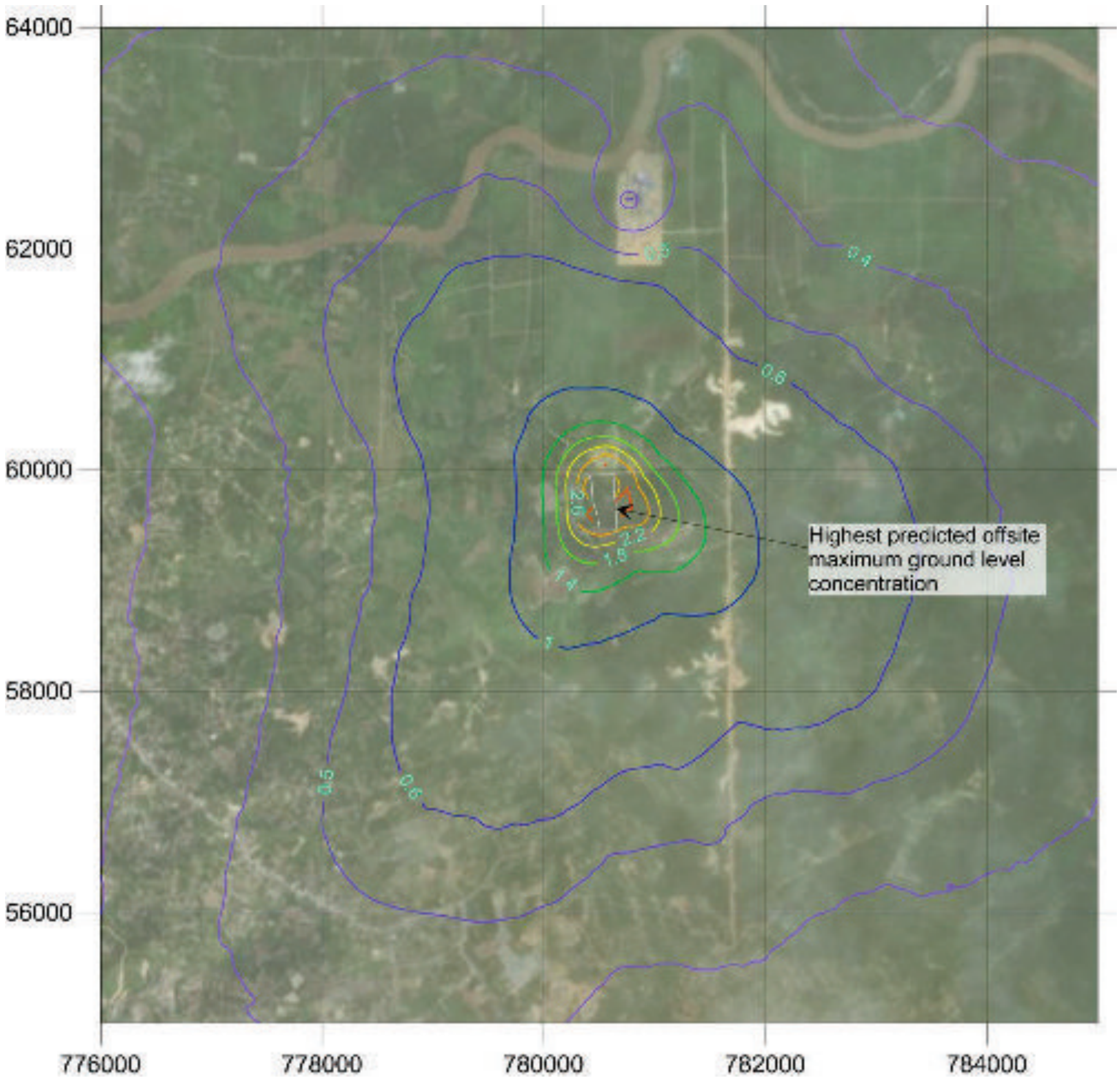


Figure 4.4 : Highest Predicted Maximum Ground Level Concentrations (Annual Average) of NO_2 (g/m³) from Discharges from the Proposed Power Plant (Excluding Background)

4.2.4 Emergency Grid Failure

The CCPP will have an emergency black start facility, comprising 4 x 1.2 MWe containerised diesel generator sets (DGs). This facility is required by the Power Purchase Agreement (PPA) and will enable the plant to start independently and reenergise the grid without any external source of power in the unlikely event of a PLN grid failure or black-out. The failure could be local to Riau or affect the whole of the Sumatra Grid.

During a normal start, power to start the GTs is imported from the grid via the generator step-up transformer. When there is a grid failure (or a "black-out" or "black grid"), no power is available from the grid and so, without black start capability, the plant would not be able to start until the grid is energised by some other power station. With the black start facility, the plant will be able to start on its own and help restore power to consumers.

When there is a black-out, power stations disconnect from the grid as there is no actual demand. In order to re-energise the grid, stations with black-start capability must be able to start without any power from the grid.

Typically, the power is provided by diesel generators. At the Riau plant, four 1.2 MWe DGs will be used for this purpose.

Under a black start scenario, the DGs would provide the power to start one of the gas turbines. The DGs will run for, perhaps, an hour or so while the plant is being readied for the start. Then, one GT would be started and synchronised to the DG sets forming an "island" grid. Then, the generator of the gas turbine set would take over the supply of the auxiliary loads and the DG sets can be shut down. The GT would run at low load in parallel with the DGT sets for approximately 30 minutes.

It is anticipated that this scenario would occur no more than once per year. In addition, each DG unit would be subject to a monthly test run to ensure they are functioning properly for a period of 15 to 30 minutes. The units would be fired up separately when conducting the monthly test runs.

Each diesel generator set will be installed in a steel container with its own chimney stack. Table 4.7 presents the estimated emission parameters of the BSDGs using the US EPA AP-42.

Due to the infrequent nature of the running of the BSDGs in an emergency situation and the short duration for which these units will operate for, these units have not been included in the dispersion modelling conducted. The impacts of emissions to air from the BSDGs will be negligible.

Table 4.7 : Estimated Black Start Diesel Generator Emissions per Unit

Parameter	Unit	Value
Stack height	m	5
Stack diameter	m	0.2
Exit velocity	m/s	30
Fuel consumption	kg/hr	327
Volume flow rate	m^3/s	5
Exit temperature	K	673
Power Output	MWe	1.2
Thermal Input	MWth	4.1
NOx emission rate	g/s	5.6
PM emission rate	g/s	0.17
CO emission rate	g/s	1.48
SO_2 emission rate (0.05% sulphur content of fuel)	g/s	0.09
SO_2 emission rate (0.3% sulphur content of fuel)	g/s	0.5

Note: US EPA AP-42 emission factors for large units have been used to generate emission rates

4.3 Mitigation and Monitoring

4.3.1 Construction Phase Mitigation

Although the unmitigated impacts of nuisance dust are not considered to be significant in the wider context of the Project, there could be individual residences within closer proximity to construction sites, as well as local use of near-by farming areas. The Project should apply good working practices to minimise potential impacts through mitigation techniques such as:

- Water spraying of or covering all exposed areas and stockpiles;
- Covering or enclosed storage of aggregates (including topsoil and sand) where practical;
- Minimising the size of exposed areas and material stockpiles and the periods of their existence;
- Covering the construction materials transported by trucks or vehicles to prevent dust emissions;

- Limiting dust generation activities in high winds or specific wind directions, if required;
- Cleaning wheels and the lower body parts of trucks at all exits of the construction site;
- Cleaning the entire construction work sites at least once per week; and,
- Maintaining and checking the construction equipment regularly.

4.3.1 Construction Phase Monitoring

As part of good working practice the construction manager for the construction phase of the Project should complete routine checks on dust generation from construction activities, and confirm that dust suppression and appropriate storage is being used where required. In addition, a mechanism for complaints regarding dust should be available to locals, and due regard given to any issues raised.

4.3.2 Operational Phase Mitigation

Mitigation of discharges from the operational phase of the project has occurred in the Project design stage, and includes high efficiency burners and low design concentration of contaminants from natural gas combustion. Drift eliminators on the cooling towers also limit particulate matter discharges from the site.

The predicted maximum contribution of air pollutants to the airshed resulting from the operation of the Project is low, at less than 25% of the relevant air quality standards for all contaminants. Since the Project is located in a non-degraded airshed with respect to the main contaminant discharged (NO_2), and the maximum Project contribution is predicted to be less than 25% of the relevant air quality standards, the cumulative impact significance is also considered **Minor** during the operation of the Project. No additional mitigation measures associated with the operation of the Project is therefore required.

4.3.3 Operational Phase Monitoring

The Project will include an environmental monitoring programme, which will include a Continuous Emissions Monitoring System (CEMS) for continuous monitoring of gases discharged from both stacks, including measurements of oxygen, carbon dioxide, nitrogen oxides and temperature.

It is recommended that ambient air monitoring for NO_2 is undertaken in the area surrounding the power plant at two locations, with sampling carried out using passive and manual methods on a monthly basis. Alternatively, a permanent continuous ambient air monitoring unit for NO_2 which utilises electro chemical cell non-reference method could be installed at one location where the highest concentration of NO_2 as a 24-hour average is predicted to occur, subject to land acquisition and security arrangements.

4.4 Assessment of Residual Impacts

4.4.1 Construction Phase

The assessment indicates that the air quality associated with the construction will be controlled to **Minor**; no adverse air quality impact during construction phase will be anticipated provided all recommended air mitigation measures will be implemented.

4.4.2 Operational Phase

The potential air quality impacts arising from the Project during the operational phase have been predicted to be small relative to the relevant WHO Ambient Air Quality Guidelines as recommended in the IFC Guidelines. Incremental impacts in the degraded air shed should therefore be minimised by NO_X emissions being less than 25% of the WHO guideline, and will be significantly less than this at the nearest residential areas. The significance of impact during the operation phase of the Project is therefore considered **Minor**.

5. Greenhouse Gas Emissions

5.1.1 General Overview of Greenhouse Gas

Greenhouse gas (GHG) is a collective term for a range of gases that are known to trap radiation in the upper atmosphere, where they have the potential to contribute to the greenhouse effect (global warming). Creating an inventory or accounting for the likely GHG emissions associated with a Project has the benefit of determining the scale of the emissions and providing a baseline from which to develop and deliver GHG reduction options, if applicable. GHGs include:

- Carbon dioxide (CO_2) – by far the most abundant, primarily released during fuel combustion;
- Methane (CH_4) – from the anaerobic decomposition of carbon based material (including enteric fermentation and waste disposal in landfills);
- Nitrous Oxide (N_2O) – from industrial activity, fertiliser use and production;
- Hydrofluorocarbons (HFCs) – commonly used as refrigerant gases in cooling systems;
- Perfluorocarbons (PFCs) – used in a range of applications including solvents, medical treatments and insulators; and
- Sulphur hexafluoride (SF_6) – used as a cover gas in magnesium smelting and as an insulator in heavy duty switch gear.

Each of the gases has a global warming potential (GWP). This is a measure of how much a given mass of greenhouse gas is estimated to contribute to the atmosphere compared with the same mass of CO_2 (whose GWP is by convention equal to 1). In order to provide comparisons between activities, greenhouse gases are usually expressed as carbon dioxide equivalents (CO_2e) which is the sum of each gas released by an activities equivalent in CO_2.

The GHG emissions can be split into three categories known as 'Scopes'. Scopes 1, 2 and 3 are defined by the Greenhouse Gas Protocol (WRI & WBCSD, 2004). The GHG Protocol is an international accounting tool for government and business leaders to understand, quantify and manage greenhouse gas emissions. The Scopes can be summarised as follows:

- **Scope 1** – Direct emissions from sources that are owned or operated by a reporting organisation (examples – combustion of diesel in company owned vehicles or used in on-site generators).
- **Scope 2** – Indirect emissions associated with the import of energy from another source (examples – import of electricity or heat).
- **Scope 3** – Other indirect emissions (other than Scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them (examples include business travel (by air or rail) and product usage).

The GHG Protocol (and many other reporting schemes) dictates that reporting Scope 1 and 2 sources is mandatory, whilst reporting Scope 3 sources is optional. Reporting significant Scope 3 sources is recommended.

5.1.2 Indonesian Context to GHG

According to data in the Ministry of Indonesia '*Indonesia Second National Communication under the United Nations Framework Convention on Climate Change (UNFCCC)*' report (MoE, 2010), Indonesia's total GHG emissions in the year 2,000 was 1.37 million giga-grams CO_2e, which is equal to 1,378 million tonnes of CO_2e. Of this total GHG emissions, 80% of this represented net CO_2, 17.2% was CH_4 and N_2O made up 2%. The main sectors contributing to these emission levels were land use and forestry, followed by energy, peat fire related emissions, waste, agricultural and industry.

Of the five sector trends considered, three sectors had a trend of increased GHG emissions, these sectors were energy, agriculture and industry.

In line with the Equator Principles this assessment considers the direct emissions arising from the physical project location. This report does not include emissions arising from:

- Transport of natural gas to Project area;
- Construction of Project;
- Emissions from the switchyard and transmission line (Special Facilities);
- Likely Scope 1 resource use projections such as vehicle use, firefighting equipment, machinery operation/maintenance or other onsite activities that would cause direct GHG emissions;
- Likely Scope 3 resource use projections such as waste, employee commuting, business travel or other likely activities that would cause indirect GHG emissions; and
- Indirect emissions *"associated with the off-site production of energy used by the project"* as per Performance Standard 3 in Figure 5.3 are also unable to be calculated at this stage of the Project as electricity needs are unable to be projected.

This assessment is based on a best understanding and interpretation of the data available while acknowledging that the number of samples and therefore statistical confidence in the data is very limited.

5.2 Specific Methodology

The impact assessment methodology applies to the assessment of potential GHG emission impacts arising from the Project. The methodology has been developed in accordance with good industry practice and the potential impacts have been identified in the context of the Project's AoI.

5.2.1 Assessment Guidelines and Standards

Regarding the general requirement for assessing Project GHG emission impacts, this report has been prepared with reference to the International Finance Corporation (IFC) Performance Standards on Social and Environmental Sustainability (IFC, 2012), the World Bank Group (WBG) Environmental, Health, and Safety Guidelines (World Bank Group, 2007), hereafter referred to as the 'EHS Guidelines' and the Asian Development Bank (ADB) Environmental Safeguards (ADB, 2012).

IFC Performance Standards

The Introduction to the Performance Standards states that:

"IFC requires its clients to apply the Performance Standards to manage environmental and social risks and impacts so that development opportunities are enhanced" (IFC, 2012).

The 'client' is the party responsible for implementing or operating the project that is being financed. Performance Standard 3 on Resource Efficiency and Pollution Prevention outlines the requirements for clients regarding GHG emissions. The objectives of Performance Standard 3 are presented in Figure 5.1 and make specific reference to GHG emissions.

Objectives

- To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- To promote more sustainable use of resources, including energy and water.
- To reduce project-related GHG emissions.

Figure 5.1 : Objectives of Performance Standard 3 (IFC, 2012)

The General Requirements of Performance Standard 3 requires good international industry practice to be applied to resource efficiency and pollution prevention regardless of the project's location. The General Requirements are presented in Figure 5.2

General Requirement
During the project life-cycle, the client will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment.[2] The principles and techniques applied during the project life-cycle will be tailored to the hazards and risks associated with the nature of the project and consistent with good international industry practice (GIIP),[3] as reflected in various internationally recognized sources, including the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).

Figure 5.2 : General Requirements of Performance Standards 3 (IFC, 2012)

The Requirements of Performance Standard 3 with regard to GHG emissions are presented in Figure 5.3.

Greenhouse Gas Emissions
In addition to the resource efficiency measures described above, the client will consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project. These options may include, but are not limited to, alternative project locations, adoption of renewable or low carbon energy sources, sustainable agricultural, forestry and livestock management practices, the reduction of fugitive emissions and the reduction of gas flaring. For projects that are expected to or currently produce more than 25,000 tonnes of CO_2- equivalent annually, the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary as well as indirect emissions associated with the off-site production of energy used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognized methodologies and good practice.

Figure 5.3 : Greenhouse Gas Emissions Requirements of Performance Standard 3 (IFC, 2012)

Environmental, Health and Safety Guidelines

The EHS Guidelines (2007) are technical reference documents with general and industry-specific examples of GIIP (World Bank Group, 2007). Reference to the EHS Guidelines by IFC clients is required under Performance Standard 3 (IFC, 2012).

IFC uses the EHS Guidelines as a technical source of information during project appraisal activities, as described in IFC's Environmental and Social Review Procedure.

The EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC and are generally considered to be achievable in new facilities at reasonable costs by existing technology. For IFC financed projects, application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets with an appropriate timetable for achieving them. The environmental assessment process may recommend alternative (higher or lower) levels or measures, which, if acceptable to IFC, become project- or site-specific requirements.

[2] Technical feasibility is based on whether the proposed measures and actions can be implemented with commercially available skills, equipment, and materials, taking into consideration prevailing local factors such as climate, geography, infrastructure, security, governance, capacity and operational reliability. Financial feasibility is based on commercial considerations, including relative magnitude of the incremental cost of adopting such measures and actions compared to the project's investment, operating, and maintenance costs.

[3] GIIP is defined as the exercise of professional skill, diligence, prudence, and foresight that would reasonably be expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally or regionally. The outcome of such exercise should be that the project employs the most appropriate technologies in the project-specific circumstances.

Asian Development Bank Environmental Safeguards

The ADB Environmental Safeguards require the client to apply pollution prevention and control technologies and practices consistent with international good practice (ADB, 2012).

Pollution prevention and abatement is said to be required if the project has the potential to generate pollution or emit GHGs. The client is required to promote the reduction of GHG emissions from the project. A significant producer of GHGs greenhouse gases is those emitting 100,000 tonnes CO_2-e per year or more of both direct and indirect emissions. Projects which are to emit this level or above of CO_2-e per year are required to quantify their GHG emissions.

The ADB safeguards recommend the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) for estimating a project's direct GHG emissions.

5.2.2 Emissions Calculation

Direct emissions from the "*facilities within the physical project boundary*" (generally Scope 1 emissions) could arise from Project sources such as: natural gas combustion; vehicles on site; use of firefighting equipment; oil burning; and machinery operation and maintenance. Based on estimated information, resource use projections are only available for natural gas combustion emission estimates (Scope 1 emissions). GHG calculations are based on this activity.

The Project is only at a design stage and limited calculations can be performed. The following have been excluded from the emissions calculations of this assessment:

- Any emissions from the switchyard and transmission line (Special Facilities) have been excluded from this assessment of the operation impacts of the Project. This is because the ownership of these facilities will be transferred to PLN, as per Performance Standard 3 regarding quantifying emissions from the facilities owned within the physical project boundary.
- Likely Scope 1 resource use projections such as vehicle use, firefighting equipment, machinery operation/maintenance or other onsite activities that would cause direct GHG emissions as no data currently exists.
- Likely Scope 3 resource use projections such as waste, employee commuting, business travel or other likely activities that would cause indirect GHG emissions as no data currently exists.
- Construction emissions. Reference has been made to the Equator Principles (2013), which considers Scope 1 and 2 emissions only and excludes Scope 3 emissions (for example construction works or those listed above), as these types of emissions are not operationally controlled by the Project.
- Indirect emissions *"associated with the off-site production of energy used by the project"* as per Performance Standard 3 in Figure 3 are unable to be calculated at this stage of the Project as electricity needs are unable to be projected. Once the Project is commissioned, it is recommended that this is quantified however it may be that that the power purchase agreement will allow for electricity to be used for the plant itself which would result in no use of offsite electricity.

In any case, it is also highly likely that due to the scale of the natural gas combustion, all other activities (both Scope 1 and 3) emissions would be insignificant (less than 5% of total onsite GHG emissions) when compared to those from natural gas combustion (Scope 1). However once the Project is commissioned, it is recommended that all relevant activities emissions are quantified.

GHG emissions are calculated by multiplying a unit of activity (such as terra joules (TJ) of energy from natural gas combusted) with an emissions factor (which is the average emission rate of a pollutant (greenhouse gas) per activity rate i.e. tonne carbon dioxide per terra joule).

Emissions factors were sourced from IPCC (2006). Only CO_2, CH_4 and N_2O emissions calculations are available and these were used in the calculation of total CO_2e for the Project.

GHG emission quantification is calculated in accordance with the principles of the GHG Protocol, with reference to World Bank Performance Standards. These calculations are detailed in Figure 5.4 below.

IPCC Methodology

Fuel	Consumption (m3/yr)	MJ/m3	TJ/yr
Natural Gas	422,822,435	39	16,359

GHG	CO2	CH_4	N_2O
GWP	1	25	298

Emission Factors - tonne of GHG per TJ on a Net Calorific Basis									
	CO_2			CH_4			N_2O		
Emissions Factor Category	Default Emissions Factor	Lower	Upper	Default Emissions Factor	Lower	Upper	Default Emissions Factor	Lower	Upper
Natural Gas	56.10	54.30	58.30	0.0010	0.0003	0.0030	0.0001	0.0000	0.0003

Tonne of GHG Emissions (annual basis)									
	CO_2			CH_4			N_2O		
	Emissions	Lower	Upper	Emissions	Lower	Upper	Emissions	Lower	Upper
Natural Gas (IPCC defaults)	917739.90	888293.70	953729.70	16.36	4.91	49.08	1.64	0.49	4.91
Natural Gas (Site specific)	858683.91	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Tonne of GHG Emissions			
	tCO_2e		
	CO_2	CH_4	N_2O
Natural Gas	858684	409	487

These calculations are based on natural gas sources and amounts that are for indicative purposes only and are subject to confirmation.

Figure 5.4 : ESIA GHG Calculations

5.2.3 Determining Impact Significance

The determination of impact significance involves making a judgment about the importance of project impacts. This is typically done at two levels:

- The significance of project impacts factoring in the mitigation inherently within the design of the project; and
- The significance of project impacts following the implementation of additional mitigation measures.

There were no known published guidelines for determining the significance of GHG emissions from a Project at the time of writing this report, due to the inherent difficultly of linking emissions of a single project to a specific climate change impact on receptors. The complexity of the relationship between single plant emissions and global emissions means that determination of the significance at a local scale is not considered possible and has therefore been unable to be undertaken as part of this GHG assessment.

The ADB Environmental Safeguards and the IFC Performance Standards have thresholds that define significant emitters of GHGs. These are 100,000 tonnes CO_2e per year (ADB, 2012) and 25,000 tonnes CO_2e per year (IFC, 2012) respectively. These have been referenced to determine how significant Project GHG emissions may be. As the Project falls above these thresholds, this has determined the level of reporting required for the Project GHG emissions and mitigation measures have been discussed.

5.3 Assessment of Potential Impacts

5.3.1 Quantification of Operational GHG Emissions - Combustion of Natural Gas

Emissions factors for national gas have been sourced from IPCC (2006). To take account of variations in the carbon content of natural gas, the IPCC provides a default emissions value as well as upper and lower factors, for CO_2, CH_4 and N_2O. These have been reproduced in Table 5.1.

Table 5.2 presents the site specific emissions factors for CO_2 on the assumption that all carbon atoms in the gas are converted to CO_2. No N_2O is generated in the process. The tonnes per year value has been generated assuming a maximum 100% load.

The site specific emission factor for CO_2 was estimated based on the design gas composition, and is slightly lower than the default value from IPCC. As per IPCC (2006) guidance recommendations on choosing of emission factors, the site specific emission factor for CO_2 in Table 5.2 has been utilised for quantification of CO_2e emissions as this is considered most appropriate, considering that a maximum load has been assumed. The default emission factor for CO_2 has however also been included for comparison purposes. The default values in Table 5.1 from IPCC (2006) for CH_4 and N_2O have been used in the absence of site specific emission factors.

Table 5.1 : Default Emission Factors for Natural Gas Combustion from IPCC (2006) Table 2.2

Tonne of GHG per terra joule (TJ)									
	CO_2			CH_4			N_2O		
	Default Emissions Factor	*Lower*	*Upper*	*Default Emissions Factor*	*Lower*	*Upper*	*Default Emissions Factor*	*Lower*	*Upper*
Natural Gas	56.1	54.3	58.3	0.001	0.0003	0.003	0.0001	0.00003	0.0003

Table 5.2 : Site Specific Emission Factors for Natural Gas Combustion

Tonne of GHG per terra joule (TJ)			
	CO_2	CH_4	N_2O
Natural Gas	52.49	n/a	n/a

Note: n/a = not applicable.

Table 5.3 shows the likely Project CO_2e emissions. The Project is expected to create approximately 860,000 tonnes CO_2e per annum from natural gas combustion, based on calculations using the site specific emission factor for CO_2 in Table 5.2 and the default emission factors for CH_4 and N_2O in Table 5.1. See Figure 5.4 for further information on the calculation.

Table 5.3 : Summary of Carbon Dioxide Equivalent Emissions from Project Natural Gas Combustion

Tonne of GHG CO_2e				
	CO_2	**CH_4**	**N_2O**	**Total**
Natural Gas	858,684	409	487	**859,580**

In comparison, the Project would be expected to create approximately 919,000 tonnes CO_2e per annum from natural gas combustion, based on calculations using only the default emission factors in Table 5.1.

5.3.2 Assessment of Impact

The potential impact to climate would be considered to be internationally adverse (i.e. negative), although it is not feasible to assess this impact locally, as discussed in Section 5.1.3. Impacts would likely be direct impacts through the release of GHG emissions from Project operation, and would likely be long-term impacts as major GHGs can remain in the atmosphere for years.

There are approximately 860,000 tonnes CO_2e per annum predicted from the Project. When this amount is compared to the total cumulative emissions of 1,378 million tonnes of CO_2e per annum in Indonesia in 2000 (MoE, 2010), the GHG emissions from the Project are **Negligible** on a national and global level.

Despite this, as the ADB Environmental Safeguards and the IFC Performance Standards thresholds that define significant emitters of GHGs (100,000 tonnes CO_2e per year and 25,000 tonnes CO_2e per year, respectively) are exceeded and are required to quantify GHG emissions on an annual basis.

5.3.3 Comparison to Other Fuels and Technologies

Natural gas as a resource provides more efficiency than coal due to high operating temperatures and when natural gas use is paired with a combined-cycle plant, this results in even better efficiencies.

Total CO_2 emissions from natural gas-fired plants are around only 25% of those from coal, despite the fact that they generate nearly half as much electricity (International Energy Agency, 2010). This is due to the lower carbon content of gas per unit of energy delivered, as well as the higher efficiency of gas-fired electricity generation compared to coal plants.

With regard to the choice of a combined cycle gas turbine power plant proposed for the Project, electricity generation efficiency is further enhanced by waste heat from the gas turbine being used as the heat source in a heat recover steam generator (HRSG) boiler to generate steam. This drives a turbine to generate further electricity, significantly increasing the amount of megawatt-hour (MWh) generation produced per terrajoule (TJ) of gas consumed.

The technology of the Project is therefore a very efficient form of power generation; this was designed for high reliability and efficiency operation with a lower environmental impact, as compared to generating power with a straight gas turbine unit fired on natural gas.

5.4 Mitigation and Monitoring

5.4.1 Evaluating Options to Reduce GHG Emissions

Introduction

As per Performance Standard 3 (IFC, 2012) shown in Figure 3.3, the consideration of alternatives to reduce project related GHG emissions is required. Regarding options to reducing GHG emissions, technology improvements in recent years have been striving for higher efficiencies and lower CO_2 emissions.

This section evaluates a number of additional options to reduce or offset GHG emissions and some recommendations on the appropriateness of these. MRPR, the owner and operator of the Project, should further research these options and assess their appropriateness for the Project.

Develop GHG Targets for Environmental Management Systems

Principle 2 of the Equator Principles requires the establishment of effective environmental and social management systems. For a natural gas CCPP plant, an environmental issue to consider operationally will be GHG emissions.

Annual monitoring and quantifying of GHG emissions can help establish current CO_2e emissions and can improve owner awareness of emissions, accurately gauge project performance, and determine the need for improvements. The ADB Environmental Safeguards supports this as a measure to effectively manage and promote future GHG emissions (ADB, 2010).

Jacobs recommends that GHG emissions are to be determined on an annual and semi-annual basis using the most appropriate internationally recognised methodology.

Jacobs recommends MRPR institute a process to identify areas of potential GHG reduction in the future.

Demand Side Measures to Reduce Need for New Generation

Typically, a country's electricity sector is structured such that increased consumer demand is satisfied through the construction of new power plants or expansion of existing plant rather than through measures to reduce consumer demand. In some jurisdictions, for example California, power utilities are required to demonstrate that they have implemented comprehensive energy efficiency programmes with customers before they are permitted to develop new power plants.

To meet the needs of its rapidly growing economy, Indonesia's electricity sector is focused on the development of new power generation rather than demand side measures. In this context, the Project will contribute to the continued growth of the Indonesian economy.

As such, Demand Side Measures are not currently considered an appropriate option to reduce GHG emissions from the Project. However, in order to influence demand side requirement.

Obtain Carbon Credits / Offsets

In a number of developed countries, large GHG emitters are participants in emissions trading schemes, under which they need to reduce GHG emissions to prescribed levels or face a penalty. Such participants can reduce emissions either directly or can purchase 'carbon credits' in the form of allowances from other scheme participants or emission reductions from projects in other countries. Participants in emissions trading schemes have clear market incentives to reduce their emissions as the penalty for non-compliance is typically much higher than costs of abatement or purchasing carbon credits.

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets (UNFCCC, 2014). For emitters in developing countries, no such market incentives exist for GHG emissions under the Kyoto Protocol or any other international or national agreements. Instead, the focus is different. That is, developers of projects which reduce GHG emissions are eligible to obtain additional finance for their project through the Clean Development Mechanism of the Kyoto Protocol. In addition, Indonesia has a number of compulsory and voluntary carbon credit schemes under development.

The ADB Environmental Safeguards notes that carbon offsetting, involving the reduction of GHG emissions elsewhere to offset or compensate for project emissions, may be undertaken as a Project GHG reduction option (ADB, 2010). This can be through:

i. the establishment, enhancement or protection of carbon sinks (e.g. forests)

ii. the promotion of sustainable forms of agriculture and forestry; or

iii. other activities that sequester carbon.

Given that there is no national regulatory requirement for the Project to reduce its GHG emissions, it is not recommended that the Project purchase carbon credits on the open market in order to reduce its emissions given the substantive cost involved and the limited benefits. The Project should however remain open to the option of future carbon emission schemes that are under development.

5.4.2 Summary of Mitigation and Monitoring

The following mitigation and monitoring are recommended:

The Project should incorporate the following into its Action Plan (Environmental and Social Management Plan):

- Quantify its annual GHG emissions using established methodologies;
- Institute a process to identify areas of potential GHG reduction in the future;
- Ensure an environmental management system designed to achieve improved environmental performance is in place; and
- Monitor and report on emissions in accordance with Annex A of the Equator Principles (2013).

The Project owner should:

- Encourage energy efficiency by end users (i.e. business and households) through voluntarily initiatives.

6. Soils, Geology and Groundwater

6.1 Specific Methodology

The impact assessment methodology applied to the assessment of potential impacts on soils, geology and groundwater arising from the Project, was undertaken in accordance with the impact assessment methodology outlined in Section 2.

6.2 Assessment of Potential Impacts

6.2.1 Construction

6.2.1.1 Excavation of Topsoil

Given groundwater beneath the power plant is likely to be shallow, the levelling of the site (cut and fill) and subsequent excavation for foundations may intercept the shallow unconfined water table. Depending on the final construction methodology, there will be a requirement for localised dewatering operations. Dewatering typically involves pumping water from open excavations with a sump pump and discharging to land. The volume of water to be dewatered is still to be confirmed however, it anticipated that water will be discharged to ground and soakaway into the local groundwater outside the power plant area, the location of which is also still to be confirmed. Dewatering has the potential (albeit small) to result in a temporary localised drawdown of water levels within neighbouring wells.

For the purpose of this assessment, we have used a conservative Theis (1937) equation to calculate potential drawdown from the dewatering. Potential drawdown was calculated using a range of estimated hydraulic parameters for the geology at the site. These of parameters are as follows:

- Transmissivities ranging from 10 to 100 m^2/day;
- Storativity ranging from 10^{-4} to 10^{-5}; and
- Pumping rates ranging from 1 to 2 L/s.

It is noted that for the purpose of this assessment, we have assumed that pumping is constant for a 50-day maximum period. However, this is unlikely to be the case as dewatering is typically only for periods of days to a few weeks, and therefore this assessment is considered to be conservative.

Potential drawdown as a result of excavation is likely to range from 0.5 to 0.8 m at a 500 m radius from the power plant, assuming dewatering is occurring constantly for a 50-day period. Only eight wells have been identified within a 500 m radius of the site, all used for irrigation purposes. The location of these 8 wells are detailed in Figure 6.1 below.

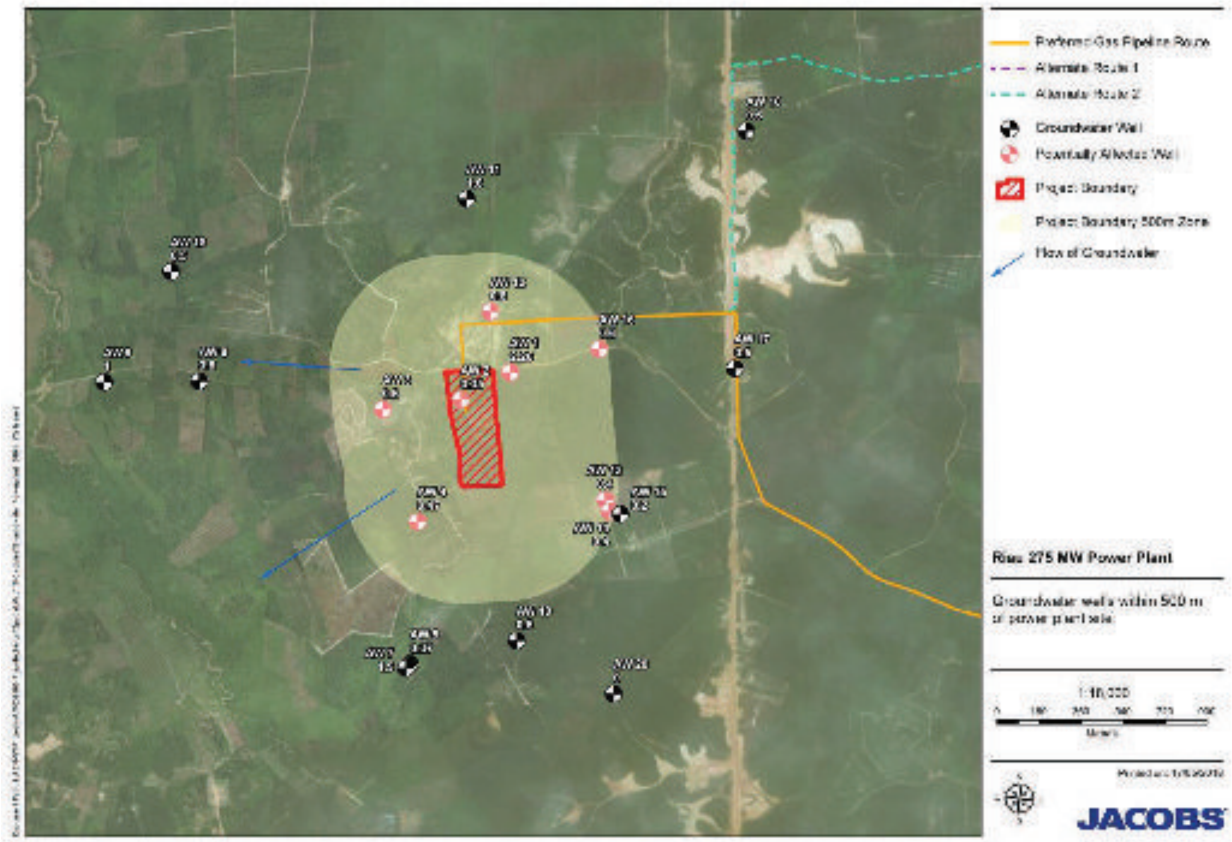


Figure 6.1 : Location of Wells within 500 m Radius of the Power Plant Site

Given the undulating nature of the area, it is highly unlikely that any of these shallow wells are hydraulically connected to groundwater at the proposed plant site. Nevertheless, monitoring based mitigations will be implemented to manage this.

Overall, the effects of dewatering drawdown, if any, would be short term during construction and most likely limited to relatively short distances from the site boundary and as such are considered to have a **Minor** level of impact.

6.2.1.2 Temporary Jetty Excavation and Dredging

For construction of the temporary jetty approximately 1,440 m^3 of material will be excavated and dredged from the Siak River bank and bed. This material will either be stockpiled at the temporary jetty site to be used as backfill once the temporary jetty to restore the site following decommissioning of the temporary jetty. Alternatively, the material may be disposed of to the approved spoil disposal areas. The sediment quality results as set out in Volume 5 Technical Appendices - Technical Report: Water Quality and Freshwater Ecology for the temporary jetty site and Siak River, have been compared to the RSLs for Chemical Contaminants for Industrial Sites and Residential Sites and the contaminant levels recorded are well below the RSLs for the protection of human health. Based on this, the impact of contaminants contained in the sediment are determined to be of **Negligible** impact.

6.2.1.3 Transmission Tower Construction & Installation

The construction and installation of transmission towers has the potential to impact on groundwater. This is likely to be localised and limited to the duration of the construction and installation of the transmission towers. The impact as a result of drawdown is likely to be less than that described in Section 6.2.1.1 given the excavation and associated dewatering with the construction and installation of the transmission towers bases will be significantly smaller in scale, and therefore the impact of the drawdown is considered to be **Negligible**.

6.2.1.4 Gas Pipeline Construction & Installation

The construction and installation of gas pipeline has the potential to impact on groundwater via dewatering and accidental spills / losses. This is likely to be localised and limited to the duration of the construction and installation of the gas pipeline. The impact as a result of drawdown is likely to be less than that described in Section 6.2.1.1 given the excavation and associated dewatering with the construction and installation of the gas pipeline will be significantly smaller in scale, and therefore the impact of the drawdown is considered to be **Negligible**.

6.2.1.5 Soil Consolidation

Soil consolidation (including secondary consolidation) as a result of the power plant has been calculated at a maximum of 25 mm. The level of consolidation is expected to have a **Negligible** impact on groundwater levels.

6.2.1.6 Accidental Contaminant Spills

Accidental contaminant spills from construction activities, such as diesel or oil leaking from machinery or storage tanks has the potential to impact soil and groundwater quality. In particular, the main concern associated with accidental contaminant spills relates to the potential impact on human health from exposure to contaminated soils or consumption of contaminated groundwater. It is noted that the impact of accidental contaminant spills is dependent on the location of the spill and the contaminant properties. However, there will be various mitigation measures built into the design of the power plant and gas pipeline. The key mitigation measures built into the design of the power plant include the following:

- Register on-site will be held and maintained during construction and operation, which sets out the types, volumes and locations of all hazardous substances;
- Appropriate bunding shall be used when there is a risk of leaks, spills or loss of containment. Bunding needs to be provided for:
  - All tanks and other vessels containing materials which can cause an environmental, safety or health hazard;
  - Any other area where spills may occur (e.g. filling stations, decanting areas, drum storage areas etc.); and
  - Bunded areas for tanks will be sized to contain 110% of the largest tank in the bund.
- Storage areas for hazardous substances (including piping systems) must be inspected on a regular basis to detect spills, leaks and the potential for such occurrences. Any deficiencies found must be recorded and immediately reported to the work area manager in order for the deficiency to be rectified as soon as practicable;
- Arrangements must be in place to ensure that the appropriate spill control equipment for storage and transport (i.e. for water and/or land) is available in sufficient quantities for any foreseeable spills;
- Any such equipment must be routinely inspected and maintained in good working order and in a state of readiness; and
- Preparation and implementation of emergency response procedures which manage spoils, fires etc., and include warning and evacuation of nearby residences.

Given the aforementioned mitigation measure built into the design of the power plant and gas pipeline, particularly in relation to bunding and preparation and implementation of emergency response procedures, the risks of accidental contaminant spills occurring is significantly reduced, meaning it is unlikely down-gradient wells will be impacted. Therefore, the impact of accidental contaminant spills is considered to be **Negligible**.

6.2.2 Operation

Accidental Contaminant Spill

Accidental contamination spills may also occur during operation of the power plant. The impacts are likely to be similar to those described in Section 6.2.1.6 given the mitigation measures built into the design of the power plant and gas pipeline, particularly in relation to bunding and preparation and implementation of emergency response procedures.

6.3 Mitigation and Monitoring

6.3.1 Construction and Operation

6.3.1.1 Water Level Monitoring of Dewatering Operations at the Power Plant Site

In order to assess the effects of localised dewatering operations at the site it is recommended that a minimum of four groundwater level monitoring wells are installed around the boundary of the site. These should be installed after the cut & fill operations but prior to foundation construction to minimise the risk of them being damaged, and so that they reflect the post earthworks water table.

The purpose of these wells is to serve as an early warning signal that dewatering may be having an affect outside of the site boundary. Should groundwater levels reduce by more than 0.5 m at the site boundary, then the monitoring of the eight neighbouring wells within 500 m of the site shall be implemented. Off-site wells should be monitored on a weekly basis until such time as dewatering operations have ceased. Should a reduction in water levels in the off-site monitoring wells reduce the available drawdown in a private well by more than 50% then the rate and duration of dewatering operations at the project site should be reduced immediately. Level monitoring of the affected well should then occur on a daily basis until available drawdown is maintained at >50%.

Groundwater dewatered from the power plant site excavations will be treated prior to disposal to land downgradient of the power plant. Furthermore, the dewatering discharges should be monitored in accordance with WBG EHS Guidelines for liquid effluents.

6.3.1.2 Accidental Contaminant Spills at the Power Plant Site

As outlined in Section 6.2.1.6, there a number of mitigation measures built into the design of the power plant to help reduce the risk of accidental contamination spill occurring. In the unlikely event that an accidental contamination spill does occur, and the mitigation measures built into the design of the power plant, such as bunding, do not stop the contaminants from entering the underlying soils, all contaminated soil should be excavated and replaced with clean fill to limit the likelihood of groundwater contamination occurring. The excavated soil should be disposed of off-site in accordance with relevant regulatory guidelines.

6.3.1.3 Water Quality Monitoring of Dewatering Operations at the Power Plant Site

Risks to neighbouring wells from accidental spills and releases are minimal given the implementation of the plan described above. In addition, the slow groundwater flow rates, and absorption capacity of the clay soils reduce the risk of accidental spills migrating far.

Nevertheless, as a precautionary measure it is recommended that any wells identified as being used for domestic purposes within a 250 m radius of the power plant site are monitored on a monthly basis for total petroleum hydrocarbons.

6.3.1.4 Accidental Contaminant Spills along the Gas Pipeline

As outlined in Section 6.2.1.6, there a number of mitigation measures built into the design of the gas pipeline to help reduce the risk of accidental contamination spill occurring and should a spill occur during operation gas will rise and therefore there are no risks of contaminating groundwater and soils. During construction, in the unlikely event that an accidental contamination spill should occur, all contaminated soil should be excavated and replaced with clean fill to limit the likelihood of groundwater contamination occurring. The excavated soil should be disposed of off-site in accordance with relevant regulatory guidelines.

6.3.1.5 Monitoring of Dewatering Operations along the Gas Pipeline

Construction of the gas pipeline will proceed at a quick pace and would typically involve having an open section of trench of up to 500 m. Depending on construction techniques, the trench would only be expected to be open for a period of days up to a week. Given this the chance of impacts associated with dewatering, extending far from the trench is minimal.

Nevertheless, as a good practice precautionary measure monitoring of wells within close proximity radius to the open trench should be monitored for water level and water quality once whilst construction is directly adjacent.

6.4 Assessment of Residual Impacts

The specific mitigation and monitoring measures proposed are likely to result in a reduction in the impacts on soil and groundwater quality identified during construction and operation of the power plant. Therefore, any residual impacts are considered to be **Negligible** if the specific mitigation and monitoring measures are implemented.

7. Hydrology

7.1 Specific Methodology

7.1.1 Catchment Areas

For consideration of the hydrology and hydraulics around the proposed power plant, catchment areas were delineated for:

- Siak River at S. Tapung Kiri-Pantai Cermin flow gauging station;
- Siak River at the Riau CCPP intake/discharge pipeline;
- Riau CCPP laydown area; and
- Riau CCPP local catchments.

The local catchments have been subject to a hydraulics assessment to determine potential peak flows and clean water diversion requirements. For this reason, a time of concentration has been calculated using the Bransby Williams formula to identify suitable peak storm intensities to apply in peak flow calculations.

Table 7.1 : Catchment Areas

Catchment Name	Catchment Area (km^2)	Comment
S.Tapung Kiri-Pantai Cermin Flow Gauging Site	1,716	This catchment area has been defined by the Pekanbaru Hydrology Center. This has been correlated with the ASTER digital elevation model with an accuracy of +-1.6%.
Power plant at Intake/Discharge	5,480	The total catchment area includes the flow gauging catchment (S. Tapung). A large river joins the Siak River between Pekanbaru City and the proposed Riau CCPP.
Power plant Laydown Area	0.091	Represents the total Riau CCPP site area (green line in Figure 3.16).
Power plant Eastern Diversion Catchment	0.090	Represents a catchment to the east of the Riau CCPP, where contour data indicates potential runoff towards the site (see Figure 3.16).
Power plant Western Diversion Catchment	0.052	Represents a catchment to the west of the RIAU CCPP, where contour data indicates potential runoff towards the site (see Figure 3.16).

Table 7.2 : Time of Concentration Using Bransby Williams formula for Rural Runoff

Catchment	Average Elevation Change (m)	Maximum flow path length (m)	Time of Concentration (Tc) in minutes
Power plant Eastern Diversion Catchment	10 m	220	7.6
Power plant Western Diversion Catchment	13 m	190	6.4

7.1.2 Observed Siak River Flows

Average daily river flow (m^3/s) is available for the Siak River, at S.Tapung Kiri-Pantai Cermin gauging station. Annual data exists from 1980 to 2013 and provides daily flow time series and flow duration exceedance curves for each year. A composite flow duration curve for the entire record is presented in Figure 7.2.

This hydrological monitoring site has a catchment area of ~1,716 km^2 (see Table 7.1) and is located ~36 km upstream of the proposed water take and discharge pipeline for the power plant. The latitude/longitude coordinates are 0°35'24.00"N, 101°11'46.00"E, with further detail provided in Figure 7.1.

Between these two locations, a tributary joins the Siak River. Subsequently, the catchment area increases to ~5,480 km^2.

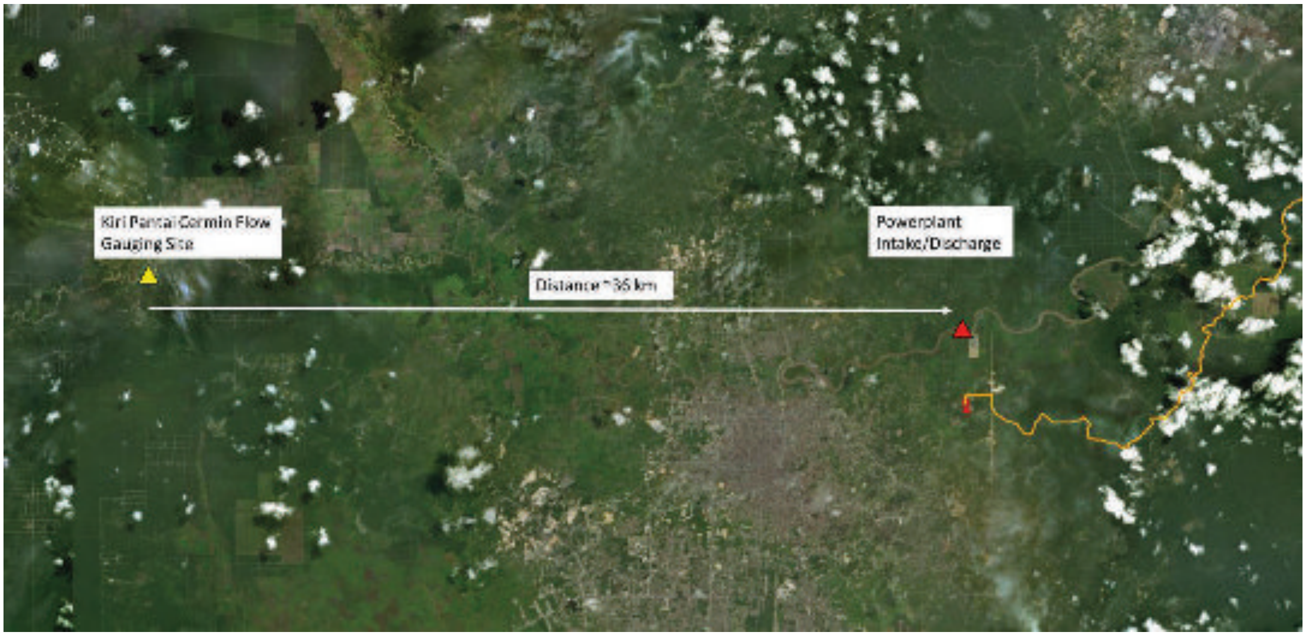


Figure 7.1 : Siak River Hydrological Monitoring Station Relevant to the Riau CCPP Intake and Discharge Pipeline

Key characteristics of this data record are documented in Table 7.3, including annual flow assessments.

Table 7.3 : Tapung Kiri Pantai Cermin Hydrological Station Background Information

Criteria	Measurement	Comment
Recording Period	1980-2013	Data gaps exist throughout this period. Records exist for a total of 24 years from 1981–1984, 1988–1993, 1995–1999, 2004–2006, 2008–2013.
Largest daily peak flow	253.0 m^3/s	There is uncertainty in the peak flow estimates above 150 m^3/s, as no manual gaugings are available to verify the flow rates.
Minimum daily low flow	7.03 m^3/s	-
Mean annual daily flow	69.2 m^3/s	Determined from 24 years of flow records

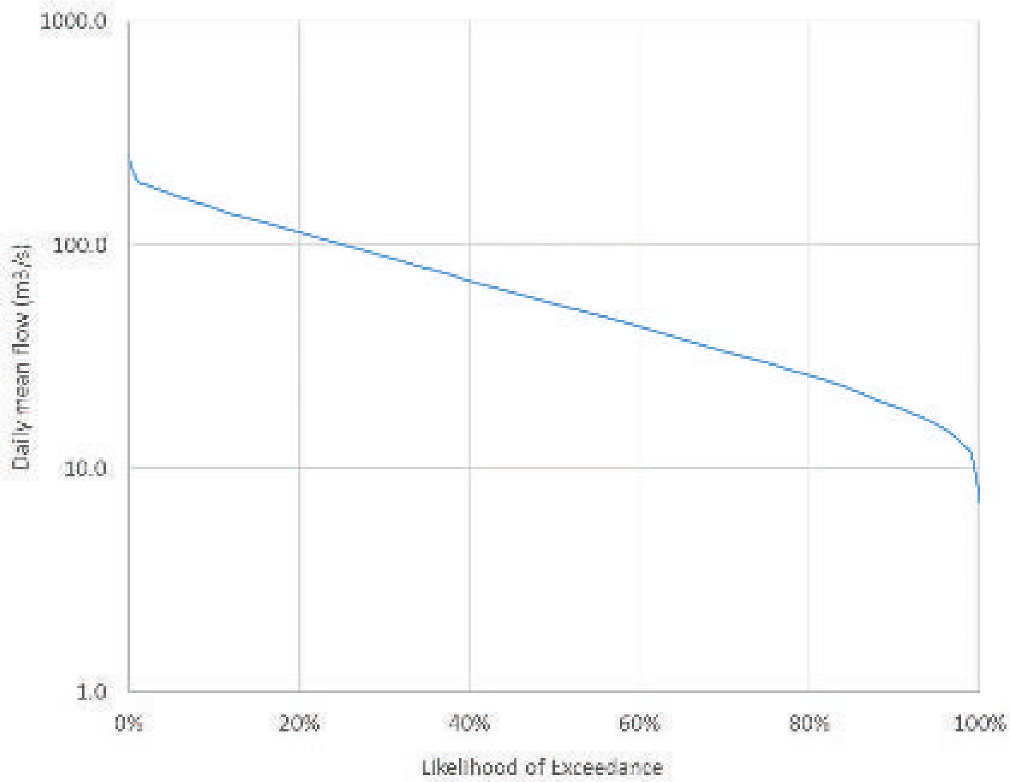


Figure 7.2 : Flow Duration Curve for Tapung Kiri Pantai Cermin Hydrological Station Between 1980–2013

A flood assessment of the 24 years of data was undertaken by fitting probability distributions to the observed daily mean flows (no instantaneous flow data was available). A number of distributions were compared (such as the Gumbel, Generalised Extreme Value (GEV) and Pearson Type III distributions).

The Gumbel distribution produced the most suitable fit to the observed annual maximum flows, and provides an indication of recurrence intervals of flood events along the Siak River.

Table 7.4 and Figure 7.3 present the Gumbel Distribution results. A flood with an average recurrence interval (ARI) or return period of 1 year has a daily mean flow of ~167 m^3/s (letter X in Figure 7.3).

Table 7.4 : Summary of Gumbel Distribution Flood Return Periods

Simulated or Observed	Period	Observed or Simulated Flow (m^3/s)	Gumbel Ranking	Annual Exceedance Probability (%)	Flood return period (ARI)
Simulated (Gumbel)	N/A	300.2	N/A	0.1	1000
		288.8		0.2	500
		273.8		0.5	200
		262.5		1	100
		250.0		2	50
		236.2		5	20
		224.1		10	10

Simulated or Observed	Period	Observed or Simulated Flow (m^3/s)	Gumbel Ranking	Annual Exceedance Probability (%)	Flood return period (ARI)
Observed	1-Jan-1991 30-Dec-1991	253.0	A	2	56.2
	1-Jan-1989 22-Jan-1989	240.0	B	4	25.7
	1-Jan-2012 06-May-2012	228.9	C	7	13.2
	1-Jan-2013 24-Oct-2013	220.4	D	12	8.1
	1-Jan-1981 18-May-1981	167.0	X	63	1.0

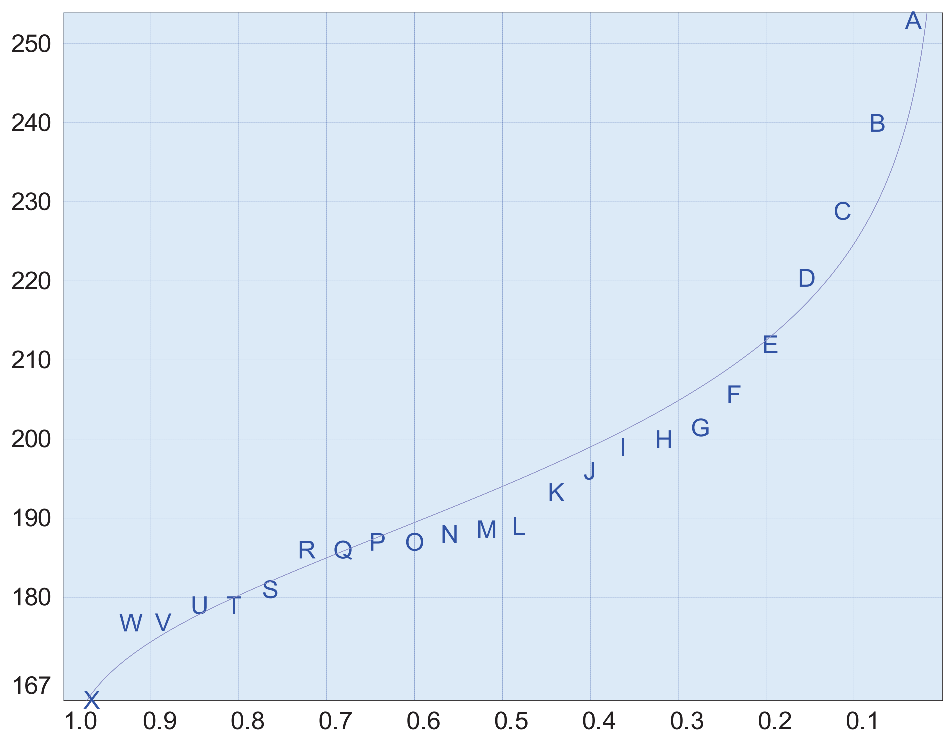


Figure 7.3 : Gumbel Distribution Fitted to Observed Annual Maximum Daily Flows (Letters A to X)

The discharge per unit catchment area ($m^3/s/km^2$) has been calculated for each of the design storms in Table 7.4 and for the minimum and annual mean daily flows in Table 7.3 for Tapung Kiri Pantai Cermin Hydrological Station. This has been multiplied with the power plant catchment area (Table 7.1) at the intake to estimate peak flood events and a corrected minimum and annual mean daily flow at this location (see Table 7.5).

This method is an estimate only and averages flow across a catchment area. When applied to the Riau CCPP catchment this assumes uniform flow generation and similar topographic, climatic and rainfall runoff characteristics.

Table 7.5 : Predicted Flows at the Riau CCPP Intake Under Various Flow Events

Flood Return Period (years)	Discharge per unit area ($m^3/s/km^2$)	Predicted Flow at Riau CCPP Intake (m^3/s)
1000	0.175	958.7
500	0.168	922.3

Flood Return Period (years)	Discharge per unit area ($m^3/s/km^2$)	Predicted Flow at Riau CCPP Intake (m^3/s)
200	0.160	874.4
100	0.153	838.3
50	0.146	798.4
20	0.138	754.3
10	0.131	715.7
1	0.097	533.3
Minimum flow	0.004	22.5
Annual Mean Daily Flow	0.040	221.0

Three flow measurements at the Riau CCPP intake have been recorded (refer to ESIA Volume 5, Appendix B – Process Description), which indicates the river flow ranged from 267.9 to 434.6 m^3/s over 2 days in March 2016. March is shown to be typically a wet month with up to 212 mm of rainfall, indicating these flows are consistent with the assessment in Table 7.5.

In order to assess the unlikely risk of flooding from the Siak River, peak flows for the 100-year flood event (Table 7.5) at the Riau CCPP intake/discharge location were assessed using the Mannings open channel flow formula and a conceptual river cross section. The measured river cross section B-B was complemented with inferred topographical data from the digital elevation model and contour lines, in order to develop the cross section presented in Figure 7.4.

The Mannings approach is empirical and is intended as a simple estimate to consider flood risk, without the need for a detailed hydrological model.

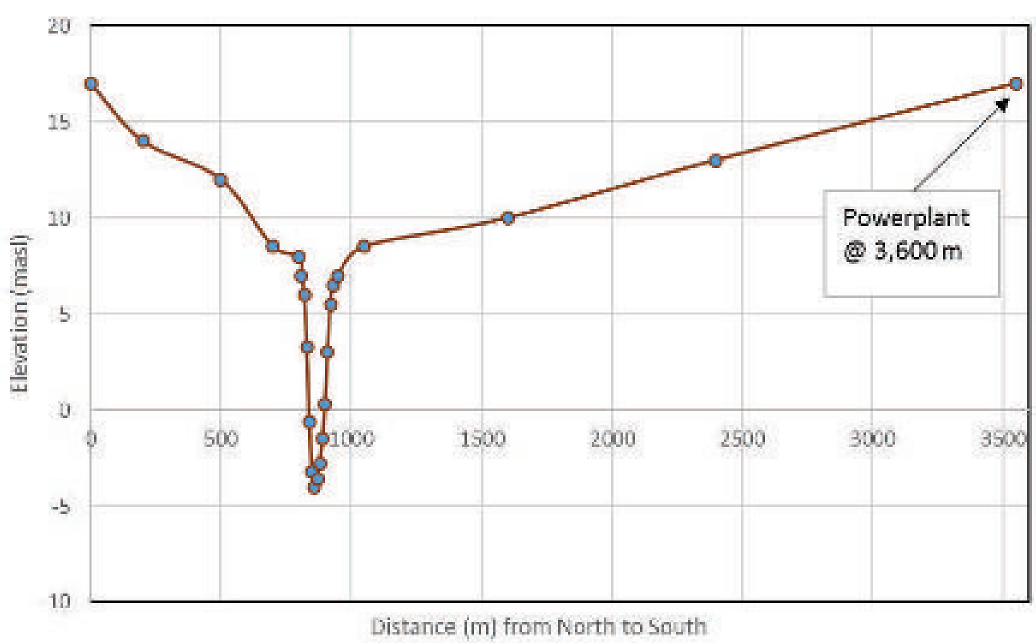


Figure 7.4 : Conceptual Siak River Cross Section Developed Using Measured River Width and Depth from Cross Section B-B, and Inferred Elevations from Contour Lines and a Digital Elevation Model for the True Left and Right Banks

The input assumptions used in the Mannings equation are outlined in Table 7.6 and the results are presented in Figure 7.5.

Table 7.6 : Input Parameters for Mannings Equation to Estimate Flood Water Levels at the Riau CCPP

Input Parameter	Value	Comment
Elevation of Siak River	7 m aMSL	Estimated off digital elevation model.
Elevation of power plant	17 m aMSL	Derived off Figure 3.16.
Distance of site from the sea	136,000 m	Direct linear measurement.
Slope of the river channel	0.000051	Assumes sea is 0 m, represents Siak River elevation divided by distance from the ocean.
Mannings n roughness value	0.035	Typical value for large natural rivers.
100-year peak flow	838.3 m^3/s	See Table 7.5.
Tidal water depth	2.2 m	See Section 3.5.2.

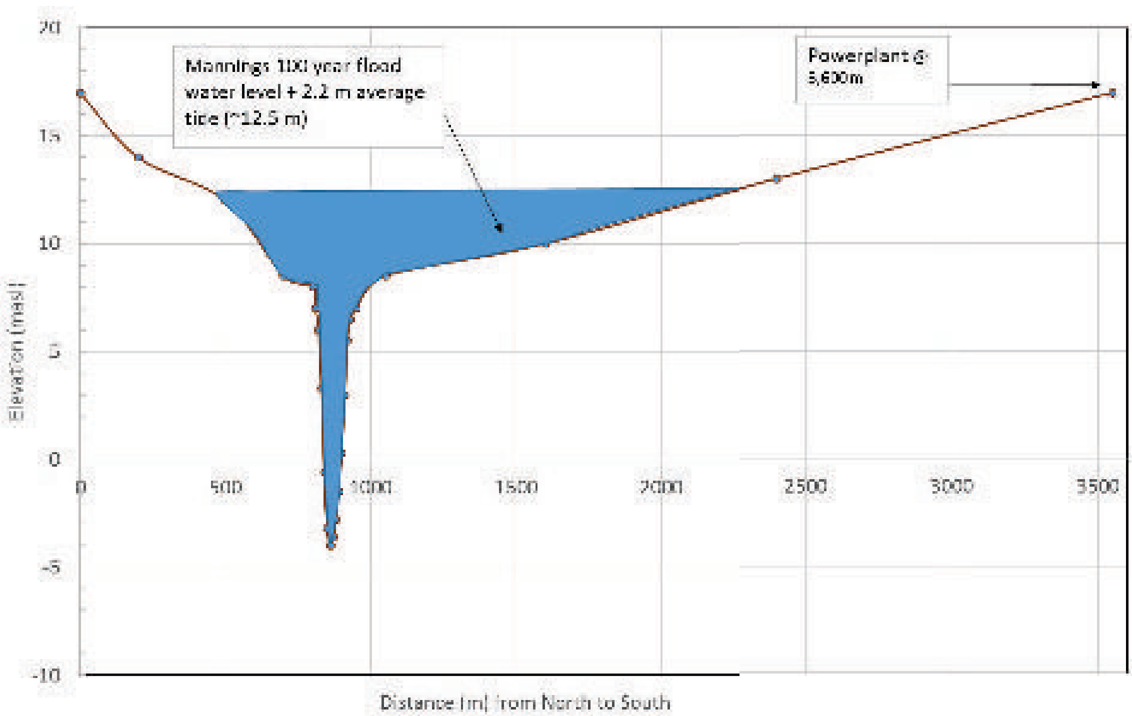


Figure 7.5 : Mannings 100-Year Peak Flood Level for the Siak River During an Average High Tide

7.1.3 Sumatra Rainfall Runoff Curves

Little local data exists to determine rainfall intensity characteristics for sub-daily intervals. This refers to the design rainfall depths (mm) and intensities (mm/hour) that are used when sizing a range of hydraulic engineering systems, such as stormwater channels, dam spillways and sediment ponds.

A method exists for determining 24-hour regional rainfall intensity curves for highway design, based on the manual “Highway and Urban Hydrology in the Tropics” (Watkins and Fiddes, 1984). This has been utilised for the Sumatra Region.

The data used for the Sumatra Region to determine constants for predicting rainfall depth and intensity is based off a single monitoring station with 30 minute to 24-hour data records. These are an estimate and local data should be sourced to help refine detailed designs.

A long term climate record from the Kantor PU Rainfall Station (~10 km west of the project location) was used to develop sub-daily rainfall intensity curves. This site had daily rainfall records from 1980–2013 (~33 years). A frequency distribution was plotted with the daily rainfall data to determine:

- Annual maximum daily rainfall depths (mm); and
- Annual probability of occurrence (and return periods in years).

The most suitable fit for the rainfall data was a GEV distribution, the outputs of which have been documented in Figure 7.6.

Following this assessment, the 24 hour (daily) rainfall depths for the recurrence intervals in Table 7.7 were incorporated into the Watkins and Fiddes (1984) method, which resulted in the proportioning of these daily rainfall totals into sub-daily intervals, or Intensity Frequency Duration (IFD) curves. The IFD table is presented in Table 7.8, and can be utilised in conceptual design and hydraulic assessments.

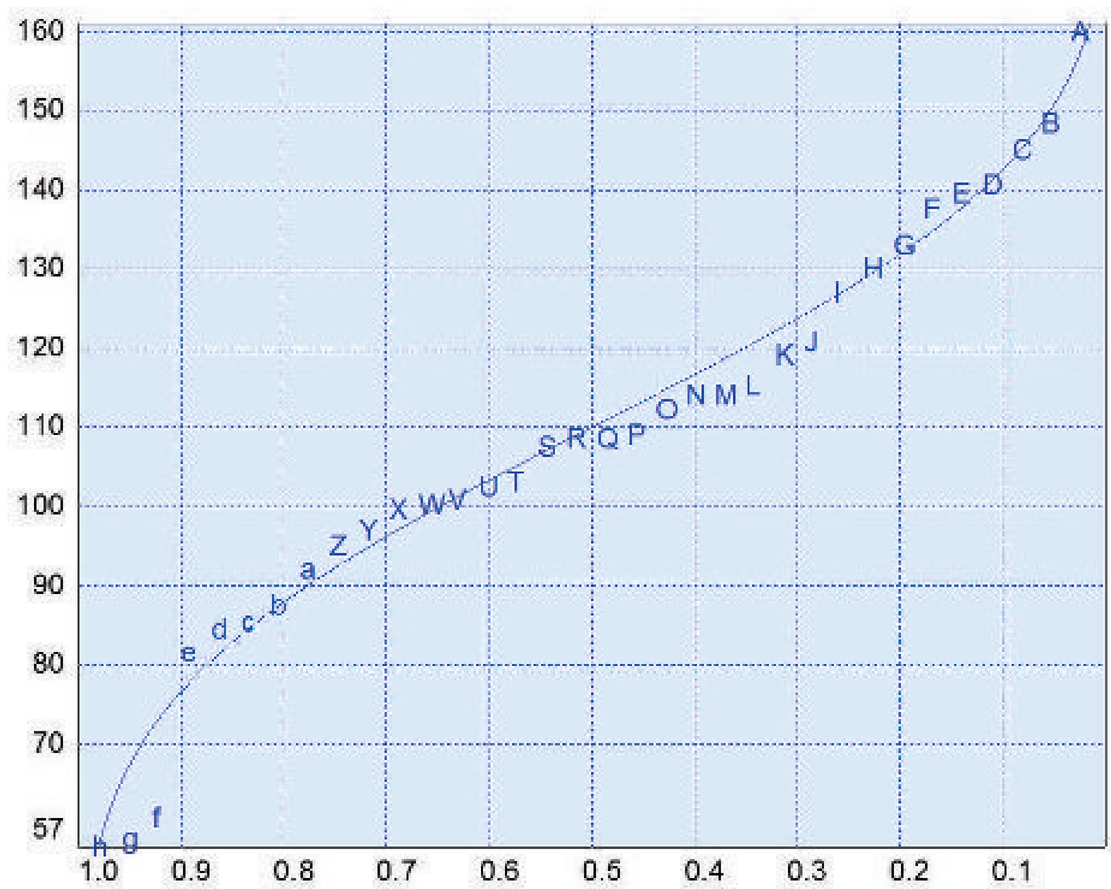


Figure 7.6 : Generalised Extreme Value Distribution Plotting Annual Daily Maximum Rainfall (mm) for the Kantor PU Rainfall Station ~10 km West of the Project Location. Each Value (A to Z, a to h) Refers to an Annual Maximum Rainfall Amount, with the Line Representing the GEV Distribution Fit

Table 7.7 : GEV Simulated Daily Rainfall Depths and Return Periods

Return Period (years)	Annual Exceedance Probability (AEP) %	GEV simulated daily rainfall depth (mm)
1000	0.1	172.5
500	0.2	170.2

Return Period (years)	Annual Exceedance Probability (AEP) %	GEV simulated daily rainfall depth (mm)
200	0.5	166.3
100	1	162.5
50	2	157.8
20	5	149.6
10	9.5	141.5
5	18	130.8
2	39	109.0
1	63	57.0

Table 7.8 : Intensity Frequency Duration Tables for Kantor PU Rainfall Station and Project Site

Time (min)	Time (hr)	Intensity (mm/hr)									
		1 yr	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr	1000 yr
1	0.02	146.7	280.5	336.6	364.2	385.0	406.1	418.2	428.0	438.0	443.9
5	0.08	122.3	234.0	280.8	303.7	321.1	338.7	348.8	357.0	365.3	370.3
6	0.10	117.5	224.7	269.6	291.7	308.4	325.3	335.0	342.8	350.8	355.6
10	0.17	101.5	194.1	232.9	252.0	266.4	281.0	289.3	296.1	303.1	307.1
15	0.25	86.8	166.0	199.2	215.5	227.9	240.4	247.5	253.3	259.3	262.8
30	0.5	60.8	116.3	139.6	151.0	159.6	168.4	173.4	177.4	181.6	184.1
60	1	38.3	73.3	88.0	95.2	100.6	106.2	109.3	111.9	114.5	116.1
120	2	22.3	42.6	51.2	55.4	58.5	61.7	63.6	65.1	66.6	67.5
180	3	15.8	30.3	36.3	39.3	41.5	43.8	45.1	46.2	47.3	47.9
360	6	8.6	16.4	19.6	21.3	22.5	23.7	24.4	25.0	25.6	25.9
720	12	4.5	8.7	10.4	11.3	11.9	12.6	12.9	13.2	13.5	13.7
1440	24	2.4	4.5	5.5	5.9	6.2	6.6	6.8	6.9	7.1	7.2

7.2 Assessment of Potential Impacts

7.2.1 Hydrogeological Impacts

The primary hydrological impacts from this project can be partitioned into the two main developments, the Riau CCPP site and the ~40 km gas pipeline. Road infrastructure has not been considered for this assessment. The magnitude of the hydrological impacts has been identified in each of the various subsections which further describe the summaries below.

Power Plant Construction

- Water supply demand for workers (potable), vehicle and equipment washdown and firefighting reserve. Concrete mixing has been assumed to be undertaken off site (brought in via trucks); and
- Stormwater management on site (including capture of runoff in sumps, development of diversion drains and treatment/discharge of runoff).

Power Plant Operation

- Flooding risk from Siak River;

- Permanent stormwater capture, treatment and discharge;
- Raw water abstraction from Siak River for the combined purposes of power generation, makeup water for cooling towers and the water treatment plant, potable water supply and fire water; and
- Discharge of treated effluent form the power plant to the Siak River.

Gas Pipeline Construction

- Water supply for construction staff and concrete mixing for foundations.

Gas Pipeline Operation

- Flooding risk at the two primary pipeline stream crossings (pipe bridges).

7.2.2 Power Plant Construction

Construction of the power plant and laydown area will cover an approximate area of 9.1 hectares (Table 7.1). The power plant buildings, cooling tower, switchyard and residual plant area between these structures has an area of ~5.4 ha (ESIA Volume 5, Appendix B - Process Description). For the purposes of this section, the total area (5.4 ha) will be referred to as the 'construction pad'. Based on the topographic contours in Figure 1.2, the site is located in an elevated area along a ridgeline. There are no permanent water courses through this area. Annual average rainfall is ~2,472 mm/year, and the one hour one-year design storm depth is ~38.3 mm (Table 7.8). During heavy rainfall, overland flow could occur on the construction pad and across the site from localised eastern and western catchments (see Table 7.1).

In addition to overland flow from single high intensity storms, the wet conditions experienced at site could lead to difficulties in ground conditions and increased sediment and contaminant discharge to the receiving environment. Inherent design would allow for a diversion drain (further described in 7.3.1) to divert this clean water around the site.

Compaction of the site and exposed topsoil due to vegetation clearance (palm oil plantations) and pad levelling would be the most direct impact during construction, and would increase runoff and sediment load, thus requiring some form of temporary treatment or retention prior to discharge. The impact of this clearing and construction pad development (without treatment) is considered to be **Minor**. This is based on an assumed Low sensitivity of the intermittent flowing streams, which would be small in size and have a lower ecological value than a perennial stream. The magnitude is considered **Moderate**, given vegetation clearance and runoff characteristics will be subjected to a permanent change.

During construction, there will be a water demand for workers (potable and toiletry), equipment washdown and potentially a reserve for fire-fighting. In addition, concrete mixing may be undertaken off-site and brought in from Pekanbaru City. In the event that mixing is undertaken on site, water demand will be ~45 m^3/d. Water for these activities is anticipated to be sourced from licensed third parties and therefore impacts relating to abstraction of water is determined to be **Negligible**.

7.2.3 Power Plant Operation

Riau CCPP Process Water

The power plant will utilise water from the Siak River. Following processing and treatment, a portion of this water will be discharged back to the river, slightly downstream of the intake location.

As detailed in ESIA Volume 5, Appendix B - Process Description, the following abstraction and discharge volumes are expected:

- Abstraction of raw water from the Siak River of 8,843 m^3/d (102.4 L/s); and
- Discharge of treated effluent water to the Siak River of 1,975.8 m^3/d (22.9 L/s).

The deficit water will be consumed throughout the process cycle. The proportional volumes this represents from the Siak River are presented in Table 7.9.

Table 7.9 : Abstraction and Discharge Volumes as a Proportion of the Siak River

Flow event	Volume (see Table 7.3)	Proportion removed from abstraction	Proportion added from discharge
Minimum daily flow	22.5 m^3/s	0.46%	0.1%
Mean annual daily flow	221.0 m^3/s	0.05%	0.01%

Effluent water temperature and mixing zone

The effluent water discharged to the Siak River will be treated to a high quality, with the effluent meeting the General World Bank EHS Guidelines for effluent discharges for a range of constituents (metals, nutrients, arsenic, pH and suspended solids).

Based on the worst case temperature of the effluent water (32.2°C) and that the average ambient river temperature is may vary between 27.2°C in the wet season (minimum) and 32.1°C in the dry season (maximum), the discharge will between 0.1°C and 5°C above ambient river temperature at the point of discharge during the year. An assessment of the mixing zone has been undertaken using two empirical approaches. This includes a thermal mass balance and a river heat exchange at the mixing zone under steady state conditions (as described in EOLSS (2009)).

The input assumptions in Table 7.10 were applied in the two empirical equations and a number of assumed discharge temperature scenarios.

Table 7.10 : River Thermal Mixing Zone Calculation Inputs

Seasons	River Temp (°C)	Actual Discharge Water Temp (°C)	Mixing Zone Temp (°C) (at discharge point)	Temp ~500 m downstream (°C)	Temp ~ 1 km downstream (°C)	Temp ~10 km downstream (°C)
Dry Season	27.9 (minimum)	32.2	27.91	27.91	27.9	27.9
	32.1 (maximum)		32.1	32.1	32.1	32.1
Wet Season	27.2 (minimum)		27.21	27.21	27.2	27.2
	28.5 (maximum)		28.51	28.51	28.5	28.5
Input Assumptions						
Input Description	**Unit**	**Value**	**Reference**			
River Flow Rate (steady state)	m^3/d (m^3/s)	1,296,000 (15.0)	Low flow exceeded 90% of the time in the Siak River (based on examination of 3-4 years of Flow Duration Curves)			
Discharge Flow Rate (steady state)	m^3/d (m^3/s)	1,975.8 (0.0229)	Water Balance Diagram (ESIA Volume 5, Appendix B – Process Description)			
River Velocity	m/s	1	Velocity (assumed)			

The results of the calculations indicate immediate mixing (approximately 20 m) at the discharge point and minimal thermal impact, due to the relatively small discharge volume and the relatively modest temperature difference.

Flood Risk

Based on the results in Figure 7.5, the flooding risk to the power plant site (from the Siak River) is considered to be low.

Once the power plant is operational, the 9.1 ha site will have a permanent change in land cover from scrub and palm oil plantation to a mixture of concrete and gravel pads. It has been assumed based on the Process Description detailed in Volume 5 – Technical Appendices of the ESIA and in discussion with project engineers that:

- The 5.4 ha power plant area will have cover comprising 80% concrete and 20% gravel; and
- The remaining 3.7 ha (switchyard and office) will be 50% gravel and 50% planted/topsoil.

This will permanently increase localised runoff however, the impact of this is considered **Minor**. This is based on a moderate magnitude due to the permanent change in runoff characteristics over a relatively large area, and a low sensitivity, due to the fact there are no perennial streams draining from the power plant area and while the runoff characteristics will change, water will continue to be discharged into these intermittent streams.

The site will be graded to drain towards a stormwater collection system to prevent surface ponding, which would then be reused in the cooling tower; if possible, or discharged to the Siak River if the quality is acceptable. While gravel will be present across a large portion of the site, the compacted pad beneath the gravel will likely have limited capacity for infiltration, but some capacity for water storage (depending on the depth of the gravel layer). Higher runoff will occur from the concreted pads and to a lesser extent, the gravel pads, and this increase in discharge which would be concentrated into a stormwater drainage channel (as opposed to the natural system being overland and subsurface flow).

All stormwater from yards and areas containing hazardous substance will be treated in a settling pond prior to discharge. The settling pond will settle any sediments and act as a temporary holding area for any unforeseen contaminant discharges (such as oil leaks from vehicles). The discharge following retention could lead to an increase in erosion within the receiving water body (the Siak River) and could have the potential to affect aquatic habitat. The impact of this is considered **Negligible**, with appropriately designed sediment and erosion mitigations in place.

Additionally, permanent capture of overland flow from the eastern and western catchments via diversion drains, which would have been established during construction, will also be required. This will concentrate the overland flow in the diversion drain and discharge this to the receiving environment, with the impact considered to be **Negligible**, due to the low sensitivity of receiving intermittent streams and minor magnitude of the small diversions (no greater than 10 ha).

The operational power plant will have a **Minor** impact on the hydrology of the Siak River, with the abstraction volumes used for processing and potable supply representing ~0.46% of the flow during the most significant drought over 24 years, and 0.05% during mean annual daily flows (Table 7.9).

Discharge of treated water from the operating power plant will help reduce the impact of some of the abstracted volumes used and consumed in the process cycle. The quality of the water being discharged to the Siak River will be treated and the higher temperatures of the effluent water are expected to have no significant impact and a small mixing zone. Therefore, the impact of discharging effluent water is considered **Negligible.**

7.2.4 Gas Pipeline Construction

During construction water supply will be the primary hydrological impact. It's likely that potable water impacts will be **Minor**, as workers will either bring water from the Pekanbaru or drink from nearby streams. In addition, some pipeline foundations for pipe bridge crossing will be concreted and will either utilise local water supplies or pre-mixed concrete trucked to site. The impact is considered to be **Negligible**.

Construction of the pipeline near watercourses could cause localised sediment inputs to streams due to soil disturbance. The overall impact is considered to be **Minor**, as while the pipeline only crosses two perennial streams, these are considered Medium sensitivity environments as trenching of the pipe could disturb aquatic life and be at risk from hydrological events (i.e. flooding). The magnitude of the impact is considered **Minor**, given the construction period will be short term.

7.2.5 Gas Pipeline Operation

The majority of the gas pipeline will be laid underground, next to an existing road. Operation of the gas pipeline does not require the use of water and therefore the hydrological impacts are considered **Negligible**.

7.3 Mitigation and Monitoring

7.3.1 Power Plant Construction

Following surveying of the boundary of the construction pad, diversion drains will be excavated around the perimeter of the site to convey clean overland flow from these local catchments (see Figure 3.16) to appropriate locations downstream. During construction these could be temporary excavations, rock or geotextile lined to reduce erosion.

Direct site runoff from the 9.1 ha area will be captured via interceptor ditches and sumps/sediment ponds. In localised areas, sediment runoff could be managed through silt fences. Grading the construction site to ensure runoff is captured and detained in the sumps/ponds is essential, as it is highly likely surface water will be sediment laden and will need some settling before discharge (likely through a decant structure or overflow spillway in a sediment pond). This has been covered in more detail in Section 7.3.2). Sediment and erosion control design should follow local regulations or alternatively, the International Erosion Control Association (Australasia) 2008 best practice guidelines. Incorporation of these devices during construction, adequately sized for certain design storms, will reduce the impact to **Negligible**, as the magnitude will be **Minor** (due to the temporary nature of construction) and the treatment will result in a Low or Negligible sensitivity.

Any discharges of concentrated flow should be to watercourses that have adequate erosion protection in place to prevent gullying of channels, bank collapse and increased sedimentation downstream. This may require installation of reno mattresses or rock rip rap (adequately sized to convey flows and velocities) at the discharge point. The receiving open channels downstream of the discharge points may require further excavation to convey the increased flows, due to greater runoff. The infrequent flows which would be concentrated into these channels, and their impact on the receiving environment are expected to be **Negligible**, if the appropriate mitigations are put in place to reduce sediment loads and the velocity of water.

Visual monitoring of stream banks, construction pad/diversion channels and any storage ponds should be undertaken to identify any areas that may be performing inadequately (resulting in bank collapses, localised erosion hot spots and scouring).

The performance of the settling ponds should be assessed during the construction phase with them being monitored for Total Suspended Solids (TSS) as a minimum once a month during or immediately after a rainfall event.

Should local water sources be required for meeting some construction demands including vehicle and equipment washdown, the use of temporary portable storage tanks or lined earth reservoir is advised. Multiple 25,000 L plastic tank (3.6 m x 2.8 m) could provide storage for firefighting and water supply, and be topped up at low abstraction rates (<5 L/s) to reduce environmental impacts. A full assessment of construction water demands will be needed to verify the infrastructure required. However, the impact is considered to be **Negligible**.

7.3.2 Power Plant Operation

The permanent power plant site and laydown area will have a stormwater system designed to capture and treat any runoff. The diversion drains to divert the overland flow (from the eastern and western catchments) put in place during the construction period will remain and given their performance, should ideally be enhanced from a temporary channel to one that is lined with concrete or rock rip rap.

For simplicity, the diversion drains should target a grade of <2–3%, to reduce velocity. Should this not be the case, a drop structure or more significant erosion prevention mechanism (such as a reno mattress) will be required within the channel.

Initial assessments of elevation change and slope for the western and eastern catchments (Table 7.2) show an elevation change of 10-13 m over a distance <220 m, resulting in a short time of concentration of <10 minutes and a grade >5.5%.

Sizing of the drains is a balance between the risk of the design storm occurring throughout the project life and the cost/benefit of the infrastructure required to prevent flooding from that event. Assuming a 50-year design life, then the risk of occurrence over the project is:

- 9.5% for a 500 year ARI storm;
- 39.5% for a 100 year ARI storm;
- 63.6% for a 50 year ARI storm; and
- 99.5% for a 10 year ARI storm.

An estimate of the diversion channel peak flows has been undertaken in Table 7.11 using the Rational Method for a range of design storms, 10-minute storm duration (based on a short time of concentration) and a runoff coefficient of 0.7, presuming these catchments maintain a natural cover, and the soil is saturated.

Table 7.11 : Diversion Channel Peak Flow Estimates Using the Rational Method and a 10-Minute Design Storm

AEP (ARI-years)	Western Catchment flows (m^3/s)	Eastern Catchment (m^3/s)
0.05 (20 years)	2.69	4.66
0.02 (50 years)	2.84	4.92
0.01 (100 years)	2.93	5.06
0.002 (500 years)	3.06	5.30

Within the power plant site, the stormwater system should be sized to convey runoff, eventually draining to a sump, settling pond or wetland prior to discharge to the receiving environment. This will capture any runoff from the pad and settle out sediment, while reducing flow velocities.

Based on the areas and cover ratios for the site, described in Section 7.2.3, a rational assessment has been undertaken for the 100 year (1% AEP) 10-minute design storm, with coefficients of 1.0 and 0.9 applied to concreted and gravelled areas. The high coefficient for gravelled zones assumes a compacted pad is present below the gravel layer, and lateral subsurface flow will still enter the stormwater system.

The assessments show the stormwater network may need to convey flows up to:

- 4.25 m^3/s from the 5.4 ha of the power plant site;
- 2.38 m^3/s from the 3.7 ha switchyard and office areas.

Design of the settling pond/sump that will receive the stormwater should take into account:

- the catchment area draining to the pond;
- sediment characteristics that may require settling (i.e. dispersion and particle size assessments); and
- design storms duration and velocities (Table 7.7).

Dependent on the soil particle size and dispersion characteristics, a stormwater pond may be designed for short duration intense events (if dispersion is low and particle size is larger), or for longer duration (24 hour) stormwater ponds when dispersion is high and particles size is smaller. The latter pond requires designs focussing on volumes of water to be treated, as the particles will need time to settle before discharge via decant structure or overflow spillway.

All stormwater ponds should be designed with an emergency spillway to convey a design event when the pond is at capacity, typically a 100 year ARI storm for permanent structures. A wetland could also be considered for treatment of stormwater, if the water quality is appropriate. A serpentine water design will help slow velocities and coupled with a sediment forbay (that is regularly cleaned) will allow treatment and settling of sediment, nutrients and some metals.

Monitoring of the effectiveness of the settling pond or wetland on sediment should be undertaken during construction and ongoing operations, with spot samples assessed for TSS at the inlet and outlet locations. Imhoff settling cones offer an inexpensive and viable method for quick onsite estimates of TSS from the inlet and outlet.

Areas of the power plant that are at risk of having contaminant discharges (such as oil leaks from vehicles or fluid spills) will be isolated, with their flows first draining through an oil water separator (as outlined in ESIA Volume 5, Appendix B – Process Description). The outflows from this separator will then drain to the final disposal pond for any further treatment required.

Incorporation of the above mitigations will reduce the power plant's operational impact on hydrology from **Minor to Negligible**. This is based on the receiving intermittent streams having Negligible sensitivity to the treated and settled stormwater runoff, and the magnitude of the impact will decrease to **Minor**, as the runoff is effectively contained, with velocities decreased and erosion control preventions in place.

7.3.3 Gas Pipeline

7.3.3.1 Construction

Minimal impacts to hydrological water courses are expected during the construction of the pipeline. Near stream works will require local sediment controls such as silt fences or downstream sediment traps to reduce the effects of disturbance. Vegetation removal will be over a small footprint, no larger than a local road. The impacts are considered to be **Negligible** if appropriate sediment control mitigations are put in place.

7.4 Assessment of Residual Impacts

The primary residual impacts from the power plant will be increased runoff and less recharge to soils/groundwater for the concreted/gravel pad. Additionally, there will be ongoing increased risk of oils and hydrocarbons entering waterways due to the new development and equipment, however mitigation measures such as bunds, oil spill training, spill kits and oil/water separators will help ensure this is limited and as a result the residual level of impact is **Negligible**.

Erosion risk around the site and to receiving water bodies can be effectively managed if appropriate mitigations are put in place and the level of residual impacts is **Negligible**.

8. Water Quality and Freshwater Ecology

This section describes the potential impacts to the water quality and freshwater ecology value of the project area from the construction and operation phases of the Project. Mitigation has been identified where necessary to reduce the scale and nature of potential impacts and monitoring has been proposed. Technical Report - Water Quality and Freshwater Ecology can be found in Volume 5 – Technical Appendices.

Changes in the flow regimes through abstraction and/or discharges can impact upon freshwater and aquatic ecology receptors. Due to the related nature of topics, this section should be considered closely with Section 7-Hydrology.

Impacts to the Tenayan River are not considered further as the Project's construction and operation will not result in any discharges to this river and therefore there are no potential impacts.

8.1 Specific Methodology

The impact assessment methodology applied to the assessment of potential impacts on water quality and freshwater ecology arising from the Project, was undertaken in accordance with the impact assessment methodology outlined in Section 2.

8.2 Assessment of Potential Impacts

8.2.1 Construction Impacts

Construction and Use of Temporary Jetty on the Siak River

A temporary jetty will be constructed in the Siak River downstream of the existing coal fired power station location. Construction of the jetty will involve sheet piling for the "tunnel" into the river, while rock and sandbagging will be used for the head area, see ESIA Volume 5: Technical Appendices – Technical Report: Water Quality and Freshwater Ecology. The tunnel will be excavated and the river bed dredged where required, the scope of which will depend on the exact location and local depth and conditions. During these works there is a risk of disturbance of the sediment from the bed into the water column and any benthic ecology in the area to be dredged will be lost. The jetty will be in use for the three to four-year construction period during which time the ecological habitat will not be available. The jetty may then be decommissioned which would allow sediment processes within the river to re-naturalise the area and benthic communities to recolonise the area. Operational use of the temporary jetty will involve a number of ships and barges with associated disturbance of the area and the risk of discharges from vessels.

The existing sediments are fine and easily disturbed into the water column, and as discussed in Section 3 contain some elevated metal concentrations (e.g. iron). These would then join the generally turbid and high suspended sediment load river water before settling out nearby. The change in water quality is not anticipated to be significant given the existing turbid water quality. As the general river sediments are expected to be of a similar quality with elevated metal concentrations the depositing sediment would not be likely to impact on surrounding ecological values as the benthic ecology is impoverished and already adapted to the existing sediment and water quality.

No specific details are available of measures to be used to minimise in river works and sediment mobilisation during pile driving and dredging. It is considered that additional mitigation is needed to control the potential impacts from these works. These are outlined in Section 8.3 below.

Through dredging and placement of the jetty structure the existing benthic ecology and habitat will be lost. Replacement of sediment and recolonization of species would occur naturally once structures are removed hence it would be a temporary change during the period of jetty use.

Water quality could be impacted by boat use of the area through spills and discharges. The use of the river by boats is, however, a common occurrence at present with numerous boats and tankers using the waterway and existing jetty's and wharves along the river. Therefore, the use of the river by boats is not a new activity and disturbance by boat wave wash and minor spills etc. would be a common occurrence that the river environment is adapted to. Potential impacts associated with boat movements for the Project construction will occur over a short period and measures should be put in place to minimise the risk and potential impact of spills.

Overall while there is a risk of impacts on water quality through sediment mobilisation these would likely be temporary during construction and not have a longer term ecological impact. The permanent loss of habitat and benthic ecological values during the jetty use is considered to be a measurable and permanent change to the area. However, the low value of the existing ecology and likelihood of it recolonising after the jetty is removed results in the change being of lower ecological concern. It is considered that these would be classed as a **Moderate** magnitude impact which has a detectable change to the water quality and ecology that results in a non-fundamental temporary or permanent change. The existing environment is considered to be of Low sensitivity to potential impacts and this is therefore evaluated as a **Minor** impact.

Construction of the Water Supply/Discharge Intake and Discharge Structures

The main structures will be constructed on the river bank with an intake pipeline extending into the river. The potential impacts therefore arise from the potential runoff of sediment laden stormwater from the works area and from direct in-river work to locate the intake pipeline.

Overall it is considered that these would be classed as a **Moderate** magnitude impact which has a detectable change to the water quality that results in a non-fundamental temporary or permanent change. The existing environment is considered to be of Low sensitivity to potential impacts and this is therefore evaluated as a **Minor** impact.

Construction of the Gas Pipeline Crossings.

The gas pipeline will cross four rivers and streams. Three of these have been assessed in this report including two on the Gasib River. Water quality and ecology data for these watercourses indicated that they are broadly similar and it is likely that the other stream crossed by the gas pipeline not included in baseline surveys will be similar to the others surveyed, as it drains similar land uses and is in the same lowland environment. The river crossings are intended to be by open cut methods with the gas pipeline then being laid below the river bed. The contractors' method statement (ESIA Volume 5, Appendix B – Process Description) outlines the way this would be undertaken. Sand bags would be placed by excavators to create a working area in the watercourse. This would be pumped dry to the downstream side of the waterway. The bed would be excavated to allow the pipe placement and then backfilled in the dry.

It is considered that the construction could potentially impact upon the water quality as the initial dam is placed and removed, and also as dewatering water is discharged. The placement and removal of the dams are expected to be short duration activities and have minor potential impacts.

The works in the rivers would limit the ability for fish to pass through the work area. The small duration of works being open to allow the pipeline to be placed is unlikely to have an impact on the overall fish populations of the area. The temporary discharges of sediment laden water would occur to waterbodies that are already turbid and thus would have limited risk of ecological impacts. By working in the dry the amount of sediment input will be minimised. Sediment quality data do not indicate a high risk of contamination of sediment that could be mobilised and impact upon the existing ecology. Overall it is considered that this would be classed as a **Moderate** magnitude impact that has a detectable but small change to the water flow and aquatic ecology values assessed. Overall given the Low sensitivity of the environment this is evaluated as a **Minor** impact.

8.2.2 Operational Impacts

Abstraction of Water

The power plant will have a continuous water take during operation and this will be on average 370 m^3/hr during peak power production. The abstraction has the potential to impact the existing ecology by modifying the natural river flow and water level. In addition, the intake itself could have the risk of fish entrainment in the structure.

At present no details are provided of measures to be taken to minimise the risk of fish entrainment in the intake structure but it is assumed that the intake would have a screen to prevent fish ingress as this is standard international practice. Given the range and number of fish species present, if unmitigated an impact could occur. However, with a screen in place, there is unlikely to be any significant impact on the fish populations within the Siak River. It is considered that this could have a **Minor** magnitude impact which has a detectable but small change to the local fish populations but not a fundamental change to the populations within the wider Siak River.

Discharge of Process Wastewaters

Based on the following:

- Average river water flows (Table 7.9);
- The nominal abstraction and discharge rates at the design condition (i.e. full load operation) (Table 7.9); and
- A conservative assumption that the same mass of a substance extracted from the Siak River is returned to the Siak River.

It has been calculated that the concentration of any substance in the river would increase by approximately 0.1% as a result of the operation of the power plant. Even at minimum river flow rates, we have calculated that the concentration of any substance in the Siak River would increase by no more than 1% as a result of the operation of the power plant.

It is noted that the Siak River which will be used as the power plant water supply has elevated concentrations of parameters including iron. Iron concentrations in the raw water supply are above the relevant discharge guidelines. The process description (ESIA Volume 5, Appendix – Process Description) details that a proportion of incoming contaminants will be removed through the water treatment process to make it suitable for use in the power plant. Through the power plant's wastewater treatment process the final discharge to the Siak River will be of a better water quality than the incoming raw water. In relation to iron the concentration discharged to the Siak River will be lower than the incoming raw water concentration and will be less than the discharge guidelines of 1 mg/L at the point of discharge. Therefore, the discharge will have no adverse impact on existing water quality within the Siak River. At the point of discharge changes in concentration of any parameters in the receiving environment would be very small even before allowing for any further dilution below the point of discharge.

It is therefore considered that the changes in water quality in the river would be classed as a Minor magnitude impact due to the potentially detectable but small change to the water quality conditions. The existing environment is considered to be of Low sensitivity to potential impacts and this is therefore evaluated as a **Negligible** impact.

8.3 Mitigation and Monitoring

Table 8.1 outlines the additional mitigation and monitoring activities that have been proposed to manage the risk of potential effects

Table 8.1 : Proposed Mitigation and Monitoring Activities

Potential Impact	Action
Construction and use of temporary jetty on the Siak River – mitigation measures to control potential impacts on water quality of instream	1. Where possible works should occur in dry working conditions with work areas being isolated from the river flow and pumped dry. 2. Sediment control devices such as vertically hanging silt curtains should be employed around the dredging area to minimise suspended material moving outside the work area. 3. Dredged material should be removed from the river channel and disposed of to an appropriate

Potential Impact	Action
pile driving and dredging.	site. 4. Daily observations should be made during in river works to visually assess whether sediment plumes are being generated and to modify the sediment controls to minimise effects. Records should be made of observations and any changes to controls undertaken. 5. Spill clean-up kits including floating booms should be available at the jetty to respond to any spills from vessels using the temporary jetty. The spill kit elements should be appropriate for the type and nature of products being imported and for general spills of oils and fuels from boats.
Construction of the water supply/discharge intake and discharge structures and gas pipeline crossings.	As Erosion and Sediment Control Plan (ESCP) should be developed for all project earthwork and construction elements with a risk of generating sediment laden runoff that could impact upon the Siak River. This should include as a minimum: 1. Measures to isolate and divert clean water around open work areas. 2. Measures and work staging to minimise the amount of bare land open at any time. 3. Measures taken to minimise erosion and the entrainment of sediment within water flowing onsite. 4. Measures taken to treat sediment once it is entrained in water prior to discharge. Measures may include silt fences and sediment settlement ponds. 5. Visual monitoring should be undertaken during and after rain of all ESCP measures and discharges. Modifications should be made to any elements leading to erosion and high sediment losses. 6. Inspections of all ESCP elements should be made at a minimum of weekly and prior to predicted rain events.
Construction of the gas pipeline crossings.	Sediment laden dewatering water from open work areas within stream crossings should be discharged after filtration to the bypass water and then back into the stream.
Abstraction of water – potential impact of entraining fish in the intake structure.	The water supply intake should be designed to minimise the risk of entrainment of fish within the intake by the installation of an appropriately sized screen.

8.4 Assessment of Residual Impacts

Mitigation has been proposed for four specific activities where the potential impacts were such that additional mitigation would be necessary. With the specific additional mitigation in place the residual impacts are considered to be as follows:

8.4.1 Construction and Use of Temporary Jetty on the Siak River

The in-river sheet piling and dredging works were considered to have potential impacts that required additional mitigation to minimise the changes to water quality and consequent potential impacts on the ecology around the work areas. Implementation of the mitigation in terms of controls on how in-river works occur and the use of sediment control will reduce the risk and magnitude of potential impacts. The preparation for potential spills and provision of kits to deal with spills should reduce potential effects from the use of the jetty.

Overall with this additional mitigation while the potential impacts may reduce there is still considered to be a Moderate magnitude impact as a detectable change to water quality could result. The existing environment is considered to be of Low sensitivity to potential impacts and this is therefore evaluated as a **Minor** significance impact.

8.4.2 Construction of the Water Supply/Discharge Intake and Discharge Structures

With a well-developed ESCP in place it is considered that the risks of erosion of soils would be reduced. The proposed methods should reduce off site losses and treatment prior to discharge should control the discharge quality. Overall the approaches are likely to reduce the amount of suspended material in site construction discharges. It is considered that site discharges would still contain elevated suspended sediments but after the implementation of good ESCP these would be at concentrations more typical of catchment flows from undeveloped land in larger rainfall events. As such the potential impact on the receiving water quality and ecology would be reduced. With the above additional ESCP mitigation in place it is considered that the magnitude of the impact is likely to be **Minor**, which is it would be a detectable but small change to the existing water quality.

This minor magnitude impact in a Low sensitivity receiving environment is considered to reduce the potential impact to a **Negligible** significance impact.

8.4.3 Construction of the Gas Pipeline Crossings.

With a well-developed ESCP in place and dewatering discharging to land thus allowing sediments to be removed via overland flow and infiltration it is considered that the risk of sediment being mobilised from the works into the water column in concentrations that could impact the existing ecology will be minimised. With the above additional ESCP and dewatering mitigation in place it is considered that the magnitude of the impact is likely to be minor, which is it would be a detectable but small change to the existing water quality.

This minor magnitude impact in a Low sensitivity receiving environment is considered to reduce the potential impact to a **Negligible** significance impact.

8.4.4 Abstraction of Water – Risk of Entrapment of Fish

The design of the intake to minimise fish entrapment should reduce the chance of fish getting caught and a local impact on the fish populations. As such the potential impact would be expected to be minor or negligible. Overall given the Low sensitivity of the environment this is evaluated as a **Negligible** significance impact.

9. Landscape and Visual

This section describes the potential impacts of the construction and operation of the Project on the existing landscape character and visual amenity of the area and sets out mitigation measures to minimise the impact of the Project.

9.1 Visual Assessment Methodology

This visual assessment assesses the sensitivity of receptors to changes in their visual amenity through the analysis of selected representative viewpoints and wider visibility analysis. It identifies the potential sources for visual effects resulting from the Project and describes the existing character of the area in terms of:

1) openness;
2) prominence;
3) compatibility of the Project with the existing visual context;
4) viewing distances; and
5) the potential for obstruction of views.

9.1.1 Identification of Key Viewpoints

A selection of key viewpoints was identified. The viewpoints are considered representative of the various viewing audiences and distances, being taken from public locations where views of the Project were possible.

9.1.2 Identification of the Zone of Theoretical Visual Influence

The Zone of Theoretical Visual Influence (ZTVI) is the area from which a development or other structures is theoretically visible. This is a desk based approach and utilises topographical data to determine the zone/s from which a feature will likely be visible. The ZTVI for the Project was determined using a combination of available topographic data, information from site visits, photographs or GIS, to predict the visibility of the Project from various locations (see Figure 9.2). The ZTVI analysis uses a test height from a normal eye level (at approximately 1.8 m above ground level). This method produces a bare ground ZTVI that relies solely upon topography and does not take into account the screening provided by trees or other structures. Neither does it address the effects of distance. This means that the results provide a worst case scenario of visibility.

9.1.3 Assessment of the Degree of Sensitivity of the Viewpoint to Changes Resulting from the Proposal

Factors affecting the sensitivity of receptors for evaluation of visual impacts include the value and quality of existing views, the type of receiver, duration or frequency of view, distance from the proposal and the degree of visibility. For example, those who view the change from their homes are considered to be highly sensitive. The attractiveness or otherwise of the outlook from their home will have a significant effect on their perception of the quality and acceptability of their home environment and their general quality of life. Those who view the change from their workplace are considered to be only moderately sensitive as the attractiveness or otherwise of the outlook will have a less important, although still material, effect on their perception of their quality of life. The degree to which this applies depends on whether the workplace is industrial, retail or commercial. Those who view the change whilst taking part in an outdoor leisure activity may display varying sensitivity depending on the type of leisure activity. For example, walkers in open country on a long distance hike are considered to be highly sensitive to change while other walkers may not be so focused on the surrounding landscape. Those who view the change whilst travelling on a public thoroughfare will also display varying sensitivity depending on the speed and direction of travel and whether the view is continuous or occasionally glimpsed.

9.1.4 Identification of Potential Mitigation Measures

These may take the form of revisions/refinements to the engineering and architectural design to minimise potential impacts, and/or the implementation of landscape design measures (e.g. mitigation planting, colour and design of hard landscape features etc.) to alleviate adverse visual impacts and generate potentially beneficial long term visual impacts.

9.1.5 3-D Model

A 3-D model of the proposed power plant has been constructed using GIS software (ArcMap) based on the plant design specifications provided in the Process Description. Still images from the 3-D model were taken for five viewpoints and modelling undertaken. For those viewpoints that the power plant was visible from, the modelled 3-D power plant image was scaled to fit the photographic image. The position of the view line in respect to the 3-D image was determined using identifiable makers contained on the Digital Globe satellite image of the site.

9.1.6 Photo-illustrations of key Visually Sensitive Receivers

Photo-illustrations of key Visually Sensitive Receivers as a tool for impact assessment which provides realistic impressions of the proposal. To assist this a 3-D model was prepared of the power plant at key points identified in proximity to the power plant site.

9.2 Assessment Criteria

9.2.1 Baseline Data

An assessment of the landscape character and visual amenity has been undertaken through fieldwork and desktop assessment to provide sufficient information against which to determine potential impacts and their significance.

9.2.2 Impact Significance

The magnitude of impact of the Project on visual amenity and sensitivity of receptors of the area will be categorised/classified using the criteria in Table 9.1 and Table 9.2 below.

Table 9.1 : Magnitude of Impact

Magnitude of Impact	Typical criteria
Major	Total loss or large scale damage to existing character or views, and/or the addition of new but uncharacteristic conspicuous features and elements.
Moderate	Partial loss or noticeable damage to existing character or views, and/or the addition of new but uncharacteristic noticeable features and elements.
Minor	Slight loss or damage to existing character or views, and/or the addition of new but uncharacteristic features and elements.
Negligible	Barely noticeable loss or damage to existing character or views/no noticeable loss, damage or alteration to character or views.

Table 9.2 : Visual Receptors Classification

Sensitivity	Typical character/use
High	Permanent occupiers of residential properties and associated outdoor areas (e.g. gardens, courtyards). Users of nationally protected areas, recreational scenic trails or users of designated tourist routes.
Medium	Workers in predominantly outdoor professions (e.g. farmers and horticulturalists) and any associated temporary accommodation. Users of secondary or minor roads in scenic areas, schools and outdoor

Sensitivity	Typical character/use
	recreational users (e.g. sports grounds).
Low	Workers in predominantly indoor professions (e.g. factories and offices). Users of main roads or passengers in public transport on main arterial routes.

Using the outputs from Table 9.1 and Table 9.2 above the following matrix has been prepared to assist with determining the overall significance of visual impacts.

Table 9.3 : Significance of Visual Impacts

		MAGNITUDE OF CHANGE (EFFECT/IMPACT)			
		NEGLIGIBLE	MINOR	MODERATE	MAJOR
SENSITIVITY OF RECEPTOR	LOW	NEGLIGIBLE	LOW	MODERATE - LOW	MODERATE
	MEDIUM	LOW	MODERATE - LOW	MODERATE	MODERATE – HIGH
	HIGH	MODERATE - LOW	MODERATE	MODERATE - HIGH	HIGH

9.3 Assessment of Potential Impacts

This section outlines the likely effects on visual amenity and potential mitigation measures.

Key visual receptors have been identified (locations where the Project will be visible from). Visual impacts are likely to occur as a result of the following key aspects of the Project:

- Power plant construction, including:
  - general site clearance (i.e. removal vegetation (including palm plantation trees), paving and earthworks) and creation of construction laydown area and temporary facilities; and
  - backfilling to create raised and stabilised building platforms.
- Presence of the new power plant and associated equipment and buildings, including:
  - Chimneys X 2 (45 m in height);
  - gas turbine generators and supplementary heat recovery steam generators; and
  - cooling tower.
- Transmission line construction:
  - Presence of the new transmission line (750 m in length) and associated towers; and
  - Water supply and discharge pipelines to and from the Siak River.

9.3.1 Zone of Theoretical Visual Influence

In order to help determine the likely level of visibility for the power plant in terms of the neighbouring population, a ZTVI was identified. The results of this are depicted in Figure 9.1 below. The model was used to produce this image depicting the expected visibility of the power plant within a 6 km radius. Using the model, it is predicted that the power plant will be visible from 18% of the neighbouring villages, while the chimney stack will be visible from 28% of neighbouring villages.

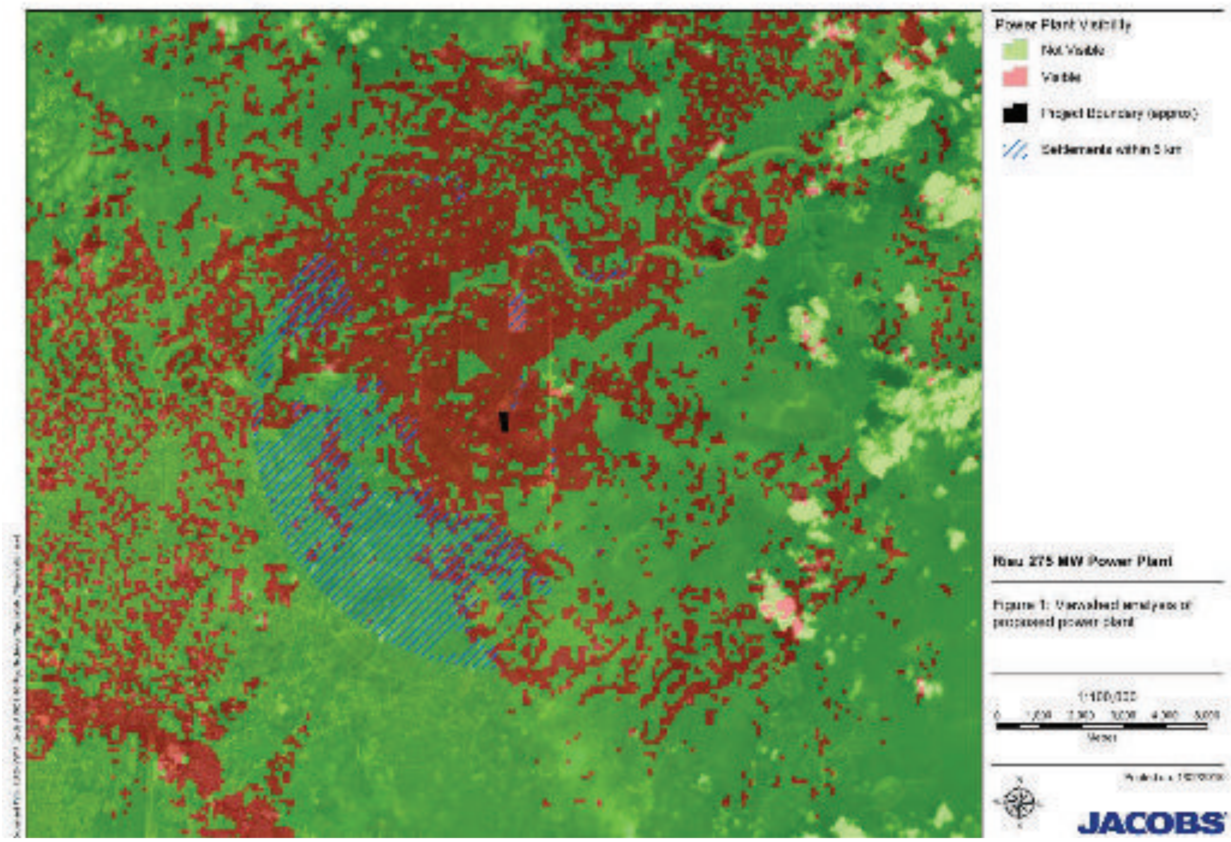


Figure 9.1 : Zone of Theoretical Visual Impact – Riau 275 MW Power Plant Figure

9.3.2 Key viewpoints

3-D modelling was utilised to assess the visibility of the proposed power plant from key viewpoints, selected and considered to be representative of key areas of visibility from neighbouring sites, the locations of which are shown below in below.

Figure 9.2 : Satellite Image of the Proposed Power Plant Site Indicating Modelling and Photograph Viewpoints (Not to Scale)

9.3.3 Photo-illustrations

The following series of photographs and photo-illustrations have been prepared in order to provide a comparison between the existing views from the viewpoint A and viewpoint B identified in Figure 9.2 above, and a post construction impression of how the power plant is likely to appear.

It is noted that the 3D modelling exercise was undertaken for the three additional areas (indicated in green in Figure 9.1 above), the exercise showing that the power plant will not be visible from these locations due to topography and existing vegetation completely obscuring visibility of the site and proposed structures.

9.3.4 Transmission Line

It is noted that the transmission line was not explicitly included in the ZTVI and 3D modelling exercise. This is due to the relatively small scale of this aspect of the proposal, with the inclusion of the 45 m stack in these exercises providing a 'worst case scenario' that would thus encapsulate any level of effect attributed to the transmission line.

Figure 9.3 : Existing View Toward the Proposed Power Plant from Viewpoint A

Figure 9.4 : Impression of the Proposed Power Plant from Viewpoint A

Figure 9.5 : Existing View of the Proposed Power Plant from Viewpoint B

Figure 9.6 : Impression of the Proposed Power Plant from Viewpoint B

9.4 Assessment of Level of Visibility

As noted, the ZTVI produces a 'bare ground' estimate of visibility, based solely on topography and does not take into account the screening provided by trees or other structures, nor distance of the viewing audience. Thus, the actual level of visibility of the Project will be significantly less than projected by the ZTVI. This is highlighted through the 3-D modelling exercise which indicated that the power plant would be completely obscured from view from three areas initially identified as potential key viewpoints', due to screening provided by existing vegetation in addition to topography. This includes a new government administration area currently under construction toward the south-east of the site and a settlement located between viewpoint A and B.

9.5 Impacts on Visual Amenity

Key visually sensitive receptors identified in the development area are:

- Permanent occupiers of residential properties – considered to be have a *High* level of sensitivity.
- Outdoor workers – farmers and horticulturalists i.e. palm plantation workers in close proximity to the power plant – considered to have a *Medium* level of sensitivity to the proposed development.

Table 9.4 outlines the likely effects on Visual Amenity of sensitive receivers resulting from the proposed power plant.

Table 9.4 : Assessment of Impacts on Visually Sensitive Receptors

Visually Sensitive Receptor (VSR)	Relevant viewpoint / Figures	Sensitivity of VSR	Magnitude of Change	Significance of Visual Impact	Comment
Permanent occupiers of residential properties	**A**: Figure 9.1; and Figure 9.2 **B**: Figure 9.3; Figure 9.4	High	Minor	Moderate	The power plant (particularly the chimney structure) will be visible to neighbouring villages and residents (i.e. from viewpoint A and B) and outdoor workers (i.e. palm plantation workers). Permanent occupiers of residential properties are generally considered to have a *High* level of sensitivity to change, and the overall significance of the visual impact can be deemed to be **Moderate** (using the effects matrix in Table 9.3). Visual impacts associated with the construction of the power plant will range from those of a temporary nature, such as the creation of construction laydown areas and temporary site facilities; to those that are permanent (i.e. the completed construction and operation of the new power plant. Outdoor workers such as farmers and horticulturalists are considered to have a *Medium* level of sensitivity to change. It is noted that the dominant land use in the wider area (and current use on the Project site) is that of palm oil plantations. In assessing the overall visual impacts of the proposed power plant, a key factor is its location within an already modified environment, containing an existing power plant and land use dominated by palm oil plantations. The proposed power plant will be located in relatively close proximity to the existing power plant (approximately 200 m toward the east), which has altered the appearance and character of the area, including the wider panorama of the area (as shown by the photomontages for viewpoints' A and B). While the dominant land use of the area for palm plantation, represents a considerable change with native vegetation having been cleared to make way for this use. In this context the significance of visual impacts resulting from the addition of the proposed power plant, is diminished. Thus, given the above, the overall level of adverse visual impacts likely as a result of the power plant is anticipated to be within acceptable limits with regards to both permanent occupiers and outdoor workers.
Outdoor workers (farmers and horticulturalists); and recreational users (recreationalists)	Area adjoining Project site	Medium	Minor	Moderate - Low	

It is noted the gas pipeline will be buried, therefore, there will be minimal long term visual effects. Furthermore, any loss of visual amenity during construction will limited to the immediate vicinity of the pipeline and be temporary. As such the impact is considered low.

9.6 Cooling Tower Plume Visibility Assessment

9.6.1 Overview

The Project involves the installation of a mechanical draught cooling tower at the site for the purposes of:

- Cooling the steam turbine condenser main cooling water flow
- Cooling auxiliary balance of pant systems – i.e. lubricating oil systems, gas turbines and steam turbine generators etc.

The cooling tower is designed to cool the hot water from 41 °C to 31 °C at the design ambient conditions of 28 °C and relative humidity of 80%. It is noted that the cooling tower performance will in reality be variable based on the prevailing meteorological conditions at the time of operation.

The proposed cooling tower system consists of five cells and will have an overall footprint of approximately 800 m^2 (80 m x 10 m). The height of the cooling tower would be approximately 13 m.

In some weather conditions cooling towers will produce a visible plume comprising small water droplets and water vapour. A visible plume will occur when temperatures are cool and relative humidity is high, and when temperatures are warm and humidity is relatively high; that is, in situations where there is a small 'saturation deficit'.

9.6.2 Method

A method for calculating visible plume dimensions is given by Fisher (1997). In this method the length and width of the plume are a function of the initial conditions of the cooling tower plume, (for example humidity and temperature) with the power plant assumed to be operating at full capacity for the entire period. A plume dilution factor is calculated to account for changes in plume temperature and humidity with distance. The plume conditions at a specified distance from the stack are then compared to the surrounding environment to determine whether condensation, and hence a visible plume exists.

It is noted that a more complex model would be required to account for the potential variation of humidity and temperature with height and time as well as the plant dispatch level, but the simple approach outlined above simple is considered suitable for a conservative assessment of the likely frequency of significant visible plumes with heights less than 100 m.

The calculations are based on ambient temperature and humidity data generated by an annualised dataset taken from Sultan Syarif Kasim II International Airport over the three-year period 2013-2015.

9.6.3 Results

The predictions for visible plumes greater than 100 m in length using the annualised dataset are provided in Table 9.5.

Table 9.5 : Predicted Plume Visibility – 2013 to 2015

Conditions	Plant Dispatch Level [MW]	Day time frequency – [%] 06:00-19:00	Night time frequency – [%] 19:00-06:00	All hours frequency – [%]
Plume length > 100m	275	1.2 %	8.9%	4.1 %

Results predict that a visible plume, of 100 m length, will occur approximately 4.1% of the time based on meteorological conditions that prevailed between 2013 and 2015. Of greatest significance, are those visible plumes that occur during daylight hours. Results predict that a 100 m long visible plume would occur during 1.5% of all daylight hours. It should also be noted that the local community may also be aware of a 'visible' plume at night, for example water droplets in cooling tower plumes would reflect light from power station lighting and moonlight.

The plume characteristics depend on the cooling tower's specification and performance parameters; in this case, plume characteristics have been calculated based on design parameters. A limitation of the technique applied is that the predictions use simple calculations based on limited humidity data

The method used to predict the occurrence of a visible plume is largely driven by relative humidity. It is noted that meteorological conditions including temperature and wind speed do play a role in the predictions; however, results are most sensitive to changes in humidity.

Figure 9.7 shows the meteorological events experienced between 2013 and 2015 that would have created a visible plume 100 m in length compared to those events where the plume would not have formed. It is noted that 100 m long visible plumes are tightly clustered at the high relative humidity end of the graph. The minimum relative humidity that would have created a visible plume was 96%, while the maximum temperature where a visible plume would have occurred was 26 ºC.

The method of calculation developed by Fisher (1997), and applied above, allows for examination of visible plumes forming to different lengths. It is noted that this assessment has adopted a plume length threshold of 100 m. 100 m is considered to be a length, beyond which, the visible impact of a plume may become significant Calculations show an inverse relationship between the frequency of a visible plume occurring and the length of the plume. That is, as the defined length of the plume is reduced, the frequency of a visible plume extending to that length will increase.

Based on the above assessment potential impacts resulting from visual plumes are determined to be **Negligible.**

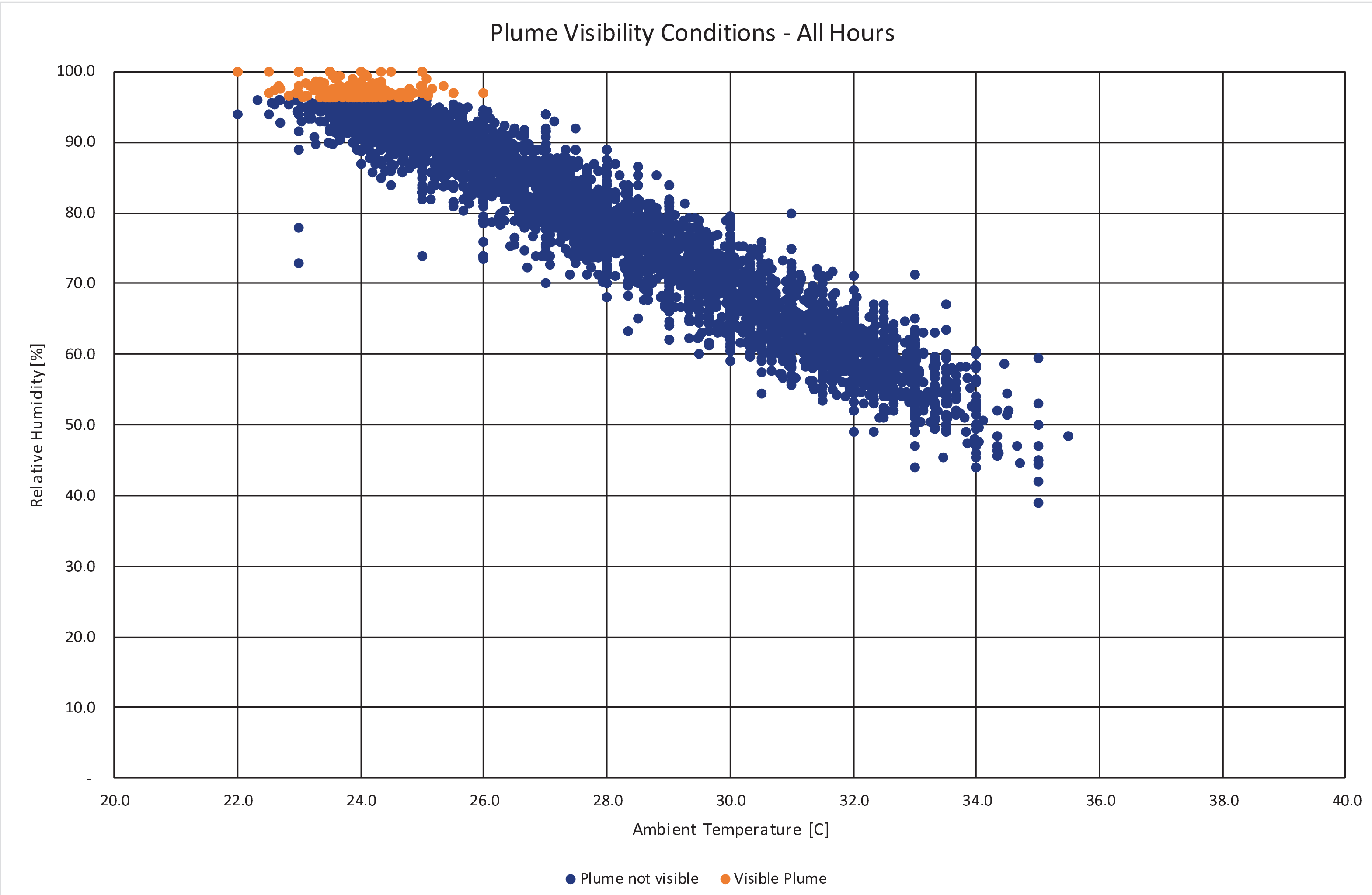


Figure 9.7 : Plume Visibility – 2013 to 2015

9.7 Mitigation and Monitoring

After construction works are completed, it is proposed that the power plant site should be landscaped in order to improve visual amenity. Additionally, this will aid in limiting soil erosion at the site during heavy rainfall events.

Plants should be nursery grown and will be sound, healthy, and vigorous and free from insect infestations. Trees and shrubs will be chosen to tolerate weather conditions and other such site characteristics. Maintenance operations should begin immediately after each plant is planted by mulching, watering, pruning, spraying, weeding and other necessary operations of maintenance. Planting beds should be kept free of weed, grass and other undesired vegetation growth.

The following recommendations are proposed for consideration for the buildings and power plant site:

- Site fencing or green barriers (hedges) have the potential to aid in mitigating adverse visual effects of the power station by partially screening and softening the visual impact of the site and ensuring light spill from the site is minimised.
- Any lighting requirements should be designed to ensure light spill is directed into the site.
- Where possible the selection of neutral/muted cladding and external finishing’s would aid in limiting the extent of adverse visual impacts.

9.8 Assessment of Residual Impacts

As noted above, potential mitigation measures are limited and the measures proposed (planting and other forms of visual screening) will not provide a great level of mitigation in terms of the visual effects of the proposed structures due to their size and scale.

However, balanced against existing factors, particularly distance from key viewing areas/sensitive receptors, natural screening and the modified nature of the area encompassed within the overall development site, it is considered that the residual level of impact will be **Moderate** to **Low**.

10. Natural Hazards and Vulnerability to Climate Change

The scope of this section includes a review of the earthquake, tsunami, volcanism, forest fire and flood risk of the area during construction and operation, and sets out mitigation measures to minimise the impacts of the Project.

10.1 Specific Methodology

This assessment utilises the baseline data on the natural hazards that typically occur within Indonesia and in particular, within the Project area, as described further in Section 3.8.

10.2 Assessment of Potential Impacts

Forest fires within the Riau region are likely during dry climatic conditions. These are generally started in order to clear natural forest to then be turned into productive land. The project site is surrounded by palm oil plantations, as such it is considered unlikely that intentional fires will started and the risk of the project site being caught in the path of a forest fire caused by clearing natural forest is considered low

Indonesia is a tectonically active area making it prone to earthquakes, tsunami's and volcanism. As outlined in Section 3.8, seismic activity causing these natural hazards is generally concentrated along the southern and western edge of Sumatra and their occurrence in the vicinity of the project site is unlikely. Therefore, the project site is considered to be of low risk to these seismic natural hazards. These events occur independently of the project are a risk to, rather than impact from, the project.

Similarly, Indonesia is subject to tropical cyclones and the risk from these is greatest in coastal areas where tropical storms are most intense. Therefore, the risk from these to the project site located approximately 120 km inland is low, as confirmed in Section 3.8. As above, tropical cyclones occur independently of the project are a risk to, rather than impact from, the project.

Heavy rainfall has the potential to cause landslides that could impact the Project. The topography surrounding the power plant site is generally undulating and subsequently, the risk of landslides here is low. A section of the proposed pipeline runs along a ridgeline and therefore there is the potential for a localised landslide to occur due to the steeper topography. However, whether a landslide occurs is influenced by a combination of rainfall, geology, topography, ground disturbance and vegetation clearance and therefore, their location is difficult to predict. Notwithstanding this, the small scale of trenching earthworks associated with pipeline construction is not expected to exacerbate the landslide risk.

The Projects potential to increase flooding to surrounding areas is discussed further in Section 7 - Hydrology. In summary the development of the power plant site will increase localised runoff. However, the impact of this is considered **Minor**. Additionally, the flood risk from the Siak River to the power plant is considered **Negligible** and flooding impacts to the pipeline are considered minor.

10.3 Mitigation and Monitoring

Natural hazards such as volcanic eruptions, earthquakes, tsunamis and tropical cyclones and occur independently of the Project. The Project will not contribute to their occurrence and therefore, mitigation measures cannot be implemented. Monitoring of these natural hazards is already undertaken at the national and international level. Notwithstanding this, all buildings will be constructed to the relevant engineering standards to reduce susceptibility to natural hazards. In addition, emergency response procedures will be developed and implemented at the site as part of the Environmental and Social Management System (ESMS) during construction and operation which detail what site personnel should do in the event of a natural hazard event.

Additionally, during construction and operation, the Project is able to mitigate its contribution and the scale of impact from existing natural hazards such as flooding and landslides through good construction practices such as: management of soil runoff and soil erosion, ensuring soil stockpiles are covered and water flow velocities in diversion channels are reduced. Further mitigation and monitoring in relation to water, is detailed within the Hydrology Impact Assessment (Section 7).

10.4 Assessment of Residual Impacts

As discussed above the potential impacts from natural hazards will be reduced by safety in design and the development of emergency response procedures. Additionally, good construction practices will reduce the Projects contribution to natural hazards when they occur. Therefore, the residual impacts are expected to be **Minor**.

11. Noise

This section describes the potential noise impacts of the project area from the construction and operation phases of the Project. Mitigation has been identified where necessary to reduce the scale and nature of potential impacts and monitoring has been proposed. The Noise Assessment technical report can be found in Volume 5 – Technical Appendices.

11.1 Specific Methodology

The impact assessment methodology has been developed in accordance with good industry practice and the potential impacts have been identified in the context of the Project's AoI, in accordance with ADB Environmental Safeguards and IFC Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts).

11.1.1 Assessment Criteria

Construction and Operation

Indonesian Standards

The State Minister of Environment Decree No 48 identifies noise limits relevant to the project in Subsection 4.2 as follows:

*"**4.2 Minimum Noise Threshold** - Decision of Environmental Minister No KEP-48/MENLH/11/96 establish standard noise levels for specific areas shown in Table 11.1. The standard level of noise is based on an A weighted equivalent noise level, L_{Aeq} over a 1 hour period."*

Table 11.1 presents the relevant Indonesian noise criteria for the project, which has in turn been reproduced from Table 1 of *KEP-48/MENLH/11/96*.

Table 11.1 : Indonesian SME Noise Limits for the Proposal

Appropriation Region - environmental Activities			Noise level dB(A)
a.	Appropriation Region		
	1	Housing and Settlements	55
	2	Trade and Services	70
	3	Office and Commerce	65
	4	Green open space	50
	5	Industry	70
	6	Government and Public Facilities	60
	7	Recreation	70
	8	Special:	
		Seaports	70
		Cultural heritage	60
b.	Environmental Activities		
	1	Hospital or the like	55
	2	Schools or the like	55
	3	Places of worship or the like	55

The relevant criterion for residential noise sensitive receivers (housing and settlement) is taken to be an L_{Aeq} (1 hour) 55 dB(A). As there is no distinction for different times of the day, this criterion would be applicable for both the day and night time periods.

Other locations for consideration include industrial sites, which have an $L_{Aeq\ 1\ hour}$ 70 dB(A) criterion for both day and night. Typically, the 70 dB(A) noise limit is applied at the boundary of the facility under assessment.

School, hospitals and places of worship have the same limits as the residential criterion and it is expected that these values represent predicted external noise levels.

World Bank EHS Guidelines

The WBG recommends noise limits for residential locations in accordance with its EHS Guidelines. These guidelines have been adopted from Guidelines for Community Noise, World Health Organization, 1999 and are values for noise levels measured outside a dwelling. The noise level guidelines from the IFC have been reproduced in Table 11.2

Table 11.2 : IFC Noise Guidelines for Noise Sensitive Locations

Receptor	Day 07:00-22:00	Night-time 22:00-07:00
	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$
Residential, Institutional Educational	55 dB(A)	45 dB(A)
Industrial, Commercial	70 dB(A)	70 dB(A)

The guidelines state:

"Noise impacts should not exceed the levels presented in Table 11.2 or result in a maximum increase in background levels of 3 dB at the nearest receptor location – off site"

The additional criteria of background plus 3 dB(A) is referred to as a maximum increase in noise levels and is only to be adopted where the guideline levels in the table are already exceeded.

Table 11.3 : World Bank Noise Guidelines for Power Stations

NCA (Residential, Institutional Educational receptors)	Initial noise limits dB(A)		Existing dB(A)*		Final noise limits dB(A)	
	Daytime 07:00-22:00	Night-time 22:00-07:00	Daytime 07:00-22:00	Night-time 22:00-07:00	Daytime 07:00-22:00	Night-time 22:00-07:00
	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$	$L_{Aeq\ period}$	$L_{Aeq\ period}$	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$
1****	55	45	59	61**	62	45
2			53	45	56	48
3***			53	45	56	48
4****			53	-	56	45
5			67	-	70	45
6			62	-	65	45

** A representative single monitoring result has been selected from each NCA*

*** Noise result is unrealistically high. As such the WBG EHS L_{Aeq} criterion of 55dB(A) has been applied.*

**** It is noted that noise monitoring was not conducted in NCA 3, and as such the noise levels from nearby NCA 2 have been applied. In reality this is a conservative approach as NCA 2 assesses semi-rural receivers on the eastern outskirts of Pekanbaru, whereas NCA 3 is located in the noisier suburban areas.*

***** Representative median values have been selected where multiple measurements have been obtained in these NCAs.*

Given that noise monitoring was not conducted during night time hours in NCAs 4, 5 and 6, the WBG EHS noise guidelines have been applied during these periods. In NCAs 1, 2 and 3 the existing noise level is greater than the guidelines and as such the alternative 'background plus 3 dB(A)' criterion has been applied at these locations.

Given that power plant noise is generally steady in nature, showing little variation throughout the day and night time period, the lowest noise criterion (night time) at each location will be applied.

11.1.2 Modelling Methodology

Noise modelling for the project utilised the SoundPLAN modelling software implementing the CONCAWE method of calculation.

Calculations have been provided for both neutral and unfavourable weather conditions. The following meteorological conditions are accounted for in the modelling:

- Neutral meteorological conditions: zero wind speed, 'D class' Pasquill category; and
- Adverse meteorological conditions: 2 m/s wind speed with the wind blowing from source to receiver, 'F class' Pasquill category.

As well as consideration of meteorological conditions, the standard also considers the following acoustic elements:

- Source directivity and size;
- Geometrical spreading;
- Air absorption;
- Ground absorption;
- Reflections; and
- Screening from terrain and major structures.

11.1.3 Modelling parameters and scenarios

Noise contours for the site were generated based on the following modelling parameters:

- Receiver height above ground of 1.5 m;
- Ground absorption = 0.75 (soft surface);
- Contour grid size of 20 m; and
- Reflection order of 3.

Modelling was conducted for the following operational scenarios:

- 24 hour emissions from Riau CCPP; and
- 24 hour emissions from both Riau CCPP and Tenayan CFPP (cumulative impact).

11.1.4 Meteorological influences

Given that the wind measurements at Pekanbaru have been influenced by buildings and local topography, typical meteorological conditions have not been assessed, instead the operational noise assessment has considered absolute worst case noise transmission. Under the modelled scenarios, wind has been assumed to be blowing at 2 m/s from each source to each receiver. Predictions have been provided for these adverse and neutral meteorological conditions.

Where the dominant wind direction is from receiver to the noise source, noise levels will be lower than the levels predicted in this assessment.

11.2 Assessment of Potential Impacts

11.2.1 Construction Noise Impacts

A summary of construction scenarios has been reproduced here to inform the prediction of noise levels from these activities.

Noise impacts during construction of the CCPP have been modelled using CONCAWE noise prediction method. Modelling inputs are similar to those used in the operational noise model.

11.2.2 Construction scenarios and impacts

The estimated construction period for the power plant, pipelines and power transmission lines is about 24 months with six months for commissioning. During this time there would be earthworks and building activities on the site as well as truck movements to and from the work areas. The truck movements adjacent to the residential areas are expected to provide the greatest degree of impact on the nearby residences with other site work mostly being completed over 600 m from the local communities.

The construction phase of the Project is scheduled to last from September 2018 to September 2020. The construction of the CCPP will be carried out in the following phases:

- Clearing and earthworks;
- Foundations and drainage works;
- Erection of buildings and plant; and
- Installation of equipment.

Construction activities also include the construction of the gas pipeline and the transmission line.

It is understood that night time construction activities will rarely be required at the site. Where night time construction work is necessary, it shall be managed so that noise does not cause annoyance to neighbours unless it:

- Is associated with an emergency; or
- Is carried out with the prior written approval of the relevant authorities, or
- Does not cause existing ambient noise levels to be exceeded.

Table 11.4 outlines an indicative construction schedule and staging and associated equipment noise levels.

Table 11.4 : Indicative Construction Staging and Equipment

Task	Equipment	Number	SWL
Clearing and earthworks	Dozer 40T - 50T (D8-D9)	2	114
	Excavator 40T - 50T	2	116
	Dump truck 40T - 50T	6	122
	Site generator	4	107
	Vibratory roller 10T - 20T	1	110
	TOTAL		**124**
Foundations and drainage	Concrete truck and pump	4	112
	Hand tools	12	116
	Concrete saw	1	114
	Bored piling rig	1	108
	Dump truck 40T - 50T	6	122

Task	Equipment	Number	SWL
	Franna / truck mounted crane	4	105
	Mobile / truck mounted cranes 100T - 200T	2	102
	Hydraulic driver	1	115
	Vibratory roller 10T - 20T	1	110
	Excavator 40T - 50T	2	116
	Front end loader	1	116
	TOTAL		**126**
Erection of buildings and plant	Mobile / truck mounted cranes 100T - 200T	4	105
	Franna / truck mounted crane	6	107
	Hand tools	12	116
	Vibratory roller 10T - 20T	2	113
	Wacker packer		107
	Concrete truck and pump	2	99
	Dump truck 40T - 50T	3	119
	TOTAL		**122**
Installation of equipment	Mobile / truck mounted cranes 100T - 200T	1	99
	Franna / truck mounted crane	4	105
	Hand tools	12	116
	Concrete saw	1	114
	Vibratory roller 10T - 20T	2	113
	TOTAL		**119**
Transmission line - Installation	Hand tools	6	110
	TOTAL		**110**
Gas pipeline - Installation	Franna / truck mounted crane	1	99
	Backhoe	2	97
	Hand tools	6	112
	TOTAL		**114**

11.2.3 Riau CCPP Construction Noise Impacts

Construction noise contour maps for each of the four phases of construction of the CCPP above are presented in Appendix B of the Technical Report – Noise Impact Assessment provided in Volume 5 – Technical Appendices. As displayed noise levels were well below site criteria outlined in Section 11.1at the nearest, most affected receiver during all four assessment scenarios. Given this, it was concluded that noise impacts during construction at the CCPP site are not expected, although measures to limit noise during these works are still proposed.

Potential noise impacts associated with the construction of the power station have been evaluated as **Negligible**, taking into account the **Negligible** magnitude and Negligible sensitivity of the predicted impacts.

11.2.4 Transmission Line Construction Noise Impacts

Owing to the linear nature of construction activities associated with construction of the transmission line, noise impacts will be temporary with the magnitude of noise levels varying as distances between receivers and the active work area changes. It is understood that construction of the towers will be largely manual, and require handtools, a truck mounted crane to deliver equipment and a concrete truck for footings.

Construction activities will be focused around each tower and are unlikely to generate noise impacts along other areas of the route.

The transmission line runs through NCA 1 only and is surrounded by very few isolated receivers. Compliance with the construction noise criteria is expected at distances of more than 100 m from each tower location. It should be noted that this assessment does not consider screening from terrain or structures and as such is a conservative estimate of construction noise.

Potential noise impacts associated with the construction of the power station have been evaluated as **Negligible**, taking into account the minor magnitude and Negligible sensitivity of the predicted impacts.

Section 11.4 provides measures to be incorporated into the Environmental and Social Management Plan to address potential noise issues during these works.

11.2.5 Gas pipeline Construction Noise Impacts

Owing to the linear nature of construction activities associated with construction of the gas pipeline, noise impacts will occur for an approximate two-week period with the magnitude of noise levels varying as distances between receivers and the active work area changes. It is understood that construction of pipeline will primarily be carried out with a truck mounted crane, single backhoe and hand tools.

The gas pipeline runs through NCAs 1, 4, 5 and 6 and passes several small villages and isolated rural residences. Compliance with the construction noise criteria is expected at receivers located more than the following distances:

- NCA 1 150 m
- NCA 4 300 m
- NCA 5 60 m
- NCA 6 110 m

It should be noted that this assessment does not consider screening from terrain or structures and as such is a conservative estimate of construction noise.

Potential noise impacts associated with the construction of the gas pipeline have been evaluated as **Minor**, taking into account the **Moderate** magnitude and Negligible sensitivity of the predicted impacts.

Section 11.4 provides measures to be incorporated into the Environmental and Social Management Plan to address potential noise issues during these works.

11.3 Operational Noise Assessment

11.3.1 Supplied operational noise modelling data

The modelling data has been supplied by the contractor for the operational noise assessment process. Sound power levels (SWLs) are represented in the noise model to provide a three dimensional layout of the proposed power plant. The three dimensional noise model propagates these noise levels to a receiver location accounting for distance, air absorption, ground absorption, and screening effects.

The data in below summarises the significant noise sources that were accounted for in the modelling of operational noise impacts.

Table 11.5 : Significant CCPP Noise Emissions

Equipment	Status	Overall SWL dB(A)	Unit of measurement
GTG inlet			
Air inlet Filter Face	dB	85.0	per unit
Air Inlet Filter Transition	dB	99.0	per unit
Air Inlet Duct and Elbow	dB	105.0	per unit
Gas Turbine Package			
GT Enclosure	dB	101.0	per unit
Oil & Gas module enclosure	dB	99.0	per unit
GT Generator	dB	104.0	per unit
Vent Fans			
88TK	dB	91.0	per unit
88BN	dB	91.0	per unit
88BT (GT enclosure) casing	dB	90.0	per unit
88BT (GT enclosure) outlet	dB	90.0	per unit
88VG (load comp) casing	dB	92.0	per unit
88VG (load comp) outlet	dB	90.0	per unit
88VG (load comp) inlet	dB	90.0	per unit
88BL (lube oil enclosure) casing	dB	88.0	per unit
88BL (lube oil enclosure) inlet	dB	90.0	per unit
88VL (gas module enclosure) casing	dB	90.0	per unit
88VL (gas module enclosure) outlet	dB	90.0	per unit
Other Fans outlet	dB	90.0	per unit
Transition to HRSG			
GT Exhaust Diffuser Enclosure	dB	92.0	per unit
HRSG, with Duct Firing			
HRSG Inlet duct	dB	103.0	per unit
HRSG Body	dB	99.0	per unit
HRSG Stack & breaching	dB	94.0	per unit
Accessories (piping + valves + continuous vents)	dB	99.0	per unit
Stack Outlet (HRSG Stack Top) with duct firing	dB	104.0	per unit
BFPs	dB	90.0	per unit
Main cooling water pumps	dB	89.8	per unit
Closed cycle cooling water pumps, if outside	dB	85.0	per unit
Main Transformer	dB	83.0	per unit

Equipment	Status	Overall SWL dB(A)	Unit of measurement
Aux. Transformer	dB	71.0	per unit
Cooling Tower	dB	84.9	per unit
Steam turbine generator / condenser building			
ST Body	dB	108.0	per unit
HP/IP Steam Valve	dB	99.0	per unit
ST Generator	dB	106.0	per unit
Gas compressor enclosure	dB	85.0	per unit
Water treatment area	dB	<85.0	per unit
150kV substation	dB	50	per m^2

A visual representation of the 3 dimensional model showing major operational noise sources in pink is provided below in Figure 11.1.

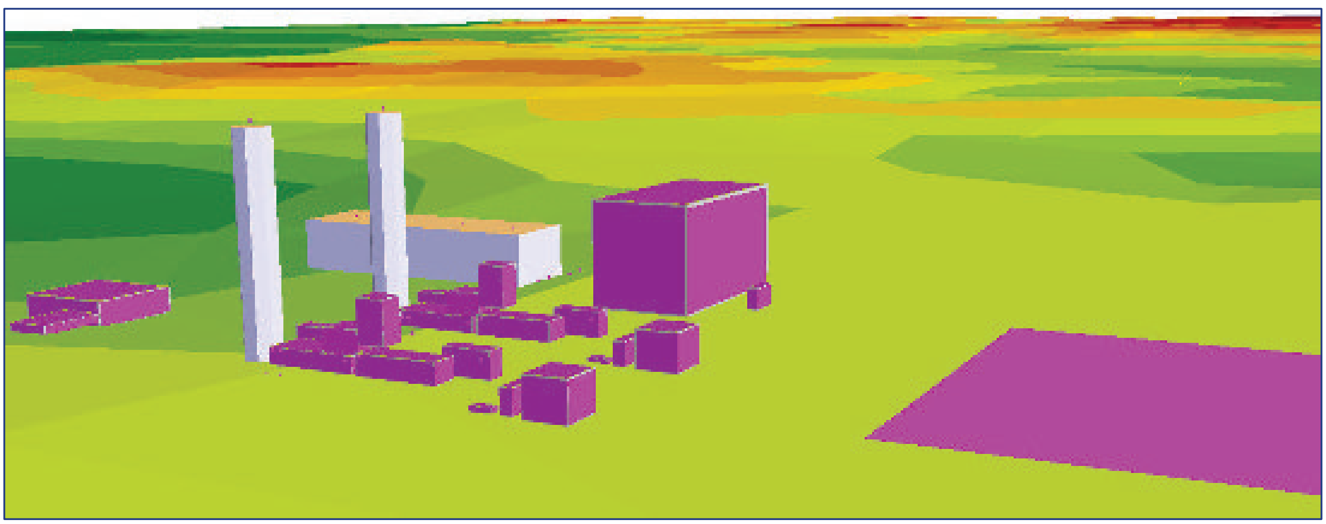


Figure 11.1 : Visual Representation of 3D Noise Model (Riau CCPP)

11.3.2 Riau CCPP impacts

11.3.3 Results of operational noise modelling

The power plant is assumed to have a constant noise emission however, in practice base load power levels are expected to decrease during the night time hours. This assessment has assumed the worst case scenario of the power station operating at full load, which may occur at any time. Figure 11.2 and Figure 11.3 present predicted noise contours for the operational impacts from Riau CCPP alone under both neutral and adverse meteorological conditions.

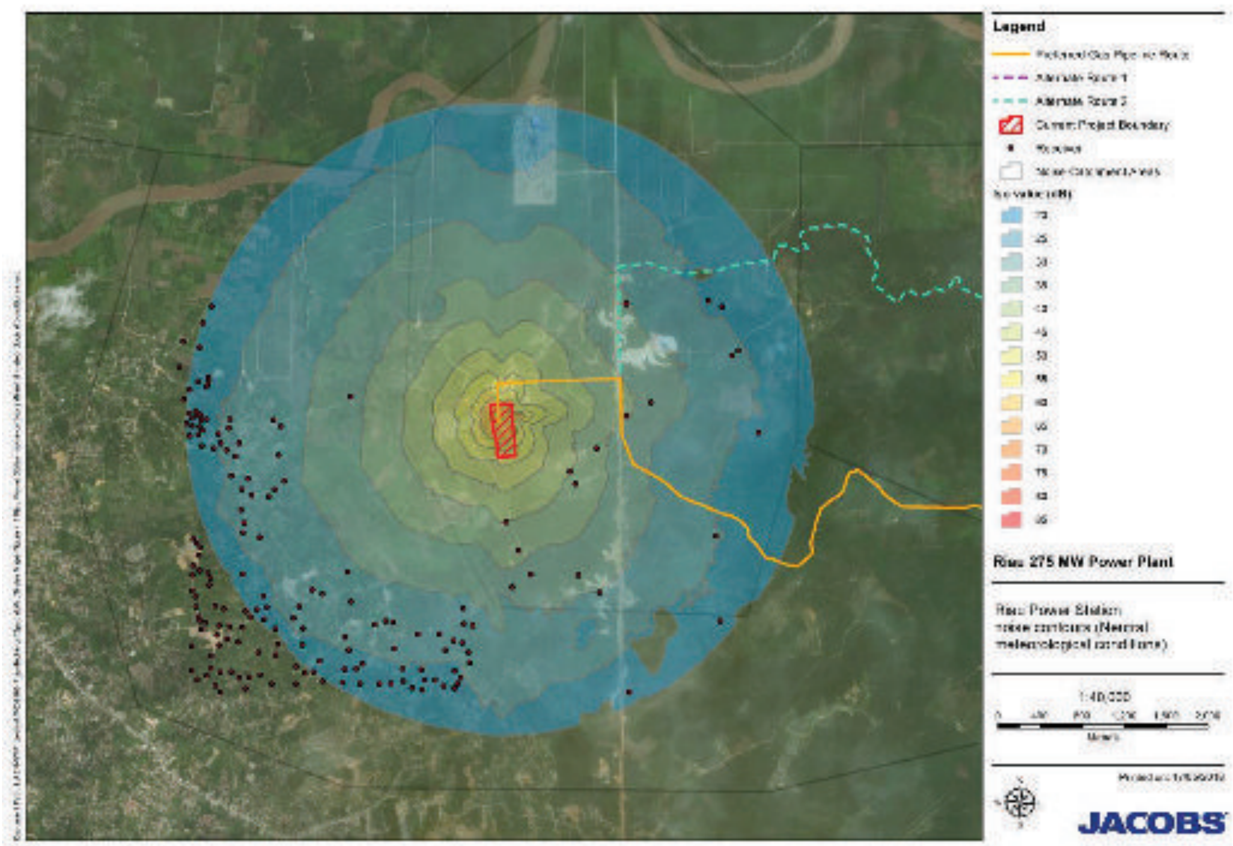


Figure 11.2 : Riau Power Station Noise Contours (Neutral Meteorological Conditions)

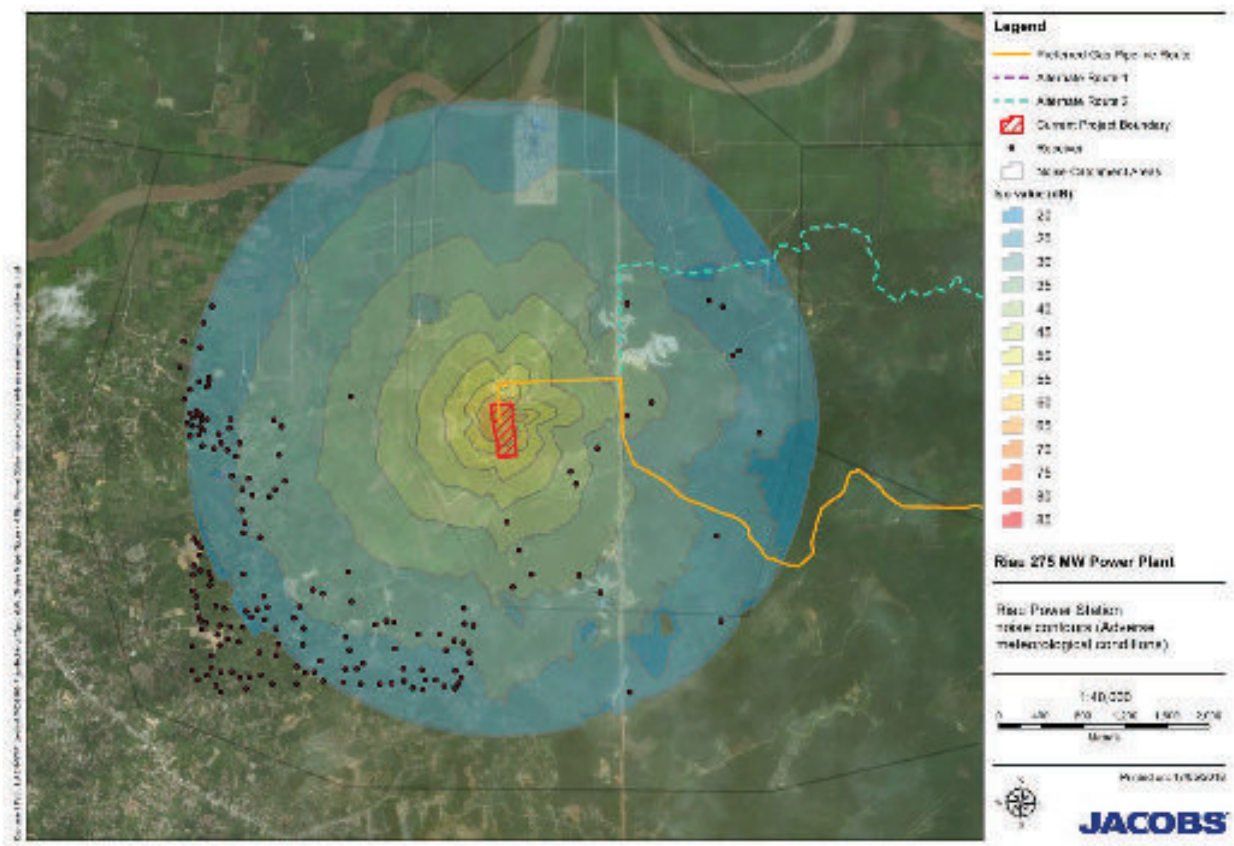


Figure 11.3 : Riau Power Station Noise Contours (Adverse Meteorological Conditions)

Under worst case, adverse weather conditions, the predicted noise levels from the plant alone at the nearest receivers (NCA 1 - sparse rural properties located to the east and northeast) are expected to be below 40 dB(A) L_{Aeq}. For semi-rural properties located on the outskirts of Pekanbaru, noise levels are expected to be below 30 dB(A), while noise levels in all other NCAs are expected to be inaudible.

Under neutral meteorological conditions, noise levels are predicted to be approximately 5 dB(A) below these levels.

Noise levels are expected to remain within project criteria at all identified receiver locations under worst case meteorological conditions.

11.3.4 Gas pipeline impacts

Following construction, the gas pipeline is not expected to generate any operational noise.

11.3.5 Electricity transmission line impacts

Under most meteorological conditions, the electricity transmission line will also not generate any operational noise. However, during sustained periods of high winds, steady rainfall or high humidity, the transmission line may generate corona / arcing noise. This noise is caused by the breakdown of air into charged particles caused by the electrical field at the surface conductors.

Research has indicated that this noise source is typically in the order of 40 dB(A) at a distance of 50 m from the source (*Nyngan Solar Plant Noise Assessment, NGH Environmental, March 2013*).

The nearest identified receivers to the power line are located approximately 1 km to the west of the proposed route. At this distance, coronal noise would be inaudible.

11.3.6 Operational impact evaluation

Potential noise impacts associated with the operation of the power station have been evaluated as **Negligible**, taking into account the **Negligible** magnitude and Negligible sensitivity of the predicted impacts.

11.4 Mitigation and Monitoring

Table 11.6 presents safeguards and measures to manage potential noise impacts during construction. These measures should be considered prior to any construction activities being undertaken.

Table 11.6 : Noise Management Measures and Safeguards During Construction

Impact	Environmental safeguards
All sites	• Regularly train workers and contractors to use equipment in ways to minimise noise. • Ensure site managers periodically check the site and nearby residences for noise problems so that solutions can be quickly applied. • Regularly inspect and maintain plant to avoid increased noise levels from rattling hatches, loose fittings etc. • Truck routes to and from the worksite should be contained to major roads where possible.
Riau CCPP	• Wherever possible, schedule noisy activities during standard hours of construction.
Transmission line	• Wherever possible, schedule noisy activities during standard hours of construction. • Use non- 'beeper' reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise sensing alarms.
Gas pipeline	• All residential properties and other key stakeholders such as schools and educational facilities should be notified prior to the commencement of noisy activity. • Use non- 'beeper' reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise sensing alarms. • Schedule noisy activities during standard hours of construction. • Turn off all vehicles, plant and equipment when not in use. • Ensure that all doors/hatches are shut during operation of plant and equipment. • Work compounds, parking areas, equipment and material stockpile sites should be positioned away from noise-sensitive locations.

11.4.1 Operational Noise Mitigation

Given the remote locations of the proposed Riau CCPP site, no operational noise impacts have been predicted. As such, noise mitigation is not considered necessary.

However, to promote best practice at the site and to ensure that noise impacts are maintained at or below the modelled levels, the following operational noise management measures are recommended:

- Where noise levels differ from those outlined in described above, remodelling should be conducted to confirm noise impacts;
- Noise levels modelled in this report should be confirmed prior during the commissioning of the plant;
- Operational equipment should be maintained and operated in the recommended manner in order to keep noise emissions to a minimum;
- Hatches on noisy plant and doors to noisy work areas should remain closed where possible; and
- It is recommended that all noise generating equipment is selected based in part on its acoustic rating where multiple choices exist.

11.4.2 Monitoring

Monitoring is not linked to the impact evaluation but is an important component of the ESIA. Monitoring and follow-up actions should be completed to:

- Continue the collection of noise data throughout construction, operation and later decommissioning to check that noise criterion is being complied with;
- Evaluate the success of mitigation measures, or compliance with project standards or requirements;
- Assess whether there are impacts occurring that were not previously predicted; and
- In some cases, it may be appropriate to involve local communities in monitoring efforts through participatory monitoring. In all cases, the collection of monitoring data and the dissemination of monitoring results should be transparent and made available to interested project stakeholders.

11.5 Assessment of Residual Impacts

The residual noise impacts during construction of the power plant are of **Negligible** significance and for the gas pipeline are of **Minor** significance.

For operation of the power plant the residual noise levels are **Negligible**.

12. Terrestrial Ecology

12.1 Specific Methodology

The impact assessment methodology applied to the assessment of potential impacts on terrestrial ecology arising from the Project, was undertaken in general accordance with the impact assessment methodology outlined in Section 2. However, the descriptors used in the sensitivity criteria have been modified, as follows.

12.1.1 Sensitivity Criteria

Sensitivity is specific to each aspect and the environmental resource or population affected, with criteria developed from baseline information. Using the baseline information, the sensitivity of the receptor is determined factoring in proximity, number exposed, vulnerability and the presence of receptors on site or the surrounding area. Generic criteria for determining sensitivity of receptors are outlined in Table 12.1. Each detailed assessment will define sensitivity in relation to its environmental or social aspect.

Table 12.1 : Criteria for Determining Impact Sensitivity

Category	Receptor	Description
High	Environmental	• IUCN Critically Endangered and Endangered species • Internationally designated sites (or equal status). Critical habitats of significant international ecological importance • Receptor with little or no capacity to absorb proposed changes
Medium	Environmental	• IUCN Vulnerable or Near Threatened species. Nationally important / protected species. • Nationally designated sites (or equal status). Regionally important natural habitats. Modified habitats with high biodiversity. • Receptor with little capacity to absorb proposed changes
Low	Environmental	• IUCN Least Concern. Species of local importance. • Undesignated sites and habitats of natural habitats of some local biodiversity interest. Modified habitats with limited ecological value. • Receptor with some capacity to absorb proposed changes
Negligible	Environmental	• IUCN Least Concern species. Species of no importance. • Highly modified habitats of no biodiversity value. • Receptor with good capacity to absorb proposed changes

12.2 Assessment of Potential Impacts

The construction and operation of the proposed Riau CCPP site could have the potential to affect the terrestrial ecology of the local area. The spatial extent of the impacts is considered to be within the Project footprint or immediately adjacent to it. The baseline data found direct and indirect evidence of IUCN Red Listed Threatened species (Vulnerable, Threatened, Endangered or Critically Endangered) within some areas of the Project being Flora transects 1.1.3, 1.1.4, 1.1.5, 2.2, 3.2, and Fauna transects TR1, TR2, TR3, TR4, TR5, UP3, WI1, WI2. However, the overall project area is considered to be Modified Habitat.

Table 12.2 provides a summary of the activities associated with construction and operation of the Riau CCPP and the potential impacts on the terrestrial ecology of the locality. The activity description set out in Table 12.2 includes any proposed management or mitigation measures inherent in the design that avoid or reduce impacts on terrestrial ecology.

Table 12.2 : Summary of Potential Impacts on Terrestrial Ecology

Phase	Activity	Potential Impact
Construction	**Construction of the CCPP** Clearance of palm oil plantation, backfilling of land and land drainage, construction of the power plant and switchyard of approximately 5.4 ha on a 9.1 ha plot of land. Site clearance and levelling is expected to take 6 months with construction of the power plant and switchyard taking 24 months. Vegetation will be cleared and any voids and water ponds drained and filled. Topsoil will be stripped and the site will be levelled Construction activities will include; • excavation for foundations and drainage, • piling foundations, • concrete pouring of foundations, and • erection of pre-fabricated modules. Controls on construction noise include restricting work hours, no night time piling, use of pre-fabricated units, use of low noise and vibration equipment and use of silencers during steam blowing. After construction and erection work are completed, the power plant site will be landscaped for visual appearance and to limit erosion from surface water during heavy rains. The upper, organic layer of soil temporarily removed and stored during construction, will be used to provide fertile soil for landscaping, where possible. **Construction and use of temporary jetty on the Siak River** The activities associated with the construction and use of the jetty will primarily affect aquatic ecology and is covered within that assessment. The roadway from the temporary jetty to the power plant site will require widening of or improvements to the route. **Construction of the access road** Construction of an 8 m wide access road of approximately 500 m length. Vegetation will be cleared and the site levelled and then the road will be permanently sealed.	Habitat loss: • Land take for the Power Plant will result in loss of 9.1 ha of oil palm plantation. • Land take for the roadway to the Jetty will result in some loss of adjacent habitats (primarily oil palm plantation). • Land take for the access road will result in the loss of approximately 0.5 ha of habitat (primarily oil palm plantation). Disturbance: • Construction noise – the noise assessment predicted noise levels below the 55 dB(A) from the closest residential receptors. The control measures proposed will reduce levels that are unlikely to disturb the species present in the locality. • Construction lighting. • Increased numbers of people due the presence of construction work force could result in disturbance of species. Habitat degradation: • Changes in air quality during construction, primarily as a result of dust deposition, would affect adjacent habitats (primarily oil palm plantation). Mortality/injury of species: • Potential increase in road traffic mortality due to increased traffic as a result of construction works.
	Construction of the 150 kV transmission line Construction 6 towers (on footprints of 20 by 20 m or 30 by 30 m) and the line through an easement of approximately 25 m wide and 750 m long. Construction is expected to take 8 months.	Habitat loss: • Land take for the transmission line will result in the loss of adjacent habitat (primarily oil palm plantation with some areas of scrub), up to approximately 1.9 ha. Any impacts on IUCN Red List threatened species *Afzelia rhomboidea* will be avoided by ensuring that the location of this species is mapped pre-construction and avoided. Disturbance: • IUCN Red List threatened species *Afzelia rhomboidea* is not considered to be affected by disturbance impacts.
	Construction of the water supply/discharge pipelines and intake/discharge points The water supply/discharge pipelines would be routed through a 6 m wide corridor of approximately 3 km long. Construction of the water pipelines is expected to take 8 months.	Habitat loss • Land take for the water supply/discharge pipelines will result in the loss of approximately 1.8 ha of habitat (modified habitat but in some parts potentially critical habitat). Measures will be included in final pipeline route design to avoid/minimise the effects on areas identified as potential Critical Habitat.

Phase	Activity	Potential Impact
		Disturbance: • Construction noise – the noise assessment predicted noise levels below the 55 dB(A) at the closest residential receptors. The control measures proposed will reduce levels that are unlikely to disturb the species present in the locality. • Construction lighting. • Increased numbers of people due the presence of construction work force could result in disturbance of species. Mortality/injury of species • Animals becoming trapped in excavations.
	Construction of the 40 km gas supply pipeline and gas metering facility The pipeline route primarily follows the existing road network and construction activities that could affect terrestrial ecology will involve: • Preparing the pipeline route by clearing vegetation (where required) and grading the immediate area (approx. 10 m wide corridor); • Digging and preparing the trench for the pipe – with the maximum open trench at any time likely to be 500 m; • Backfilling the trench and compaction; and • General area reinstatement	• Land take for installation of the gas pipeline is within the road reserve. The land take for the gas metering facility is directly adjacent to the existing gas offtake location in an area of already cleared land. The land use in the project area is predominantly oil palm plantation determined to be modified habitat of low ecological value. In addition, land take will not occur in areas where Critically Endangered and Endangered Species have been identified along the route. Disturbance: • Construction noise – the noise assessment predicted noise levels below the 55 dB(A) for the closest residential receptors. The control measures proposed will reduce levels that are unlikely to disturb the species present in the locality. • Construction lighting. • Increased numbers of people due the presence of construction work force could result in disturbance of species. Mortality/injury of species • Animals becoming trapped in excavations.
Operation	**Riau CCPP operation.** Noise levels from the Project will not exceed the Indonesia and World Bank / IFC noise limits. Noise reduction measures are included within the plant design. All emissions to air will be within the limits outlined in the IFC/World bank guidelines and within the requirements of the Indonesian regulations.	Disturbance: • Operational noise resulting in species avoiding area.

12.2.1 Construction Impacts

The construction impacts as a result of the proposed project likely to have an effect on terrestrial ecology are;

- Habitat loss;
- Disturbance;
- Habitat degradation; and
- Mortality/injury of species.

12.2.1.1 Habitat Loss

Riau CCPP

The total area of land required to construct (the footprint) the Riau CCPP, transmission line and access roads is approximately 13.3 ha. The areas affected are predominantly oil palm plantation with some pockets of more diverse habitat including scrub and wetland. All of the modified habitats and smaller pockets of natural habitats within the footprint will be permanently lost. The species recorded within the locality were of limited conservation interest with no IUCN Threatened Red Listed species present and are considered likely to be relatively resilient to habitat change given their presence within this area of modified habitat. The loss of the modified habitat is considered to be of a **Moderate** magnitude and given the Low sensitivity of the terrestrial ecology receptors a **Minor** impact is predicted.

150kV Transmission Line

The construction of the transmission line and towers will result in the loss of habitat (primarily oil palm plantation with some areas of scrub) to allow tower construction and stringing, up to approximately 1.9 ha (easement area is included). The IUCN Red List threatened species *Afzelia rhomboidea* (Vulnerable) was recorded within the habitat survey transect, however any loss of this species will be avoided by ensuring that the locations are mapped pre-construction and avoided. The loss of habitat is considered to be of a **Minor** magnitude and given the Medium sensitivity (and avoidance of Vulnerable plant species) a **Minor** impact is predicted.

Water Pipeline

The habitat loss associated with the water pipeline routes is considered to be limited to the working area which will be a 6 m corridor 3 km long. The habitat recorded along the route was a mix of plantation and mangrove forest with a number of IUCN Vulnerable species recorded. The loss of habitat is considered to be temporary as once the pipeline is installed the vegetation will regenerate and the narrowness of the corridor is unlikely to affect the vulnerable species recorded given they are inhabiting an area that has seen considerable modification to oil palm plantation. Any loss of the Vulnerable species *Afzelia rhomboidea* will be avoided by ensuring that the locations are mapped pre-construction and avoided. The loss of habitat is considered to be of a **Minor** magnitude and given the Medium sensitivity (and avoidance of Vulnerable plant species) a **Minor** impact is predicted

Gas Pipeline

The habitat loss associated with the gas pipeline route and gas metering facility is considered to be limited to the working area and does not include any areas where Critically Endangered or Endangered species have been identifed. The route is alongside unpaved and paved roads for the majority of its 40 km length and the working area generally within the road reserve.

Where the gas pipeline route is adjacent to the unpaved roads and the gas metering facility is adjacent to the existing gas offtake location, the adjacent habitat is predominantly oil palm plantation with only at worst an edge strip requiring removal to allow the pipeline to be constructed. The Vulnerable species (black partridge) recorded within some of these areas is unlikely to be sensitive to loss of this type of habitat. The loss of the habitat is considered to be of a **Negligible** magnitude and given the Medium sensitivity of the terrestrial ecology receptors a **Negligible** impact is predicted.

Where the gas pipeline route is adjacent to the paved highway and the gas metering facility is adjacent to the existing gas offtake location, it has been designed to sit within the road reserve which is either bare ground or grass/scrub habitat. Although the areas of native regrowth and plantation adjacent to that strip may support ecologically sensitive species e.g. Critically Endangered and Endangered, they will not be affected by any vegetation clearance required by the gas pipeline. Therefore, the magnitude of this impact is considered to be **Negligible** and given the adjacent habitat is of High sensitivity a **Negligible** impact is predicted.

12.2.1.2 Disturbance

Riau CCPP

The site lighting and presence of the work force that will result from the construction works has the potential to disturb species using adjacent areas. The extent of the impact is likely to only affect the habitat immediately adjacent to the construction areas therefore is considered to be of **Minor** magnitude. The species recorded in the locality are considered likely to be relatively resilient to these types of changes in the environment and would be likely to be of Low sensitivity. The resulting impact of disturbance is therefore considered likely to be **Negligible**.

Water Pipeline

The habitat adjacent to the water pipeline had a greater diversity of fauna species present including a number of IUCN threatened species. These receptors are considered to be of Medium sensitivity. The noise, vibration and presence of work force within the working area has the potential to result in these species avoiding the area and potentially reducing their home range with secondary effects on their ability to feed for example. The work on the pipelines will be carried out in sections so only relatively small areas will be affected as the construction works progress and no night time working is proposed. The magnitude of the effect is therefore likely to be **Minor** with a **Minor** impact predicted for the water pipeline construction.

Gas Pipeline

Where the gas pipeline is routed along the unpaved roads and the gas metering facility is adjacent to the existing gas offtake location, the surrounding habitat is predominantly oil palm plantation and is not considered to be sensitive to the effects of disturbance and a **Negligible** impact is predicted.

Where the gas pipeline route is adjacent to paved roads the adjacent habitat is more varied with a greater diversity of fauna species present including a number of IUCN threatened species. These receptors are considered to be of High sensitivity. The noise, vibration and presence of work force within the working area has the potential to result in these species avoiding the area and potentially temporarily reducing their home range with secondary effects on, for example, their ability to feed. The work on the pipelines will be carried out in sections so only relatively small areas will be affected as the construction works progress and no night time working is proposed. The magnitude of the effect is therefore likely to be **Minor** and a **Moderate** impact predicted for the gas pipeline construction along the paved highway.

12.2.1.3 Habitat Degradation

Riau CCPP and Pipeline Construction

The dust generated as a result of the construction works on all parts of the project is likely to affect areas of vegetation adjacent to the working area. The smothering of plants by dust can affect their ability to photosynthesise, thus affecting growth with potential secondary effects on the species that use them. The dominant vegetation type, oil palm, is unlikely to be particularly susceptible to such effects given the tree height and form. However, lower growing species may be in areas where they are present. The measures in place include low speed limit enforcement, damping down haul routes, and a wheel wash which will reduce dust track out along the highway. Therefore, dust emissions from excavations at the proposed site and for the water and gas pipelines are considered to be of **Negligible** magnitude. The sensitivity of the receptors (Low and High) varies depending on location but with the measures to avoid and reduce duct emissions a **Negligible** impact is predicted.

12.2.1.4 Mortality / Injury of Species

Riau CCPP and Pipeline Construction

The construction work will result in an increase in the numbers of truck movements during the construction period and this could increase the likelihood of species being struck by vehicles. The impact is likely to be **Minor**

to Moderate in magnitude. Assuming delivery vehicles are operating in daytime hours with low speed limits enforced then it seems reasonable to assume that the receptors most at risk, mammals and herpetofauna are less likely to be active and therefore the sensitivity of the receptor is considered to be Low. There is potential for **Minor** impact during the construction period.

Water Pipeline

There is potential for animals to become trapped within the excavations. However, the trench shall have "escape" ramps with slopes less than 45 degrees for each 500 m open trench to provide a means of escape to any animals that may fall into the trench. This measure is considered to reduce the risk of any mortality of species but not necessarily injury therefore the magnitude is considered to be **Minor**. The sensitivity of the receptor is Medium along the water pipeline route therefore a **Minor** impact is predicted.

Gas Pipeline

There is potential for animals to become trapped within the excavations, however, the trench shall have "escape" ramps with slopes less than 45 degrees for each 500 m open trench to provide a means of escape to any animals that may fall into the trench. This measure is considered to reduce the risk of any mortality of species but not necessarily injury therefore the magnitude is considered to be **Minor**. The sensitivity of the receptor is High for the gas pipeline route adjacent to the paved therefore a **Moderate** impact respectively is predicted.

12.2.2 Operational Impacts

The operational impacts as a result of the proposed project likely to have an effect on terrestrial ecology are;

- Disturbance; and
- Habitat degradation.

12.2.2.1 Disturbance

The ongoing operational noise associated with the proposed power plant has the potential to result in species avoiding the area. The baseline surveys have recorded species that are generally considered to be resilient to anthropogenic changes in their environment (IUCN, n.d.) and adapt quickly to change. Therefore, the receptors are considered to be of Low sensitivity.

The operational noise assessment concluded that the change in noise at the nearest residential receptors would be of the order of 40 dB(A) and meet the minimum project noise criteria of LAeq 54 dB(A) for night time operations. This is considered to be of **Minor** magnitude and given the Low sensitivity of the receptors the impact is considered likely to be **Negligible**.

12.2.2.2 Habitat Degradation

The proposed power plant will have exhaust stack and cooling tower emissions that include oxides of nitrogen and very minor quantities of sulphur oxides and particulates. The deposition of these compounds have the potential to affect habitats through acidification and nitrification.

All emissions will be within the limits outlined in the EHS Guidelines and within the requirements of the Indonesian regulations. Therefore, **no impact** on terrestrial ecology is predicted.

12.3 Mitigation and Monitoring and Residual Impacts

The potential impacts on terrestrial ecology as a result of the project were limited to the construction phase and were:

- Loss of Modified Habitats;
- Disturbance; and
- Mortality/injury of species.

Table 12.3 sets out the mitigation measures proposed to avoid or compensate for the impacts predicted. All of the Project working areas will be subject to a pre-construction survey to; identify the locations of any IUCN Red List Threatened species, and locations of any invasive species which will require removal or control.

Table 12.3 : Proposed Mitigation Measures and Assessment of Residual Impacts

Summary of potential impact	Proposed mitigation	Residual impact
Permanent habitat loss of 9.1 ha of predominantly oil palm plantation (Modified Habitat)	Provision of wetland areas and swamp forest within the green zones of the Riau CCPP. This is likely to be approximately 3.5 ha of habitat provided on completion of the construction phase.	In the long term this type of habitat change could be considered to benefit the local habitats and species. Depending on how successful the mitigation land is would mean that at worst a negligible impact and at best a **Minor positive impact** would be predicted.
Temporary loss of Modified Habitat along water pipeline	• The vegetation clearance required in these areas should be kept to a minimum with felling of mature trees (except oil palm), and large areas of scrub/immature vegetation avoided. • Clear demarcation of the site limits should occur to avoid any accidental incursion in to the adjacent habitats. • Replant the temporary working areas, if possible by using saplings salvaged from the site clearance phase.	These measures will ensure any loss is minimised and also give the recovery of vegetation a “good start”. With these measures in place it is considered that any loss of habitat would result in a **Negligible** effect on the Critical Habitats crossed by the water pipeline.
Disturbance to species as a result of the presence of the work force.	The site management measures should include clear demarcation of site limits, directional site lighting and tool box talks to construction staff to highlight the presence of local wildlife and behaviour towards it. Clear demarcation of the site and other measures highlighted above will need to occur in areas where Critical Habitat is close to the working area, for example where the gas pipeline is being installed along the paved road section.	The measures proposed will reduce the effects of the proposed project to a Negligible magnitude with a **Negligible** effect on terrestrial ecology predicted as a result of disturbance.
Mortality/injury of species	• No night-time deliveries of construction equipment and material • Speed limit enforced between jetty and power plant site of 20 kph. • Cover excavations at end of working day where the gas pipeline route is adjacent to the paved road, or fence the excavations to prevent incursion by species.	The mitigation proposed is considered to reduce the likelihood of the impact occurring and although it may not be completely avoided the residual impact will be reduced to **Negligible**.

12.3.1 Pre-Clearance Terrestrial Ecological Surveys

It is recommended that pre-clearance terrestrial ecological surveys are undertaken of the power plant, water pipeline route and gas pipeline route, prior to any vegetation clearance to identify, capture and relocate vulnerable, threatened or endangered species from the project area.

12.3.2 Pre-Construction Survey of Confirmed Gas Pipeline

It is further noted that a pre-construction survey will be undertaken of the confirmed gas pipeline route where there is currently a number of options being considered. This monitoring is to identify any potential vulnerable/ critically endangered flora and fauna and where possible capture and relocate fauna.

As noted in Section 3.10.6, some areas adjacent to the pipeline route have identified ecologically sensitive species. However, as no potential impacts to these specieshave been determined no further information on population size and distribution of species is required to be collected. If the pre-construction survey of the confirmed gas pipeline route identifies any further concerns, then further assessment / mitigation will be undertaken as required.

13. Traffic

13.1 Specific Methodology

13.1.1 Magnitude Criteria

The assessment of impact magnitude is undertaken by identifying the impacts of the project on the safe and efficient use of the transport network. Then the impacts are categorised as 'Major', 'Moderate', 'Minor' or 'Negligible' based on consideration of parameters such as:

- Duration of the impact – whether the impact is temporary or whether it is ongoing;
- Safety – how much additional risk that traffic associated with the project would present to road users; and
- Efficiency – how much delay road users would experience from traffic associated with the project.

Table 13.1 below presents generic criteria for determining impact magnitude. This impact criterion intentionally places a higher weighting on safety than on traffic delay.

Table 13.1 : General Criteria for Determining Impact Magnitude

Category	Description
Major	Moderate to significant increase in safety risk to road users and significant delay to road users for extended periods of time.
Moderate	Minor increased safety risk to road users and/or significant delay to traffic for short periods of time.
Minor	No increase is safety risk to road users and/ or minor disruption to traffic.
Negligible	No noticeable change to the baseline conditions

13.1.2 Sensitivity Criteria

The ability of the road to accommodate any additional traffic from the construction and operation of the proposed power plant depends the characteristics of the road corridor. From a safety perspective there is a higher risk on roads with high traffic volume and high road side activity (generally main urban roads) than on quiet roads with little roadside activity (generally minor rural roads). For traffic delay roads which are at or near capacity are more sensitive to increases in traffic flow as this would as this would further add to traffic congestion. The generic criteria for determining the sensitivity of the road to additional traffic is outlined in Table 13.2 below.

Table 13.2 : General Criteria for Determining Impact Sensitivity

Category	Description
High	There is high traffic volume and significant road side activity and/or the road has no spare capacity even during off peak times
Medium	There is moderate traffic volume and some road side activity and/or there is some capacity to accommodate additional traffic but only during off peak times
Low	There is low traffic volume and little road side activity and/or the road has some spare capacity to accommodate additional traffic
Negligible	Traffic volume is very low and the road has plenty of spare capacity

13.1.3 Impact Evaluation

The determination of impact significance involves making a judgment about the importance of project impacts. This is typically done at two levels:

- The significance of project impacts factoring in the mitigation measures in the construction methodology; and
- The significance of project impacts following the implementation of feasible additional mitigation measures.

The impacts are evaluated taking into account the interaction between the magnitude and sensitivity criteria as presented in the impact evaluation matrix in Table 13.3 below.

Table 13.3 : Impact Matrix

		Magnitude			
		Major	**Moderate**	**Minor**	**Negligible**
Sensitivity	**High**	Major	Major	Moderate	Negligible
	Medium	Major	Moderate	Minor	Negligible
	Low	Moderate	Minor	Negligible	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

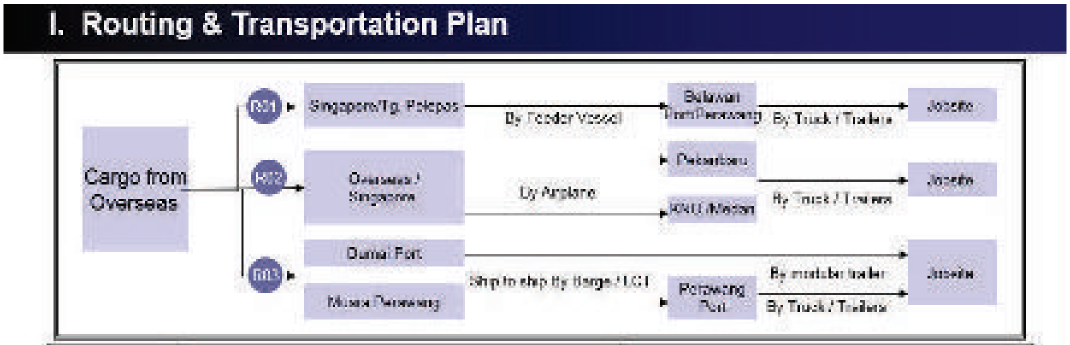
13.2 Assessment of Potential Impacts

During the construction stages it is expected that overall the volume of traffic generated by the development and the impacts of this traffic would be lower than might be expected due to ability to barge materials almost directly to the site using the nearby Siak River.

Traffic generation during the construction stages will result from two activities. Staff travelling to or from the site at the beginning and end of the working day, and the carting of materials to or from site.

13.2.1 Routing of Materials from Overseas

Typically, road transport will be used for carting of materials to the site. For materials being transported from overseas there are a number of possible routes that could be used. These routes are shown in the below diagram, which has been copied from the EPC Contractor's Transportation Plan (Transportation Plan as Preliminary, 2017)



	Cargo by	1st Route	2nd Route
R01	Containerized	• POD : Belawan Port, Medan • Routing : Overseas – Singapore – Belawan Port • Transit time : 2 Days • Belawan to Pekan Baru Project Site by Inland Transportation – 18 Hours	• POD : Perawang Port, Pekan baru • Routing : Overseas – Tg. Pelapas/Port Kelang – Perawang Port, Pekan Baru (T/Time 2 days) • Perawang Port to Project Site by Inland Transportation - 1 Hours
R02	Airfreight	• POD : Overseas / Singapore – Pekanbaru • Routing : Singapore – Pekanbaru – Jobsite • Transit time : 2 Days including clearance	• POD : Kualanamu (KNO) Airport, Medan • Routing : Overseas KNO – Jobsite • Transit Time : 3 Days including clearance
R03	General Bulk, & Heavy Parts	• POD : Dumai Port for Huge vessel / Heavy cargo • Routing : Overseas - Dumai – Jobsite • Transit time : 4 Days including clearance • Customs Process in Dumai	• POD : Muara Perawang -> ships to ships by barge to Perawang Port • Routing : Overseas – Muara Perawang – Perawang Port - Jobsite • Customs process in Perawang Port area

Figure 13.1 : Routing of Materials from Overseas

Figure 13.1 shows materials coming from overseas will generally be off loaded at ports / airports at Belawan Port (Medan), Dumai, or Pekanbaru and will then be transported overland to the site. The Transport Plan also lists movements of overweight loads. Movement of these loads are described in Table 13.4, as shown almost all overweight loads will be transported to the site by barge using the temporary jetty.

Table 13.4 : Movement of overweight loads

V. Heaviest Loads Cargo List (Preliminary)

#	DESCRIPTION	Q'ty	Dimension (m)			CBM (m³)		G.Weight (Ton)		Transportation		Remarks
			L	W	H	Unit	Total	Unit	Total	Barge	Category	
1	Turbine a Gaz / Gaz Turbine	2	9.9	3.6	4.6	163.9	328	91	182	Barge	Heavy	
2	Alternateur / Generator	2	9.1	3.5	3.5	111.5	223	150	300	Barge	Heavy	
3	GT AIR FILTER	2	10.2	3.2	4.6	150.1	300	17	33	Barge	Heavy	
4	GT AIR FILTER	2	10.2	2.4	4.6	112.6	225	11	22	Barge	Heavy	
5	GT AIR FILTER	2	10.2	2.5	4.7	119.9	240	16	33	Barge	Heavy	
6	DUCT ARRANGEMENT INLET	2	6.1	4.4	4.0	107.4	215	18	36	Barge	Heavy	
7	EXHAUST DIFFUSER	2	4.8	3.9	4.1	76.8	154	6	12	Barge	Heavy	
8	LIQUID/AIR/ WATER INJECTION SK	2	6.4	4.1	4.1	107.6	215	34	67	Barge	Heavy	
	GT Total	16					1,898		685			
9	Stator (Including Air Cooler)	1	8.0	3.6	4.1	118.1	118	141	141	Barge	Heavy	
	ST Total	1					118		141			
10	MODULE 1A	1	27.2	4.2	1.5	171.4	171	85	85	Barge	Super H	
11	MODULE 2A	1	27.2	4.2	3.0	342.7	343	113	113	Barge	Super H	
12	MODULE 3A	1	27.2	4.2	3.3	377.0	377	122	122	Barge	Super H	
13	MODULE 4A	1	27.2	4.2	3.3	377.0	377	122	122	Barge	Super H	
14	MODULE 5A	1	27.2	4.2	2.8	319.9	320	110	110	Barge	Super H	
15	SIDE PANEL1	2	24.9	3.9	1.3	126.2	252	38	77	Barge	Super H	
16	SIDE PANEL2	4	20.0	3.0	0.8	48.0	192	6	24	Barge	Heavy	
17	SIDE PANEL3	2	24.9	4.2	1.3	136.0	272	39	78	Barge	Super H	
18	SIDE PANEL4	4	20.0	3.3	0.8	52.8	211	7	30	Barge	Heavy	
19	SIDE PANEL5	2	24.9	4.3	1.3	139.2	278	39	79	Barge	Super H	
20	TOP PANEL3	1	4.9	4.2	1.0	20.6	21	6	6	Barge	Heavy	
21	TOP PANEL5	1	4.9	4.3	1.0	21.1	21	6	6	Barge	Heavy	
22	TOP PANEL6	1	4.9	4.3	1.0	21.1	21	6	6	Barge	Heavy	
23	BOTTOM PANEL3	1	4.9	4.2	1.0	20.6	21	6	6	Barge	Heavy	
24	BOTTOM PANEL5	1	4.9	4.3	1.0	21.1	21	6	6	Barge	Heavy	
25	BOTTOM PANEL8	1	4.9	4.3	1.0	21.1	21	6	8	Barge	Heavy	
26	SHELL PLATE	5	10.0	6.0	4.3	258.0	1,290	15	77	Barge	Super H	
27	LIFTING JIG	2	23.1	3.5	1.2	97.0	194	14	29	Barge	Super H	
28	FRAME ASS'Y	1	29.7	1.8	0.9	48.1	48	26	28	Barge	Super H	
	HRSG Total	33					4,452		1,010			
29	Generator Step-Up Transformer	3	9.0	4.0	8.1	291.6	875	98	295	Barge or other	Super H	
30	Unit Auxiliary Transfor	2	6.0	4.7	3.6	101.5	203	27	53	Barge or other	Super H	
	Transformer Total	5					1,078		349			
	GRAND TOTAL	55					7,547		2,188			

13.2.2 Site Clearance and Levelling

It is anticipated that 45,000 m^3 of excess soil will need to be deposited offsite. Assuming trucks have an average capacity of 20 m^3, then it will take around 2,250 loads to cart this soil resulting in 2,250 trips in and 2,250 trips out of the site over three months to remove the excess soil. Approximate daily traffic generation will be 30 trips in and 30 trips out per day.

There are two locations that are currently being investigated to receive the excess soil, both of which are close to the power plant site in surplus land surrounded by palm oil plantations. If one of these sites is used to deposit the excess soil, then the truck trips to and from the site will be short.

13.2.3 Gas Pipeline Construction

Assuming that each length of each section of pipe is 18 m long and that each flatbed truck is loaded with the maximum of 10 sections of pipe then it will take around 220 loads to deliver the pipe section to the site.

13.2.4 Power Plant and Switchyard Construction

At this stage it is planned that much of the heavy equipment for the power plant and switchyard will be transported via river barge on the Siak River. Once the river barge reaches the purpose built jetty the equipment will be off loaded onto specialist trailers that will be towed by a truck 3 km south to the site. The heaviest piece of equipment that needs to be transported to site is a generator which is 150 tonnes with there being a total of 55 pieces of equipment and modules that are over 6 tonnes. To transport the heaviest pieces of equipment a specialist 20 axle trailer or equivalent will be needed in order to spread the weight of the cargo across a large enough surface area.

Even with the use of the river barge there is a large amount of construction material such as concrete and steel rebar that still need to arrive at site by road. Therefore, it is expected that around 20 light truck and 100-120 heavy truck movements will be made per day to and from the power plant site.

13.2.5 Labour Force

As noted, it is expected that the labour force will peak at close to 1,000 workers with many of the workers likely to come from the local community. All these workers will need to get to and from the construction site each day with the nearest settlement being 2 km. However, the majority of housing is further away.

Therefore, a large number of workers will need motorised transport which likely be in the form of individual motorbike or car trips or via shuttle buses to site. There are no plans at this point in time to house workers on camps at or close to the site.

Assuming transport is provided for construction workers to be transported to or from work and 70 % of workers arrive by this transport then in total the workers are likely to only generate 600 trips per day (total movements, in and out).

13.2.6 Peak Road Traffic Generated During Construction

Peak traffic generation is likely to occur when work is being undertaken on the power plant and switchyard. At that time the workforce is likely to be at a peak. Traffic generation at this time is estimated in Table 13.5.

Table 13.5 : Road Traffic Generated

Source of traffic generation	Daily trip generation estimate (peak) (total in and out)
Power plant and switchyard construction	140

Source of traffic generation	Daily trip generation estimate (peak) (total in and out)
Gas pipeline construction	24
Labour force (1000 workers)	600
TOTAL	**764**

It is estimated that the peak traffic generation from the construction activity will be around 800 vehicles per day (vpd) (total in and out). A large proportion relates to the movement of workers to and from the site and so this estimate is very much dependent on the mode of transport used by workers to travel to and from work

13.2.7 Boat Traffic Generated During Construction

In total there are 55 pieces of equipment and modules that are proposed to be transported by river barge over a 24-month construction period. These deliveries are likely to occur over a period of approximately six months. Therefore, the volume of additional boat trips is low with 9 loads being carted per month on average over a six-month period.

13.2.8 Operation of the Power Plant

As noted in Section 13.2.5, the day to day operation of the power plant will require around 60 full time employees and during scheduled maintenance the additional temporary workers will raise the total number to around 200. All of these employees would likely live in Pekanbaru and travel to and from the power plant each day.

It is likely that some car / motorbike sharing would occur, some of the employees will be shift workers and many will normally work from Monday to Friday. However, in addition to the permanent staff, there will be deliveries and visits associated with the ongoing operations and maintenance of the facility e.g. to deliver spares, or for specialist subcontractors to perform maintenance or inspections. Therefore, it is assumed that there will be approximately an additional 120 trips per day to the surrounding road network (total in and out).

13.2.9 Road Network Surrounding the Power Plant

The main impacts of the proposed power plant on the surrounding road network are likely to be along Jl. Badak Ujung. This road provides access to the power plant site and so is going to be traversed by almost all traffic entering or exiting the site. There is a mixture of low density developing along the edge of the road which would be affected by the need to walk, cycle and travel in amongst the higher traffic flows when accessing the properties.

The sealed carriageway width is in some places is only 5.5 m wide. While this width would be adequate for the general traffic which uses the road, it is inadequate for two trucks to pass, even at low speed, without the need to traverse onto the shoulder. To pass, trucks would need to drive off the carriageway, which could cause safety concerns, cause damage to the road surface, or result in dirt being carried onto the carriageway.

Closer to the site the rural nature of the road means the impacts are likely to be lower. Some development of the roads closer to the site would have occurred for the development of the Tenayan CFPP.

The intersection of Jl. Hantuah and Jl. Badak Ujung is an uncontrolled T-intersection with an unpaved triangular shaped island in the middle of the intersection. Flows through the intersection will increase during construction, probably by around 10%. Assuming the flows on Jl. Badak Ujung did not exceed 2,000 vpd then the intersection is expected to perform adequately as a priority controlled intersection. This is seen by examining the Figure 13.2 which has been extracted from the Institution of Highways and Transportation (UK) document titled "*Road and Traffic in Urban Areas*".

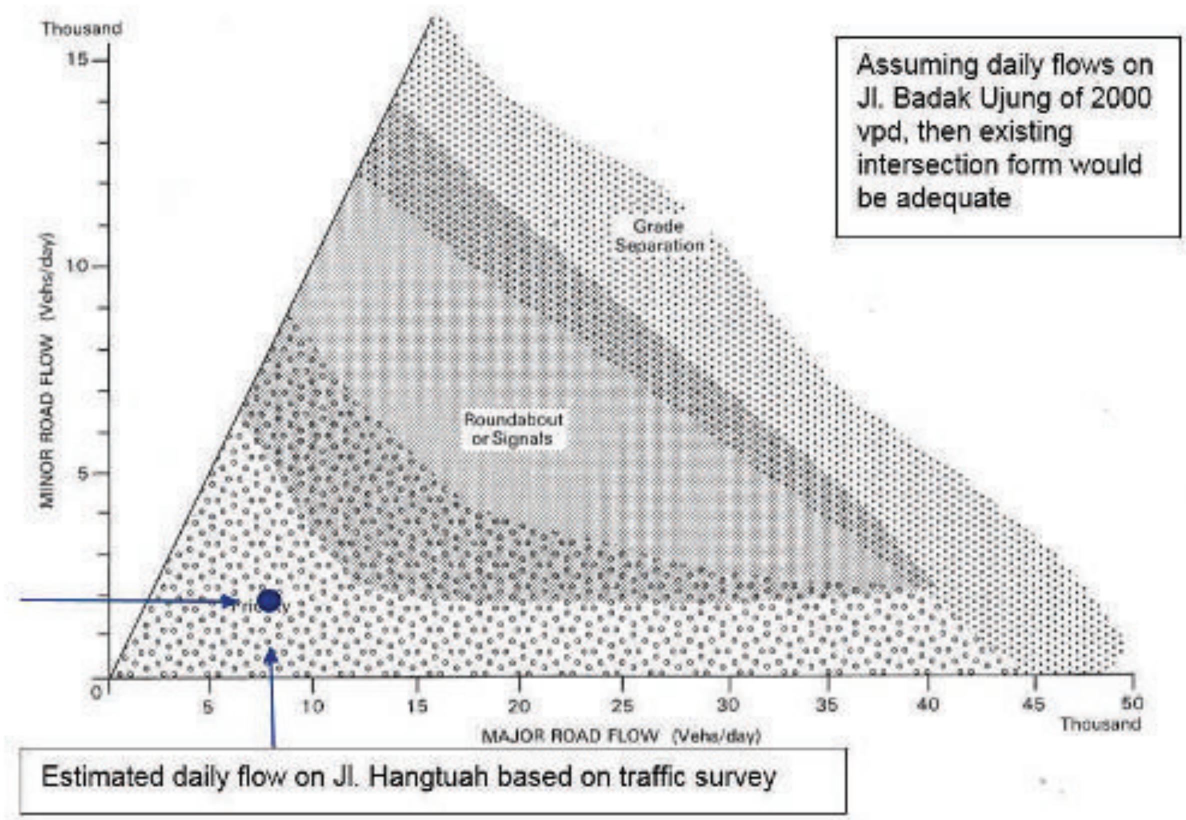


Figure 13.2 : Jl. Hangtuah / Jl. Badak Ujung Intersection Control

The impacts of on the intersection of Jl Hantuah with Jl Badak Ugung and also on Jl.Badak Ugung itself will be very dependent on the construction methodology and traffic management. In particular, making use of the Siak River for transporting materials, and by encouraging / organising shared transport for staff will greatly reduce the impacts. If these mitigation measures are implemented then the residential impact of construction traffic on Jl.Badak Ugung are considered to be moderate. This is because of the potential increase in safety risk to residents and traffic on Jl. Badak Ugung, the disruption to traffic using this road was found to be minor. Even with transporting oversized equipment via the Siak River much of the construction material will still need to be trucked to site via Jl.Badak Ugung. The increase in traffic from construction deliveries and from workers commuting to site will greatly increase the traffic volumes and put many more trucks on this road.

The road network immediately surrounding the proposed power plant will have been used previously during the construction of the Tanayan CFPP. As such these roads are wide and straight which makes them suitable for construction traffic. The volume of traffic using these roads is low as the only destinations as palm oil plantations and the coal power plant. Therefore, it is considered that the impact of construction traffic on these roads will be **Minor**.

13.2.10 Road network Surrounding the Pipeline Route

The road which the proposed 40 km gas pipeline runs along is a rural arterial road which has scattered residential development along its length.

Along some sections, there is a very limited road corridor width to allow for construction work and so it would seem likely that lane closures will need to occur to carry out some of the work. Temporary traffic management will be required and it will be important to warn and slow down drivers before they reach the construction site.

The pipeline will need to cross a number of roads and constructing these sections will result in traffic disruptions and possibly temporary lane closures. This is because the road will need to be dug up in order to lay the pipeline section, then the road will need to be rebuilt once the trench has been backfilled and compacted.

Overall it is considered that the construction of the gas pipeline construction will have a **Moderate** impact on traffic. This is because the lane closures could result in significant delays to road users during the construction period.

13.2.11 Public Transport Network

It is anticipated that construction traffic will only have a **Minor** impact on public transport services. This is because there are no bus services in the area surrounding the power plant or the pipeline. Construction traffic travelling through Pekanbaru (where there is bus services) will add to congestion however the delay created from these additional trips will be **Minor**.

13.2.12 Operation of the Plant

The operation of the power plant could result in an increase in traffic on the Jl. Hangtauh – Jl. Badak Ujung intersection during the morning peak. This is a worst case scenario assuming that all staff take separate vehicles to work and that they all travel during peak times. In reality there is likely to be some vehicle sharing and shift work and therefore the traffic would be lower. Overall it is considered that the operation of the power plant will have a **Minor** impact on traffic in terms of potential for minor delays for road users.

13.2.13 River Traffic

The transportation of equipment via river barge on the Siak River is expected to add an additional two to three boat trips to the jetty per month. The Siak River is already used by large river barges and therefore this increase in boat traffic is considered to have **Negligible** impact.

Additionally, there is little traffic on the river at present and so the generated traffic should be able to move safely in amongst existing boat traffic.

13.3 Mitigation and Monitoring

The following table outlines the recommended mitigation and monitoring measures for the construction phase of the project.

Table 13.6 : Recommended Traffic Management Measures

Potential Impact	Recommendation	Additional Detail
General construction impacts	Ensure a Traffic Management Plan (TMP) is created and implemented for all work undertaken for the project.	This will ensure the transport impacts of the project are able to be minimised.
	That where possible heavy and / or oversized loads are transported to site via barge to avoid the need to truck the cargo through	Moving heavy power plant equipment such as gas turbines, generators and transformers safety via road would be difficult and therefore using barge transport instead

Potential Impact	Recommendation	Additional Detail
	local roads. Where possible also transport other loads via barge to further reduce impacts on local roads.	would be a safer and easier option.
Impacts on the local road network, including Jl. Badak Ujung, related to potential safety issues from increased flow, possible dust issues, reduced ease of access to properties and increased noise	That deliveries are made at off-peak times when there are fewer local people using the road and when children would not be walking to and from school.	There are typically no footpaths and so children walk along the edge of the carriageway close to moving traffic.
	That the project and the associated construction traffic is discussed with the local community so that residents are aware of what is happening.	Residents will be able to plan ahead in anticipation of delays caused by construction traffic if they are kept informed of the construction process.
	That workers are transported to and from the site via minibus instead of by car or motorbike.	If every construction worker travels to and from the site via private vehicles, then it will add a significant volume of traffic to the local road network.
	On Jl. Badak Ujung consider measures for improving pedestrian and cyclist safety possibly by separating pedestrians from moving traffic, or slowing moving traffic.	
	That a Community Liaison Officer discusses road safety with community leaders and residents to encourage the safe use of the road	This would involve discussing the need to not let children play on the road or to place advertising signs and food stalls on the road.
	Provide a truck wheel wash facility to clean truck wheels prior to exiting the site in order to prevent dust and spoil being transported on to the public road.	
	Where local roads are going to be used by significant volumes of heavy vehicles (more than 200 vpd) then it is recommended that where the road has a narrow carriageway, the width be increased to be at least 6.0 m wide.	This width would enable two trucks to pass each other without having to drive on the shoulder.
	Monitor the safety performance of the local roads, and where necessary make physical changes to improve safety or encourage road user behavioural changes.	
Over dimension vehicles using the road network	If it is not possible to transport an over width load by barge, then it is recommended that pilot vehicles are used when transporting oversized and/or heavy equipment to site to warn drivers of approaching hazards.	Pilot vehicles can radio the driver the truck carrying the main cargo of any approaching hazards and the pilot vehicles warn oncoming traffic of the oversized/ heavy vehicle approaching.
Impacts on traffic from the construction of the 40km long gas pipeline	Provide adequate temporary traffic management along the route of the 40km long gas pipeline to ensure impacts on traffic movement (from safety and delays) are	

Potential Impact	Recommendation	Additional Detail
	minimised.	
Minimise the impacts from soil removal from the site	That the traffic impacts from removing the excess soil from the site are minimised by careful choice of the site for disposing of soil and also through developing a traffic management plan for this component of the work which addresses impacts related to this work.	
Road closures on Jl. Lintas Maredan – Simpang Beringin from digging up sections of road where the pipeline needs to change sides of the road	Where possible digging up only half the road at a time to allow traffic to continue to use the other lane with a stop start control.	
	Where a full road closure is required providing a short detour around the construction site for traffic.	

13.4 Assessment of Residual Impacts

Overall, with the implementation of mitigation measures outlined, the impacts of construction traffic are likely to be **Moderate**.

Post construction, the operation of the plant will only typically require less than 60 staff per shift, and so any movement of staff to or from the site is likely to have a **Minor** impact on the road network.

14. Hazardous Substances and Waste

14.1 Introduction

This section describes the following:

- The hazardous substances that will used, stored and disposed of during the construction and operation of the Project, the potential impacts and the management/mitigation measures.
- The solid wastes that will be generated, stored and disposed of during construction and operation of the Project, the potential impacts and the management/mitigation measures.

14.2 Methodology

14.2.1 Spatial Scope of Assessment

The Project will generate waste and if properly managed, the area impacted will not extend beyond the boundary of the power plant and gas pipeline during construction and the power plant during operation. Hazardous substances will be used and stored within the Project area of influence (AoI) and if properly stored, handled and managed will not result in impacts beyond the boundary of power plant, and gas pipeline during construction and operation. However, if any hazardous substances, wastes or spoil/excavated materials that require special disposal treatment and disposal offsite are not handled and stored properly, there is potential that soil, and/or surface water could become contaminated outside the Project boundary.

14.2.2 Impact Assessment

There are a range of impacts which can occur from the mismanagement of waste materials and hazardous substances arising from the construction and operation of the Riau CCPP and the construction of the transmission line, gas pipeline, water pipelines and temporary jetty. Therefore, materials and waste handling impact assessment is primarily about identifying waste streams and adopting an appropriate good practice management approach, which seeks to avoid the generation of waste in the first instance, rather than mitigating potential impacts to a defined baseline environment. After identifying the potential sources and, where possible, quantifying waste arising, the assessment focuses on measures to reduce, reuse and recycle, as well as the solutions available for waste disposal.

For hazardous substances the impact assessment relates to identifying volume, types and intrinsic hazards of the different hazardous substances to be used, stored and disposed of during the construction and operation phases. Mitigation measures are then recommended to prevent any mismanagement or misuse which could result in an uncontrolled release to the environment, the frequency and magnitude of such a release and therefore the level of adverse impact.

The assessment of significance has been determined based on a function of the expected sensitivity of the receiving environment / receptor(s) and the resultant magnitude of any identified impact on the receiving environment / receptor(s) should there be a failure of the waste management and hazardous substances management controls.

14.3 Assessment of Impacts – Hazardous Substances

14.3.1 Hazardous Substances

Hazardous substances can be defined as materials that represent a risk to human health, property, or the environment due to their physical or chemical characteristics. Hazardous substances can be classified according to their hazardous properties such as; explosiveness, flammability, oxidising capacity, corrosiveness, toxicity, and ecotoxicity. A substance is also hazardous if it generates a substance with any one or more of these hazardous properties when it comes into contact with air or water (other than air or water where the temperature or pressure has been artificially increased or decreased) (NZ EPA, 2012).

The overall objective of hazardous substance management is to avoid or, when avoidance is not practicable, minimise uncontrolled releases of hazardous substances or accidents during their handling, storage and use.

14.3.2 Types and Quantities - Construction

The construction of the Project will involve the use of various hazardous substances, predominantly liquids, which, if mismanaged or spilt, could cause adverse effects on the environment or present a hazard. Hazardous substances likely to be stored or used during the construction of the project are detailed in Table 14.1 below.

Table 14.1 : Summary of Hazardous Substances Potentially used During Construction

Hazardous Substance	Estimated Quantity	Use	Typical Composition	Storage Location
Diesel, petrol, oil, hydraulic fluids, lubricants and greases.	To be determined	Used for the operation of machinery, vehicles and other equipment.	Varied	Temporary fuel storage tanks; Secure Hazardous Substances Store
Paints, glues and various solvents	To be determined	Used primarily in the erection of buildings and structures on the Project site, including installation and fixing of cladding and roofing, concreting, installation of building linings, plumbing, carpentry, plastering, painting and electrical work.	Varied	Secure Hazardous Substances Store
Compressed Gas Cylinders	To be determined	Used for welding and metal cutting.	Acetylene; oxygen	Secure Hazardous Substances Store

There will be no deliberate discharges of these substances to the natural environment as part of the construction activities. Accidental discharges will be kept to an absolute minimum and impacts confined to within the site as part of the housekeeping procedures of the EPC Contractors.

14.3.3 Types and Quantities - Operation

The operation of the Project will similarly involve the use of various hazardous substances, predominantly liquids, which, if mismanaged or spilt, could cause adverse impacts on the environment or present a hazard. Hazardous substances likely to be stored or used during the operation of the Project are detailed in Table 14.2 below.

Table 14.2 : Summary of Hazardous Substances Potentially used During Operation

Hazardous Substance	Estimated Quantity	Use	Typical Composition	Storage Location
Sulphuric acid	600 L	Demineralisation system	-	Bunded bulk tank or IBC
Hydrochloric acid	1,000 L	Demineralisation and cooling water systems	-	Bunded bulk tank or IBC
Scale inhibitor		Cooling water systems	-	Secure Hazardous Substances

Hazardous Substance	Estimated Quantity	Use	Typical Composition	Storage Location
				Store
Caustic (e.g. NaOH)	100 kg	Demineralisation system	-	Secure Hazardous Substances Store
Turbine oils (e.g. Terrestic 32 or 68, Exxon)	100 L	Turbines, pumps, air compressor, lubrication	-	Secure Hazardous Substances Store
SAE 15 W - 40 Oil	1,000 L	Diesel fire pumps	-	Secure Hazardous Substances Store
Hydraulic fluid	500 L	Steam turbine electrohydraulic fluid	-	Secure Hazardous Substances Store
Ammonia (NH_3)	50 kg	Boiler water treatment	-	Secure Hazardous Substances Store
Trisodium Phosphate	1,000 L	Boiler water treatment	-	Bunded bulk tank or IBC
Sodium Hypochlorite	4,000 kg	Water treatment biocide for raw water and possible for cooling water	-	Secure Hazardous Substances Store
Insulating Oil (non PCB)	600 L	Transformers	-	Secure Hazardous Substances Store
O_2 Scavenger	1,000 L	Deaerator tanks	-	Bunded bulk tank
Misc. Chemical Reagents for Water Laboratory		Water testing lab chemicals	-	Secure Hazardous Substances Store
Water Wash Liquid	100 kg	Gas turbine water wash	-	Secure Hazardous Substances Store
CO_2	100 L	Fire protection	-	Secure Hazardous Substances Store
Diesel, fuel oil and oil.	To be determined	Used for the operation of machinery, vehicles and other equipment.	Varied	Bunded fuel storage tanks; Secure Hazardous Substances Store
Paints, glues and various solvents	To be determined	Used primarily in the erection of buildings and structures on the Project site, including installation and fixing of cladding and roofing, concreting, installation of building linings, plumbing, carpentry, plastering, painting and electrical work.	Varied	Secure Hazardous Substances Store

14.3.4 Potential Impacts

The storage, use, and transport of hazardous substances during all phases of the Project provide potential pathways by which contamination of sensitive receptors could occur. Impacts which could occur at all phases of the development include:

- Accidental spills from containers, vehicles or vessels: Damage to vehicles and vessels transporting hazardous substances to and from the temporary jetty and within the Project area have the potential to result in spills which can contaminate soil, groundwater, waterways, and freshwater environments.

- Incorrect disposal of old containers used for hazardous chemicals and or fuels/oils: if not disposed of correctly could contaminate soil, groundwater, waterways, and freshwater environments.
- Tampering and vandalism: Access to hazardous substances by unauthorised persons leading to spills, which could contaminate soil, groundwater, waterways, and freshwater environments.
- Toxicity and corrosiveness: The toxicity hazards of the substances relates to the potential adverse effects on workers at the site via ingestion/inhalation or dermal/ocular exposure in the case of corrosive liquids. The level of toxicity is variable and relates to the intrinsic properties of the substance and its concentration.
- Fire and explosion: Along with the risk of burns, a fire could also result in toxic by-products (from the combustion of chemicals) being discharged to air.
- Natural hazards: Such as volcanoes, earthquakes, tsunamis, flooding and tropical cyclones. Natural hazards could cause damage to tanks/containers, which may spill their contents. In addition, they could cause concrete paving and bunding to crack resulting in their inability to contain spills of hazardous substances.

Impacts specific to construction and operation of the power plant and gas pipeline are detailed in the following sections.

Potential Impacts During Construction

- Fuel spill: The largest potential spill volumes during construction will be from fuel from the equipment and machinery being used on site and to transport equipment to site, which could impact soil, groundwater, and surface water.

Potential Impacts During Operation

- Spillages: Operational requirements for sulphuric acid, hydrochloric acid and sodium hypochlorite (biocide) have the potential to impact on the environment from any bund enclosure containment failures. In addition, there will be transformer and turbine oils. Failure of containment systems is a highly unlikely event.

14.3.5 Management and Mitigation

Hazardous substances will be controlled according to a Hazardous Substances Management Plan for construction and operation. This will include ensuring that the following information must be readily available to employees and employee representatives for all hazardous substances in the workplace:

- A register should be held and maintained onsite during construction and operation, which sets out the types, volumes and locations of all hazardous substances.
- Safety Data Sheets (SDSs) should be compiled in accordance with the approved code of practice for the preparation of material safety data sheets.
- Labels on containers should be compiled in accordance with the approved code of practice for the labelling workplace substances.
- Induction and training should be provided to all those employees whose work potentially exposes them to hazardous substances; and those employees who are supervising others who are using hazardous substances at work.
- Hazardous substances storage containers (including gas cylinders) which are unsafe (e.g. damaged, leaking etc.) should be clearly marked as 'out of service' to prevent them from being used, until their disposal.

- Designated stores which are appropriately designed and fire rated should be used to store hazardous substances.
- Incompatible substances should be stored separately.
- Appropriate bunding should be used when there is a risk of leaks, spills or loss of containment. Bunding needs to be provided for:
  - All tanks and other vessels containing materials which can cause an environmental, safety or health hazard.
  - Any other area where spills may occur (e.g. filling stations, decanting areas, drum storage areas etc.).
  - Bunded areas for tanks will be sized to contain 110% of the largest tank in the bund.
- Level protection (including automatic trips) is required to avoid overflow during the filling of tanks.
- Storage areas for hazardous substances (including piping systems) should be inspected on a regular basis to detect spills, leaks and the potential for such occurrences. Any deficiencies found must be recorded and immediately reported to the work area manager in order for the deficiency to be rectified as soon as practicable.
- Standard Operating Procedures (SOPs) and/or guidelines (if appropriate, by means of signage) should be prepared and implemented to cover at least the following:
  - Incompatibility of substances when mixed (e.g. mixing may result in fire or explosion);
  - Precautions when pouring, decanting or transferring substances;
  - Steps to be taken in the event of a spill or exposure; and
  - Personal protective equipment to be used with the substance.
- Operations which require the mixing of substances should be assessed by personnel with the appropriate handling training prior to work commencement. In addition, areas where mixing and decanting of hazardous substances occur will be fitted with eye wash baths and emergency showers.
- Transport of hazardous substances should be carried out in full compliance with the relevant legislative requirements.
- Transport vehicles should have appropriate signage and carry documentation on the hazardous substances to be transported.
- Arrangements should be in place to ensure that the appropriate spill control equipment for storage and transport (i.e. for water and/or land) is available in sufficient quantities for any foreseeable spills.
- Suitable firefighting equipment should be available to suit the type/s of substances being transported.
- Any such equipment should be routinely inspected and maintained in good working order and in a state of readiness.
- Chemicals should not be accepted onto the Project sites or off-loaded without the relevant health, safety and emergency information being made available by the supplier this includes SDSs. Vehicles and other equipment should be turned off while fuelling operations takes place.
- Provisions should be made for the containment, collection and disposal of waste oil and spills that are generated as a result of refuelling activities. Provisions should be in the form of a bunded and impervious area, with a spill and effluent collection system. Alternatively, a portable collection sump should be placed underneath the maintenance and refuelling areas to contain any spillage and/or minor leaks.
- An Emergency Response Procedure will be developed and implemented to manage spoils, fires etc., and include warning and evacuation of nearby residences.

- Firefighting systems should be fitted as required by the design.

Disposal of Hazardous Substances

All hazardous waste, including used spill response items, oils and residues, including drums and containers which were used to hold hazardous substances, and sludge removed from septic tanks, should be collected and transported an appropriately licenced hazardous waste disposal facility for disposal.

A Hazardous Waste Store should be developed at the site during construction and operation for the temporary storage of hazardous wastes generated including contaminated soil waiting to be disposed of offsite to a licenced hazardous waste disposal facility.

14.4 Waste

A waste is any solid, liquid, or contained gaseous material that is discarded by disposal, recycling, burning or incineration. It can be a by-product of a manufacturing process or an obsolete commercial product that can no longer be used for its intended purpose and requires disposal.

Waste management during construction and operation phases of the Project should follow the waste management hierarchy that consists of prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes (see Figure 14.1). The hierarchy states that as far as practicable, the generation of wastes should be avoided or minimised. Where waste generation cannot be avoided it should be reused, recycled or recovered. Where waste cannot be recovered or reused it should be stored, treated and disposed of in an environmentally sound manner.

Combined cycle power plants when operating produce small amounts of solid and liquid waste and suitable disposal methods need to be found, often in engineered locations. Wastes produced in combined cycle developments are as follows:

- Wastewater sludge from cooling tower, water steam cycle, wastewater treatment plant and water filtration and treatment plants;
- Used oil products and lubricants;
- Domestic and office waste; and
- Construction and normal maintenance debris including paper, metals, waste oils etc.

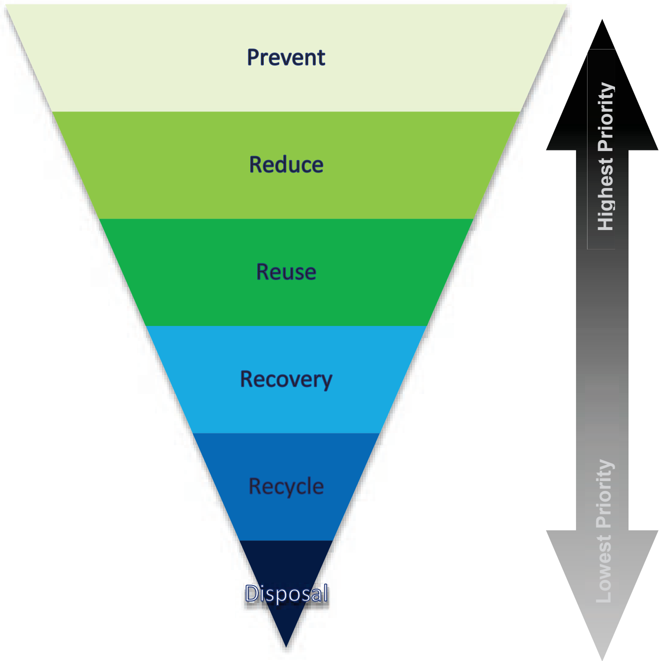


Figure 14.1 : The Waste Management Hierarchy

14.4.1 Types and Quantities - Construction

Summaries of the wastes produced during the construction phase of the Project are presented in Table 14.3.

Table 14.3 : Summary of Potential Construction Phase Waste Generation

Waste Material	Estimated Quantity	Generation Point/Use	Composition	Storage Location	Disposal Route
Bio solids	To be determined.	Generated by staff. Includes sludge from septic tanks.	Sludge	Septic Tanks	Sludge from septic tanks will be collected and disposed of offsite in an appropriate facility. Treated liquid effluent will be allowed to soak into the ground.

Waste Material	Estimated Quantity	Generation Point/Use	Composition	Storage Location	Disposal Route
Construction Waste	Dependent on the construction process. In general terms it should be assumed that 10% of the total construction material used will be disposed of as waste.	General construction activities at point of use.	This will include excess material and packaging. Generally made up of Inorganic substances: cement, broken rock plastic, metal, glass; fabrics, synthetic resins, earth, sand, cardboard, paper, inert and nontoxic waste. Hazardous waste may include used containers of chemicals (i.e. solvents, oils, paints) and oily rags.	General Waste Depot	Reuse, Recycling and Disposal
General Waste	100 kg per day[4]	Staff areas	Office Material (paper, small amount of packaging)	General Waste Depot	Recycling and Disposal
Oils	To be determined. Required for operation and maintenance of machinery	Mostly form maintenance areas and at point of use in the power plant	Oil (lubricants, diesel, petrol) containers with residue, oily rags, used oil filters	Hazardous Waste Store	Disposal at an appropriate facility.
Vegetation	To be determined. The majority of power plant area will require clearance and sections of the gas and water pipelines	Clearance access tracks, power plant site and gas and water pipeline	Wood and Foliage	Will be moved to the edges of the cleared areas.	On site decomposition, burning, or be recycled as fire wood or building material where possible.

14.4.2 Types and Quantities - Operation

A summary of the wastes produced during the operation phase of the Project are presented in Table 15.4.

[4] Based on 200workers producing 0.5 kg waste per day each.

Table 14.4 : Summary of Potential Operation Phase Waste Generation

Waste Material	Estimated Quantity	Generation Point/Use	Composition	Storage Location	Disposal Route
Wastewater	80m^3/h from cooling tower, water steam cycle and other users including losses from water filtration and treatment	Generated as part of normal power plant operation	Wastewater	ponds and basins, before discharge	Water discharge pipeline.
Bio solids	To be determined	Sludge and filter cake from cooling tower, wastewater treatment plant, water treatment plant and sewage treatment plant	Sludge	Sludge tanks and filter cake skip bin in wastewater treatment plant	Sludge will be collected and disposed of to an appropriate facility.
General Waste	< 20kg per day	Staff areas	Office Material (paper, small amount of packaging)	General Waste Depot	Recycling and Disposal
Maintenance activities	To be determined	Across the power plant and associated infrastructure areas and gas pipeline.	Includes steel and aluminium scrap, pallets, wood, and plastic containers.	General Waste Depot	Reuse, Recycling and Disposal
Oils	To be determined. Required for operation and maintenance of machinery. Will also include lubricating oil is used to lubricate the turbine bearings, and other moving parts in small quantities, and oil for transformers and switchgear	Mostly form maintenance areas and at point of use in the power plant	Oil (lubricants, diesel, petrol) containers with residue, oily rags, used oil filters	Hazardous Waste Depot	Disposal at an appropriate facility.

14.4.3 Potential Impacts

The storage and transport of wastes during the construction and operation of the Project, if inappropriately managed, has a number of potential negative impacts through releases to air, soil and water. Impacts which could occur at all phases of the development include:

- Accidental spills from containers, or vehicles: Damage to vehicles transporting waste and hazardous substances to and from the Project and within the Project area have the potential to result in spills which can contaminate soil, groundwater, waterways, and freshwater environments.
- Insufficient disposal frequencies or inappropriate storage containers could result in odour concerns.
- Old container used for hazardous chemicals and or fuels/oils not disposed of correctly could contaminate both streams and groundwater.
- Waste that is stored incorrectly and may blow around the site or offsite. This waste would have the potential to pollute waterways and sensitive habitats.
- Runoff from waste storage areas that is not collected and has the potential to contaminate soil, stormwater, and groundwater.

- Incorrect storage such as storage of incompatible wastes together may lead to items not able to be reused or recycled.
- Incorrect and/or illegal disposal of wastes resulting in breaches of local regulations.
- Erosion of stored soil leading to sedimentation of streams.
- Inappropriately placed/protected soil stockpiles can result in erosion of stored soil which could lead to sedimentation of near-by streams.

Impacts specific to the various Project phases are detailed in the following sections.

Potential Impacts of Waste During Construction

- Incorrect handling, separation and storage of construction wastes resulting in soil and water contamination impacts.
- Ablutions for the construction workforce: Human wastewater can carry harmful micro-organisms that easily contaminate soils and water sources. Domestic wastewater from amenities at the laydown camp will need be collected and treated in septic tanks, or off-site disposal (i.e. portable latrines).

Potential Impacts of Waste During Operation

- Incorrect handling, separation and storage of construction and operation wastes resulting in soil and water contamination.
- Incorrect treatment and disposal of liquid and hazardous wastes.
- In correct disposal of biosolids from wastewater treatment plant.

14.4.4 Waste Management

Waste Management Plans' for the construction and the operation phases will be prepared to minimise waste generation and ensure proper disposal methods. Particular attention will be given to the use and re-use of materials to minimize waste and, whenever practicable, using materials and products from sustainable sources. The Waste Management Plan shall include steps to:

- Minimise the amount of waste produced;
- Prepare designated waste storage areas for the wastes which are not able to be immediately disposed of. The waste storage areas should be covered and clearly signed;
- Educate and train staff on separation of wastes and recycling;
- Dispose of hazardous waste via a licensed third party operator; and
- Record the disposal of wastes by "Waste Manifest".

14.4.5 Mitigation of Waste

Waste should be stored so as to prevent or control accidental releases to air, soil, and water resources. The Waste Management Plans should include steps to:

- Encourage waste separation and recycling, and waste minimisation at source;
- Store waste in the appropriate place once work has finished for the day;
- Store waste in closed containers away from direct sunlight, wind and rain. Cover the waste storage areas e.g. with lids and/or roofs to prevent rain water from getting in. The waste storage area should be in good condition, undamaged, corrosion and leak free;

- Preferably store liquid wastes on impermeable surfaces with spill containment systems. Spill containment systems should be constructed with materials appropriate for the wastes being contained and with a drainage and collection system. Spill containment should be included wherever liquid wastes are stored in volumes greater than 220 litres. The available volume of spill containment should be at least 110% of the largest storage container, or 25% of the total storage capacity (whichever is greater), in that specific location;
- Waste signs should be put on all waste containers and collection areas. Each sign shall be highly visible and easily seen by the person using the waste container or area. Each container or waste area sign shall be labelled as Domestic Waste, Non-Hazardous Waste or Hazardous Waste and include the responsible person with contact information and how to handle the waste. Recyclable waste bins will be designated for metal, plastic, paper, etc.;
- Waste should be stored in a manner that prevents the commingling or contact between incompatible wastes. Sufficient space is needed between incompatibles or physical separation such as walls or containment curbs. For example, hazardous waste should be stored separately from other wastes and in sealed container;
- Hazardous wastes should be stored in a separate storage area which is bunded and hazardous wastes will be removed for treatment and disposal form the site by an approved licensed third party operator. Destruction certificates will be supplied by the operator to indicate how and when the hazardous wastes were treated and disposed of;
- Provide adequate ventilation where volatile wastes are stored; and
- Record the amount and destination of the wastes, removed and disposed of off-site.

14.4.6 Waste Disposal

Solid waste produced during construction and operation of the Project should be collected onsite as outlined above, and then transferred to a designated waste disposal facility, fortnightly or as required.

Hazardous waste during construction should be collected and stored in a Temporary Hazardous Waste Store and when sufficient quantities are held and then it will be disposed of to a licenced hazardous waste disposal facility.

14.4.7 Monitoring

As part of the Waste Management Plan a monitoring plan will be developed to inspect waste collection skips, to check wastes are being separated correctly and hazardous wastes are not being included with non-hazardous. The inspection should also include a check of the waste skips and bins condition to be sure waste is being held securely and not able to impact the environment through leakage or being blown away.

Records should be kept on the types of wastes generated, the volume generated and the location/volume of waste disposed off-site. Types and volumes of hazardous waste must be recorded and destruction certificates obtained from the hazardous waste removal contractor.

14.5 Assessment of Residual Impacts

If the measures identified above for the storage, use, management, disposal and spill management for hazardous substances are well implemented there should be no significant release of hazardous substances to the environment and therefore **Negligible** impact on the environment.

The impact on the environment from wastes during construction will be **Negligible** if the waste is appropriately managed at the site.

15. Working Conditions and Occupational Health and Safety

15.1 Introduction

This section provides an overview of the working conditions, occupational health and safety considerations during the construction and operation of the Project, which will be common to a gas fired power plant. This section will discuss general health and safety, and working conditions for workers on site during both the construction and operation phase.

To protect workers from potential hazards, as well as ensuring that appropriate measures are put in place to deal with any disputes that may arise between workers and their employers, it is anticipated that detailed labour (human resources, employment conditions etc.) health and safety documents will be prepared by the Construction Contractors prior to commencement of Project construction works. These would cover hazard identification, safe work practices, emergency response plans, incident/accident management, auditing and review.

Further detail is provided in the Technical Report - Working Condition, Occupational Health and Safety Assessment (ESIA Volume 5: Appendices).

15.2 Working Conditions Legislation and Guidance

15.2.1 WBG EHS Guidelines

The occupational health and safety issues during the construction and operation of the Project are common to those of large industrial facilities and their prevention and control is discussed in the WBG EHS General Guidelines (April 2007) and specifically in the EHS Guidelines for Thermal Power Plants (April 2008), Electric Power Transmission and Distribution (April 2007), and for Onshore Oil and Gas Development (April 2007). These include exposure to physical hazards, trip and fall hazards, exposure to dust and noise, falling objects, working at heights, working in confined spaces, exposure to hazardous material, fire and explosion hazards and exposure to electrical hazards.

15.2.2 Indonesian Legislation and Guidelines

The Project shall be constructed and operated in accordance with the laws and regulations pertaining to employment, human rights, and worker rights in Indonesia. The Project and all Contractors and Subcontractors of the site will be required to meet Indonesian standards for employment and working conditions, including minimum wage standards, working hours and amenities. All Contractors and Subcontractors will be required to meet minimum working condition standards, and provide proof as part of tendering and contracting. Safety requirements will be part of tender specification for all Contractors and Subcontractors who will necessarily need to sign on to the safety management system of the project and demonstrate appropriate procedures, such as health and safety plans for activities and stop work protocols for unsafe conditions.

All activities conducted in relation to the Project shall comply with the laws and regulations of Indonesia. Key Health and Safety legislation in Indonesia includes, but is not limited to:

- Law No. 1 of 1970 on Work Safety;
- Law No. 13 of 2003 on Manpower;
- Ministry of Health Decree No. 1405 / Menkes / SK / XI / 2002 on Requirements of Occupational Environmental Health for Office and Industrial;

- Regulation of the Minister of Manpower and Transmigration No. Per.03 / Men / 1982 on Occupational Health Services; and
- Government Regulation No. 50 of 2012 on the Implementation of Safety Management and Occupational Health System.

The Manpower Act (No.13/2003) was enacted in Indonesia in 2003 and consolidated eleven existing labour-related laws into one. Provincial and district authorities, not central government, now establish minimum wages, which vary by province, district, and sector. This legislation is relevant to establishing values for income restoration measures with respect to workers involved in the construction and operation of the Project. MRPR and the EPC Contractors are aware of these legislative requirements and procedures will be implemented to ensure the requirements are complied with. At the time of writing this report a number of the labour and working condition policies and procedures for the construction and operation of the power station have yet to be written.

15.2.3 Contract Legislation

Article 50 of the Manpower Act (No.13/2003) provides that employment relations are the result of the work agreement between the employer and the worker/ labourer. The Act requires a set of particular features to be met by the work agreement in order to protect the worker from unfair practices or abuses and to guarantee legal certainty in respect to the rights and obligations of the worker/labourer and employer.

The work agreement is made in writing or orally (Article 51) and shall at least include (Article 54):

- Name, address, and area of business of the company;
- Name, sex, age, and address of the worker/labourer;
- Occupation or type of job of the worker/labourer;
- Working place;
- Wage and how it should be paid;
- Terms of employment, including the rights and obligations for workers/laborers' and employer;
- Starting and the period of time the work agreement is effective;
- Place and date that the work agreement is made; and
- Signatures of employer and worker/labourer.

The EPC Contractors shall initiate, maintain and supervise all safety precautions and programs in connection with the construction work. The EPC Contractors and their subcontractors will issue all Project staff with an individual contract of employment detailing their rights and conditions in accordance with the national law and IFC requirements related to hours of work, wages, overtime, compensation and benefits such as maternity or annual leave, and update the contract when material changes occur.

15.2.4 International Labour Organisation (ILO) and United Nations Conventions

Personnel working on the site through the construction phase will be employed through MRPR, the EPC Contractors and Subcontractors providing specific services to the project. It will be a contractual requirement for all providers to the Project that they comply fully with the laws and regulations of the government of Indonesia concerning employment of labour and working conditions. MRPRs policy for its employees will also follow the laws and regulations of the government of Indonesia and an employment policy framework will be developed which will comply with (at a minimum):

- ILO Convention 87 on Freedom of Association and Protection of the Right to Organise;

- ILO Convention 98 on the Right to Organise and Collective Bargaining;
- ILO Convention 29 on Forced Labour;
- ILO Convention 105 on the Abolition of Forced Labour;
- ILO Convention 138 on Minimum Age (of Employment);
- ILO Convention 182 on the Worst Forms of Child Labour;
- ILO Convention 100 on Equal Remuneration;
- ILO Convention 111 on Discrimination (Employment and Occupation);
- UN Convention on the Rights of the Child, Article 32.1; and
- UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families.

Indonesia was the first Asian country and the fifth country in the world to ratify all eight fundamental ILO Conventions mentioned above.

15.3 Overarching Site Safety Management and Awareness

The following general safety measures will be applied during the construction phases of the Project:

- Establishment of Health and Safety Management Systems for construction including safety management organisation / reporting chain; construction methodology; hazard / risk assessment and proposed mitigation measures; and safety checklists;
- Development of a Health and Safety Risk Registers and hazard identification and assessment procedures;
- Training and distribution of Personal Protective Equipment (PPE) to all staff on site;
- Safe Work Rules and Procedures designed to be generic rules provided within employment contracts and task specific procedures will be communicated during tool box talks and displayed on machinery or within hazardous work areas;
- Permits to Work systems for hazardous activities;
- Use of site safety facilities such as first-aid equipment and stations, emergency response equipment etc;
- Health and Safety Meetings such as daily tool box talks, weekly HSE meetings and the creation of a Safety and Health Committee, which includes worker representatives;
- Regular safety inspections and monitoring of exposure to hazards;
- Security Procedures on site;
- Emergency Response Procedures for managing incidents onsite and where they may have offsite impacts;
- Accident /incident reporting and investigation; and
- Monitoring of Health and Safety Management Systems.

15.3.1 Occupational Health and Safety Plans

MRPR and the EPC Contractors will both be required to develop Occupational Health, and Safety Plans (OHS) for the construction and operation activities for the Project. These will apply to all personnel involved in the Project, including Subcontractors and part-time workers. The primary health and safety objectives will be to ensure effective measures and management of occupational health and safety to minimise workplace accidents and injuries. All Occupational Health and Safety (OHS) systems developed for the Project will also need to meet the requirements of the Equator Principles , WBG EHS Guidelines and any other relevant international or national legislation.

The OHS Plans will outline the procedures essential for the protection of personnel during construction and operation. They will be designed to assist all those who deal with OHS as a functional responsibility within the context of their job.

In particular, they will include:

- demonstration of compliance with Indonesian and WBG health and safety requirements;
- OHS responsibility / reporting structure;
- details of site inductions and ongoing training;
- hazard identification and risk assessment;
- mitigation measures including mandatory PPE;
- safe working procedures and safety rules (includes permit-to-work procedures, working at height, etc.);
- response to health and safety incidents, including investigation and reporting;
- emergency response plans;
- reporting and record keeping systems;
- scheduled HS meetings; and
- inspection and auditing procedures.

The key goal of the plans will be to instil a safety culture within the site employees through education, good communication, a motivated workforce, recognition of individual/team effort and safety incentive programmes.

15.3.2 Roles and Responsibilities

MRPR and the EPC Contractors will establish a hierarchy of responsibility with regards for the provision of health and safety. The precise titles and roles of each member will be determined by MRPR and the EPC Contractors prior to work on the site

Management of OHS during construction will primarily be the responsibility of the EPC Contractor. The EPC Contractor's HSE Plan will be implemented at the Project site taking into account the management, mitigation and monitoring requirements contained in the Project ESIA/Environmental and Social Management Plan (ESMP). During the construction phase, MRPR will review and monitor EPC Contractor's performance in accordance with their OSH Plan to ensure alignment with the Project ESMS. MRPR is responsible for reporting findings every six months to relevant authorities.

15.4 Labour and Working Conditions

The Project shall be constructed and operated in accordance with the laws and regulations pertaining to employment, human rights and worker rights in Indonesia. Furthermore, MRPRs policy for its employees will also follow the laws and regulations of Indonesia and an employment policy framework will be developed which will comply with ILO Conventions.

A Human Resources Policy to demonstrate compliance with Indonesia's Labour Legislation and WBG EHS Guidelines will be developed prior to commencement of any work by employees of either MRPR or the EPC

Contractors on the Project. This will be supplied to the local labour authority and regularly reviewed as the Project progresses.

15.4.1 Worker Contracts

In addition to contract legislation outlined in Section 15.2.3 and in accordance with international good practice, all employees working on the Project will have a mutually agreed Contract of Employment and will be provided with regular health assessments and the appropriate health and safety training. MRPR and the EPC Contractors will issue all Project staff with an individual contract of employment detailing their rights and conditions in accordance with the national law and WBG requirements related to hours of work, wages, overtime, compensation and benefits such as maternity or annual leave, and update the contract when material changes occur. A Human Resource Policy will be established by MRPR which will meet the laws and regulation of Indonesia.

15.4.2 Workers Grievance Mechanism

A worker's grievance mechanism will be established for the construction and operation phases by MRPR and its contractors. This grievance mechanism is set out in Volume 5: Technical Appendices (Technical Report Working Conditions, Occupational Health and Safety). It has been designed to receive and facilitate resolution of concerns and grievances about the Project's working conditions and safety performance. It will be scaled to the risks and impacts of the Project and have workers as its primary user. It will seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate, readily accessible, at no cost, and without retribution to the party that originated the issue or concern. The mechanism should not impede access to judicial or administrative remedies. MRPR and the EPC contractor's will inform the workers about the mechanism in the course of the worker's engagement and induction process.

16. Gas Pipeline Qualitative Risk Assessment (QRA)

16.1 Gas Pipeline Route and Surrounding Environment

The proposed gas pipeline route is presented in Figure 16.1. The preferred gas pipeline route (sections 1 to 4) is located in Siak District/Regency and Pekanbaru City, and will pass through the villages of Kuala Gasib, Pinang Sebatang, Tualang Timur, Melebung and Meredan. MRPR are currently considering two options for the first 7.2 km section of gas pipeline and two options for the third section of the gas pipeline route from the Jl Pekanbaru Perwang to connect to the CCPP site. For the first section the preferred option is to run the gas pipeline along the road reserve around 6 metres to south of the existing Chevron Oil Pipeline, the alternative option (Alternate Route 1) is to run the gas pipeline to north of the road, on the opposite side to the Chevron Oil Pipeline. For the third section both options traverse land which is palm oil plantation, limited number of dwellings and a very limited number of people working in that particular area. The preferred option to the south and the alternate option (Alternate D Route 2) to the north.

There are five villages located along the asphalt paved roads from the gas take-off point to the point that the pipeline leaves the main road and traverses down the private road into the palm plantation (see Figure 16.1). The villages located along the route are relatively sparse in terms of density and dwellings and buildings are generally well set back from the main road and the proposed location of the gas pipeline route in the road reserve. However, there are some stalls and structures constructed in the road reserve which will be close to the proposed pipeline route. Based on the CPM survey of the route there would appear to be four dwellings at Desa Tualang Timur within 5 m of the pipeline right of way (RoW) that could be impacted by the proposed pipeline route, however this would need to be confirmed once the final design of the pipeline route is confirmed by CPM.

There are two schools and three mosques located along the proposed route. The school fence in Meredan Village is located approximately 2 m from the gas pipeline RoW with the closest buildings being around 5 m from the gas pipeline RoW. The mosques and the other school are further back from the RoW at distances of 20 m or more from the proposed gas pipeline route.

For the first 7.2 km of the gas pipeline route from the gas take-off point on Skiang Mati-Simpang Logo to where the gas pipeline turns off on to Jl Pekanbaru Perwang there is an above ground oil pipeline which is operate by Chevron Indonesia. This preferred route for this section is to run the gas pipeline 6 m to the south of the existing Chevron Oil Pipeline. The pipeline is heated so that the oil will flow. Running along this section of road on the northern side is a 33 kV transmission line.

The second section of the route is from the turn-off on to Jl Pekanbaru Perwang down to a road crossing which has the villages Pinang Sebatang, and Tualang Timur on it. The third section is predominantly through palm oil plantations and is very sparsely populated through Meredan Village down to Melebung Village which is more densely populated around the road. From this point the route (4th section) goes on to private plantation roads through palm oil plantations to the power plant.

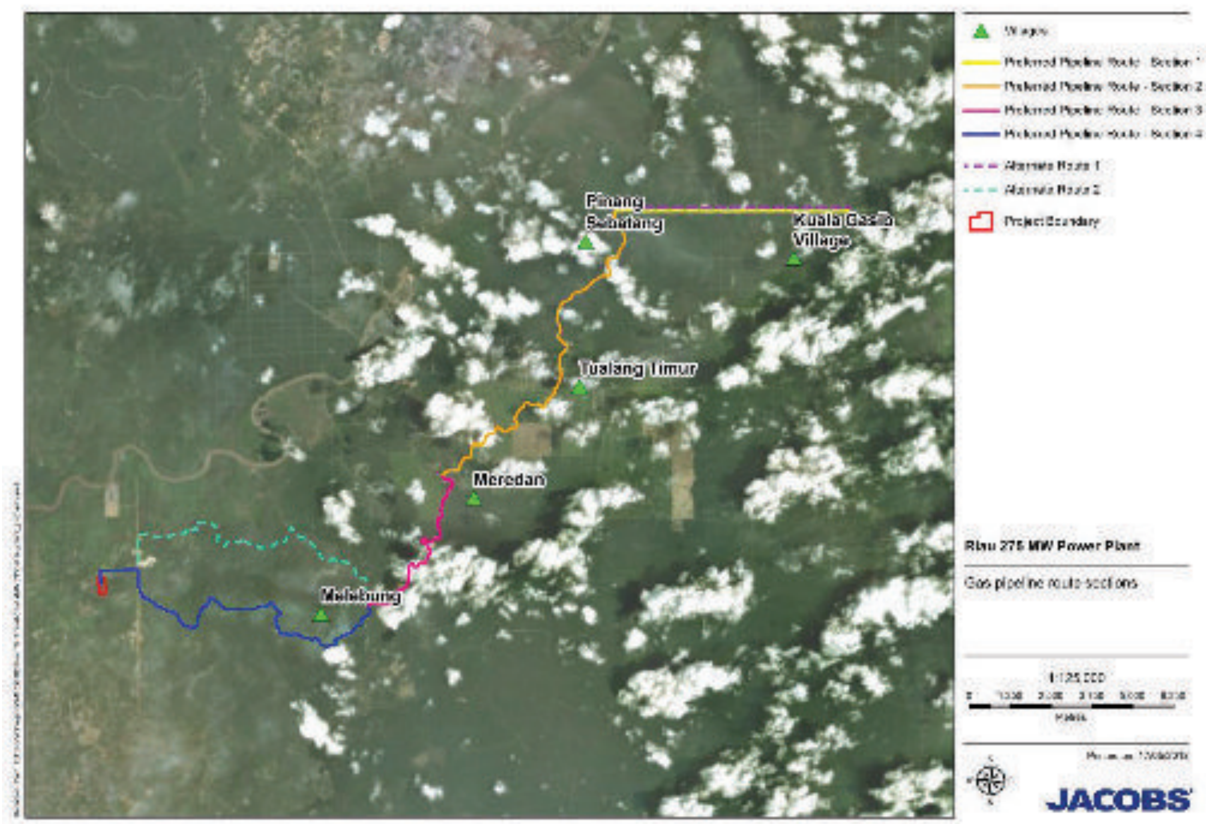


Figure 16.1 : Gas Pipeline Route and Village Locations Along the Route

16.1.1 Pipeline Specification

The following pipeline details relevant to the QRA in Table 16.1 below, for more details on the gas pipeline please refer to the Process Description section detailed in Volume 1 of the ESIA.

Table 16.1 : Pipeline Specification

Pipeline Aspect	Specification
Gas pipe steel flange welded	12” (300 mm) internal diameter
Gas pipe thickness	Varies – 8 to 12.5 mm
Depth that pipeline will be buried	1.2 m from top of the pipe in natural ground 1.5 m form top of pipe for road crossings 2.0 from top of the pipe for river crossings
Pipe Trench width	1.0 m
Extent of excavation open at any time	500 m
Distance from Chevron above ground pipeline	Approximately 6 m minimum
Hazard marking ribbon	Hazard marking ribbon will be placed at 500 mm above the gas pipeline to indicate to any persons digging in the area that the

Pipeline Aspect	Specification
	pipeline is located below.
Signage	Signs will be placed along the pipeline route to warn people of the presence of the underground pipeline.
Corrosion protection	Pipe coating and cathodic protection.
Normal Construction	Cover from top of pipe 900 mm minimum to 1,200 mm maximum – subject to construction risk assessment.
Crossings: - Water	Cover from top of pipe 2.0 m.
Crossings: - Road	• Type 1 (Major Sealed Road): 1,500 mm minimum to 3,000 mm maximum cover under the road surface. • Type 2 (Sealed/Gravel Formed Roads): 1,200 mm minimum to 1,500 mm cover under the road surface. • Type 3 (Formed Track): 1,000 mm minimum to 1,200 mm maximum under the track surface.
Crossings: - Foreign Services	• Varied depth of cover dependent on depth of the service. • Concrete slabs will be installed a minimum of 300 mm above the pipe between the services, with a nominal separation of 800 mm between the pipe and service. • The pipeline minimum depth of cover for the construction type of the area shall be maintained.
Crossings: - Chevron Oil Pipeline and pipeline expansion loops	• Below ground crossing with 1,500 mm minimum cover to made ground under the oil pipeline.

16.2 Qualitative Risk Assessment

16.2.1 General Approach

The NSW Department of Planning (NSW DoPI) Multi Level Risk Assessment[5] approach was used for this study. The Multi-Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied. In addition to the Multi-Level Risk Assessment approach guidance from AS2885 specific to the risk assessment of linear gas pipelines was used to conduct the QRA.

The Multi-Level Risk Assessment approach is summarised in Figure 16.2. There are three levels of assessment, depending on the outcome of preliminary screening. These are:

- **Level 1** – **Qualitative Analysis**, primarily based on the hazard identification techniques and qualitative risk assessment of consequences, frequency and risk;
- **Level 2** – **Partially Quantitative Analysis**, using hazard identification and the focused quantification of key potential offsite risks; and
- **Level 3** – **Quantitative Risk Analysis (QRA)** based on the full detailed quantification of risks, consistent with Hazardous Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis.

[5] Assessment Guideline Multi-Level Risk Assessment, New South Wales Department of Planning – 2011

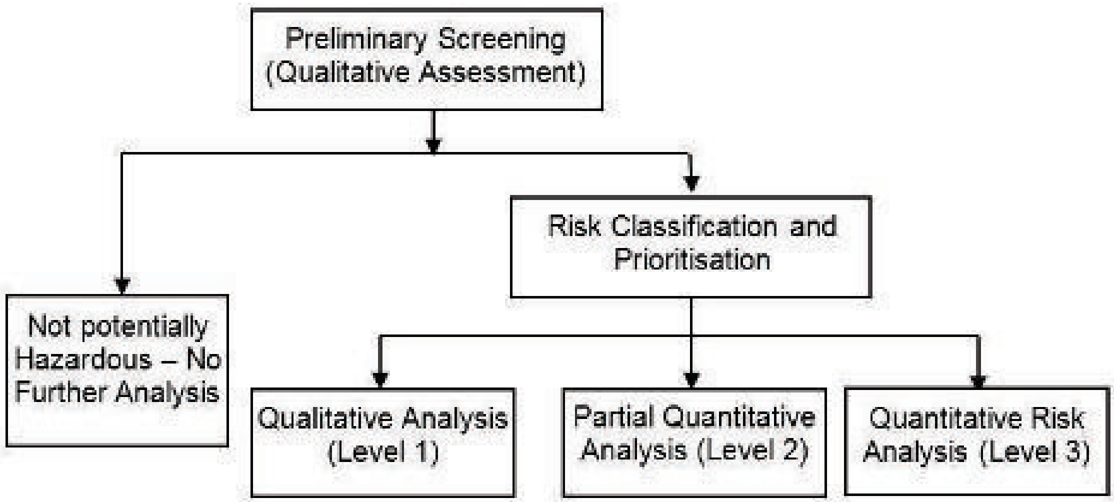


Figure 16.2 : Multi-Level Risk Assessment Steps

The document “Applying SEPP 33” guideline supports the Multi-Level Risk Assessment process and provides guidance on the selection of the type of risk assessment that should be conducted (qualitative, semi-quantitative, or fully quantitative). The guideline states the following:

“It is considered that a qualitative QRA may be sufficient in the following circumstances:

- *Where materials are relatively non-hazardous (for example corrosive substances and some classes of flammables);*
- *Where the quantity of materials used are relatively small;*
- *Where the technical and management safeguards are self-evident and readily implemented; and*
- *Where the surrounding land uses are relatively non-sensitive.*

In these cases, it may be appropriate for a QRA to be relatively simple. Such a QRA should:

- *Identify the types and quantities of all dangerous goods to be stored and used;*
- *Describe the storage/processing activities that will involve these materials;*
- *Identify accident scenarios and hazardous incidents that could occur (in some cases, it would also be appropriate to include consequence distances for hazardous events);*
- *Consider surrounding land uses (identify any nearby uses of particular sensitivity); and*
- *Identify safeguards that can be adopted (including technical, operational and organisational), and assess their adequacy (having regards to the above matters).*

A sound qualitative QRA which addresses the above matters could, for some proposals, provide the consent authority with sufficient information to form a judgement about the level of risk involved in a particular proposal.”

As a significant portion of the gas pipeline route is through relatively non-sensitive areas, the hazards posed by underground gas pipeline are well documented and understood, and the technical and management safeguards are self-evident and readily implemented, and for these reasons a qualitative risk assessment is regarded as being appropriate.

16.2.2 Detailed Approach

A Qualitative Risk Assessment (QRA) was conducted for the proposed gas pipeline operation phase. The risks posed during the construction of the pipeline and the mitigation, construction methods to reduce that level of risk will be assessed by the EPC Contractor via HAZID and HAZOP workshops as part of the detailed design process, which is part of good engineering practice.

The following steps were used to conduct the QRA:

1) Location Analysis – The pipeline route is reviewed and the general land use in the area identified. Areas of particular significance that could pose additional threats to pipeline integrity (e.g., road crossings) are noted.

2) Threat Identification (Hazards) – Identification of threats considers all threats with the potential to damage the pipeline, cause supply interruption, cause release of fluid, or harm to people and/or environment. A decision is made whether each identified threat is credible or not credible. For threats that are considered not credible, a reason for this is given and the threat not assessed further.

3) External Interference Protection – Physical and procedural measures that could reduce the threat of external interference to the pipeline are identified where applicable. If these are considered sufficient to control the threat to the pipeline (commensurate with the relevant location class), then the threat does not require further assessment.

4) Protection by Design and/or Procedures – Design measures and procedures that protect the integrity of the pipeline are identified. If these were considered sufficient to control the threat to the pipeline, then the threat does not require further assessment.

5) Failure Analysis – Where controls may not prevent failure for a particular threat, the threat is analysed to determine the damage that it may cause to the pipeline.

6) Risk Assessment – The frequency and severity of a potential event are determined, and categorised as high, intermediate, low or negligible risks using the AS2885.1-2007 likelihood and consequence descriptors and risk matrix shown in Tables 4.1, 4.2 and 4.3.

Recommendations are made regarding risk reduction measures to reduce risk to a level ALARP, for those risks described as tolerable.

Table 16.2 : Consequence Descriptors

		Effects			
Level	**Descriptor**	**People (Health and Safety)**	**Community**	**Environmental**	**Fiscal**
5	Trivial	Minimal impact on health & safety	Workforce concern	No effect; minor on-site effects rectified rapidly with negligible residual effect	Low financial loss <$10,000.
4	Minor	First aid treatment. Incidental injury or health effects to persons exposed.	Local community concern	Effect very localised (<0.1 ha) and very short term (weeks), minimal Reduction in abundance / biomass of flora fauna in affected area. No	Medium financial loss. $10 -100 k.

				changes to biodiversity. Minor environmental nuisance.	
3	Moderate	Injuries or health effects to persons requiring hospital treatment.	Regional community concern and local reputational risk	Localised (<1 ha) & short-term (<2 yr) effects, easily rectified.	High financial loss. $100k -1million
2	Major	Few fatalities, or several people with life threatening injuries	Widespread reputation risk to a single business unit. Widespread community outrage	Off-site release with significant impact to biodiversity and ecological functioning with eventual recovery (maybe not to pre impact conditions).	Major financial loss. $1-10 million.
1	Catastrophic	Multiple fatalities result.	Widespread reputation risk to more than a business unit. Extreme community outrage	Effects widespread; viability of ecosystems or species affected; permanent major	Huge financial loss. >$10 million.
These tables are based on AS2885.1-2007 Risk Assessment Matrix Descriptors					

Table 16.3 : Likelihood Descriptors

Level	Descriptor	Project Frequency	Incident Frequency
A	Frequent	Expected to occur once per year of more	1/month
B	Occasional	May occur occasionally in the life of the pipeline	1/Year
C	Unlikely	Unlikely to occur within the life of the pipeline, but possible.	1/10 years
D	Remote	Not anticipated fort his pipeline at this location.	1/100 years
E	Rare	Theoretically possible, but has never occurred on a similar pipeline.	1/1,000 years

Table 16.4 : Risk Ranking Matrix

LIKELIHOOD	5 (Trivial)	4 (Minor)	3 (Moderate)	2 (Major)	1 (Catastrophic)

A (Frequent)	L	I	H	VH	VH
B (Occasional)	L	L	I	H	VH
C (Unlikely)	N	L	I	H	H
D (Remote)	N	N	L	I	H
E (Rare)	N	N	N	L	I

Note: This matrix is based on AS2885.1-2007 Risk Assessment Matrix

Key:

N	NEGLIGIBLE	Negligible risk; managed by routine procedures.
L	LOW	Low risk, managed by routine procedures
I	INTERMEDIATE	Intermediate risk; requires above normal attention. ALARP must be applied
H	HIGH	High risk; reduce level of risk to Intermediate and ALARP must be applied.
VH	VERY HIGH	Very High risk; not acceptable and must be reduced.

16.2.3 Location Analysis

For the first 7.2 km of the route (Section 1) from the gas take-off point on Skiang Mati-Simpang Logo to where the gas pipeline turns off on to Jl Pekanbaru Perwang is six metres south of the above ground oil pipeline which is operate by Chevron Indonesia. This pipeline is on the same side of the road to the preferred route for the Riau CCPP gas pipeline. The pipeline is heated so that the oil will flow.

Running along this section of road on opposite to side that the gas pipeline will be installed is a 33 kV transmission line. Jacobs understands that if the gas pipeline is located on this side of the road it will be between the road and the transmission line.

Figure 16.3 : Photograph Showing Road, Transmission Line and Chevron Pipeline to RHS

There are five villages (Kuala Gasib, Pinang Sebatang, Tualang Timur, Melebung and Meredan) located along the pipeline route. Dwellings at Kuala Gasib for the option north of the road for the first section are generally 20 m or more set back from the proposed gas pipeline route. There are around 13 warungs (stalls of light wooden construction) located within 5 m of the gas pipeline route at this village, as surveyed by CPM (Constructability Review Plan). A survey of dwellings and buildings along the southern option next to the Chevron Oil Pipeline has not been undertaken yet, but based on a review of satellite imagery the density of properties for the southern option for section one is significantly less than for the northern option with improved set back distances from the road and Chevron Oil Pipeline.

In Pinang Sebatang Village there 10 commercial enterprises of light construction and a more substantial food premise (at the intersection of Skiang Mati-Simpang Logo and Jl Pekanbaru Perwang) within 5 m of the proposed gas pipeline RoW. At Tualang Timur Village area there are approximately 15 commercial enterprises and stalls within 5 m of the gas pipeline RoW and 4 residential homes.

At Mareden Village there are 5 commercial operations and 7 homes within 5 m of the gas pipeline RoW. At Melebung Village there are 5 stalls and a small musholla within 5 m of the gas pipeline

There are two schools and three mosques located along the proposed route. The school fence in Meredan Village is located approximately 2 m from the gas pipeline RoW with the closest buildings being around 5 m from the gas pipeline RoW. The mosques and the other school are further back from the RoW at distances of 20 m or more from the proposed gas pipeline route.

Figure 16.4 : Road Crossing at Tualang Timur Village

Outside of villages/towns, the majority of the land either side of the pipeline is scrub and grasses for out to a distance of at least 10 m or more form the existing road.

Three small areas where evidence of critically endangered and endangered species has been identified, adjacent to the gas pipeline route at transects TR3, 4 and 5 (see Volume 2 – Terrestrial Ecology Assessment for site map showing locations). This area is set back around 30 m from the proposed pipeline route and between the road and the areas identified is a buffer of native grasses.

For the initial section of the route, along the main road, the pipeline will run parallel to an existing, above ground crude oil pipeline. The crude oil line, is on the same side of the road from where it is proposed to run the gas pipeline, is heat traced and insulated. Separation between the pipelines will nominally be at least 6 m. The fact that the oil pipeline is above-ground, heat traced and insulated should not pose any incremental risk to the gas pipeline. The fact that it is above-ground is preferred to being buried from asset management, operation and maintenance, leak detection, and spill clean-up perspectives.

16.2.4 Threats/Hazards

A number of Threats/Hazards have been identified relating to the operation of the gas pipeline. Only those threats that are deemed to be credible and could result could result in an accidental release to the environment, or accidental human exposure, if a failure or incident event occurs have been taken through to the risk analysis. The likelihood of the incident occurring and the consequences of the event is covered in the risk analysis section.

A hazard is defined as *a source of potential harm, or situation with the potential to cause loss or adverse impacts*[6]. Threats that could impact on the gas pipeline include:

1. Horizontal/directional drilling by other utility service providers
2. Trench excavations by other service providers
3. Maintenance of existing land owner's underground services
4. Excavations for possible bollards, fences, power poles, stall footings etc.
5. Water boring activities
6. Maintenance of roads and bridges
7. Construction of proposed roads parallel of close to pipeline
8. Pipeline operator exposing the pipe for maintenance
9. Vehicle strike
10. Deliberate tapping/vandalism of pipeline
11. Seismic events
12. Power pole replacement on existing TL by gas pipeline
13. Corrosion of pipeline (internal and external)
14. Slope stability
15. Flooding
16. Cyclones
17. Lighting strike
18. Wildfires
19. Incident to Chevron pipeline resulting in oil spillage and fire impacting on Riau CCPP gas pipeline

The following natural hazard threats (lighting strike, cyclones, wildfires and flooding) have been assessed as not being credible due to the pipeline being operated as an underground pipeline and as such damage as a result of the natural hazards threat to a buried pipeline is not going to occur. In regards to seismic events the pipeline will be designed and constructed to meet Indonesian seismic standards for construction of gas pipelines and as such apart from extreme major seismic events the pipeline will not be damaged. Further modifying this conclusion is that the Riau Province is not a seismically active area as compared to other parts of Indonesia. For these reasons the level of risk from seismic events has not been assessed in the risk analysis.

It should be noted that the pipeline will be buried 2 m below the base of rivers it crosses and the threat pose by flood scouring from these relatively slow flowing, low gradient rivers is negligible.

Internal corrosion of the installed gas pipeline is not a credible threat due to the sweet nature of the natural gas which means it has a very low potential to corrode the pipe overtime. External corrosion of the pipe is also deemed not to be a credible threat due to the design and engineering controls applied to protecting the external surface of the pipe being a plastic coasting and the application of a cathodic protection system.

Vehicle strike is considered not to be a credible threat as the pipeline will be buried along length of the route.

Water boring activities is not considered to a credible threat as the pipeline route is located mainly in road reserve and residential properties are well set back from the road and as such any water boring activities would not be expected to impact on the pipeline. In addition, wells used in the general areas are shallow and are dug by hand away for sources of contamination such as the road run-off.

[6] Environmental risk management – Principles and process (HB203:2000)

The remaining threats are deemed to be credible and they have been taken through to the qualitative risk analysis to determine the level of risk.

16.2.5 Level of Risk

The following sections set out the qualitative risk analysis conducted for the credible threats/hazards identified in respect to the operation of the Riau CCPP gas pipeline. There are extensive kilometres of gas transmission pipes throughout the world and although rare incidents do occur from time to time. For the 40 km long Riau gas pipeline the level of risk has been determined using the likelihood and consequence descriptors and the risk matrix set out in Table 16.2 to Table 16.4 for each of the credible threats. The assigned level of risk for the credible threat taking into account the mitigation measures associated with the design and operation of the gas pipeline and is presented in Table 4.4 below. For the risk analysis a leak is classified as a pinhole, crack, connection failure, seal or packing failure, whereas a rupture is classified as circumferential, longitudinal of other type of rupture.

Statistical data reviewed in the conducting of this QRA indicates that the majority (85%) of incidents[7] with gas pipelines do not involve ignition. For those ignited incidents about half of them lead to explosions (7% of all incidents lead to explosions). It should be noted that ignition means only a jet fire created in the incident, whereas explosion means that a fireball precedes the jet fire. Also the statistic indicate that the likelihood of ignition is very small about 10% in pipeline puncture incidents. This information has been used to guide the QRA in the setting of likelihood and consequence levels.

[7]Statistical Analyses of Historical Pipeline Incident Data with Application to the Risk Assessment of Onshore Natural Gas Transmission Pipelines, Chio Lam, Western University, 2015

Table 16.5 : Credible Major Accident Event Hazards Level of Risk

Threat/Hazard	Event	Cause	Effect	Recommended Mitigation	Risk Analysis		
					Consequence	Likelihood	Risk
Horizontal/directional drilling by other utility service providers	The gas pipeline is accidentally hit and punctured.	Horizontal drilling hits the pipe underground. Ignition sources present due sparks as result of pipe to drill contact.	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Third part liaison • Patrolling • Penetration resistance may provide some protection • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.	**Major**	**Remote**	**Intermediate**
Trench excavations by other service providers	The gas pipeline is accidentally hit and punctured.	Excavator hits pipe with bucket	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Third part liaison • Hazard tape place above the pipe warning of its presence • Patrolling • Penetration resistance • Vertical separation greater than 1200 mm • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.	**Major**	**Remote**	**Intermediate**
Maintenance of existing land owner's underground services	The gas pipeline is accidentally hit and punctured.	Excavator hits pipe with bucket	Gas release from punctured piped. Jet fire due to ignition source	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area	**Moderate**	**Rare**	**Negligible**

Threat/Hazard	Event	Cause	Effect	Recommended Mitigation	Risk Analysis		
					Consequence	Likelihood	Risk
			present.	• Hazard tape place above the pipe warning of its presence • Socialisation of risk with local communities • Third part liaison • Patrolling • Penetration resistance. • Vertical separation greater than 1200 mm. • There are no underground services (water, sewerage etc.,) currently existing along the pipeline route • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.			
Excavations for possible bollards, fences, power poles, stall footings etc.	The gas pipeline is accidentally hit and punctured.	Excavator hits pipe with bucket	Gas release from punctured piped. Jet fire due to ignition source present.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Socialisation of risk with local communities • Hazard tape place above the pipe warning of its presence • Third part liaison • Patrolling • Penetration resistance may provide some protection • Vertical separation greater than 1,200 mm • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.	**Moderate**	**Rare**	**Negligible**

Threat/Hazard	Event	Cause	Effect	Recommended Mitigation	Risk Analysis		
					Consequence	Likelihood	Risk
Maintenance of roads and bridges	Excavations are deep on side of road where pipeline is located. Piling work required for bridge repairs. The gas pipeline is accidentally hit and punctured.	Excavator or pile hits pipe	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Third part liaison. • Patrolling • Penetration resistance. • Vertical separation greater than 1,200 mm • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.	**Major**	**Rare**	**Low**
Construction of proposed roads parallel of close to pipeline	Excavations are deep on side of road where pipeline is located. The gas pipeline is accidentally hit and punctured.	Excavator hits pipe	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Third part liaison. • Patrolling • Penetration resistance. • Vertical separation greater than 1,200 mm • Work instruction • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.	**Major**	**Rare**	**Low**
Pipeline operator exposing the pipe for maintenance	Pipeline maintenance and maintainer strikes pipe, puncturing it.	Excavator hits pipe	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Hazard tape place above the pipe warning of its presence • Third part liaison	**Major**	**Rare**	**Low**

Threat/Hazard	Event	Cause	Effect	Recommended Mitigation	Risk Analysis		
					Consequence	Likelihood	Risk
				• Patrolling • Penetration resistance • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route • Work Instruction • Supervision.			
Deliberate tapping/vandalism of pipeline	A person deliberately digs down to the pipe line and drills into to take an illegal.	Pipeline deliberately drilled.	Gas release from punctured piped. Jet fire due to ignition source present.	• Signage advising presents of pipeline • Patrolling • Hazard tape place above the pipe warning of its presence • Socialisation as to dangers with local communities • Penetration resistance. • Vertical separation greater than 1200 mm • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route.	**Major**	**Rare**	**Low**
Power pole replacement on existing TL by gas pipeline	Auguring for new power pole or replacement pole hits the gas pipeline and punctures it.	Augur hits gas pipeline	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Third part liaison. • Patrolling • Penetration resistance • Work Instruction • Supervision • Separation of gas pipeline from existing transmission line poles • The gas supply can be shut off at the	**Major**	**Rare**	**Low**

Threat/Hazard	Event	Cause	Effect	Recommended Mitigation	Risk Analysis		
					Consequence	Likelihood	Risk
				point of supply or at one of the several line break valve to be installed along the route.			
Slope stability	Slope that pipeline runs through slips away exposing the pipeline.	Slope instability and high rain	Pipeline is exposed and may rupture which is highly unlikely based on previous incidents where pipeline remain intact but suspended	• Route planning to avoid areas of slope instability • Geotechnical works to strengthen slopes stability (rock bolts, crib walls etc.) • Monitoring of slopes which were identified as having less than desirable stability as to movement • Diversion of water around slopes with low stability.	**Minor**	**Unlikely**	**Low**
Incident to Chevron pipeline resulting in oil spillage and fire impacting on Riau CCPP gas pipeline	The Chevron oil pipeline is ruptured by vehicle impact, or natural event.	Vehicle impact and or natural event and ignition source is present which ignites oil and vapour leading to an explosion	Oil spillage and vapour release which flows a limited distance from pipeline due to rupture and then is ignited.	• Separation of gas pipeline from oil pipeline 6 m • Vertical separation greater than 1,200 mm as gas pipeline is buried • Heavy oil which has to be heated in pipeline to flow and will not flow quickly if pipe ruptured • Vapour concentrations in heavy oil limited and will quickly disperse in open air. • Emergency response plans	**Moderate**	**Remote**	**Low**
Incident to gas pipeline rupturing/puncturing Chevron Oil Pipeline	The gas pipeline is accidentally hit and punctured.	Excavator hits pipe with bucket	Gas release from punctured piped. Jet fire and potential explosion due to ignition source present which results in Chevron Oil Pipeline being punctured.	• Signage advising presents of pipeline • Signage advising to contact Riau CCPP prior to conducting drilling/excavations in this area • Hazard tape place above the pipe warning of its presence • Third part liaison. • Patrolling • Penetration resistance	**Major**	**Remote**	**Intermediate**

Threat/Hazard	Event	Cause	Effect	Recommended Mitigation	Risk Analysis		
					Consequence	Likelihood	Risk
				• Work Instruction • Vertical separation greater than 1,200 mm as gas pipeline is buried • Supervision • Separation of gas pipeline from Chevron Oil • Heavy oil which has to be heated in pipeline to flow and will not flow quickly if pipe ruptured • The gas supply can be shut off at the point of supply or at one of the several line break valve to be installed along the route • Vapour concentrations in heavy oil limited and will quickly disperse in open air.			

16.2.6 ALARP

The risk analysis identified three threats/hazards which have an “Intermediate” level of risk and as such are required to be assessed as to whether the level of risk can be further reduced or is ALARP and is therefore tolerable. The three threats are:

1) Horizontal/directional drilling by other utility service providers

2) Trench excavations by other service providers.

3) Incident to gas pipeline and rupturing/puncturing Chevron Oil Pipeline

All other credible threats/hazards assessed in the risk analysis are either low or negligible levels of risk and are therefore acceptable.

Further mitigation that can be applied to the first two threats listed as having an Intermediate level of risk is to increase the level of signage through areas where residential and commercial premises exist along route in order to provide regular reminders to local communities about the presence of the pipeline and the risk it poses. When this additional mitigation is considered the level of risk still remains as Intermediate and as such this level is deemed to be tolerable.

Should one of the first two list threats occur next to the three adjacent areas that have been identified as modified habitat which host critically endangered species the level of risk has taken into account that there is a potential for an offsite release(fire) which could significantly impact on biodiversity and ecological function of these habitats. However, this level of risk can be reduced when one considers that the likelihood of a puncture event igniting is rare (15% of all puncture events) and in most instance it is a jet fire directly to air from the punctured pipe and as such it is unlikely to ignite nearby vegetation. The likelihood of a wildfire occurring in these areas as a result of an incident to the gas pipeline is significantly lower than from a cigarette being tossed out from a passing car. A such the level of risk posed is tolerable.

The level of risk of an impact incident to the gas pipeline resulting in the Chevron Oil Pipeline being punctured could be reduced by increasing the level of separation between the two pipelines. In order to achieve this would mean significant re-routing of the gas pipeline away from the road corridor at considerable cost due to increase land acquisition and earthworks requirements and potentially increased damage to the existing environment. Increased mitigation for the current route such as providing a concrete barrier above the pipe to prevent hits by excavators is expensive and not practicable. Given that the level of risk is Intermediate the mitigation proposed meets good industry practice, then the level of risk is deemed to be ALARP and is tolerable.

16.3 Additional Mitigation and Monitoring

Further mitigation that can be applied is covered in the ALARP assessment section and it includes increasing the level of signage through areas where residential and commercial premises exist along route so the signs are more frequent in these areas. Regular reminders to local communities about the presence of the pipeline and the risk it poses.

In respect to mitigating the level of risk related to the two pipelines, there is no single industry standard that dictates what is required, but rather guidance is found in several pertinent documents and from experience. Mitigations would include the preparation and implementation of leak detection and fire prevention methods as well as spill response plans that are comprehensive, integrated, and thoroughly consider the two pipelines. Also, included would be the development of relevant hazard scenarios and communication protocols that involve suitable shut-down and line purging procedures for both pipelines.

An Emergency Response Plan for the pipeline operation will be developed and implemented.

Regular patrols of the pipeline should be undertaken to check that all warning signs are in place, identify any areas where people are undertaking works close to the pipeline and to discuss the risks with local communities and village leaders

16.4 Conclusion of Qualitative Risk Assessment

A list of credible threats which could result in puncturing/rupturing of the pipeline and being ignited have been evaluated as having a negligible to intermediate level of risk to human health and environment. The proposed mitigation measures detailed in the preceding sections are robust, of a good international industry practice standard and have a low likelihood of failure. The mitigation, standard operating procedures, emergency response procedures and safety design measures that will be in place will limit the risk resulting from the operation of the gas pipeline to as low as is reasonably practical.

17. Assessment of Cumulative Impacts

17.1.1 Introduction

The assessment of cumulative impacts will identify where particular resources or receptors would experience significant adverse or beneficial impacts as a result of a combination of projects (inter-project cumulative impacts). In order to determine the full combined impact of the development, potential impacts during construction and operational phases have been assessed where relevant.

There are no relevant cumulative impacts that need to be considered for the construction phase of the Project. The main existing industrial discharge in the Project area is the Tenayan CFPP located to the north of the Project, given that it is important to consider the cumulative impacts of both operating in unison. In particular, there is potential for cumulative impacts on air quality, noise, water quality and freshwater ecology, terrestrial ecology and hydrology.

The following section provides an assessment of the cumulative impacts of the Tenayan CFPP and proposed Riau CCPP for air quality, noise water quality and freshwater ecology, terrestrial ecology and hydrology in accordance with the corresponding Technical Reports appended at Volume 5.

17.1.2 Air Quality

The MGLCs predicted by the AERMOD dispersion model for the combined Riau CCPP and Tenayan CFPP are presented in Table 17.1 below.

The relevant international air quality standards and guidelines are provided for comparison. Isopleths of predicted MGLCs of NO_2 are provided as 1-hour averages (99.9th percentile) in Figure 17.1 and 24-hour averages in Figure 17.2 maximum concentrations including existing background concentrations are also provided. As previously discussed, the background concentrations are adopted from monitoring undertaken in Pekanbaru, and are expected to be higher than what would be observed in the Project area. It should also be noted that the existing Tenayan CFPP has been included in the modelling assessment, which will account for these discharges which might not be observed (or would be observed at a lower level) at the Pekanbaru ambient air monitoring station.

Table 17.1 : Highest MGLCs from Cumulative Discharges (Proposed Riau CCPP and Existing Tenayan CFPP), for Comparison with International and Indonesian Guidelines

Pollutant and Averaging Period	Highest Predicted MGLCs (µg/m^3)		International Guidelines (µg/m^3)	Indonesian Ambient Air Standards (µg/m^3)
	Excluding Background	Including Background		
CO (1-hour highest 99.9th percentile)	10.5	1210.5	30,000 (NZ)	30,000
CO (24-hour)	2.6	602.6	10,000 (WHO)	10,000
NO_2 (1-hour highest 99.9th percentile)	53.4	67.4	200 (WHO)	400
NO_2 (as NO_2, 24-hour average)	15.7	27.7	100 (NZ)	150
NO_2 (as NO_2, annual average)	4.4	14.4	40 (WHO)	100
PM_{10} (24-hour average)	2.7	39.7	150 (WHO Interim target 1); 100 (WHO Interim target 2); 75 (WHO Interim target 3); 50 (WHO)	150

Pollutant and Averaging Period	Highest Predicted MGLCs (µg/m^3)		International Guidelines (µg/m^3)	Indonesian Ambient Air Standards (µg/m^3)
	Excluding Background	Including Background		
PM_{10} (annual average)	0.8	48.8	70 (WHO Interim target 1); 50 (WHO Interim target 2); 30 (WHO Interim target 3); 20 (WHO)	n/a
$PM_{2.5}$ (24-hour average)	2.7	21.7	75 (WHO Interim target 1); 50(WHO Interim target 2); 37.5 (WHO Interim target 3); 25 (WHO)	65
$PM_{2.5}$ (annual average)	0.8	24.8	35 (WHO Interim target 1); 25 (WHO Interim target 2); 15 (WHO Interim target 3); 10 (WHO)	n/a
SO_2 (1-hour highest 99.9th percentile)	141.9	224.9	350 (NZ)	900
SO_2 (24-hour average)	29.1	112.1	125 (WHO Interim target 1); 50 (WHO Interim target 2); 20	365
SO_2 (annual average)	6.4	72.4	10 – 30 (NZ)	60

Isopleth diagrams showing the highest predicted concentrations of NO_2 resulting from the combined discharges from the Project and the existing Tenayan CFPP are provided as Figure 17.1 (1-hour averages), Figure 517.2 (24-hour averages), and Figure 17.3 (annual averages) below. The highest predicted MGLC of NO_2 as a 1-hour average (99.9th percentile) from the cumulative discharges is 53 µg/m^3 (67 µg/m^3 including the assumed background NO_2 concentration), which is well below the WHO one-hour average guideline value of 200 µg/m^3, and the Indonesian Standard of 400 µg/m^3. The highest predicted concentrations occur at the site boundary of the Project. There is little overlap in the plumes in NO_2 concentrations between the Project and the existing Tenayan CFPP. This is likely due to the distance between the two power plants as well as the differences in emission heights of the two sources.

Predicted MGLCs of NO_2 as 24-hour averages are similarly well below the 100 µg/m3 International guideline value, and the 150 µg/m^3 Indonesian Standard. Highest predicted MGLCs are shown to occur approximately 1.5 km to the southwest of the Project site.

Predicted MGLCs of NO_2 as annual averages (including background) are also low, being less than 40% of the 40 µg/m^3 WHO Guideline, but are less than 15% of the 100 µg/m^3 Indonesian Standard.

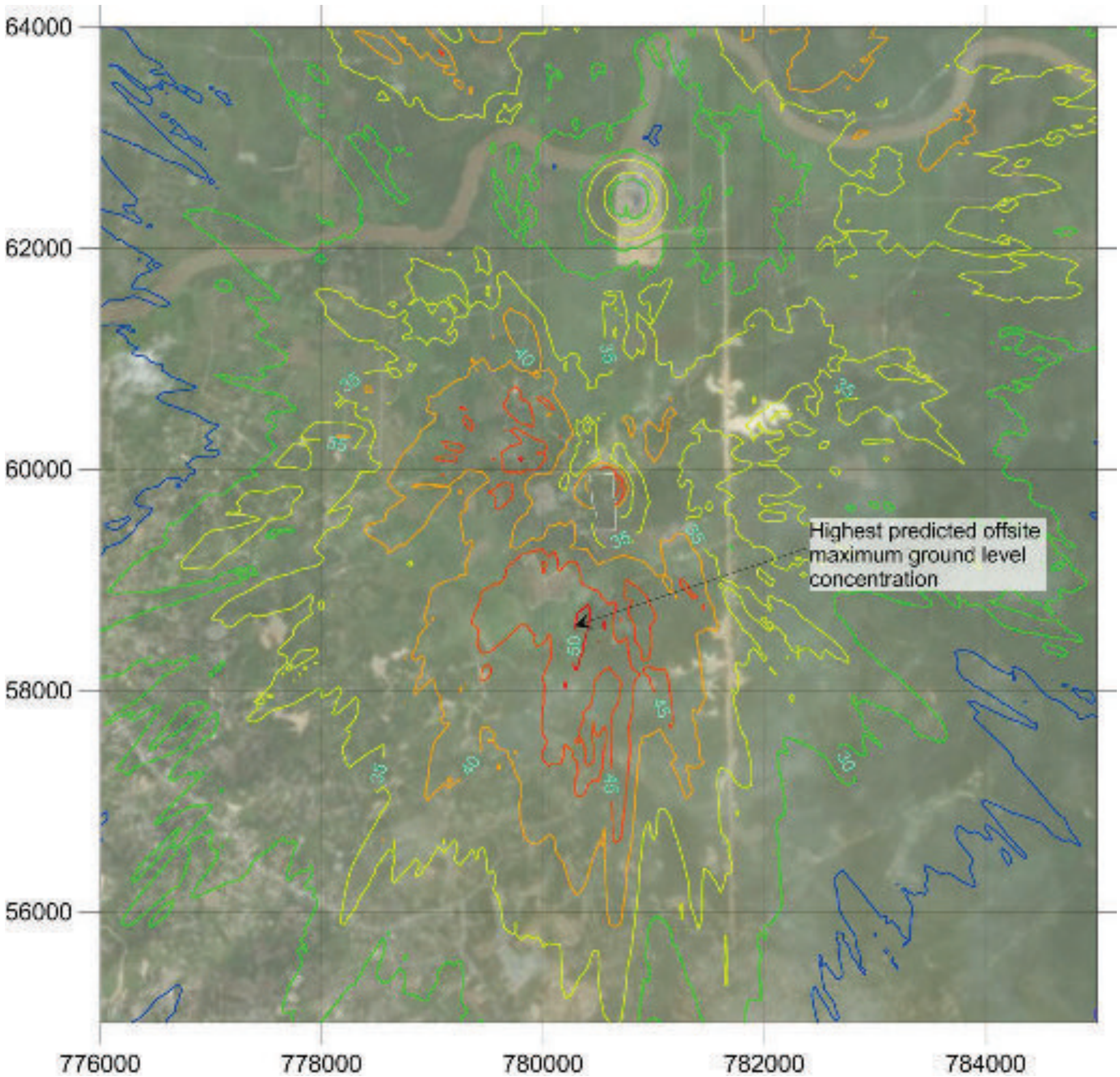


Figure 17.1 : Highest Predicted MGLCs (1-Hour Average, 99.9th Percentile) of NO_2 from Discharges from the Existing and Proposed Power Complexes (Excluding Background)

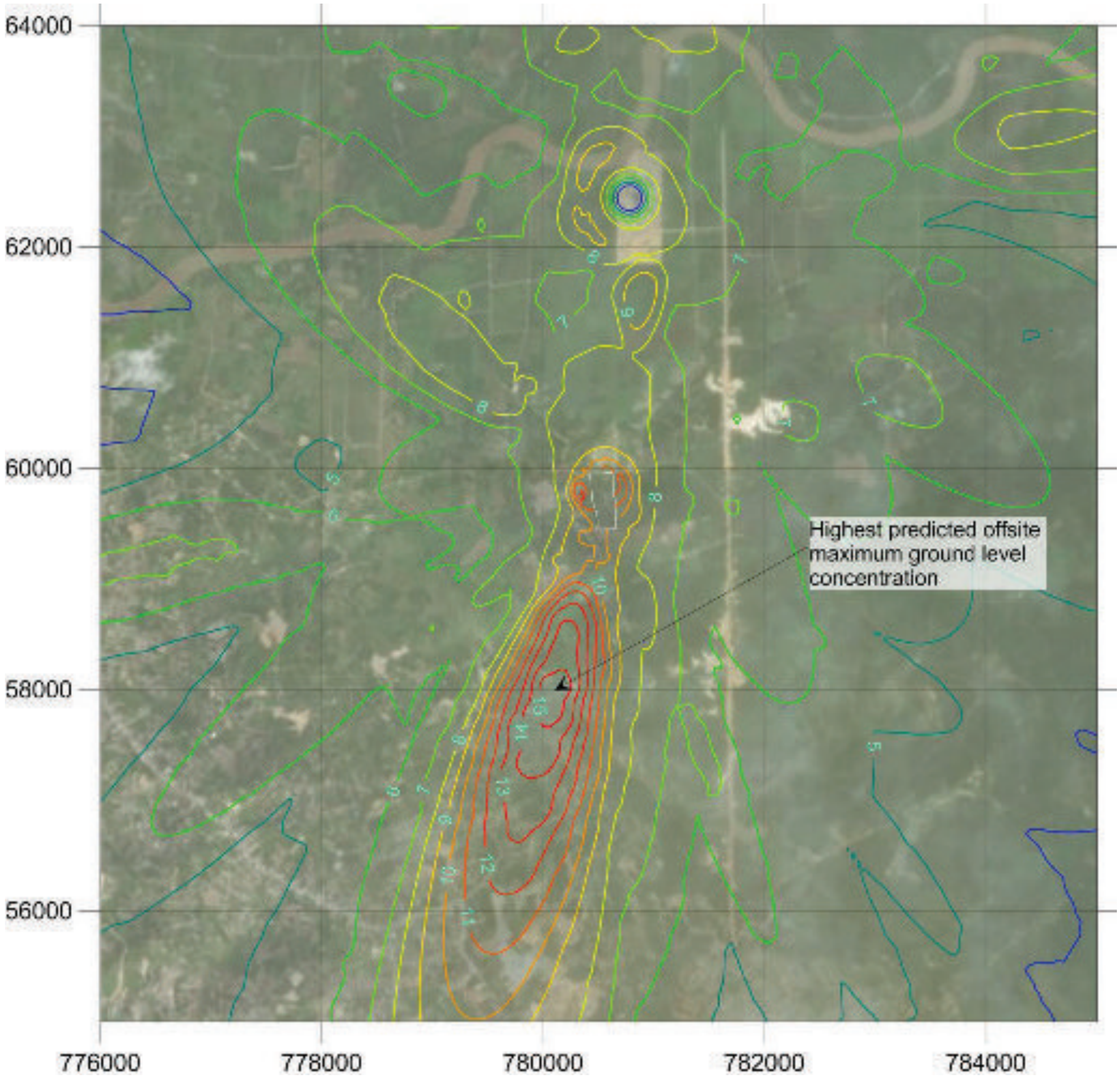


Figure 17.2 : Highest Predicted MGLCs (24-Hour Average) of NO_2 from Discharges from the Existing and Proposed Power Complexes (Excluding Background)

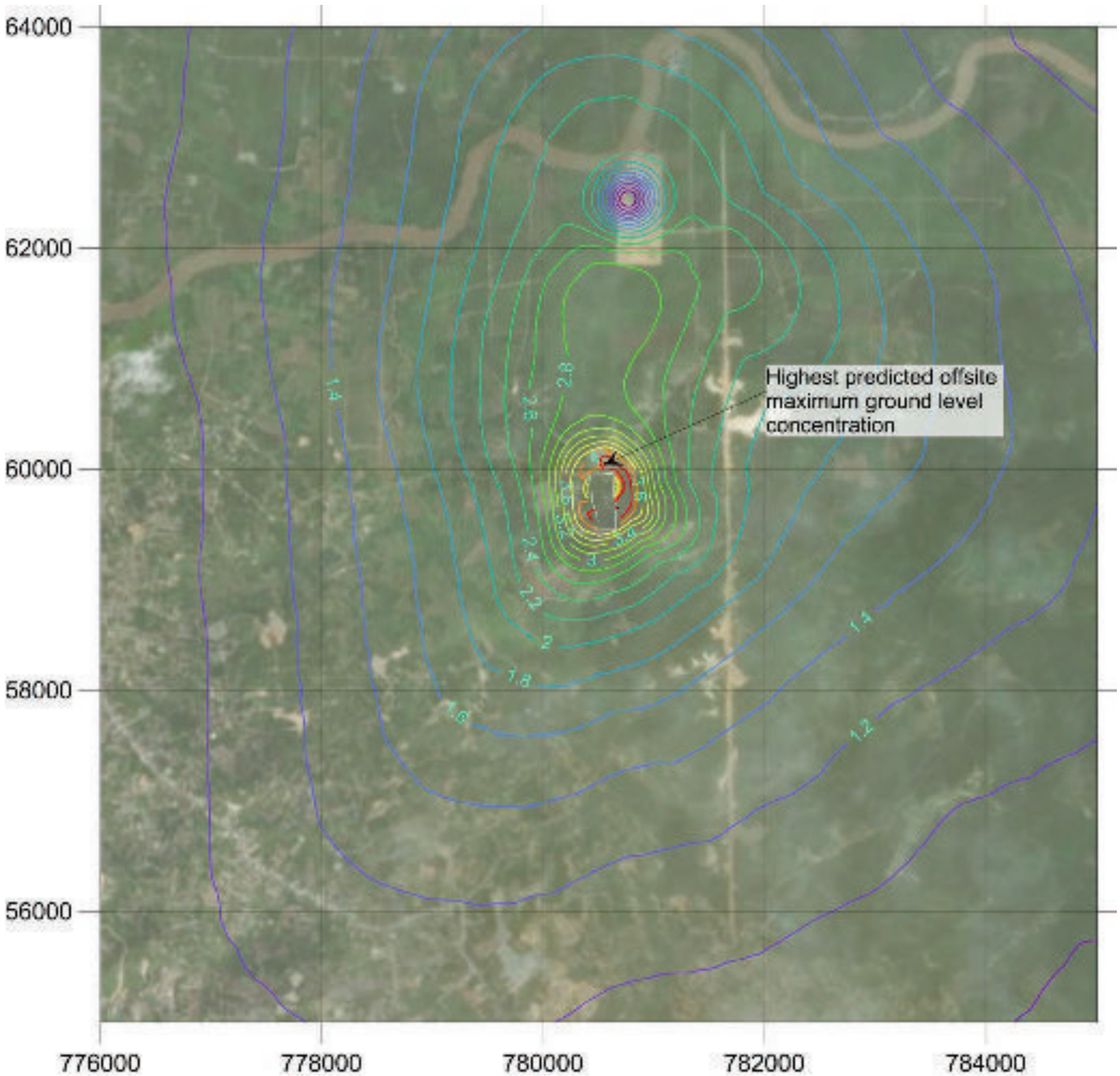


Figure 17.3 : Highest Predicted Maximum Ground Level Concentrations (Annual Average) of NO_2 (g/m^3) from Discharges from the Existing and Proposed Power Complexes (Excluding Background)

The Tenayan CFPP discharges contaminants to air at a greater rate than the Project due to the nature of coal-fired power plants, and consequently the model predictions are higher for the cumulative assessment. It is noted that the existing background concentrations as measured at both Pekanbaru and at the baseline monitoring sites would include the Tenayan CFPP discharges, and so adding the background concentrations to the model predictions could be seen as ‘double counting’.

Regardless, the incremental increase in ambient concentrations of CO, PM_{10} and SO_2 resulting from the combined Tenayan CFPP and the Project’s air discharges are well below the ambient air guidelines. It is also noted that the very low discharge rates of these contaminants from the Project mean that the contribution to the ambient concentrations in the region are relatively minor and will not result in significant increases in ambient air concentrations.

Based on the above assessment, the impact magnitude as per the matrix provided in Section 2 of the operation of the Project is expected to be Moderate, in that there will be a permanent and detectable change to the contaminant concentrations (principally NO_X) in the surrounding environment.

The sensitivity of the receiving environment, as per the matrix provided in Section 2, is considered to be Low, in that the dispersion modelling assessment indicates that the surrounding area has some capacity to absorb the change to the increase in the air contaminants without resulting in significant degradation of air quality.

The impact significance on air quality from the operation of the Project (i.e. an activity with a ‘Moderate’ impact upon a Low sensitivity receiving environment) as therefore assessed as being Minor as determined by the matrix provided in Section 2.

17.1.3 Noise

The Technical Report – Noise Impact Assessment (Volume 5 – Technical Appendices) provides an assessment on the cumulative noise impacts of the combined operation of both the Tenayan CFPP and proposed Riau CCPP.

Figure 17.4 and Figure 17.5 present the predicted noise contours for the operational impacts from the combined operation of both power stations.

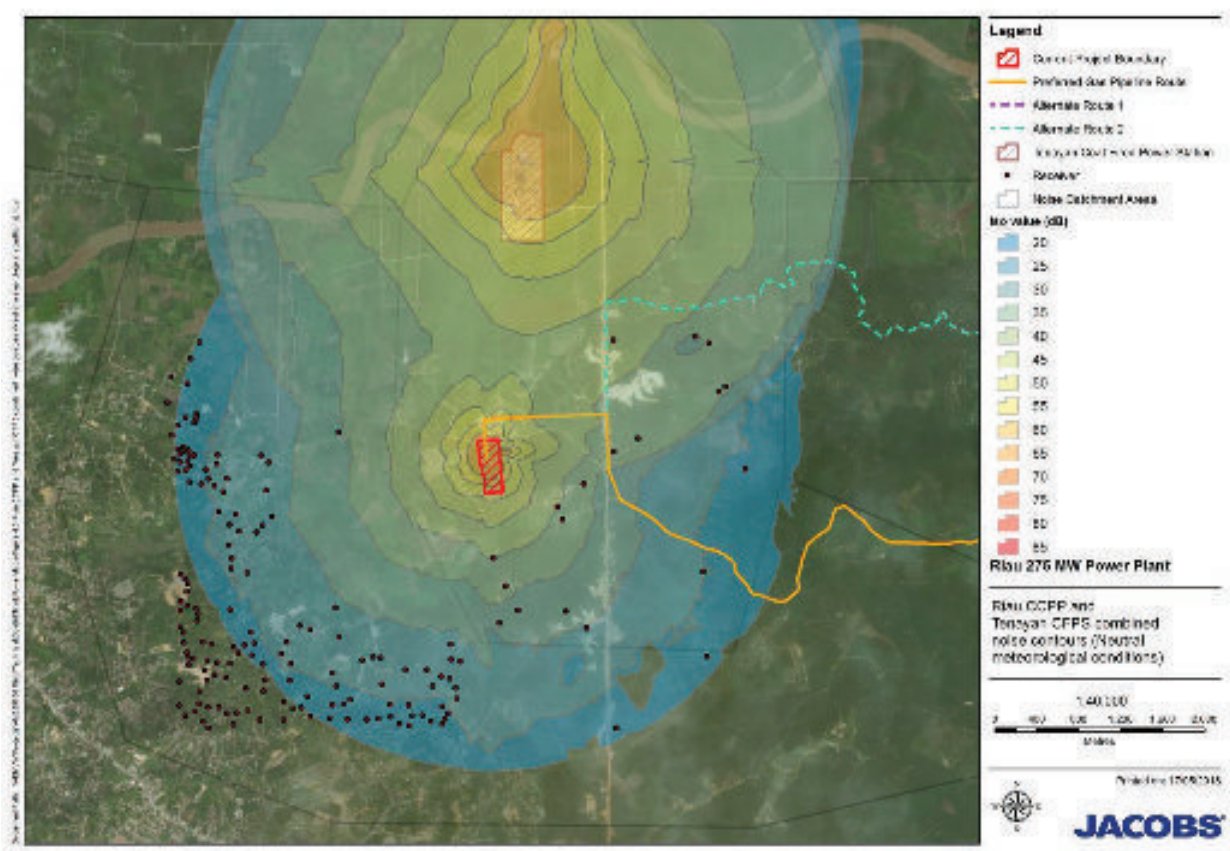


Figure 17.4 : Riau CCPP and Tenayan CFPP Combined Noise Contours (Neutral Meteorological Conditions)

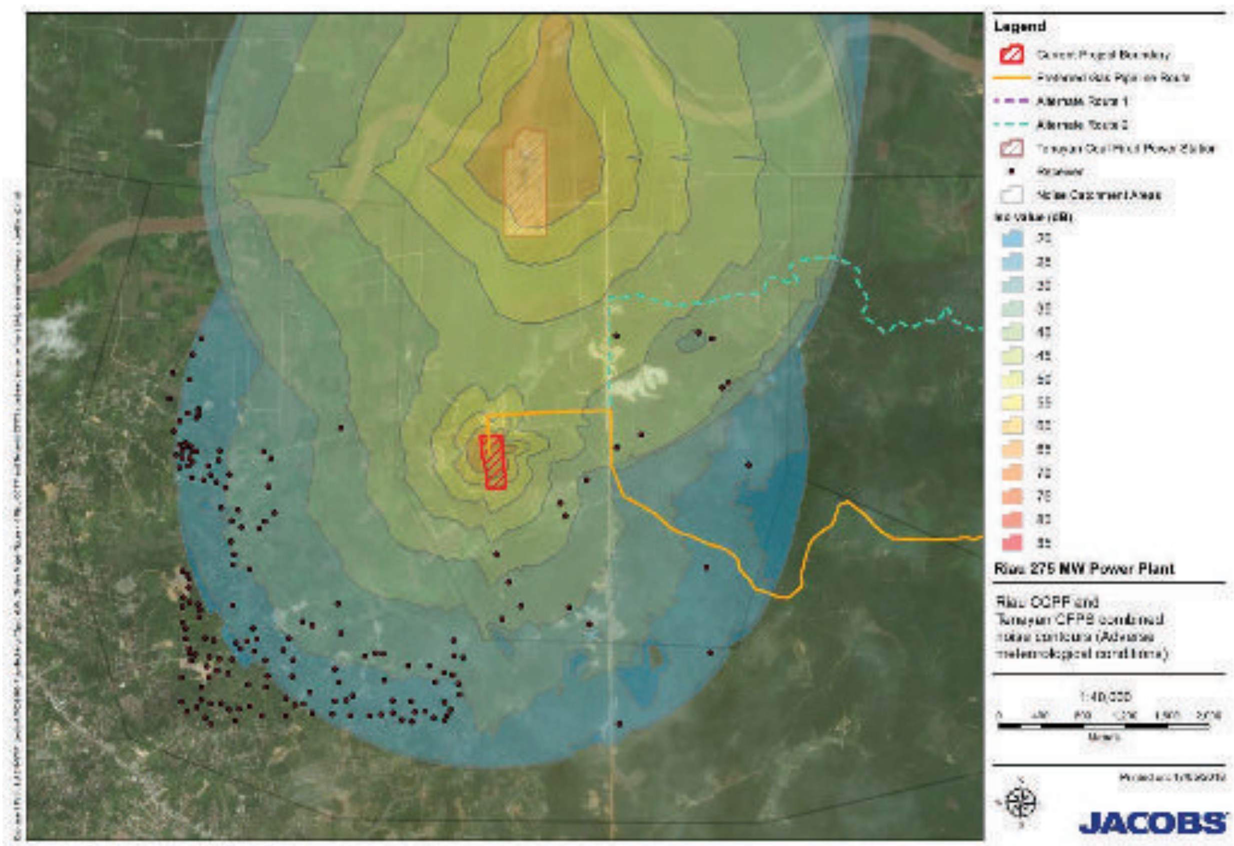


Figure 17.5 : Riau CCPP and Tenayan CFPP Combined Noise Contours (Adverse Meteorological Conditions)

It can be seen that as most noise receivers are generally located south of the Riau CCPP, combined impacts are not substantially different to those from the Riau CCPP alone.

Under worst case, adverse weather conditions, the largest increases in noise under accumulative scenario are predicted for receivers located to the north east and north west of the Riau CCPP. In these areas cumulative noise levels are forecast to be up to 5 dB(A) above those of the Riau CCPP alone, however they are predicted to remain below the project criteria at all receiver locations. No change to predicted noise levels is expected in other NCAs.

Predicted noise levels under neutral meteorological conditions are expected to be 5 dB(A) below those predicted above for NCA, while no change is predicted in other NCAs.

Cumulative noise impacts are expected to remain below the project criteria at all receiver properties under all meteorological conditions.

17.1.4 Water Quality and Freshwater Ecology

The primary operational impacts that may have cumulative impacts are the water take and discharge. It is assumed that the Tenayan CFPP would require similar water take volumes to the Project and also give rise to similar effluent volumes treated to comply with the same guidelines.

The water supply volume of the project is very small as a portion of river flow and thus unlikely to modify flows and levels and impact upon the ecology. If the existing Tenayan CFPP were taking a similar or even double the volume proposed by the Project, then the potential impacts are still likely to be less than 5% of the low flow in the river and thus unlikely to give rise to cumulative environmental impacts which are no more than **Minor**.

The discharges from both power plants both have to meet the same local and international guidelines at the point of discharge. While discharges are likely to be physically located close to each other the risk of any cumulative impact is small as the effluents should be appropriately treated and the mixing zones will be small given the size of the river and amount of available dilution. The cumulative impact of these discharges on the Siak River will be **Minor**.

17.1.5 Terrestrial Ecology

The proposed power plant is within an area zoned for Industrial and Warehousing according to the Pekanbaru City Spatial Plan. From a terrestrial ecology perspective, although much of the surrounding area is considered to be *modified habitat*, the loss of the palm oil plantations to further development projects is likely to be detrimental to the species still present in the local area.

A mitigation measure that could compensate for this would be to protect an area of land that could be either allowed to revert to the natural habitat type, wetland/ swamp forest; or be managed to diversify the species grown so that the oil palm is not so dominant. Either option would provide an area of land that could support species displaced from the locality and have an aim of increasing the diversity of species in the long term.

17.1.6 Hydrology

The cumulative impacts relating to the abstraction and discharge of treated water from the Riau CCPP and the Tenayan CFPP will be **Negligible**. The Riau CCPP water intake and discharge points are located upstream of the Tenayan CFPP on the Siak River. The Riau CCPP water take is small which is in part offset by the treated wastewater discharged back to the Siak River for the power plant above the Tenayan CFPP and as such will have no impacts on the operation of the Tenayan CFPP. The Tenayan CCFP's water take is also small and the combined take will have **Negligible** cumulative impacts on the Siak River

The discharge of effluent water from the operation of the Riau CCPP with slightly higher temperatures (3.6 °C above that of the Siak River) is expected to have a small mixing zone (<20 m) and will due to the large level of dilution provided by the Siak River flow rapidly mix and not be distinguishable from the Siak River's background temperature. The Tenayan CFPP discharge is below that of the Riau CCPP discharge and at the point that it discharges into the Siak River the Riau CCPP discharge would not be distinguishable above background. Due to the location and size of the discharges form the power plants the thermal plumes would not overlap and there would be no noticeable cumulative impacts.

18. Summary of Environmental Impact Assessment

This section provides a summary of residual impacts assessed in this volume. The residual impacts are those that remain once the recommended mitigation measures outlined within each assessment have been applied and therefore represents the most likely impacts from construction and operation of the power plant and pipeline.

Table 18.1 : Summary of Residual Impacts

Receptor	Residual Impact
Air	
Power plant construction phase	Minor
Power plant operational phase	Minor
Greenhouse Gas	
Overall	Negligible
Hydrology	
Power plant construction	Negligible
Power plant operation	Negligible
Pipeline construction	Negligible
Landscape and Visual	
Overall	Moderate - low
Noise	
Power plant construction	Negligible
Transmission line construction	Negligible
Pipeline construction	Minor
Power plant, transmission line and pipeline operation	Negligible
Soils, Geology and Groundwater	
Overall	Negligible
Terrestrial Ecology	
Temporary habitat loss on pipeline route	Negligible
Disturbance	Negligible
Mortality/injury of species	Negligible
Traffic	
Construction	Moderate
Post-construction	Minor
Water Quality and Freshwater Ecology	
Construction and use of temporary jetty	Minor
Construction of water supply and discharge structures	Negligible
Pipeline construction	Negligible
Abstraction of water	Negligible

Receptor	Residual Impact
Hazardous Substances and Waste	
Overall	Negligible

In addition to the above it is also noted that a minor positive impact is anticipated in regards to permanent habitat loss, through mitigation planting that would replace the highly modified vegetation dominating the site, being palm plantation.

No cumulative impacts have been assessed as High or Moderate in relation to the combined operation of both the Tenayan CFPP and proposed Riau CCPP.

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