Draft Environmental and Social Impact Assessment Report (ESIA) – Part 4

Project Number: 51112-001
March 2018

INO: Jawa-1 LNG to Power Project

Prepared by ERM for PT Jawa Satu Power (JSP)

PLTGU Jawa 1 Independent Power Project

ANNEX E
ACOUSTICS ASSESSMENTS

Prepared for:

PT Jawa Satu Power (JSP)

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CONTENTS

EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) on behalf of PT Jawa Satu Power (JSP) has completed a preliminary acoustics assessment for the PLTGU Jawa-1 project (the project).

Overview

Nuisance, or an unacceptable level of noise (and vibration) amenity, may arise due to construction and operational activities associated with new or existing developments. This potential for issues to arise is associated with air-borne, ground-borne and underwater emissions from significant project noise and vibration generating sources that are in close proximity to potentially sensitive human and wildlife receptors i.e. nearby dwellings, schools, churches, commercial/industrial facilities, or sea life near off-shore assets.

The assessment was conducted to achieve a scope of works that addressed these potential noise and vibration issues by evaluating, predicting and assessing construction and operational noise and vibration from the project (offshore, nearshore and onshore components) at the closest and/or potentially most affected sensitive receptors near the project site.

A qualitative assessment has been conducted for project noise and vibration components that have limited or no potential to generate any impacts at nearby receptors, whilst a quantitative assessment has been conducted for other components where a potential for impacts to occur has been identified. The focus of the quantitative (modelling) assessment was air-borne operational noise associated with the CCGT Power Plant and the 500 kV transmission line.

Findings

Based on the qualitative assessment documented in Chapter 3 of this report, potential construction (including road traffic) air-borne noise and ground-borne vibration impacts to human receptors and underwater noise impacts to wildlife receptors were identified. On this basis, construction safeguards and provisions are presented in Chapter 7 of this report and target significant emission generating works and activities, for the various offshore, nearshore and onshore components associated with the development, that are proposed to occur within and near the project site.

The CCGT Power Plant results presented in Chapter 6 of this report identify that the predicted project noise levels ($L_{eq,\ 1hour}$) associated with the CCGT Power Plant are below project-specific noise criteria adopted for this assessment. Evaluating the predicted noise levels with regard to the project-specific noise criteria and the method described in Section 5.1.2 of this report, identifies that an acceptable level of impact is anticipated. On this basis, additional operational noise mitigation to that already implemented into the project design is not recommended. Suitable safeguards and provisions are however provided in Chapter 7 of this report.

The 500 kV results presented in Chapter 6 of this report identify that predicted project noise levels ($L_{eq, 1hour}$) associated with the 500 kV transmission line are at or below the project-specific criteria for the majority of potential receptors. Evaluating the predicted noise levels with regard to the project-specific noise criteria and the method described in Section 5.1.2 of this report, identifies that an acceptable level of impact is anticipated for the majority of receptors. An unacceptable level of impact could occur but this is limited to receptors situated in close proximity to the transmission line. On this basis, additional operational noise mitigation to that already implemented into the project design is not recommended. Suitable safeguards and provisions are however provided in Chapter 7 of this report.

Residual Impacts and Closing

Construction and operational noise and vibration levels will be reduced and impacts (if any) minimised with the successful implementation of the safeguards and provisions provided in Chapter 7 of this report. Impacts may not be reduced to negligible (low) levels for all receptors and for all project components and phases; however the recommendations presented here will ensure that any residual impacts are minimised as far as may be practically achievable.

No further recommendations for mitigation and management measures to those established by the findings of this noise and vibration assessment, and documented in this report, are provided or warranted. JSP should however remain aware of the potential for nuisance, or an unacceptable level of amenity, to occur due to construction or operational noise and vibration and continue to plan for and then manage the works and design accordingly.

1 INTRODUCTION

This report has been prepared by Environmental Resources Management Australia Pty Ltd (ERM) on behalf of PT Jawa Satu Power (JSP). It presents the methodology, results and findings of the preliminary acoustics assessment (the assessment) conducted for the PLTGU Jawa-1 project (the project).

Nuisance, or an unacceptable level of noise (and vibration) amenity, may arise due to construction and operational activities associated with new or existing developments. This potential for issues to arise is associated with air-borne, ground-borne and underwater emissions from significant project noise and vibration generating sources that are in close proximity to potentially sensitive human and wildlife receptors i.e. nearby dwellings, schools, churches, commercial/industrial facilities, or sea life near off-shore assets.

The purpose of this assessment is to address these potential issues by evaluating, predicting and assessing construction and operational noise and vibration from the project (offshore, nearshore and onshore components) at the closest and/or potentially most affected sensitive receptors near to the project site. A qualitative assessment has been conducted for project noise and vibration components that have limited or no potential to generate any impacts at nearby potentially sensitive receptors, whilst a quantitative assessment has been conducted for other components where a potential for impacts to occur has been identified.

This report has been prepared to present the preliminary findings of the assessment; provide an evaluation of potential project impacts; identify potential mitigation and/or management measures, that may be required to reduce emissions and minimise impacts at nearby sensitive receptors; provide recommendations for further acoustics assessment and/or additional monitoring (if warranted); and then highlight any residual issues and impacts associated with project's noise and vibration.

1.1 PROJECT OVERVIEW

The Project involves the development of a Combined Cycle Gas Turbine (CCGT) Power Plant, a Liquefied Natural Gas (LNG) Floating Storage and Regasification Unit (FSRU), a 500kV power transmission line and an ancillary Substation.

The Project includes the following main components:

- **Floating Storage and Regasification Unit (FSRU)** - an FSRU with a nominal capacity of 86,400 DWT will be permanently moored offshore at a distance of 4.79 nautical miles off the north Ciasem Bay coast. The FSRU will receive LNG deliveries from BP Tangguh via Tankers with capacities of 125,000 m^3 to 155,000 m^3. The FSRU will be equipped with facilities to regassify the LNG for delivery to an **Onshore Receiving Facility (ORF)**.

- **Gas Delivery Pipelines** – a subsea gas pipeline of approximately 14 km will be required to deliver gas to shore. An onshore pipeline of approximately seven kilometres will deliver gas to the ORF.

- **Seawater Water Intake** and **Cooling Water Outfall Discharge Pipeline** – a sea water intake pipeline and pump station will be established close to shore front while a cooling water discharge pipeline will also be established.

- **Jetty** – a Jetty will be built to support mobilisation of heavy equipment and material. The jetty will be constructed at Muara Village, approximately 1.34 kilometres from the mouth of the Cilamaya River. After the construction is complete the jetty will remain to support emergency operations and CCGT maintenance. The Jetty will occupy an area of 500 m^2 (50 m x 10 m). Dredging is expected to be carried out during construction.

- **1,760 MW CCGT Power Plant** – the CCGT Power Plant will occupy an area of approximately 36.7 Hectares. This will house the gas turbine buildings, cooling towers and associated facilities and infrastructure.

- **Onshore Receiving Facility** – an onshore receiving facility will be developed to treat gas prior delivery to the Gas Turbines within CCGT Power Plant.

- **Construction and Access Road** – the construction road is a temporary road which will be used for the mobilisation of pipelines as well as the mobile heavy vehicles i.e. backhoes, excavators etc. An access road will be constructed between the equipment jetty and the power plant. An access road will be six metres in width and has one metre slope on both sides.

- **500 kV Transmission Line** – a 52.16 kilometre transmission line will be developed to transfer electricity from the Power Plant to the Cibatu Baru II/ Sukatani substation.

- **Cibatu Baru II/Sukatani Substation** – a 500kV substation will be developed to connect the 500kV transmission line to the Java-Bali grid.

Of particular importance to this preliminary acoustic assessment includes the operation of the CCGT Power Plant and 500kV transmission line, as they are expected to generate substantial noise. A summary of the anticipated noise-generating activities associated with the operation of the CCGT Power Plant and 500kV transmission line is provided below.

1.1.1 CCGT Power Plant

The 1,760 MW Combine Cycle Gas Turbine (CCGT) Power Plant will be developed on a 36.7 ha or 367 m^2 parcel of land located in Cilamaya Village, Cilamaya Wetan District and Karawang Regency. Cilamaya Village is located next to the site with some residences sharing a boundary with the site, which may pose an issue in regards to noise and nearby affected landowners. The power plant complex will consist of five main buildings supported by other infrastructure, including the ORF, two turbine buildings, Heat Recovery Steam Generator (HRSG), Control and Electrical building (CEB), Cooling Towers, administration building and a workshop/warehouse building.

Anticipated noise-generating components associated with the operation of the CCGT Power Plant include:

- ORFs which are used to receive and measure the amount of gas used by the power plant, and houses a pig receiver, gas filters, pressure letdown skid, metering packages, indirect fired water bath heater, vent stack and flow computer building.
- Steam Turbine, which includes a Condenser, Condensate System, Feedwater System and an array of Air and Gas Systems.
- Cooling of the CCGT Power Plant through the use of indirect wet cooling system, using seawater cooling towers.
- Operation and maintenance of the Seawater Supply System and associated infrastructure (seawater intake structure and pumping stations), and Water Treatment and Waste Water Treatment Plants.

The most significant operational noise emission sources are discussed in *Section 3* and assessed in *Section 6.1* of this report.

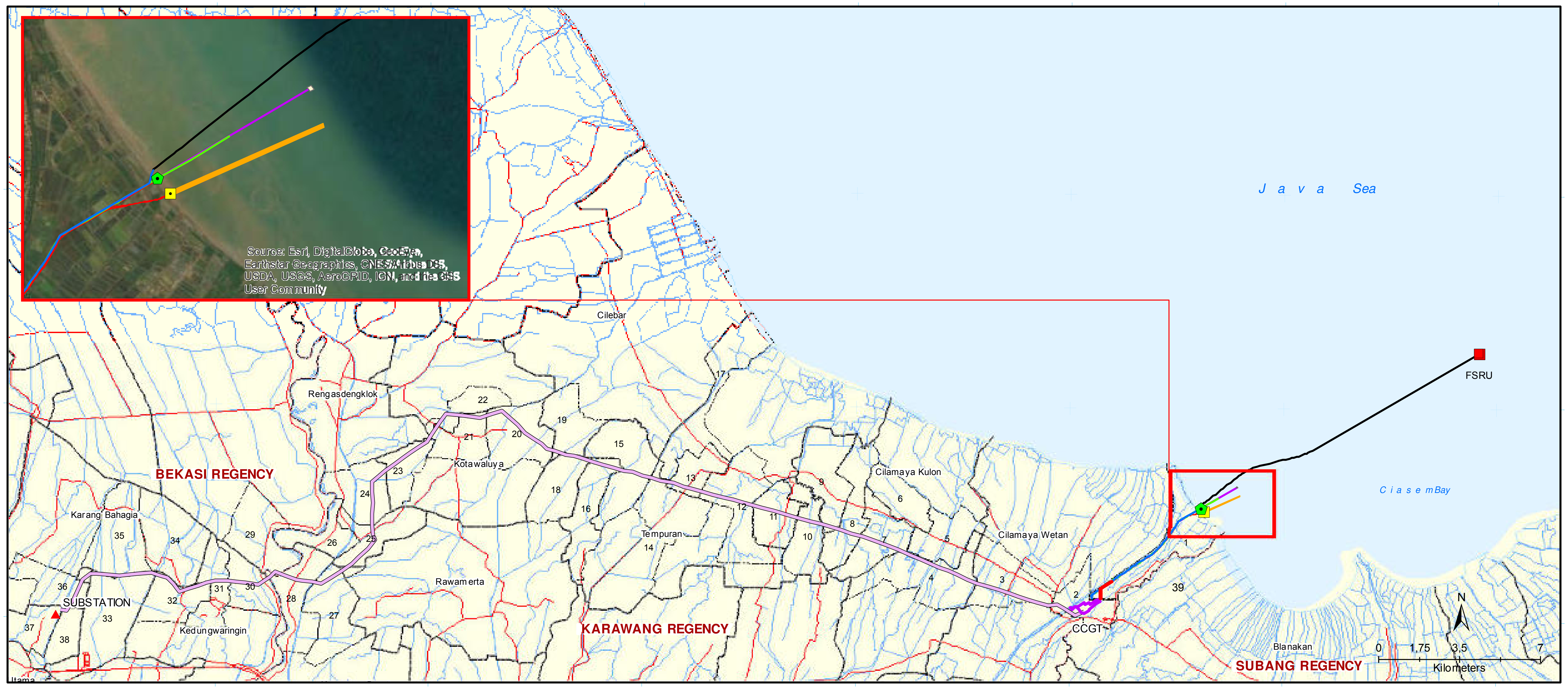
1.1.2 500 kV Transmission Line

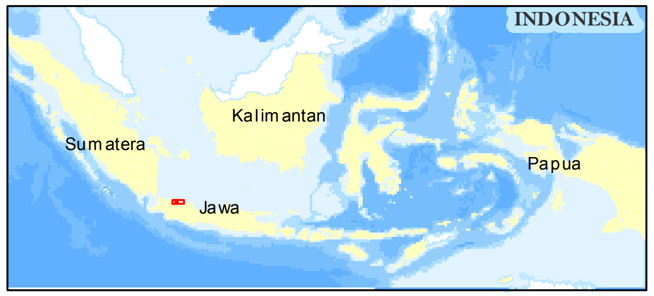
A 52.16 km 500kV Transmission Line will be established from the CCGT Power Plant in Cilamaya to Cibatu Baru II/Sukatani EHV Substation in Sukatani. The line will comprise 118 transmission towers with a transmission corridor of approximately 17 metres each side of the transmission lines established, as required by local regulation.

The line will run through two regencies; Karawang and Bekasi and will affect 35 villages. The proposed transmission line route crosses mainly areas of land used for agricultural purposes e.g. rice paddy fields etc. The primary noise-generating activity associated with the operation of the transmission line is associated with corona noise which as discussed in *Section 3.2* and assessed in *Section 6.2* of this report.

1.2 SITE DESCRIPTION

The proposed project spans across sections of the Subang, Karawang and Bekasi Regencies of Western Java, approximately 100 kilometres east of Jakarta, Indonesia. The JAWA-1 Project, surrounding area and other items of importance to this assessment are identified in *Figure 1.1* to *Figure 1.3* below.





LEGEND

- Village Boundary
- District Boundary
- Regency Boundary
- Road
- River/Irrigation

Project Plan

- FSRU Loaction
- Jetty Location
- Pump Station
- Offshore Gas Pipeline from FSRU
- Discharge Pipeline
- Intake Pipeline
- Dredging Plan for Jetty Access
- Onshore Pipeline (Gas, Intake, and Outflow)
- Access Road to Pump Station and Jetty
- Transmission Line
- CCGT Power Plant

Impacted Village and Lcoation

Regency	District	Village
Karawang	Cilamaya Wetan	1. Muara
		2. Cilamaya
		3. Sukatani
	Cilamaya Kulon	4. Sukamulya
		5. Pasirukem
		6. Muktijaya
		7. Tegalurung
		8. Manggungjaya
		9. Sumurgede
	Tempuran	10. Jayanegara
		11. Purwajaya
		12. Pagadungan
		13. Pancakarya
		14. Lemahduhur
		15. Lemahkarya
		16. Dayeuhluhur
		17. Tanjungjaya
	Rawamerta	18. Sukaraja
	Cilebar	19. Sukaratu

Regency	District	Village
Karawang	Kutawaluya	20. Sindangsari
		21. Sampalan
		22. Waluya
		23. Mulyajaya
	Rengasdengklok	24. Karyasari
		25. Kalangsuria
		26. Kalangsari
	Karawang Barat	27. Mekarjati
		28. Tinggarjati
Bekasi	Pebayuran	29. Bantarjaya
	Kedungwaringin	30. Karangmekar
		31. Mekarjaya
		32. Karangharum
	Cikarang Timur	33. Karangsari
	Karang Bahagia	34. Karangmukti
		35. Karangsatu
		36. Karangrahayu
	Cikarang Utara	37. Karangraharja
		38. Waluya
Subang	Blanakan	39. Blanakan

Source:
- Jawa Satu Power, 2017
- Administgration Map of Bekasi Regency, Govenment ofBekasi Regency 2011
- Indonesia Topographical Map Sheet1209-631 Cilamaya, First Edition, 1990
- Indonesia Topographical Map Sheet1209-542 Purwajaya, First Edition, 1990
- Indonesia Topographical Map Sheet1209-541 RengasdengklokFirst Edition, 1999
- Indonesia Topographical Map Sheet1209-532 Sukatani, First Edition, 2001
- Indonesia Topographical Map Sheet1209-514 Cikarang, First Edition, 2000
- Indonesia Topographical Map Sheet209-523 Karawang,First Edition,1999
- Indonesia Topographical Map Sheet1209-524 Lemahabang, First Edition, 1999
- Indonesia Topographical Map Sheet1209-613 Jatisari, First Edition,1999

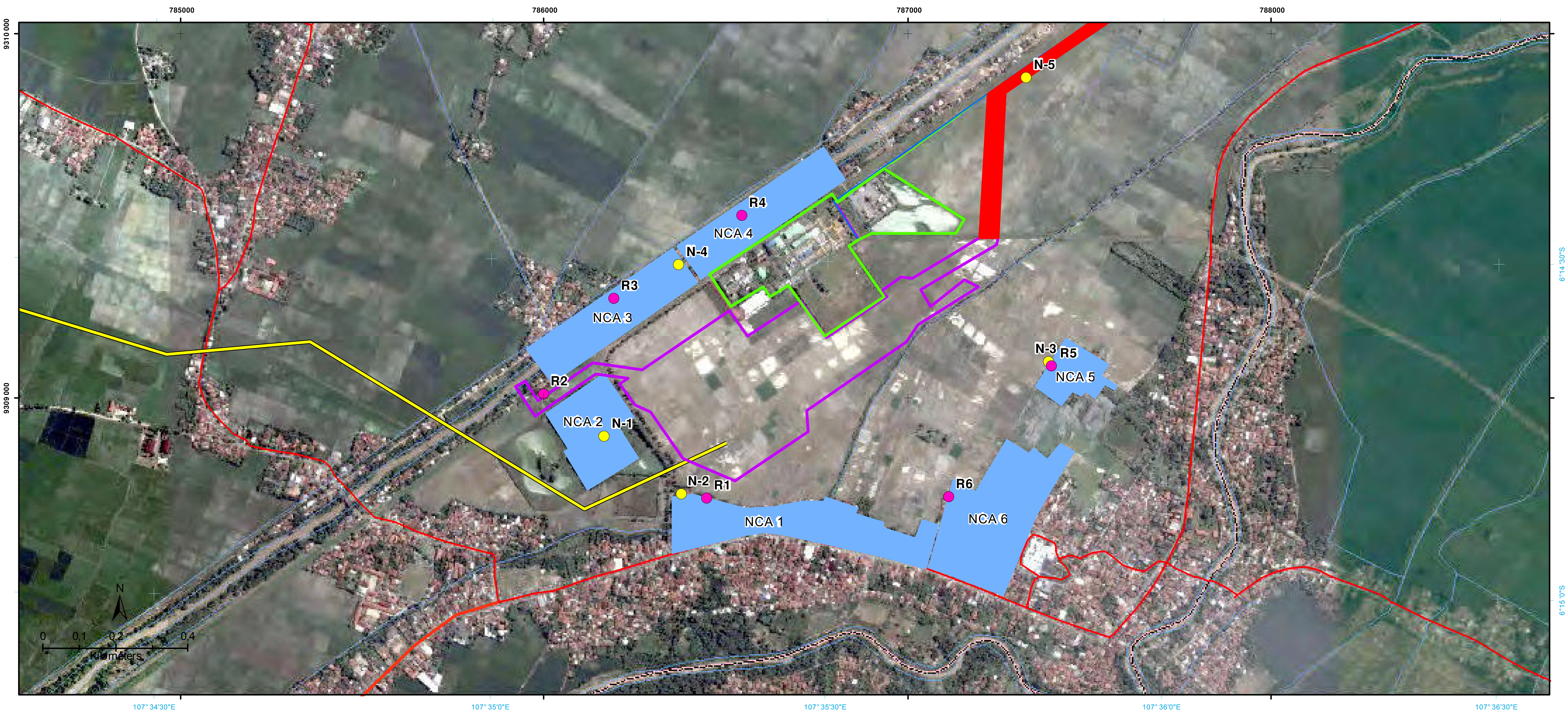
JAWA SATU POWER

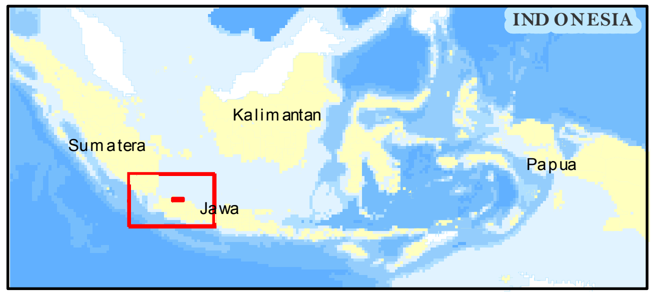
Environmental and Social Impact Assessment (ESIA) for Jawa-1 Project

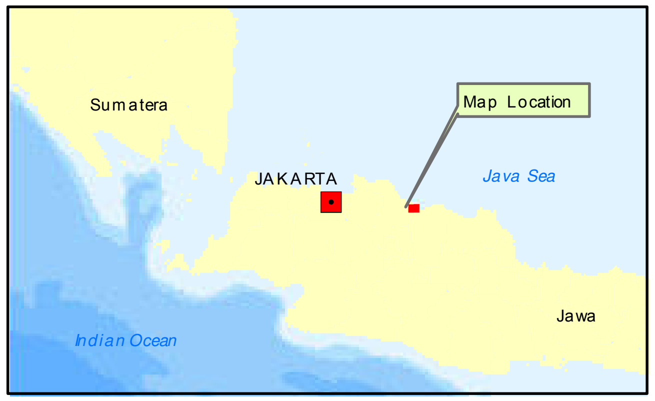
Figure 1.1
Project Location

ERM

Drawn By : IF & IA	Client : Jawa Satu Power
Checked By : FF	Date : 13/03/2018
Revision :	Map Number :







LEGEND

- Arterial Road
- River/Irrigation
- Distict Boundary
- Regency Boundary

Project Plan

- Onshore Pipeline (Gas, Intake, and Outflow)
- Access Road to Pump Station and Jetty
- Transmission Line
- CCGT Power Plant
- Nearest Receiver

Sampling Point

- Samsung Noise Monitoring Location
- ESIA Noise Monitoring Location

Source:
- ESRI Online Imagery, 2017
- Jawa Satu Power, 2017

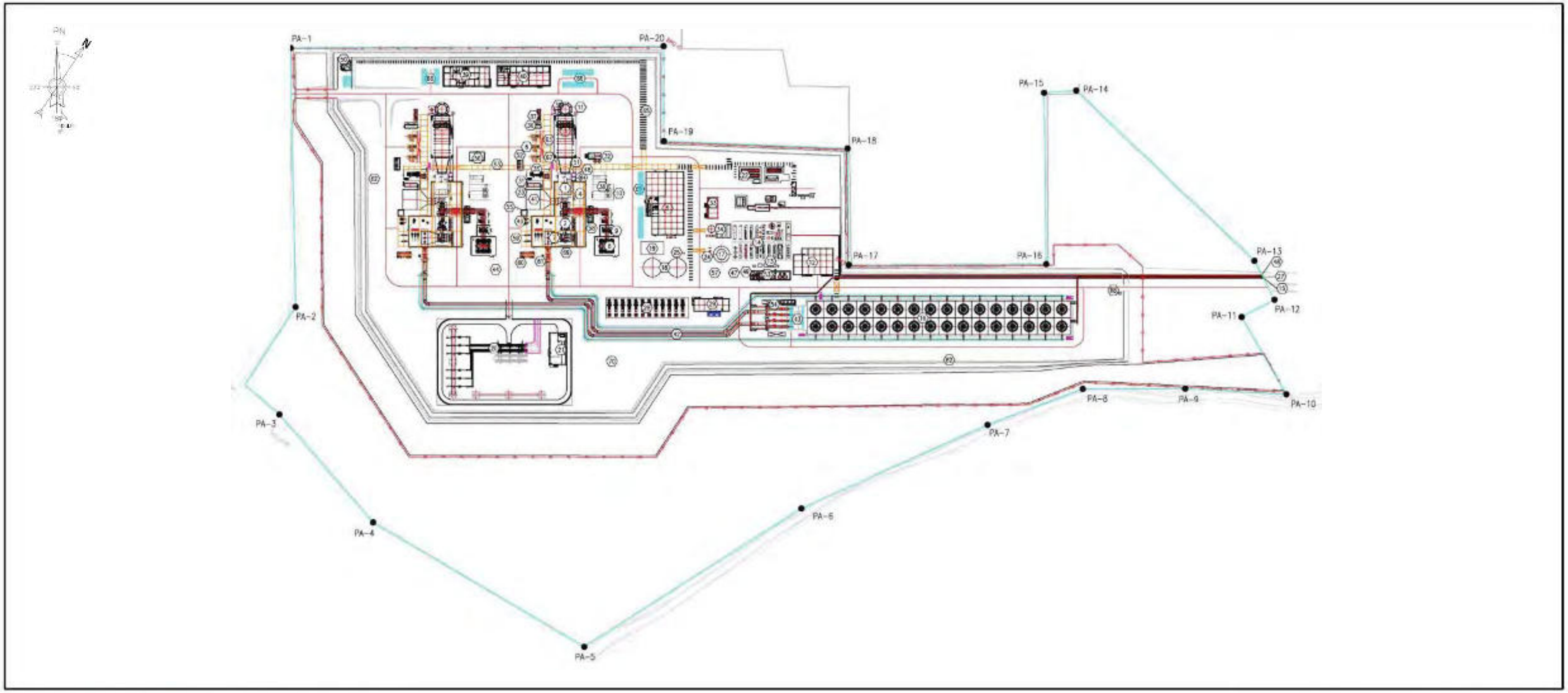
JAWA SATU POWER

Environmental and Social Impact Assessment (ESIA) for Jawa-1 Project

Figure 1.2
CCGT Power Plant
Noise Catchment Areas (NCA)
and Receptors

Drawn By :	IA	Client :	Jawa Satu Power
Checked By :	NL	Date :	13/03/2018
Revision :		Map Number :	

ERM



LEGEND

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JAWA SATU POWER

Environmental and Social Impact Assessment (ESIA) for Jawa-1 Project

Figure 1.3
CCGT Power Plant General Arrangement

Drawn By :	IA	Client :	Jawa Satu Power
Checked By :	NL	Date :	09/02/2018
Revision :		Map Number :	

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2 *ASSESSMENT METHODOLOGY*

This chapter summarises the general methodology adopted to assess potential noise and vibration impacts associated with the project (offshore, nearshore and onshore components), at nearby receptors.

A qualitative assessment of project components and potential impacts is provided in *Chapter 3* of this report, for project components and phases where limited or no potential to generate impacts at nearby potentially sensitive receptors is anticipated, or where further assessment is not warranted at this stage as their impacts are readily mitigated or managed via standard industry practices.

Chapter 3 also presents the justification of the quantitative operational noise assessment for significant emission generating sources, such as the CCGT Power Plant facility and the 500 kV Transmission Line. Further information regarding these quantitative assessments is provided in *Chapter 3* below.

2.1 *OVERVIEW*

The scope of this assessment is limited to the supplied project information and designs and was completed based on the preliminary information available at the time the assessment was conducted. The assessment includes consideration of the following features:

- Construction (including road traffic) air-borne noise and ground-born vibration impacts to human receptors from significant emission generating works and activities, for the various on-shore components and phases associated with the development, that are proposed to occur within and near the project site.
- Construction underwater noise impacts to wildlife receptors from significant emission generating works and activities, for the various off-shore components and phases associated with the development, that are proposed to occur within and near the project site[1].
- Operational air-borne noise and ground-born vibration impacts to human receptors from significant emission generating activities, for the various on-shore components and phases associated with the development (i.e. significant fixed infrastructure assets such as the CCGT Power Plant and the transmission line) that are proposed to occur within and near the project site.

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[1] This acoustical feature is being assessed in more detail by other specialists but given its association with the potential project noise, has been evaluated in this assessment with conceptual recommendations being provided.

2.2 *SCOPE OF WORKS*

To achieve the assessment summarised in *Section 2.1* above the following scope of works was required:

- Reviewing existing relevant information and data to identify significant noise and vibration generating machinery and equipment that are being used, or activities undertaken, as part of the projects construction and operation.

- Identifying the closest and/or potentially most affected human (onshore) and wildlife (offshore) receptors situated within the potential area of influence of the project.

- Describing and quantifying (where possible) the existing acoustics environment and general noise conditions near the human and wildlife receptors identified above.

- Adopting the existing project-specific noise criteria and establishing project-specific vibration criteria.

- Providing a quantitative operational noise assessment by establishing a project-specific noise model to predict levels from significant emission generating fixed infrastructure, such as the CCGT Power Plant and the transmission line. Then, providing a comparison of the predicted levels to the project-specific noise criteria to identify project components and associated emissions that are likely to exceed criteria, and therefore, have potential to generate impacts at nearby potentially sensitive receptors.

- Providing a qualitative construction noise and vibration and operational vibration assessment of project components and associated emissions that are unlikely to exceed criteria and have limited or no potential to generate impacts at nearby potentially sensitive receptors.

- Developing conceptual mitigation and management measures that are designed to reduce noise and vibration levels to acceptable or compliant values and estimating their effect. These measures are provided as recommendations, safeguards and provisions for construction and operational noise and vibration mitigation and management measures in this report. They are intended for consideration and implementation by JSP. It is beyond the scope of this assessment to evaluate whether these measures are feasible, reasonable or practical to implement at the project.

- Evaluating the magnitude and extent of potential residual impacts associated with the project's construction and operation. Then, providing recommendations for further acoustics assessment e.g. during detailed design and/or additional monitoring e.g. post construction, where the potential residual impacts warrant it.

2.3 *RELEVANT DOCUMENTS, POLICY AND STANDARDS*

This assessment has been conducted with due regard to the following documents, policy and standards:

- British Standards Institution (BSI, United Kingdom) – BS 6472 - *Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* (BS 6472), dated 1992.
- British Standards Institution (BSI, United Kingdom) – BS 5228 - *Code of Practice for Noise and Vibration Control on Construction and Open Sites* , Part 2: Vibration (BS 5228:2), dated 2009.
- Department of Environment and Conservation NSW (DECC, Australia) – *Assessing Vibration: a Technical Guideline* (DECC Guideline, 2006), dated February 2006.
- German Institute for Standardisation (GIS, Germany) – DIN 4150 Part 3: *Structural Vibration: Effects of Vibration on Structures* (DIN 4150:3), dated February 1999.
- International Organisation for Standardisation (ISO) 9613-2:1996 (ISO 9613:2) - *Acoustics - Attenuation of Sound during Propagation Outdoors - Part 2: General Method of Calculation*.
- Joint Nature Conservation Committee (JNCC) - *Annex A - Guidelines for Minimising the Risk of Disturbance and Injury to Marine Mammals from Seismic Surveys* (JNCC Annex A: Guideline, 2009), dated June 2009.
- Joint Nature Conservation Committee (JNCC) - *Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys* (JNCC Guideline, 2017), dated August 2017.
- World Bank Group: International Finance Corporation (IFC) - *Environmental, Health, and Safety Guidelines for Thermal Power Plants* (IFC Thermal Power Plants Guideline, 2017), draft for second public consultation, dated May/June 2017.
- World Bank Group: International Finance Corporation (IFC) - *Environmental, Health and Safety (EHS) Guidelines - General EHS Guidelines: Environmental Noise Management*, Section 1.7 Noise (IFC 1.7 Noise), dated 30 April 2007.
- World Bank Group: International Finance Corporation (IFC) - *Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution* (IFC Electrical Power Guideline, 2007), dated 30 April 2007.

2.4 *ACOUSTICS GLOSSARY*

A glossary of relevant acoustical concepts and terminology is provided in *Annex A* of this report.

3 PRELIMINARY EVALUATION OF IMPACTS

The overall assessment features were summarised in *Section 2.1* of this report. This chapter outlines the evaluation of all potential construction and operational noise and vibration sources and impacts for the various project components and activities.

This preliminary evaluation is a key feature of the assessment methodology established for a project of this scale and design and enables a focused assessment of the most significant issues with the potential to impact surrounding receptors or the broader community.

A qualitative assessment of project components and potential emissions is provided here for project components and phases where limited or no potential to generate impacts at nearby potentially sensitive receptors is anticipated, or where further assessment is not warranted at this stage as their impacts are readily mitigated or managed via standard industry practices.

This chapter also presents the justification of the quantitative operational noise assessment for significant emission generating sources, such as the CCGT Power Plant facility and the 500 kV Transmission Line. Further information and technical methods regarding these quantitative assessments is provided in *Section 3.2* below.

The remainder of this document focuses on the quantitative assessment that has been conducted for offshore, nearshore and onshore project components and phases where a potential for residual impacts to occur has been identified. Regardless, conceptual recommendations for general mitigation and management measures are provided in *Chapter 7* of this report to assist minimise impacts if needed.

3.1.1 Construction Noise and Vibration Impacts

An evaluation of likely construction (general works and activities, and road traffic) air-borne noise and ground-born vibration impacts to human receptors has been conducted. An evaluation of likely construction underwater noise impacts to wildlife receptors was also completed.

General Construction (Onshore and Nearshore)

The evaluation of likely construction (general works and activities) air-borne noise and ground-born vibration impacts to human receptors, and underwater noise impacts to wildlife receptors did however identify a potential for issues to occur.

Based on the type of construction works and activities that will be required for the onshore a) 1,760 MW CCGT Power Plant, b) Onshore Receiving Facility, c) 500 kV Transmission Line d) onshore gas delivery pipeline and e) Cibatu Baru II/Sukatani Substation identify it is likely that significant noise and vibration impacts would occur that may warrant consideration of mitigation and management measures. Consistent with the statement above for nearshore activities, recommendations to reduce levels and minimise onshore impacts can be established without the need for a quantitative (modelling) assessment to occur.

Similarly, the type of construction works and activities that will be required for the nearshore a) Seawater Water Intake, b) Cooling Water Outfall Discharge Pipeline and c) Jetty, it is likely that significant noise and vibration impacts would occur that may warrant consideration of mitigation and management measures.

This is however typical of projects of this scale and design and recommendations to reduce levels and minimise impacts can be established without the need for a quantitative (modelling) assessment to occur. These recommended noise and vibration mitigation and management measures are commonly incorporated into good construction management practices that are feasible, reasonable and practical to implement on-site.

Further Discussion: noise emissions from construction works can also vary significantly depending on the type of activity being conducted e.g. site preparation, bulk earthworks, building construction etc and the level of noise reducing mitigation being implemented. The distance offset to potentially sensitive receptors also influences the received noise level and magnitude of impacts. Construction fleet noise emissions values (combined emission from multiple sources) can vary but are commonly in the range of 110 dBA (e.g. site preparation) to 130 dBA (e.g. demolition), and good practice construction mitigation can readily achieve noise level reductions of approximately 10 dBA.

These parameters provided above are only conceptual but identify that noise levels may comply with the IFC 1.7 Noise "Disturbance" criteria (refer *Chapter 5*) at a worst-case (130 LW, dBA) distance of 2,250 metres during the daytime and 7000 metres during the night time. With a lower noise fleet (110 LW, dBA) these distances reduce to 225 metres during the daytime and 700 metres during the night.

Based on the conceptual 10 dBA reduction due to mitigation being implemented noise levels may comply with the IFC 1.7 Noise "Disturbance" noise criteria (refer *Chapter 5*) at a worst-case (130 LW, dBA) distance of 700 metres during the daytime and 2,250 metres during the night time. This feature identifies the significant spatial reduction to potential impacts due to effective noise reducing mitigation being implemented. With a lower noise fleet (110 dBA) this distance reduces again to 70 metres during the daytime and 225 metres during the night.

Based on these general statements provided above it is possible to derive "safe work distance offsets" which require consideration of mitigation and/or management measures to be considered and implemented, but beyond which no further mitigation may be required.

For vibration, impacts are usually not experienced for the majority of normal construction works and activities that are commonly conducted for projects of this nature at distances beyond 100 metres. Inside this distance good construction management practices should be implemented and vibration will likely be perceptible and may generate significant human exposure and annoyance issues, within 50 metres there is potential for structural damage impacts, depending on the works being undertaken. Beyond 100 metres vibration may be perceptible but is unlikely to generate significant human exposure and annoyance or structural damage impacts.

Accordingly, recommendations for conceptual general construction noise and vibration mitigation and management measures are provided in *Chapter 7* of this report to assist minimise impacts.

General Construction (Offshore)

The evaluation of likely construction (e.g. piling) underwater noise impacts to wildlife receptors also identified a potential for issues to occur.

Based on the type of construction works and activities that will be required for the offshore a) Floating Storage and Regasification Unit (FSRU) and b) Gas Delivery Pipelines, it is likely that significant underwater noise impacts would occur that may warrant consideration of mitigation and management measures. This is limited however to significant underwater noise generating sources, such as piling, that would require specific measures to be implemented to minimise impacts to wildlife receptors.

As noted earlier in this report, this acoustical feature is being assessed in more detail by other specialists. Given its association with the potential project noise, *Chapter 7* of this report presents recommended safeguard mitigation and management measures specific to this task that are commonly incorporated into good construction management practices.

These recommended safeguards and provisions were derived with due regard to the JNCC Annex A: Guideline, 2009 and JNCC Guideline, 2017), dated August 2017.

Construction Road Traffic (Onshore)

This evaluation identified that significant construction road traffic (noise and vibration) impacts from the project i.e. from vehicles on the construction and access road are not anticipated. Traffic volumes on public roads for the substation and CCGT will be high due to bringing in the soils/rocks etc to site and removing; however they are limited to 12 hour daily haulage. Although project noise levels will be sometimes audible at receptors, the construction road is temporary and will only be used for the mobilisation of pipelines as well as the mobile heavy vehicles i.e. backhoes, excavators etc and the access road (constructed between the equipment jetty and the power plant) will have a limited number of vehicles generating minimal noise emissions when compared to the overall site contribution from other site components. On this basis, significant construction road traffic (noise and vibration) impacts from the project are not anticipated and no further assessment is warranted or provided in this report. Regardless, recommendations for conceptual road traffic noise and vibration mitigation and management measures are provided in *Chapter 7* of this report to assist minimise impacts if needed.

3.1.2 Operational Noise and Vibration Impacts

An evaluation of likely operational air-borne noise and ground-born vibration impacts to human receptors has been conducted. An evaluation of likely operational underwater noise impacts to wildlife receptors was also completed.

General Operation (Onshore and Nearshore)

The evaluation of likely operational air-borne noise and ground-born vibration impacts to human receptors identified a potential for issues to occur for select components of the project.

Based on the type of operational activities proposed for the onshore a) 1,760 MW CCGT Power Plant, and b) 500 kV Transmission Line it is likely that significant noise and vibration impacts could occur that may warrant consideration of mitigation and management measures. Unlike the statements made above for construction works and activities recommendations to reduce levels and minimise onshore impacts are best established via a quantitative (modelling) assessment. This has been completed for the project as documented in *Chapter 6* of this report.

A detailed assessment of operational vibration has not been conducted however based on a) the type of operational equipment that is required for the project and b) the distance offset to the closest and/or potentially most affected receptors, perceptible levels of vibration may be experienced. Specific recommendations for noise and vibration mitigation and management measures are provided in *Chapter 7* of this report.

For the proposed operational activities associated with the nearshore a) Seawater Water Intake, b) Cooling Water Outfall Discharge Pipeline and c) Jetty, and onshore a) b) Onshore Receiving Facility and b) Cibatu Baru II/Sukatani Substation, it is unlikely that significant noise and vibration impacts occur that may warrant consideration of mitigation and management measures.

This is primarily due to significant influence of the key operational activities noted above, or typical design measures that are implemented during detailed design of the project to ensure impacts are minimal, if any at all. Accordingly, suitable recommendations for conceptual noise and vibration mitigation and management measures are provided in *Chapter 7* of this report to assist minimise impacts.

General Operation (Offshore)

The evaluation of likely operational underwater noise impacts to wildlife receptors identified that significant issues are not anticipated to occur. This outcome is broadly based on the type of operational activities, plant, equipment and machinery that are proposed for the Project, and a general evaluation that they do not commonly cause underwater noise impacts.

This acoustical feature is however being assessed in more detail by other specialists and any recommendations by them for underwater noise mitigation and/or management measures (to reduce noise levels and minimise impacts) should be implemented.

Operational Road Traffic (Onshore)

An evaluation of likely operational road traffic air-borne noise and ground-born vibration impacts to human receptors identified that significant operational road traffic (noise and vibration) impacts from the project i.e. from vehicles on the access road are not anticipated. Although project noise levels will be sometimes audible at receptors, the operational access road (constructed between the equipment jetty and the power plant) will have a limited number of vehicles generating minimal noise emissions when compared to the overall site contribution from other site components.

On this basis, significant operational road traffic (noise and vibration) impacts from the project are not anticipated and no further assessment is warranted or provided in this report. Regardless, recommendations for conceptual road traffic noise and vibration mitigation and management measures are provided in *Chapter 7* of this report to assist minimise impacts if needed.

3.2 QUANTITATIVE ASSESSMENTS - FEATURES, INPUTS AND ASSUMPTIONS

Based on the outcomes of the preliminary evaluation of impacts summarised in *Section 3* above, the key features, inputs and assumptions that have informed quantitative aspects of this preliminary acoustics assessment are outlined in *Table 3.1* below.

Information regarding the evaluation of impact significance with due regard to the relevant IFC guidelines is provided in *Chapter 5* of this report, which also presents the project-specific assessment criteria.

Table 3.1 Assessment Features, Inputs and Assumptions

ID	Feature	Description
1	General Acoustics	All sound pressure levels (L_P) presented in this report (eg noise levels predicted at a receptor) are in decibels referenced to 2 x 10^{-5} Pa, with A-weighting applied. All sound power levels (L_W) presented in this report (eg noise levels assigned to specific sources) are decibels referenced to 10^{-12}W, with A-weighting applied. L_W is a measure of the total power radiated by a source. The "sound power" of a source is a fundamental property of the source and is independent of the surrounding environment. This differs from the L_P which is the level of "sound pressure" as measured at distance by a standard sound level meter with a microphone. L_P is the received sound as opposed to LW that is the sound 'intensity' at the source itself.
2a	Noise Modelling	CadnaA (Version 4.5) noise modelling software package was utilised to calculate operational noise levels using the ISO9613:2 and CONCAWE, 1981 noise propagation algorithms (international method for general purpose, 1/1 octaves). For sound calculated using ISO9613:2, the indicated accuracy is ±3dBA at source to receiver distances of up to 1000 metres and unknown at distances above 1000 metres.
2b		The CadnaA noise modelling takes into consideration the sound power level of the proposed site operations, activities and equipment, and applies adjustments for attenuation from geometric spreading, acoustic shielding from intervening ground topography, ground effect, meteorological effects and atmospheric absorption. A mixture of point sources, area sources, emitting facades and roofs, line sources and moving point sources have been adopted to accurately represent project emissions.
2c		A ground factor of 0.7 was adopted for the modelling domain: 0.0 is hard and 1.0 is soft.
2c		Meteorological factors have been incorporated into the CadnaA operational noise model based on representative conditions of the region, including an average temperature of 25° Celsius and a relative humidity of 80%. Modelling was undertaken for neutral (Class D) atmospheric stability conditions, nil winds.
3	Noise Source Data	Sound Power Level (L_W, dBA) data (overall L_W values and spectral data, level per frequency band in 1/1 octaves) incorporated into the project-specific operational noise model was provided for use in the assessment or derived by ERM based on items of similar duty or use. Further information regarding the operational source emission data is provided in *Section 3.2.1* below. Further information regarding the transmission line source emission data is provided in *Section 3.2.1* below.
4	Receptors	A total of eleven noise receptors have been considered in this assessment. Receptors identified as N-1 to N-5 were adopted from the *Samsung C&T – Engineering and Construction Group (Samsung) – Indonesia Jawa-1 Noise Study Review – Ver. 07 - Cooling Tower Re-location to East-Side* report, dated 2016.7.9 and prepared by Samsung - Quality Technology Division, Technical Team (Samsung, 2016 Noise Study Review). An additional six receptors were identified for this assessment to better understand the spatial extents of potential noise impacts. Noise Catchment Areas (NCA) were first established, these are areas where acoustic conditions are expect to be broadly similar for each area. Receptor points were then selected for each NCA where impacts were expected to be highest. These NCA's are identified in *Figure 1.2* of this report. All noise levels were calculated at 1.5 metres above ground level, with due regard to IFC 1.7 Noise requirements and other relevant acoustical standards. A receptor height of 1.5 metres is representative of a human in a seated position and is commonly adopted as a general noise assessment height.

3.2.1 *Source Emission Data*

This section presents the source emission data for the modelling and quantitative assessments conducted for:

- Operational noise associated with the onshore 1,760 MW CCGT Power Plant.
- Corona noise associated with the onshore 52.16 kilometre, 500 kV transmission line connecting the CCGT Power Plant to the Cibatu Baru II/ Sukatani substation.

Operational Noise (Normal Operations)

As stated in Section 1.1.59 of the IFC Thermal Power Plants Guideline, 2017 "*principal sources of noise in thermal power plants include the turbine generators and auxiliaries; boilers and auxiliaries, such as coal pulverisers; reciprocating engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers*".

Section 1.1.59 goes on to state that "*thermal power plants used for base load operation may operate continually while smaller plants may operate less frequently but still pose a significant source of noise if located in urban areas*", which aligns with the assumption drawn for this assessment that the proposed development and project power plant will generate constant emissions.

As stated in Section 1.1.60 of the IFC Thermal Power Plants Guideline, 2017 "*noise impacts, control measures, and recommended ambient noise levels are presented in Section 1.7 of the General EHS Guidelines. Additional recommended measures to prevent, minimize, and control noise from thermal power plants include*:

- *Siting new facilities with consideration of distances from the noise sources to the receptors (e.g. residential receptors, schools, hospitals, religious places) to the extent possible. If the local land use is not controlled through zoning or is not effectively enforced, examine whether residential receptors could come outside the acquired plant boundary. In some cases, it could be more cost effective to acquire additional land as buffer zone than relying on technical noise control measures, where possible;*
- *Use of noise control techniques such as: using acoustic machine enclosures; selecting structures according to their noise isolation effect to envelop the building; using mufflers or silencers in intake and exhaust channels; using sound-absorptive materials in walls and ceilings; using vibration isolators and flexible connections (e.g. helical steel springs and rubber elements); applying a carefully detailed design to prevent possible noise leakage through openings or to minimize pressure variations in piping; and*
- *Modification of the plant configuration or use of noise barriers such as berms and vegetation to limit ambient noise at plant property lines, especially where sensitive noise receptors may be present*".

Section 1.1.61 of the IFC Thermal Power Plants Guideline, 2017 recognises the effectiveness of noise modelling and as such modelling was completed to quantify the potential impact of the project's operation on surrounding receptors.

Noise emission source values (LW, dBA) were established based on information provided for significant noise generating plant, equipment and machinery, or activities to be undertaken, as associated with the near and onshore items noted above.

Emission data for key power station sources was provided for noise modelling. The individual LW, dBA values are identified in *Table 3.2* below. The sound power levels listed include source mitigation.

Table 3.2 Significant Operational Noise Sources and Emissions Data

Type	Sound Power Level (LW in dBA)
GT Inlet	107
CT Inlet duct	108
GT Package	119
Generator Package	103
ST Package	114
GT Fan Casing	98
GT Vent Fan outlet	99
Condensor Vent	98
HRSG Inlet Duct	104
HRSG Body	99
Stack Tip	101
Pre Heat Pumps	103
HP Water Feed Pump	105
Cooling Tower, (per unit)	105
CT Pump	85
Transformers	93

Building Components and Enclosures: the modelling has incorporated the presence of several buildings and enclosures, as discussed in the broader environmental assessment. These include the following buildings:

- There will be two cooling tower blocks, one for each single shaft CCGT unit. The preliminary design foresees 16 cells per unit, with each cell having dimensions 16 x 16 x 18.7 metres (18.7 metres high from finished ground level).

- Two turbine buildings, one for each of the two single shaft CCGT units. Each building has an area of 2,500 square metres (m^2) squared and will be 25 meters in height. Constructed of sheet steel.

- There will be two (2) HRSGs, one (1) for each single shaft CCGT unit. Each HRSG will be approximately 40 m in height.

- Exhaust stacks for each CCGT unit with heights of 60m.

Ancillary buildings will provide noise shielding, including:

- Administration Building

- Workshop

- Electrical Control Buildings

Noise Barriers; the Project design includes the following noise barriers:

- 17m high 300m long barrier located 20m from the southern façade of the cooling tower block

- 7m high 40m long barrier located 50m south west of the turbine hall and HRSG.

Transmission Line (Corona Noise)

A 52.16 kilometre 500kV Transmission Line is proposed to be established from the CCGT Power Plant in Cilamaya to Cibatu Baru II/Sukatani EHV Substation in Sukatani. As stated in the IFC Electrical Power Guideline, 2007 (Page 13) "*noise in the form of buzzing or humming can often be heard around transformers or high voltage power lines producing corona. Ozone, a colourless gas with a pungent odour, may also be produced. Neither the noise nor ozone produced by power distribution lines or transformers carries any known health risks*".

The IFC Electrical Power Guideline, 2007 goes on to state that "*the acoustic noise produced by transmission lines is greater with high voltage power lines (400-800 kilo volts, kV) and even greater with ultra-high voltage lines (1000 kV and higher). Noise from transmission lines reaches its maximum during periods of precipitation, including rain, sleet, snow or hail, or as the result of fog. The sound of rain typically masks the increase in noise produced by the transmission lines, but during other forms of* *precipitation (e.g. snow and sleet) and fog, the noise from overhead power lines can be troubling to nearby residents*".

These features are to be expected for the proposed development and as such modelling was completed to quantify the potential impact of transmission line operation on surrounding receptors based on an indicative line source emission value of 64 dBA per metre, at a nominal minimum height of 15m above ground level, to identify distance offsets from the transmission line centre alignment.

Consistent with the approach described in the IFC Electrical Power Guideline, 2007 this enables measures to be identified that are designed to mitigate impacts, where necessary. These may be implemented "*during project planning stages to locate rights-of-way away from human receptors, to the extent possible*".

4 EXISTING ENVIRONMENT

A key element in assessing environmental noise impacts is an understanding of the existing ambient and background noise levels at or in the vicinity of the closest and/or potentially most affected receptors situated within the potential area of influence of a project. Existing vibration levels are less significant to the assessment as it is assumed that in the absence of the project, ambient vibration is imperceptible at the closest and/or potentially most affected receptors situated within the potential area of influence of a project. Hence, this chapter focuses on noise herein.

4.1 POTENTIALLY SENSITIVE RECEPTORS

The potentially sensitive receptors where CCGT Power Plant noise and vibration has been assessed were identified in *Figure 1.2* above and are tabulated in *Table 4.1* below.

Table 4.1 Potentially Sensitive Noise Receptor Locations

Noise ID	Desc.	GPS Co-ordinates (X and Y, Zone 48)	
N-1[1]	Residential (Dwelling) Receptor/s situated south-west of the CCGT Power Plant.	786166	9308897
N-2[1]	Residential (Dwelling) Receptor/s situated south of the CCGT Power Plant.	786376	9308737
N-3[1]	Residential (Dwelling) Receptor/s situated east of the CCGT Power Plant.	787390	9309099
N-4[1]	Residential (Dwelling) Receptor/s situated north of the CCGT Power Plant.	786369	9309369
N-5[1]	Residential (Dwelling) Receptor/s situated north-east of the CCGT Power Plant.	786997	9309091
R1[2]	Residential (Dwelling) Receptor/s situated south of the CCGT Power Plant, within NCA 1	786447	9308724
R2[2]	Workforce Accommodation Receptor situated west of the CCGT Power Plant, within NCA 2.	785997	9309012
R3[2]	Residential (Dwelling) Receptor/s situated north-west of the CCGT Power Plant, within NCA 3.	786192	9309274
R4[2]	Residential (Dwelling) Receptor/s situated north of the CCGT Power Plant, within NCA 4.	786542	9309507
R5[2]	Residential (Dwelling) Receptor/s situated east of the CCGT Power Plant, within NCA 5.	787397	9309090
R6[2]	Residential (Dwelling) Receptor/s situated south-east of the CCGT Power Plant, within NCA 6.	787113	9308727

1. Source: Samsung, 2016 Noise Study Review.
2. Source: identified for this assessment.

These locations were adopted from the Samsung, 2016 Noise Study Review or identified for this assessment via a rapid review of aerial photography and based on their proximity to key emission sources.

These locations do not represent all receptors located in the vicinity or area of influence of the project but have been selected for the purposes of this assessment. They are considered to be representative of locations that will experience the highest noise or vibration levels and most significant impacts associated with the construction and ongoing operation of the project.

Furthermore, where additional receptors are identified (beyond those presented in *Table 4.1* the predicted noise levels at the nearest assessed receptor (N-1 to N-5 and R1 to R6) provides an indication of potential project emissions and impacts that could be experienced at these other locations not specifically identified in this assessment.

4.2 *EXISTING NOISE LEVELS*

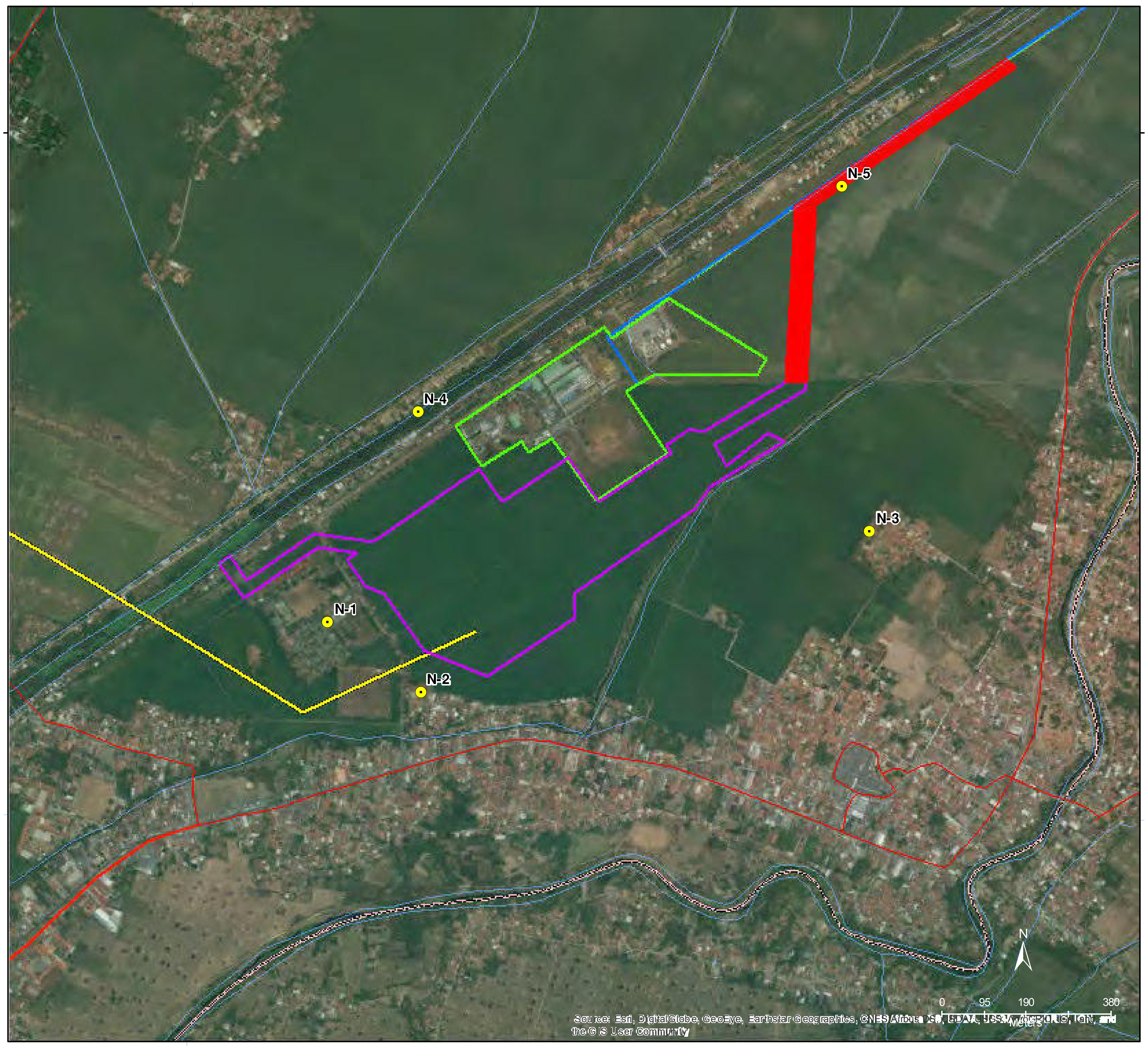
Existing ambient and background noise levels were measured for this assessment such that an understanding of the existing acoustics environment can be described and existing noise levels quantified. This section presents a consolidated summary of all measured data available at the time of this assessment and other items of importance.

Existing (baseline) ambient noise level monitoring was also conducted in November 2015 at five (5) locations (IEE, 2016). Two (2) points i.e. Cilamaya IV State Primary School and Paddi Field in Cilamaya Village (N-2 and N-5 respectively) exceeded the noise level standards, particularly at night-time. This was due to the influence of road traffic and dominated by natural sounds such insects during evening and night time i.e. Cricket (Gryllidae) and Tonggeret (Tettigarctidae).

In addition to the monitoring conducted in November 2015 and July 2017 - Regulatory Environmental Monitoring (RKL and RPL) Semester 2, 2016 and Regulatory Environmental Monitoring (RKL and RPL) Semester 1, 2017also provided the noise monitoring data (SGK Cilamaya, 2016; SGK Cilamaya, 2017). Monitoring was conducted at five (5) points of a compressor for 24-hrs. It was noted that the main contributors to the noise emission during the monitoring activities were from the generator sets and from moving vehicles and road traffic.

The existing (baseline) environmental noise monitoring was also conducted at seven (7) monitoring points surrounding the CCGT Power Plant site in July 2017 for 48 hours (ERM, 2017). Exceedances of Indonesian regulatory standards were frequently recorded during business hours (09.00 – 22.00). This was believed to be due to high level of community activities and particularly traffic activity in and around the measurement points. Exceedances of IFC standards for ambient noise were also frequently recorded, particularly at night-time.

The baseline noise monitoring locations are identified in *Figure 4.1* and *Figure 4.2* below and a summary of all baseline monitoring results available at the time of this assessment are then provided in *Table 4.2* to *Table 4.6*.



JAWA SATU POWER

Environmental and Social Impact Assessment
(ESIA) for Jawa-1 Project

Figure 4.1
Samsung, 2016 Noise Study Review
Noise Monitoring Locations

LEGEND

- Arterial Road
- Regency Boundary
- Onshore Pipeline (Gas, Intake, and Outflow)
- Access Road to Pump Station and Jetty
- Transmission Line
- CCGT Power Plant
- SKG Cilamaya

Sampling Point

- Noise Sampling Location

Coordinate of Noise Sampling Locationon Noise Review Study

Sampling	Code	Geographic		UTM	
		South	East	X	Y
Noise	N1	-6,2460	107,5861	786166,00	9308896,00
	N2	-6,2475	107,5880	786376,00	9308736,00
	N3	-6,2441	107,5969	787369,00	9309098,00
	N4	-6,2418	107,5879	786369,00	9309368,00
	N5	-6,2442	107,5936	786997,00	9309091,00

Source:
- ESRI Online Imagery, 2017
- Jawa Satu Power, 2017

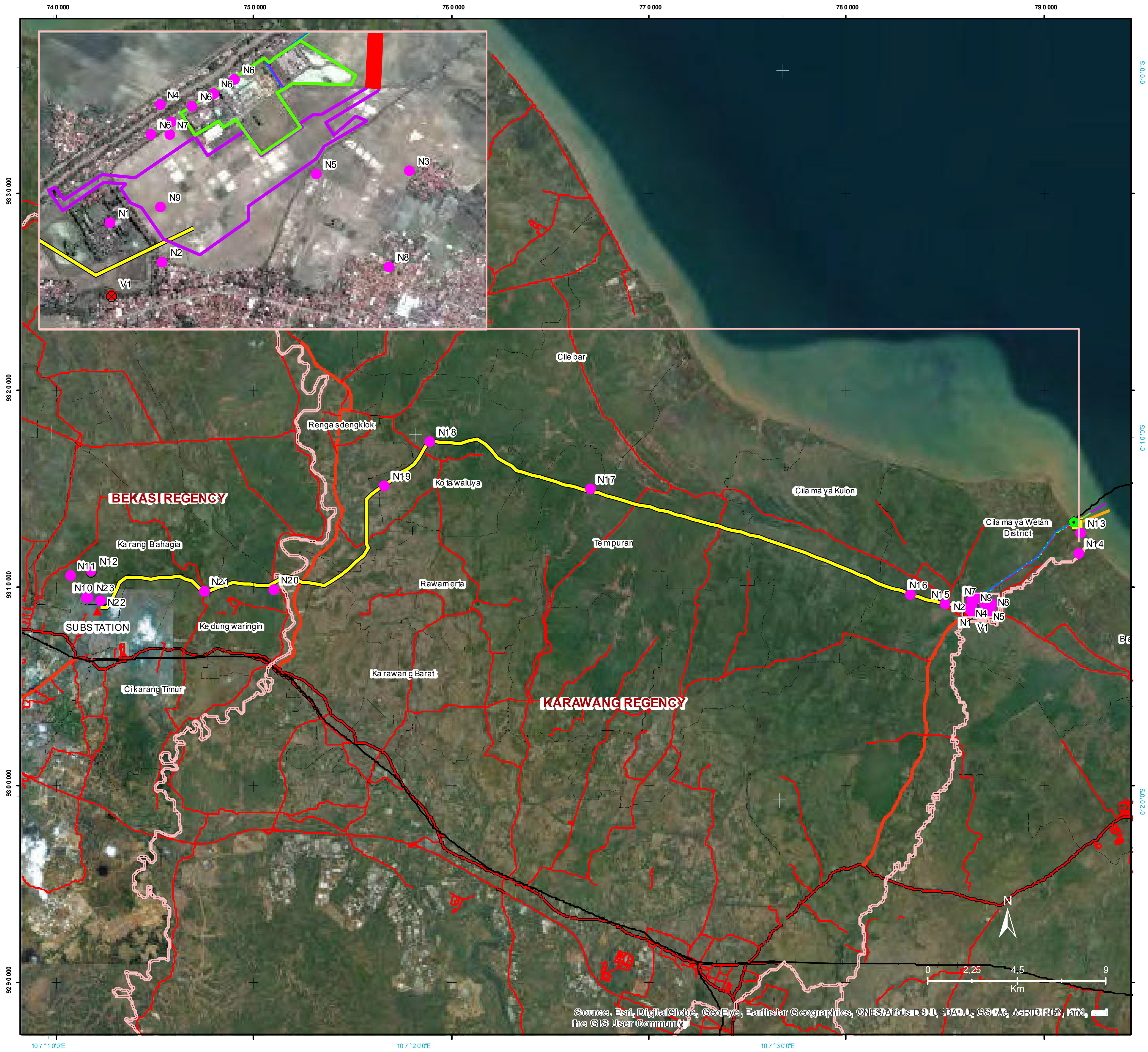
Drawn By :	IA	Client :	Jawa Satu Power
Checked By :	NL	Date :	13/03/2018
Revision :		Map Number :	

ERM

JAWA SATU POWER

Environmental and Social Impact Assessment (ESIA) for Jawa-1 Project

Figure 4.2
ESIA – Noise and Vibration Monitoring Locations.



LEGEND

- Arterial Road
- Regency Boundary
- Distict Boundary
- Cibatu 2 Substation
- Onshore Pipeline (Gas, Intake, and Outflow)
- Access Road to Pump Station and Jetty
- Transmission Line
- CCGT Power Plant
- SKG Cilamaya

Sampling Point

- Noise Sampling Location
- Vibration Sampling Location

Source:
- Jawa Satu Power, 2017

Drawn By:	IA & IF	Client:	Jawa Satu Power
Checked By:	NL	Date:	13/03/2018
Revision:		Map Number:	

ERM

Table 4.2 Noise Monitoring (IEE, 2016)

ID, Co-ordinates	Description	Measured Noise Levels
N-1 786166,9308897	In the PT Pertamina adjacent to existing staff housing area	Leq Daytime 55.0 dBA Leq Night-time 48.5 dBA Leq Day/Night 54.6 dBA
N-2 786376, 9308737	Cilamaya IV State Primary School	Leq Daytime 62.0 dBA Leq Night-time 51.5 dBA Leq Day/Night 60.9 dBA
N-3 787390, 9309099	Bunut Ageung Hamlet. Cilamaya Village. Cilamaya Wetan District	Leq Daytime 59.3 dBA Leq Night-time 45.4 dBA Leq Day/Night 57.8 dBA
N-4 786369, 9309369	In the Pertamina (adjacent to wall (irrigation area)	Leq Daytime 57.8 dBA Leq Night-time 51.7 dBA Leq Day/Night 57.5 dBA
N-5 786997, 9309091	Paddy field in Cilamaya Village. Cilamaya Wetan District	Leq Daytime 54.7 dBA Leq Night-time 51.5 dBA Leq Day/Night 55.4 dBA

1. Source: IEE, 2016 as presented in Annex B, Table B.20 of the March 2018 environmental assessment.

Table 4.3 Noise Monitoring (Report of Environmental Assessment, Table 2.9)

ID	Description	Measured Noise Levels
N-1	In the PT Pertamina adjacent to existing staff housing area	Leq Daytime 55.0 dBA Leq Night-time 44.9 dBA Leq Day/Night 52.6 dBA
N-2	Cilamaya IV State Primary School	Leq Daytime 59.4 dBA Leq Night-time 50.8 dBA Leq Day/Night 57.4 dBA
N-3	Bunut Ageung Hamlet. Cilamaya Village. Cilamaya Wetan District	Leq Daytime 56.9 dBA Leq Night-time 45.5 dBA Leq Day/Night 52.2 dBA
N-4	In the Pertamina (adjacent to wall (irrigation area)	Leq Daytime 59.9 dBA Leq Night-time 44.9 dBA Leq Day/Night 52.1 dBA
N-5	Paddy field in Cilamaya Village. Cilamaya Wetan District	Leq Daytime 55.5 dBA Leq Night-time 53.8 dBA Leq Day/Night 53.9 dBA

1. Source: Section 2.2.2, Table 2.9 of the Report of Environmental Assessment CCGT Java-1 Power Plant Development – Cilamaya – West Java.

Table 4.4 Noise Monitoring (Samsung, 2016 Noise Study Review)

ID	Description	Measured Noise Levels (Night time)
N-1	In the PT Pertamina adjacent to existing staff housing area	Leq (8 hour) 48.9 dBA
N-2	Cilamaya IV State Primary School	Leq (8 hour) 52.1 dBA
N-3	Bunut Ageung Hamlet. Cilamaya Village. Cilamaya Wetan District	Leq (8 hour) 45.6 dBA
N-4	In the Pertamina (adjacent to wall (irrigation area)	Leq (8 hour) 52.0 dBA
N-5	Paddy field in Cilamaya Village. Cilamaya Wetan District	Leq (8 hour) 51.5 dBA

1. Source: Section 2, *Samsung C&T – Engineering and Construction Group (Samsung) – Indonesia Jawa-1 Noise Study Review – Ver. 07 - Cooling Tower Re-location to East-Side* report, dated 2016.7.9 and prepared by Samsung - Quality Technology Division, Technical Team (Samsung, 2016 Noise Study Review).
2. Refer *Annex B* of this report for further information.

Table 4.5 Noise Monitoring (2017)

ID	Description	Measured Noise Levels
N7	Pertamina Cilamaya	Leq Daytime 56.5 dBA Leq Night-time 55.7 dBA Leq Day/Night 58.9 dBA
N8	Masjid Al-Hidayah	Leq Daytime 70.8 dBA Leq Night-time 73.0 dBA Leq Day/Night 74.6 dBA
N9	Pertamina Residential Area	Leq Daytime 57.5 dBA Leq Night-time 56.0 dBA Leq Day/Night 56.9 dBA
N10	GCC Residential Area	Leq Daytime 50.4 dBA Leq Night-time 51.0 dBA Leq Day/Night 53.1 dBA
N11	MTsN 2 Bekasi	Leq Daytime 41.9 dBA Leq Night-time 56.3 dBA Leq Day/Night 56.6 dBA
N12	Access road to GITET Development area	Leq Day/Night 53.2 dBA

1. Source: ERM, 2018b as presented in Annex B, Table B.22 of the March 2018 environmental assessment.

Table 4.6 Noise Monitoring (2018)

ID, Co-ordinates	Description	Measured Noise Levels
NEMF 1 (N17) S: 06o14'38.5" E:107o34'32.8"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 60 dBA Leq Night-time 58 dBA
NEMF 2 S: 6°14'23.0" E: 107°33'34.0""	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 60 dBA Leq Night-time 58 dBA
NEMF 3 (N26) S: 6°14'34.1" E: 107°11'01.5"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 72 dBA Leq Night-time 74 dBA
NEMF 4 (N19) S: 06o11'33.1" E: 107o24'46.6"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 63 dBA Leq Night-time 55 dBA
NEMF 5 (N20) S: 06o10'14.1" E: 107o20'23.5"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 62 dBA Leq Night-time 65 dBA
NEMF 6 (N21) S: 06o11'27.0" E: 107o19'08.7"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 62 dBA Leq Night-time 54 dBA
NEMF 7 S: 6°14'19.3" E: 107°16'06.2"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 57 dBA Leq Night-time 54 dBA
NEMF 8 S: 6°13'55.82" E: 107°16'26.92"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 58 dBA Leq Night-time 54 dBA
NEMF 9 (N24) S: 6°14'23.8" E: 107°14'12.4"	Transmission line site. Adjacent residential, 48hr sample	Leq Daytime 62 dBA Leq Night-time 66 dBA
NEMF 10 (N25) S: 6°14'40.248" E: 107°11'21.66"	Adjacent residential 48hr sample	Leq Daytime 69 dBA Leq Night-time 67 dBA
AQJ1 (N15) S: 6°12'41.1" E: 107°38'13.4"	Coastal, Background no residential, 48hr sample	Leq Daytime 80 dBA Leq Night-time 53 dBA
AQJ1 (N16) S: 6°13'13.7" E: 107°38'11.3"	Coastal, nearest village, residential, 48hr sample	Leq Daytime 53 dBA Leq Night-time 45 dBA
N18	North of Kotawaluya	Leq Daytime 52.5dBA Leq Night-time 51.4 dBA
N22	Near substation	L90 45.2 dBA Leq Daytime 54.4 dBA Leq Night-time 57.6 dBA
N23	Near substation	Leq Daytime 54.4 dBA Leq Night-time 57.6 dBA

1. Source: ERM, 2018c as presented in Annex B, Table B.24 of the March 2018 environmental assessment.

4.2.1 *Existing Industrial Influence*

The power plant site is located adjacent to an existing industrial operation, being the SKG plant, Pertamina's existing Gas Compressor Station. The main noise source at SKG Cilamaya are the three gas compressors which are driven by Solar Centaur gas turbines. Ambient noise levels in the vicinity of the plant would be affected by existing industrial influence from these operations. While the assessment of industrial contribution is not specifically addressed as part of the IFC guidance, these levels would contribute to cumulative industrial noise impacts.

5 PROJECT-SPECIFIC ASSESSMENT CRITERIA

This chapter summarises the project-specific noise and vibration criteria adopted and established for this assessment. These criteria were considered for this assessment and utilised when conducting the preliminary evaluation of impacts, and for the operational noise assessment presented in *Chapter 6* of this report. Although impacts associated with all potential noise and vibration impacts are not anticipated, a complete set of criteria and limits is presented in this chapter.

5.1 NOISE CRITERIA

The project-specific noise criteria for the eleven receptors (previously described in *Table 4.1* of this report) were adopted from the *Samsung C&T – Engineering and Construction Group (Samsung) – Indonesia Jawa-1 Noise Study Review – Ver. 07 - Cooling Tower Re-location to East-Side* report, dated 2016.7.9 and prepared by Samsung - Quality Technology Division, Technical Team (Samsung, 2016 Noise Study Review). Refer to *Annex B* of this report for further information.

These project-specific criteria values, as adopted from the Samsung, 2016 Noise Study Review, were derived with due regard to the existing night time L_{eq} noise levels presented in *Table 4.4* of this report and with due regard to the requirements of IFC 1.7 Noise. The basis of these project-specific criteria values as stated in the Samsung, 2016 Noise Study Review is: existing $L_{eq,\ 8\ hour\ night}$ + 3 dBA = $L_{eq,\ 1\ hour}$ project-specific criteria, for each receptor.

For locations N-1 to N-5 identified in the Samsung, 2016 Noise Study Review the criteria values were adopted as reported. For each of the additional six receptors (R1 to R6) identified for this assessment the criteria value from the closest Samsung, 2016 Noise Study Review location (of N-1 to N-5) has been used. The consolidated set of criteria values are presented in *Table 5.1* below.

Table 5.1 Project-Specific Noise Criteria

Noise ID	Desc.	Noise Criteria, dBA Leq, 1 hour in dBA
N-1[1]	Residential (Dwelling) Receptor/s situated south-west of the CCGT Power Plant.	51.9
N-2[1]	Residential (Dwelling) Receptor/s situated south of the CCGT Power Plant.	55.1
N-3[1]	Residential (Dwelling) Receptor/s situated east of the CCGT Power Plant.	48.6
N-4[1]	Residential (Dwelling) Receptor/s situated north of the CCGT Power Plant.	55.0
N-5[1]	Residential (Dwelling) Receptor/s situated north-east of the CCGT Power Plant.	54.5

Noise ID	Desc.	Noise Criteria, dBA Leq, 1 hour in dBA
R1[2]	Residential (Dwelling) Receptor/s situated south of the CCGT Power Plant, within NCA 1	55.1
R2[2]	Workforce Accommodation Receptor situated west of the CCGT Power Plant, within NCA 2.	51.9
R3[2]	Residential (Dwelling) Receptor/s situated north-west of the CCGT Power Plant, within NCA 3.	55.0
R4[2]	Residential (Dwelling) Receptor/s situated north of the CCGT Power Plant, within NCA 4.	55.0
R5[2]	Residential (Dwelling) Receptor/s situated east of the CCGT Power Plant, within NCA 5.	48.6
R6[2]	Residential (Dwelling) Receptor/s situated south-east of the CCGT Power Plant, within NCA 6.	48.6

1. Source: Samsung, 2016 Noise Study Review.
2. Source: identified for this assessment.

5.1.1 *Transmission Line*

For the purpose of this assessment, predicted transmission line (Corona) noise levels have been compared to the most stringent criteria (48.6 dBA) shown for receptor N-3 in *Table 5.1* above.

This approach enables consistency between the general operational CCGT Power Plant noise assessment, where detailed noise modelling was conducted, and the transmission line noise assessment where modelling was completed to identify potential impacts at distance offsets from the transmission line centre alignment.

5.1.2 *Evaluating Noise Impacts*

For the purpose of this assessment, any noise levels that are predicted to exceed the project-specific noise criteria identified in *Table 5.1* above are assumed to generate an unacceptable level of impact, based on which additional noise mitigation would be required to reduce levels and minimise impacts to acceptable levels.

5.2 *VIBRATION CRITERIA*

The key international documents adopted for the terms of reference from which vibration criteria (human exposure/annoyance and structural damage) were established are:

- British Standards Institution (BSI, United Kingdom) – BS 6472 - *Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* (BS 6472), dated 1992.

- British Standards Institution (BSI, United Kingdom) – BS 5228 - *Code of Practice for Noise and Vibration Control on Construction and Open Sites* , Part 2: Vibration (BS 5228:2), dated 2009.

- Department of Environment and Conservation NSW (DECC, Australia) – *Assessing Vibration: a Technical Guideline* (DECC Guideline, 2006), dated February 2006.

- German Institute for Standardisation (GIS, Germany) – DIN 4150 Part 3: *Structural Vibration: Effects of Vibration on Structures* (DIN 4150:3), dated February 1999.

Unlike noise where Impact significance ratings may be derived from incremental thresholds the combined impact magnitude with receptor sensitivity and/or exposure: vibration guidelines are typically adopted in a manner that recognises any levels that are predicted to exceed the criteria are likely to generate a significant impact that should be mitigated.

Values predicted to exceed the structural damage criteria would be considered a significant adverse impact and further detailed assessment, investigation or monitoring would likely be required.

5.2.1 Human Exposure and Annoyance Guidelines

The DECC Guideline, 2006 presents preferred and maximum vibration values for use in assessing human responses to vibration (based on BS 6472, 1992) and provides recommendations for measurement and evaluation techniques.

At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The DECC Guideline, 2006 defines three vibration types and provides direction for assessing and evaluating the applicable criteria; examples of the three vibration types and has been reproduced in *Table 5.3*.

Table 5.2 *Example of Types of Vibration*

Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

The impulsive vibration criteria considered relevant to this assessment are then presented in *Table. 5.4*.

Table 5.3 *Criteria for Exposure to Impulsive Vibration*

Place	Time	Assessment Criteria - Peak Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (hospital operating theatres, precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	8.6	17
	Night time	2.8	5.6
Offices	Day or night time	18.0	36.0
Workshops	Day or night time	18.0	36.0

Intermittent vibration is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Section 2.4 of the DECC Guideline, 2006 provides acceptable values for intermittent vibration in terms of Vibration Dose Values (VDV) which requires the measurement of the overall weighted RMS (Root Mean Square) acceleration levels over the frequency range 1 Hz to 80 Hz.

To calculate VDV the following formula is used:

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted RMS of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in *Table 5.5* below.

Table 5.4 *Criteria for Exposure to Intermittent Vibration*

	Assessment Criteria - VDV, $m/s^{1.75}$			
	Daytime[1]		Night-time[1]	
Location	**Preferred Value**	**Maximum Value**	**Preferred Value**	**Maximum Value**
Critical working areas (hospital operating theatres, precision laboratories)	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and placed of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1. Daytime is 7am to 10 pm and Night time is 10pm to 7am.

5.2.2 *Structural Damage Criteria*

The DIN 4150-3 safe limit values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor) are summarised in *Table 5.6* below.

Table 5.5 Structural Damage Safe Limit Values (DIN 4150-3)

Line	Type of Structure	Vibration Velocity in mm/s			
		Vibration at foundation at a Frequency of:			Plane of Floor of Uppermost Storey at all Frequencies
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz[1]	
1	**Commercial Buildings:** Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	**Residential Buildings:** Dwellings and buildings of similar design and/or use	5	5 to 15	5 to 20	15
3	**Sensitive Buildings:** Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

1. At frequencies above 100Hz, the values given in this column may be used as a minimum.

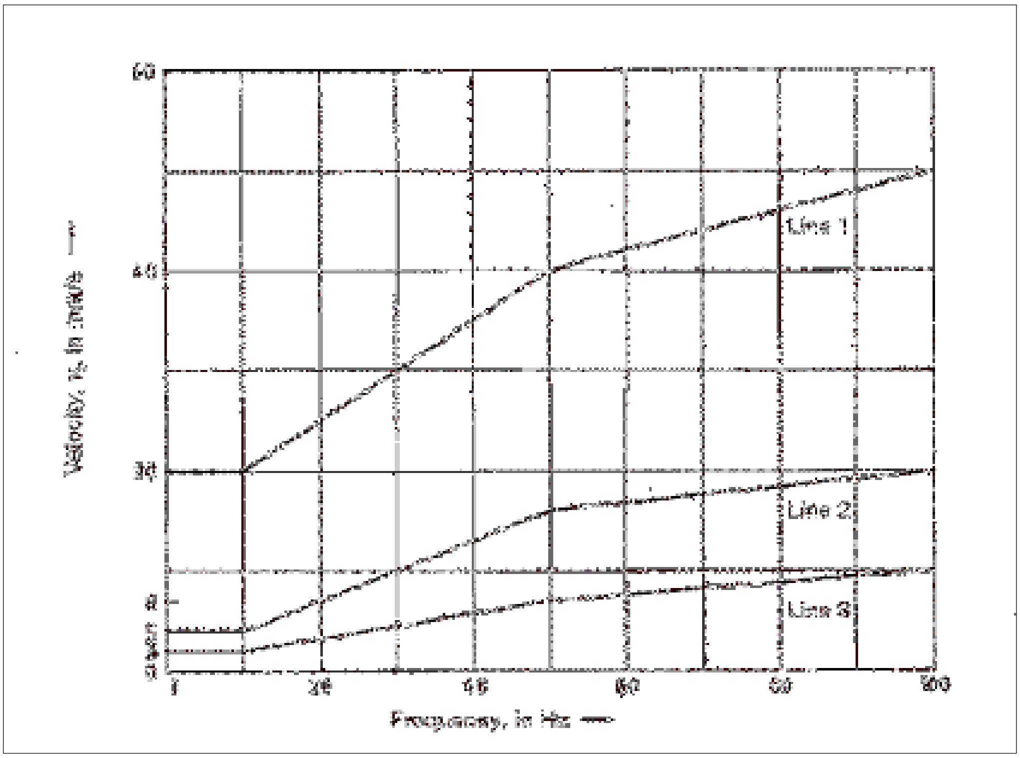
Guidance Note

These levels are safe limits, for which damage due to vibration is unlikely to occur. Damage is defined in DIN 4150 to include minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Should such damage be observed without vibration levels exceeding the safe limits then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the safe limits are present, it does not necessarily follow that damage will occur.

As indicated by the criteria from DIN 4150 high frequency vibration has less potential to cause damage than that from lower frequencies - this is visually presented in *Figure 5.1* below. Furthermore, the point source nature of vibration from mining equipment causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion and hence reducing the potential for damage.

Figure 5.1 Structural Damage Safe Limits for a variety of building types



5.2.3 Project-Specific Vibration Criteria

Human annoyance and structural damage vibration criteria applicable to residential premises are summarised in *Table 5.6* above which have be adopted as the project-specific vibration criteria by which potential impacts have been assessed at the closest and/or potentially most affected sensitive receptor locations in the vicinity of the site.

This criterion summarised in *Table 5.7* includes recommended "Trigger Action Levels" for human annoyance vibration criteria which is considered appropriate for the assessment of intermittent vibration from construction, and operation of the project, as applied to residential (dwelling) premises.

Table 5.6 Project-Specific Vibration Criteria

Factor		Vibration Criterion	Trigger Action Level
Structural Damage		5 mm/s	3 mm/s
Human Disturbance	Daytime	0.2 VDV, $m/s^{1.75}$	3 mm/s
	Night time	0.13 VDV, $m/s^{1.75}$	1 mm/s

6 *OPERATIONAL NOISE ASSESSMENT*

Based on the methodology, inputs and assumptions described in *Chapter 2* of this report L_{eq} noise levels have been predicted for operational project components where a potential for impacts to occur has been identified. This includes general operational noise emissions associated with the CCGT Power Plant and corona noise emissions from the transmission line.

6.1 *GENERAL OPERATIONAL NOISE*

The resultant general operational noise levels for the CCGT Power Plant, comparison to the project-specific noise criteria documented in *Chapter 5*, of this report are presented in *Table 6.1* below.

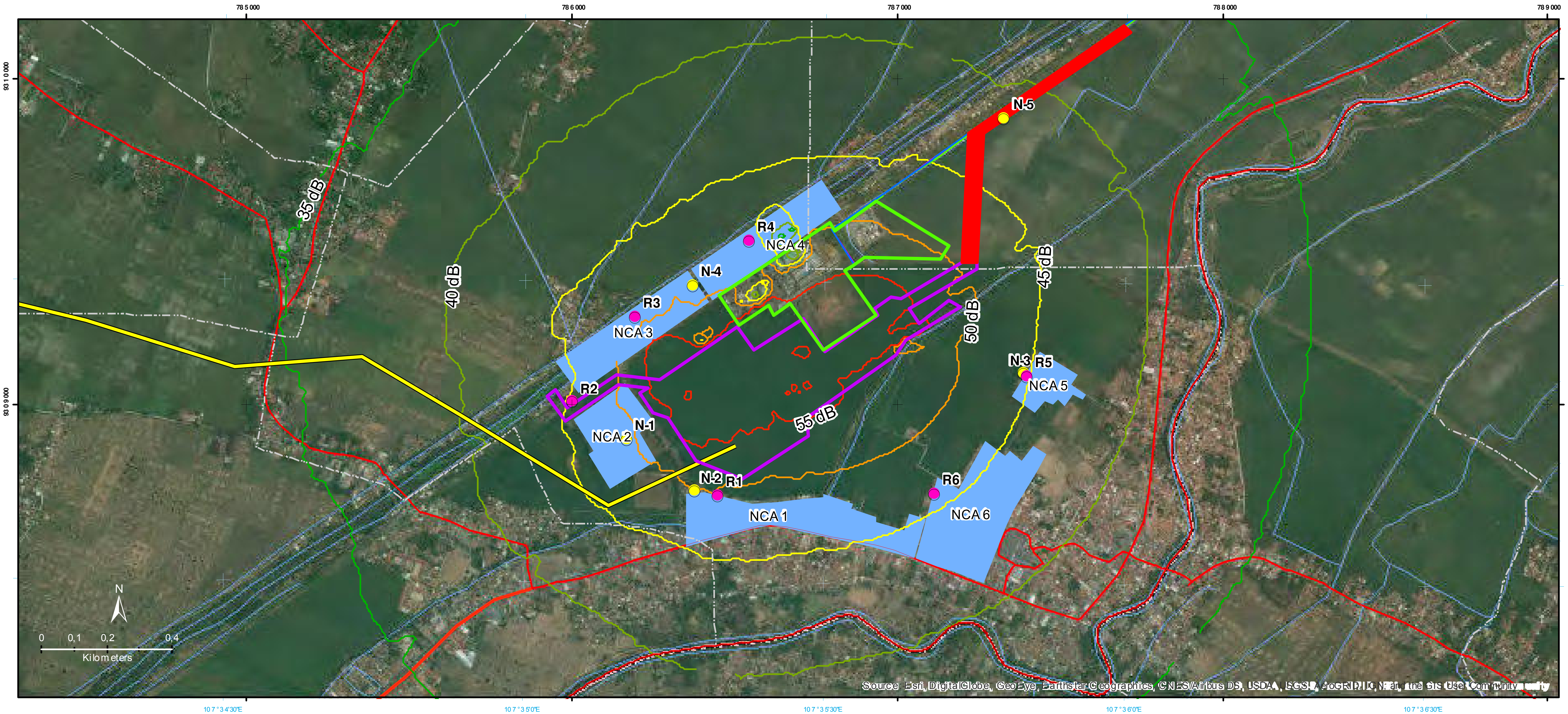
Any noise levels that exceed criteria by >0.5 dBA are highlighted in **bold** typeset. Differences in noise levels of less than approximately 2 dBA are generally imperceptible in practice hence an increase of 2 dBA is hardly perceivable; such that a level which exceeds criteria by less than 0.5 dBA is insignificant.

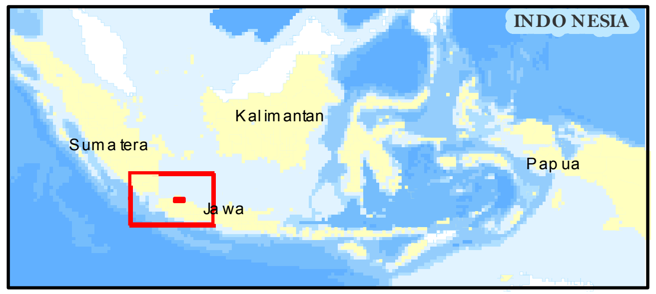
Noise contours, which illustrate the spatial extents of the predicted project CCGT Power Plant noise levels, are presented in *Figure 6.1* below.

Table 6.1 Predicted CCGT Power Plant Noise Levels

Noise ID	Project-specific Noise Criteria Leq, 1hour in dBA	Predicted Noise Levels Leq, 1hour in dBA	Comparison to Criteria Leq, 1hour in dBA
N-1[1]	51.9	49.2	-2.7
N-2[1]	55.1	50.2	-4.9
N-3[1]	48.6	45.4	-3.2
N-4[1]	55.0	48.4	-6.6
N-5[1]	54.5	41.7	-12.8
R1[2] (NCA 1)	55.1	50.0	-5.1
R2[2] (NCA 2)	51.9	45.3	-6.6
R3[2] (NCA 3)	55.0	49.2	-5.8
R4[2] (NCA 4)	55.0	47.9	-7.1
R5[2] (NCA 5)	48.6	45.2	-3.4
R6[2] (NCA 6)	48.6	45.9	-2.7

1. Source: Samsung, 2016 Noise Study Review.
2. Source: identified for this assessment.





LEGEND

- Arterial Road
- River/Irigation
- Distict Boundary
- Regency Boundary
- Contour Line

Project Plan

- Onshore Pipeline (Gas, Intake, and Outflow)
- Access Road to Pump Station and Jetty
- Transmission Line
- CCGT Power Plant
- Nearest Receiver

Noise Contour (dB)

- 35 dB
- 40 dB
- 45 dB
- 50 dB
- 55 dB

Sampling Point

- Samsung Noise Monitoring Location
- ESIA Noise Monitoring Location

Source:
- ESRI Online Imagery, 2017
- Jawa Satu Power, 2017

JAWA SATU POWER

Environmental and Social Impact Assessment (ESIA) for Jawa-1 Project

Figure 6.1
CCGT Power Plant
Noise Contour Map

Drawn By :	IA & IF	Client :	Jawa Satu Power
Checked By :	NL	Date :	13/03/2018
Revision :		Map Number :	

ERM

6.1.1 *Summary of Findings*

The results presented in *Table 6.1* and illustrated in *Figure 6.1* above identify that the predicted project noise levels ($L_{eq,\ 1hour}$) associated with the CCGT Power Plant are below project-specific noise criteria adopted for this assessment.

Evaluating the predicted noise levels with regard to the project-specific noise criteria and the method described in *Section 5.1.2* of this report, identifies that predicted noise levels are not expected to exceed the adopted criteria. On this basis an acceptable level of noise impact is expected.

Suitable safeguards and provisions are however provided in *Chapter 7* of this report.

6.2 *TRANSMISSION LINE CORONA NOISE*

The resultant operational noise levels (corona noise) for the 500 kV transmission line and comparison to the project-specific noise criteria are presented in *Table 6.2* below.

As per the *Chapter 2* methodology these predictions are provided for a range of horizontal distance offsets from transmission line center line, in metres. This approach does not predict levels at specific receptors but provides an understanding of the likely noise that will be experienced at different distances along the transmission line full alignment.

Any noise levels that exceed criteria by >0.5 dBA are highlighted in **bold** typeset. Differences in noise levels of less than approximately 2 dBA are generally imperceptible in practice hence an increase of 2 dBA is hardly perceivable; such that a level which exceeds criteria by less than 0.5 dBA is insignificant.

Table 6.2 Predicted Transmission Line (Corona) Noise Levels

Horizontal Distance Offset from Transmission Line Centre Line, metres	Project-specific Noise Criteria[1] Leq, 1hour in dBA	Predicted Noise Levels $L_{eq,\ 1hour}$ in dBA	Comparison to Criteria Leq, 1hour in dBA
0	48.6	**50.7**	**2.1**
10	48.6	**50.2**	**1.6**
20	48.6	49.1	**0.5**
30	48.6	47.9	-0.7
40	48.6	46.8	-1.8
50	48.6	45.8	-2.8
60	48.6	45.0	-3.6
70	48.6	44.2	-4.4

1. Source: N-3 limiting criteria value from the Samsung, 2016 Noise Study Review.

6.2.1 *Summary of Findings*

The results presented in *Table 6.2* above identify that predicted project noise levels ($L_{eq, 1hour}$) associated with the 500 kV transmission line are at or below the project-specific criteria for potential receptors situated at distances > 30 metres from the transmission line centre alignment.

Predicted 500 kV transmission line project noise levels ($L_{eq, 1hour}$) are however above the project-specific criteria for potential receptors situated at distances ≤ 20 metres. At a distance of 20 metres the predicted project noise level ($L_{eq, 1hour}$) is reported to exceed criteria by 0.5 dBA. As stated above, differences in noise levels of less than approximately 2 dBA are generally imperceptible in practice; such that a level which exceeds criteria by less than 0.5 dBA is insignificant. At a distance of 10 metres the predicted project noise level ($L_{eq, 1hour}$) is reported to exceed criteria by 1.6 dBA, which although potentially imperceptible is considered significant. At a distance of 0 metres (beneath the transmission line) the predicted project noise level ($L_{eq, 1hour}$) is reported to exceed criteria by 2.1 dBA, which again although potentially imperceptible is considered significant. These results indicate that unacceptable impacts are only anticipated for receptors situated in close proximity i.e. < 20 metres to the 500 kV transmission line.

The predicted transmission line (Corona) noise levels have been compared to the most stringent criteria shown in *Table 5.1* of this report, as based on N-3 monitoring data where a value of 48.6 dBA was previously established, refer Samsung, 2016 Noise Study Review.

This approach enables consistency between the general operational CCGT Power Plant noise assessment, where detailed noise modelling was conducted, and the transmission line noise assessment where modelling was completed to identify potential impacts at distance offsets from the transmission line centre alignment. It is however expected that existing noise levels will vary somewhat along the transmission line.

Consideration of the measured data presented in *Chapter 4*, *Table 4.6* of this report supports this finding as existing $L_{eq, night\ time}$ levels (the parameter adopted in the Samsung, 2016 Noise Study Review to establish criteria) were measured vary between 45 and 67 dBA (but were generally > 50 dBA), excluding the potentially spurious result recorded at NEMF 3.

Evaluating these predicted noise levels with regard to the project-specific noise criteria and the method described in *Section 5.1.2* of this report, identifies that an acceptable level of impact is anticipated for the majority of receptors. An unacceptable level of impact could occur at receptors < 20 metres from the 500 kV transmission line. On this basis, considering the minimum vertical height will be 18m above any building additional noise mitigation to that already implemented into the project design is not recommended. Suitable safeguards and provisions are however provided in *Chapter 7* of this report.

7 *SAFEGUARDS AND PROVISIONS*

This chapter presents safeguards and provisions for construction and operational noise and vibration associated with the project. They are based on the impacts evaluated in *Chapter 3* and assessed in detail in *Chapter 6* of this report. These safeguards and provisions are designed to minimise impacts at the most affected receptors and on the broader community.

The focus of these safeguards and provisions are associated with potential construction (including road traffic) air-borne noise and ground-borne vibration impacts to human receptors and underwater noise impacts to wildlife receptors[2]. These construction safeguards and provisions are presented in *Section 7.1* below and target significant emission generating works and activities, for the various offshore, nearshore and onshore components associated with the development, that are proposed to occur within and near the project site.

In addition, safeguards and provisions are provided in *Section 7.2* below for potential operational air-borne noise and ground-born vibration impacts to human receptors. These operational safeguards and provisions target post commercial operation noise verification and compliance monitoring for significant emission generating activities, for the various nearshore and onshore components associated with the development (i.e. the CCGT Power Plant and the 500 kV transmission line) that are proposed to occur within and near the project site.

7.1 *CONSTRUCTION PHASE*

To ensure noise emissions associated with construction works and activities are kept to acceptable levels, the following mitigation and management measures are recommended:

- Work and activities should be carried out during the IFC daytime hours (i.e. 7am to 10pm). Any work that is performed outside these hours (i.e. during the night time period, 10pm to 7am) should be suitably managed with a goal of achieving levels compliant with the IFC 1.7 Noise Disturbance criteria, at all potentially affected sensitive receptors. Where this is not possible it may be necessary to undertake the night works with agreement from nearby and potentially affected neighbours.

- Where unforeseen works will occur in close proximity to a receptor and these works are anticipated to generate high levels of noise (e.g. >75 dBA), potential respite periods (e.g. three hours of work, followed by one hour of

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[2] This acoustical feature is being assessed in more detail by other specialists but given its association with the potential project noise, has been evaluated in this assessment with conceptual recommendations being provided.

respite) should be considered. Respite should be implemented if they are the preference of the affected receptors and if they are feasible and reasonable, and practicable, to implement during the works. In some circumstances respite may extend the duration of works and inadvertently increase noise impacts, hence due care should be taken when considering this management measure.

- During the construction design, choose appropriate machines for each task and adopt efficient work practices to minimise the total construction period and the number of noise sources on the site. Select the quietest item of plant available where options that suit the design permit.

- During the works, avoid unnecessary noise due to idling diesel engines and fast engine speeds when lower speeds are sufficient.

- During the works, instruct drivers to travel directly to site and avoid any extended periods of engine idling at or near residential areas, especially at night.

- During any night works, any activity that has the potential to generate impulsive noise should be avoided. These types of events are particularly annoying, especially at night and have the limited potential to generate sleep disturbance or awakening impacts.

- During the works, ensure all machines used on the site are in good condition, with particular emphasis on exhaust silencers, covers on engines and transmissions and squeaking or rattling components. Excessively noisy machines should be repaired or removed from the Site.

- During the works, ensure that all plant, equipment and vehicles movements are optimised in a forward direction to avoid triggering motion alarms that are typically required when these items are used in reverse.

No further recommendations for mitigation and management to those established by the findings of this assessment, and documented in this report, are provided. JSP should however remain aware of the potential for nuisance, or an unacceptable level of amenity, to occur due to construction noise and vibration and continue to plan for and then manage construction works accordingly.

7.1.1 Underwater Noise

As noted earlier in this report, this acoustical feature is being assessed in more detail by other specialists. Given its association with the potential project noise the following safeguard mitigation and management measures specific to this type of issue (that are commonly incorporated into good construction offshore management practices) are provided:

- Undertake significant offshore construction works and activities in the presence of 'Marine Mammal Observers" (MMO) where possible.

- Establish a mitigation zone for marine mammals around the area of activity. The size of the mitigation zone should be prepared to adequately protect any nearby marine life.

- Pre-works searches could be conducted before commencement of any significant works. The MMO would be strategically positioned in the most appropriate location to make a visual assessment to determine if any marine mammals are within the mitigation zone.

- Providing for construction works and activities to be delayed if marine mammals within the mitigation zone, and the inclusion of a full soft-start procedure. Soft-starts will involve starting equipment at low power, and gradually (and systematically) increasing the output until full power is achieved. The appropriate soft-start method is dependent upon the type of equipment and should be modified accordingly.

- Passive Acoustic Monitoring (PAM) could be undertaken in order to verify underwater noise and detect the vocalisation of marine mammals, especially in poor-visibility conditions (i.e. night works) if considered appropriate.

7.2 *OPERATIONAL PHASE*

Based on the generally compliant results presented in *Chapter 6* of this report, no additional noise mitigation of plant and equipment is expected.

JSP should however remain aware of the potential for nuisance, or an unacceptable level of amenity, to occur due to operational noise and vibration and continue to plan for and then manage the project design accordingly.

Post commercial operation noise and vibration verification and compliance monitoring should be conducted to measure and compare the site noise level contributions ($L_{eq, 1hour}$ in dBA) to a) the predicted values, and b) the criteria presented in this report. The same should occur if any validated noise or vibration complaints are received. All site noise (or vibration) levels should be measured in the absence of any influential sources not associated with the project. If the measured project noise levels are below the predicted values and noise/vibration levels comply with the criteria presented in this report, no further mitigation or management measures may be required. If the measured project levels are above the predicted noise levels and/or criteria presented in this report, further mitigation and/or management measures should be considered.

8 CONCLUSION

ERM on behalf of JSP has completed a preliminary acoustics assessment for the PLTGU Jawa-1 project (the project).

Nuisance, or an unacceptable level of noise (and vibration) amenity, may arise due to construction and operational activities associated with new or existing developments. This potential for issues to arise is associated with air-borne, ground-borne and underwater emissions from significant project noise and vibration generating sources that are in close proximity to potentially sensitive human and wildlife receptors i.e. nearby dwellings, schools, churches, commercial/industrial facilities, or sea life near off-shore assets.

The assessment was conducted to achieve a scope of works that addressed these potential noise and vibration issues by evaluating, predicting and assessing construction and operational noise and vibration from the project (offshore, nearshore and onshore components) at the closest and/or potentially most affected sensitive receptors near the project site.

A qualitative assessment has been conducted for project noise and vibration components that have limited or no potential to generate any impacts at nearby receptors, whilst a quantitative assessment has been conducted for other components where a potential for impacts to occur has been identified. The focus of the quantitative (modelling) assessment was air-borne operational noise associated with the CCGT Power Plant and the 500 kV transmission line.

Based on the qualitative assessment documented in Chapter 3 of this report, potential construction (including road traffic) air-borne noise and ground-borne vibration impacts to human receptors and underwater noise impacts to wildlife receptors were identified. On this basis, construction safeguards and provisions are presented in *Chapter* 7 of this report and target significant emission generating works and activities, for the various offshore, nearshore and onshore components associated with the development, that are proposed to occur within and near the project site.

The CCGT Power Plant results presented in *Chapter 6* of this report identify that the predicted project noise levels ($L_{eq,\ 1hour}$) associated with the CCGT Power Plant are below project-specific noise criteria adopted for this assessment. Evaluating the predicted noise levels with regard to the project-specific noise criteria and the method described in *Section 5.1.2* of this report, identifies that predicted noise levels are not expected to exceed the adopted criteria. On this basis an acceptable level of noise impact is expected. Suitable safeguards and provisions are however provided in *Chapter 7* of this report.

The 500 kV results presented in *Chapter 6* of this report identify that predicted project noise levels ($L_{eq,\ 1hour}$) associated with the 500 kV transmission line are at or below the project-specific criteria for the majority of potential receptors. Evaluating the predicted noise levels with regard to the project-specific noise criteria and the method described in *Section 5.1.2* of this report, identifies that an acceptable level of impact is anticipated for the majority of receptors. An unacceptable level of impact could occur but this is limited to receptors situated in close proximity to the transmission line. On this basis, additional operational noise mitigation to that already implemented into the project design is not recommended. Suitable safeguards and provisions are however provided in *Chapter 7* of this report.

Construction and operational noise and vibration levels will be reduced and impacts (if any) minimised with the successful implementation of the safeguards and provisions provided in *Chapter 7* of this report. Impacts may not be reduced to negligible (low) levels for all receptors and for all project components and phases; however the recommendations presented here will ensure that any residual impacts are minimised as far as may be practically achievable.

No further recommendations for mitigation and management measures to those established by the findings of this noise and vibration assessment, and documented in this report, are provided or warranted. JSP should however remain aware of the potential for nuisance, or an unacceptable level of amenity, to occur due to construction or operational noise and vibration and continue to plan for and then manage the works and design accordingly.

REFERENCES

British Standards Institution (BSI, United Kingdom) – BS 6472 - **Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)** (BS 6472), dated 1992.

British Standards Institution (BSI, United Kingdom) – BS 5228:2 - **Code of Practice for Noise and Vibration Control on Construction and Open Sites** (BS 5228-2), dated 2009.

Department of Environment and Conservation NSW (DECC, Australia) – **Assessing Vibration: a Technical Guideline** (DECC Guideline, 2006), dated February 2006.

German Institute for Standardisation (GIS, Germany) – DIN 4150 Part 3 - **Structural Vibration: Effects of Vibration on Structures** (DIN4150-3), dated February 1999.

International Organisation for Standardisation (ISO) 9613-2:1996 (ISO9613:2) - **Acoustics - Attenuation of Sound during Propagation Outdoors - Part 2: General Method of Calculation.**

Joint Nature Conservation Committee (JNCC) - *Annex A - Guidelines for* **Minimising the Risk of Disturbance and Injury to Marine Mammals from Seismic Surveys** (JNCC Annex A: Guideline, 2009), dated June 2009.

Joint Nature Conservation Committee (JNCC) - **Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys** (JNCC Guideline, 2017), dated August 2017.

World Bank Group: International Finance Corporation (IFC) - **Environmental, Health, and Safety Guidelines for Thermal Power Plants** (IFC Thermal Power Plants Guideline, 2017), draft for second public consultation, dated May/June 2017.

World Bank Group: International Finance Corporation (IFC) - **Environmental, Health and Safety (EHS) Guidelines - General EHS Guidelines: Environmental Noise Management**, Section 1.7 Noise (IFC 1.7 Noise), dated 30 April 2007.

World Bank Group: International Finance Corporation (IFC) - **Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution** (IFC Electrical Power Guideline, 2007), dated 30 April 2007.

Annex A

Acoustics Glossary

A.1 *Noise – Acoustical Concepts and Terminology*

A.1.1 *What Is Noise And Vibration?*

Noise

Noise is often defined as a sound, especially one that is loud or unpleasant or that causes disturbance[3] or simply as unwanted sound, but technically, noise is the perception of a series of compressions and rarefactions above and below normal atmospheric pressure.

Vibration

Vibration refers to the oscillating movement of any object. In a sense noise is the movement of air particles and is essentially vibration, though in regards to an environmental assessment vibration is typically taken to refer to the oscillation of a solid object(s). The impact of noise on objects can lead to vibration of the object, or vibration can be experienced by direct transmission through the ground, this is known as ground-borne vibration.

Essentially, noise can be described as what a person hears, and vibration as what they feel.

A.1.2 *What Factors Contribute To Environmental Noise?*

The noise from an activity, like construction works, at any location can be affected by a number of factors, the most significant being:

- How loud the activity is;
- How far away the activity is from the receiver;
- What type of ground is between the activity and the receiver location e.g. concrete, grass, water or sand;
- How the ground topography varies between the activity and the receiver (is it flat, hilly, mountainous) as blocking the line of sight to a noise source will generally reduce the level of noise; and
- Any other obstacles that block the line of sight between the source to receiver e.g. buildings or purpose built noise walls.

A.1.3 *How to Measure and Describe Noise?*

Noise is measured using a specially designed 'sound level' meter which must meet internationally recognised performance standards. Audible sound

[3] Copyright © 2011 Oxford University Press

pressure levels vary across a range of 10^7 Pascals (Pa), from the threshold of hearing at 20µPa to the threshold of pain at 200Pa. Scientists have defined a statistically described logarithmic scale called Decibels (dB) to more manageably describe noise.

To demonstrate how this scale works, the following points give an indication of how the noise levels and differences are perceived by an average person:

- 0 dB - represents the threshold of human hearing (for a young person with ears in good condition).
- 50 dB – represents average conversation.
- 70 dB – represents average street noise, local traffic etc.
- 90 dB – represents the noise inside an industrial premises or factory.
- 140 dB - represents the threshold of pain – the point at which permanent hearing damage may occur.

A.1.4 Human Response to Changes in Noise Levels

The following concepts offer qualitative guidance in respect of the average response to changes in noise levels:

- Differences in noise levels of less than approximately 2 dBA are generally imperceptible in practice; an increase of 2 dB is hardly perceivable.
- Differences in noise levels of around 5 dBA are considered to be significant.
- Differences in noise levels of around 10 dBA are generally perceived to be a doubling (or halving) of the perceived loudness of the noise. An increase of 10 dB is perceived as twice as loud. Therefore an increase of 20 dB is four times as loud and an increase of 30 dB is eight times as loud etc.
- The addition of two identical noise levels will increase the dB level by about 3 dB. For example, if one car is idling at 40 dB and then another identical car starts idling next to it, the total dB level will be about 43 dB.
- The addition of a second noise level of similar character which is at least 8 dB lower than the existing noise level will not add significantly to the overall dB level.
- A doubling of the distance between a noise source and a receiver results approximately in a 3 dB decrease for a line source (for example, vehicles travelling on a road); and a 6 dB decrease for a point source (for example, the idling car discussed above). A doubling of traffic volume for a line source results approximately in a 3 dB increase in noise, halving the traffic volume for a line source results approximately in a 3 dB decrease in noise.

A.1.5 *Terms to Describe the Perception of Noise*

The following terms offer quantitative and qualitative guidance in respect of the audibility of a noise source:

- **Inaudible / Not Audible** - the noise source and/or event could not be heard by the operator, masked by extraneous noise sources not associated with the source. If a noise source is 'inaudible' its noise level may be quantified as being less than the measured L_{A90} background noise level, potentially by 10 dB or greater.

- **Barely Audible** – the noise source and/or event are difficult to define by the operator, typically masked by extraneous noise sources not associated with the source. If a source is 'barely audible' its noise level may be quantified as being 5 - 7 dB below the measured L_{A90} or L_{Aeq} noise level, depending on the nature of the source e.g. constant or intermittent.

- **Just Audible** – the noise source and/or event may be defined by the operator. However there are a number of extraneous noise sources contributing to the measurement. The noise level should be quantified based on instantaneous noise level contributions, noted by the operator;

- **Audible** - the noise source and/or event may be easily defined by the operator. There may be a number of extraneous noise sources contributing to the measurement. The noise level should be quantified based on instantaneous noise level contributions, noted by the operator.

- **Dominant** – the noise source and/or event are noted by the operator to be significantly 'louder' than all other noise sources. The noise level should be quantified based on instantaneous noise level contributions, noted by the operator.

The following terms offer qualitative guidance in respect of acoustic terms used to describe the frequency of occurrence of a noise source during an operator attended environmental noise measurements:

- **Constant** – this indicates that the operator has noted the noise source(s) and/or event to be constantly audible for the duration of the noise measurement e.g. an air-conditioner that runs constantly during the measurement.

- **Intermittent** – this indicates that the operator has noted the noise source(s) and/or event to be audible, stopping and starting intervals for the duration of the noise measurement e.g. car pass-bys.

- **Infrequent** – this indicates that the operator has noted the noise source(s) and/or event to be constantly audible, however; not occurring regularly or at intervals for the duration of the noise measurement e.g. a small number of aircraft are noted during the measurement.

A.1.6 How to Calculate or Model Noise Levels?

There are two recognised methods which are commonly adopted to determine the noise at particular location from a proposed activity. The first is to undertake noise measurements whilst the activity is in progress and measure the noise, the second is to calculate the noise based on known noise emission data for the activity in question.

The second option is preferred as the first option is largely impractical in terms of cost and time constraints, notwithstanding the meteorological factors that may also influence its quantification. Furthermore, it is also generally considered unacceptable to create an environmental impact simply to measure it. In addition, the most effective mitigation measures are determined and implemented during the design phase and often cannot be readily applied during or after the implementation phase of a project.

Because a number of factors can affect how 'loud' a noise is at a certain location, the calculations can be very complex. The influence of other ambient sources and the contribution from a particular source in question can be difficult to ascertain. To avoid these issues, and to quantify the direct noise contribution from a source/site in question, the noise level is often calculated using noise modelling software packages. The noise emission data used in may be obtained from the manufacturer or from ERM's database of measured noise emissions.

A.1.7 Acoustic Terminology & Statistical Noise Descriptors

Environmental noise levels such as noise generated by industry, construction and road traffic are commonly expressed in dBA. The A-weighting scale follows the average human hearing response and enables comparison of the intensity of noise with different frequency characteristics. Time varying noise sources are often described in terms of statistical noise descriptors. The following descriptors are commonly used when assessing noise and are referred to throughout this acoustic assessment:

- **Decibel (dB is the adopted abbreviation for the decibel)** – The unit used to describe sound levels and noise exposure. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.

- **dBA** - unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.

- **dBC** – unit used to measure 'C-weighted' sound pressure levels. C-weighting is an adjustment made to sound-level measurements which takes account of low-frequency components of noise within the audibility range of humans.

- **dBZ or dBL** – unit used to measure 'Z-weighted' sound pressure levels with no weighting applied, linear.

- **Hertz (Hz)** - the measure of frequency of sound wave oscillations per second. 1 oscillation per second equals 1 hertz.

- **Octave –** a division of the frequency range into bands, the upper frequency limit.

- **1/3 Octave** – single octave bands divided into three parts.

- **L_{eq}** - this level represents the equivalent or average noise energy during a measurement period. The $L_{eq, 15min}$ noise descriptor simply refers to the L_{eq} noise level calculated over a 15 minute period. Indeed, any of the below noise descriptors may be defined in this way, with an accompanying time period (e.g. $L_{10, 15 minute}$) as required.

- **L_{max}** - the absolute maximum noise level in a noise sample.

- **L_N -** the percentile sound pressure level exceeded for N% of the measurement period calculated by statistical analysis.

- **L_{10} -** the noise level exceeded for 10 per cent of the time and is approximately the average of the maximum noise levels.

- **L_{90}** - the noise level exceeded for 90 per cent of the time and is approximately the average of the minimum noise levels.

- **Sound Power Level (L_W)** - this is a measure of the total power radiated by a source. The Sound Power of a source is a fundamental property of the source and is independent of the surrounding environment.

- **Sound Pressure Level (L_P)** - the level of sound pressure; as measured at a distance by a standard sound level meter with a microphone. This differs from L_W in that this is the received sound as opposed to the sound 'intensity' at the source.

- **Background noise** – the underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed.

- **Ambient noise** – the all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.

- **Cognitive noise** – noise in which the source is recognised as being annoying.

- **Masking** – the phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.

- **Extraneous noise** – noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.

- **Most affected location(s)** – locations that experience (or will experience) the greatest noise impact from the noise source under consideration. In determining these locations, one needs to consider existing background levels, exact noise source location(s), distance from source (or proposed source) to receiver, and any shielding between source and receiver.

- **Noise criteria** – the general set of non-mandatory noise level targets for protecting against intrusive noise (for example, background noise plus 5 dB) and loss of amenity (for example, noise levels for various land uses).

- **Noise limits** – enforceable noise levels that appear in conditions on consents and licences. The noise limits are based on achievable noise levels which the proponent has predicted can be met during the environmental assessment. Exceedance of the noise limits can result in the requirement for either the development of noise management plans or legal action.

- **Compliance** – the process of checking that source noise levels meet with the noise limits in a statutory context.

- **Feasible and Reasonable measures** – feasibility relates to engineering considerations and what is practical to build; reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors:

  - Noise mitigation benefits (amount of noise reduction provided, number of people protected);

  - Cost of mitigation (cost of mitigation versus benefit provided);

  - Community views (aesthetic impacts and community wishes); and

  - Noise levels for affected land uses (existing and future levels, and changes in noise levels).

- **Meteorological Conditions** – wind and temperature inversion conditions.

- **Temperature Inversion** – an atmospheric condition in which temperature increases with height above the ground.

- **Adverse Weather** – weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).

8.1.2 *Operator Attended Noise Measurements*

Table A.1 below presents typical abbreviations that are used to describe common noise sources that may be noted during environmental noise measurements.

Table A.1 ***General Field Note Abbreviations***

Noise Source	Abbreviation
'Wind-blown vegetation'	WBV
'Car pass-by'	CP
'Operator Noise'	OP
'Animal Noise'	AN
'Distant Traffic'	DT
'Near Traffic'	NT
'Aircraft Noise'	AN
'Metal on Metal contact'	MMC

During operator attended noise measurements, the sound level meter will present the instantaneous noise level and record acoustical and statistical parameters. In certain acoustical environments, where a range of noise sources are audible and detectable, the sound level meter cannot measure a direct source noise level and it is often necessary to account for the contribution and duration of the sources.

Noted Percentile Contribution – *Table A.2* presents noise level deductions that are typically applied based on the percentage contribution of a noise source(s). **Noted Time Contribution** – *Table A.3* presents noise level deductions that may be applied based on the percentage of time that a noise source(s) is audible during a 15 minute measurement.

Where the noise emission from a source is clearly detectable and the contribution can be measured, these deductions are not necessary.

Table A.2 ***Noise Level Deductions – Noted Percentile Contribution***

Percentage Contribution	Noise Level Adjustment, dBA
5%	-13.0
10%	-10.0
15%	-8.2
20%	-7.0
25%	-6.0
30%	-5.2
35%	-4.6
40%	-4.0
45%	-3.5
50%	-3.0
55%	-2.6
60%	-2.2

Percentage Contribution	Noise Level Adjustment, dBA
65%	-1.9
70%	-1.5
75%	-1.2
80%	-1.0
85%	-0.7
90%	-0.5
95%	-0.2
100%	0.0

1. **EXAMPLE:** the measured $L_{Aeq, 15 minute}$ noise level is 49 dB and the site contribution was observed to be 10% of this level (extraneous noise sources were noted to dominate the measurement), therefore the $L_{Aeq, 15 minute}$ noise level deduction is 10 dB, with a resultant noise level contribution of approximately 39 dB.

Table A.3 Noise Level Deductions – Noted Time Contribution

Event Duration (minutes)	Noise Level Adjustment, dBA
1	-11.8
2	-8.8
3	-7.0
4	-5.7
5	-4.8
6	-4.0
7	-3.3
8	-2.7
9	-2.2
10	-1.8
11	-1.3
12	-1.0
13	-0.6
14	-0.3
15	0.0

1. **EXAMPLE:** the measured $L_{Aeq, 15 minute}$ noise level contribution of an excavator was noted to be 56 dB, however it was only audible for 6 minutes during the 15 minute measurement period, therefore the $L_{Aeq, 15 minute}$ noise level deduction is 4 dB, with a resultant noise level contribution of approximately 52 dB.

A.2 VIBRATION - ACOUSTICAL CONCEPTS AND TERMINOLOGY

A.2.1 *How to Measure and Control Vibration*

Vibration refers to the oscillating movement of any object. In relation to construction projects, ground-borne vibration is the most likely outcome of works and potentially has three (3) effects on vibration sensitive receivers, these are:

- Ground-borne vibration that may cause annoyance;
- Ground-borne vibration that may have adverse effect on a structure e.g. a building; and
- Regenerated noise due to ground-borne vibration.

Each of these potential effects can be assessed with due regard to the relevant standard. Perceptible levels of vibration often create concern for the surrounding community at levels well below structural damage guideline values; this issue needs to be managed as part of the vibration monitoring program.

Vibration is typically measured using specific devices that record the velocity or acceleration at a designated receiver location – usually being the closest premises to works. Modern vibration monitoring devices will typically capture amplitude data for the three (3) orthogonal axes being, the transverse, longitudinal and vertical and also the frequency at which the measured vibration event occurs.

Monitoring of this level of detail enables analysis of significant vibration events to determine compliance with relevant guidelines such as the NSW Department of Environment and Conservation – NSW Environmental Noise Management – *Assessing Vibration: a Technical Guideline* (the NSW vibration guideline), February 2006 and the German Institute for Standardisation – DIN 4150 (1999-02) Part 3 (DIN4150-3) – *Structural Vibration - Effects of Vibration on Structures*.

Vibration propagates in a different manner to noise and can be difficult to control depending on the frequency of the source in question, although identifying the strategy best suited to controlling vibration follows a similar approach to that of noise. This includes elimination, control at the source, control along the propagation path and control at the receiver and/or a combination of these, such as no work/respite periods.

A.2.2 *Vibration Descriptors*

The following terms are often used to describe measured vibration levels.

- **Parameter** – an attribute with a value - for example, weighting.

- **Particle Velocity** – the instantaneous value of the distance travelled by a particle per unit time in a medium that is displaced from its equilibrium state by the passage of a sound or vibration wave.

- **Peak Component Particle Velocity (PCPV)** – is the highest (maximum or peak) particle velocity which is recorded during a particular vibration event over the three (3) axes. PCPV is measured in the unit, mm/s.

- **Phase** – the relative position of a sound wave to some reference point, the phase of a wave is given in radians, degrees, or fractions of a wavelength.

- **Acceleration** – the change in velocity over time. Acceleration is dependent on the velocity and the frequency of the vibration event (velocity is a vector), as such acceleration changes in two ways - magnitude and/or direction. Acceleration is measured in the unit; m/s^2.

- **Perceptible** – vibration levels that a receiver of building occupant may 'feel'. 0.2 mm/s is typically considered to be the human threshold for perception of vibration.

- **Geophone or accelerometer** – the transducer/device typically used to measure vibration.

- **Damage** – is defined in DIN 4150-3 to include minor non-structural effects such as cosmetic damage or superficial cracking in paint or cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

- **Vibration Dose Value (VDV)** – a concept outlined in the DECC Guideline, which is a calculative approach to assessing the impact of intermittent vibration or extended periods of impulsive vibration. VDV require the measurement of the overall weighted RMS (Root Mean Square) acceleration levels over the frequency range 1Hz to 80Hz. To calculate VDV the following formula (refer Section 2.4.1 of the guideline) is used:

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

  Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted RMS of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

- **MIC** - Maximum Instantaneous Charge or explosive charge mass (kg) detonated per delay (any 8ms interval).

- **SD** (m) - The scaled distance for air-blast and ground vibration from the charge to the receiver.

Annex B

Samsung, 2016 Noise Study Review: Noise Limits (Section 1 and Section 2)

Source: *Samsung C&T – Engineering and Construction Group (Samsung) – Indonesia Jawa-1 Noise Study Review – Ver. 07 - Cooling Tower Relocation to East-Side* report, dated 2016.7.9 and prepared by Samsung - Quality Technology Division, Technical Team (Samsung, 2016 Noise Study Review)

1. ITB Review results (Noise Requirement review)

1) Near Field Noise Limits: below 85 dB(A)

2) Far Field Noise Limits: below 70 dB(A) (Industrial Area)

3) Noise requirement: IFC Guideline Limit

Receptor	IFC Guideline Limit One Hour LAeq (dBA)	
	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

※ IFC Guideline Limit states that the noise impacts should not exceed the limits given in the table or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

2. Noise impacts in background level of 3dB at the off-site

※ IFC Guideline Limit states that the noise impacts should not exceed the limits given in the table or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Table 3.2
Noise level results in five location measurement per hour

No	Location	Parameter	Unit	Result	Environmental Quality Standard
1	Perumahan Karyawan Pertamina (Mess) Kec Cilamaya Wetan Kabupaten Karawang S : 93 06896,65 E : 78 6166,15	L1 (Hour 06.00 – 09.00)	dBA	52.6	55
		L2 (Hour 09.00 – 14.00)	dBA	55.0	
		L3 (Hour 14.00 – 17.00)	dBA	54.9	
		L4 (Hour 17.00 – 22.00)	dBA	56.2	
		L5 (Hour 22.00 – 24.00)	dBA	51.2	Leq8h: 48.9 Noise Limit : 51.9
		L6 (Hour 24.00 – 03.00)	dBA	44.8	
		L7 (Hour 03.00 – 06.00)	dBA	46.6	
2	SDN Cilamaya VI Kec. Cilamaya Wetan Kab Karawang S : 93 06736,57 E : 78 6376,12	L1 (Hour 06.00 – 09.00)	dBA	57.4	55
		L2 (Hour 09.00 – 14.00)	dBA	65.7	
		L3 (Hour 14.00 – 17.00)	dBA	63.2	
		L4 (Hour 17.00 – 22.00)	dBA	59.0	
		L5 (Hour 22.00 – 24.00)	dBA	55.1	Leq8h: 52.1 Noise Limit : 55.1
		L6 (Hour 24.00 – 03.00)	dBA	50.8	
		L7 (Hour 03.00 – 06.00)	dBA	46.5	
3	Kp. Bunut Agung Ds.Cilamaya Kec.Cilamya Weta Kab.Karawang S : 93 09098,72 E : 78 7388,57	L1 (Hour 06.00 – 09.00)	dBA	52.5	55
		L2 (Hour 09.00 – 14.00)	dBA	54.9	
		L3 (Hour 14.00 – 17.00)	dBA	60.0	
		L4 (Hour 17.00 – 22.00)	dBA	61.2	
		L5 (Hour 22.00 – 24.00)	dBA	46.8	Leq8h : 45.6 Noise Limit : 48.6
		L6 (Hour 24.00 – 03.00)	dBA	44.4	
		L7 (Hour 03.00 – 06.00)	dBA	45.3	
4	Area Jalur Irigasi Kec. Cilamaya Wetan Kab.Karawang S : 93 09368,53 E : 78 6969,98	L1 (Hour 06.00 – 09.00)	dBA	44.9	55
		L2 (Hour 09.00 – 14.00)	dBA	59.9	
		L3 (Hour 14.00 – 17.00)	dBA	53.8	
		L4 (Hour 17.00 – 22.00)	dBA	60.9	
		L5 (Hour 22.00 – 24.00)	dBA	53.9	Leq8h : 52.0 Noise Limit : 55.0
		L6 (Hour 24.00 – 03.00)	dBA	46.0	
		L7 (Hour 03.00 – 06.00)	dBA	52.9	
5	Area Persawahan Desa Cilamaya Kec. Cilamaya Wetan Kab Karawang S : 93 0991,07 E : 78 6997,16	L1 (Hour 06.00 – 09.00)	dBA	53.9	55
		L2 (Hour 09.00 – 14.00)	dBA	56.1	
		L3 (Hour 14.00 – 17.00)	dBA	55.1	
		L4 (Hour 17.00 – 22.00)	dBA	53.8	
		L5 (Hour 22.00 – 24.00)	dBA	51.9	Leq8h : 51.5 Noise Limit : 54.5
		L6 (Hour 24.00 – 03.00)	dBA	51.2	
		L7 (Hour 03.00 – 06.00)	dBA	51.5	

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ANNEX F
WASTE REGULATORY REQUIREMENTS

Prepared for:

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ANNEX F WASTE REGULATORY REQUIREMENT

Table 0.1 List of Applicable Regulatory Documents

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
General Waste Management					
Act No 18 of 2008 regarding Waste Management	No	General	Republic of Indonesia	Waste management in general	General information on waste types and general implementation method
State Minister of Environment Regulation No 5 of 2009 regarding Waste Management at Port	Yes	Sea	Republic of Indonesia	• Prohibition to dispose waste from vessel routine operational or port supporting activities to sea; • Obligation to dispose waste to waste management facility at port; and • Facility permit and periodic reporting	The Project is responsible for their waste from routine ship operational activities and tank cleaning until it is received by the waste management company. Waste transmission must be reported by the Project responsible party for the ship to port administrator or head of port authority (Article 3)
State Minister of Transportation Regulation No PM 29 year 2014 regarding Pollution Prevention for Maritime Environment	Yes	Sea	Republic of Indonesia	Requirement for preventing pollution from operational activities conducted at Indonesian flagged ship and at port	Information for Project on pollution prevention from operating ship (Article 3)
Non Hazardous Waste - General					
Government Regulation No 81 year 2012 regarding Household and Household-Like Wastes (Garbage) Management	No	General	Republic of Indonesia	Waste minimisation program; Waste treatment hierarchy	The Project will need to prepare Plan/Program and perform waste minimisation, recycling, reuse and waste treatment (Article 12-16)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
State Minister of Environmental Decree No 112 year 2003 regarding Domestic Wastewater Quality Standard	No	Land	Republic of Indonesia	Quality standard for domestic wastewater generated	The Project will need to conduct domestic wastewater treatment to meet the required wastewater quality standard, provide closed and impermeable channel for wastewater disposal to prevent leakage to environment and provide sampling facility at the outlet of wastewater treatment system (Article 8)
State Minister of Environment Regulation No 12 year 2006 regarding Requirement and Procedure of Permit for Waste Water Discharge into Sea	Yes	Sea	Republic of Indonesia	Requirement and procedure of permit for wastewater discharge to sea and reporting	The Project will need to treat their wastewater to meet the requirement of this regulation and obtain wastewater discharging permit before this wastewater is discharged into the sea (Article 2-3)
State Minister of Environment Regulation No 19 year 2010 regarding Wastewater Quality Standard for Oil, Gas, and Geothermal Business and/or Activities	Yes	Water Media	Republic of Indonesia	• Applicable wastewater quality standard; and • Wastewater discharge management, including monitoring and reporting	The Project shall conduct wastewater discharge management, monitor wastewater quality at least 1 (one) time in a month, develop procedures in case of abnormal condition and/or emergency, record wastewater discharge rate daily, report wastewater discharge rate and quality at least every 3 (three) months to the relevant governmental agencies, report the occurrence of abnormal conditions within 2 x 24 hour and emergency situations within 1 x 24 hours to the relevant governmental agencies, and handle abnormal or emergency conditions by running a predetermined handling procedures (Article 10)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
State Minister of Environmental Regulation No 13 year 2012 regarding Implementation Guidelines for Reduce, Reuse and Recycle through Waste Bank	No	Land	Republic of Indonesia	This regulation is for reduce, reuse and recycle activities for Household and Household-Like Wastes (Garbage), through waste bank	Information for Project on the requirement, work mechanism, implementation and implementer of waste bank (Appendix I – III)
Hazardous Waste – General					
Government Regulation No 101 of 2014 regarding Hazardous and Toxic Waste Management	Yes	General	Republic of Indonesia	• Waste minimisation program; • Waste storage, storage period, permit, collection and disposal arrangement • Waste dumping; • Exclusion/delisting of hazardous waste; • By-products arrangement; • Environmental guarantee fund; • Transboundary movement; • Emergency response arrangement	The Project will need to minimise, submit a waste reduction implementation report, obtain hazardous waste temporary storage permit, and send the waste to licensed third party or utilise/process/dispose (if owning the permit) the hazardous waste (Article 10-12 and Article 28-29); and The Project can exclude some of their hazardous waste from specific source, after conducting the required characteristic test (LD50 and TCLP) (Article 192-195, and Attachment II)
Head of Environment Impact Management Decree No KEP-01/BAPEDAL/09/1995 regarding Procedures and Requirements for the Storage and Collection of Hazardous and Toxic Waste	Yes	Land	Republic of Indonesia	Procedures and requirement for storing and collection system	Information for Project on guidance and technical requirement of storage and collection of B3 waste (Article 5)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
Head of Environment Impact Management Decree No KEP-02/BAPEDAL/09/1995 regarding Hazardous and Toxic Waste Document	No	Other	Republic of Indonesia	Manifest and reporting	The Project shall ensure that the manifest shall be provided at the place of collection of hazardous and toxic waste by the generator of the waste for use when transporting it to a storage location outside the premises of generation or when collecting, transporting, treating, using, or disposing of the treatment products (Article 1)
Hazardous Waste – Transportation					
President Decree No 109 of 2006 regarding Emergency Response for Oil Spillage in the Sea	Yes	Sea	Republic of Indonesia	• Oil spill response, mitigation and reporting procedure; • Responsibility for cost caused; and • Levelling of oil spill emergency response (Tier 1 until Tier 3)	The Project will need to be responsible for responding the emergency condition on oil spill in the sea that come from their activities and to report the incident to the officer (Article 2)
State Minister of Transportation Decree No KM 69 of 1993 regarding Implementation of Goods Transportation	No	Land	Republic of Indonesia	• Permit for hazardous waste and material transporter; and • Requirement for vehicle equipment and operational method (loading/unloading, journey management)	Information for Project on the need of Government permit for the hazardous material and waste transporter and method of transporting hazardous material and waste (Article 12 and 15)
Director General of Land Transportation Decree No SK.725/AJ.302/DRJD/2004 regarding Implementation of Hazardous and Toxic Waste Transportation on Road	No	Land	Republic of Indonesia	• More detail requirement for hazardous and toxic waste's utilised vehicle; • Driver and helper of the vehicle Road path; and • How to operate the vehicle	The Project shall ensure that every vehicle must meet the general and specific requirements, relevant to the transported hazardous and toxic waste type and characteristic (Article 4)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
Circular Letter from Directorate General of Sea Transportation No UM.003/1/2/DK-15	Yes	Sea	Republic of Indonesia	Requirement for ship that transporting hazardous and toxic waste and format for the approval letter that need to be gained from the main harbour master	The Project shall ensure that the ship that they will use in hazardous and toxic waste transportation meet the requirement stated in this Circular Letter and have the approval from main harbour master prior to transporting the waste
International Convention for the Safety of Life at Sea (SOLAS), 1974	No	Water	International	• Minimum standards for the construction, equipment and operation of ships, compatible with their safety; • Fire Protection, Fire Detection and Fire Extinction; and • Carriage of Dangerous Goods	Information for Project on carriage of dangerous goods, including the requirement of packing, marking, labelling, placarding, documentation, storage, and to comply with International Bulk Chemical Code (IBC Code), International Gas Carrier Code (IGC Code), and International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code) (Chapter VII, Part A-D)
MARPOL - International Convention for the Prevention of Pollution from Ships (1973) consolidated Edition 2006	No	Water	International	• International convention covering prevention of pollution of the marine environment by ships from operational or accidental causes; • Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk; and • Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form	The Project shall not discharge residues containing noxious substances within 12 miles of the nearest land (Annex II)

Title	Critical Regulatory Guideline	Environmental Segment	Jurisdiction	Regulatory Keyword	Summary of Implications for Project
International Maritime Dangerous Goods (IMDG) Code Volume 1 (2006) and Volume 2 (2012)	Yes	Water	International	• Safe transportation or shipment of dangerous goods or hazardous materials by water on vessel; • List of harmful substances; and • Advice on the management of the materials including terminology, packaging, labelling, placarding, markings, stowage, segregation, handling, and emergency response	Information for Project on the implementation of IMDG code

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ANNEX G
VISUAL IMPACT ASSESSMENT

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CONTENTS

CONTENTS

1 INTRODUCTION

PT Pertamina (Persero), Sojitz Corporation and Marubeni Corporation (the Sponsors) have established a joint venture project company named PT Jawa Satu Power (JSP) to develop a Liquefied Natural Gas (LNG) Floating Storage and Regasification Unit (FSRU), Combined Cycle Gas Turbine (CCGT) Power Plant, 500kV power transmission lines and Substation. Together, these elements comprise the PLTGU Jawa-1 Project (the Project).

The Project will be developed within the Karawang and Bekasi Regencies of West Java, Indonesia.

The construction of this Project is expected to commence in 2018. Operation of the 1,760 MW CCGT Power Plant and delivery of first power expected in 2021.

1.1 PURPOSE OF THIS REPORT

This report will determine visual impacts that might be brought about by the construction and operation of the Project. The assessment will establish the existing conditions of the Project area and where specific potential visual impacts or interactions with the environment are identified, provides suggested management recommendations to mitigate the potential visual impacts of the Project.

The Performance Requirements are incorporated into the Environmental Management Framework (EMF) and embody the recommendations of environmental management arising from the environmental impact and risk assessment process. The specific Performance Requirements relevant to this study area are presented within this report along with relevant suggested management and mitigation measures relating to the Project.

2 METHODOLOGY

The methodology used within this Visual Assessment is set out below.

Figure 2.1 Assessment Methodology

2.1 DEFINE THE VISUAL COMPONENTS OF THE PROJECT

Describe the key components of the Project that may contribute to visual impact during the construction and operation phases of the Project.

2.2 ESTABLISH STUDY AREA /VIEWSHED

The extent of the study area for visual assessment of the Project will be determined based on the Parameters of the Human Vision and the proposed visual changes that might be brought about by the project. This report will describe the extent of the study area as the Project viewshed.

The rationale behind the definition of the viewshed is appended to this report (Refer **Annex A**).

2.3 LANDSCAPE UNITS AND SENSITIVITY

This step seeks to determine areas of visual sensitivity within the view shed and the ability of those areas to accommodate the visual change of the project.

Landscape Units are underpinned by geology, soils, vegetation and drainage systems and statutory protection. However visually, Landscape Units often distil to predominant visual characteristics such as land-use, vegetation and topography, which have determined historical land management practices.

2.4 *Seen Area Analysis*

Typically, a Seen Area Analysis is provided as part of a visual assessment to determine those areas from which key Project infrastructure may be screened from view by topography. This analysis utilises a GIS mapping study that is based on topography only. It does not consider the potential screening that may be afforded by vegetation and buildings.

The Project is located in agricultural plains of Karawang and Bekasi Regencies of West Java, Indonesia. The landscape surrounding the Project is flat with little topographical relief, which may afford screening of the Project.

It is therefore assumed that the Project is potentially visible throughout the viewshed the identified zones of visual influence.

2.5 *Assessment of Publicly Accessible Viewpoints*

The visual assessment of the Project will be undertaken from a selection of viewpoints, which provide for the range of view angles, distances and settings towards the Project.

Visual Impact Assessment (VIA) from the public domain is based on four criteria; visibility, distance, and landscape character & viewer sensitivity and viewer number. A description of influence of each of the four (4) criteria is outlined below.

Visibility: Project visibility can be affected by intervening topography, vegetation and buildings.

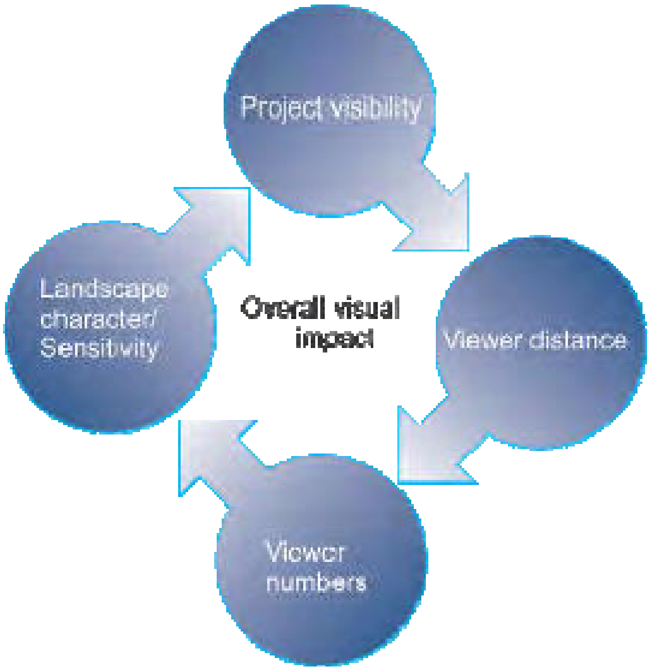
Distance: Visibility and scale of project infrastructure decreases as distance increases. This is considered by Zones of Visual Influence (ZVI) where an indication of impact based solely on distance is provided for.

Landscape character and viewer sensitivity: The character of the landscape around the site and adjacent to the viewing location will influence the ability of the project changes to be absorbed within existing change. That is, a landscape such as farmland is considered of low sensitivity, whereby a pristine landscape such as a national park is considered highly sensitive. Similarly, a greater sensitivity to visual change is afforded to a residential area or township than that of an industrial landscape.

Number of viewers: The level of visual impact decreases where there are fewer people able to view the Project. Alternatively, the level of visual impact may increase where views are from a recognised vantage point. Viewer numbers from a recognised vantage point would be rated as high.

The ratings of each criterion are not numerically based and cannot be simply added together and averaged to arrive at an overall rating. These four criteria need to be considered in the assessment of each viewpoint.

The overall effect of the Project at each viewpoint will be assessed by evaluating the value of each of those criteria, ranking those as being either low, moderate, or high, and subsequently making an assessment as to the overall effect by balancing each of those criteria.



2.6 SCALE OF EFFECTS

In a visual assessment, it is important to differentiate between a "visual impact" and a "landscape impact". Viewer numbers are important in the assessment of a visual impact, as if no one sees a particular development then the visual impact is nil, even though there may be a significant change to the landscape and hence a large landscape impact.

The overall visual impact of the Project when assessed from each viewpoints will use the following scale of effects:

- ***Negligible*** – minute level of effect that is barely discernible over ordinary day to day effects.
- ***Low adverse effect*** – adverse effects that are noticeable but that will not cause any significant adverse impacts.
- ***Moderate adverse effect*** – significant effects that may be able to be mitigated/remedied.

- ***High or unacceptable adverse effect*** – extensive adverse effects that cannot be avoided, remedied or mitigated.

A description of each of the effects is provided below:

Negligible Adverse effect: The assessment of a "*negligible*" level of impact is usually based on distance. That is, the Project is at such a distance that, when visible in good weather, it would be a minute element in the view across a modified landscape or screening afforded by vegetation can lead to a similar level of assessment.

Low adverse effect: The assessment of a "*low*" level of impact can be derived if the rating of any one of three factors, that is distance, viewer numbers and landscape sensitivity, is assessed as low. The reasoning for this "*low*" assessment is as follows:

- If the distance to the Project is great (i.e. towards the edge of the viewshed) then even if the viewer numbers and the landscape sensitivity were high, the overall visual impact would be minor because the Project would only just visible in the landscape.

- If viewer numbers were low, (i.e. few people can see the Project from a publicly accessible viewpoint); Project was close to the viewpoint and the landscape sensitivity was high, the overall visual impact would be low because the change would be seen by few viewers.

- If landscape sensitivity was low (i.e. within a highly modified landscape) then even if the Project was in close proximity to the viewpoint and it was visible to a large number of viewers, the overall visual impact would also be low because the viewpoint is not in a landscape of such sensitivity that further change would be unacceptable.

Moderate adverse effect: The assessment of a "*more than minor effect*" will depend upon all three assessment criteria (distance, viewer numbers and landscape sensitivity) being assessed as higher than "low"

High or Unacceptable adverse effect: The assessment of a "*high*" or "*unacceptable adverse effect*" from a publicly accessible viewpoint usually requires the assessment of all these three elements to be high. For example, a highly sensitive landscape, viewed by many people, with the development in close proximity would lead to an assessment of an unacceptable adverse effect. This assessment is also usually based on the assumption that such a view cannot be mitigated.

An example may be a well-frequented viewpoint in a National Park, that is in close proximity to the Project and that currently overlooks what appears to be a natural, pristine, un-modified landscape.

Landscape treatment would block this view and even though it would mitigate the view to the Reference Project such treatment would be unacceptable as it would also block the view from the lookout.

2.7 MITIGATION MEASURES FOR PUBLICLY ACCESSIBLE VIEWPOINTS

Where required, the ability for landscape mitigation to contribute to visual impacts will also be discussed at particular viewpoints or where required. For example, existing or supplementary roadside planting along a section of road or sensitive boundary may significantly reduce the visual impact of the Project.

2.8 RESIDENTIAL VIEWPOINTS

Visual impact from residential dwellings will be undertaken by way of representational view angles towards the edges within villages in proximity to the Project.

The assessment of visual impact from residences and villages is different to publicly accessible viewpoints in the following ways. An assessment of visitor numbers is not applicable and the landscape sensitivity is always rated as "high", as it must be recognised that people feel most strongly about the view from their dwelling and from their outdoor living spaces.

2.9 MITIGATION MEASURES FOR RESIDENTIAL VIEWPOINTS

Mitigation measures are also being considered and these will be evaluated to see how they may reduce the visual impact from residences.

2.10 RECOMMENDATIONS

Recommendations are based on the findings of this landscape and visual impact assessment.

3 PROJECT DESCRIPTION

The Project involves the development of a Liquefied Natural Gas (LNG) Floating Storage and Regasification Unit (FSRU), Jetty and on-shore pumping, buried water and gas transfer pipelines, Combined Cycle Gas Turbine (CCGT) Power Plant, 500kV power transmission line and a Substation.

Figure 3.1 shows the location and layout of the key project components.

The following will describe the features of Project as relevant to assessing the visual impacts of the Project.

3.1 FLOATING STORAGE AND REGASIFICATION UNIT (FSRU)

The FSRU with a nominal capacity of approximately 82,000 metric tons at design draught (or 86,400 metric tons at summer draught) will be permanently moored offshore of Ciasem Bay within Subang Regency at a distance of approximately of eight (8) km off the north Ciasem Bay coast and at depth of 16 m of sea level.

The FSRU will receive LNG deliveries via Carriers, mainly from BP Tangguh Liquefaction Plant. The LNG transfer will occur between 19-27 times a year with a total capacity of 125,000 m^3 to 155,000 m^3. The onboard re-gasification system will process the LNG suitable for delivery to an Onshore Receiving Facility (ORF).

The key components of the FSRU relevant to visual assessment summarised below.

Table 3.1 ***FSRU Specifications***

FSRU	Description
Dimensions	292.5 x 43.4 x 26.6 (m)
Draft	11.9 / 12.3 (Td summer)
Capacity	170,150 m^3

Figure 3.2 shows an FSRU of similar size and dimensions to that proposed by the Project.

Figure 3.1 *Project Layout*

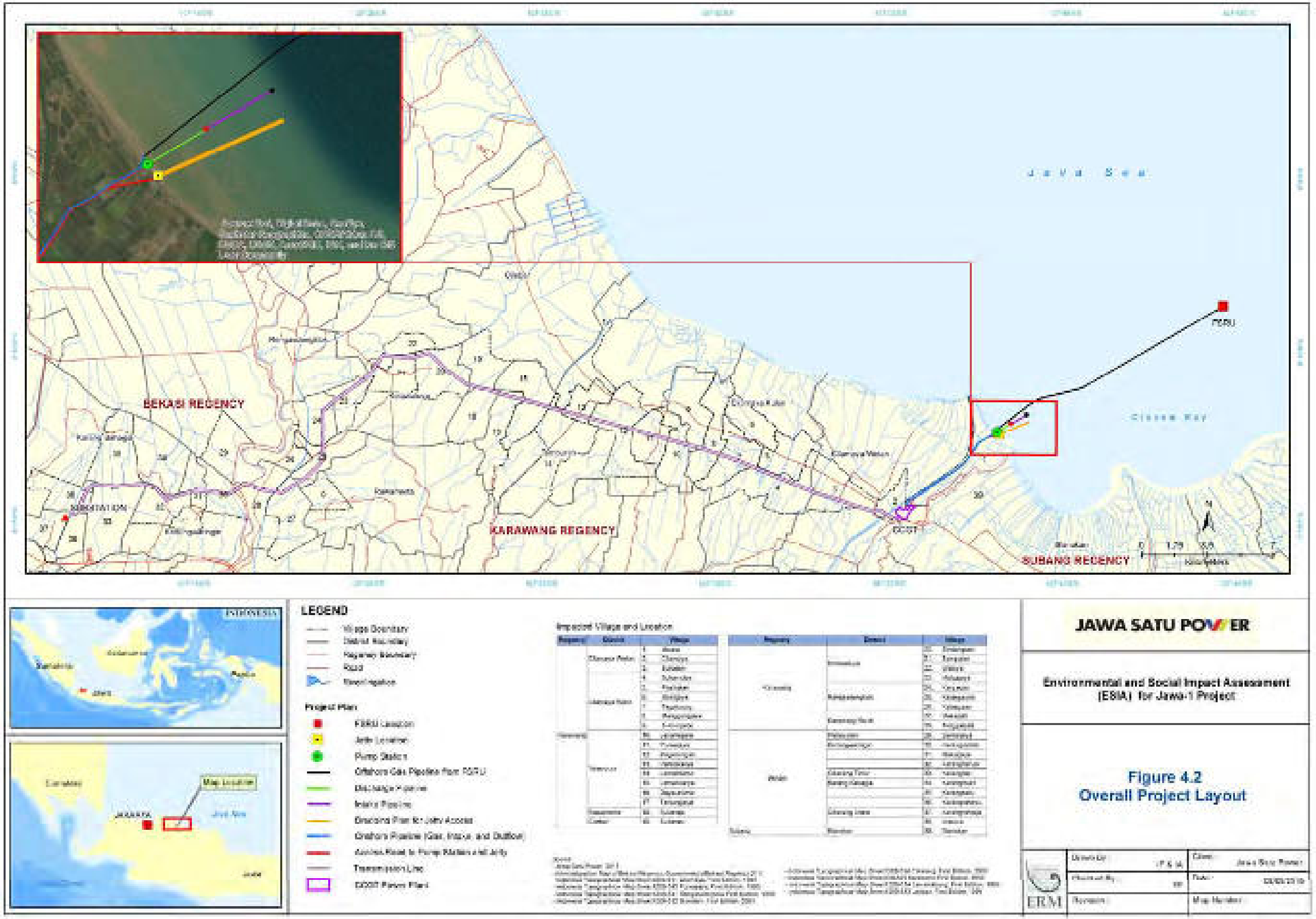


Figure 3.2 *Indicative FSRU*

Visually the FSRU will not be dissimilar to other ocean going vessels such as cargo ships and bulk material transporters and therefore commensurate and compatible with land based views towards the ocean.

Although the FSRU may be visible and potentially noticeable from the nearest land based viewing locations, because of the visual compatibility of the FSRU within ocean views, the visual change and impact would be minimal.

3.2 PIPELINES

The Project proposes to construct a gas pipeline for the purposes of transporting LNG between the FSRU and the power plant and water transfer pipes for cooling of power station.

3.2.1 Gas Pipelines

Gas transportation infrastructure will include approximately 14 km of sub-sea pipeline between the FSRU and shoreline and approximately seven (7) km of buried pipeline between the shoreline and the Onshore Receiving Facility (ORF) within the power plant site.

3.2.2 *Seawater Water Intake and Cooling Water Outfall Discharge Pipeline*

A seawater intake pipeline and pump station will be established close to shorefront. An offshore a cooling water discharge pipeline will also be established.

Figure 3.3 shows an existing buried pipeline corridor in close proximity to that proposed by this project.

Figure 3.3 *Existing Pipeline Corridor*

Once rehabilitated, the pipelines proposed by the Project would not be dissimilar to those that already existing in the area.

The majority of the onshore pipelines will be constructed within an existing easement. Following construction of the pipelines, the pipeline easements would be rehabilitated and returned to its current visual condition.

3.2.3 *Onshore Pumping station*

The onshore pumping station will deliver seawater the CCGT for various operational purposes including cooling and potable uses.

A pump station will be installed in a fenced enclosure at the Java Sea shoreline. The Pump station will be construed in a concrete basis approximately 25 m length x 7.8 m width x 12.7 m high. The floor of the basin will be approximately 9.6 m below the mean sea level (MSL) and the top of the basin approximately 3.1 m above MSL.

The site of the seawater pumping station (including electro chlorination plant, electrical building, etc.) will be elevated on the ground level of +2.6 m MSL, approximately two (2) m above high tide (+0.59m MSL).

An access road will be constructed beside the SKG Cilamaya ROW to connect the power plant to the Intake Pumping Station area. This road will be four (4) m wide.

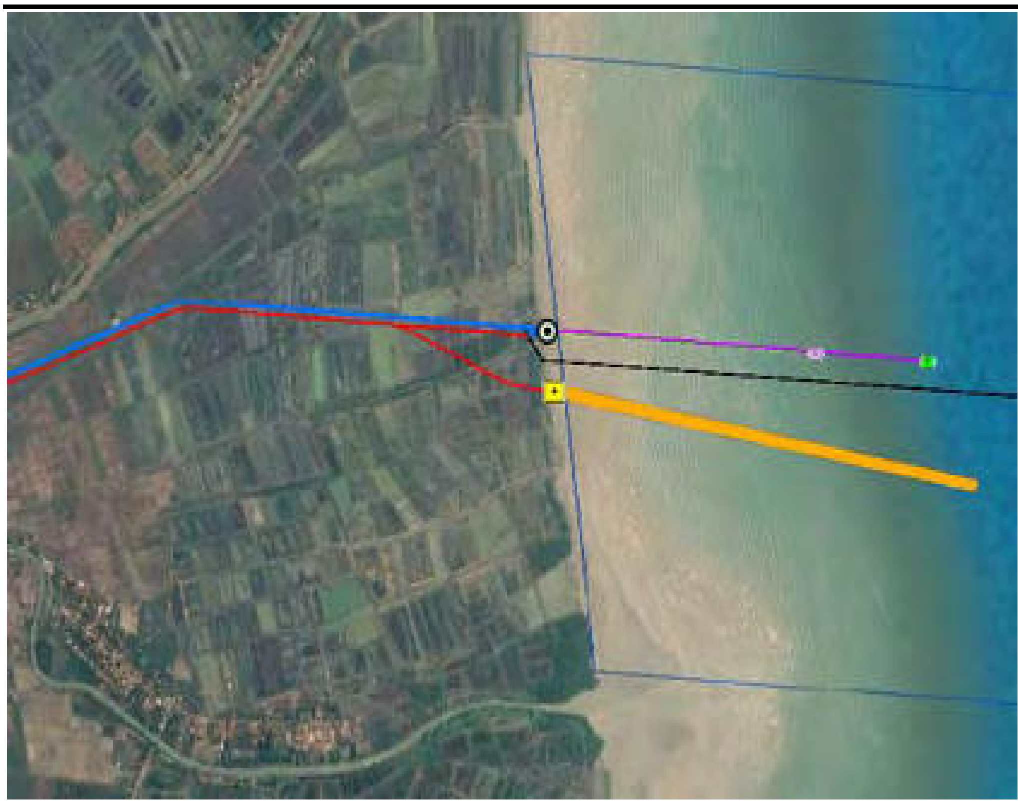
With the exception of the on shore pump station for the cooling water system, all pipelines and associated infrastructure will be either under sea or buried and therefore not visible.

3.3 *JETTY*

A new Jetty will be built to support mobilisation of heavy equipment and material. The jetty will be constructed at Muara Village, approximately 1.34 km from the mouth of the Cilamaya River. After the construction is complete, the jetty will remain to support emergency operations and CCGT maintenance.

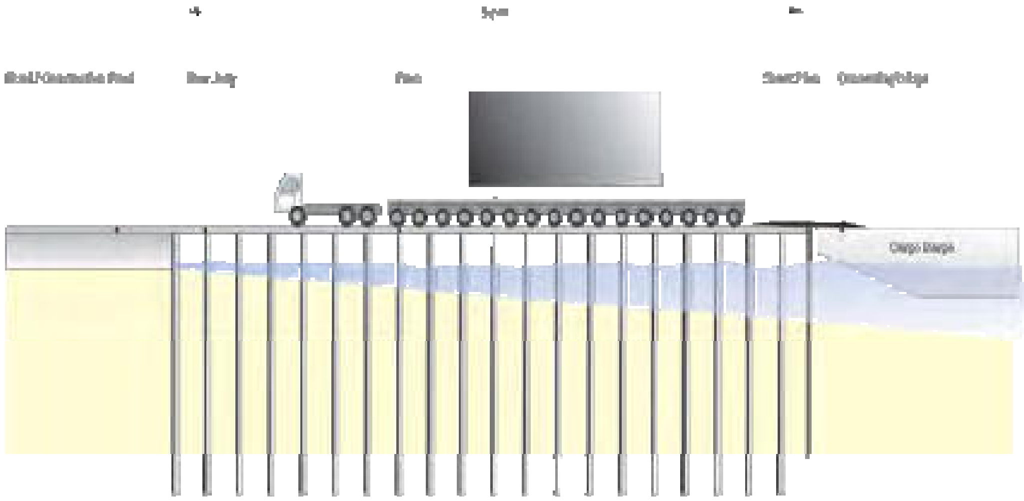
Figure 3.4 shows the proposed location and layout of the Jetty in relation Muara Village, Cilamaya River, the surrounding land-use and other project infrastructure.

Figure 3.4 Jetty Location and Layout



The Jetty will be approximately 50 m L x 10 m w. Dredging is expected to be carried out during construction.

Figure 3.5 *Indicative Jetty Elevation*



The land take off point of the proposed Jetty is located amongst farming areas and the shoreline.

There are no nearby dwellings or roads, which would encourage visitors to the area or where people may see the Jetty. Visually the jetty would be similar to other Land/Sea supporting infrastructure found along the shoreline and in close proximity to the project.

3.4 *CCGT POWER PLANT*

The Combined Cycle Gas Turbine (CCGT) Power Plant will include the gas turbine buildings, cooling towers, noise walls, lighting, drainage works and associated infrastructure.

The CCGT development site is approximately 36.7 ha is area and lies to the north east of Cilamaya Village. The site was formerly part of a larger development site under the ownership of Pertamina (Persero). The site is currently undeveloped and used for agricultural purposes.

Site levels will be raised to 4.0m above mean sea level. A raised embankment with varying crest levels ranging from MSL+ 4.2 to MSL +6.0m MSL will surround the site to further flood proof the power plant.

The power plant complex will consist of five (5) main buildings supported by other infrastructure. The main buildings include the Onshore Receiving Facilities (ORF), two (2) turbine buildings, Heat Recovery Steam Generator (HRSG), Control and Electrical building (CEB), Cooling Towers, administration building and a workshop/warehouse building.

The key components relevant visual impacts is summarised below:

- Onshore Receiving Facility (ORF) will be located within a fenced compound to the north east of the power plant site. The ORF will be equipped with a control room and a meter room. A 70 m high vent stack and emergency flare.

- Two (2) turbine buildings, one (1) for each of the two (2) single shaft CCGT units. Each building has an area of 2,150 m^2 and will be 28 meters in height.

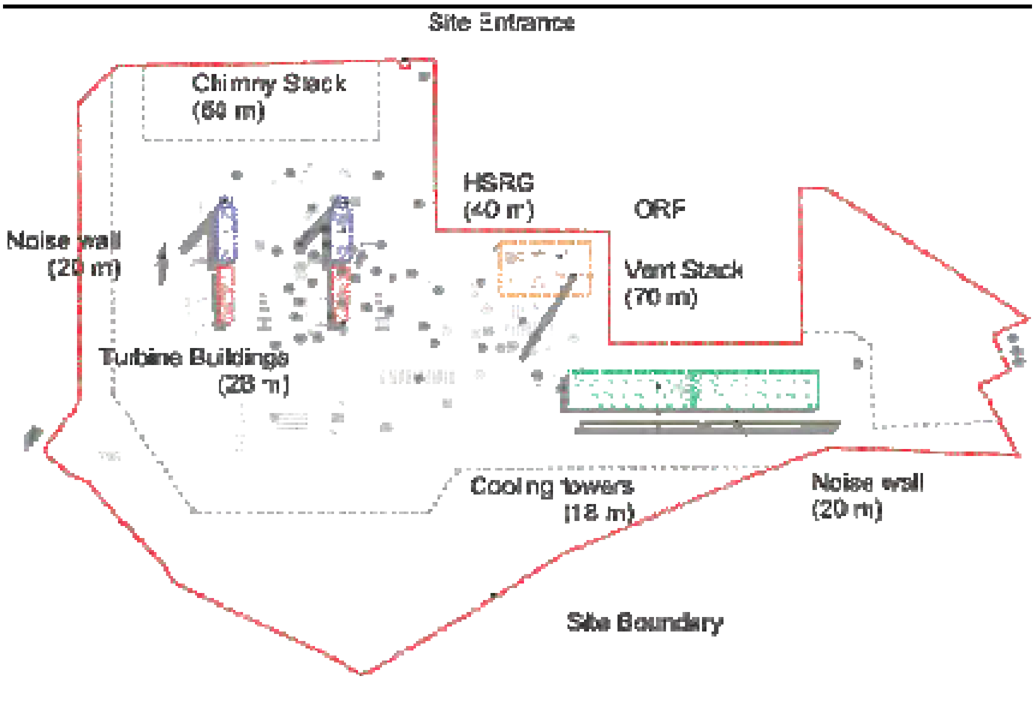
- Two (2) Heat Recovery Steam Generator (HRSG) will be housed in a building approximately 40 m in height with 60 m high, nine (9) m dia. Chimney Stack. Each will be equipped with a Continuous Emission Monitoring System (CEMS).

- Two (2) cooling tower blocks approximately 16 m L x 16 W x 18.7 m high will be constructed along the south eastern boundary of the site. The preliminary design includes 16 cells in each block. The final dimensions will be confirmed at the detailed design stage.

- A bank of cooling towers will be located in along the sites south eastern boundary. The Cooling Towers themselves are low level; however, a 20 m noise attenuation wall would be constructed along the length and to a height of 20 m.

Figure 3.6 shows the location and height of the key components relevant to visual impact.

Figure 3.6 *CCGT Key Visual Components*



Other buildings include:

- The Control and Electrical Building which houses the central control room, document room, kitchen/mess facilities, toilets, electronic and computer rooms, telecommunication room, MV and LV switchgear rooms and battery rooms.
- Administration Building will be constructed to include facilities such as a reception area, offices, meeting rooms and prayer room. The building will be not dissimilar is size and scale to others in the general area.
- The Workshop and Warehouse will contain machine tools, equipment, and storage of material required for routine maintenance.
- Service and Fire Water Storage system will comprise two (2) water storage tanks approximately 628 m^2.
- Chemical and Oil Storage Shelter (340 m^2) will store chemicals and lubricating oils for the operation and maintenance of the power plant.
- The Water Treatment Plant treat seawater for operational use throughout the plant including:
    - Cooling tower make up water;
    - Evaporative cooler make up water;
    - Process water (boiler make up, chemical dosing system dilution water, closed circuit cooling water make up etc.);
    - Service water (for cleaning and maintenance purposes);
    - Fire water; and
    - Potable water.

3.4.1 *Adjoining Boundaries*

Surrounding Land uses include paddy fields, and irrigation channel and linear village to the north, paddy fields to the east and south east, Cilamyan Village to the south west and the Pertagas Housing Complex to the west.

The plant sites adjoining boundaries include:

- An existing ROW, Power and LNG plant to the north,
- Paddy Fields to the south east,
- Cilamayan Village to the south west, and

3.4.2 Jalan Simpang Tiga Pertamina (Road) to the west.

The power plant site is set within an area that comprises a range of uses from agricultural and farming to industrial. The sites boundaries and adjoining development area shown in **Figure 3.7.**

Figure 3.7 Adjoining Boundaries and Layout

The components of the CCGT that will contribute to visual impacts are the 70 m high vent stack in the ORF, the 40 m high chimney stacks and buildings associated with the turbine generators, and the cooling blocks.

It is expected that the two noise walls to the south and west of the project would be solid and would therefore assist to shield views to some of the direct light sources within the plant.

3.4.3 Visual Plume

The CCGT Power Plant options indicate that a visual plume associated with either options of the Power Plant is rare to unlikely.

A visual plume due to particulates is unlikely unless there is a major engine fault. If this was to occur, the plume would be brief due to on board engine management systems that are designed to shut the engines down should in such an event.

Visual plumes due to water vapour are also possible and would likely occur on engine start-up on cold, damp mornings and where the exhaust system is also cold. This would also be short term until the engines and exhaust reach operating temperature.

Visual plumes associated with the conversion of NO to NO^2 generally occur where temperatures in the exhaust stacks are in excess of 500°C. This results in a slightly brown to red visual plume.

The Gas Fired Power Station options operate on natural gas. The exhaust temperatures for natural gas are less than 400°C and therefore below the temperature range where NO to NO2 conversion takes place. There is unlikely to be a visual plume associated with NO to NO2 conversion.

There is the potential for visual plumes to be generated by the Gas Fired Power Station. The most regular instance of visual plumes will be on engine start-up on cold damp mornings. When these occur, they will be short in duration and until the engines and exhausts, temperatures reach operation temperatures. The visual impact of visual plumes associated with the Gas-Fired Power Station will be low.

3.5 500 KV TRANSMISSION LINE

A new 52.16 kilometre transmission line will be developed to transfer electricity from the Power Plant to the Cibatu Baru II/ Sukatani substation. The transmission will be approximately 34 m wide.

The transmission corridor will pass through two regencies; Karawang and Bekasi and near to 35 villages. The proposed transmission line route crosses mainly areas of land used for agricultural purposes (rice paddy fields) (*Spatial Planning, 2011*) therefore limiting any requirement to remove vegetation or trees.

Upgrades to the local electricity grid would also be required for the pumping station.

3.5.1 Tower Design

The transmission line infrastructure will comprise up to 118 lattice transmission towers with an overall height of 50 m to the catenary wire.

There are six (6) tower types proposed to be installed across the project. The reason for the different types is to allow for flexibility in design to accommodate minimum clearance heights above various land-uses, variabilities in spans to clear ground based features and layout or articulation in the line.

Table 3.2 *Tower types*

Tower Type	Angle (deviation)
AA	0° -5°
BB	0°-10°
CC	10° - 15°
DD	30° - 60°
EE	60° - 90 °
FF	Terminal Towers

The standard lattice tower height proposed by the project is 36 m. Similar to the reasons above; this height will vary depending on span width, clearance heights and topography. Typical tower heights range from 36 m-3 (33 m above ground) to 36 m+12 (48). The height difference will not be perceptible over most distances. **Figure 3.8** shows a typical lattice tower.

Figure 3.8 *Indicative Transmission Towers*

At close distances, the pylons will appear large. Their apparent size will diminish over distance.

Table 3.3 shows the specifications for lattice towers and steel poles, which have formed the basis for both the visual impact assessment in this report.

Table 3.3 *Lattice Tower*

Span length on level ground	390 – 530 m
Height range	33 – 48 m
Base dimensions	10 – 12 m square
Top dimensions	1.5 x 7.5 m diameter
Height to lower conductor at tower/pole	20 – 36 m
Easement width	34 m

Insulator arrangement	Conventional cross arms
Typical foundation dimensions	4 off 0.9 m diameter (above ground), or 0.9 m diameter x 6 m deep pile

Source: Land Procurement for 500 kV Transmission Line & Substation of Jawa 1 Combined Cycle Power Plant IPP Project, June 2017

To ensure that this assessment is based on a 'worse case' scenario, this report has assumed that the following dimensions apply to all lattice towers have a height of 48 m and a span length on level ground of 360 m

3.5.2 *Ancillary Power Infrastructure*

Sections of existing distribution power lines will be upgraded to provide power for pumping station and marine Structures. These upgraded power lines will be a combination of single 66kV and 22kV construction.

Indicative photographs of the poles associated with this type of infrastructure are shown in **Figure 3.9.**

Figure 3.9 ***(Left to right) Single Circuit 66 kV with Subsidiary (Wood poles), Double Circuit 66 kV with Subsidiary***

Electrical infrastructure and light poles are found in many locations within the project area and is not considered to have a high visual impact.

3.6 CIBATU BARU II/SUKATANI SUBSTATION

A new 500kV substation will be developed at the western end of the new 500kV transmission line to the Java-Bali grid.

The substation will be located within an area currently used as paddy fields and agriculture. An existing 500 kV power line to the east of the site runs between Muara Tawar to the northwest and Cibatu to the south east.

Figure 3.10 shows location and setting of the proposed substation.

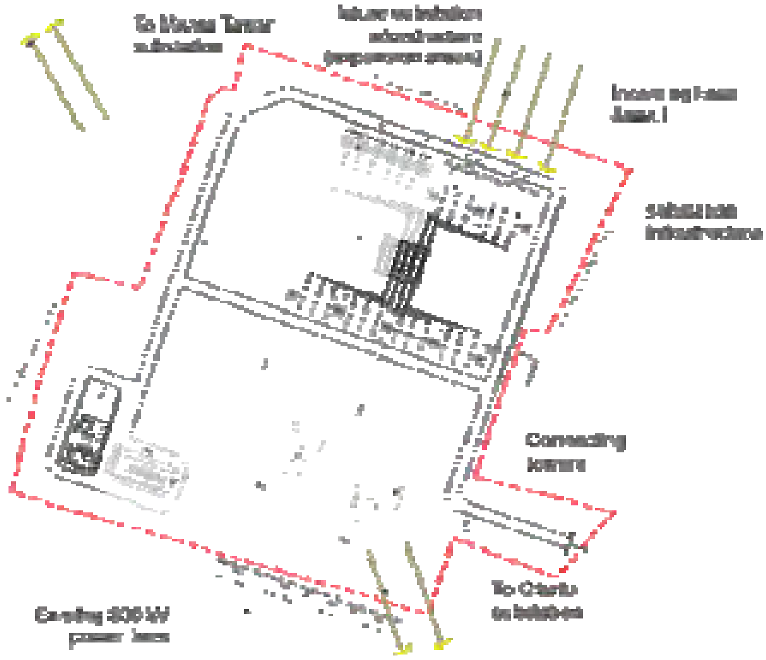
Figure 3.10 *Substation Location and surrounding area*

The existing 500 kV overhead power line and associated infrastructure are also located within agricultural land.

The 500kV Cibatu Baru II/Sukatani Substation will be an outdoor gas insulated design comprising:

- Two (2) outgoing lines to the 500kv Muara Tawar substation;
- Two (2) outgoing lines to the 500kv Cibatu substation; and
- Two (2) incoming lines from PLTGU Java-1 Power Plant.

Figure 3.11 Substation Layout



The substation area includes additional capacity for additional substation bays.

A small substation control building shall be provided which will consist of an office room, communications room, control room, and protection room.

Substation construction consists of control and switchyard building and:

- Transformer and assemblies;
- Filtering and internal wiring transformer equipment;
- Disconnecting Switch;
- Circuit Breaker;
- Lightning Arrester;
- Current Transformer;
- Positive Transformer;
- Neutral Current Transformer;
- Capacitor Voltage Transformer;
- Neutral Grounding Resistance;
- Panels and Cubicle Installation;
- Grounding System Installation; and
- Internal Wiring.

The substation and associated connecting infrastructure would be similar or at a lower scale to that of the existing 500 kV power line and the incoming lines from the Jawa1 Power Station.

3.7 CONSTRUCTION

This section will briefly describe the types of construction activities associated with the project as relevant to visual impact. This includes timeframes, material handling, plant, and equipment.

3.7.1 Pipelines

The onshore transfer Pipelines are approximately seven (7) km in length. The majority of the Transfer pipeline will be constructed using open trenching and backfilling. **Figure 3.12** shows the construction of a 1700 mm diameter steel pipe. Construction timeframes for open trenching allow for approximately 80 – 100 lineal meters per day within the construction area.

Figure 3.12 Typical Pipeline Construction

In addition, a seawater intake structure and pump station will be established in a fenced compound at the shoreline of the Java sea, close to the jetty and intake and discharge pipelines. The seawater will be abstracted using one (1) offshore intake pipe connected to a submerged intake head located in a dredged pit located at -4.5 meters MSL. The offshore intake pipe is preliminary sized at 1.3 meter diameter. The approximate length of the intake pipe is 2000 m.

The CCGT Power Plant process wastewater will be discharged using one (1) offshore discharge pipe connected to a submerged discharge diffuser located at -2.5m MSL. The offshore wastewater discharge pipe is preliminary sized at 0.9 meter diameter. The approximate length of the discharge pipe is 1000 m. The seawater intake pipeline and wastewater discharge pipeline will be made of HDPE material.

3.7.2 CCGT Power Plant

The construction of CCGT Power Plant is predicted to be completed within 36 months, which consists of material and heavy equipment mobilisations/demobilisation, installation of main building, supporting facilities and onshore gas pipes and commissioning test.

During the construction activities, it is expected that more than 4000 vehicles per year will be utilised for material transportation. This includes the mobilisation of the proposed construction equipment will include heavy equipment for land clearing and road construction such as bulldozer, loader, excavator, mobile crane, pile machine, molen, grader, scrapper, batching plant, asphalt mixing plant, and pile driver and gas turbine equipment transportation.

The majority of materials and heavy equipment will also be transported through temporary jetty for the CCGT construction.

3.7.3 500 kV transmission line

Tower foundation installation consists of land excavation, piling, setting, working floor making, stub shoes making, stub setting, crooked cut and supporting, formwork installation, cast preparation, earthing angle installation and grounding, cast foundation concrete, formwork disposal, filling and equipment demobilisation, and PLN boundary stacks installation.

Excavation to a depth of 3.5 m will be required where towers are located within the paddy fields or areas of soft ground. The excavated soils will be stockpiled for re-use following construction of foundations. The foundation of flooring will be constructed by drilling bore holes for the bored piers with a casing to prevent bore hole collapse prior to placing and shaping concrete.

Once the tower foundations are established, the lattice towers will be transported to site and assembled in place.

3.7.4 Construction Camps

Construction camps will be established at locations where accommodation is in short supply. Camps will be temporary only and used to shelter workers and storage of construction materials and equipment. Camp sites will be rented from the local community and rehabilitated following completion of construction.

There are no landscape techniques that can be employed to mitigate the visual impacts associated with the construction of the Project. However best practice construction management would be employed to maintain construction areas to the minimum required.

4 *VIEWSHED*

The viewshed is the area that can potentially be visually affected by a development or the zone of visual influence (ZVI). This report will use the term "viewshed". The viewshed extends to a distance at which the built elements are considered visually insignificant, even though they may still be visible.

The viewshed for the Gas-Fired Power Station has been based on an exhaust stack height of 70 m, which is the tallest proposed structure within the project.

The viewshed for the transmission lines and substation has been based on a tower height of 50 m.

No viewshed has been established for either the pipelines or on shore pumping station. This is because the pipelines will be buried and therefore not discernible once rehabilitated. The onshore pumping station would only be approximately 2 – 4 m above ground level and below the height of nearby and surrounding vegetation.

4.1 *VIEWSHED DEFINITION*

The extent of a viewshed for a development can be determined by an analysis based upon the parameters of human vision. For readers not familiar with the parameters of human vision these are set out in **Annex** A.

This analysis shows that a 70 m high structure becomes visually insignificant within this landscape at a distance of approximately 8.2 km.

This analysis shows that a 50 m high structure becomes visually insignificant within this landscape at a distance of approximately 5.7 km.

4.2 *PROPOSED VIEWSHED FOR THE PROJECT*

The extent of the viewshed and the ranges of visual impact are shown in **Table 4.1**. These tables also describe the levels of visual impact within the viewshed that will be used to assess the visual impact of the Project.

Table 4.1 *Viewshed and Zones of Visual Influence Gas-Fired Power Station*

Visual Impact	Vertical View angle	Distance CCGT	Distance 500 kV
Visually insignificant- A very small element in the viewshed, which is difficult to discern and will be invisible in some lighting or weather circumstances.	< 0.5°	<8.2 km	<5.7 km
Potentially noticeable, but will not dominate the landscape - The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer; however the wind turbines do not dominate the landscape.	0.5° - 1°	4.1 – 8.2 km	2.8 – 5.7 km
Potentially noticeable and can dominate the landscape - The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer	1°- 2.5°	1.6 - 4.1 km	1.2 - 2.8 km
Highly visible and will usually dominate the landscape - The degree of visual intrusion will depend on the wind turbines' placement within the landscape and factors such as foreground screening.	2.5° - 5°	800 m - 1.6 km	570 m – 1.2 km
Will be visually dominant in the landscape from most viewing locations - Unless screened by topography or vegetation, wind turbines will dominate the landscape in which they are sited.	>5°	800 m	570 m

Distance ranges are used as a guide to determine zones of visual impact. It is recognised that built form visibility does not dramatically change at each defined band. For example, visibility does not dramatically change when a viewer moves from 1.9 km to 2.1 km from the nearest proposed building, even though these locations are within different bands that, for the purposes of this analysis, show differing levels of impact. It must also be recognised that climatic factors such as rainfall, sea haze, cloudy skies and sun angle will also affect the visibility of development.

Figure 4.1 shows a view along an existing transmission line easement, west of the Project.

Figure 4.1 ***Atmospheric Effects***

Here the atmospheric effects on the visibility of the existing transmission line can be seen. Where there is haze, fog or low visibility long views can be dramatically reduced.

5 THE SURROUNDING LANDSCAPE

This section of the report describes the physical characteristics of the existing landscape to determine the range of landscape units that exist within the viewshed.

5.1 TOPOGRAPHY

The Project is located within flat agricultural land and paddy fields. With the exception of villages and other community infrastructure, the area is primarily used for the rice growing. The predominant land management practise within the entire project area is flood irrigation.

Figure 5.1 shows the landscape at several locations the project viewshed.

Figure 5.1 Predominant Land Use

With the exception of developed urban and industrial areas and roads, the area is generally flat with little topographical variation.

5.2 VEGETATION

Vegetation plays an important role in determining landscape character, visibility and screening as well as landscape mitigation for sensitive uses such as villages and urban areas.

Based on the images shown in **Figure 5.2.** It is apparent that the majority of the land within the project area has been cleared for agricultural purposes. Canopy vegetation tends to be confined to road and track edges, along waterways, the margins of development and within private allotments. **Figure 5.2** shows vegetation at one such village within the project area.

Figure 5.2 *Vegetation around Villages*

The preceding sections have mapped those areas with existing vegetation and changes in topography. Other features that may determine landscape character are the presence of water. In the viewshed surrounding the Project.

The landscape units described in the following sections have been identified by a combination of the topographical and vegetative features as well as descriptions of the landscape character found within the Project viewshed.

6 LANDSCAPE UNITS & CHARACTER

Landscape units are based on areas with similar visual characteristics in terms of their ability to absorb visual change. Often the landscape units relate to areas with similar environmental, geological and land-use features. There are four predominant landscape units that have been identified within the Project viewshed. These are:

- Landscape Unit 1 – "Coastal";
- Landscape Unit 2 – "Agricultural";
- Landscape Unit 3 – "Townships/Residential"; and
- Landscape Unit 4 – "Industrial".

These landscape units are described in the following section.

6.1 LANDSCAPE UNIT 1 – "COASTAL"

The Landscape Unit 1 – "Coastal" runs along the coastline to the northeast of the Project. This landscape unit describes the narrow band of shoreline and mangroves, which runs along the ocean's edge.

Figure 6.1 shows a view of landscape unit 1 looking North West across proposed Jetty location.

Figure 6.1 View of the Coastline looking North West

Landscape Unit 1 is narrow and some sections are relatively inaccessible. The section of coast between the subject site and this landscape unit is well vegetated.

6.2 *LANDSCAPE UNIT 2 – "AGRICULTURAL"*

Landscape Unit 2 – "Agricultural" includes much of the area within the Project viewshed. These areas are low, lying with little topographical variation. Agricultural areas are typically covered with low vegetation, bisected by raised roads and tracks with canopy vegetation. Infrequently, Landscape Unit 2 contains trees and tall shrubs

Figure 6.2 shows the typical vegetation and landform characteristics of Landscape Unit 2.

Figure 6.2 *Agricultural Land*

This image demonstrates the flatness of landscape unit and fragmentation of views contributed to by vegetation along roadsides, track and within villages.

6.3 *LANDSCAPE UNIT 3 – "TOWNSHIPS"*

Landscape Unit 3 – "Townships" describes the urban areas, which include villages, residential areas, schools, businesses and places of worship as well as industrial and manufacturing precincts. There are 37 villages within the visual catchment of Project.

Figure 6.3 *Village Structures*

Housing and the landscape associated with residential areas generally tends to screen views to the surrounding rural areas. It is only on the periphery of townships that views across the adjacent agricultural areas are usually possible.

6.4 LANDSCAPE SENSITIVITY

Landscape sensitivity can be defined as the ability of a landscape to absorb visual change, and its visual influence thereof on the viewers. While change is an integral part of any landscape, development and infrastructure are significantly different to the natural processes that occur in a landscape. The sensitivity of viewers to change in the previously described landscape units will depend upon a number of factors, such as:

Location. The sensitivity of a viewer varies according to location. For example, visitors to a conservation reserves where the landscape appears untouched or pristine will be more sensitive to the imposition of new or modified elements within that landscape. The same viewer, travelling along roads in agricultural areas that contains highly modified landscape such as paddy fields or agricultural land, will be less sensitive to the presence of new elements.

Modifications or artificial elements are not confined to vertical structures or built-form. They also include removal of vegetation, visibility of roads, tracks, fences, power lines and other infrastructure - all of which decrease the sensitivity of a landscape to further change.

The rarity of a particular landscape. Landscapes that are considered rare or threatened are valued more highly by a particular community with an attachment to the particular landscape.

The scenic qualities of a particular landscape. Landscapes that are considered scenic because of dramatic topographical changes, the presence of water, coastlines, etc., may be extensive, however viewers have greater sensitivity to alterations within these scenic landscapes. As discussed above the presence of modifications or artificial elements including built form, roads, tracks, fences, silos and rail as well as farming practices including land clearing, cropping and burning, all decrease the sensitivity of a landscape's scenic qualities.

The landscape surrounding the Project has been extensively modified through agricultural practices. These practices include clearing of vegetation, levelling of land for cropping, construction of elevated roads and tracks and construction of irrigation and drainage infrastructure.

The resultant cleared landscape is interspersed with village, roads and agricultural buildings. Associated with these structures are plantings along roadsides or as shelter belts.

This landscape unit in which the Project is proposed to be located is not rare, nor is it high in scenic quality and for these reasons the landscape sensitivity is considered to be low.

However, it must be recognised that some people value the appearance of these areas, particularly paddy fields. For these viewers, the presence of the Project may be perceived as a high visual impact due to the presence of large-scale structures in a rural landscape.

Village and townships are also not an uncommon feature in the project area, nor are they of high scenic qualities. They often contain many forms of infrastructure and development including industrial areas, power and light poles as well as communication and other towers. However, given the concentration of housing which is a sensitive land-use, these have been given a moderate sensitivity rating.

Table 6.1 rates the sensitivity of the various landscape units within the visual catchment of the Project.

Table 6.1 ***Landscape Sensitivity***

Landscape Unit	Sensitivity	Comments
Landscape Unit Type 1 "Coastal"	HIGH	Planning controls, strategies and guidelines all support the value of this coastal edge.
Landscape Unit Type 2 "Agricultural"	LOW	These areas contain many man-made modifications to a landscape type that has been largely cleared and, what vegetation is evident, is often planted wind breaks.
Landscape Unit Type 3 "Townships"	MODERATE	Views from residential townships are always important, so there is an increased sensitivity. However, urban areas are also able to accommodate change, as that is a regular occurrence within this type of landscape unit.

7 ASSESSMENT OF THE VISUAL IMPACT FROM PUBLICLY ACCESSIBLE VIEWPOINTS

The viewpoints selected to determine the extent of visual impact from publicly accessible locations is shown **Figure 7.1.**.

Figure 7.1 ***Map showing Viewpoint Locations***

Each viewpoint is described in *Table 7.1* and will be discussed in detail in the following section.

As discussed in Section 4, this assessment will consider viewing locations within 1.6km of the Project, as this was determine that viewpoints within this distance have the greatest potential for visual impacts.

Views within this distance are also influenced by the benefit of screening afforded by existing vegetation.

Table 7.1 ***Viewpoint Locations***

VP	Description	Distance to nearest Project boundary	VP	Description	Distance to nearest Project boundary
PPVP1	Jl. Raya Muara CIlamaya	480m NW	T20-30C	Unknown Road	860m NE
PPVP2	Jl. Simpang Tiga Pertamina	20m NE	T20-30D	Unknown Road	135m NE
PPVP3	Jl. Simpang Tiga Pertamina	10m E	T30-40A	Jl. Raya Junti	215m NW
PPVP4	Jl. Simpang Tiga Pertamina	25m SE	T30-40B	Unknown Road	150m SW
T0-10A	Jl. Singa Perbangsa Dusun Kostim	520m SW	T30-40C	Unknown Road	385m N
T0-10B	Jl. Singaperbangsa	870m S	T40-50A	Unknown Road	215m NW
T0-10C	Raya Tegal Urung	1.1km SW	T40-50B	Jl. Raya Pebayuran	75m SE
T0-10D	Raya Tegal Urung	1.2km SW	T40-50C	Jl. Kalenderwak Panjang	355m NW
T10-20A	Polo Cebang	485m SW	SVP1	Jl. Kampang Pisang Batu	835m N
T20-30A	Unknown Road	135m E	SVP2	Jl. Rawa Makmur	690m NE
T20-30B	Unknown Road	680m N			

7.1 *POWER PLANT VIEWPOINT 1 – JL. RAYA-MUARA CILAMAYA*

Power Plant Viewpoint 1 is located on Jl. Raya-Muara Cilamaya approximately 780m north west of the proposed CCGT Power Plant.

PPVP1 GPS (48M 787865E, 9309671S)

Figure 7.2 ***Power Plant Viewpoint 1 looking South West***

Figure 7.2 shows the view looking south west towards the proposed CCGT Power Plant across rice paddies which has a low landscape sensitivity.

This view also shows existing vegetation located next to roadways and at the rear of villages and urban development. This vegetation will filter views for those users of the road when looking towards the project. In an urban setting or village location this vegetation will screen or filter views to the Project.

This view also shows existing infrasturcutre such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the vent stack (70m high) and chimney stacks (60m high).

Table 7.2 CCGT Power Plant VP 1 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed CCGT Power Plant	Approx. 780m south west	Low
Distance to proposed Pipeline	Approx. 480m north west	Low
Overall visual impact		**Low**

7.2 *POWER PLANT VIEWPOINT 2 – JL. SIMPANG TIGA PERTAMINA*

Power Plant Viewpoint 2 is located on Jl. Simpang Tiga Pertamina approximately 20m south west of the proposed CCGT Power Plant.

PPVP2 GPS (48M 786343E, 9308724S)

Figure 7.3 Power Plant Viewpoint 2 looking North

Figure 7.3 shows the view looking north towards the proposed CCGT Power Plant across the school. **Figure 7.4** shows the existing vegetation located along the northern edge of the school and along the side of the roadway. This vegetation will assist in filtering or screening views towards the proposed development.

This vegetation will filter views for those within the school grounds and users of the roadwhen looking towards the project.

This view also shows existing infrastrucutre such as light poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the vent stack (70m high) and chimney stacks (60m high).

Figure 7.4 View of Vegetation along Northern Edge of School

Table 7.3 CCGT Power Plant VP2 - Summary of visual impact

Item	**Description**	**Evaluation**
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed CCGT Power Plant	Approx. 20m north east	Moderate
Overall visual impact		**Moderate**

7.3 *POWER PLANT VIEWPOINT 3 – JL. SIMPANG TIGA PERTAMINA*

Power Plant Viewpoint 3 is located on Jl. Simpang Tiga Pertamina approximately 10 m west of the proposed CCGT Power Plant.

PPVP3 GPS (48M 786233E, 9308975S)

Figure 7.5 Power Plant Viewpoint 3 Looking East

Figure 7.5 shows the view looking east towards the proposed CCGT Power Plant from the entry to the Pertagas housing complex. Views towards the project from the entry way are across a gap in roadside vegetation.

Figure 7.6 shows an aerial view of the complex. This aerial view shows that the extensive vegetation located within the complex would assist in filtering views to the Project.

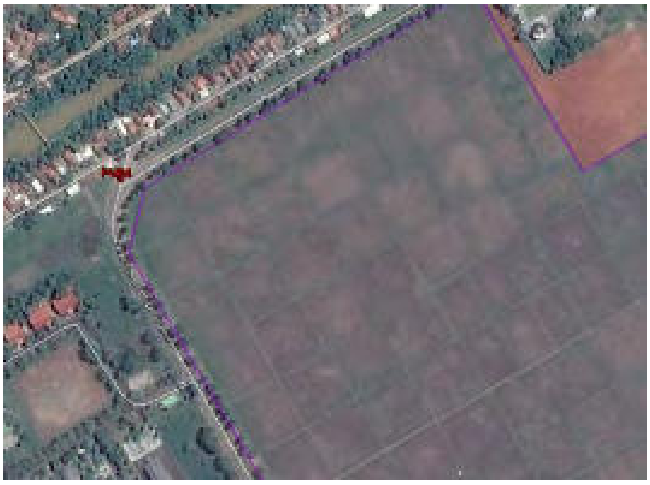
Figure 7.6 Aerial view of Housing Complex

Table 7.4 CCGT Power Plant VP3 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed CCGT Power Plant	Approx. 10m east	High
Overall visual impact		**Moderate-High (Prior to mitigation)**

7.4 *POWER PLANT VIEWPOINT 4 – JL. SIMPANG TIGA PERTAMINA*

Power Plant Viewpoint 4 is located on Jl. Simpang Tiga Pertamina approximately 25m north west of the proposed CCGT Power Plant.



PPVP4 GPS (48M 786164E, 9309138S)

Figure 7.7 ***Power Plant Viewpoint 4 looking South East***

Figure 7.7 shows the view looking south east towards the Project.

This view also shows existing infrasturcutre such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the vent stack (70m high) and chimney stacks (60m high).

Figure 7.8 View of Housing to North

This view also shows existing vegetation located next to the ROW and within the villages and urban development. This vegetation will filter views for those users of the road when looking towards the Project. In an urban setting or village location this vegetation will screen or filter views to the Project.

Table 7.5 CCGT Power Plant VP 4 - Summary of Visual Impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed CCGT Power Plant	Approx. 25m south east	Moderate
Overall visual impact		**Moderate**

7.5 *VIEWPOINT T0-10 A – JL. SINGA PERBANGSA DUSUN KOSTIM*

Viewpoint T0-10A is located on Jl. Singa Perbangsa Dusun Kostim approximately 520m north east of the proposed Transmission Line.

Viewpoint T0-10A GPS (48M 784822E, 9309721S)

Figure 7.9 ***Viewpoint T0-10A looking South***

Figure 7.9 shows the view looking south towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in vegtation and development that allows views towards the Project. Vegetation located along the roadside within the residential areas will filter views for those users of the road when looking towards the Project.

This view also shows existing infrasturcutre such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.6 Transmission Viewpoint T0-10A - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 520m south west (T06C)	Low
Overall visual impact		**Low**

7.6 *VIEWPOINT T0-10 B – JL. SINGAPERBANGSA*

Viewpoint T0-10B is located on Jl. Singaperbangsa approximately 870m north of the proposed Transmission Line.

Viewpoint T0-10B GPS (48M 783501E, 9310473S)

Figure 7.10 *Viewpoint T0-10B looking South*

Figure 7.10 shows the view looking south towards the proposed transmission line across the canal between built form within the residential area. This landscape character has a moderate level of sensitivity to change.

Existing vegetation along the edge of the canal as well as built form either side of the image will block the majority of the view towards the Project. The canal allows for a small unobstructed view towards the Project.

This view also shows existing infrastructure such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.7 Transmission Viewpoint T0-10B - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 870m south (T09C)	Low
Overall visual impact		**Low**

7.7 *VIEWPOINT T0-10 C – RAYA TEGAL URUNG*

Viewpoint T0-10C is located on Raya Tegal Urung approximately 1.1km north east of the proposed Transmission Line.

Viewpoint T0-10C GPS (48M 781944E, 9311292S)

Figure 7.11 Viewpoint T0-10C looking South West

Figure 7.11 shows the view looking south west towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in vegtation and development that allows views towards the Transmission Line. Vegetation located along the roadside and within the residential areas will filter views for those users of the road when looking towards the Project.

Whilst this view is clear of any vegetation or infrastructure, at a distance of 1.1km the transmission line will form a small element in the view and is not inconsistent with the surrounding infrastructure in a view metres down the road.

Table 7.8 Transmission Viewpoint T0-10C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 1.1km south west (T13C)	Low
Overall visual impact		**Low**

7.8 *VIEWPOINT T0-10 D - RAYA TEGAL URUNG*

Viewpoint T0-10D is located on Raya Tegal Urung approximately 1.2km north east of the proposed Transmission Line.

Viewpoint T0-10D GPS (48M 779413E, 9312433S)

Figure 7.12 Viewpoint T0-10D looking South

Figure 7.12 shows the view looking south towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a narrow gap in roadside vegtation that allows views towards the Project. Vegetation located along the roadside will filter views for those users of the road when looking towards the Project.

This view also shows existing infrastructure to the centre of the image. This infrastructure will appear in similar scale to the taller visible elements of the Project such as the transmission line.

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.9 *Transmission Viewpoint T0-10D - Summary of visual impact*

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 1.2km south west (T19C)	Low
Overall visual impact		**Low**

7.9 *VIEWPOINT T10-20A – POLO CEBANG*

Viewpoint T10-20A is located on Polo Cebang on the outskirts of the township approximately 485m north of the proposed Transmission Line.

Viewpoint T10-20A GPS (48M 773675, 9313551)

Figure 7.13 Viewpoint T10-20A looking South East

Figure 7.13 shows the view looking south east towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in vegtation that allows views towards the Project. Vegetation located along the roadside will filter views for those users of the road when looking towards the Project.

Figure 7.14 shows the vegetation within and along the southern edge of the township. This along with the buildings within the township will assist in filtering views.

Figure 7.14 View Along Back of Housing at Edge of Township

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.10 Transmission Viewpoint T10-20A- Summary of visual impact

Item	**Description**	**Evaluation**
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 485m south west (T31C)	Low
Overall visual impact		**Low-Moderate**

7.10 *VIEWPOINT T20-30A– UNKNOWN ROAD*

Viewpoint T20-30A is located on a local unknown road approximately 135m west of the proposed Transmission Line.

Viewpoint T20-30A GPS (48M 767744E, 9314682S)

Figure 7.15 Viewpoint T20-30A looking East

Figure 7.15 shows the view looking east along the alignment of the transmission line. This view is taken from the bridge near the T-intersection of the road and allows for a clear view of the Project.

This view also shows existing infrasturcutre such as electricity poles. From this location at only 135m away, the transmission line tower will be central to the view and will appear larger in scale to the existing infrastructure.

Table 7.11 Transmission Viewpoint T20-30A - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 135m east (T44C)	Low
Overall visual impact		**Low-Moderate**

7.11 *VIEWPOINT T20-30B– UNKNOWN ROAD*

Viewpoint T20-30B is located on a local unknown road approximately 680m south of the proposed Transmission Line.

Viewpoint T20-30B GPS (48M 766449E, 9314300S)

Figure 7.16 Viewpoint T20-30B looking North

Figure 7.16 shows the view looking north towards the proposed transmission line across rice paddies which has a low landscape sensitivity.

This view is taken from a gap in roadside vegtation that allows views towards the Project. Vegetation located along the roadside will filter views for those users of the road when looking towards the Project.

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.12 Transmission Viewpoint T20-30B - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 680m north (T47C/TS9)	Low
Overall visual impact		**Low**

7.12 *VIEWPOINT T20-30C– UNKNOWN ROAD*

Viewpoint T20-30C is located on a local unknown road approximately 860m south west of the proposed Transmission Line.

Viewpoint T20-30C GPS (48M 762305E, 9315609S)

Figure 7.17 Viewpoint T20-30C looking North East

Figure 7.17 shows the view looking north east towards the proposed transmission line across the canal between built form within the residential area. This landscape character has a moderate level of sensitivity to change.

Existing vegetation along the edge of the canal as well as built form to the right of the image will block the majority of the view towards the Project to the east. The canal allows for an unobstructed view towards the western section of the Project.

Table 7.13 Transmission Viewpoint T20-30C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 860m north east (T57C)	Low
Overall visual impact		**Low**

7.13 *VIEWPOINT T20-30D– UNKNOWN ROAD*

Viewpoint T20-30D is located on a local unknown road approximately 135m south west of the proposed Transmission Line.

Viewpoint T20-30D GPS (48M 761891E, 9316883S)

Figure 7.18 Viewpoint T20-30D looking North

Figure 7.18 shows the view looking north towards the proposed transmission line.

This view appears to be over local grave sites as shown in **Figure 7.19**. This would have a higher sensitivity to change that the agricultural land that surrounds it.

Figure 7.19 View of Graves

Table 7.14 Transmission Viewpoint T20-30D - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 135m north east (T59C)	Low
Overall visual impact		**Low**

7.14 *VIEWPOINT T30-40A– JL. RAYA JUNTI*

Viewpoint T30-40A is located on Jt. Raya Junti approximately 215m south east of the proposed Transmission Line.

Viewpoint T30-40A GPS (48M 758984E, 9316597S)

Figure 7.20 Viewpoint T30-40A looking North East

Figure 7.20 shows the view looking north east towards the proposed transmission line across the mosque development located within the residential area. This landscape character has a moderate to high level of sensitivity to change.

Existing built form of the mosque will block views to parts of the Project to the north.

This view also shows existing infrastructure such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.15 Transmission Viewpoint T30-40A - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed Transmission Line	Approx. 215m north west (T67C/TS12)	Low
Overall visual impact		**Moderate**

7.15 *VIEWPOINT T30-40B–UNKNOWN ROAD*

Viewpoint T30-40B is located on a local unknown road approximately 150m north east of the proposed Transmission Line.

Viewpoint T30-40B GPS (48M 755813E, 9312406S)

Figure 7.21 Viewpoint T30-40B looking South West

Figure 7.21 shows the view looking south west towards the proposed transmission line across the canal between built form within the residential area to the right of the image and rice paddies to the left. This landscape character has a low level of sensitivity to change.

Existing vegetation as well as built form to the right of the image will block the majority of the view towards the Project to the north. The canal allows for an unobstructed view towards the south western section of the Project.

When looking across paddy fields, vegetation along these edges fragments views and generally contains them to the near views. For these reasons, it will only be the nearest two or three pylons that will be visible and on clear days.

Table 7.16 Transmission Viewpoint T30-40B - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	150m south west (T81C)	Low
Overall visual impact		**Low**

7.16 *VIEWPOINT T30-40C–UNKNOWN ROAD*

Viewpoint T30-40C is located on a local unknown road approximately 385m south of the proposed Transmission Line.

Viewpoint T30-40C GPS (48M 753569E, 9309684S)

Figure 7.22 *Viewpoint T30-40C looking North West*

Figure 7.22 shows the view looking north west towards the proposed transmission line across the canal between built form or temple structure to the right of the image and extensive vegetation and residential development to the left. This landscape character has a low level of sensitivity to change.

Existing vegetation as well as built form to the right of the image will block the majority of the view towards the Project to the north east. The canal allows for an unobstructed view towards the north western section of the Project.

Table 7.17 Transmission Viewpoint T30-40C - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 385m north (T88C) Nearest tower in view – 470m north west (T89C)	Low
Overall visual impact		**Moderate**

7.17 *VIEWPOINT T40-50A–UNKNOWN ROAD*

Viewpoint T40-50A is located on a local unknown road approximately 215m south east of the proposed Transmission Line.

Viewpoint T40-50A GPS (48M 752775E, 9309307S)

Figure 7.23 Viewpoint T40-50A looking North

Figure 7.23 shows the view looking north across the canal and weir structure towards the proposed transmission line.

This view also shows existing infrastructure such as electricity poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.18 Transmission Viewpoint T0-10A - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 215m north west (T90C/TS19)	Low
Overall visual impact		**Low**

7.18 *VIEWPOINT T40-50B– JL. RAYA PEBAYURAN*

Viewpoint T40-50B is located on Jt. Raya Pebayuran approximately 75m north west of the proposed Transmission Line.

Viewpoint T40-50B GPS (48M 751272E, 9309916S)

Figure 7.24 Viewpoint T40-50B looking West

Figure 7.24 shows the view looking west towards the proposed transmission line. This view is taken from a small gap in roadside vegetation and development that allows views towards the Project.

Bands of vegetation within the view will assist in filtering views towards the proposed transmission line.

Figure 7.25 shows the view looking south east along the roadway. The proposed transmission tower will be approximately 75 m away. The existing roadside vegetation being closer to the view will appear a similar or larger scale to the proposed transmission tower and will therefore assist in filtering views.

Figure 7.25 *View looking South East along Roadway*

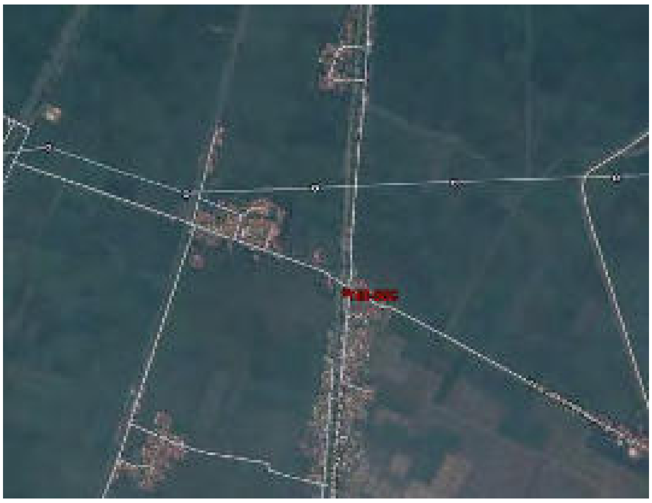
This view also shows existing infrastructure such as electricity and light poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.19 ***Transmission Viewpoint T40-50B - Summary of visual impact***

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	75m south east (T93C/TS21), Nearest tower in view 240m west (T94C/TS22)	Low
Overall visual impact		**Low**

7.19 VIEWPOINT T40-50C– JL. KALENDERWAK PANJANG

Viewpoint T40-50C is located on Jt. Kalenderwak Panjang approximately 335m south east of the proposed Transmission Line.



Viewpoint T40-50C GPS (48M 744048E, 9309906S)

Figure 7.26 Viewpoint T40-50C looking North

Figure 7.26 shows the view looking north towards the proposed transmission line. From this section of residential development, existing development and vegetation will filter or screen the majority of views towards the proposed transmission line.

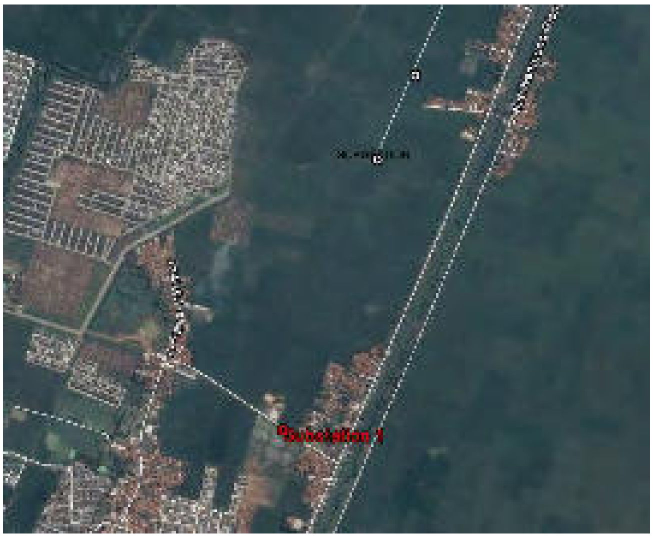
This view also shows existing infrastructure such as electricity and light poles. The proximity of this infrastructure to the road and therefore viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line.

Table 7.20 *Transmission Viewpoint T40-50C - Summary of visual impact*

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Low	Low
Distance to proposed Transmission Line	Approx. 355m north west (T112C)	Low
Overall visual impact		**Low**

7.20 *SUBSTATION VIEWPOINT 1 – JL. KAMPUNG PISANG BATU*

Substation Viewpoint 1 is located on Jt. Kampung Pisang Batu approximately 835m south of the proposed Substation.



Substation VP1 GPS (48M 741824E, 9308317S)

Figure 7.27 *Substation Viewpoint 1 looking North*

Figure 7.27 shows the view looking north towards the proposed substation.

This view also shows existing infrastructure such as the existing transmission line. The proximity of this infrastructure to viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line towers and substation infrastructure.

Table 7.21 Substation Viewpoint 1 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 2 - "Agricultural"	Low
Viewer numbers	Moderate	Moderate
Distance to proposed Substation	Approx. 835m north	Low
Overall visual impact		**Low**

7.21 *SUBSTATION VIEWPOINT 2 – JL. RAWA MAKMUR*

Substation Viewpoint 2 is located on Jt. Rawa Makmur approximately 690m south west of the proposed Substation.

Substation VP2 GPS (48M 741500E, 9308775S)

Figure 7.28 Substation Viewpoint 2 looking North East

Figure 7.28 shows the view looking north towards the proposed substation at a gap in residential development.

This view also shows existing infrastructure such as the existing transmission line. The proximity of this infrastructure to viewers will mean that it is larger and more visually noticable than taller visible elements of the Project such as the transmission line towers and substation infrastructure.

Table 7.22 Substation Viewpoint 2 - Summary of visual impact

Item	Description	Evaluation
Landscape sensitivity	Landscape Unit 3 - "Township/Residential"	Moderate
Viewer numbers	Moderate	Moderate
Distance to proposed Substation	Approx. 690m north east	Low
Overall visual impact		**Low**

7.22 *ASSESSMENT OF THE VISUAL IMPACT DURING CONSTRUCTION*

Major construction activities will include:

- clearing of vegetation;
- excavation of the shafts and tunnels;
- general earthworks (including topsoil stripping, excavation, filling, topsoil spreading and rehabilitation works);
- building construction;
- drainage installation (including, where required, measures to protect water quality and groundwater flows);
- power connection;
- equipment fabrication and installation; and
- landscaping.

The major areas that will be visible would be the earthworks and temporary structures such which may include material stockpiles, laydown areas and concrete batching plant.

8 ASSESSMENT OF THE VISUAL IMPACT OF NIGHT LIGHTING

The operational lighting of the Project will be minimised where practical whilst maintaining light levels adequate for safety and security. The CCGT and substation site will be the only project elements that require night lighting.

The majority of critical equipment (that may require operational personnel at night) will be within and around the base of buildings. Some light will be expected to spill from the buildings through windows.

Plant lighting will be visible from roads and the margins of villages where vegetation does not currently screen or filter views to the project.

The area around the proposed CCGT and many of the villages located within the entire project area already contains many examples of night lighting either through street lighting, shops and business or form within dwellings.

Figure 8.1 shows existing lighting associated with the existing power plant to the north of the CCGT.

Figure 8.1 ***Existing Power Plan***

Figure 8.2 Village Lighting

Existing vegetation found within the villages and roadsides that surround the CCGT site will assist to reduce the visual impact of night lighting over time to a moderate to low level of illumination.

8.1 LIGHTING DURING CONSTRUCTION

Extensive and intense lighting will be required consistently during the construction period. This lighting will have a much greater impact, as it will be more concentrated and an obvious change on the coastal plain.

However, given the existing lighting in the village and townships its addition, while noticeable, will not have a great visual impact.

9 LANDSCAPE MITIGATION

This section provides an overview of landscape mitigation strategies available to mitigation the predicted visual impacts of the Project.

Landscape planting is a mitigation option for residential properties or fixed viewpoints. Planting may be designed to either screen or significantly reduce the visual dominance through filtering. The effectiveness of landscape as a mitigation measure varies in accordance with landowner objectives and visibility of the Project.

9.1 REDUCING VISUAL IMPACT BY LANDSCAPING ALONG ROADS

Landscape mitigation is a proven method whereby even large existing structures, such as the 500 kV power line or 70 m vent stack can be screened from view.

Strategic landscaping may be installed in publicly accessible areas or along the boundaries of sensitive locations to assist with screening views to project features. For example, vegetation may provide screening of views if undertaken along sections of the rear of villages where breaks in vegetation permit views to the project from sensitive areas.

Figure 9.1 shows an existing view along a roadway within a village area.

Figure 9.1 Potential Mitigation along Roads

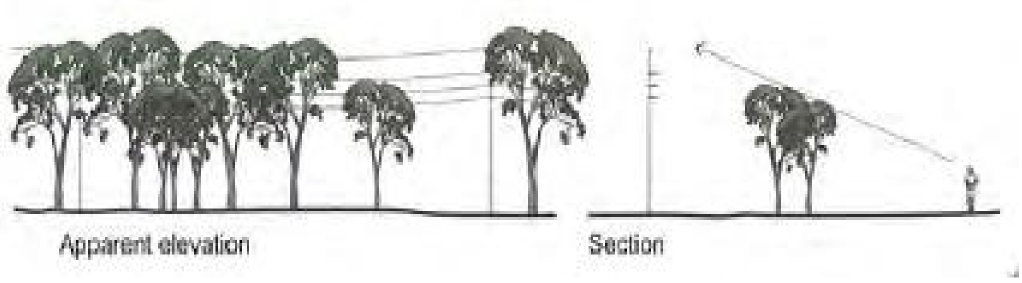
Planting such as that shown in **Figure 9.1** can easily screen views of large infrastructure even when in close proximity to a sensitive receptor.

A number of options are illustrated below which may be appropriate at different locations and for various Project infrastructure.

9.1.1 Tree Planting

It is clear from photographs in the preceding chapters that vegetation in this area can reach heights sufficient to screen or filter views to even the largest Project features. This screening can be achieved by planting large trees in front of power lines. Even though they might be smaller than that of the lattice towers, it is the effect of perspective that will afford the screening potential of the foreground vegetation.

Figure 9.2 Vegetation in the Foreground

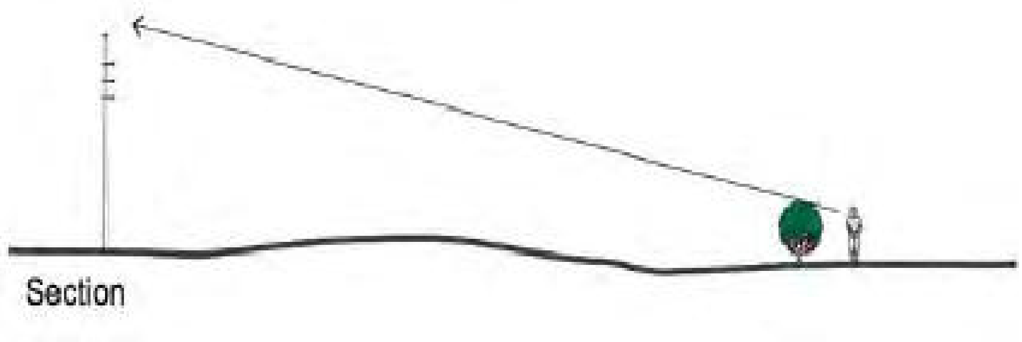


In **Figure 9.2**, trees planted between the power lines and the viewer. They have the potential to completely screen the poles and interconnecting wires.

9.1.2 Smaller planting near a viewer

When planted near the transmission towers and / or poles, trees need to reach almost the height of the poles to screen them from view. However if planting is located closer to an observer it needs to reach only 2-3 m before it forms an effective screen.

Figure 9.3 Foreground Planting



This example is particularly appropriate immediately adjacent to residential viewpoints where the owner does not like large trees or where there is insufficient space for their establishment.

10 CONCLUSION

This assessment has reviewed the likely landscape and visual impacts of the Project. The Project will be located within an "Agricultural Plain" that is flat and with little topographical variation. This landscape is one with low sensitivity to visual change and one that has the ability to absorb the visual change of such a proposal.

The landscapes within the project viewshed are not rare or unique. There are no protected areas or landscapes that would attract a high level of visual sensitivity in the region, particularly the beaches running along the water's edge.

The major impact may be on nearby adjacent residential properties; particularly those that lie along the edges of villages and that are oriented toward the project. For the majority or residential dwellings, it would appear that the visual impact would be minimal due to existing planting that screens views to the Project.

It is also clear that were visual impacts from sensitive locations may be experienced that landscape mitigation strategies that include new landscaping around either the proposed CCGT or in off-site locations such individual residential properties along the transmission corridor would be possible.

This is demonstrated by the existing vegetation in views and images contained within the assessment.

Annex A

Parameters of Human Vision

PARAMETERS OF HUMAN VISION

The visual impact of a development can be quantified by reference to the degree of influence on a person's field of vision. The diagrams on the following pages illustrate the typical parameters of human vision. These provide a basis for assessing and interpreting the impact of a development by comparing the extent to which the development would intrude into the central field of vision (both horizontally and vertically).

Horizontal Cone of View

The central field of vision for most people covers an angle of between 50^{O} to 60^{O}. Within this angle, both eyes observe an object simultaneously. This creates a central field of greater magnitude than that possible by each eye separately.

This central field of vision is termed the 'binocular field' and within this field images are sharp, depth perception occurs and colour discrimination is possible.

These physical parameters are illustrated in the figure opposite.

The visual impact of a development will vary according to the proportion in which a development impacts on the central field of vision. Developments, which take up less than 5% of the central binocular field, are usually insignificant in most landscapes (5% of 50^{O} = 2.5^{O}).

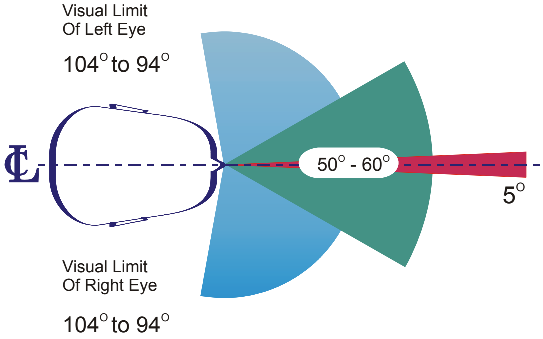


Figure A.1 Horizontal Field Of View

Table A.1: Visual Impact based on the Horizontal Field of View

Horizontal Field of View	Impact	Distance from an observer to a 500m wide built form
<2.5^{O} of view	Insignificant The development will take up less than 5% of the central field of view. The development, unless particularly conspicuous against the background, will not intrude significantly into the view. The extent of the vertical angle will also affect the visual impact.	> 11.5km
2.5^{O} – 30^{O} of view	Potentially noticeable The development may be noticeable and its degree of visual intrusion will depend greatly on its ability to blend in with its surroundings.	866m – 11.5km

>30° of view	Potentially visually dominant Developments that fill more than 30 percent of the central field of vision will always be noticed and only sympathetic treatments will mitigate visual effects.	< 866m

These calculations suggest that the impact of a built form stretching approximately 500m wide reduce to insignificance at 11.5km, as they would form less than 5% or 2.5° of the horizontal field of view.

Vertical Field of View

A similar analysis can be undertaken based upon the vertical line of sight for human vision.

The typical line of sight is considered to be horizontal or 0°. A person's natural or normal line of sight is normally a 10° cone of view below the horizontal and, if sitting, approximately 15°.

Objects, which take up 5% of this cone of view (5% of 10° = 0.5°) would only take up a small proportion of the vertical field of view, and are only visible when one focuses on them directly. However, they are not dominant, nor do they create a significant change to the existing environment when such short objects are placed within a disturbed or man-modified landscape.

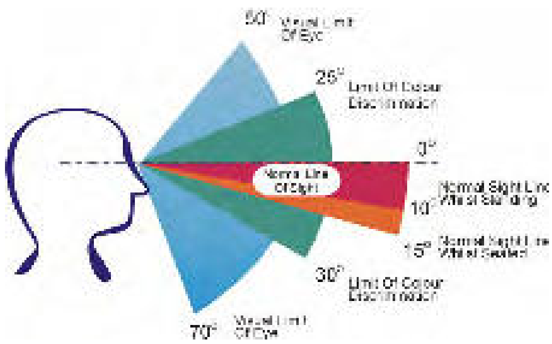


Figure A.2 Vertical Field Of View

The table below shows the relationship between impact and the proportion that the development occupies within the vertical line of sight.

Table A.2 Visual Impact based on the Vertical Field of View

Vertical Line of Sight	Impact	Distance from an observer to a 20m high built form
< 0.5° of vertical angle	Insignificant A thin line in the landscape.	>2,291 metres
0.5° – 2.5° of vertical angle	Potentially noticeable The degree of visual intrusion will depend on the development's ability to blend in with the	450 – 2,291 metres

	surroundings.	
> 2.5° of vertical angle	Visually evident Usually visible, however the degree of visual intrusion will depend of the width of the object and its placement within the landscape.	< 450 metres

These calculations suggest distances at which the magnitude of visual impact of the built form associated with the Project is reduced with distance.

At distances greater than 2.5 km, a fully visible 20 m high building would be an insignificant element within the landscape. At distances from 0.5 km to 2.5 km the built form would be potentially noticeable and at distances less than 0.5 km the built form (without intervening topography or vegetation) would be a dominant element in the landscape.

Proposed Viewshed & Zones of Visual Influence

The preceding analysis shows that a 500 m wide built form recedes into an insignificant element in the landscape at approximately 11.5 km. A building that is 20 m high recedes to an insignificant element in the landscape at approximately 2.5 km

Usually the extent of the viewshed is based on the lower number. This may seem counter intuitive, but one needs only to examine the visual impact of a farm fence. Whilst the fence may be many kilometres long, visible across the top of a ridgeline, the distance at which it recedes into an insignificant element in the landscape, is based on its height. A one metre high fence is indiscernible at a distance of a few hundred metres. Similarly, in this case the vertical field of view analysis is a better indicator of viewshed.

However to be conservative it is proposed that the viewshed extend out to 4km and that the zones of visual influence are also set at conservative levels. These are set out in **Table A.3**.

Table A.3 Viewshed and Zones of Visual Influence

Distance from an observer to the Project	**Zones of visual influence**
	Visually insignificant – outside the viewshed A very small element, which are difficult to discern and will be invisible in some lighting or weather conditions.
2-4 km	*Potentially noticeable, but will not dominate the landscape.* The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer; however, the wind turbines do not dominate the landscape.
0.5 – 2 km	*Potentially noticeable and can dominate the landscape.* The degree of visual intrusion will depend on the landscape sensitivity and the sensitivity of the viewer
<0.5 km	*Highly visible and will usually dominate the landscape* The degree of visual intrusion will depend on the buildings placement within the landscape and factors such as foreground screening.

PLTGU Jawa 1 Independent Power Project

ANNEX H
QUANTATIVE RISK ASSESSMENT

Prepared for:

PT Jawa Satu Power (JSP)

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1 INTRODUCTION

1.1 BACKGROUND

The PLTGU Jawa-1 Project involves the development of a Combined Cycle Gas Turbine (CCGT) Power Plant, a Liquefied Natural Gas Floating Storage and Regasification Unit (FSRU), a 500 kV power transmission lines and a Substation. These project elements will be developed within the Karawang and Bekasi Regencies of West Java, Indonesia.

PT Pertamina (Persero), Sojitz Corporation and Marubeni Corporation (together, the "Sponsors") have concluded an agreement to develop the Project via a project company named PT. Jawa Satu Power (JSP).

Sponsors are seeking a financial investment from "Lenders" i.e. a consortium of Japan Bank for International Corporation (JBIC), Nippon Export and Investment Insurance (NEXI), Asian Development Bank (ADB) and a group of Equator Principles Financing Institutions (EPFIs). Project is therefore required to comply with the applicable bank's health and safety policies, developed for managing the health and safety risks.

PT ERM Indonesia (ERM) is assisting the Sponsors and Lenders to develop a Quantitative Risk Assessment (QRA) to meet the requirements. This QRA study is performed for the FSRU which poses as major accident hazards in the Project. Findings from the QRA from the community perspective along with the appropriate risk reduction measures where necessary will be incorporated in the Environmental and Social Impact Assessment (ESIA).

1.2 SCOPE OF WORK

The scope of work for this QRA Study includes the following hazardous facilities and operation:

- FSRU, including LNG storage, LNG regasification, high pressure natural gas send-out;
- LNG unloading operation from LNG CARRIER; and
- Subsea pipeline within 500 m radius from the FSRU.

1.3 OBJECTIVE

The objective of this QRA Study is to assess the risk levels associated with the operation of the FSRU and compare the risk against the risk criteria stipulated in the British Standard EN 1473: 2007 in terms of individual risk and societal risk

2 *PROPOSED QUANTITATIVE RISK ASSESSMENT METHODOLOGY*

The elements of this QRA Study are depicted in ***Figure 2-1***, and each of the elements is depicted as follows:

2.1 *HAZARD IDENTIFICATION*

This QRA Study concerns the fire and explosion hazards associated with the transport, storage and use of LNG/ natural gas at the FSRU. The associated failures may be partial or catastrophic because of corrosion, fatigue, etc. These failures were taken into account for the detailed analysis in this QRA Study.

2.2 *FREQUENCY ANALYSIS*

This task involves the frequency analysis for each of the identified hazardous scenarios. Frequency analysis includes quantification of the frequency of the initiating events (e.g. pipework failure), and conducting Event Tree Analysis (ETA) to model the development of an event to its final outcomes (pool fire, flash fire, jet fire, fireball, vapour cloud explosion, etc.).

2.3 *CONSEQUENCE ANALYSIS*

Consequence analysis involves the modelling of the physical effects, and *SAFETI 6.7*, was adopted in this QRA Study. Consequence modelling results were used to establish levels of harm to critical equipment at varying distances from the identified hazards. Probit equations are used to relate levels of harm to exposure.

2.4 *RISK SUMMATION AND ASSESSMENT*

Risk summation was conducted using *SAFETI 6.7*, which calculates the risk based on different failure outcomes, failure event location, and weather conditions prevailing at the proposed FSRU location. This step involves the integration of consequence and frequency data to give the risk results in terms of the required risk measures.

The products of the frequency and consequence for each outcome event above are summed and the total risk expressed in individual risk and societal risk terms. Individual risk results were presented as iso-risk contours overlaid on the FSRU plot plan. The acceptability of the risks for the both off-site and on-site population was compared with risk criteria stipulated in the British Standard EN 1473 in terms of individual risk and societal risk.

2.5 *RISK MITIGATION*

The practical and cost-effective risk mitigation measures based on this QRA Study are recommended, if required, to demonstrate the risks are as Low As Reasonably Practicable (ALARP).

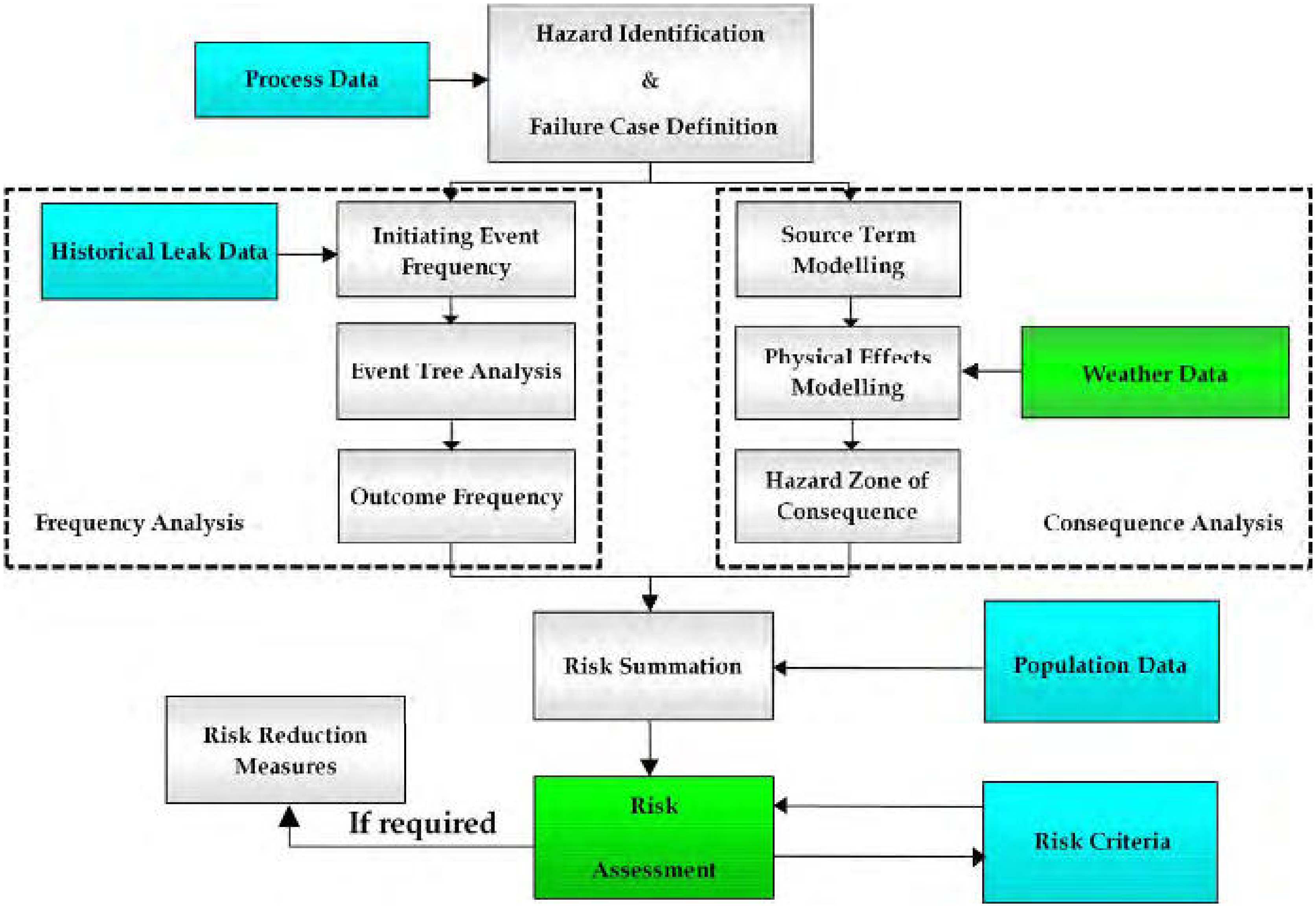

Figure 2-1 Proposed Quantiative Risk Assessment Methodology

3 DESCRIPTION OF SURROUNDING ENVIRONMENT

3.1 SURROUNDING POPULATION

3.1.1 Off-site Population

The Indonesian Government Regulation No. 5 Year 2010 regarding Navigation, article 38 describes two (2) zones for navigational aids, which are:

- Prohibited zone within 500 m radius from the outermost point of a navigational aids installation or building; and
- Limited zone within 1,250 m radius from the outermost point from the prohibited zone.

These zones are set to protect the navigational aids from other activities. Furthermore, article 40 explains that marine ships/ vessels can only pass outside these two (2) zones.

Based on this regulation, the likelihood of having passing vessels in the vicinity of FSRU is deemed to be unlikely. In addition, generally the credible hazardous scenarios associated with the FSRU is not foreseen to reach outside 500 m. Nevertheless, it conservatively assumed that about 100 fishing vessels per day passing through the 500 m radius from the FSRU.

The marine population for the fishing vessels is assumed as five (5) persons per one marine vessel and assumed as outdoor population without any protection.

3.2 ENVIRONMENTAL CONDITIONS

Based on the historical meteorological data, the average temperature and humidity is about 25 °C and 90% adopted for this QRA Study.

FSRU is located at open sea, the surface roughness of 0.2 mm for open water was adopted for the detailed consequence analaysis as part of this QRA Study.

3.3 METEOROLOGICAL DATA

The 10-year meteorological data from Year 2000 to Year 2009 at the FSRU location from Badan Meteorologi, Klimatologi, dan Geofisika (BMKG), the Indonesia Agency for Meteorology, Climatology, and Geophysic, has been selected to represent local meteorological conditions including wind speed, wind direction, atmospheric stability class, temperature, and relative humidity.

With reference to "Guidelines for Quantitative Risk Assessment, CPR 18E (Purple Book)", at least six (6) representative weather classes are recommended to be used in this QRA Study, covering the stability conditions of stable, netural and unstable, low and high wind speed. At least the following six (6) weather classes have to be covered in terms of Pasquill classes.

- "B" stability class, with medium wind speed (3 – 5 m/s);
- "D" stability class, with low wind speed (1 – 2 m/s);
- "D" stability class, with medium wind speed (3 – 5 m/s);
- "D" stability class, with high wind speed (8 – 9 m/s);
- "E" stability class, with medium wind speed (3 – 5 m/s); and
- "F" stability class, with low wind speed (1 – 2 m/s).

The probability of each weather state for each direction during the day and night are rationalised for analysis based on the requirements presented in "Guidelines for Quantitative Risk Assessment, CPR 18E (Purple Book". Based on the analysis on raw data, the summary of meteorological data is presented in Table xx, which was used for this QRA Study.

The wind speeds are quoted in units of meters per second (m/s), while the atmospheric stability classes refer to:

- A – Turbulent;
- B – Very Unstable;
- C – Unstable;
- D – Netural;
- E – Stable; and
- F – Very Stable.

Atmospheric stability suppresses or enhances the vertical element of turbulent motion. The vertical element of turbulent motion is a function of the vertical temperature profile in the atmosphere (i.e. the greater the rate of decrease in temperature with heigh, the greater the level of turbulent motion). Category D is netural and neither enhances nor suppresses turbulence.

Table 3-1 Historical Meteorlogical Data at FSRU Location from BMKG (Year 2000 – 2009)

Wind Direction/ Wind Stability Classes	Day Time						Night Time						Total
	1.5D	**1.5F**	**3.5B**	**3.5D**	**3.5E**	**7.5D**	**1.5D**	**1.5F**	**3.5B**	**3.5D**	**3.5E**	**7.5D**	
N	0.24	0.24	0.05	0.05	0.05	0.00	0.24	0.24	0.05	0.05	0.05	0.00	**1.26**
NE	0.28	0.28	0.11	0.11	0.11	0.05	0.28	0.28	0.11	0.11	0.11	0.05	**1.85**
E	0.57	0.57	1.88	1.88	1.88	9.18	0.57	0.57	1.88	1.88	1.88	9.18	**31.90**
SE	0.53	0.53	1.45	1.45	1.45	8.29	0.53	0.53	1.45	1.45	1.45	8.29	**27.38**
S	0.38	0.38	0.16	0.16	0.16	0.07	0.38	0.38	0.16	0.16	0.16	0.07	**2.63**
SW	0.49	0.49	0.44	0.44	0.44	0.37	0.49	0.49	0.44	0.44	0.44	0.37	**5.30**
W	0.65	0.65	1.24	1.24	1.24	5.28	0.65	0.65	1.24	1.24	1.24	5.28	**20.60**
NW	0.43	0.43	0.51	0.51	0.51	2.14	0.43	0.43	0.51	0.51	0.51	2.14	**9.08**
Sub-Total	**3.57**	**3.57**	**5.83**	**5.83**	**5.83**	**25.37**	**3.57**	**3.57**	**5.83**	**5.83**	**5.83**	**25.37**	**100.00**

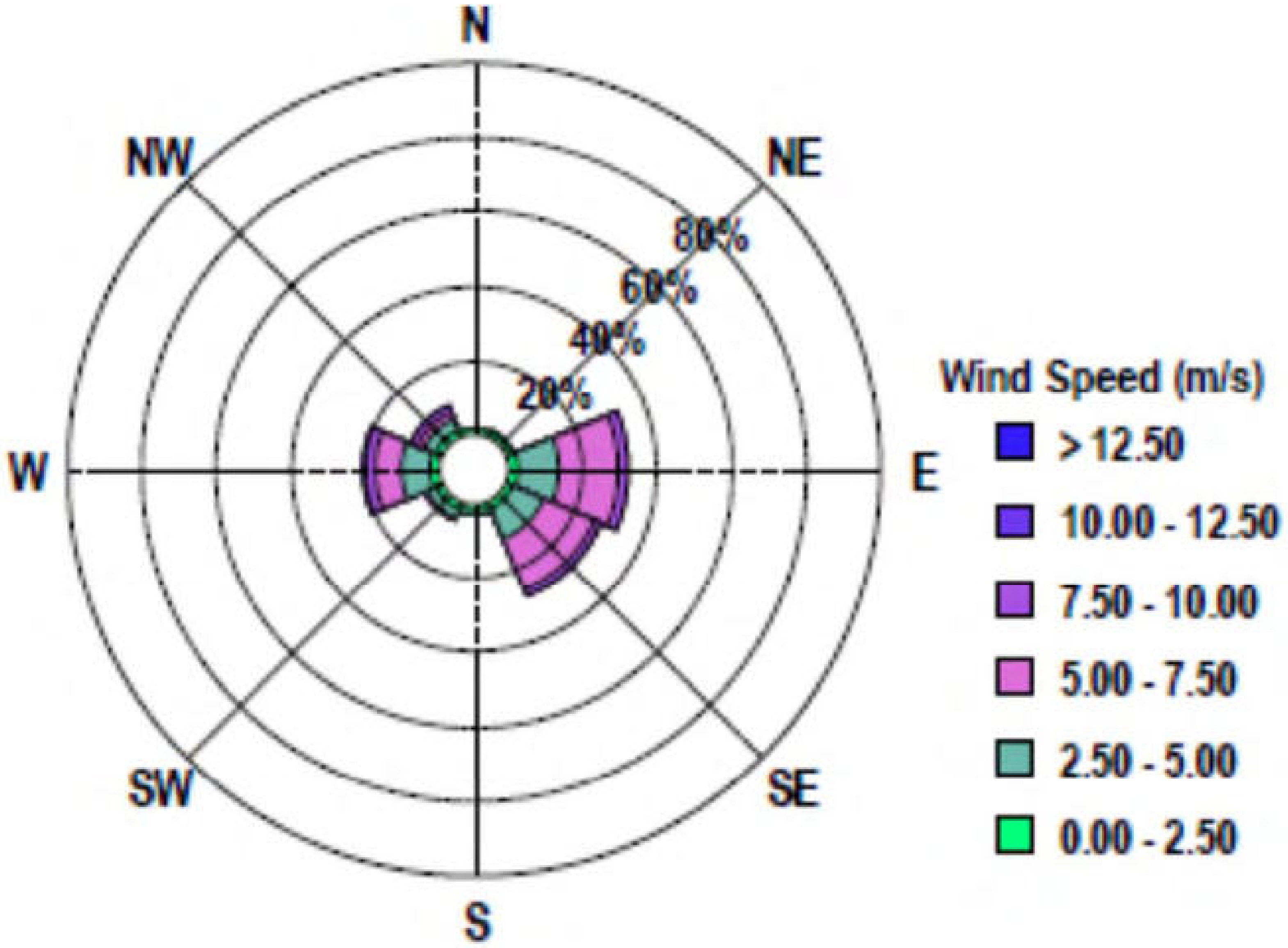

Figure 3-1 Wind Rose of Historical Meteorological Data at FSRU Location (2000 – 2009)

4 DESCRIPTION OF FSRU

This section descripts the process facilities, operation and key safety features for the FSRU.

4.1 FSRU PROCESS FACILITIES

4.1.1 LNG Storage and Loading System

The LNG storage capacity the FSRU is designed as 170,000 m^3 and its storage system is membrane type double containment system as per the requirement of the Class and Regulatory bodies concerned. The containment system will be provided with a full secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, of preventing lowering of the temperature of the ship structure to an unsafe level. The In-Tank LNG Storage Pumps load LNG to LNG regasification plant for regasification process.

4.1.2 LNG Booster Pump System

The LNG from the discharge of the In-Tank LNG Storage Pump is pumped at about 5 barg to the LNG Booster Pump Suction Drum, which acts as a buffer volume. The LNG inside the Suction Drum is then pumped via the LNG Booster Pumps, at a capacity of 210 m^3 for each Booster pump, to the Regasification System up to 41.7 barg.

4.1.3 LNG Regasification System

Four (4) regasification trains are provided at the Regasification Module of the FSRU, with a maximum installed capacity of 400 mmscfd.

The LNG from the discharge of the LNG Booster Pumps is re-gasified and superheated to the required send-out temperature of 5 °C. The LNG is re-gasified by a simple heat exchange process using glycol water and seawater. Shell and tube type heat exchanger is used for Regas Vaporizer (LNG/glycol water) and plate type heat exchanger is used for Glycol Water Heater (Glycol water/ Sea water).

4.1.4 Boil Off Gas System

This facility aims to release BOG from the FSRU tank. As the LNG will be stored under a cryogenic saturated condition, BOG will form as a result of leakage and environmental heat. The BOG should be removed from the tank to prevent excess pressure. The excess of BOG in the tank will be siphoned via a compressor which will be channelled into a fuel gas system or a BOG recondenser.

4.1.5 *Utility System – Power Generation System*

The FSRU is provided with its own dedicated power generation system. The dual fuel type power generators can operate on both boil off gas (BOG) as fuel gas and marine diesel oil (MDO). Under normal circumstances, power generation will consume BOG as fuel gas. However, under start-up or special maintenance repair circumstances as well as under emergency conditions, the fuel gas may not be available and diesel oil will be the fuel supply to the power generator. In addition, a dedicated emergency diesel power generator is also provided on the FSRU for back-up power generation and black start-up.

4.1.6 *Utility System – Diesel Oil Storage and Transfer System*

Marine diesel oil (MDO) is used for dual fuel generator engines, pilot fuel of gas combustion unit, incinerator and auxiliary boilers while marine gas oil (MGO) is used for inert gas generator, emergency generator engine, main dual fuel generator engines, and pilot fuel of gas combustion unit, incinerator and auxiliary boilers.

MDO/ MGO storage tanks, settling tank and service tanks are provided for the FSRU, and the maximum capacity of the MDO/ MGO storage tank was considered as 1,000 m^3 respectively in the QRA Study.

Bunkering of diesel oil will be conducted within reach of the supply crane on the FSRU to handle bunker hoses. A bunker hose reel will be provided. In this QRA Study, it was conservatively considered that the bunkering operation will be performed three (3) times a year with duration of six (6) hours for each operation.

4.1.7 *Utility System – Lubricating Oil Storage and Transfer System*

Lube oil storage and settling tanks are typically provided for the FSRU. Lube oil is used for the power generation prime movers and for major rotating equipment.

4.1.8 *Utility System – Nitrogen Generation System*

Nitrogen generators will be typically provided for the FSRU to generate nitrogen for the purpose of inert gas purging.

4.1.9 *Utility System – Seawater System*

Seawater will be used to vaporize LNG in the heat exchanger. The seawater will be filtered by intake screens, and pumped by seawater pumps. The seawater used from the LNG vaporisation system will return to the sea via gravity discharge off the FSRU.

4.1.10 *Utility System – Instrument Air System*

Redundant air compressors will be provided to generate the utility and instrument air for the FSRU. An instrument air receiver will also be provided for a specified hold up volume.

4.1.11 *Utility System – Fuel Gas System*

The BOG from the LNG storage tanks will be sent to BOG Compressor. Part of the compressed BOG will be used for fuel gas for power generation. In addition, LNG/ forcing vaporisers are also provided for forced BOG generation to provide fuel gas for the FSRU. Under normal circumstances, power generation will consume BOG treated by the fuel gas skid and delivered at approximately 6 barg.

4.1.12 *Utility System – Fresh Water and Demineralised Water System*

Fresh water generation system and sterilization system for domestic water will be provided for the FSRU. A demineralised water system will be required for the boilers. Demineralised water generator will be provided to ensure sufficient demineralised water is available for the boilers.

4.2 *FSRU OPERATIONS*

4.2.1 *LNG Unloading Operation*

The LNG offloading process is carried out under cryogenic conditions (ambient temperature of -160 °C and pressure of about 3-5 barg) using unloading pump and channeled through loading arm or cryogenic expansion hose and LNG piping installed in mooring system and connecting LNG CARRIER to FSRU.

The LNG from LNG CARRIER is unloaded via three (3) standard 16-inch loading arms on the LNG CARRIER and FSRU (1 for LNG unloading; 1 for vapour return; 1 hybrid for spare). The maximum LNG unloading rate (5,000 m^3/hr) for each of LNG unloading arms was conservatively considered in the QRA Study. The LNG unloading time from LNG CARRIER to FSRU is about 25 hours.

To compensate for the depreciation of volume in the LNG Carrier tank and to avoid the occurrence of the vacuum due to the LNG offloading process, a number of boil off gas (BOG) formed in the FRSU tank are returned to the LNG Carrier tank via the vapour arm.

During the transfer process there is a potential of leakage on the LNG piping connection and loading arm. To overcome the damage to the ship wall path due to LNG leak, the ship wall around the loading arm is watered continuously (water curtain). However, in the practice, leakage is very rare due to strict preparation procedures before the operation of LNG transfers.

Loading arm and vapour arm mounted on the offshore unloading platform or integrated in the FSRU are also equipped with a security system that can stop the offloading process and release the loading connection automatically when hazard occurs. Emergency shutdown system is connected between the offshore unloading platform with FSRU and LNG CARRIER, so it can be activated from both sides.

At the end of unloading, pressurised nitrogen gas will be used to purge the unloading arms of LNG before disconnecting.

To maintain the balance of LNG CARRIER and FSRU drafts during offloading operations, ballast water and seawater are fed to the ballast tank and vice versa, ballast water removed from the FSRU ballast tank to the sea. Ballast water does not undergo processing or addition of chemicals.

After the offloading process is complete, the LNG CARRIER will be removed from the offshore unloading platform or LNF-FSRU to then return to the loading port. The LNG that has been transferred to the FSRU storage tank will be temporarily stored in cryogenic saturation, at about -160 °C and about 3-5 barge, until later pumped into the vaporizer system. Once the LNG supply in the FSRU tank is low, the LNG CARRIER will come in for further offloading.

4.2.2 LNG Regasification Operation

The operation of the regasification unit installation consists of four (4) units of trains each having a maximum LNG regasification capacity of 100 mmscfd or a total of 400 mmscfd with an optimum regasification result of 300 mmscfd. The regasification unit working system is based on an open loop intermediate indirect regasification system, which uses seawater as a heat source in its regasification process.

The gas regasification process in FSRU consists of LNG send out system process, and regasification process.

4.2.3 LNG Send-Out System

The LNG send out system is used to pump LNG from the FSRU storage tank to the regasification unit. The LNG send out facility is integrated in the FSRU.

The send out process is still in cryogenic condition with temperature between -155 °C to -160 °C. The process of send out using two kinds of pump pressure levels are.

- Low Pressure Pump (submersible) to pump LNG from storage tank and send it to suction drum. The output pressure of this pump is between 3-5 barg.
- High Pressure Pump (booster pump) is used to increase LNG pressure that can be adjusted to the needs of gas power plant pressure and overcome

pressure drop on piping system. The pump output pressure is between 60-98 barg

During this process, the ballast water is pumped into the FSRU ballast tank to compensate for the LNG volume decrease in the storage tank.

4.3 *FSRU KEY SAFETY FEATURES*

4.3.1 *Emergency Shutdown System*

The emergency shutdown (ESD) system has two (2) mode, including LNG CARRIER mode and FSRU mode. The cause & effect for ESD (LNG CARRIER and FSRU) should be determined at detailed design stage.

In the event of fire or other emergency conditions, the enter cargo system, gas compressors and cutout valve to the engine room should be able to be shut downed by a single control to prevent major accident event.

4.3.2 *Fire Detection and Protection System*

Flammable gas and fire detectors are provided at the FSRU to detect leakage of natural gas and fire events respectively. The detectors will be positioned at strategic locations to provide adequate detection coverage for the FSRU.

4.3.3 *Fire Fighting System*

Firefighting system is provided in the FSRU as follows:

- High expansion foam in the Engine Room;
- Dry chemical powder in the cargo area, cargo manifolds, cargo tank domes & LNG regasification plant;
- Water spray system in the accommodation front wall, cargo machinery room wall, paint stores, chemical stores, oil/ grease store; and
- High pressure CO_2 in Electric Motor Room, Cargo Switch Board rooms, Emergency Generator Room, Main S/W Board Room, Engine Control Room Converter Room, Regas Switch Board Room, FWD Pump Room, and Cargo Machinery Room.

5 HAZARD IDENTIFICATION

Hazardous scenarios associated with the operation of the FSRU, including an LNG unloading from the LNG carrier and sending out high-pressure natural gas were identified through the following tasks:

- Review of hazardous materials;
- Review of potential MAEs;
- Review of relevant industry incidents; and
- Review of potential initiating events leading to MAEs.

5.1 REVIEW OF HAZARDOUS MATERIALS

LNG on board the LNG carrier and FSRU, and natural gas associated with the FSRU were the major hazardous material considered in this QRA Study, while the other dangerous goods including marine diesel oil, marine gas oil, lubricating oil, nitrogen and calibration gas were also taken into account in this QRA Study.

The details of the storage of LNG, natural gas and other dangerous goods associated with the FSRU are summarised in ***Table 5-1***.

Table 5-1 LNG, Natural Gas and Other Dangerous Goods Associated with the FSRU

Chemical	Maximum Storage Quantity	Temperature (°C)	Pressure (barg)
LNG	170,000 m^3	-163	5
Natural gas	On-site generation	5	41.7
Marine Diesel Oil	≤1,000 m^3	25	ATM
Marine Gas Oil	≤1,000 m^3	25	ATM
Lubricating Oil	≤ 200 m^3	25	ATM
Nitrogen	On-site generation	-	-
Calibration Gas	~2 Cylinders		

5.1.1 LNG

LNG is an extremely cold, non-toxic, non-corrosive and flammable substance.

If LNG is accidentally released from a temperature-controlled container, it is likely to come in contact with relatively warmer surfaces and air that will transfer heat to the LNG. The heat will begin to vapourise some of the LNG, returning it to its gaseous state.

The relative proportions of liquid LNG and gaseous phases immediately following an accidental release depends on the release conditions. The released

LNG will form a LNG pool on the surface of the sea in the vicinity of the FSRU which will begin to "boil" and vapourise due to heat input from the surrounding environment. The vapour cloud may only ignite if it encounters an ignition source while its concentration is within its flammability range.

Any person coming into contact with LNG in its cryogenic condition will be subjected to cryogenic burns.

5.1.2 Natural Gas

Upon the regasification of LNG, high pressure natural gas is formed. Natural gas is composed of primary methane gas with other fossil fuels such as ethane, propane, butane and pentane, etc. Natural gas is extremely flammable when mixed with appropriate concentration of air or oxygen in the presence of an ignition source.

Not only is the maximum surface emissive power of pure methane higher, but the consequence distances for both flash fire and jet fire hazardous scenarios associated with pure methane is larger than that of natural gas. As such, pure methane has been conservatively selected as representative material for the natural gas in the consequence modelling conducted using *PHAST*.

The major hazards arising from loss of containment of natural gas may lead to hazardous scenarios including jet fire, flash fire, fireball, and vapour cloud explosion (VCE).

5.1.3 Diesel (Marine Diesel Oil, Marine Gas Oil), and Lubricating Oil

Diesel (marine diesel oil, marine gas oil) and lubricating oil have a relatively higher flash point (greater than 66 °C), which is above ambient temperature, and with a high boiling point. Thus, evaporation from a liquid pool is expected to be minimal.

5.1.4 Nitrogen

CAS number of nitrogen is 7727-37-9, nitrogen is a nontoxic, odourless, colorless, non-flammable compressed gas generated on board the FSRU. However, it can cause rapid suffocation when concentrations are sufficient to reduce oxygen levels below 19.5%.

The expected off-site impact associated with nitrogen is limited as nitrogen is generated for the purpose of inert gas purging after LNG unloading operation. Therefore, nitrogen was not further assessed in this QRA Study.

5.1.5 Calibration Gas

The volume of the compressed calibration gas inside the cylinders is limited, the associated hazardous impact upon loss of containment is considered localized. It is expected that the calibration gas does not pose any risk to the off-site population and hence is not further assessed in the QRA Study.

5.2 *REVIEW OF POTENTIAL MAEs*

5.2.1 *LNG*

The possible hazardous scenarios considered in this QRA Study upon the release of LNG are:

- Jet fire;
- Pool fire;
- Flash fire; and
- VCE.

5.2.2 *Natural Gas*

The possible hazardous scenarios considered in this QRA Study upon the release of high pressure natural gas are:

- Jet fire;
- Flash fire;
- Fireball; and
- VCE.

Considering that the regasification unit on board the FSRU is relatively congested, a VCE may potentially occur if flammable gas cloud accumulate in these congested areas and is ignited, leading to damaging overpressure.

5.2.3 *Other Dangerous Goods*

Considering the high flash point temperature of other dangerous goods such as marine diesel oil present in the FSRU, the possible hazardous scenarios considered in this QRA Study are a pool fire and flash fire.

5.3 *REVIEW OF RELEVANT INDUSTRY INCIDENTS*

To investigate further the possible hazardous scenarios from the FSRU, and the LNG CARRIER unloading operation, a review of the applicable past industry incidents at similar facilities worldwide was conducted based on the following incident/ accident database:

- MHIDAS database; and
- SIGTTO.

Details of the past industry incident analysis are presented in ***Appendix A***.

5.4 *REVIEW OF POTENTIAL INITIATING EVENTS LEADING TO MAES*

The potential hazardous scenarios arising from the FSRU were identified as loss of containment of LNG, natural gas and other dangerous goods. The potential initiating events which could result in the loss of containment of flammable material including LNG, natural gas and diesel are listed below:

- Collision with other passing / visiting marine vessels;
- Mooring line failure;
- Dropped objects from crane operations on the FSRU;
- General equipment/piping failure (due to corrosion, construction defects etc.);
- Sloshing;
- LNG containment system failure; and
- Natural hazards.

5.4.1 *Ship Collision*

The Indonesian Government Regulation No. 5 Year 2010 regarding Navigation, article 38 describes two (2) zones for navigational aids, which are:

- Prohibited zone within 500 m radius from the outermost point of a navigational aids installation or building; and
- Limited zone within 1,250 m radius from the outermost point from the prohibited zone.

These zones are set to protect the navigational aids from other activities. Furthermore, article 40 explains that marine ships/ vessels can only pass outside these two (2) zones. Based on this regulation, the likelihood of having passing vessels in the vicinity of FSRU is deemed to be unlikely.

As such, the failures due to ship collision incidents is unlikely, nevertheless, the ship collision failure has been taken into account in the unloading arm failure frequency, as suggested in the UK HSE, which was incorporated and assessed in this QRA Study.

5.4.2 *Mooring Line Failure*

The mooring lines at the FSRU may fail due to various reasons such as extreme loads, fatigue, corrosion and wear, and improper selection of mooring lines etc. Upon failure of the mooring lines, drifting of LNG CARRIER or FSRU may occur leading to potential failure of unloading arms and collision impact with another vessel, with ultimately potential release of LNG or natural gas. Mechanical integrity program (including testing and maintenance) for the mooring lines, as well as tension monitoring system for the mooring lines are provided at the FSRU. The mooring line failure has been taken into account in the unloading arm failure frequency, as suggested in the UK HSE, which was incorporated and assessed in this QRA Study.

5.4.3 *Dropped Objects from Supply Crane Operation*

Supply cranes are provided at the FSRU for lifting operations. Swinging or dropped objects from crane operation may lead to potential damage on the LNG or natural gas pipework and subsequent loss of containment. Generally, lifting activity is not expected at FSRU during normal operation. However, during certain circumstances where lifting is required; safety management system will be in place to minimize the dropped object hazard.

Even with supply crane operation, the lifting equipment operation procedure will be in place to ensure that any lifting operation near or over live equipment should be strictly minimised. If such lifting operation cannot be avoided, lifting activities will be assessed. Also, adequate protection covers will be provided on the existing facilities in case the operation of lifting equipment has a potential to impact live equipment at the FSRU. Process isolation will also be achieved in case that live equipment protection becomes impractical.

A Job Safety Analysis should be conducted for the supply crane operation, to identify and anlayse hazards associated with the lifting operation. In addition, risk from lifting operation will be minimised through the work permit system, strict supervision and adequate protection covers on live equipment. The potential for a dropped object to cause damage on the live equipment and cause a release event is therefore considered included in the generic leak frequency in ***Table 6-1***.

5.4.4 *General Equipment/ Piping Failure*

Loss of integrity of the equipment and piping may occur because of material defects, construction defects, external corrosion etc., and leading to loss of containment of LNG and natural gas. Material defect may occur due to wrong materials being used during construction. Construction defect may result from poor welding. The generic failure frequency of the equipment and piping for this QRA Study was obtained from the International Association of Oil and Gas Producers (OGP), which was subsequently incorporated and assessed in this QRA Study.

5.4.5 *Sloshing*

Under high wind or sea conditions, excessive motion while operating partially-filled LNG cargo tanks may lead to membrane damage and loss of membrane structural integrity. In addition, boil off gas will be vented to atmosphere, where safety impact may occur if the vent gas is ignited. The cargo tanks are generally either full (inbound voyage) or empty (outbound voyage), hence the chance of sloshing during transit is minimized. In case of the unforeseen need to depart the berth before fully unloading of LNG, the LNG CARRIER or FSRU can conduct an internal cargo transfer between tanks such that sloshing would not be a potential hazard. Annulus between membrane and ship structure is also monitored for hydrocarbon presence, with vent to safe location. Flame arrestors are also provided at vent location to minimize the chance of vent gas ignition. Therefore, considering adequate safety systems are in place to minimize the chance of sloshing, this scenario was not considered as a significant contributor to the overall risk and not further assessed in this QRA Study.

5.4.6 *Natural Hazards*

The natural hazards to FSRU, such as earthquake, tsunami, subsidence, lightning, etc. should be already taken into account in the design, as such, the historical failure database are indeem sufficient covering all possible failure modes into consideration for this QRA Study.

5.5 *IDENTIFICATION OF ISOLATABLE SECTIONS*

A total of nineteen (19) isolatable sections were identified from the FSRU, with consideration of the location of emergency shutdown valves and process conditions (e.g. operating temperature and pressure). The details of each isolatable section (including temperature, pressure, flow rate, etc.) are summarised in ***Table 5-2***. These isolatable sections formed the basis for the development of loss of containment scenarios.

Table 5-2 Identified Hazardous Sections Associated with FSRU

Section Code	Description	Operating Temperature (°C)	Operating Pressure (barg)
OLNGT_01	LNG Loadout from LNG CARRIER to LNG Storage Tank in FSRU (including LNG unloading lines)	-160	5.0
OLNGT_02	LNG Storage Tanks	-160	0.7
OLNGT_03	LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	-160	7.0
OLNGT_04	LNG Transfer from Recondenser to LNG Regasification Plant using Booster Pump (High Pressure Pump)	-140	35.0
OLNGT_05	LNG Regasification Plant including four Regasification Trains	3	35.0
OLNGT_06	Natural gas from LNG Regasification Plant to Loading Platform	5	41.7
OLNGT_07	Natural gas in Loading Platform to Emergency Shutdown Valve of Riser for the Subsea Pipeline	5	41.7
OLNGT_08	Riser for Subsea Pipeline	5	41.7
OLNGT_09	Subsea Pipeline within the Vicinity of the FSRU (within 500 m from the FSRU)	5	41.7
OLNGT_10	LNG Transfer from LNG Storage Tank to Vaporisation Unit	-160	7.0
OLNGT_11	Natural gas in Vaporisation Unit for Gas Combustion Unit/ Engine	5	6.0
OLNGT_12	BOG from LNG Storage Tank to BOG Compressor	-160	0.5
OLNGT_13	Compressed BOG for Gas Combustion Unit/ Engine	10	6.0
OLNGT_14	BOG in Gas Combustion Unit/ Engine	-120	0.5
OLNGT_15	LNG CARRIER Vapour (BOG) return line during loudout operation	-120	1.5
OLNGT_16	FSRU Vapour (BOG) return line during loudout operation	-120	1.5
OLNGT_17	Marine Diesel Oil Storage &Transfer System	25	1.0
OLNGT_18	Marine Gas Oil Storage & Transfer System	25.0	1.0
OLNGT_19	Lubricating Oil Storage & Transfer System	25.0	1.0

6 FREQUENCY ANALYSIS

6.1 RELEASE FREQUENCY DATABASE

The historical database from the International Association of Oil and Gas Producers (OGP) was adopted in this QRA Study for estimating the release frequency of hazardous scenarios associated with the FSRU. The release frequency in OGP is based on the analysis of the HSE hydrocarbon release database (HCRD) which collected all offshore releases of hydrocarbon in the UK (including the North Sea) reported to the HSE Offshore Division from 1992-2006. Considering that the FSRU is located around 14 km offshore, this database was considered adequate for purpose of this QRA Study.

The release frequencies of various equipment items are summarised in ***Table 6-1***.

Table 6-1 Historical Process Failure Release Frequency

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
Piping 2" to 6"	10 mm hole	Liquid/ Gas	3.45E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.70E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	6.00E-07	per metre per year	OGP
Piping 8" to 12"	10 mm hole	Liquid/ Gas	3.06E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.40E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.70E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.70E-07	per metre per year	OGP
Piping 14" to 18"	10 mm hole	Liquid/ Gas	3.05E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.40E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.60E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.70E-07	per metre per year	OGP
Piping 20" to 24"	10 mm hole	Liquid/ Gas	3.04E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.40E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.60E-07	per metre per year	OGP

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
	>150 mm hole	Liquid/ Gas	1.60E-07	per metre per year	OGP
Piping 26″ to 48″	10 mm hole	Liquid/ Gas	3.04E-05	per metre per year	OGP
	25 mm hole	Liquid/ Gas	2.30E-06	per metre per year	OGP
	50 mm hole	Liquid/ Gas	3.60E-07	per metre per year	OGP
	>150 mm hole	Liquid/ Gas	1.60E-07	per metre per year	OGP
Pressure Vessel - Large Connection (> 6″)	10 mm hole	Liquid/ Gas	5.90E-04	per year	OGP
	25 mm hole	Liquid/ Gas	1.00E-04	per year	OGP
	50 mm hole	Liquid/ Gas	2.70E-05	per year	OGP
	>150 mm hole	Liquid/ Gas	2.40E-05	per year	OGP
Pump Centrifugal - Small Connection (up to 6″)	10 mm hole	Liquid	4.40E-03	per year	OGP
	25 mm hole	Liquid	2.90E-04	per year	OGP
	50 mm hole	Liquid	5.40E-05	per year	OGP
Pump Centrifugal - Large Connection (> 6″)	10 mm hole	Liquid	4.40E-03	per year	OGP
	25 mm hole	Liquid	2.90E-04	per year	OGP
	50 mm hole	Liquid	3.90E-05	per year	OGP
	>150 mm hole	Liquid	1.50E-05	per year	OGP
Compressor Reciprocating - Large Connection (> 6″)	10 mm hole	Gas	3.22E-02	per year	OGP
	25 mm hole	Gas	2.60E-03	per year	OGP
	50 mm hole	Gas	4.00E-04	per year	OGP
	>150 mm hole	Gas	4.08E-04	per year	OGP
Shell and Tube Heat Exchanger - Large Connection (> 6″)	10 mm hole	Liquid/Gas	1.20E-03	per year	OGP
	25 mm hole	Liquid/Gas	1.80E-04	per year	OGP
	50 mm hole	Liquid/Gas	4.30E-05	per year	OGP
	>150 mm hole	Liquid/Gas	3.30E-05	per year	OGP

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
Unloading Arm	10 mm hole	Liquefied Gas	4.00E-06*	per transfer operation	UK HSE
	25 mm hole	Liquefied Gas	4.00E-06*	per transfer operation	UK HSE
	>150 mm hole	Liquefied Gas	7.00E-06	per transfer operation	UK HSE
Riser	10 mm hole	Gas	7.2E-05	per year	OGP
	25 mm hole	Gas	1.8E-05	per year	OGP
	>150 mm hole	Gas	3.0E-05	per year	OGP
Diesel Storage Tank	10 mm hole	Liquid	1.6E-03	per year	OGP
	25 mm hole	Liquid	4.6E-04	per year	OGP
	50 mm hole	Liquid	2.3E-04	per year	OGP
	Rupture	Liquid	3.0E-05	per year	OGP
Unloading Hose	10 mm hole	Liquid	1.3E-05#	per hour	Purple Book
	25 mm hole	Liquid	1.3E-05	per hour	Purple Book
	50 mm hole	Liquid	1.3E-05	per hour	Purple Book
	Rupture	Liquid	4.0E-06	per hour	Purple Book

*Notes: The leak frequency of unloading arm, presented in the UK HSE, has been evenly distributed into 10 mm and 25 mm hole sizes.
#Notes: The leak frequency of unloading hose, presented in the Purple Book, has been evenly distributed into 10 mm, 25 mm and 50 mm hole sizes.

6.2 *RELEASE HOLE SIZES*

The release hole sizes presented in ***Table 6-2***, which are consistent with the OGP database, were adopted in the QRA Study.

Table 6-2 Hole Sizes Considered in the QRA

Leak Description	Hole Size
Very Small Leak	10 mm
Small Leak	25 mm
Medium Leak	50 mm
Rupture	>150 mm

6.3 *FLAMMABLE GAS DETECTION AND EMERGENCY SHUTDOWN PROBABILITY*

With reference to the Purple Book, the effect of block valve system is determined by various factors, such as the position of gas detection monitors and the distribution thereof over the various wind directions, the direction limit of the detection system, the system reaction time and the intervention time of an operator. The probability of failure on demand of the block valve system as a whole is 0.01 per demand.

Considering that the FSRU is provided with gas detection systems and automatic emergency shutdown systems, the probability of executing the isolation successfully when required was selected as 99% in the QRA Study.

6.4 *IGNITION PROBABILITY*

The immediate ignition probability was estimated based on offshore ignition scenarios No. 24 from the OGP Ignition Probability Database. For flammable liquids with flash point of 55°C or higher (e.g. diesel, fuel oil etc.), a modification factor of 0.1 was applied to reduce the ignition probability as suggested in OGP.

6.5 *IGNITION SOURCES*

In order to calculate the risk from flammable materials, information is required on the ignition sources which are present in the area over which a flammable cloud may drift. The probability of a flammable cloud being ignited as it moves downwind over the sources can be calculated. The ignition source has three factors:

- Presence factor is the probability that an ignition source is active at a particular location;
- Ignition factor defines the "strength" of an ignition source. It is derived from the probability that a source will ignite a cloud if the cloud is present over the source for a particular length of time; and
- The location of each ignition source is specified. This allows the position of the source relative to the location of each release to be calculated. The results of the dispersion calculations for each flammable release are then used to determine the size and mass of the cloud when it reaches the source of ignition.

The ignition sources are site specific. The typical ignition sources are marine traffic and the population nearby.

Marine traffic are area ignition sources in *SAFETI 6.7*. The presence factor for a line source is determined based on traffic densities, average speed. The location of the line source is drawn onto the site map in *SAFETI 6.7*. Probability of ignition for a vehicle is taken as 0.4 in 60 seconds based on TNO Purple Book.

SAFETI 6.7 will automatically allow for people acting as ignition sources. These are based on the population data. The presence of such sources (e.g.

cooking, smoking, heating appliances, etc.) is derived directly from the population densities in the area of concern.

6.6 *PROBABILITY OF VAPOUR CLOUD EXPLOSION*

The probability of explosion given an ignition was taken from the Cox, Lees and Ang model, as shown in ***Table 6-3***. VCE occurs upon a delayed ignition from a flammable gas release at a congested area.

Table 6-3 Probability of Explosion

Leak Size (Release Rate)	**Explosion Probability**
Minor (< 1 kg s^{-1})	0.04
Major (1 – 50 kg s^{-1})	0.12
Massive (> 50 kg s^{-1})	0.30

6.7 *EVENT TREE ANALYSIS*

An event tree analysis was performed to model the development of each hazardous scenario outcome (jet fire, pool fire, flash fire, fireball and VCE) from an initial release scenario. The event tree analysis considered whether there is immediate ignition, delayed ignition or no ignition, with consideration of the associated ignition probability as discussed above. The development of the event tree is depicted at ***Figure 6-1***, ***Figure 6-2*** and ***Figure 6-3*** for LNG, natural gas and diesel release scenarios respectively.

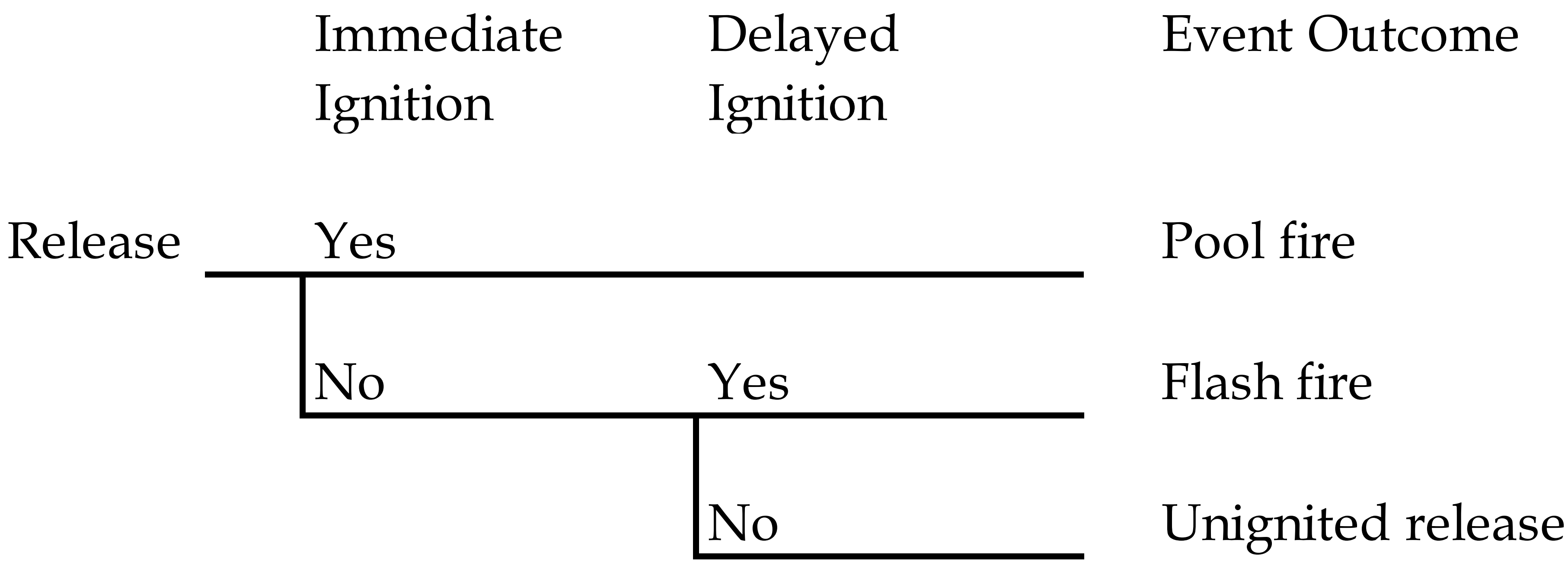

Figure 6-1   Event Tree Analysis for LNG Release from the FSRU

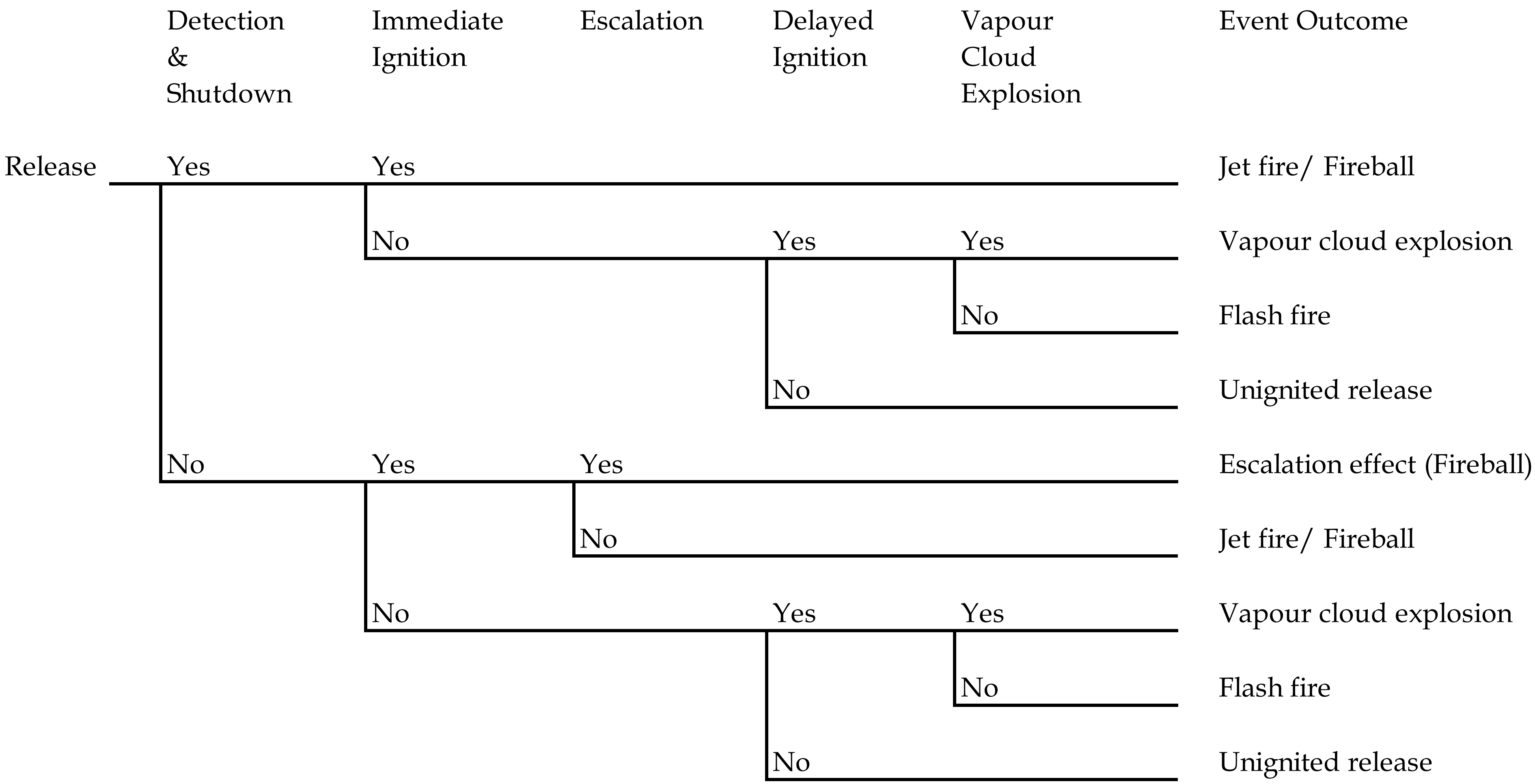

Figure 6-2 Event Tree Analysis for Natural Gas Release from the FSRU

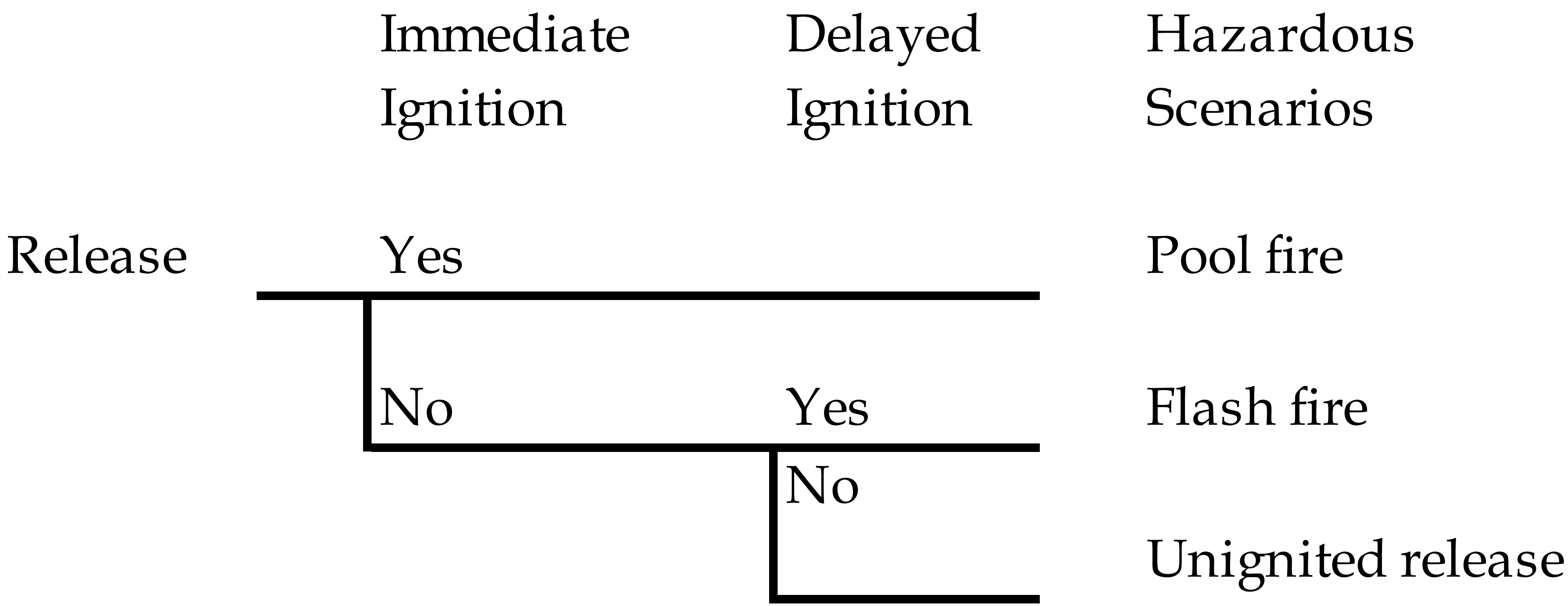

Figure 6-3 Event Tree Analysis for Diesel Release from the FSRU

7 *CONSEQUENCE ANALYSIS*

This section summarises the approaches to model the major hazardous scenarios from the continuous and catastrophic releases considered in this QRA Study. Consequence analysis comprises the following items:

- Source term modelling, which involves determining the release rate variation with time and thermodynamic properties of the released fluids;
- Physical effects modelling, which involves estimating the effect zone of the various hazardous scenarios; and
- Consequence end-point criteria, which involves assessing of the impact of hazardous scenarios on the exposed population.

7.1 *SOURCE TERM MODELLING*

PHAST was used to estimate the release rates, which were used to determine the ignition probability. Source term modelling was carried out to determine the maximum (e.g. initial) release rate that may be expected should a loss of containment occur.

7.2 *RELEASE DURATION*

For LNG unloading arm failure at the LNG carrier and FSRU, as per the previous EIA Report that was approved by the relevant authorities in Hong Kong, two (2) release durations were considered:

- 30 seconds release; and
- 2 minutes release.

A shorter release time (i.e. 30 seconds) was adopted in this QRA Study due to the presence of personnel in the vicinity who can initiate emergency shutdown successfully on top of the fire and gas detection system, and also due to the provision of detectors for excessive movement of the unloading arm which will initiate an automatic shutdown. The 2-minute release duration represents the case of failure of isolation of one unloading arm. Duration longer than two (2) minutes was not considered significant given that the transfer pumps on the LNG can be stopped, which will stop any further release.

For other process facilities in the FSRU, with reference to Purple Book, the closing time of an automatic blocking system is two (2) minutes, representing the release duration for isolation success case. Detection and shutdown system may however fail due to some reasons, also as per Purple Book, the release duration is limited to a maximum of thirty (30) minutes. The release duration of thirty (30) minutes was conservatively adopted in this QRA Study as the release duration for isolation failure case.

7.3 *RELEASE DIRECTION*

The orientation of a release can have some effects on the hazard footprint calculated by *PHAST*. The models take into account the momentum of the release, air entrainment, vaporization rate and liquid rainout fraction.

For a horizontal, non-impinging release, momentum effects tend to dominate for most releases giving a jet fire as the most serious outcome. If a release is vertically upwards, the hazard footprint will be significantly less compared to a horizontal release. In addition, if a release impinges on the ground or other obstacles, the momentum of the release and air entrainment is reduced, thereby reducing the hazard footprint but also increasing the liquid rainout fraction. In this scenario, a pool fire may become more likely.

Therefore, for all pool fire scenarios, the release orientation was set to "*downward impinging release*" in order to obtain the worst-case consequence pool fire, while "*horizontal non-impinging*" was representatively selected for modelling fire effects such as jet fire and flash fire as a conservative approach.

7.4 *PHYSICAL EFFECTS MODELLING*

PHAST was used to perform the physical effects modelling to assess the effects zones for the following hazardous scenarios:

- Jet fire;
- Pool fire;
- Flash fire;
- Fireball; and
- VCE.

7.4.1 *Jet Fire*

A jet fire results from an ignited release of the pressurised flammable gas. The momentum of the release carries the flammable materials forward in form of a long plume entraining air to give a flammable mixture. Combustion in a jet fire occurs in the form of a strong turbulent diffusion flame that is strongly influenced by the momentum of the release.

A jet fire was modelled for a pressurised flammable gas release. The default jet fire correlation model in *PHAST* was selected, and the release orientation was set as a horizontal non-impinging release.

7.4.2 *Flash Fire*

If there is no immediate ignition, the flammable gas such as natural gas and hydrogen may disperse before subsequently encountering an ignition source giving a jet fire or pool fire. The vapour cloud will then burn with a flash back to the source of the leak. A flash fire is assumed to be fatal to anyone caught within the flash fire envelope, although the short duration of a flash fire means that radiation effects are negligible. The fatality probability is therefore zero for persons outside the flash fire envelope.

Dispersion modelling was conducted by *PHAST* to calculate the extent of the flammable vapour cloud. This takes into account both the direct vaporisation from the release, and also the vapour formed from evaporating pools. The extent of the flash fire was assumed to be the dispersion distance to LFL in this QRA Study.

7.4.3 *Pool Fire*

In case of an early ignition of a liquid pool such as LNG pool, an early pool fire will be formed and the maximum pool diameter can be obtained by matching the burning rate with the release rate. Under such a condition, the size of the pool fire will not increase further and will be steady. In case of a delay ignition, the maximum pool radius is reached when the pool thickness at the centre of the pool reaches the maximum thickness.

7.4.4 *Fireball*

Immediate ignition of releases caused by a rupture in the pipeline may give rise to a fireball upon an ignition. Due to the transient nature of a release for high pressure condition, the mass of fuel entering the fireball for high pressure (> 40 barg) natural gas pipeline is difficult to estimate. A method proposed in is to calculate at each time step the quantity of fuel that can be consumed in a fireball with the same burning time as the time since the start of the release. The size of the fireball is determined by equating these two (2) values.

Numerical modelling should be carried out to estimate the release rate and the mass released for different duration.

The discharge rate model for release from a high pressure natural gas pipeline is based on the equation for flow of an ideal gas through an orifice under isentropic conditions. If the ratio of the upstream pressure to that of the downstream pressure is sufficiently high, the flow is choked or sonic and the corresponding discharge rate will follow the critical flow relationship which is independent of downstream pressure as given below:

$$Q = c_d A_h \left[p \rho_0 \gamma \left(\frac{2}{\gamma+1} \right)^{\frac{\gamma+1}{\gamma-1}} \right]^{1/2}$$

where

c_d is discharge coefficient

p is upstream pressure, N/m²

ρ_0 is gas density in the pipeline, kg/m³

γ is gas specific heat ratio, 1.31 for natural gas supplying to the Project facility

A_h is puncture area, m²

For gas releases from pipeline ruptures, an empirical correlation developed by Bell and modified by Wilson 0 is adopted which expresses an isothermal pipeline gas release as a 'double exponential' that decreases with time with two (2) important time constants. The model applies to mass of gas present in the pipeline of length L_p (m) and area A_p (m²) (with the release isolated, i.e. upstream supply cut-off).

$$Q_t = \frac{Q_0}{(1+\alpha)}\left[e^{\frac{-t}{\alpha^2\beta}} + \alpha e^{\frac{-t}{\beta}}\right]$$

where

Q_t is time dependent mass flow rate, kg/s

Q_0 is initial mass flow rate at the time of rupture, kg/s

t is time in seconds

α is nondimensional mass conservation factor

$$\alpha = \frac{M_T}{\beta Q_0}$$

M_T is the total mass in the pipeline, kg

β is time constant for release rate in seconds

For small release:

$$\beta \approx \frac{L\sqrt{K_r}}{CK_A}$$

For large holes where $\frac{K_A^2}{K_F K_\gamma} > 30$

$$\beta \approx \frac{2L}{3C\sqrt{K_F}}$$

where

$$K_F = \frac{D_p}{\gamma f L_p} \;\; ; \; K_A = \frac{A_h}{A_p} \;\; ; \; K_\gamma = \left[\frac{\gamma+1}{2}\right]^{\frac{\gamma+1}{\gamma-1}}$$

D_p is diameter of pipeline, m

f is pipeline friction factor, dimensionless

The above equations have been used to model release rate with time for full bore ruptures.

The mass/duration correlation in the fireball model used in "TNO Yellow Book" is given as:

$$t = 0.852M^{0.26}$$

$$r = 3.24M^{0.325}$$

where:

M is the mass in kg

t is duration in seconds

r is the radius of the fireball in m

Based on the above, the fireball mass and duration was estimated as 2,000 kg for fireball consequence modelling, and the consequence analysis for a fireball scenario was conducted by Roberts (HSE) method in *PHAST* as the calculation method.

7.4.5 Vapour Cloud Explosion (VCE)

Explosions may only occur in areas of high congestion, or high confinement. An ignition in the open may only result in a flash fire or an unconfined VCE yielding relatively a lower damaging overpressure.

When a large amount of flammable gas is rapidly released, a vapour cloud forms and disperses in the surrounding air. The release can occur from the process facilities on the FSRU Vessel. If this cloud is ignited before the cloud is diluted below its LFL, a VCE or flash fire will occur. The main consequence of a VCE is damage to surrounding structures while the main consequence of a flash fire is a direct flame contact. The resulting outcome, either a flash fire or a VCE depends on a number of parameters.

Pietersen and Huerta (1985) has summarised some key features of 80 flash fires and AIChE/CCPS (2000) provides an excellent summary of vapour cloud behaviour. They describe four (4) features which must be present in order for a VCE to occur. First, the release material must be flammable. Second, a cloud of sufficient size must form prior to an ignition, with ignition delays of 1 to 5 minutes considered the most probable for generating VCEs. Lenoir and Davenport (1992) analysed historical data on ignition delays, and found delay times from six (6) seconds to as long as sixty (60) minutes. Third, a sufficient amount of the cloud must be within the flammable range. Fourth, sufficient confinement or turbulent mixing of a portion of the vapour cloud must be present.

The blast effects produced depend on whether a deflagration or detonation results, with a deflagration being, by far, the most likely. A transition from deflagration to detonation is unlikely in the open air. The ability for an explosion to result in a detonation is also dependent on the energy of the ignition source, with larger ignition sources increasing the likelihood of a direct detonation.

In order to calculate the distances to given overpressures, the Baker-Strehlow-Tang (BST) model, which is a congestion based model, was adopted in this QRA

Study. The volume of flammable material in congested areas was estimated as well as the flame expansion characteristics, and then the BST model predicts the overpressures at a given distance. The BST model predicts the blast levels based on:

- Mass of flammable material involved in an explosion (determined based on dispersion modelling by *PHAST*);
- Reactivity of the flammable material (high, medium, or low)
- Degree of freedom for the flame expansion (1D, 2D, 2.5D or 3D); and
- Congestion level of a potential explosion site (high, medium, low).

To apply the BST model, the FSRU was identified with one (1) potential explosion sites based on the facility layout. Leaks from the isolatable sections of the FSRU were then modelled to cause explosion in the nearest potential explosion site.

Similar to thermal radiation levels, overpressure levels, corresponding to specific fatality levels, were taken from the data published by Purple Book for indoor/ outdoor population. The various overpressure levels considered in this QRA Study are presented in ***Table 7-2***.

Table 7.1 summarises the input parameters, such as level of congestion, reactivity of material, etc., to the BST model performed by *PHAST*.

Table 7.1 Identified PES at the FSRU

Tag	PES Location	Reactivity of Material	Degree of Freedom for Flame Expansion	Level of Congestion	Length (m)	Width (m)	Height (m)	Estimated PES Volume (m^3)
PES 1	Regasification Plant on FSRU	Low	2D	Medium	30	20	10	6,000

7.5 *CONSEQUENCE END-POINT CRITERIA*

The estimation of the fatality/ injury caused by a physical effect such as thermal radiation requires the use of probit equations, which describe the probability of fatality as a function of some physical effects. The probit equation takes the general form:

$$Y = a + b \ln V$$

where

Y is the probit

a, b are constants determined from experiments

V is a measure of the physical effect such as thermal dose

The probit is an alternative way of expressing the probability of fatality and is derived from a statistical transformation of the probability of fatality.

7.5.1 *Thermal Radiation*

The following probit equation is used to determine impacts of thermal radiation from a jet fire, pool fire or fireball to persons unprotected by clothing.

$$Y = -36.38 + 2.56 \ln (t I^{4/3})$$

where:

Y is the probit

I is the radiant thermal flux (W m^{-2})

t is duration of exposure (s)

The exposure time, t, is limited to maximum of twenty (20) seconds.

7.5.2 *Fireball*

The fatality rate within the fireball diameter is assumed to be 100%.

7.5.3 *Flash Fire*

With regard to a flash fire, the criterion chosen is that a 100% fatality is assumed for any person outdoors within the flash fire envelope. The extent of the flash fire is conservatively assumed to be the dispersion to its LFL

7.5.4 *Overpressure*

For an explosion, a relatively high overpressure is necessary to lead to significant fatalities for persons outdoor. Indoor population tends to have a higher harm probability due to the risk of structural collapse and flying debris such as breaking windows. ***Table 7-2*** presents the explosion overpressure levels from the Purple Book, which were adopted in this QRA Study.

Table 7-2 Effect of Overpressure - Purple Book

Explosion Overpressure (barg)	Fraction of People Dying	
	Indoor	Outdoor
> 0.3	1.000	> 0.3
> 0.1 to 0.3	0.025	> 0.1 to 0.3

8 RISK SUMMATION AND ASSESSMENT

8.1 OVERVIEW

The hazardous scenarios, the associated frequencies, meteorological data, population data, and suitable modelling parameters identified were input into *SAFETI 6.7*, and all risk summation was modelled using *SAFETI 6.7*. The inputs to the software comprise of:

- Release cases file detailing all identified hazardous scenarios, and their associated frequencies and probabilities;
- Release location of hazardous scenarios either at given points or along given routes;
- Weather probabilities file that details the local meteorological data according to a matrix of weather class (speed/stability combinations) and wind directions;
- Population data with the number of people and polygonal shape as well as indoor faction; and
- Ignition sources with ignition probabilities in a given time period.

8.2 RISK MEASURES

Two (2) types of risk measures considerd in this QRA Study are individual risk and societal risk.

8.2.1 Individual Risk

Individual risk for fatality is defined as the frequency of fatality per individual per year due to the realisation of specified hazards. Individual risk may be derived for a hypothetical individual present at a location 100% of time or a named individual considering the probability of his/ her presence etc. (the latter case is known as personal individual risk). In this QRA study, the former type of individual risk is reported, considering that it gives an estimate of maximum individual risk.

8.2.2 Societal Risk

Societal risk is defined as the risk to a group of people due to all hazards arising from a hazardous installation or activity. The simplest measure of societal risk is the rate of death or potential loss of life (PLL), which is the predicted equivalent fatality per year. The PLL is calculated as follows:

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

where f_n is the frequency and N_n is the number of fatalities associated with n^{th} hazardous outcome event.

Societal risk can also be expressed in the form of an F-N curve, which represents the cumulative frequency (F) of all event outcomes leading to N or more fatalities. This representation of societal risk highlights the potential for accidents involving large number of fatalities.

8.3 *RISK CRITERIA*

The Annex L "Level of Risk" of the BS EN 1473 has given the risk criteria for the off-site population for LNG installations.

8.3.1 *Individual Risk Criteria*

As stipulated in EN standard, any scenario causing one (1) to ten (10 fatalities is categorised into Class 2, the associated risk levels corresponding Class 2, summarised in ***Table 8-1***, are selected for the individual risk criteria adopted in this QRA Study.

Table 8-1 Individual Risk Criteria for Off-site Population

Individual Risk Criteria	Off-site Population
Not Acceptable	
ALARP Region	1E-03 per year 1E-05 per year
Normal Situation	

8.3.2 *Societal Risk Criteria*

As stipulated in EN standard, any scenario causing more than ten (10 fatalities is categorised into the most severe consequence Class 1, the associated risk levels corresponding Class 1, depicted at ***Figure 8-1***, are selected for the societal risk criteria adopted in this QRA Study.

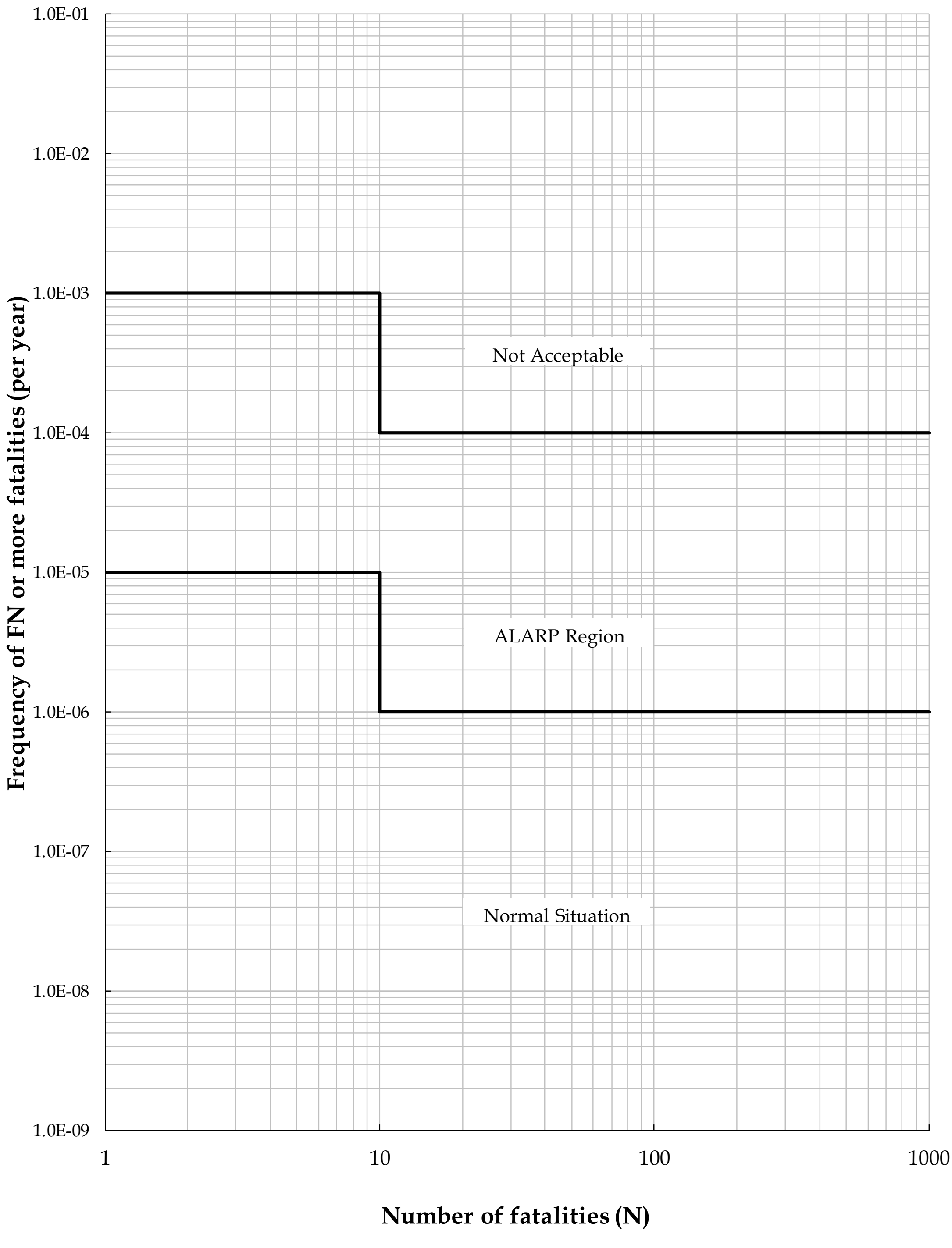

Figure 8-1 Societal Risk Criteria for Off-Site Population

8.4 RISK RESULTS

8.4.1 Individual Risk Results

The individual risk contours from 1E-04 to 1E-07 per year were depicted at Figure 8-2, and no individual risk contours from 1E-02 to 1E-03 per year were reached. As such, the individual risks for the off-site population are within the ALARP region as per EN standards.

8.4.2 Societal Risk Results

8.4.2.1 Potential Loss of Life

The total potential loss of life (PLL) to the off-site population in the vicinity of the FSRU are 3.19E-4, and the major risk contributors in terms of PLL are summarised in ***Table 8-2***. The highest risk contributor is from the fireball scenario from the line rupture of hazardous section "OLNG_06 - Natural Gas from LNG Regasification Plant to Loading Platform" due to the associated relative larger consequence impact area and higher failure frequency.

Table 8-2 Potential Loss of Life to Off-site Population

Hazardous Scenario Code	Description	PLL
FB_OLNGT_06	Fireball scenario from the line rupture of natural gas from LNG Regasification Plant to Loading Platform	2.63E-04
OLNGT_03_L	Flammable effect scenarios (pool fire and flash fire) from large hole size release of LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	1.84E-05
FB_OLNGT_08	Fireball scenario from the line rupture of Riser for Subsea Pipeline	1.30E-05
FB_OLNGT_05	Fireball scenario from the line rupture of LNG Regasification Plant including four Regasification Trains	1.14E-05
FB_OLNGT_07	Fireball scenario from the line rupture of natural gas in Loading Platform to ESDV of Riser for the Subsea Pipeline	2.72E-06
Others		1.01E-05
Total		3.19E-04

8.4.2.2 F-N Curves

The societal risk result, in terms of F-N curves, for the and off-site population is depicted at Figure 8-3, demonstrating that the associated social risks are not in "Not Acceptable" region EN standards even a conservative assumption was made for off-site population.

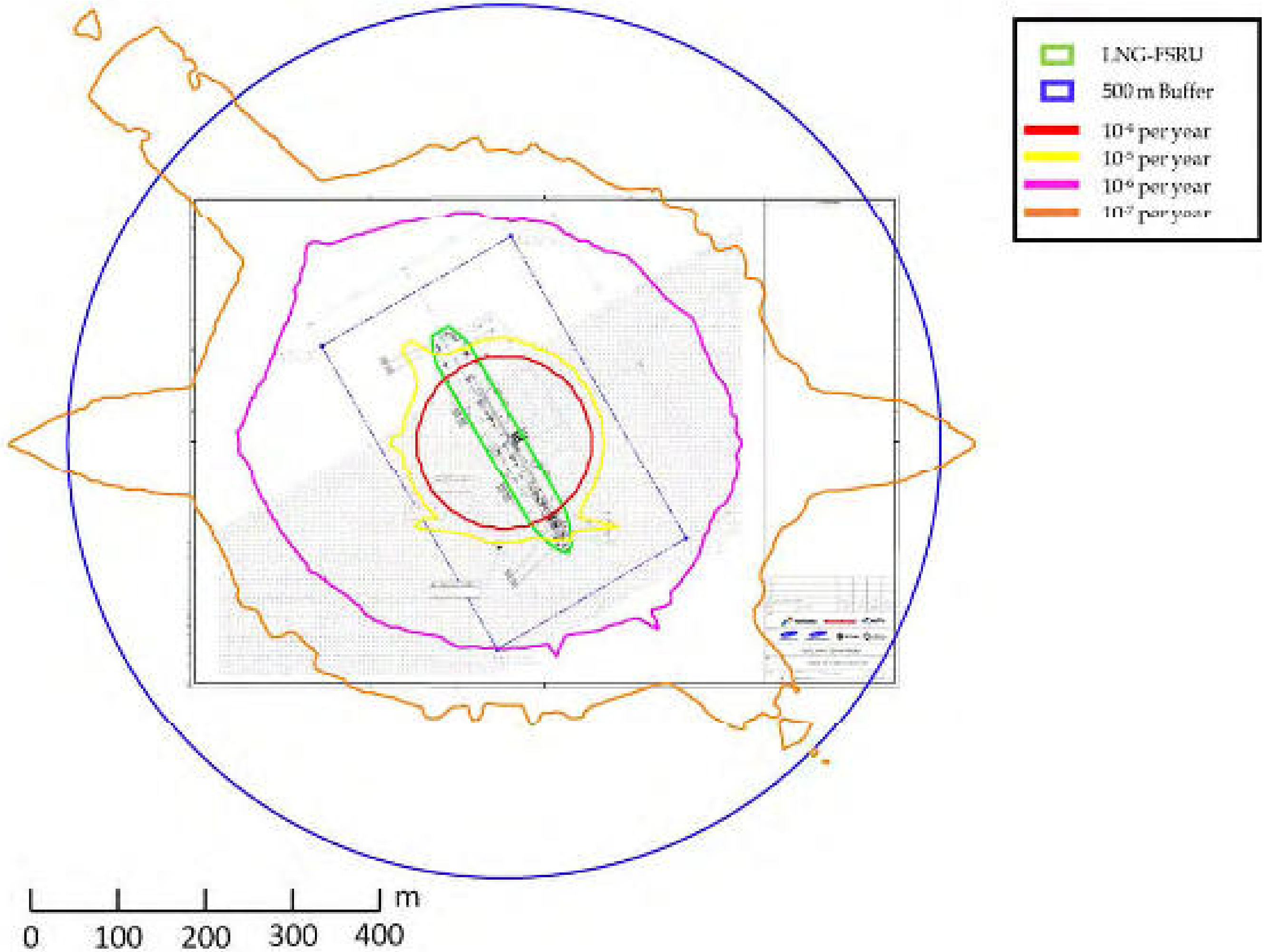

Figure 8-2 Individual Risk Associated with the FSRU

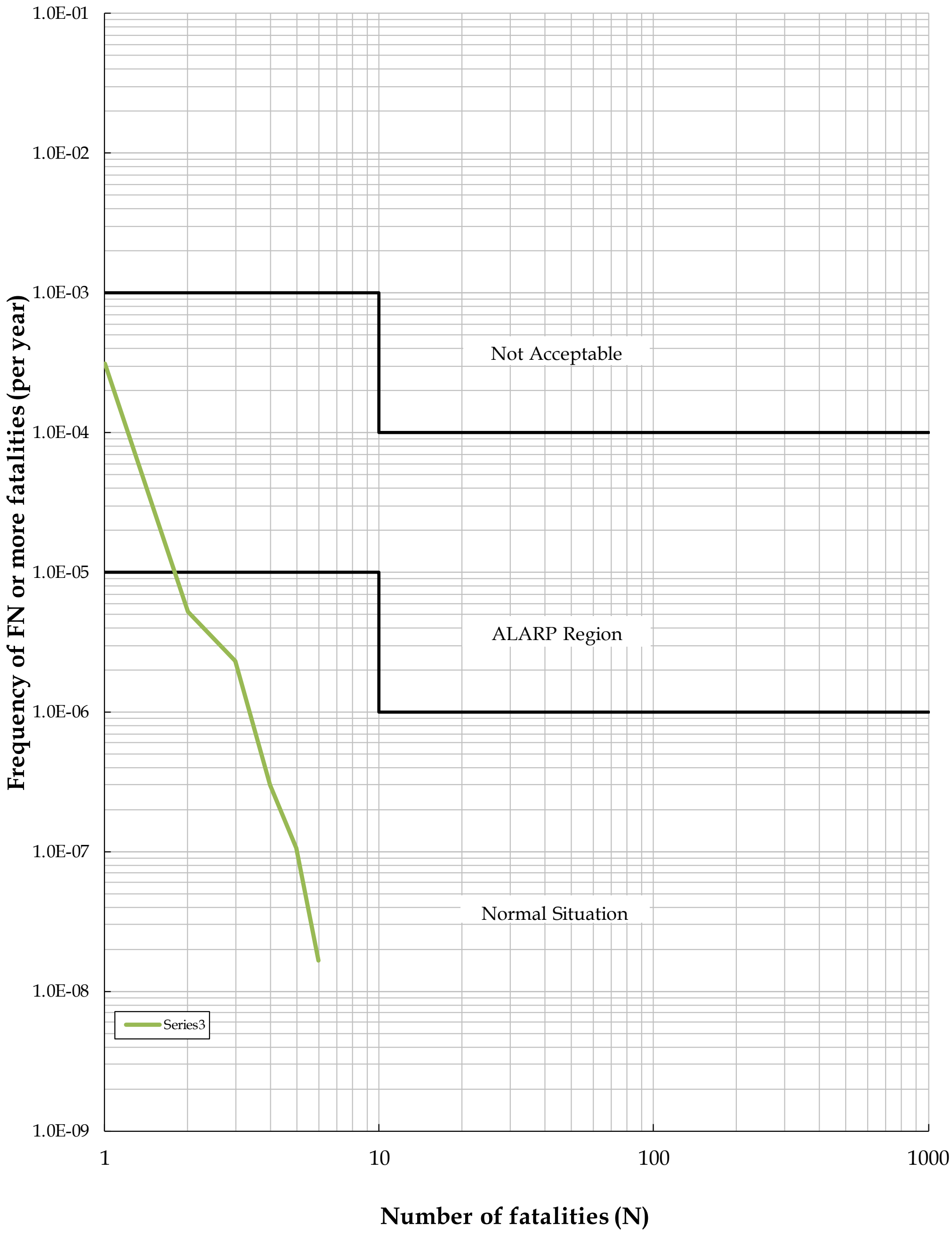

Figure 8-3 F-N Curve for Off-Site Population

9 *CONCLUSION & RECOMMENDATIONS*

A Quantitative Risk Assessment Study has been conducted to evaluate the risk level associated with the transport, storage and use of LNG, natural gas and other dangerous goods (marine diesel oil, etc.) associated with the FSRU during the operational phase.

Both individual risks and societal risk associated with the FSRU to the off-site population are at ALARP region as per EN standards, in order to manage the risk levels associated with the FSRU so that the risk levels will not exceed to the "Not Acceptable" region as per EN standards, the following recommendations are made to further consideration:

- A Safety Zone covering the individual risk contour of 1E-06 per year should be considered to manage the off-site population in the vicinity of the FSRU;
- Emergency response plan should be implemented to evacuate the community in the vicinity of the FSRU and minimise the impact on the community in case major accident events associated with the FSRU occurred;
- Formal Safety Studies such as Hazard and Operability (HAZOP) Study, Safety Integrity Level (SIL) Study, etc., should be conducted during the detailed engineering stage to make sure process hazards are well controlled; and
- QRA Study for the FSRU should be considered to be regularly updated (such as update per 5 years) to assess potential off-site population and marine traffic growth.

10 REFERENCE

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Annex A

Summary of Industry Incidents Review

11 SUMMARY OF INDUSTRY INCIDENTS REVIEW

A review of the past industry incidents at similar facilities worldwide has been conducted to further investigate the possible hazards from the Project's facilities. ***Annex A*** summarises the findings on the past industry incidents based on the review of comprehensive incidents/ accidents database.

11.1 INCIDENTS RELATED TO LNG CARRIER AND FSRU VESSEL

Incidents/ accidents related to LNG Carriers are summarised in **Table 11.1**.

Based on the listed sources in the table below, no safety incident has been recorded for the FSRU since the world's first FSRU began operation more than 10 years ago.

Table H.1 Summary of Incident Review for LNG Carrier

Date, place	Cause	Description	Source
Negeshi, Japan (1970)	External Event	A few hours out of Japan heavy seas caused sloshing of cargo tanks in LNG ship steaming from Japan to Alaska. A thin membrane wall bent in four places and a half inch crack formed in a weld seam.	MHIDAS
Boston, Massachusetts, USA (1971)	Mechanical-Failure	LNG ship "Descartes" had gas leak from tank, faulty connection between tank dome and membrane wall, crew reportedly tried to conceal leak from authorities.	MHIDAS
Terneuzen; Algeria (1974)	Collision	LNG ship "Euclides" sustained contact damage with another vessel, causing damage to bulwark plating and roller fairlead.	MHIDAS
Canvey Island; Essex; UK (1974)	Collision	The coaster "Tower Princess" struck the "Methane Progress" as it was tied up at the LNG jetty tearing a 3 ft gash in its stern. No LNG was spilled & no fire	MHIDAS
El Paso Paul Kayser (1979)	Grounding	While loaded with 99,500 m^3 of LNG, the ship ran at speed onto rocks and grounded in the Straits of Gibraltar. She suffered heavy bottom damage over almost the whole length of the cargo spaces resulting in flooding of her starboard double bottom and wing ballast tanks. Despite this extensive damage, the inner bottom and the membrane cargo containment maintained their integrity. Five days after grounding, the ship was refloated on a rising tide by discharge of ballast by the ships' own pumps and by air pressurisation of the flooded ballast spaces.	SIGTTO (Society of International Gas Tankers Terminal and Operators Ltd.)
Libra (1980)	Mechanical Failure	While on passage from Indonesia to Japan, the propeller tail shaft fractured,	SIGTTO (Society of

Date, place	Cause	Description	Source
		leaving the ship without propulsion. The Philippine authorities granted a safe haven in Davao Gulf to which the ship was towed. Here, with the ship at anchor in sheltered water, the cargo was transferred in thirty two (32) hours of uneventful pumping to a sister ship moored alongside. The LNG Libra was then towed to Singapore, gas-freeing itself on the way and was repaired there. In this casualty, there was, of course, no damage to the ship's hull and no immediate risk to the cargo containment.	International Gas Tankers Terminal and Operators Ltd.)
Taurus (1980)	Grounding	Approaching Tobata Port, Japan to discharge, the ship grounded in heavy weather with extensive bottom damage and flooding of some ballast tanks. After off-loading some bunkers and air pressurising the ruptured ballast spaces, the ship was refloated four days grounding. Despite the extent of bottom damage, the inner hull remained intact and the spherical cargo containment was undistributed. After a diving inspection at a safe anchorage, the ship proceeded under its own power to the adjacent LNG reception terminal and discharged its cargo normally.	SIGTTO (Society of International Gas Tankers Terminal and Operators Ltd.)
Thurley, United Kingdom (1989)	Human Error	While cooling down vaporisers in preparation for sending out natural gas, low-point drain valves were opened. One of these valves was not closed when pumps were started and LNG entered the vaporisers. LNG was released into the atmosphere and the resulting vapor cloud ignited, causing a flash fire that burned two operators.	Cabrillo Port Liquefied Natural Gas Deepwater Port Final EIS/EIR
Bachir Chihani (1990)	Mechanical Failure	Sustained structural cracks allegedly caused by stressing and fatigue in inner hull.	Cabrillo Port Liquefied Natural Gas Deepwater Port Final EIS/EIR
BOSTON, MASSACHUSETTS, USA (1996)	External Fire Event	Loaded LNG carrier sustained electrical fire in main engine room whilst tied up alongside terminal. Fire extinguished by crew using dry chemicals. Cargo discharged at reduced rate (over 90 h instead of 20 h) & vessel sailed under own power.	MHIDAS
SAKAI SENBOKU, Japan (1997)	Collision	LNG tanker sustained damage to shell plating on contact with mooring dolphin at pier. No spillage or damage to cargo system.	MHIDAS

Date, place	Cause	Description	Source
BOSTON, MASSACHUSETTS, USA (1998)	Human Factor	LNG carrier was discharging cargo when arcs of electricity shorted out two of her generators. The US coast guard removed the vessel's certification of compliance as this incident was the latest in a series of deficiencies on the vessel.	MHIDAS
POINT FORTIN, TRINIDAD (1999)	Collision	A LNG carrier collided with a pier after it suffered an engine failure. There was no pollution or any injuries. The pier was closed for 2 weeks. $330,000 of damage done.	MHIDAS
EVERETT, MASSACHUSSETTS, USA (2001)	Mechanical	Suspected overpressurisation of No. 4 cargo tank resulted in some cracking of the outer tank dome. A minor leakage resulted in offloading being temporarily suspended. The tank itself was not damaged and offloading was completed. Vessel not detained.	MHIDAS
East of the Strait of Gibraltar (2002)	Collision	Collision with a U.S. Navy nuclear-powered attack submarine, the U.S.S Oklahoma City. In ballast condition. Ship suffered a leakage of seawater into the double bottom dry tank area.	Cabrillo Port Liquefied Natural Gas Deepwater Port Final EIS/EIR

Annex B

Summary of Frequency Analysis Results

Section		Phase	Leak Size (mm)	Frequency											
				Isolation Success Case						Isolation Failure Case					
				JF[1]	PF[2]	FF[3]	VCE[4]	FB[5]	Total	JF	PF	FF	VCE	FB	Total
OLNGT_01	LNG Loadout from LNGC to LNG Storage Tank in LNG-FSRU (including LNG unloading lines)	L	10	3.14E-07	-	3.01E-07	1.26E-08	-	4.84E-04	3.14E-07	-	3.01E-07	1.26E-08	-	4.84E-04
			25	2.99E-07	-	2.63E-07	3.59E-08	-	5.18E-05	2.99E-07	-	2.63E-07	3.59E-08	-	5.18E-05
			50	1.44E-07	-	1.27E-07	1.73E-08	-	4.64E-06	1.44E-07	-	1.27E-07	1.73E-08	-	4.64E-06
			Full bore	-	2.75E-06	1.92E-06	8.25E-07	-	3.67E-05	-	2.75E-06	1.92E-06	8.25E-07	-	3.67E-05
OLNGT_03	LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	L	10	7.41E-06	-	6.52E-06	8.90E-07	-	9.67E-03	7.41E-06	-	6.52E-06	8.90E-07	-	9.67E-03
			25	5.75E-06	-	5.06E-06	6.90E-07	-	8.12E-04	5.75E-06	-	5.06E-06	6.90E-07	-	8.12E-04
			50	5.21E-06	-	4.58E-06	6.25E-07	-	1.37E-04	5.21E-06	-	4.58E-06	6.25E-07	-	1.37E-04
			Full bore	-	5.57E-06	3.90E-06	1.67E-06	-	7.43E-05	-	5.57E-06	3.90E-06	1.67E-06	-	7.43E-05
OLNGT_04	LNG Transfer from Recondenser to LNG Regasification Plant using Booster Pump (High Pressure	L	10	4.01E-05	-	3.53E-05	4.81E-06	-	2.05E-02	4.01E-05	-	3.53E-05	4.81E-06	-	2.05E-02
			25	2.51E-05	-	2.21E-05	3.01E-06	-	1.39E-03	2.51E-05	-	2.21E-05	3.01E-06	-	1.39E-03
			50	1.43E-05	-	1.00E-05	4.30E-06	-	1.91E-04	1.43E-05	-	1.00E-05	4.30E-06	-	1.91E-04
			Full bore	5.72E-06	-	4.00E-06	1.72E-06	-	7.62E-05	5.72E-06	-	4.00E-06	1.72E-06	-	7.62E-05
OLNGT_05	LNG Regasification Plant including four Regasification Trains	V	10	1.04E-05	-	9.95E-06	4.14E-07	-	1.69E-02	1.04E-05	-	9.95E-06	4.14E-07	-	1.69E-02
			25	3.87E-06	-	3.40E-06	4.64E-07	-	1.66E-03	3.87E-06	-	3.40E-06	4.64E-07	-	1.66E-03
			50	3.96E-06	-	3.49E-06	4.76E-07	-	3.17E-04	3.96E-06	-	3.49E-06	4.76E-07	-	3.17E-04
			Full bore	-	-	1.04E-05	4.46E-06	1.49E-05	1.98E-04	-	-	1.04E-05	4.46E-06	1.49E-05	1.98E-04
OLNGT_06	Natural gas from LNG Regasification Plant to Loading Platform	V	10	5.51E-06	-	5.29E-06	2.20E-07	-	8.85E-03	5.51E-06	-	5.29E-06	2.20E-07	-	8.85E-03
			25	9.41E-06	-	8.28E-06	1.13E-06	-	3.27E-03	9.41E-06	-	8.28E-06	1.13E-06	-	3.27E-03
			50	1.13E-06	-	9.98E-07	1.36E-07	-	7.33E-05	1.13E-06	-	9.98E-07	1.36E-07	-	7.33E-05
			Full bore	-	-	2.40E-04	1.03E-04	3.43E-04	4.58E-03	-	-	2.40E-04	1.03E-04	3.43E-04	4.58E-03
OLNGT_07	Natural gas in Loading Platform to ESDV of Riser for the Subsea Pipeline	V	10	5.21E-06	-	5.00E-06	2.09E-07	-	8.38E-03	5.21E-06	-	5.00E-06	2.09E-07	-	8.38E-03
			25	1.75E-06	-	1.54E-06	2.10E-07	-	6.09E-04	1.75E-06	-	1.54E-06	2.10E-07	-	6.09E-04
			50	1.44E-06	-	1.27E-06	1.73E-07	-	9.33E-05	1.44E-06	-	1.27E-06	1.73E-07	-	9.33E-05
			Full bore	-	-	2.48E-06	1.06E-06	3.55E-06	4.73E-05	-	-	2.48E-06	1.06E-06	3.55E-06	4.73E-05
OLNGT_08	Riser for Subsea Pipeline	V	10	3.36E-07	-	3.23E-07	1.34E-08	-	5.41E-04	3.36E-07	-	3.23E-07	1.34E-08	-	5.41E-04
			25	3.89E-07	-	3.42E-07	4.67E-08	-	1.35E-04	3.89E-07	-	3.42E-07	4.67E-08	-	1.35E-04
			Full bore	-	-	1.18E-05	5.07E-06	1.69E-05	2.25E-04	-	-	1.18E-05	5.07E-06	1.69E-05	2.25E-04
OLNGT_09	Subsea Pipeline within the Vicinity of the LNG-FSRU (within 500 m from the LNG-FSRU)	V	10	-	-	8.99E-06	-	-	8.99E-06	-	-	8.99E-06	-	-	8.99E-06
			25	-	-	3.01E-06	-	-	3.01E-06	-	-	3.01E-06	-	-	3.01E-06
			50	-	-	2.43E-06	-	-	2.43E-06	-	-	2.43E-06	-	-	2.43E-06
			Full bore	-	-	4.16E-06	-	-	4.16E-06	-	-	4.16E-06	-	-	4.16E-06
OLNGT_10	LNG Transfer from LNG Storage Tank to Vaporisation Unit	L	10	6.92E-06	-	6.09E-06	8.30E-07	-	9.03E-03	6.92E-06	-	6.09E-06	8.30E-07	-	9.03E-03
			25	5.05E-06	-	4.45E-06	6.06E-07	-	7.13E-04	5.05E-06	-	4.45E-06	6.06E-07	-	7.13E-04
			50	-	4.08E-06	3.59E-06	4.89E-07	-	1.07E-04	-	4.08E-06	3.59E-06	4.89E-07	-	1.07E-04
			Full bore	-	3.56E-06	2.49E-06	1.07E-06	-	4.75E-05	-	3.56E-06	2.49E-06	1.07E-06	-	4.75E-05
OLNGT_11	Natural gas in Vaporisation Unit for Gas Combustion Unit/ Engine	V	10	3.14E-06	-	3.02E-06	1.26E-07	-	5.79E-03	3.14E-06	-	3.02E-06	1.26E-07	-	5.79E-03
			25	3.87E-07	-	3.71E-07	1.55E-08	-	6.24E-04	3.87E-07	-	3.71E-07	1.55E-08	-	6.24E-04
			50	2.30E-07	-	2.03E-07	2.76E-08	-	1.45E-04	2.30E-07	-	2.03E-07	2.76E-08	-	1.45E-04

Section		Phase	Leak Size (mm)	Frequency											
				Isolation Success Case						Isolation Failure Case					
				JF[1]	PF[2]	FF[3]	VCE[4]	FB[5]	Total	JF	PF	FF	VCE	FB	Total
			Full bore	1.50E-06	-	1.32E-06	1.80E-07	-	6.53E-05	1.50E-06	-	1.32E-06	1.80E-07	-	6.53E-05
OLNGT_12	BOG from LNG Storage Tank to BOG Compressor	V	10	5.39E-06	-	5.17E-06	2.15E-07	-	9.03E-03	5.39E-06	-	5.17E-06	2.15E-07	-	9.03E-03
			25	1.02E-06	-	8.96E-07	1.22E-07	-	7.13E-04	1.02E-06	-	8.96E-07	1.22E-07	-	7.13E-04
			50	8.22E-07	-	7.23E-07	9.86E-08	-	1.07E-04	8.22E-07	-	7.23E-07	9.86E-08	-	1.07E-04
			Full bore	3.56E-06	-	2.49E-06	1.07E-06	-	4.75E-05	3.56E-06	-	2.49E-06	1.07E-06	-	4.75E-05
OLNGT_13	Compressed BOG for Gas Combustion Unit/ Engine	V	10	3.84E-06	-	3.68E-06	1.53E-07	-	7.07E-03	3.84E-06	-	3.68E-06	1.53E-07	-	7.07E-03
			25	2.27E-07	-	2.18E-07	9.08E-09	-	3.66E-04	2.27E-07	-	2.18E-07	9.08E-09	-	3.66E-04
			50	7.33E-08	-	6.45E-08	8.79E-09	-	4.65E-05	7.33E-08	-	6.45E-08	8.79E-09	-	4.65E-05
			Full bore	4.38E-07	-	3.85E-07	5.25E-08	-	1.93E-05	4.38E-07	-	3.85E-07	5.25E-08	-	1.93E-05
OLNGT_14	BOG in Gas Combustion Unit/ Engine	V	10	1.51E-06	-	1.45E-06	6.06E-08	-	3.03E-03	1.51E-06	-	1.45E-06	6.06E-08	-	3.03E-03
			25	1.32E-07	-	1.27E-07	5.29E-09	-	2.38E-04	1.32E-07	-	1.27E-07	5.29E-09	-	2.38E-04
			50	2.25E-08	-	2.16E-08	9.02E-10	-	3.66E-05	2.25E-08	-	2.16E-08	9.02E-10	-	3.66E-05
			Full bore	6.30E-08	-	5.55E-08	7.57E-09	-	1.68E-05	6.30E-08	-	5.55E-08	7.57E-09	-	1.68E-05
OLNGT_15	LNGC Vapour (BOG) return line during loadout operation	V	10	4.96E-06	-	4.77E-06	1.99E-07	-	9.68E-03	4.96E-06	-	4.77E-06	1.99E-07	-	9.68E-03
			25	4.82E-07	-	4.62E-07	1.93E-08	-	8.22E-04	4.82E-07	-	4.62E-07	1.93E-08	-	8.22E-04
			50	8.85E-08	-	8.49E-08	3.54E-09	-	1.37E-04	8.85E-08	-	8.49E-08	3.54E-09	-	1.37E-04
			Full bore	8.04E-07	-	7.08E-07	9.65E-08	-	9.15E-05	8.04E-07	-	7.08E-07	9.65E-08	-	9.15E-05
OLNGT_16	LNG-FSRU Vapour (BOG) return line during loadout operation	V	10	4.63E-06	-	4.45E-06	1.85E-07	-	9.04E-03	4.63E-06	-	4.45E-06	1.85E-07	-	9.04E-03
			25	4.24E-07	-	4.07E-07	1.69E-08	-	7.23E-04	4.24E-07	-	4.07E-07	1.69E-08	-	7.23E-04
			50	6.92E-08	-	6.65E-08	2.77E-09	-	1.07E-04	6.92E-08	-	6.65E-08	2.77E-09	-	1.07E-04
			Full bore	5.69E-07	-	5.01E-07	6.83E-08	-	6.48E-05	5.69E-07	-	5.01E-07	6.83E-08	-	6.48E-05
OLNGT_17	Marine Diesel Oil Storage &Transfer System	L	10	-	2.02E-06	1.94E-06	8.07E-08	-	3.21E-02	-	2.02E-06	1.94E-06	8.07E-08	-	3.21E-02
			25	-	1.09E-06	9.61E-07	1.31E-07	-	3.21E-03	-	1.09E-06	9.61E-07	1.31E-07	-	3.21E-03
			50	-	1.89E-06	1.67E-06	2.27E-07	-	1.04E-03	-	1.89E-06	1.67E-06	2.27E-07	-	1.04E-03
			Full bore	-	6.68E-07	4.68E-07	2.00E-07	-	8.91E-05	-	6.68E-07	4.68E-07	2.00E-07	-	8.91E-05
OLNGT_18	Marine Gas Oil Storage & Transfer System	L	10	-	1.92E-06	1.84E-06	7.67E-08	-	3.05E-02	-	1.92E-06	1.84E-06	7.67E-08	-	3.05E-02
			25	-	9.37E-07	8.24E-07	1.12E-07	-	2.76E-03	-	9.37E-07	8.24E-07	1.12E-07	-	2.76E-03
			50	-	1.48E-06	1.30E-06	1.77E-07	-	8.09E-04	-	1.48E-06	1.30E-06	1.77E-07	-	8.09E-04
			Full bore	-	4.46E-07	3.12E-07	1.34E-07	-	5.94E-05	-	4.46E-07	3.12E-07	1.34E-07	-	5.94E-05
OLNGT_19	Lubricating Oil Storage & Transfer System	L	10	-	5.63E-06	5.41E-06	2.25E-07	-	8.97E-02	-	5.63E-06	5.41E-06	2.25E-07	-	8.97E-02
			25	-	1.85E-06	1.63E-06	2.22E-07	-	5.45E-03	-	1.85E-06	1.63E-06	2.22E-07	-	5.45E-03
			50	-	3.05E-06	2.69E-06	3.66E-07	-	1.67E-03	-	3.05E-06	2.69E-06	3.66E-07	-	1.67E-03
			Full bore	-	1.34E-06	9.36E-07	4.01E-07	-	1.78E-04	-	1.34E-06	9.36E-07	4.01E-07	-	1.78E-04

Note:
1: JF stands for Jet Fire
2: PF stands for Pool Fire
3. FF stands for Flash Fire
4. VCE stands for vapour cloud explosion
5. FB stands for Fireball

Annex C

Summary of Consequence Analysis Results

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
OLNGT_01	LNG Loadout from LNGC to LNG Storage Tank in LNG-FSRU (including LNG unloading lines)	L	10	Jet Fire	35.35 kW/m^2	23	23	20	20	20	18	23	23	20	20	20	18
					28.3 kW/m^2	24	24	21	21	21	18	24	24	21	21	21	18
					19.5 kW/m^2	26	26	22	22	22	20	26	26	22	22	22	20
					9.8 kW/m^2	28	28	25	25	25	22	28	28	25	25	25	22
				Flash Fire	LFL	17	21	13	18	19	20	17	21	13	18	19	20
			25	Jet Fire	35.35 kW/m^2	52	52	44	44	44	39	52	52	44	44	44	39
					28.3 kW/m^2	54	54	46	46	46	41	54	54	46	46	46	41
					19.5 kW/m^2	57	57	49	49	49	44	57	57	49	49	49	44
					9.8 kW/m^2	63	63	55	55	55	50	63	63	55	55	55	50
				Flash Fire	LFL	78	79	67	76	78	71	78	79	67	76	78	71
			50	Jet Fire	35.35 kW/m^2	95	95	81	81	81	72	95	95	81	81	81	72
					28.3 kW/m^2	98	98	84	84	84	75	98	98	84	84	84	75
					19.5 kW/m^2	104	104	89	89	89	80	104	104	89	89	89	80
					9.8 kW/m^2	115	115	101	101	101	91	115	115	101	101	101	91
				Flash Fire	LFL	172	165	196	200	185	216	172	165	196	200	185	216
			Full bore	Pool Fire	35.35 kW/m^2	114	113	137	137	137	159	152	152	181	181	181	210
					28.3 kW/m^2	132	132	156	156	156	174	176	176	205	205	205	230
					19.5 kW/m^2	165	164	186	186	186	199	218	218	245	245	245	264
					9.8 kW/m^2	232	230	247	247	247	257	305	305	326	326	326	340
				Flash Fire	LFL	325	462	320	449	444	437	329	458	403	552	513	582
OLNGT_03	LNG Transfer from LNG Storage Tank Pump to Recondenser using Submersible Pump (Low Pressure Pump)	L	10	Jet Fire	35.35 kW/m^2	25	25	21	21	21	19	25	25	21	21	21	19
					28.3 kW/m^2	26	26	22	22	22	19	26	26	22	22	22	19
					19.5 kW/m^2	27	27	23	23	23	21	27	27	23	23	23	21
					9.8 kW/m^2	30	30	26	26	26	24	30	30	26	26	26	24
				Flash Fire	LFL	22	24	16	22	23	23	22	24	16	22	23	23
			25	Jet Fire	35.35 kW/m^2	55	55	47	47	47	42	55	55	47	47	47	42
					28.3 kW/m^2	57	57	49	49	49	43	57	57	49	49	49	43
					19.5 kW/m^2	60	60	52	52	52	46	60	60	52	52	52	46
					9.8 kW/m^2	67	67	58	58	58	53	67	67	58	58	58	53
				Flash Fire	LFL	82	82	72	83	83	83	82	82	72	83	83	83
			50	Jet Fire	35.35 kW/m^2	101	101	86	86	86	76	101	101	86	86	86	76
					28.3 kW/m^2	104	104	89	89	89	79	104	104	89	89	89	79
					19.5 kW/m^2	110	110	95	95	95	85	110	110	95	95	95	85
					9.8 kW/m^2	122	122	107	107	107	97	122	122	107	107	107	97
				Flash Fire	LFL	171	166	192	196	182	225	171	166	192	196	182	225
			Full bore	Pool Fire	35.35 kW/m^2	130	130	153	152	151	173	130	130	153	152	151	173
					28.3 kW/m^2	147	146	170	168	168	187	147	146	170	168	168	187
					19.5 kW/m^2	175	175	197	195	194	209	175	175	197	195	194	209
					9.8 kW/m^2	235	234	251	249	248	261	235	234	251	249	248	261
				Flash Fire	LFL	1253	1058	1056	1069	1118	851	1112	1089	862	905	977	778
OLNGT_04	LNG Transfer from Recondenser to LNG Regasification Plant using Booster Pump (High Pressure Pump)	L	10	Jet Fire	35.35 kW/m^2	31	31	26	26	26	23	31	31	26	26	26	23
					28.3 kW/m^2	32	32	27	27	27	24	32	32	27	27	27	24
					19.5 kW/m^2	33	33	29	29	29	26	33	33	29	29	29	26
					9.8 kW/m^2	37	37	32	32	32	29	37	37	32	32	32	29
				Flash Fire	LFL	30	30	27	30	29	28	30	30	27	30	29	28
			25	Jet Fire	35.35 kW/m^2	69	69	59	59	59	52	69	69	59	59	59	52
					28.3 kW/m^2	71	71	61	61	61	54	71	71	61	61	61	54

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					19.5 kW/m^2	75	75	64	64	64	58	75	75	64	64	64	58
					9.8 kW/m^2	82	82	72	72	72	66	82	82	72	72	72	66
				Flash Fire	LFL	84	83	79	89	86	97	84	83	79	89	86	97
			50	Jet Fire	35.35 kW/m^2	128	128	108	108	108	96	128	128	108	108	108	96
					28.3 kW/m^2	131	131	112	112	112	100	131	131	112	112	112	100
					19.5 kW/m^2	137	137	118	118	118	106	137	137	118	118	118	106
					9.8 kW/m^2	152	152	133	133	133	121	152	152	133	133	133	121
				Flash Fire	LFL	177	176	179	190	186	208	177	176	179	190	186	208
			Full bore	Jet Fire	35.35 kW/m^2	532	532	455	455	455	406	532	532	455	455	455	406
					28.3 kW/m^2	547	547	470	470	470	422	547	547	470	470	470	422
					19.5 kW/m^2	575	575	499	499	499	452	575	575	499	499	499	452
					9.8 kW/m^2	639	639	564	564	564	519	639	639	564	564	564	519
				Flash Fire	LFL	621	606	707	710	684	902	926	928	915	911	908	1075
OLNGT_05	LNG Regasification Plant including four Regasification Trains	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	7	7	7	9
					9.8 kW/m^2	9	9	10	10	10	10	9	9	10	10	10	10
				Flash Fire	LFL	7	7	6	7	6	6	7	7	6	7	6	6
			25	Jet Fire	35.35 kW/m^2	19	19	20	20	20	22	19	19	20	20	20	22
					28.3 kW/m^2	20	20	21	21	21	22	20	20	21	21	21	22
					19.5 kW/m^2	22	22	23	23	23	24	22	22	23	23	23	24
					9.8 kW/m^2	25	25	26	26	26	27	25	25	26	26	26	27
				Flash Fire	LFL	17	17	16	16	16	16	17	17	16	16	16	16
			50	Jet Fire	35.35 kW/m^2	37	37	39	39	39	43	37	37	39	39	39	43
					28.3 kW/m^2	38	38	41	41	41	45	38	38	41	41	41	45
					19.5 kW/m^2	42	42	44	44	44	47	42	42	44	44	44	47
					9.8 kW/m^2	49	49	50	50	50	52	49	49	50	50	50	52
				Flash Fire	LFL	36	36	35	37	36	37	36	36	35	37	36	37
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	119	120	118	122	121	129	119	120	118	122	121	129
OLNGT_06	Natural gas from LNG Regasification Plant to Loading Platform	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	24	21	21	22	22	22	24
					28.3 kW/m^2	22	22	23	23	23	25	22	22	23	23	23	25
					19.5 kW/m^2	24	24	25	25	25	26	24	24	25	25	25	26
					9.8 kW/m^2	27	27	28	28	28	29	27	27	28	28	28	29
				Flash Fire	LFL	18	18	17	18	18	17	18	18	17	18	18	17
			50	Jet Fire	35.35 kW/m^2	40	40	42	42	42	47	40	40	42	42	42	47
					28.3 kW/m^2	41	41	44	44	44	49	41	41	44	44	44	49
					19.5 kW/m^2	46	46	48	48	48	51	46	46	48	48	48	51

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					9.8 kW/m^2	53	53	54	54	54	57	53	53	54	54	54	57
				Flash Fire	LFL	40	40	39	41	40	41	40	40	39	41	40	41
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	133	141
OLNGT_07	Natural gas in Loading Platform to ESDV of Riser for the Subsea Pipeline	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	24	21	21	22	22	22	24
					28.3 kW/m^2	22	22	23	23	23	25	22	22	23	23	23	25
					19.5 kW/m^2	24	24	25	25	25	26	24	24	25	25	25	26
					9.8 kW/m^2	27	27	28	28	28	29	27	27	28	28	28	29
				Flash Fire	LFL	18	18	17	18	18	17	18	18	17	18	18	17
			50	Jet Fire	35.35 kW/m^2	40	40	42	42	42	47	40	40	42	42	42	47
					28.3 kW/m^2	41	41	44	44	44	49	41	41	44	44	44	49
					19.5 kW/m^2	46	46	48	48	48	51	46	46	48	48	48	51
					9.8 kW/m^2	53	53	54	54	54	57	53	53	54	54	54	57
				Flash Fire	LFL	40	40	39	41	40	41	40	40	39	41	40	41
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	133	141
OLNGT_08	Riser for Subsea Pipeline	V	10	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	11	11	11	11	11	11	11	11	11	11	11	11
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Jet Fire	35.35 kW/m^2	21	21	22	22	22	24	21	21	22	22	22	24
					28.3 kW/m^2	22	22	23	23	23	25	22	22	23	23	23	25
					19.5 kW/m^2	24	24	25	25	25	26	24	24	25	25	25	26
					9.8 kW/m^2	27	27	28	28	28	29	27	27	28	28	28	29
				Flash Fire	LFL	18	18	17	18	18	17	18	18	17	18	18	17
			Full bore	Fireball	FB Radius	36	36	36	36	36	36	36	36	36	36	36	36
					35.35 kW/m^2	94	94	94	94	94	94	94	94	94	94	94	94
					28.3 kW/m^2	106	106	106	106	106	106	106	106	106	106	106	106
					19.5 kW/m^2	127	127	127	127	127	127	127	127	127	127	127	127
					9.8 kW/m^2	178	178	178	178	178	178	178	178	178	178	178	178
				Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	133	141
OLNGT_09	Subsea Pipeline within the Vicinity of the LNG-FSRU (within 500 m from the LNG-	V	10	Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			25	Flash Fire	LFL	18	18	17	18	18	17	18	18	17	18	18	17
			50	Flash Fire	LFL	40	40	39	41	40	41	40	40	39	41	40	41

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
	FSRU)		Full bore	Flash Fire	LFL	131	131	129	134	133	141	131	131	129	134	133	141
OLNGT_10	LNG Transfer from LNG Storage Tank to Vaporisation Unit	L	10	Jet Fire	35.35 kW/m^2	25	25	21	21	21	19	25	25	21	21	21	19
					28.3 kW/m^2	26	26	22	22	22	19	26	26	22	22	22	19
					19.5 kW/m^2	27	27	23	23	23	21	27	27	23	23	23	21
					9.8 kW/m^2	30	30	26	26	26	24	30	30	26	26	26	24
				Flash Fire	LFL	22	24	16	22	23	23	22	24	16	22	23	23
			25	Jet Fire	35.35 kW/m^2	55	55	47	47	47	42	55	55	47	47	47	42
					28.3 kW/m^2	57	57	49	49	49	43	57	57	49	49	49	43
					19.5 kW/m^2	60	60	52	52	52	46	60	60	52	52	52	46
					9.8 kW/m^2	67	67	58	58	58	53	67	67	58	58	58	53
				Flash Fire	LFL	82	82	72	83	83	83	82	82	72	83	83	83
			50	Pool Fire	35.35 kW/m^2	26	25	31	26	25	2	26	25	31	26	25	2
					28.3 kW/m^2	27	26	33	27	26	2	27	26	33	27	26	2
					19.5 kW/m^2	29	28	37	29	27	2	29	28	37	29	27	2
					9.8 kW/m^2	33	31	41	32	30	2	33	31	41	32	30	27
				Flash Fire	LFL	171	165	191	195	182	225	171	166	192	195	182	225
			Full bore	Pool Fire	35.35 kW/m^2	109	108	128	127	126	143	149	149	175	174	173	198
					28.3 kW/m^2	122	121	141	140	138	154	168	168	194	193	192	214
					19.5 kW/m^2	144	144	162	161	159	171	201	201	226	224	223	240
					9.8 kW/m^2	190	190	204	202	201	211	271	270	289	288	287	301
				Flash Fire	LFL	550	533	684	702	656	814	1466	1372	1062	1281	1490	912
OLNGT_11	Natural gas in Vaporisation Unit for Gas Combustion Unit/ Engine	V	10	Jet Fire	35.35 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					28.3 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					19.5 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					9.8 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	8	9	9	9	9	9	8
					9.8 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			50	Jet Fire	35.35 kW/m^2	17	17	17	17	17	19	17	17	17	17	17	19
					28.3 kW/m^2	17	17	18	18	18	19	17	17	18	18	18	19
					19.5 kW/m^2	18	18	19	19	19	20	18	18	19	19	19	20
					9.8 kW/m^2	22	22	22	22	22	23	22	22	22	22	22	23
				Flash Fire	LFL	14	14	13	14	14	13	14	14	13	14	14	13
			Full bore	Jet Fire	35.35 kW/m^2	46	46	48	48	48	54	46	46	48	48	48	54
					28.3 kW/m^2	47	47	51	51	51	56	47	47	51	51	51	56
					19.5 kW/m^2	53	53	55	55	55	59	53	53	55	55	55	59
					9.8 kW/m^2	62	62	63	63	63	66	62	62	63	63	63	66
				Flash Fire	LFL	48	48	47	49	48	50	48	48	47	49	48	50
OLNGT_12	BOG from LNG Storage Tank to BOG Compressor	V	10	Jet Fire	35.35 kW/m^2	15	15	13	13	13	12	15	15	13	13	13	12
					28.3 kW/m^2	15	15	13	13	13	12	15	15	13	13	13	12
					19.5 kW/m^2	16	16	14	14	14	13	16	16	14	14	14	13
					9.8 kW/m^2	19	19	16	16	16	14	19	19	16	16	16	14
				Flash Fire	LFL	5	4	5	6	5	9	5	4	5	6	5	9
			25	Jet Fire	35.35 kW/m^2	31	31	28	28	28	26	31	31	28	28	28	26

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					28.3 kW/m^2	33	33	30	30	30	27	33	33	30	30	30	27
					19.5 kW/m^2	36	36	32	32	32	28	36	36	32	32	32	28
					9.8 kW/m^2	41	41	35	35	35	32	41	41	35	35	35	32
				Flash Fire	LFL	5	74	6	6	6	8	5	74	6	6	6	8
			50	Jet Fire	35.35 kW/m^2	57	57	51	52	52	47	57	57	51	52	52	47
					28.3 kW/m^2	60	60	53	54	54	48	60	60	53	54	54	48
					19.5 kW/m^2	65	65	56	57	57	51	65	65	56	57	57	51
					9.8 kW/m^2	73	73	64	65	65	58	73	73	64	65	65	58
				Flash Fire	LFL	220	166	128	158	152	97	220	166	128	158	152	97
			Full bore	Jet Fire	35.35 kW/m^2	107	107	94	95	96	88	107	107	94	95	96	88
					28.3 kW/m^2	112	112	97	99	99	91	112	112	97	99	99	91
					19.5 kW/m^2	120	120	104	105	106	97	120	120	104	105	106	97
					9.8 kW/m^2	134	135	117	119	119	110	134	135	117	119	119	110
				Flash Fire	LFL	199	161	188	236	213	200	200	161	188	236	213	200
OLNGT_13	Compressed BOG for Gas Combustion Unit/ Engine	V	10	Jet Fire	35.35 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					28.3 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					19.5 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
					9.8 kW/m^2	4	4	4	4	4	4	4	4	4	4	4	4
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					28.3 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					19.5 kW/m^2	9	9	9	9	9	9	9	9	9	9	9	9
					9.8 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
				Flash Fire	LFL	7	7	7	7	7	7	7	7	7	7	7	7
			50	Jet Fire	35.35 kW/m^2	17	17	17	17	17	19	17	17	17	17	17	19
					28.3 kW/m^2	17	17	18	18	18	19	17	17	18	18	18	19
					19.5 kW/m^2	18	18	19	19	19	20	18	18	19	19	19	20
					9.8 kW/m^2	21	21	22	22	22	22	21	21	22	22	22	22
				Flash Fire	LFL	14	14	13	14	14	13	14	14	13	14	14	13
			Full bore	Jet Fire	35.35 kW/m^2	46	46	48	48	48	54	46	46	48	48	48	54
					28.3 kW/m^2	47	47	50	50	50	56	47	47	50	50	50	56
					19.5 kW/m^2	53	53	55	55	55	59	53	53	55	55	55	59
					9.8 kW/m^2	61	61	63	63	63	65	61	61	63	63	63	65
				Flash Fire	LFL	47	48	47	48	48	50	47	48	47	48	48	50
OLNGT_14	BOG in Gas Combustion Unit/ Engine	V	10	Jet Fire	35.35 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					28.3 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					19.5 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					9.8 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
				Flash Fire	LFL	2	2	2	2	2	2	2	2	2	2	2	2
			25	Jet Fire	35.35 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
					28.3 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
					19.5 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
					9.8 kW/m^2	6	6	6	6	6	6	6	6	6	6	6	6
				Flash Fire	LFL	5	5	5	5	5	5	5	5	5	5	5	5
			50	Jet Fire	35.35 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
					28.3 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
					19.5 kW/m^2	8	8	11	11	11	13	8	8	11	11	11	13

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					9.8 kW/m^2	11	11	12	12	12	14	11	11	12	12	12	14
				Flash Fire	LFL	9	9	9	9	9	8	9	9	9	9	9	8
			Full bore	Jet Fire	35.35 kW/m^2	22	22	26	26	26	33	22	22	26	26	26	33
					28.3 kW/m^2	24	24	27	27	27	33	24	24	27	27	27	33
					19.5 kW/m^2	26	26	29	29	29	34	26	26	29	29	29	34
					9.8 kW/m^2	32	32	34	34	34	36	32	32	34	34	34	36
				Flash Fire	LFL	31	31	30	31	31	31	31	31	30	31	31	31
OLNGT_15	LNGC Vapour (BOG) return line during loadout operation	V	10	Jet Fire	35.35 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					28.3 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					19.5 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					9.8 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					28.3 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					19.5 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					9.8 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
				Flash Fire	LFL	6	6	6	6	6	6	6	6	6	6	6	6
			50	Jet Fire	35.35 kW/m^2	13	13	13	13	13	13	13	13	13	13	13	13
					28.3 kW/m^2	11	11	13	13	13	15	11	11	13	13	13	15
					19.5 kW/m^2	13	13	14	14	14	16	13	13	14	14	14	16
					9.8 kW/m^2	15	15	16	16	16	18	15	15	16	16	16	18
				Flash Fire	LFL	11	11	10	11	11	10	11	11	10	11	11	10
			Full bore	Jet Fire	35.35 kW/m^2	32	32	12	12	12	41	32	32	12	12	12	41
					28.3 kW/m^2	33	33	36	36	36	42	33	33	36	36	36	42
					19.5 kW/m^2	36	36	39	39	39	44	36	36	39	39	39	44
					9.8 kW/m^2	44	44	45	45	45	48	44	44	45	45	45	48
				Flash Fire	LFL	38	38	38	39	38	40	38	38	38	39	38	40
OLNGT_16	LNG-FSRU Vapour (BOG) return line during loadout operation	V	10	Jet Fire	35.35 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					28.3 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					19.5 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
					9.8 kW/m^2	3	3	3	3	3	3	3	3	3	3	3	3
				Flash Fire	LFL	3	3	3	3	3	3	3	3	3	3	3	3
			25	Jet Fire	35.35 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					28.3 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					19.5 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
					9.8 kW/m^2	7	7	7	7	7	7	7	7	7	7	7	7
				Flash Fire	LFL	6	6	6	6	6	6	6	6	6	6	6	6
			50	Jet Fire	35.35 kW/m^2	10	10	10	10	10	10	10	10	10	10	10	10
					28.3 kW/m^2	11	11	13	13	13	15	11	11	13	13	13	15
					19.5 kW/m^2	13	13	14	14	14	16	13	13	14	14	14	16
					9.8 kW/m^2	15	15	16	16	16	18	15	15	16	16	16	18
				Flash Fire	LFL	11	11	10	11	11	10	11	11	10	11	11	10
			Full bore	Jet Fire	35.35 kW/m^2	32	32	12	12	12	41	32	32	12	12	12	41
					28.3 kW/m^2	33	33	36	36	36	42	33	33	36	36	36	42
					19.5 kW/m^2	36	36	39	39	39	44	36	36	39	39	39	44
					9.8 kW/m^2	44	44	45	45	45	48	44	44	45	45	45	48
				Flash Fire	LFL	38	38	38	39	38	40	38	38	38	39	38	40

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
OLNGT_17	Marine Diesel Oil Storage &Transfer System	L	10	Pool Fire	35.35 kW/m^2	10	10	11	11	11	13	10	10	11	11	11	13
					28.3 kW/m^2	11	11	13	13	12	15	11	11	13	13	12	15
					19.5 kW/m^2	13	13	15	15	14	17	13	13	15	15	14	17
					9.8 kW/m^2	16	16	18	18	17	19	16	16	18	18	17	19
				Flash Fire	LFL	5	5	6	6	5	6	5	5	6	6	5	6
			25	Pool Fire	35.35 kW/m^2	14	14	14	14	14	15	14	14	14	14	14	15
					28.3 kW/m^2	14	14	15	15	14	15	14	14	15	15	14	15
					19.5 kW/m^2	17	17	19	19	19	21	17	17	19	19	19	21
					9.8 kW/m^2	24	24	27	27	27	29	24	24	27	27	27	29
				Flash Fire	LFL	7	6	7	7	7	7	7	6	7	7	7	7
			50	Pool Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					19.5 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					9.8 kW/m^2	28	28	32	32	32	36	28	28	32	32	32	36
				Flash Fire	LFL	7	7	8	8	7	8	7	7	8	8	7	8
			Full bore	Pool Fire	35.35 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					28.3 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					19.5 kW/m^2	261	268	261	264	279	272	261	268	261	264	280	272
					9.8 kW/m^2	264	271	273	276	291	297	264	271	273	276	291	297
				Flash Fire	LFL	47	54	47	50	65	58	47	54	47	50	65	58
OLNGT_18	Marine Gas Oil Storage & Transfer System	L	10	Pool Fire	35.35 kW/m^2	10	10	11	11	11	13	10	10	11	11	11	13
					28.3 kW/m^2	11	11	13	13	12	15	11	11	13	13	12	15
					19.5 kW/m^2	13	13	15	15	14	17	13	13	15	15	14	17
					9.8 kW/m^2	16	16	18	18	17	19	16	16	18	18	17	19
				Flash Fire	LFL	5	5	6	6	5	6	5	5	6	6	5	6
			25	Pool Fire	35.35 kW/m^2	14	14	14	14	14	15	14	14	14	14	14	15
					28.3 kW/m^2	14	14	15	15	14	15	14	14	15	15	14	15
					19.5 kW/m^2	17	17	19	19	19	21	17	17	19	19	19	21
					9.8 kW/m^2	24	24	27	27	27	29	24	24	27	27	27	29
				Flash Fire	LFL	7	6	7	7	7	7	7	6	7	7	7	7
			50	Pool Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					19.5 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					9.8 kW/m^2	28	28	32	32	32	36	28	28	32	32	32	36
				Flash Fire	LFL	7	7	8	8	7	8	7	7	8	8	7	8
			Full bore	Pool Fire	35.35 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					28.3 kW/m^2	255	255	255	255	255	255	255	255	255	255	255	255
					19.5 kW/m^2	261	268	261	264	279	272	261	268	261	264	280	272
					9.8 kW/m^2	264	271	273	276	291	297	264	271	273	276	291	297
				Flash Fire	LFL	47	54	47	50	65	58	47	54	47	50	65	58
OLNGT_19	Lubricating Oil Storage & Transfer System	L	10	Pool Fire	35.35 kW/m^2	10	10	11	11	11	13	10	10	11	11	11	13
					28.3 kW/m^2	11	11	13	13	12	15	11	11	13	13	12	15
					19.5 kW/m^2	13	13	15	15	14	17	13	13	15	15	14	17
					9.8 kW/m^2	16	16	18	18	17	19	16	16	18	18	17	19
				Flash Fire	LFL	5	5	6	6	5	6	5	5	6	6	5	6
			25	Pool Fire	35.35 kW/m^2	14	14	14	14	14	15	14	14	14	14	14	15
					28.3 kW/m^2	14	14	15	15	14	15	14	14	15	15	14	15

Section		Phase	Leak Size (mm)	Hazard Effects	End Point Criteria	Hazard Extent (m)											
						Isolation Success Case						Isolation Failure Case					
						Weather Conditions						Weather Conditions					
						1.5D	1.5F	3.5B	3.5D	3.5E	7.5D	1.5D	1.5F	3.5B	3.5D	3.5E	7.5D
					19.5 kW/m^2	17	17	19	19	19	21	17	17	19	19	19	21
					9.8 kW/m^2	24	24	27	27	27	29	24	24	27	27	27	29
				Flash Fire	LFL	7	6	7	7	7	7	7	6	7	7	7	7
			50	Pool Fire	35.35 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					28.3 kW/m^2	12	12	12	12	12	12	12	12	12	12	12	12
					19.5 kW/m^2	21	21	21	21	21	21	21	21	21	21	21	21
					9.8 kW/m^2	28	28	32	32	32	36	28	28	32	32	32	36
				Flash Fire	LFL	7	7	8	8	7	8	7	7	8	8	7	8
			Full bore	Pool Fire	35.35 kW/m^2	114	114	114	114	114	114	114	114	114	114	114	114
					28.3 kW/m^2	114	114	114	114	114	114	114	114	114	114	114	114
					19.5 kW/m^2	118	121	118	120	125	123	118	121	118	120	125	123
					9.8 kW/m^2	121	124	130	131	137	145	121	124	130	131	137	145
				Flash Fire	LFL	26	29	27	28	34	32	26	29	27	28	34	32

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ANNEX I
RESETTLEMENT PLAN

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ANNEX J
CRITICAL HABITAT SCREENING ASSESSMENT

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J. SPECIES LISTS FROM BIODIVERSITY FIELDS SURVEYS, 2017

J.1 FLORA SURVEYS

Table J.1 List of Flora Species encountered in Mangrove Vegetation Type

No	Scientific name	Family	IUCN Listing	Indonesian Listing
1.	*Abutilon indicum*	Malvaceae	-	-
2.	*Acanthus ilicifolius*	Acanthaceae	-	-
3.	*Achyranthes aspera*	Acanthaceae	-	-
4.	*Alternanthera sessilis*	Amaranthaceae	LC	-
5.	*Avicennia marina*	Acanthaceae	LC	-
6.	*Breynia coronata*	Phyllanthaceae	-	-
7.	*Canna indica*	Cannaceae	-	-
8.	*Cayratia trifolia*	Vitaceae	-	-
9.	*Centrosema molle*	Fabaceae	-	-
10.	*Chloris barbata*	Poaceae	-	-
11.	*Cordia dichotoma*	Boraginaceae	-	-
12.	*Cyperus compactus*	Cyperaceae	LC	-
13.	*Cyperus javanicus*	Cyperaceae	-	-
14.	*Dendrophthoe pentandra*	Loranthaceae	-	-
15.	*Derris scandens*	Fabaceae	LC	-
16.	*Derris trifoliata*	Fabaceae	-	-
17.	*Eclipta prostrata*	Asteraceae	LC	-
18.	*Eichhornia crassipes Solms*	Pontederiaceae	-	-
19.	*Fimbristylis dichotoma*	Cyperaceae	LC	-
20.	*Fimbristylis littoralis*	Cyperaceae	LC	-
21.	*Hibiscus tilliaceus*	Malvaceae	-	-
22.	*Indigofera hirsuta*	Fabaceae	-	-
23.	*Ipomoea pes-caprae*	Convolvulaceae	-	-
24.	*Ipomoea sp*	Convolvulaceae	-	-
25.	*Leucaena leucocephala*	Fabaceae	-	-
26.	*Lindernia antipoda*	Linderniaceae	LC	-
27.	*Malachra capitata*	Malvaceae	-	-
28.	*Melanthera biflora*	Asteraceae	-	-
29.	*Ocimum tenuiflorum*	Lamiaceae	-	-
30.	*Passiflora foetida*	Passifloraceae	-	-
31.	*Pluchea indica*	Asteraceae	-	-
32.	*Rhizophora apiculata*	Rhizophoraceae	LC	-
33.	*Ruellia tuberosa*	Acanthaceae	-	-
34.	*Sarcocornia perennis*	Amaranthaceae	-	-
35.	*Schoenoplectiella mucronata*	Cyperaceae	-	-
36.	*Sesuvium portulacastrum*	Aizoaceae	-	-
37.	*Sonneratia alba*	Lythraceae	-	-
38.	*Sonneratia caseolaris*	Lythraceae	-	-
39.	*Sphagneticola trilobata*	Asteraceae	-	-
40.	*Suaeda maritima*	Amaranthaceae	-	-
41.	*Tectona grandis*	Lamiaceae	-	-
42.	*Terminalia catappa*	Combretaceae	-	-
43.	*Urena lobata*	Malvaceae	-	-
44.	*Volkameria inermis*	Lamiaceae	-	-

Notes:

No	Scientific name	Family	IUCN Listing	Indonesian Listing
CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern				

Table J.2 List of Flora Species in Courtyard Vegetation Type

No	Scientific name	Family	IUCN Listing	Indonesia Listing
1.	*Abrus precatorius*	Fabaceae	-	-
2.	*Acacia auriculiformis*	Fabaceae	LC	-
3.	*Acalypha indica*	Euphorbiaceae	-	-
4.	*Annona muricata*	Annonaceae	-	-
5.	*Bougainvillea spectabilis*	Nyctaginaceae	-	-
6.	*Canna indica*	Cannaceae	-	-
7.	*Ceiba pentandra*	Malvaceae	-	-
8.	*Citrus maxima*	Rutaceae	-	-
9.	*Dimocarpus longan*	Sapindaceae	-	-
10.	*Euphorbia milii*	Euphorbiaceae	-	-
11.	*Heliotropium indicum*	Boraginaceae	-	-
12.	*Jasminum multiflorum*	Oleaceae	-	-
13.	*Lannea coromandelica*	Anacardiaceae	-	-
14.	*Leonotis nepetifolia*	Lamiaceae	-	-
15.	*Leucaena leucocephala*	Fabaceae	-	-
16.	*Mangifera indica*	Anacardiaceae	DD	-
17.	*Manihot esculenta*	Euphorbiaceae	-	-
18.	*Opuntia cochenillifera*	Cactaceae	DD	-
19.	*Parkia speciosa*	Fabaceae	-	-
20.	*Portulaca umbraticola*	Portulacaceae	-	-
21.	*Pouteria campechiana*	Sapotaceae	-	-
22.	*Punica granatum*	Lythraceae	LC	-
23.	*Sesbania grandiflora*	Fabaceae	-	-
24.	*Syzygium cumini*	Myrtaceae	-	-
25.	*Urena lobata*	Malvaceae	-	-

Notes:

CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern

Table J.3 List of Flora Species in Dry Land Agriculture Vegetation Type

No	Scientific name	Family	IUCN Listing	Indonesian Listing
1.	*Acacia auriculiformis Benth*	Fabaceae	LC	-
2.	*Acacia mangium*	Fabaceae	-	-
3.	*Albizia saman*	Fabaceae	-	-
4.	*Annona squamosa*	Annonaceae	-	-
5.	*Artocarpus camansi*	Moraceae	-	-
6.	*Artocarpus heterophyllus*	Moraceae	-	-
7.	*Axonopus compressus*	Poaceae	-	-
8.	*Basilicum polystachyon*	Lamiaceae	-	-
9.	*Bougainvillea glabra*	Nyctaginaceae	-	-
10.	*Breynia Sp*	Phyllanthaceae	-	-
11.	*Carica papaya*	Caricaceae	-	-
12.	*Casuarina equisetifolia*	Casuarinaceae	-	-
13.	*Cayratia trifolia*	Vitaceae	-	-

No	Scientific name	Family	IUCN Listing	Indonesian Listing
14.	*Centella asiatica*	Apiaceae	LC	-
15.	*Chromolaena odorata*	Asteraceae	-	-
16.	*Coccinia grandis*	Cucurbitaceae	-	-
17.	*Cocos nucifera*	Arecaceae	-	-
18.	*Colocasia esculenta*	Araceae	-	-
19.	*Cyperus niveus var. leucocephalus*	Cyperaceae	-	-
20.	*Dendrophthoe pentandra*	Loranthaceae	-	-
21.	*Falcataria moluccana*	Fabaceae	-	-
22.	*Gymnopetalum chinense*	Cucurbitaceae	-	-
23.	*Hydrolea spinosa*	Hydroleaceae	-	-
24.	*Ipomoea cairica*	Convolvulaceae	-	-
25.	*Kyllinga brevifolia*	Cyperaceae	LC	-
26.	*coromandelianum*	Malvaceae	-	-
27.	*Manihot carthaginensis*	Euphorbiaceae	-	-
28.	*Melochia umbellata*	Malvaceae	-	-
29.	*Merremia gemella*	Convolvulaceae	-	-
30.	*Muntingia calabura*	Muntingiaceae	-	-
31.	*Musa acuminata*	Musaceae	-	-
32.	*Persicaria barbata*	Polygonaceae	LC	-
33.	*Physalis minima*	Solanaceae	-	-
34.	*Pinanga coronata*	Arecaceae	-	-
35.	*Plumeria rubra*	Apocynaceae	-	-
36.	*Polyalthia longifolia*	Annonaceae	-	-
37.	*Pouzolzia zeylanica*	Urticaceae	-	-
38.	*Pseudosasa japonica*	Poaceae	-	-
39.	*Pterocarpus indicus*	Fabaceae	VU	-
40.	*Solanum melongena*	Solanaceae	-	-
41.	*Sphagneticola trilobata*	Asteraceae	-	-
42.	*Swietenia macrophylla*	Meliaceae	VU	-
43.	*Syzygium aqueum*	Myrtaceae	-	-
44.	*Tarlmounia elliptica*	Asteraceae	-	-
45.	*Tectona grandis*	Lamiaceae	-	-

Notes:

CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern

Table J.4 List of Vegetation in Riparian Vegetation Type

No		Scientific name	Family	IUCN Listing	Indonesian Listing
1.	1	*Abelmoschus sp*	Malvaceae	-	-
2.	2	*Acacia auriculiformis*	Fabaceae	LC	-
3.	3	*Acalypha indica*	Euphorbiaceae	-	-
4.	4	*Achyranthes aspera*	Acanthaceae	-	-
5.	5	*Alternanthera philoxeroides*	Amaranthaceae	-	-
6.	6	*Alternanthera pungens Kunth*	Amaranthaceae	-	-
7.	7	*Amaranthus blitum*	Amaranthaceae	-	-
8.	8	*Amaranthus retroflexus*	Amaranthaceae	-	-
9.	9	*Ammannia baccifera*	Lythraceae	LC	-
10.	1	*Amorphophallus variabilis Blume*	Araceae	-	-
11.	1	*Ananas comosus Merr*	Bromeliaceae	-	-
12.	1	*Anoda sp*	Malvaceae	-	-
13.	1	*Artocarpus camansi Blanco*	Moraceae	-	-

No		Scientific name	Family	IUCN Listing	Indonesian Listing
14.	1	*Asystasia gangetica T.Anderson*	Acanthaceae	-	-
15.	1	*Axonopus compressus*	Poaceae	-	-
16.	1	*Barringtonia racemosa*	Lecythidaceae	-	-
17.	1	*Blechum pyramidatum*	Acanthaceae	-	-
18.	1	*Breynia coronata*	Phyllanthaceae	-	-
19.	1	*Callicarpaongifoliaam*	Lamiaceae	-	-
20.	2	*Calopogonium mucunoides*	Fabaceae	-	-
21.	2	*Calotropis gigantea*	Apocynaceae	-	-
22.	2	*Capsicum annuum*	Solanaceae	-	-
23.	2	*Cardiospermum halicacabum*	Sapindaceae	-	-
24.	2	*Carica papaya*	Caricaceae	DD	-
25.	2	*Ceiba pentandra*	Malvaceae	-	-
26.	2	*Centrosema molle*	Fabaceae	-	-
27.	2	*Cerbera manghas*	Apocynaceae	-	-
28.	2	*Cheilocostus speciosus*	Costaceae	-	-
29.	2	*Chloris barbata*	Poaceae	-	-
30.	3	*Cleome rutidosperma*	Cleomaceae	-	-
31.	3	*Coccinia grandis*	Cucurbitaceae	-	-
32.	3	*Combretum indicum*	Combretaceae	-	-
33.	3	*Commelina diffusa*	Commelinaceae	LC	-
34.	3	*Crotalaria pallida*	Fabaceae	-	-
35.	3	*Cyanthillium cinereum*	Asteraceae	-	-
36.	3	*Cyathula prostrata*	Acanthaceae	-	-
37.	3	*Cymbopogon nardus*	Poaceae	-	-
38.	3	*Cyperus imbricatus*	Cyperaceae	LC	-
39.	3	*Dendrophthoe pentandra*	Loranthaceae	-	-
40.	4	*Echinochloa colona*	Poaceae	LC	-
41.	4	*Eclipta prostrata*	Asteraceae	LC	-
42.	4	*Eichhornia crassipes*	Pontederiaceae	-	-
43.	4	*Eleusine indica*	Poaceae	LC	-
44.	4	*Falcataria moluccana*	Fabaceae	-	-
45.	4	*Fimbristylis dichotoma*	Cyperaceae	LC	-
46.	4	*Flemingiaineata*	Fabaceae	-	-
47.	4	*Gliricidia sepium*	Fabaceae	-	-
48.	4	*Hydrolea spinosa*	Hydroleaceae	-	-
49.	4	*Hyptis capitata*	Lamiaceae	-	-
50.	5	*Imperata cylindrica*	Poaceae	-	-
51.	5	*Indigofera hirsuta*	Fabaceae	-	-
52.	5	*Ipomoea aquatica*	Convolvulaceae	LC	-
53.	5	*Ipomoea obscura*	Convolvulaceae	-	-
54.	5	*Ipomoea sp*	Convolvulaceae	-	-
55.	5	*Ipomoeae carnea*	Convolvulaceae	-	-
56.	5	*Ischaemum ciliare*	Poaceae	-	-
57.	5	*Jatropha curcas*	Euphorbiaceae	-	-
58.	5	*Jatropha gossypiifolia*	Euphorbiaceae	-	-
59.	5	*Lantana camara*	Verbenaceae	-	-
60.	0	*Leea rubra Blume ex*	Vitaceae	-	-
61.	6	*Leonotis nepetifolia*	Lamiaceae	-	-
62.	6	*Leucaenaeucocephala*	Fabaceae	-	-
63.	6	*Limnocharis flava*	Alismataceae	-	-
64.	6	*Lindernia antipoda*	Linderniaceae	LC	-
65.	6	*Ludwigia octovalvis*	Onagraceae	LC	-
66.	6	*Macaranga tanarius*	Euphorbiaceae	-	-
67.	6	*Malvastrum coromandelianum*	Malvaceae	-	-

No		Scientific name	Family	IUCN Listing	Indonesian Listing
68.	6	*Mangifera indica*	Anacardiaceae	DD	-
69.	6	*Manihot esculenta*	Euphorbiaceae	-	-
70.	7	*Melia azedarach*	Meliaceae	-	-
71.	7	*Merremia gemella*	Convolvulaceae	-	-
72.	7	*Merremia vitifolia*	Convolvulaceae	-	-
73.	7	*Mimosa diplotricha*	Fabaceae	-	-
74.	7	*Mimosa pigra*	Fabaceae	-	-
75.	7	*Mimosa pudica*	Fabaceae	-	-
76.	7	*Morinda citrifolia*	Rubiaceae	-	-
77.	7	*Moringa oleiferaam*	Moringaceae	-	-
78.	7	*Musa acuminata Colla*	Musaceae	-	-
79.	7	*Nardus stricta*	Poaceae	-	-
80.	8	*Neolamarckia cadamba*	Rubiaceae	-	-
81.	8	*Oldenlandia diffusa*	Rubiaceae	LC	-
82.	8	*Oxalis barrelieri*	Oxalidaceae	-	-
83.	8	*Passiflora foetida*	Passifloraceae	-	-
84.	8	*Pennisetum purpureum*	Poaceae	LC	-
85.	8	*Persicaria barbata*	Polygonaceae	LC	-
86.	8	*Phyllanthus debilis*	Phyllanthaceae	-	-
87.	8	*Phyllanthus niruri*	Phyllanthaceae	-	-
88.	8	*Pistia stratiotes*	Araceae	LC	-
89.	8	*Plumbago zeylanica*	Plumbaginaceae	-	-
90.	9	*Plumeria obtusa*	Apocynaceae	-	-
91.	9	*Pouzolzia zeylanica*	Urticaceae	-	-
92.	9	*Pueraria phaseoloides*	Fabaceae	-	-
93.	9	*Ricinus communis*	Euphorbiaceae	-	-
94.	9	*Ruellia tuberosa*	Acanthaceae	-	-
95.	9	*Saccharum officinarum*	Poaceae	-	-
96.	9	*Saccharum spontaneum*	Poaceae	LC	-
97.	9	*Senna occidentalis*	Fabaceae	-	-
98.	9	*Senna siamea*	Fabaceae	-	-
99.	9	*Sesbania grandiflora*	Fabaceae	-	-
100.	1	*Sida acuta*	Malvaceae	-	-
101.	1	*Solanum americanum*	Solanaceae	-	-
102.	1	*Solanum melongena*	Solanaceae	-	-
103.	1	*Spathodea campanulata*	Bignoniaceae	-	-
104.	1	*Sphagneticola trilobata*	Asteraceae	-	-
105.	1	*Spondias dulcis*	Anacardiaceae	-	-
106.	1	*Struchium sparganophorum*	Asteraceae	-	-
107.	1	*Swietenia macrophylla*	Meliaceae	VU	-
108.	1	*Synedrella nodiflora*	Asteraceae	-	-
109.	1	*Syzygium aqueum*	Myrtaceae	-	-
110.	1	*Tamarindus indica*	Fabaceae	-	-
111.	1	*Terminalia catappa*	Combretaceae	-	-
112.	1	*Tridax procumbens*	Asteraceae	-	-
113.	1	*Triumfetta rhomboidea*	Malvaceae	-	-
114.	1	*Typha angustifolia*	Thypaceae	LC	-
115.	1	*Vernonia amygdalina*	Asteraceae	-	-
116.	1	*Waltheria indica*	Malvaceae	-	-

Notes:

CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern

Table J.5 List of Flora Species in Paddy Field Vegetation Type

No	Scientific name	Family	IUCN Listing	Indonesian Listing
1.	*Abutilon indicum*	Malvaceae	-	-
2.	*Acacia auriculiformis*	Fabaceae	LC	-
3.	*Achyranthes aspera*	Acanthaceae	-	-
4.	*Adenanthera pavonina*	Fabaceae	-	-
5.	*Aegle marmelos*	Rutaceae	-	-
6.	*Aeschynomene indica*	Fabaceae	LC	-
7.	*Ageratum conyzoides*	Asteraceae	-	-
8.	*Albizia saman*	Fabaceae	-	-
9.	*Alinsoga parviflora*	Asteraceae	-	-
10.	*Alternanthera paronychioides*	Amaranthaceae	-	-
11.	*Alternanthera philoxeroides*	Amaranthaceae	-	-
12.	*Alternanthera pungens*	Amaranthaceae	-	-
13.	*Amaranthus blitum*	Amaranthaceae	-	-
14.	*Amaranthus retroflexus*	Amaranthaceae	-	-
15.	*Ammannia baccifera*	Lythraceae	LC	-
16.	*Annona muricata*	Annonaceae	-	-
17.	*Artocarpus camansi*	Moraceae	-	-
18.	*Artocarpus heterophyllusam*	Moraceae	-	-
19.	*Axonopus compressus*	Poaceae	-	-
20.	*Bambusa vulgaris*	Poaceae	-	-
21.	*Barringtonia racemosa*	Lecythidaceae	-	-
22.	*Basilicum polystachyon*	Lamiaceae	-	-
23.	*Blechum pyramidatum*	Acanthaceae	-	-
24.	*Breynia coronata*	Phyllanthaceae	-	-
25.	*Calopogonium mucunoides*	Fabaceae	-	-
26.	*Canna indica*	Cannaceae	-	-
27.	*Cardiospermum halicacabum*	Sapindaceae	-	-
28.	*Carica papaya*	Caricaceae	DD	-
29.	*Cascabela thevetia ippold*	Apocynaceae	-	-
30.	*Cayratia trifolia*	Vitaceae	-	-
31.	*Ceiba pentandra*	Malvaceae	-	-
32.	*Celosia argentea*	Amaranthaceae	-	-
33.	*Centrosema molle*	Fabaceae	-	-
34.	*Cerbera manghas*	Apocynaceae	-	-
35.	*Chloris barbata*	Poaceae	-	-
36.	*Chrysopogon aciculatus*	Poaceae	-	-
37.	*Cleome rutidosperma*	Cleomaceae	-	-
38.	*Coccinia grandis*	Cucucrbitaceae	-	-
39.	*Cocos nucifera*	Arecaceae	-	-
40.	*Colocasia esculenta*	Araceae	LC	-
41.	*Combretum indicum*	Combretaceae	-	-
42.	*Commelina diffusa*	Commelinaceae	LC	-
43.	*Cosmos caudatus*	Asteraceae	-	-
44.	*Cucumis sativus*	Cucucrbitaceae	-	-
45.	*Cyanthillium cinereum*	Asteraceae	-	-
46.	*Cyclea barbata*	Menispermaceae	-	-
47.	*Cyclosorus opulentus*	Thelypteridaceae	-	-
48.	*Cynodon plectostachyus*	Poaceae	-	-
49.	*Cyperus difformis*	Cyperaceae	LC	-
50.	*Cyperus imbricatus*	Cyperaceae	LC	-
51.	*Cyperus iria*	Cyperaceae	LC	-
52.	*Cyperus javanicus*	Cyperaceae	-	-
53.	*Cyperus rotundus*	Cyperaceae	LC	-

No	Scientific name	Family	IUCN Listing	Indonesian Listing
54.	*Dendrophthoe pentandra*	Loranthaceae	-	-
55.	*Desmodium gangeticum*	Fabaceae	-	-
56.	*Desmodium triflorum*	Fabaceae	LC	-
57.	*Digitaria didactyla*	Poaceae	-	-
58.	*Echinochloa colona*	Poaceae	LC	-
59.	*Echinochloa crus-galli*	Poaceae	-	-
60.	*Eclipta prostrata*	Asteraceae	-	-
61.	*Eichhornia*	Pontederiaceae	-	-
62.	*Eleusine indica*	Poaceae	-	-
63.	*Eleutheranthera ruderalis*	Asteraceae	-	-
64.	*Euphorbia hirta*	Euphorbiaceae	-	-
65.	*Fimbristylis dichotoma*	Cyperaceae	LC	-
66.	*Fimbristylisittoralis*	Cyperaceae	LC	-
67.	*Flemingiaineata*	Fabaceae	-	-
68.	*Gigantochloa apus*	Poaceae	-	-
69.	*Gliricidia sepium*	Fabaceae	-	-
70.	*Gymnopetalum chinense*	Cucucrbitaceae	-	-
71.	*Heliotropium indicum*	Boraginaceae	-	-
72.	*Hydrolea spinosa*	Hydroleaceae	-	-
73.	*Hyptis capitata*	Lamiaceae	-	-
74.	*Imperata cylindrica*	Poaceae	-	-
75.	*Ipomoea aquatica*	Convolvulaceae	LC	-
76.	*Ipomoea batatas*	Convolvulaceae	-	-
77.	*Ipomoea obscura*	Convolvulaceae	-	-
78.	*Ipomoea triloba*	Convolvulaceae	-	-
79.	*Ipomoeae carnea*	Convolvulaceae	-	-
80.	*Ischaemum rugosum*	Poaceae	-	-
81.	*Ischaemum timorense*	Poaceae	-	-
82.	*Kyllinga brevifolia*	Cyperaceae	LC	-
83.	*Lagenaria siceraria*	Cucucrbitaceae	-	-
84.	*Lannea coromandelica*	Anacardiaceae	-	-
85.	*Leonotis nepetifolia*	Lamiaceae	-	-
86.	*Leucaenaeucocephala*	Fabaceae	-	-
87.	*Limnocharis flava*	Alismataceae	-	-
88.	*Lindernia crustacea*	Linderniaceae	LC	-
89.	*Lindernia sp.*	Linderniaceae	-	-
90.	*Ludwigia adscendens*	Onagraceae	-	-
91.	*Ludwigia hyssopifolia*	Onagraceae	LC	-
92.	*Ludwigia octovalvis*	Onagraceae	LC	-
93.	*Malachra fasciata*	Malvaceae	-	-
94.	*Mangifera indica*	Anacardiaceae	DD	-
95.	*Manihot esculenta*	Euphorbiaceae	-	-
96.	*Marsilea crenata*	Marsileaceae	-	-
97.	*Melia azedarach*	Meliaceae	-	-
98.	*Melochia umbellata*	Malvaceae	-	-
99.	*Merremia hederacea*	Convolvulaceae	-	-
100.	*Merremia sp*	Convolvulaceae	-	-
101.	*Mikania micrantha*	Asteraceae	-	-
102.	*Mimosa diplotricha*	Fabaceae	-	-
103.	*Mimosa pigra*	Fabaceae	-	-
104.	*Mimosa pudica*	Fabaceae	-	-
105.	*Momordica charantia*	Cucucrbitaceae	-	-
106.	*Morinda citrifolia*	Rubiaceae	-	-
107.	*Moringa oleiferaam*	Moringaceae	-	-
108.	*Mukia maderaspatana*	Cucucrbitaceae	-	-

No	Scientific name	Family	IUCN Listing	Indonesian Listing
109.	*Musa acuminata*	Musaceae	-	-
110.	*Neolamarckia cadamba*	Rubiaceae	-	-
111.	*Oldenlandia auricularia*	Rubiaceae	-	-
112.	*Oldenlandia diffusa*	Rubiaceae	LC	-
113.	*Ormocarpum cochinchinense*	Fabaceae	-	-
114.	*Oryza sativa*	Poaceae	LC	-
115.	*Pandanus amaryllifolius*	Pandanaceae	-	-
116.	*Panicum maximum*	Poaceae	-	-
117.	*Passiflora foetida*	Passifloraceae	-	-
118.	*Phyllanthus amarus*	Phyllanthaceae	-	-
119.	*Phyllanthus niruri*	Phyllanthaceae	-	-
120.	*Phyllanthus tenellus*	Phyllanthaceae	-	-
121.	*Pistia stratiotes*	Araceae	LC	-
122.	*Pluchea indica*	Asteraceae	-	-
123.	*Portulaca oleracea*	Portulacaceae	-	-
124.	*Pouzolzia zeylanica*	Urticaceae	-	-
125.	*Psidium guajava*	Myrtaceae	-	-
126.	*Pterocarpus indicus*	Fabaceae	VU	-
127.	*Rhynchospora corymbosa*	Cyperaceae	LC	-
128.	*Ricinus communis*	Euphorbiaceae	-	-
129.	*Ruellia simplex*	Acanthaceae	-	-
130.	*Ruellia tuberosa*	Acanthaceae	-	-
131.	*Saccharum spontaneum*	Poaceae	LC	-
132.	*Sacciolepis indica*	Poaceae	-	-
133.	*Sauropus androgynus*	Phyllanthaceae	-	-
134.	*Scoparia dulcis*	Plantaginaceae	-	-
135.	*Senna occidentalis*	Fabaceae	-	-
136.	*Sesbania grandiflora*	Fabaceae	-	-
137.	*Sida acuta*	Malvaceae	-	-
138.	*Sida rhombifolia.*	Malvaceae	-	-
139.	*Sida sp*	Malvaceae	-	-
140.	*Sphaeranthus africanus*	Asteraceae	LC	-
141.	*Sphagneticola trilobata*	Asteraceae	-	-
142.	*Sphenoclea zeylanica*	Sphenocleaceae	LC	-
143.	*Stenotaphrum secundatum*	Poaceae	-	-
144.	*Streblus asperour*	Moraceae	-	-
145.	*Struchium sparganophorum*	Asteraceae	-	-
146.	*Swietenia mahagoni* (introduced)	Meliaceae	EN	-
147.	*Synedrella nodiflora*	Asteraceae	-	-
148.	*Syzygium aqueum*	Myrtaceae	-	-
149.	*Syzygium cumini*	Myrtaceae	-	-
150.	*Tamarindus indica*	Fabaceae	-	-
151.	*Tectona grandis*	Lamiaceae	-	-
152.	*Terminalia catappa*	Combretaceae	-	-
153.	*Themeda arundinacea*	Poaceae	-	-
154.	*Tinospora crispa*	Menispermaceae	-	-
155.	*Urenaobata*	Malvaceae	-	-
156.	*Urochloa glumaris Veldkamp*	Polygonaceae	-	-
157.	*Vigna radiata*	Fabaceae	-	-

Notes:

CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern

Table J.6 Additional Flora identified during the IEE Study

No	Scientific name	Family	IUCN Listing	Ind. Listing	Endemic
1.	*Acacia greggii*	Fabaceae	-	-	-
2.	*Albizia chinensis*	Fabaceae	-	-	-
3.	*Arachis hypogaea*	Fabaceae	-	-	-
4.	*Artocarpus altilis*	Moraceae	-	-	-
5.	*Averrhoa bilimbi*	Oxalidaceae	-	-	-
6.	*Averrhoa carambola*	Oxalidaceae	-	-	-
7.	*Bambusa sp.*	Poaceae	-	-	-
8.	*Barringtonia asiatica*	Lecythidaceae	LC	-	-
9.	*Casuarina sp.*	Casuarinaceae	-	-	-
10.	*Citrus aurantifolia*	Rutaceae	-	-	-
11.	*Codiaeum variegatum*	Euphorbiaceae	-	-	-
12.	*Cordyline terminalis*	Laxmanniaceae	-	-	-
13.	*Cyrtostachys renda*	Arecaceae	-	-	-
14.	*Delonix regia*	Fabaceae	LC	-	-
15.	*Dillenia sp.*	Dilleniaceae	-	-	-
16.	*Excoecaria bicolor*	Euphorbiaceae	-	-	-
17.	*Ficus benjamina*	Moraceae	-	-	-
18.	*Ficus sp.*	Moraceae	-	-	-
19.	*Filicium decipiens*	Sapindaceae	-	-	-
20.	*Lansium domesticum*	Meliaceae	-	-	-
21.	*Manilkara kauki*	Sapotaceae	-	-	-
22.	*Manilkara zapota*	Sapotaceae	-	-	-
23.	*Melaleuca leucadendra*	Myrtaceae	-	-	-
24.	*Michelia champaca*	Magnoliaceae	-	-	-
25.	*Mimusops elengi*	Sapotaceae	-	-	-
26.	*Musa paradisiaca*	Musaceae	-	-	-
27.	*Roystonea regia*	Arecaceae	-	-	-
28.	*Samanea saman*	Fabaceae	-	-	-
29.	*Solanum lycopersicum*	Solanaceae	-	-	-
30.	*Syzigium oleina*	Myrtaceae	-	-	-
31.	*Tabebuia rosea*	Bignoniaceae	-	-	-
32.	*Tabebuia sp.*	Bignoniaceae	-	-	-
33.	*Thyrsostachys siamensis*	Poaceae	-	-	-
34.	*Vigna unguiculata*	Fabaceae	-	-	-
35.	*Zea mays*	Poaceae	-	-	-

J.2 FAUNA SURVEYS

Table J.7 Bird Species Identified within the Study Area

No	Scientific Name	Common Name	Dara Source		IUCN	Ind. Listing	Migrant	Endemic
1.	*Aegithina tiphia*	Common Iora	ERM 2017	-	LC	-	-	-
2.	*Alcedo atthis*	Common Kingfisher	ERM 2017	-	LC	X	-	-
3.	*Amaurornis phoenicurus*	White-breasted Waterhen	ERM 2017	IEE 2017	LC	-	-	-
4.	*Anthreptes malacensis*	Brown-throated Sunbird	ERM 2017	IEE 2017	LC	X	-	-
5.	*Anthus novaeseelandiae*	New Zealand Pipit	ERM 2017		LC	-	-	-
6.	*Apus affinis*	little swift	-	IEE 2017	LC	-	-	-
7.	*Ardea alba*	Great Egret	ERM 2017	-	LC	X	X	-
8.	*Ardeola speciosa*	Javan Pond Heron	ERM 2017	IEE 2017	LC	X	-	-
9.	*Artamus leucorynchus*	White-breasted Woodswallow	ERM 2017	IEE 2017	LC	-	-	-
10.	*Bubulcus ibis*	Cattle Egret	ERM 2017	-	LC	X	X	-
11.	*Butorides striata*	Striated Heron	ERM 2017	-	LC	-	-	-
12.	*Cacomantis merulinus*	Plaintive Cuckoo	ERM 2017	-	LC	-	-	-
13.	*Cairina moschata*	Muscovy duck	-	IEE 2017	LC	-		-
14.	*Caprimulgus affinis*	Savanna Nightjar	ERM 2017	-	LC	-	-	-
15.	*Charadrius javanicus*	Javan Plover	ERM 2017	-	NT	-	-	-
16.	*Cisticola juncidis*	Zitting Cisticola	ERM 2017	IEE 2017	LC	-	-	-
17.	*Cuculus sepulcralis*	Rusty-breasted Cuckoo	-	IEE 2017	NE	-	-	-
18.	*Cygnus olor*	Mute swan	-	IEE 2017	LC	-	-	-
19.	*Dendrocopos moluccensis*	Sunda Pygmy Woodpecker	ERM 2017	-	LC	-	-	-
20.	*Dicaeum trochileum*	Scarlet-headed Flowerpecker	ERM 2017	IEE 2017	LC	-	-	-
21.	*Egretta garzetta*	Little Egret	ERM 2017	IEE 2017	LC	X	-	-

No	Scientific Name	Common Name	Dara Source		IUCN	Ind. Listing	Migrant	Endemic
22.	*Egretta sacra*	Pacific Reef Egret	ERM 2017	-	LC	X	X	-
23.	*Gallinula chloropus*	Common Moorhen	ERM 2017	-	LC	-	-	-
24.	*Gallus gallus domesticus*	Domesticated chicken	-	IEE 2017	NE	-		-
25.	*Gerygone sulphurea*	Golden-bellied Gerygone	ERM 2017	-	LC	-	-	-
26.	*Halcyon chloris*	Collared Kingfisher	ERM 2017	-	LC	X	-	-
27.	*Himantopus leucocephalus*	White-headed Stilt	ERM 2017	-	LC	X	-	-
28.	*Hirundo tahitica*	Pacific Swallow	ERM 2017	-	LC	-	-	-
29.	*Lanius schach Linnaeus*	Long-tailed Shrike	ERM 2017	IEE 2017	LC	-	-	-
30.	*Lonchura ferruginosa*	White-capped Munia	ERM 2017	-	LC	-	-	X
31.	*Lonchura leucogastroides*	Javan Munia	ERM 2017	IEE 2017	LC	-	-	X
32.	*Lonchura maja*	White-headed Munia	ERM 2017	-	LC	-	-	-
33.	*Lonchura punctulata*	Scaly-breasted Munia	ERM 2017	IEE 2017	LC	-	-	-
34.	*Merginae sp.*	Domesticated duck	-	IEE 2017	NE	-	-	-
35.	*Nectarinia jugularis*	Olive-backed sunbird	-	IEE 2017	LC	X	-	-
36.	*Nycticorax caledonicus*	Rufous Night Heron	ERM 2017	-	LC	X	-	-
37.	*Orthotomus ruficeps*	Ashy tailorbird	-	IEE 2017	LC	-		-
38.	*Orthotomus sepium*	Olive-backed Tailorbird	ERM 2017	-	LC	-	-	-
39.	*Orthotomus sutorius*	Common Tailorbird	ERM 2017	-	LC	-	-	-
40.	*Passer montanus*	Eurasian Tree Sparrow	ERM 2017	IEE 2017	LC	-	-	-
41.	*Picoides moluccensis*	Sunda pygmy woodpecker	-	IEE 2017	LC	-		-
42.	*Plegadis falcinellus*	Glossy Ibis	ERM 2017	-	LC	X	X	-
43.	*Prinia familiaris*	Bar-winged Prinia	ERM 2017	-	LC	-	-	-
44.	*Prinia flaviventris*	Yellow-bellied Prinia	ERM 2017	IEE 2017	LC	-	-	-
45.	*Prinia inornata*	White-browed wren-warbler	-	IEE 2017	LC	-	-	-

No	Scientific Name	Common Name	Dara Source		IUCN	Ind. Listing	Migrant	Endemic
46.	*Pycnonotus aurigaster*	Sooty-headed Bulbul	ERM 2017	IEE 2017	LC	-	-	-
47.	*Pycnonotus goiavier*	Yellow-vented Bulbul	ERM 2017	IEE 2017	LC	-	-	-
48.	*Rhipidura javanica*	Pied Fantail	ERM 2017	-	LC	X	-	-
49.	*Streptopelia bitorquata*	Island Collared Dove	ERM 2017	-	LC	-	-	-
50.	*Streptopelia chinensis*	Spotted Dove	ERM 2017	IEE 2017	LC	-	-	-
51.	*Todirhamphus chloris*	Collared kingfisher	-	IEE 2017	LC	X		-
52.	*Turnix suscitator*	Barred Buttonquail	ERM 2017	-	LC	-	-	-
53.	Zosterops palpebrosus	Oriental white-eye	-	IEE 2017	LC	-	-	-
Notes:								
CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern								

Table J.8 List of Encountered Mammal Species

No	Scientific Name	Common Name	Data Source		IUCN Status	Ind. Listing	Endemic
1.	*Axis axis*	Spotted deer	IEE 2017		LC	-	-
2.	*Bos taurus*	Cattle	IEE 2017		-	-	-
3.	*Bubalus bubalis*	Domestic buffalo	IEE 2017		-	-	-
4.	*Canis lupus*	Domestic dog	IEE 2017		-	-	-
5.	*Capra aegagrus hircus*	Domestic goat	IEE 2017		-	-	-
6.	*Cynopterus brachyotis*	lesser short-nosed fruit bat	IEE 2017		-	-	-
7.	*Felis catus*	Domestic cat	IEE 2017		-	-	-
8.	*Herpestes javanicus*	Javan Mongoose	IEE 2017	ERM 2017	LC	-	-
9.	*Ovis aries*	Domestic sheep	IEE 2017		-	-	-
10.	*Paradoxurus hermaphroditus*	Common Palm Civet	IEE 2017	ERM 2017	LC	-	-
11.	*Rattus argentiventer*	Ricefield Rat		ERM 2017	LC	-	-

12.	*Rattus sp.*	Rats	IEE 2017	-	-	-

Notes:
CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern

Table J.9 Herpetofauna Species Recorded

No	Scientific Name	Common Name	Data Source	IUCN Status	Ind. Listing	Endemic
Reptiles						
1.	*Dendrelaphis pictus*	Common Bronze-back	ERM 2017	NE	-	-
2.	*Oligodon octolineatus*	Eight-lined Kukri Snake	ERM 2017	LC	-	-
3.	*Not Identified-snake species*	-	ERM 2017	-	-	-
4.	*Cosymbotus platyurus*	flat-tailed house gecko	ERM 2017	NE	-	-
5.	*Cyrtodactylus marmoratus*	Javan bent-toed gecko	ERM 2017	NE	-	-
6.	*Gekko gecko*	Tokay Gecko	ERM 2017	NE	-	-
7.	*Hemidactylus frenatus*	Common House Gecko	ERM 2017	LC	-	-
8.	*Calotes versicolor**	Oriental Garden Lizard	ERM 2017	NE	-	-
9.	*Takydromus sexlineatus*	Asian Grass Lizard	ERM 2017	LC	-	-
10.	*Eutropis multifasciata*	Common Sun Skink	ERM 2017	NE	-	-
Amphibians						
1.	*Fejervarya cancrivora*	Asian Brackish Frog	ERM 2017	LC	-	-
2.	*Fejervarya limnocharis*	Asian Grass Frog	ERM 2017	LC	-	-
3.	*Duttaphrynus melanostictus*	Asian Common Toad	ERM 2017	LC	-	-

Notes:
CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern
* The Oriental garden lizard (*Calotes versicolor*), known as introduced species in Java (*Das I., 2015*). This lizard usually introduced by pet owners who brought from Sumatra or another native habitat of this species and then escape or released by its owner.

PLTGU Jawa 1 Independent Power Project

ANNEX K
ELECTROMAGENTIC FIELD ASSESSMENT

Prepared for:

PT Jawa Satu Power (JSP)

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1. *METHODOLOGY*

The calculation of the impacts of the Electro Magnetic Field (EMF) is one of the factors which must be considered during the design process of a high voltage transmission lines. This will help to determine if the Right of Way (ROW) is sufficient to manage community health and safety issues as a result of the power line.

An excel based software developed by the Electrical Engineering Portal[1] for the calculation of EMF around the transmission and distribution overhead lines is used to calculate EMF for the 500kv transmission line proposed for the Project. The tool can be used to calculate one or two circuit lines in which ground wires can be incorporated. In addition, the tool allows combining and creating examples of power lines where two independent power lines can interact with each other. The EMF calculations used in this tool use the analytical approach described in The Electric Power Research Institute (EPRI) Red Book "Transmission Line Reference Book" and follow the guidance set out by the IFC/WB Group in the Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution. In addition, accuracy of these EMF calculations were checked with others commercial software.

1.1. *INPUT DATA*

The input data used for setting up the transmission tower and circuit lines is given in **Table 1.1** and shown in **Figure 1.1**.

Table 1.1 ***Transmission Line Parameters***

		X [m]	Y [m]	U_{max} [kV]	I[A]	r_A [mm]	d_A [mm]	n	Ph-seq
Circuit 1	L1	-12.675	53.285	500	3724	28.60	450	4	1
	L2	-12.675	40.985	500	3724	28.60	450	4	2
	L3	-13.375	28.585	500	3724	28.60	450	4	3
	g.w.	-8.975	61.2	0	0	10	0	1	0
	g.w.	8.975	61.2	0	0	10	0	1	0
Circuit 2	L3	13.375	28.585	500	3724	28.60	450	4	3
	L2	12.675	40.985	500	3724	28.60	450	4	2
	L1	12.675	53.285	500	3724	28.60	450	4	1

X [m] – horizontal length from the middle of the line; Y [m] – height in which wires are suspended; Umax [kV] – maximum permissible line voltage; I [A] – maximum permissible line current (in case of bundle it is; determined for all wires); r_A [mm] – wire radius; d_A [mm] – distance between wires in bundle; n – number of wires in bundle; Ph-seq – phase sequence. 1 – L1, 2 – L2, 3 – L3, 0 – Ground Wire

[1] http://electrical-engineering-portal.com/download-center/electrical-ms-excel-spreadsheets/emf-td-overhead-lines

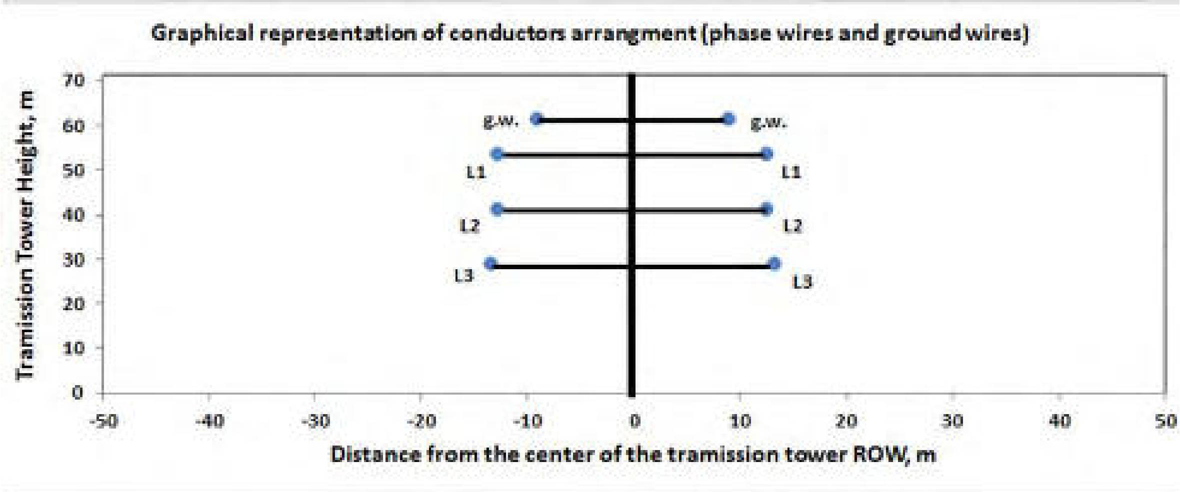

Figure 1.1 *Schematic Representation of Transmission Tower with Power Lines Arrangement*

2. *REGULATIONS*

Electric fields are normally measured in kilovolts per metre (kV/m), while magnetic fields are defined by magnetic flux density, measured in micro-tesla (μT) or milli-gauss. One micro-tesla is equivalent to 10 milli-gauss and 0.7974 Ampere/m. The Environmental, Health and Safety (EHS) Guideline[2] for Power Transmission and Distribution, published by WBG[3], is the relevant guideline used in conducting this assessment. The EHS guideline refers to ICNIRP[4] for the management of ELF for electricity transmission and distribution. **Table 2.1** shows the ICNIRP reference levels below which the proposed transmission line fields will be assessed against for regulatory compliance.

Table 2.1 *Reference Levels for Exposure to 50 Hz EMF*

Exposure Characteristics	Reference Levels			
	Electric Field Strength (kV/m)	Magnetic Flux Intensity		
		Micro-tesla (□T)	Milli-gauss (mG)	Ampere/m (A/m)
Occupational	10	500	5000	399
General Public	5	100	1000	80

[2] EHS Guidelines for Power Transmission and Distribution, April 30, 2007
[3] World Bank Group
[4] The International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic field (up to 300GHz) (http://www.icnirp.de/PubEMF.htm)

3. *RESULTS AND DISCUSSIONS*

Figure 3.1 and **Figure 3.2** illustrate the electric and magnetic fields with distance from the line, respectively. The maximum magnetic and electric fields are 14.86 µT and 3.21 kV/m, respectively for the proposed 500kV tower configuration directly below the line (at 1 meter above the ground surface) and reduce rapidly with distance from the lines. The calculated values are well below the "Occupational" and "Public" reference limits indicated in **Table 2.1**.

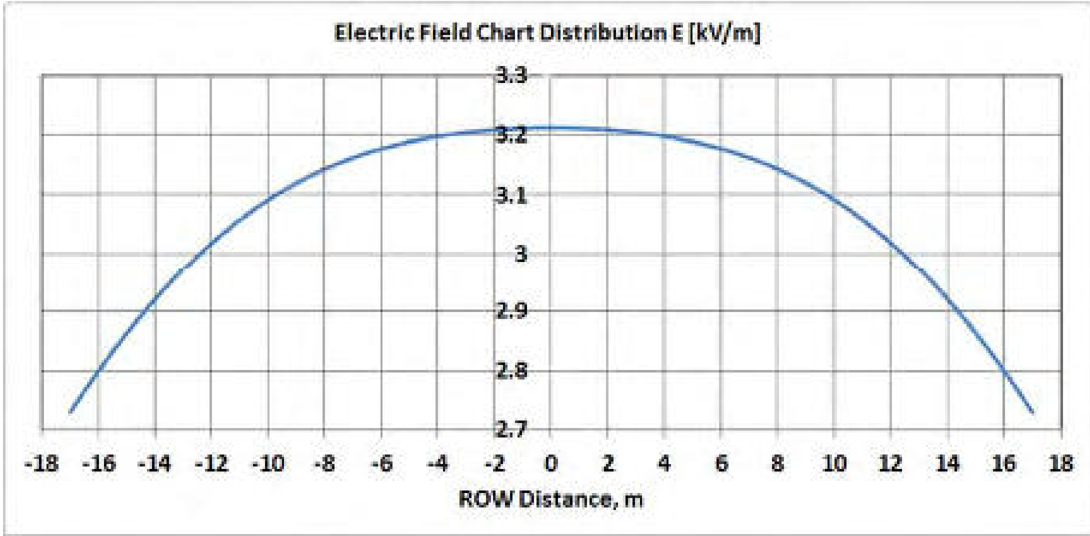

Figure 3.1 Electric Field Distribution for the Proposed Transmission Tower

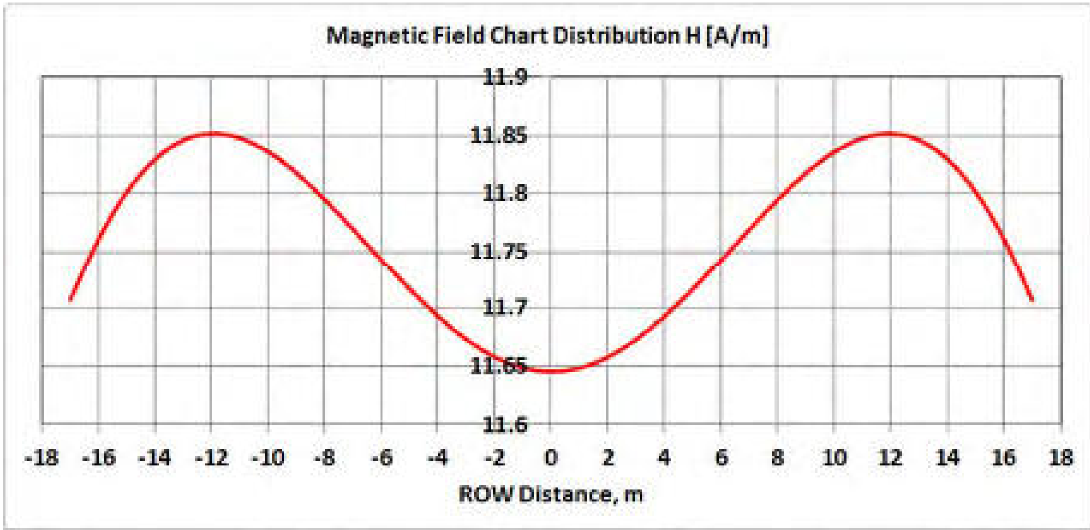

Figure 3.2 Magnetic Field Distribution for the Proposed Transmission Tower

PLTGU Jawa 1 Independent Power Project

ANNEX L
FLOOD STUDY ANALYSIS

Prepared for:

PT Jawa Satu Power (JSP)

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EXECUTIVE SUMMARY

ERM referred to a flood risk assessment report titled 'Cilamaya Flood Report and associated Appendices completed by Pöyry Energy GmbH for the proposed Cilamaya Combined Cycle Gas Power Plant in West Java, Indonesia. The objective of the study was to determine 100-year flood water levels for the design of the flood dike around the proposed Project site. The approach comprised of hydrological analyses that included flow regionalisation approaches and rainfall-runoff modelling which were used to compute 100-year flood hydrographs for the Irrigation Canal (729 m^3/sec – peak flow) and the Cilamaya River (600 m^3/sec – peak flow).

A 2D-hydraulic model was built from LiDAR-based Digital Terrain Model (DTM), cross-sectional surveys and sea bed elevations, after ground-truthing and modifying some of the input-data. In order to account for the uncertainties in the data input, a set of conservative model assumptions were made. Model simulation was run for Project state (site area was excluded from active discharge domain), to understand the changes in flow direction due to the flood dike.

The maximum flood inundation depth in most regions in the immediate vicinity of the Project site ranges from 0.1 to 0.5 m, with few small local spots with higher inundation depths ranging between 1.5 to 2m. Also, model simulation was run for current state scenario (site area was included in the modeling domain). The increase in water levels compared to Project state in most areas in the immediate vicinity of the Project site were in the range of 0.01 to 0.2 m. Also, there are few local spots in south and north-west direction of site area where the water level increase was up to 1 m.

Due to the uncertainties in the input data, sensitivity analyses were performed for the several scenarios, the simulated water levels at the Project site were found to be insensitive to the variation of a number of input parameters.

A swale adjoining the flood dike was recommended to mitigate the increase of water levels in the areas surrounding the Project site. Finally, the hydraulic model was run to re-define the dike heights and dimensions of the swale/flood flow paths around the site as well as to demonstrate that the sensitive areas near the Project site would not be subjected to increased flood levels

The flood modeling study results clearly shows that the implementation of the proposed dike along with the swale around the Project site will not increase the flood risks (unchanged or decrease in flood inundation levels compared to the current state) in the sensitive neighboring assets that includes schools and residential areas for the combined 100-yr inland flooding and extreme coastal flooding events. However, agriculture regions in the vicinity of the Project site can exhibit some level of water logging that may not still pose any level of flood risk for the same combined flood event.

The backfilling of the Project site within the dike does not pose any flood risk to the neighboring communities. However, an internal drainage system must be designed in such a way that there are no backflow effects on the Site or any waterlogging in the neighboring areas.

1 INTRODUCTION

The Project is located near the town of Cilamaya, close to West Java's north coast about 100 km east of Jakarta. The site is situated between the Cilamaya Main River and Cilamaya Irrigation Canal. The Cilamaya Irrigation Canal receives flood flows from the upstream catchment Via the Ciherang River which are diverted at the Barugbug weir.

Figure 1.1 ***Project Site with River and Canal Network (blue) and Main Flood Flow Paths labelled, Barugbug weir and the Preliminary Hydraulic Model Domain (yellow)***

Prior to this study, it was not clear if the main flood risk to the Project site originates from Cilamaya Irrigation Canal or from Cilamaya Main River. In addition, tidal storm surges may significantly influence the flood situation in combination with backwater effects. In the study area, several other larger and smaller irrigation canals are operated. Their discharge capacities seem to be limited in terms of cross-sections and by structures as bridges and inverted syphons. Thus, these other canals were not considered as relevant factors of flood risk to the Project site and were not studied in detail. Hence, a major focus of the study is to evaluate the riverine flood risk associated with Cilamaya Main River and Cilamaya Irrigation Canal at Projects site, and tidal flood risk associated with tides, storm surge and sea level rise impact at the Project site.

In terms of climate change, under extreme storm tide conditions applied to the downstream boundary, the following phenomena were considered:

- Astronomic Tides (+2.02 m);
- Atmospheric Forcing (+0.38 m surge, +0.02 m wind and pressure);
- Sea level rise (+0.5 to 1.0 m);
- Significant wave height (+0.75 m); and
- Total: MSL +2.02 m.

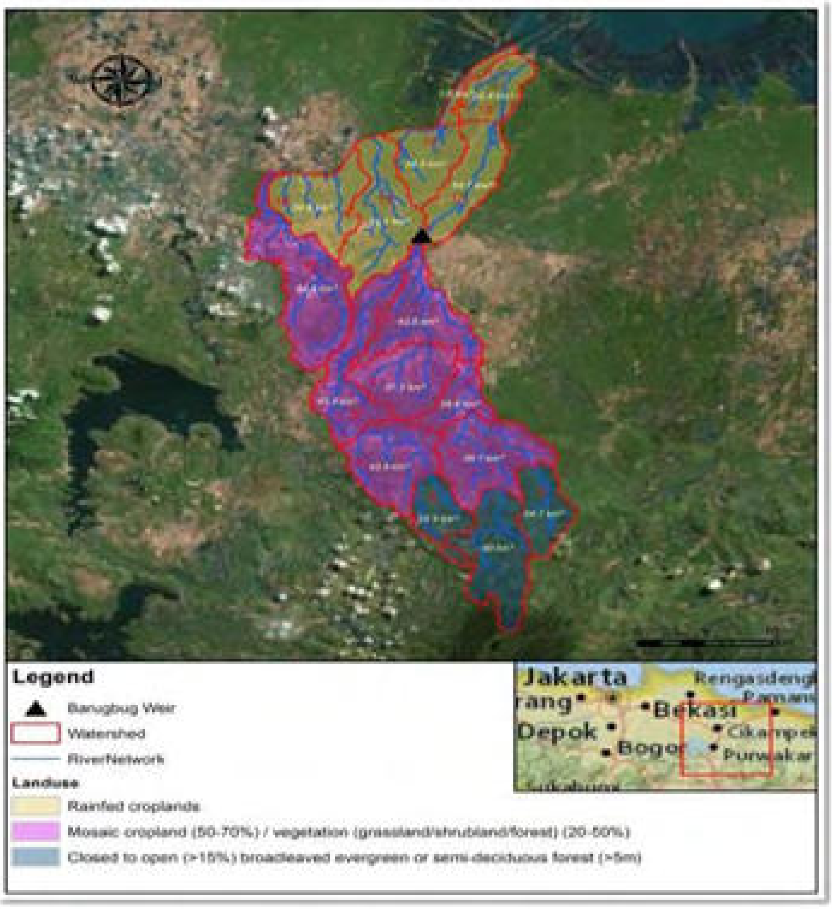
2 HYDROLOGICAL ANALYSIS

The objective of this study was to determine 100-year flood water levels for the design of the flood dike around the proposed Cilamaya Combined Cycle Gas Power Plant. For that purpose, hydrological analyses were carried out using rainfall–runoff modeling in order to obtain the 100-year design flood hydrograph. This hydrologic analysis was supported with flood regionalisation approaches.

Details of hydrologic analysis are summarised below in subsequent sections. Hydrologic analysis needs catchment delineation of the Cilamaya River and the Cilamaya Irrigation Canal, which contributes flow at Project site. Catchment and sub catchment/sub basins were delineated using Digital Elevation Model (DEM) in GIS. The DEM data was provided by the Japanese Earth observing satellite program, especially the Advanced Land Observing Satellite (ALOS). Each Sub basins has associated Stream/River in the Catchment.

Figure 2.1 presents the catchment of the Project area and gives an overview of the determined sub-basins. Major land uses and area values of each sub basin are highlighted.

Figure 2.1 GIS-Analysis Map of the Cilamaya Basin



2.1 RAINFALL RUN-OFF MODELLING

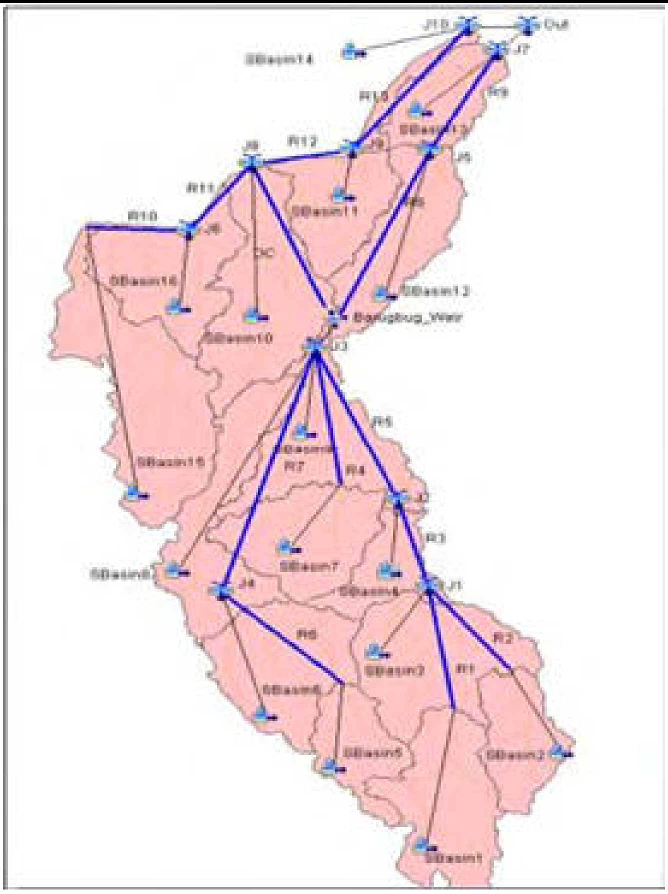
Hydrologic Modeling System (HEC-HMS) software by USACE-HEC was used to obtain the design flood hydrograph at Project site. HEC-HMS is designed to simulate the complete hydrologic processes of event-based scenarios. The software includes many traditional hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing.

This study used Soil Conservation Service (SCS; presently known as USDA Natural Resources Conservation Service) based hydrologic analysis procedure.

Figure 2.2 shows the setup of the HEC-HMS model. It consists of a basin model (catchment) and a meteorological model (precipitation). The basin model converts atmospheric conditions (precipitation) into streamflow at the sub-basin outlets. These outlets are connected by river reaches which account for flood routing.

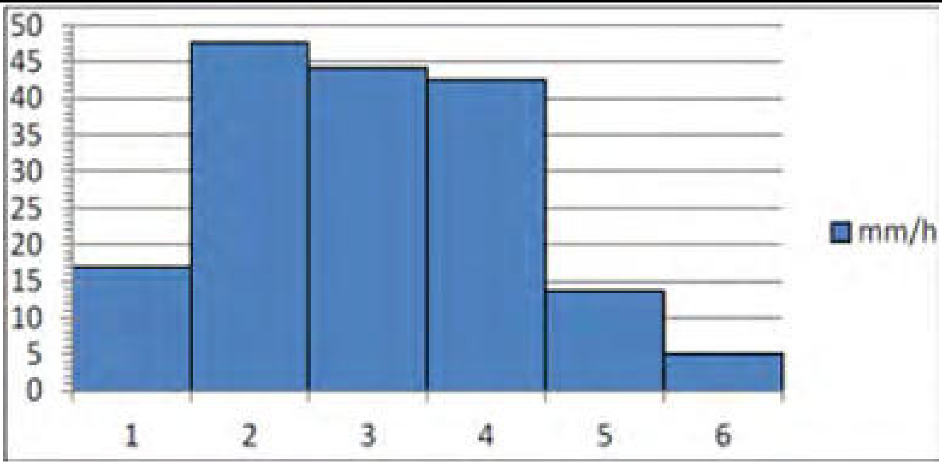
The basin model consists of sub-basins (SBasin), river reaches (R), junctions (J) and the diversion at Barugbug weir. Barugbug weir is located approximately 20 km upstream the Project site and it consists of two spillways for diverting floods into the Cilamaya main river (J7) and via the Ciherang River into the Cilamaya Irrigation Canal (J10).

Figure 2.2 Overview of the HEC-HMS Model



Design storm rainfall input for the HMS meteorological model was obtained by a combination of 100-yr point precipitation estimate, areal reduction, and consideration of IDF curves, critical storm duration and temporal storm pattern. Design storm hyetograph with a total accumulative precipitation of 170 mm was given as input to HMS model and shown below in **Figure 2.3**.

Figure 2.3 100-yr Design Storm Hyetograph Input



The rainfall-runoff HMS model was roughly evaluated with the flood of January 18, 2013 before estimating the 100-yr design flood at Project site. Limited rainfall and spillway data documented in the Barugbug weir's operator notebook was used to evaluate the model.

Result of the 100-yr design flood simulation is shown below in **Figure 2.4**. It is based on the above described model and an aerial precipitation of 170 mm/6 hr. The simulation using curve number (CN-SCS1 parameter) values from the GIS-analysis was considered representative for the current situation (Cilamaya catchment covered by vegetation and no soil degradation), resulting in a peak flow of 1095 m^3/sec (total flow at the Project site). A more conservative projection is to increase the CN-values by 10%.

For the design of a power plant, such conservatism seems reasonable as in the absence of calibration data, the curve number and other estimates are subject to considerable uncertainty.

Figure 2.4 100-yr Peak Flows at Project Site from Rainfall-Runoff Modelling in m/s

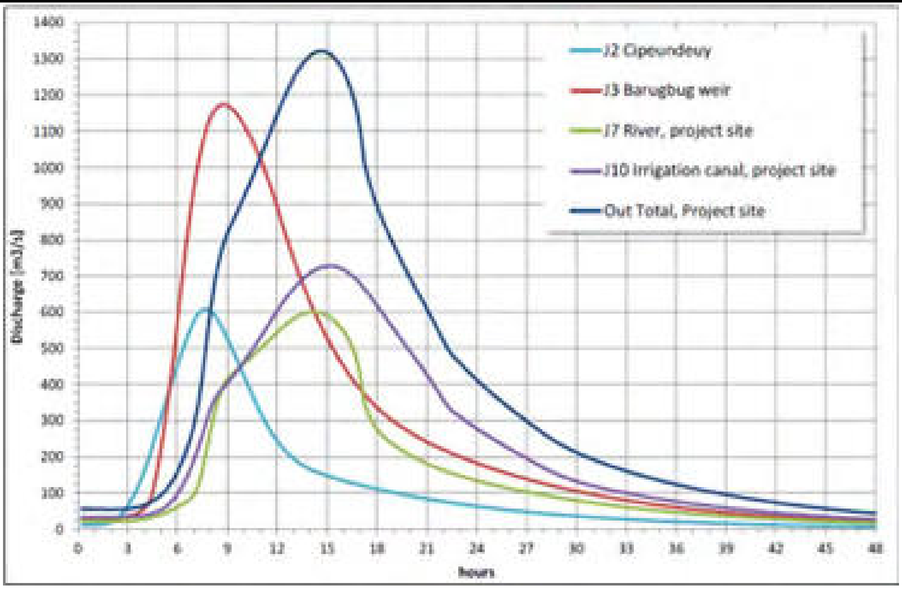
Scenario	CN	CN +10 % (used in hydraulic analysis)
Total	1095	1322
Irrigation Canal	602	729
Cilamaya River	502	600

[1] CN refers to runoff curve number which is an empirical parameter used in hydrology from predicting direct runoff or infiltration from rainfall excess. The curve number method was developed by USDA Natural Resources Conservation Service, which was formerly called Soil Conservation Service (SCS).

Figure 2.5 shows the 100-yr design flood hydrographs for the conservative scenario (CN +10%). The total outflow is composed of flows at junction J10 (Irrigation Canal) and junction J7 (Cilamaya River).

In summary, for design purposes with hydraulic simulations of 100-year scenarios, a hydrograph with a total peak flow at the Project site of approx. 1320 m^3/sec is proposed. The suggested distribution into inflow from the Irrigation Canal and inflow from the Cilamaya River as well as the hydrograph is presented in **Figure 2.5**.

Figure 2.5 *100-yr peak flows at Project area from the CN + 10% scenario*



Above proposed design peak flow is supported with flood regionalisation approach. Mean Annual Flood (MAF) has been used as a basic index for regionalisation of flood data and for the present study, MAF has been used together with growth factors according to IH 1983 as one means to estimate design floods at the Project site. These growth factors account for the return period and the catchment area.

Design floods estimates based on the IH 1983 method are given below in **Figure 2.6.** In addition to the design floods Q_T the IH 1983 approach provides uncertainty estimates quantified in terms of standard deviation. It was observed that the magnitude of the resulting discharge variability based on rainfall-runoff modelling is in line with the uncertainty in the flood regionalisation approach.

Figure 2.6 Design Flood Estimates for the Project Site Based on the IH 1983 Method

Return interval T [yrs.]	Q_T [m^3/s]	Q_T + std.dev.[m^3/s]
5	389	622
10	459	739
20	539	875
50	669	1104
100	**787**	**1315**
200	919	1558
500	1132	1960
1000	1321	2327

3 *HYDRAULIC ANALYSIS*

For analyzing design flood scenarios at the Cilamaya Project site, a two-dimensional hydraulic model was established from several survey datasets. Boundary conditions in terms of inflow hydrographs were taken from the hydrologic analysis and water level boundary conditions at the sea were derived from the tidal and storm surge analysis.

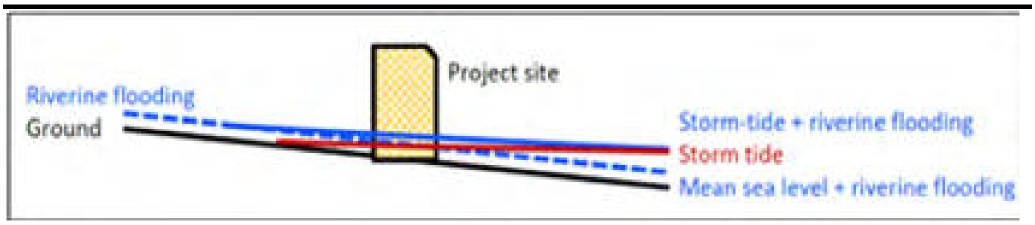
3.1 *TIDE AND STORM SURGE ANALYSIS*

Owing to the location of the Project site, it may be subject to inundation from:

- Riverine flooding (hydrologic analysis) – inland flooding;
- Extreme storm-tidal conditions combined with sea level rise - coastal flooding); and
- Combination of inland and coastal flooding.

Three (3) schematic flood scenarios are shown in the **Figure 3.1**.

Figure 3.1 Schematic of Flood Scenarios



In absence of data for extrapolating a 100-year sea level and specific model result of 100-year sea level highs, estimates of three relevant phenomena were analysed:

- Astronomic tides;
- Atmospheric forcing (increase from wind, air pressure, storm surge); and
- Sea level rise (possible land subsidence is not considered).

Astronomic Tides

According to the first report version by Kwarsa Hexagon, the highest measured sea level in a 16-day period (**Figure 3.2** - most likely without extreme levels) was 1 to 1.1 m above mean sea level (MSL) and a maximum sea level of 2.02 m above MSL was forecasted for a 20-year period (refer to **Figure 3.3**).

Figure 3.2 Observed and Calculated Sea Level Data at Cilamaya (First Report by Kwarsa Hexagon, 2016)

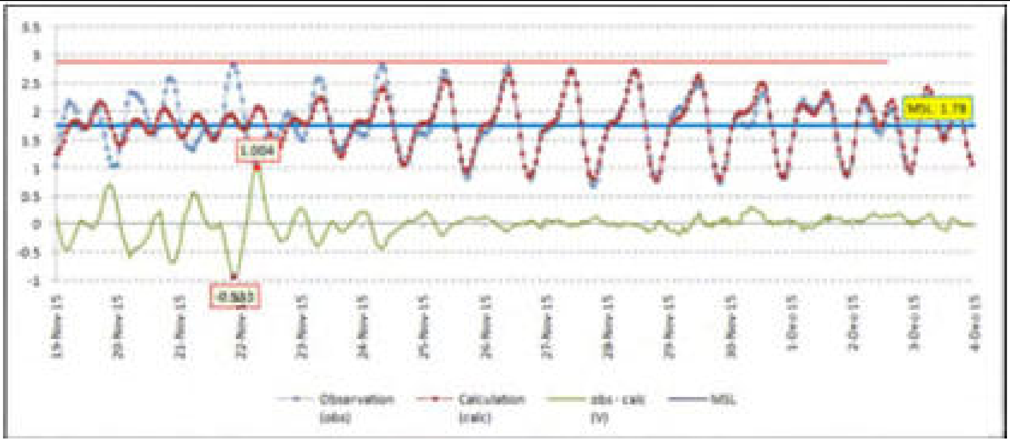


Figure 3.3 Water Levels in the 20-year forecast (First Kwarsa Hexagon Report, 2016)

Water Level Reference	m +MSL
Highest High Water Level	2.02
Mean High Water Spring	0.70
Mean High Water Level	0.37
Mean Sea Level	0
Mean Low Water Level	-0.37
Mean Low Water Spring	0.07 (sic)
Lowest Low Water Level	-2.03

This observation-based analysis was double-checked with model studies by Ningsih et al. (2010) of the November 2007 cyclones which report of 0.49 m tidal sea level maxima at Cilamaya (without atmospheric forcing; approx. 0.54 m including wind and pressure).

The apparent difference of these model results to the observations and forecasts by Kwarsa Hexagon (2016) was discussed within the Project team and also with an external expert. Instead of continuing with the conservative value of 2.02 m, as it was suggested in the Pöyry's Draft Flood Study Report, Kwarsa Hexagon revised the tidal forecast in May 2016 by specifying the Highest Astronomical Tide with 0.59 m above MSL. This magnitude seems to be consistent with the published values as stated above.

Atmospheric Forcing (increase from wind, air pressure, storm surge)

Only few reports provide estimates of increased water levels due to atmospheric forcing in the greater study area are shown in **Figure 3.4**.

Figure 3.4 ***Reported Storm Surge Heights (cm) from Observation Data and Model Results***

Cyclone / Typhoon	Jakarta	Semarang	Surabaya	Cilamaya	Source (Analysis type)
Pelpah (Nov. 9 2007)	38	20	21		Ningsih et al. 2011 (Observation data analysis)
Hagibs (19-27 Nov. 2007) and Mitag (20-27 Nov. 2007)	10	8	17		
	12	13	15	14	Ningsih 2014 (Model analysis)

Sea Level Rise

The sea level rise near the Project site was estimated from projections for Jakarta, Pekalongan and from the most recent IPCC report as shown in **Figure 3.5.**

Figure 3.5 ***Selected Projections of Sea Level Rise***

Jakarta	
3 mm/yr	+5 cm within 18-19 years (i.e. between 1989, 2007 and 2025; Hongjoo & Brinkman 2008) corresponding to 3 mm/year
5.1 mm/yr	Analysis 1993-2003 using Satellite Altimetry Fenoglio-Marc (2011)
5.7 mm/yr	Firman et al. (2011) with reference to S. Hadi, n.d. ITB
Pekalongan	
6-10 mm/yr	Nashrulla et al. (2013) with reference to the Ministry of Marine Affairs and Fisheries-DKP).
Global and regional	
Roughly up to +1 m	Projection until 2100 for conservative scenario ("IPPC-Report". Reference: Stocker et al. 2013)

The assumptions for extreme sea levels for hydraulic analysis are summarised in **Figure 3.6**.

Figure 3.6 ***Summary of Relevant Phenomena and Assumptions for Extreme Sea Levels***

Phenomenon	Assumptions (reference: MSL)	After revision by Kwarsa Hexa
1. Astronomic tides	*+2.02 m (before revision)*	+0.75 m
2. Atmospheric forcing	+0.38 m surge +0.02 m wind & pressure	
3. Sea level rise	+0.5 to 1.0 m	
4. Significant wave height	+0.75 m (roughly assumed)	
Total	*+3.7 to 4.2 m (rounded)*	**+2.4 to 2.9 m (rounded)**

4 FLOOD MODELLING

For analysing the three (3) design flood scenarios at the Project site, a two-dimensional hydraulic model was established.

4.1 INPUT DATA

The data for the model set up was collected from various sources such as surveys and online databases. The summary of the data sources used in the model setup is shown in **Table 4.1.**

Table 4.1 Summary of Data Sources Used In Hydraulic Analysis

Data	Source	Geographical Coverage	Resolution
Digital Terrain Model	Airborne Laser Scanning (LiDAR)	40 km^2	0.2 m
Cross-sections	Topographical survey	70 Cross-sections at Cilamaya River , 71 Cross-sections at Irrigation Canal	
Bathymetric Map	Kwarsa Hexagon, 2016	Small portions of the model area	
Web-Based satellite Imageries	Google Earth, Bing Maps, ArcGIS Online Imagery		
Flood Marks	Tigenco, 2016	Four (4) locations from floods in March 17, 2014	

THE DTM at the Project site and the corridor to the sea was found mostly within +/- 20 cm from the surveys points. However, the majority of the terristric/bathymetric cross-section surveys points were found to be significantly lower than the DTM (DTM minus survey: median +0.81 m).

4.2 MODEL SET-UP

The hydraulic simulations were carried out with 2-D hydrodynamic finite volume shallow-water model Hydro-as_2d V2.2, parallel version with a first order scheme for momentum advection.

Mesh Generation

A mesh of 397 thousand numbers to nodes comprises of triangular and quadrilateral elements of varying resolution were generated. Distinct point reduction methods were applied to various parts of the mesh as shown in **Figure 4.1**.

Figure 4.1 Mesh Parts, Basic Data and Typical Point Distances

Mesh part, area	Basic data used	Typical distance of mesh-nodes
River bed of Cilamaya river and Irrigation Canal	Cross-section survey (modified)	Approx. 10 m in main flow direction, 2 to 1.5 m across
Floodplains including agricultural areas, residential areas, roads, etc.	DTM (from LiDAR)	Data converted to a 10 m raster and thinned out with maintaining a 0.1 m accuracy
Topographic breaklines	DTM (from LiDAR)	10 m
Sea bed	Bathymetric survey	Approx. 20 - 200 m

Figure 4.2 Model Domain with Monitoring Elements

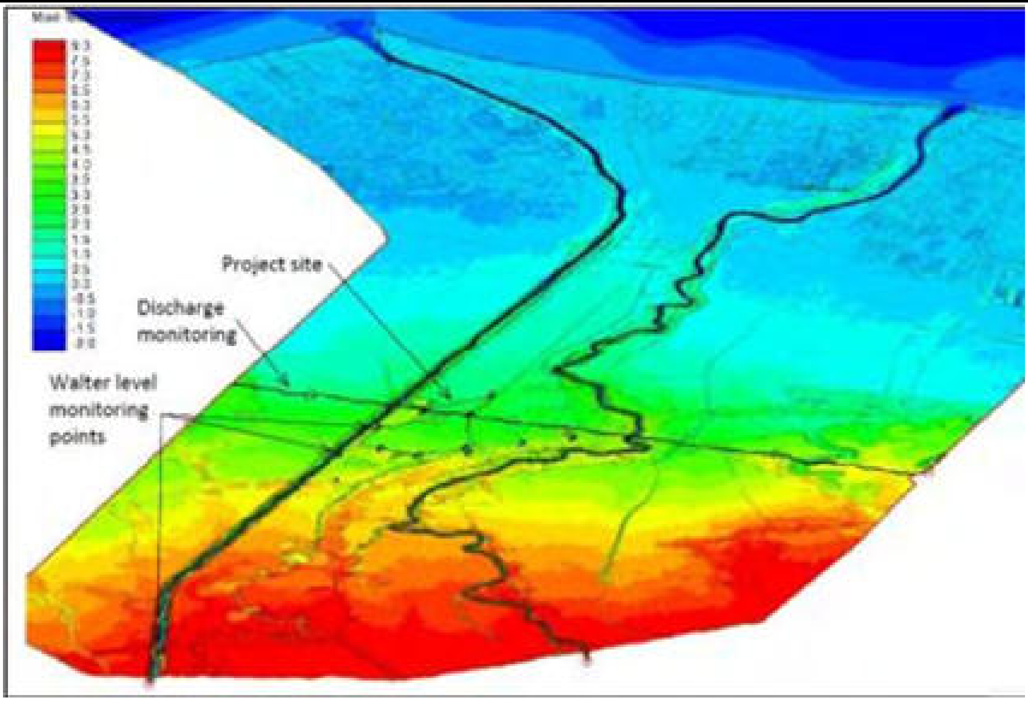
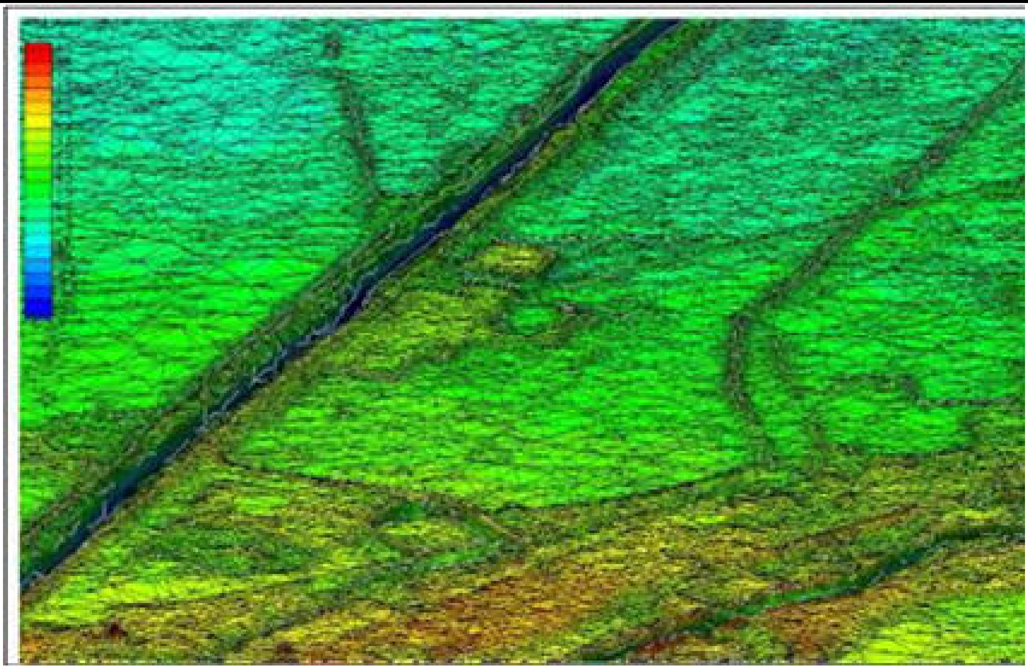


Figure 4.3 ***Details of Computational Mesh (Black) and Topographic Breaklines (Grey) At The Project Site***



Roughness Coefficients

The coefficients of surface roughness were varied between specific areas within the model domain as shown in the **Figure 4.4**.

Figure 4.4 ***Roughness Coefficients of Specific Areas***

Roughness coefficient according to	Strickler (KSt)	Manning (n)
Cilamaya River bed and lower banks	25	0.04
Irrigation Canal bed and lower banks	25	0.04
Agricultural areas, roads, etc. (open areas)	15	0.067
Larger vegetation-covered areas, densely-built residential areas	8	0.125
Sea bed	50	0.02

The model was set up to simulate the flood that occurred in March 17, 2014. Flood marks at four locations were collected during a survey. However, the discharge observation for the flood event was not available, so two (2) steady discharge scenarios were estimated along with a mean sea level boundary condition.

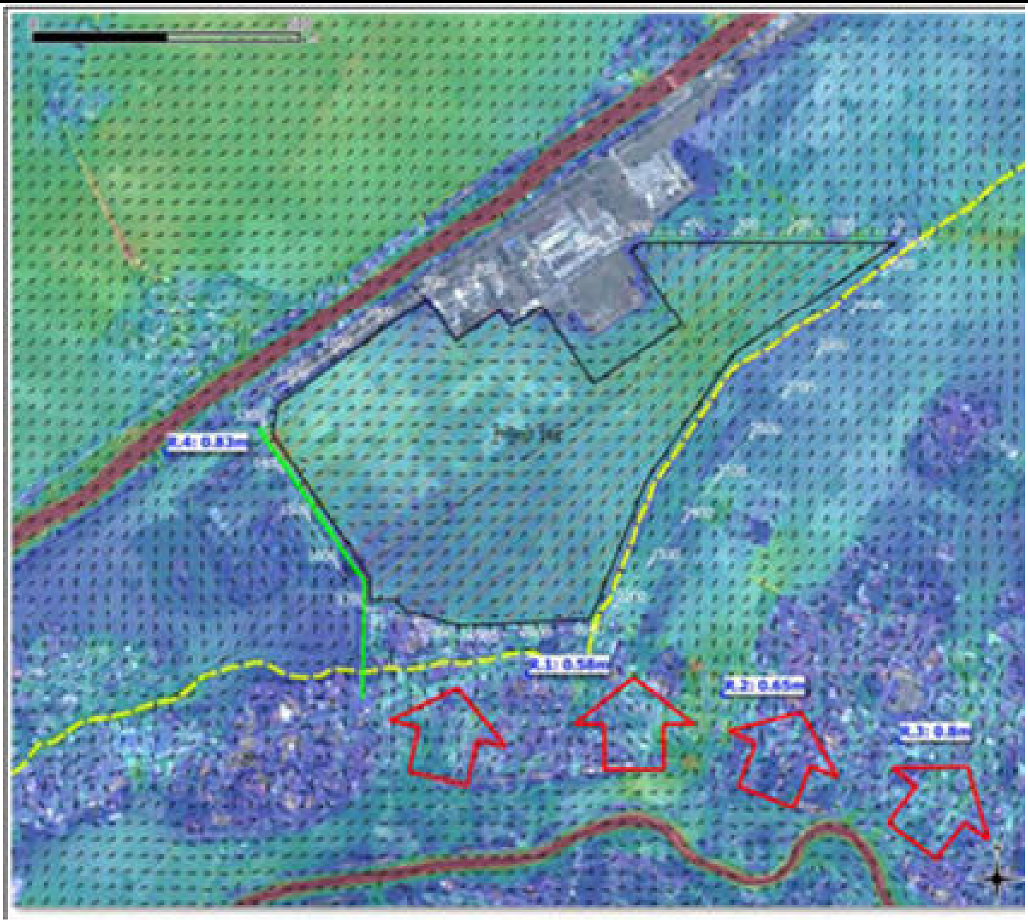
The inundation was reportedly not caused by extreme basin-wide rainfall-runoff processes but by waterways being jammed by debris. As the depths and water levels at the flood marks are relatively high in relation to the simulation results as shown in the **Figure 4.5**.

Nonetheless, there is also a slight chance that the hydraulic model underestimates the overland flow from Cilamaya River towards the Project site (refer to **Figure 4.6**). This possible underestimation only applies to the areas downstream of the existing road embankment. Upstream of this embankment, the simulated water levels were higher and considered as conservative.

Figure 4.5 ***Flood Marks (Italic: Measurements by Trigenco 2016) and simulated water levels for two scenarios, indicated as Irrigation Canal flow +Cilamaya River flow. Maximum simulated water levels nearby are added (in paranthesis).***

Site	X	Y	Ground level (Z)	Depth (H)	Water level (Z+H)	DTM near flood mark	Sim. W. level 300 + 300 m³/s	Sim. W. level 720 + 600 m³/s
R.1	*786654*	*9308623*	*4.192*	*0.58*	4.77	4.48	4.31 (max. 4.8)	4.53 (max. 4.8)
R.2	*787020*	*9308584*	*4.187*	*0.65*	4.84	4.3	4.50 (max. 4.6)	4.66 (max. 4.8)
R.3	*787348*	*9308499*	*3.792*	*0.8*	4.59	4.2	4.34 (max. 4.4)	4.47 (max. 4.6)
R.4	*785978*	*9309040*	3.45	*0.83*	4.28	4.1	4.55 (max. 5.0)	4.88 (max. 5.3)

Figure 4.6 Possible Model Underestimation of Flood Flows (Red Arrows, Schematic) Downstream (East) of The Existing Road Embankment (Green), Flood Marks R1 And R4 with Reported Depths and Existing Canal with Uncertain Hydraulic Performance (Yellow)



4.3 RESULTS AND DISCUSSION

Simulation Results for 100-year flood at Mean Sea Level; Project State
In this scenario, the 100-year inflow hydrographs in Figure 3 5 were applied to the inflow boundaries of the Irrigation Canal and the Cilamaya River. A mean sea level was defined at the outflow boundary.

The Project site within the flood protection dike was excluded from the active flow domain so that the changed flow fields due to the flood dike were accounted for.

The following figures show maximum water levels, depths and velocities for the 100-year flood scenario. Water level details are presented in two (2) longitudinal sections of the floodplain and a perimeter section around the flood dike as well as selected water level hydrographs.

Figure 4.7 Maximum Water Levels (M). Detail with Longitudinal Sections and Perimeter Section (With Stations in White)

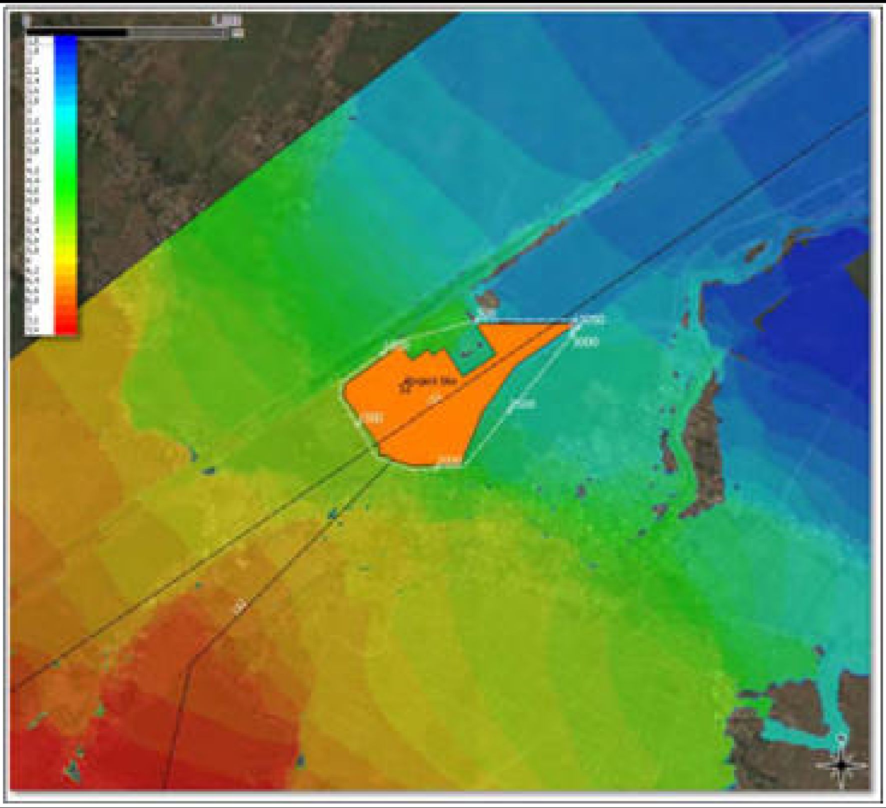


Figure 4.8 Maximum depths (m). Detail with Longitudinal Sections and Perimeter Section (with station in white)

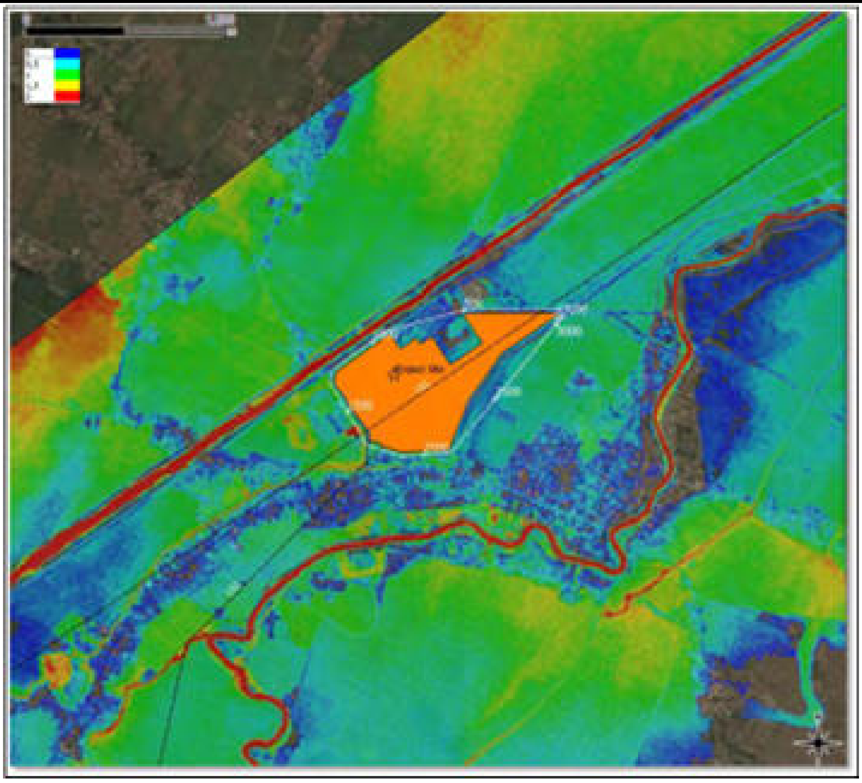
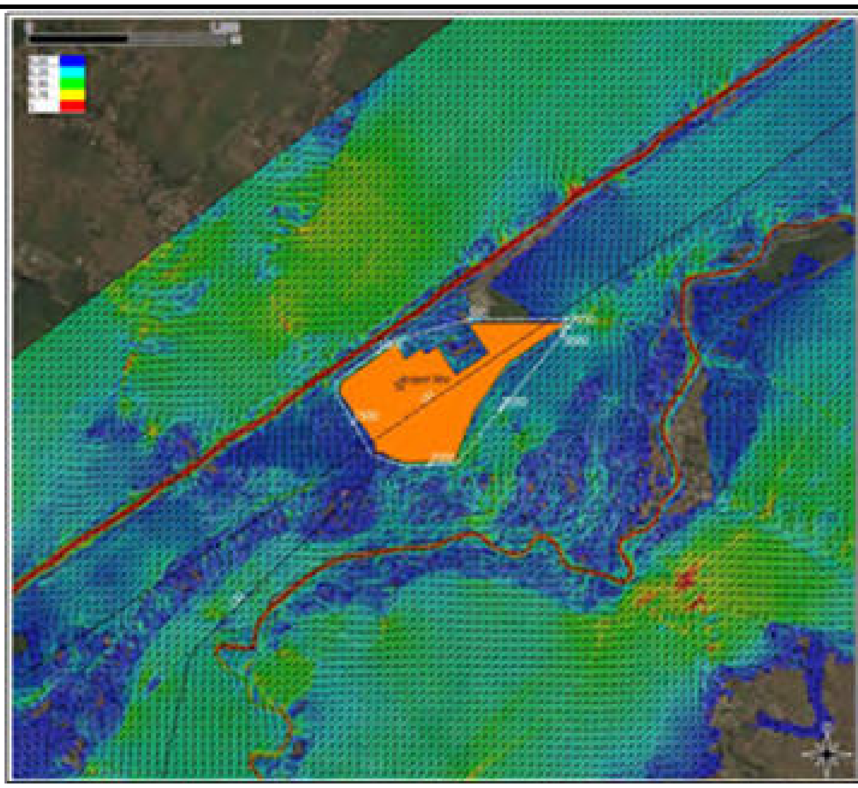


Figure 4.9 Velocity of 16 hours simulation time (m/s). Detail with Longitudinal Sections and Perimeter Section (with station in white)



The maximum water level at the upstream side of the flood dike (longitudinal and perimeter sections in **Figure 4.10** and **Figure 4.11**) reaches 5.4 m which is significantly higher than at the downstream side with 3.5 to 2.5 m.

For comparison purposes, these figures include the ground elevation of the hydraulic model and the DTM – which are very similar.

Figure 4.10 ***Longitudinal Sections LS1 and LS2 of Maximum Simulated Water Levels and Ground Elevations in the Hydraulic Model and DTM***

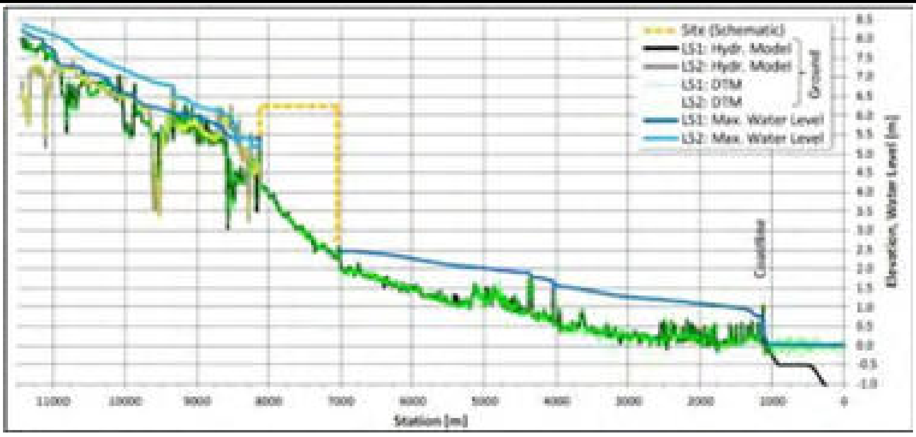
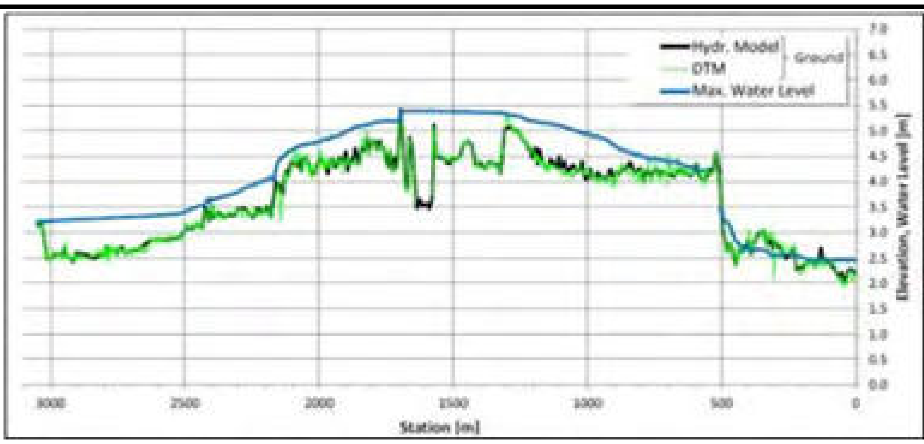
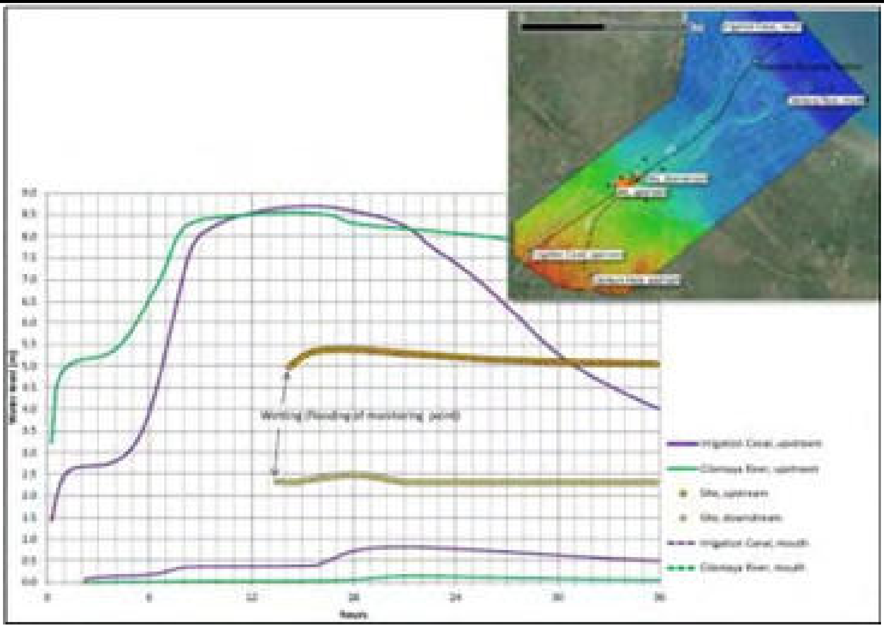


Figure 4.11 ***Perimeter Section of Maximum Simulated Water Levels and Ground Elevations in the Hydraulic Model and DTM***



The water level hydrographs in **Figure 4.12** indicate that the inundation around the Project site would persist for approximately six (6) to 18 hours.

Figure 4.12 Simulated Water Level Hydrographs at selected Monitoring Points (mapping white)



For quantifying the water level sensitivity on uncertainties associated with input data and model assumptions, additional sensitivity simulations were carried out.

Figure 5.1 Simulations and Assumptions for Sensitivity Analysis

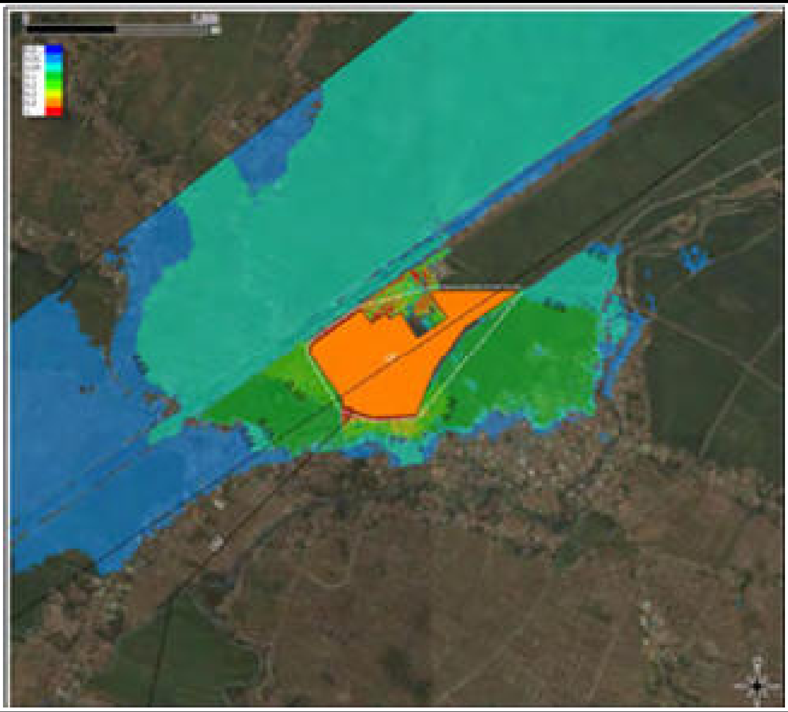
Nr	Simulation	Description
1	**Reference**	100-yr. flood, MSL+0 m, Project State (see 5.5.1)
2	**Current State**	As 1, but with project area as part of the active discharge pattern (see 5.5.3)
3	**High Sea Level**	As 1, but with sea level at MSL+2.02 m (highest high water level in 20-year forecast by Kwarsa Hexagon 2016 – before revision)
4	**Additional model outflows to NW and SE**	As 1, but assuming that the flood discharge would not be confined by the (artificial) model boundaries. For that, additional lateral outflows into plain areas outside the model domain were assumed with an energy grade of 0.5‰. This scenario was considered relevant because larger water depths at the model boundaries as presented in Figure 5-15 seem artificial and highly conservative.
5	**Reduced Hydraulic Capacity**	As 1, but hydraulic capacity of Irrigation Canal and Cilamaya River reduced by 20% (i.e. Roughness coefficients of river beds reduced form K_{St} = 25 to K_{St} = 20) in order to account for uncertainty associated with the river bed elevation (possible sedimentation issues, uncertainty in survey data see chapter 5.3)
6	**Flood discharge increased by 20%**	As 1, but accounting for larger discharges. +20% would result in peak flows of 874 m^3/s (Irrigation canal), 720 m^3/s (Cilamaya River) and 1586 (Total) which approximately corresponds to a 200-yr. flood in Table 3-2, right column. The discharges of the inflow hydrographs were up-scaled by +20%, the time-axis remained unchanged.
7	**Steady Flow: Current State**	As 2 but assuming steady (constant) inflows at peak discharge instead of hydrograph inflows. This quantifies the theoretical maximum water levels assuming there was absolutely no retention.
8	**Steady Flow: Project State**	As 1 but assuming steady (constant) inflows at peak discharge instead of hydrograph inflows. Same concept as 7.

Project-induced changes; Comparison to current state

In order to determine Project-induced changes to the maximum water level, the scenario presented earlier as "Project state" was adopted and simulated for the current state, i.e. with the Project area as part of the active discharge domain (see Nr 2 in **Figure 5.1**).

Figure 5.2 highlights areas with increased flood levels and areas which were dry in the current state and are flooded by a certain depth in the Project state. Increase in the water levels due to the flood dike is of the order of 1.05 m near the Southern side of the flood dike and about 1.00 m near the North-west of the flood dike.

Figure 5.2 Increased 100-Year Water Levels due to The Project (M). Areas Without Changes And Decreased Water Levels Are Not Coloured.



6 FLOOD PROTECTION DESIGN

After evaluation of the Project-induced water level inundations, a revised flood dike design provided by the EPC-Contractor and the Owner's Engineer (August 21, 2016) was digitised, georeferenced (Figure 7 1) and used in final hydraulic modelling.

For the drainage canal / flood flow path, a trapezoidal typical cross-section was assumed using hydraulic standard procedures (normal-flow) and applied along with the new dike design to the hydraulic model. Simulations for the revised Project state were compared to the current state results.

The basic design parameters of trapezoidal flood flow path / swale are (**Figure 6.1**):

- Bed (base) width: 25 m;
- Side slope approx. 1V: 2H (assumed in modelling). In detailed design, slopes may be less steep if covered by grass wherever sufficient space is available;
- Strickler roughness coefficient: 20 (e.g. grass-covered bed and banks assumed);
- Bed level, upstream: 2.7 m;
- Bed level, downstream: 1.0 m;
- Continuous bed slope between bed levels 2.7 and 1.0 m;
- Base widths at narrow reach near cooling towers may be preferably 25 m (if possible for cooling tower design) or may be reduced locally to a minimum of approx. 13 m. In the latter case, the dike slope is rather steep and stabilisation measures should be considered (Rock, concrete); and
- Smooth transitions between bed and existing ground are suggested for both ends of the swale.

Figure 6.1 ***Revised Flood Dike Lines (Dashed Red) with Drainage Canal/Flood Flow Path (Dashed Blue) and Entire Project Site (Black Polygon)***

The effect of the proposed swale (**Figure 6.2**) is to intercept floodwaters along the flood dike and convey them downstream (**Figure 6.3)**. Thus, the design water levels in particular around the flood dike decrease (**Figure 6.4**) and the dike levels may be slightly reduced to values indicated in **Figure 6.2**. The downstream dike reach may be situated closer to the power plant (**Figure 6.2**) and also the downstream end of the swale may be rotated to the north towards the dike.

Figure 6.2 ***Proposed Flood Flow Path (Swale) Along the Revised Flood Dike (Red Line) with Dike Levels, Suggested Re-Alignment at the Downstream Dike Reach (Grey) and Ground Elevations (Coloured)***

Figure 6.3 Product of Velocity and Depth Indicating Interception and Conveyance of Floodwaters in the Swale (Coloured Green)

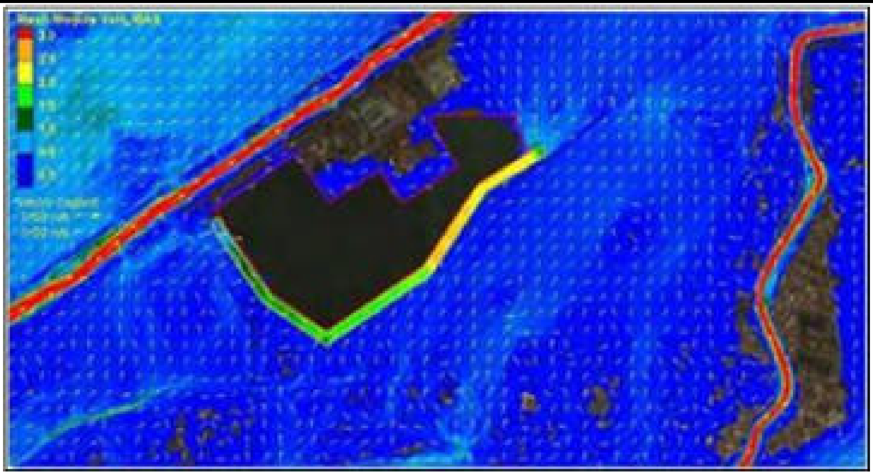
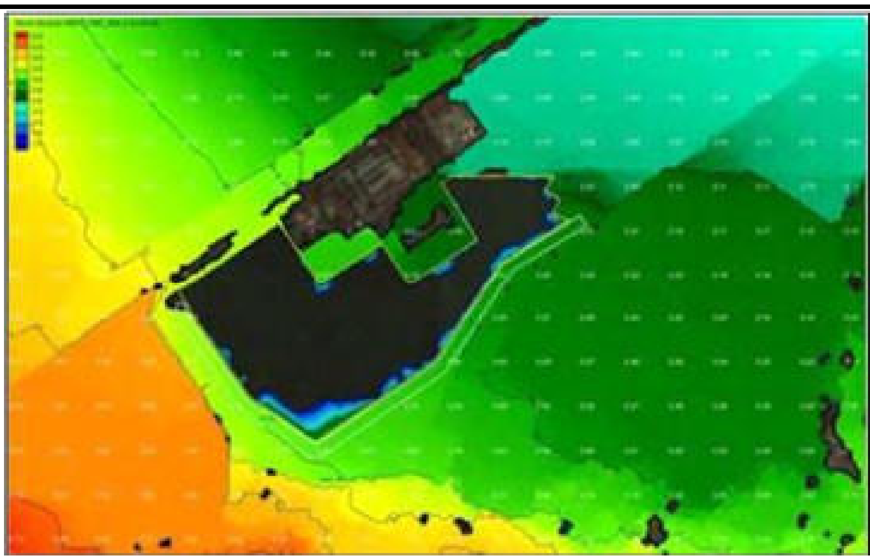
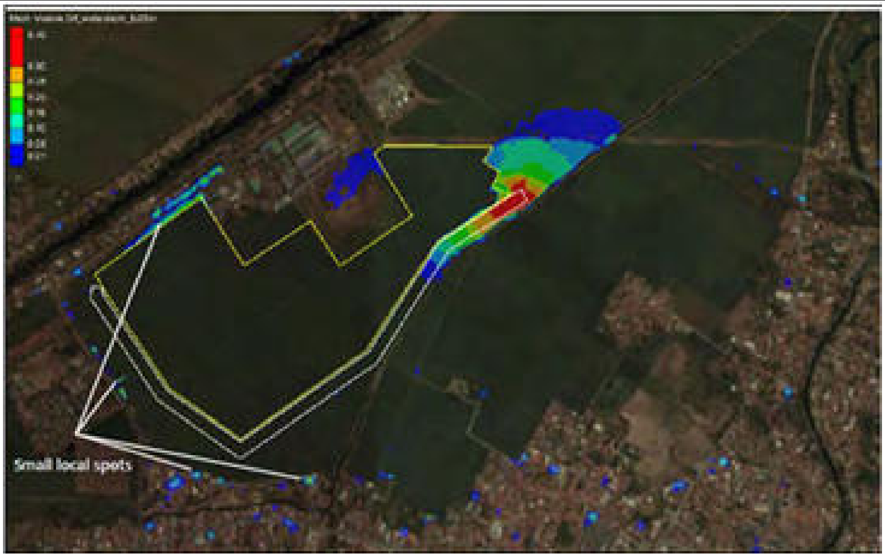


Figure 6.4 Maximum Simulated Water Levels (m)



Areas where water levels are higher than the current state are reduced to a small region near the agricultural land (**Figure 6.5**) where water level increases may be accepted. In larger areas including sensitive use (residential, school etc.) the water levels remain unchanged or decrease slightly.

Figure 6.5 Coloured Areas Indicate Increased Water Levels, Non-Coloured Areas Indicate No Change or Slight Decrease. Small Local Spots are considered as Non-Representative or Artefacts



7 *CONCLUSION*

ERM reviewed a flood risk assessment report titled 'Cilamaya Flood Report' completed by Pöyry Energy GmbH for the proposed Cilamaya Combined Cycle Gas Power Plant in West Java, Indonesia.

The objective of the study was to determine 100-year flood water levels for the design of the flood dikes around the proposed Project site. Following conclusions were made from the review of flood risk assessment report:

- Project site and neighbouring area has history of flooding owing to the proximity to Cilamaya River, Cilamaya Canal and Sea. In addition, there is one (1) minor canal located next to site area which also may prone to flooding risks;

- Flood dike around the periphery of Project site boundary area was designed based on 100-yr flood water level. The approach comprised of hydrologic and hydraulic analysis in order to predict the 100-year design flow hydrograph and flood water level respectively at the Project site area. Hydrologic analysis was performed using HEC- HMS (rainfall –runoff model) and flow regionalisation approach. Hydraulic analysis was performed using Hydro-as 2D model. Input data to hydraulic model includes LiDAR-based digital terrain model (DTM), cross-sectional surveys, sea bed elevations, upstream boundary conditions in terms of hydrologically derived flow hydrograph and downstream boundary conditions in terms of tidal derived water level. Model was roughly calibrated with limited data of flood event dated on March 17, 2014;

- Impact associated with the Project was quantified by comparing two hydraulic model scenarios: namely current state (no dike) and Project state. It was concluded that Project state increases the flood water level typically in the range of 0.01 to 0. 2 m in the site vicinity area. A trapezoidal drainage canal/swale system around the flood dike was proposed to compensate for the increased water level in site vicinity due to Project; and

- The flood dike and an adjoining trapezoidal drainage canal/swale system was suggested as flood mitigation measures to avoid the site area being getting inundated and compensated for Project impact, respectively. However, the hydraulic model simulation shows that flood inundation typically in the range of up to one (1) m could happen, which may cause obstruction to transportation to and from **the Project site area in case of extreme flooding event.**

PLTGU Jawa 1 Independent Power Project

ANNEX M: GREENHOUSE GAS ASSESSMENT (GHG)

Prepared for:

PT Jawa Satu Power (JSP)

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1 INTRODUCTION

1.1 OVERVIEW

The PLTGU Jawa-1 Project (hereafter referred to as 'the Project') involves the development of a 1,760 MW Combined Cycle Gas Turbine (CCGT) Power Plant, a Liquefied Natural Gas (LNG) Floating Storage and Regasification Unit (FSRU) and 500kV power transmission lines and a Substation.

This technical annexure provides an estimate of the Greenhouse Gas (GHG) emissions that are likely to be emitted by the Project, as related to the issue of climate change. GHGs are assessed to provide an indication of what the Project's GHG emissions will be, and to evaluate ways to minimise / mitigate them early on in the development process.

2 *LEGAL FRAMEWORK AND GUIDANCE DOCUMENTATION*

Indonesia participated at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro and signed the United Nations Framework Convention on Climate Change (UNFCCC) on 5 June 1992. This was subsequently ratified by the Indonesian government in August 1994, and came into force in November of the same year (*UNFCCC, 2018*).

2.1 *INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE*

The Intergovernmental Panel on Climate Change (IPCC) is a panel established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to provide independent scientific advice on climate change. The panel was originally asked to prepare a report, based on available scientific information, on all aspects relevant to climate change and its impacts and to formulate realistic response strategies. This first assessment report of the IPCC served as the basis for negotiating the UNFCCC.

The IPCC also produce a variety of guidance documents and recommended methodologies for GHG emissions inventories, including (for example):

- 2006 IPCC Guidelines for National GHG Inventories; and
- Good Practice Guidance and Uncertainty Management in National GHG Inventories (2000).

Since the UNFCCC entered into force in 1994, the IPCC remains the pivotal source for scientific and technical information relevant to GHG emissions and climate change science.

The IPCC operates under the following mandate: "to provide the decision-makers and others interested in climate change with an objective source of information about climate change". The IPCC does not conduct any research nor does it monitor climate-related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide, relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation.

IPCC reports should be neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical and socio economic factors. (IPCC, 2018).

The stated aims of the IPCC are to assess scientific information relevant to:

- Human-induced climate change;
- The impacts of human-induced climate change; and

- Options for adaptation and mitigation.

IPCC reports are widely cited within international literature, and are generally regarded as authoritative.

2.1.1 *United Nations Framework Convention on Climate Change*

The UNFCCC sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognises that the climate system is a shared resource, the stability of which can be affected by industrial and other emissions of CO_2 and other GHGs. The convention has near-universal membership, with 172 countries (parties) having ratified the treaty, the Kyoto Protocol.

Under the UNFCCC, governments:

- Gather and share information on GHG emissions, national policies and best practices;
- Launch national strategies for addressing GHG emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries; and
- Cooperate in preparing for adaptation to the impacts of climate change.

2.2 *KYOTO PROTOCOL*

The Kyoto Protocol entered into force on 16 February 2005. The Kyoto Protocol built upon the UNFCCC by committing to individual, legally binding targets to limit or reduce GHG emissions. Annex I Parties are countries that were members of the Organisation for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition such as Russia. Given the above definition, Indonesia did not comprise an Annex 1 Party. The GHGs included in the Kyoto Protocol were:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous xide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs); and
- Sulfur hexafluoride (SF_6).

Each of the above gases has a different effect on the earth's warming and this is a function of radiative efficiency and lifetime in the atmosphere for each individual gas. To account for these variables, each gas is given a 'global warming potential' (GWP) that is normalised to CO_2. For example, CH_4 has a

GWP of 28 over a 100 year lifetime (IPCC, 2014). This factor is multiplied by the total mass of gas to be released to provide a CO_2 equivalent mass, termed 'CO_2-equivalent', or CO_2-e.

The emission reduction targets were calculated based on a party's domestic GHG emission inventories (which included land use change and forestry clearing, transportation and stationary energy sectors). Domestic inventories required approval by the Kyoto Enforcement Branch. The Kyoto Protocol required developed countries to meet national targets for GHG emissions over a five year period between 2008 and 2012.

To achieve their targets, Annex I Parties had to implement domestic policies and measures. The Kyoto Protocol provided an indicative list of policies and measures that might help mitigate climate change and promote sustainable development.

Under the Kyoto Protocol, developed countries could use a number of flexible mechanisms to assist in meeting their targets. These market-based mechanisms include:

- Joint Implementation – where developed countries invest in GHG emission reduction projects in other developed countries; and
- Clean Development Mechanism – where developed countries invest in GHG emission reduction projects in developing countries.

Annex I countries that failed to meet their emissions reduction targets during the 2008-2012 period were liable for a 30 percent penalty (additional to the level of exceedance).

2.3 *PARIS AGREEMENT*

In 2015, a historic global climate agreement was reached under the UNFCCC at the 21st Conference of the Parties (COP21) in Paris (known as the Paris Agreement). The Paris Agreement sets in place a durable and dynamic framework for all countries to take action on climate change from 2020 (that is, after the Kyoto period), building on existing efforts in the period up to 2020. Key outcomes of the Paris Agreement include:

- A global goal to hold average temperature increase to well below 2°C and pursue efforts to keep warming below 1.5°C above pre-industrial levels;
- All countries to set mitigation targets from 2020 and review targets every five years to build ambition over time, informed by a global stocktake;
- Robust transparency and accountability rules to provide confidence in countries' actions and track progress towards targets;
- Promoting action to adapt and build resilience to climate change; and

- Financial, technological and capacity building support to help developing countries implement the Paris Agreement.

Indonesia signed the Paris Agreement on 22 April 2016. This was ratified by the Indonesian government in October 2016 and came into force on 30 November 2016.

In preparation for the Paris Agreement, Indonesia submitted its Intended Nationally Determined Contribution (INDC) in 2015. This document outlines the country's transition to a low carbon future by describing the enhanced actions and the necessary enabling environment during the 2015-2019 period that will lay the foundation for more ambitious goals beyond 2020 (*Republic of Indonesia, 2015*).

Indonesia has committed to reduce unconditionally 26% of its greenhouse gases against the business as usual scenario by the year 2020.

The above commitment will be implemented through effective land use and spatial planning, sustainable forest management, improved agriculture and fisheries productivity, energy conservation and the promotion of clean and renewable energy sources, and improved waste management.

Relevant to the energy sector, Indonesia has embarked on a mixed energy use policy, with at least 23% coming from new and renewable energy by 2025. Indonesia has also established the development of clean energy sources as a national policy directive. Collectively, these policies are intended to put Indonesia on the path to de-carbonisation.

2.4 INTERNATIONAL FINANCE CORPORATION PERFORMANCE STANDARDS

In recognition of the international efforts to mitigate greenhouse gas emissions summarised above, the International Finance Corporation (IFC) Performance Standards (IFC, 2012) explicitly require assessment of climate change risk and an understanding of greenhouse gas (GHG) emissions and energy use:

- IFC Performance Standard 1: The risks and impacts identification process will consider the emissions of greenhouse gases, the relevant risks associated with a changing climate and the adaptation opportunities, and potential transboundary effects, such as pollution of air, or use or pollution of international waterways;

- IFC Performance Standard 3 requires:

  - Consideration of alternatives and implementation of 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; and

- for projects > 25,000 t CO_2-e/year, quantification of direct greenhouse gas emissions within the physical project boundary and indirect emissions associated with off-site production of energy (i.e. purchased electricity). Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognised methodologies and good practice.

2.5 *IFC EHS GUIDELINES FOR THERMAL POWER PLANTS, 2008*

The *IFC EHS Guidelines for Thermal Power Plants* provides industry specific examples of good engineering practices to be used in conjunction with the *IFC General EHS Guidelines*. The *IFC EHS Guidelines for Thermal Power Plants* (hereafter, *"the TPP Guidelines"*) contain performance levels and measures that are applied to boilers, reciprocating engines, and combustion turbines in new and existing facilities at reasonable cost. Environmental issues in thermal power plant projects which the Guidelines provide requirements on include the following:

- Air emissions;
- Energy efficiency and Greenhouse Gas emissions;
- Water consumption and aquatic habitat alteration;
- Effluents;
- Solid wastes;
- Hazardous materials and oil; and
- Noise.

The TPP Guidelines provide the following recommendations to avoid, minimise, and offset emissions of carbon dioxide from new and existing thermal power plants:

- Use of less carbon intensive fossil fuels (i.e., less carbon containing fuel per unit of calorific value -- gas is less than oil and oil is less than coal) or co-firing with carbon neutral fuels (i.e., biomass);
- Use of combined heat and power plants (CHP) where feasible;
- Use of higher energy conversion efficiency technology of the same fuel type / power plant size than that of the country/region average. New facilities should be aimed to be in top quartile of the country/region average of the same fuel type and power plant size. Rehabilitation of existing facilities must achieve significant improvements in efficiency.

- Consider efficiency-relevant trade-offs between capital and operating costs involved in the use of different technologies. For example, supercritical plants may have a higher capital cost than subcritical plants for the same capacity, but lower operating costs. On the other hand, characteristics of existing and future size of the grid may impose limitations in plant size and hence technological choice. These trade-offs need to be fully examined in the EIA;

- Use of high performance monitoring and process control techniques, good design and maintenance of the combustion system so that initially designed efficiency performance can be maintained;

- Where feasible, arrangement of emissions offsets (including the Kyoto Protocol's flexible mechanisms and the voluntary carbon market), including reforestation, afforestation, or capture and storage of CO_2 or other currently experimental options;

- Where feasible, include transmission and distribution loss reduction and demand side measures. For example, an investment in peak load management could reduce cycling requirements of the generation facility thereby improving its operating efficiency. The feasibility of these types of off-set options may vary depending on whether the facility is part of a vertically integrated utility or an independent power producer; and

- Consider fuel cycle emissions and off-site factors (e.g., fuel supply, proximity to load centers, potential for off-site use of waste heat, or use of nearby waste gases (blast furnace gases or coal bed methane) as fuel. etc).

Table 4 within the TPP Guidelines provides typical CO_2 emissions performance of new thermal power plants, expressed as gCO_2/kWh (gross).

2.6 IFC EHS Guidelines for Air Emissions and Ambient Air Quality, 2007

The *IFC EHS Guidelines for Air Emissions and Ambient Air Quality, 2007* (hereafter, *"the Air Guidelines"*) are applicable to facilities or projects that generate emissions to air at any stage of the project life-cycle. The guidelines complement the industry-specific emissions guidance (e.g. the *TPP Guidelines*) in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts.

The Air Guidelines provide the following recommendations for reduction and control of greenhouse gases include:

- Carbon financing;

- Enhancement of energy efficiency;

- Protection and enhancement of sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forms of agriculture and forestry;
- Promotion, development and increased use of renewable forms of energy;
- Carbon capture and storage technologies; and
- Limitation and / or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy (coal, oil, and gas).

2.7 *OECD COMMON APPROACHES AND EQUATOR PRINCIPLES*

The Organisation for Economic Co-operation and Development (OECD)'s Common Approaches and the Equator Principles III (Principle 2) reference the TPP Guidelines as the export credit conditions.

The Equator Principles III notes that for all Projects, in all locations, when combined Scope 1 (i.e. direct GHG emissions from facilities owned or controlled within the physical Project boundary) and Scope 2 (i.e. indirect GHG emissions associated with the off-site production of energy used by the Project) emissions are expected to exceed 100,000 tonnes of CO_2 equivalent (tCO_2-e) annually, an alternatives analysis will be conducted to evaluate less GHG intensive alternatives.

OECD's Common Approaches state in paragraphs 46 and 47 that:

(*Paragraph 46*) To facilitate the building of the body of experience and to give further consideration to climate change issues, Adherents shall:

- Report the estimated annual greenhouse gas emissions from all fossil-fuel power plant projects; and
- Report the estimated annual greenhouse gas emissions from other projects, where such emissions are projected exceed 25,000 tonnes CO_2-equivalent annually, and where the applicant or project sponsor has provided the Adherents with necessary information, e.g. via an ESIA report.

In this context, where relevant and feasible, Adherents shall try to obtain and report the estimated annual direct and indirect greenhouse gas emissions (Scope I and Scope II respectively) in CO_2-equivalent and/or the estimated annual direct greenhouse gas emissions (Scope 1) by carbon intensity (*e.g.* in g/kWh) for the six greenhouse gases (i.e. Carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6)) to be generated during the operations phase of the project as provided during the environmental and social review.

(*Paragraph 47*) Adherents shall give further consideration to issues relating to support for thermal power plants and nuclear power plants, particularly the use of international standards and relevant sources of international guidance. This work should be based on:

- Reporting of any specific actions taken to avoid, minimise and/or offset CO_2 emissions, pursuant to the recommendations outlined in the EHS Guidelines for Thermal Power Plants, for all high carbon intensity fossil fuel power projects exceeding 700g/kWh, taking into account, where appropriate, the context of the low carbon growth framework of the country where the project is located, the use of best appropriate technology to reduce carbon emissions, and other recommended actions.

3 METHODOLOGY

Quantification of GHG emissions has been performed in accordance with the GHG Protocol (WRI & WBCSD, 2004) and IPCC GHG accounting / classification systems.

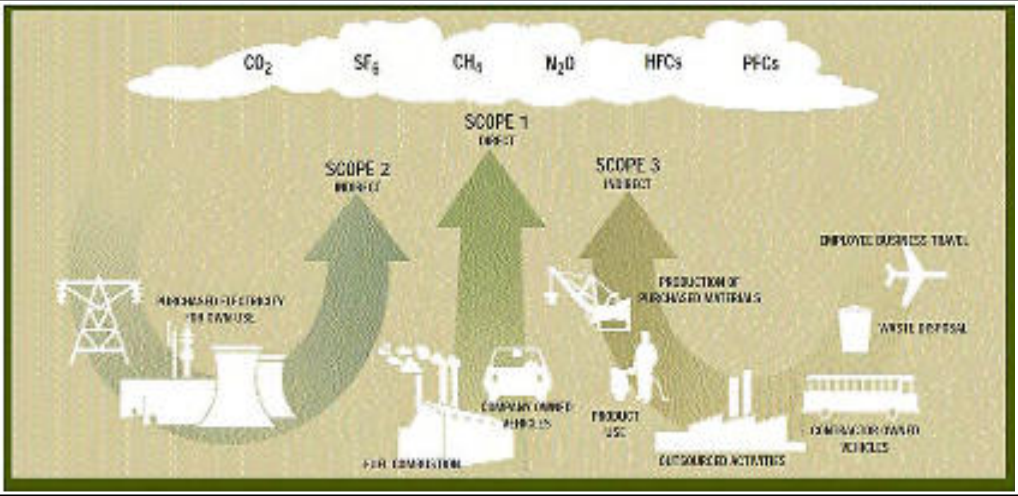
3.1 THE GHG PROTOCOL

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Organisation for Standardisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Under this protocol, three "scopes" of emissions (Scope 1, Scope 2 and Scope 3) are defined for GHG accounting and reporting purposes. This terminology has been adopted in International GHG reporting and measurement methods and has been employed in this assessment.

The definitions for Scope 1, Scope 2 and Scope 3 emissions are provided in the following sections, with a visual representation provided in Figure 3.1.

Figure 3.1 Overview of Scopes and Emissions across a Reporting Entity



Source: WRI & WBCSD 2004

3.1.1 *Scope 1: Direct Greenhouse Gas Emissions*

Direct greenhouse gas emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct greenhouse gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources, the principal source of greenhouse emissions associated with the operation of the proposed CCGT Power Plant;

- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials, e.g., the manufacture of cement, aluminium, etc.;

- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources, e.g., trucks, trains, ships, aeroplanes, buses and cars; and

- Fugitive emissions. These emissions result from intentional or unintentional releases, e.g., equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting; HFC emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport. The fugitive release of LNG (predominantly CH_4) is likely to comprise a significant GHG emission pathway during the operational phase of the FSRU, CCGT Power Plant and associated pipelines. This is in part due to the GWP of CH_4.

3.1.2 *Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions*

Scope 2 emissions are a category of indirect emissions that accounts for greenhouse gas emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 emissions are associated with the production of electricity that is purchased or otherwise brought into the organisational boundary of the entity. Scope 2 emissions physically occur at the facility where electricity is generated. Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as Scope 2.

In the context of this assessment, it is assumed that electricity required by auxiliary plant would be provided directly by the CCGT Power Plant during the operational phase. On this basis, Scope 2 emissions are confined to electricity that is imported at times when the plant is offline.

3.1.3 *Scope 3: Other Indirect Greenhouse Gas Emissions*

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services. In the case of the Project, Scope 3 emissions will include emissions associated with fuel cycles. This includes the extraction, processing and shipping of LNG by third parties.

The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that Scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with Scope 1 and

Scope 2. However, the GHG Protocol notes that reporting Scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

Under the IFC Performance Standards, facilities triggering greenhouse emission thresholds (> 25,000 t CO_2-e/year) are required to quantify Scope 1 and Scope 2, but not Scope 3.

4 EMISSION INVENTORY DEVELOPMENT

4.1 OVERVIEW

This section provides and overview of Project activities, processes and emissions as they relate to GHG emissions, for both the construction and operational phases of the Project.

For quantification of each distinct Project activity, has been used to estimate the emission in terms of CO_2-e for emissions of CO_2, CH_4 and N_2O. The individual gas types have then been summed to provide the total CO_2-e for each activity.

Figure 4.1 Greenhouse Gas Emission Estimation

$$E_{ij} = \frac{Q_i \times EF_{ijoexec}}{1000}$$

Where:
E_{ij} is the emissions of gas type j, (CO_2, CH_4 or N_2O) from gaseous fuel type (i) ($CO_{2\text{-}e}$ tonnes);
Q_i is the quantity of fuel type (i) in tonnes or GJ (depending on the emission factor type); and
$EF_{ijoexec}$ is the emission factor for each gas type (j) which includes the effect of an oxidation factor) for fuel type (i) (kilograms $CO_{2\text{-}e}$ per gigajoule or tonne of fuel type (i).

Activity data (i.e. fuel consumption) has been sourced from the proponent, or where data gaps exist, have been derived using professional judgement.

The emission factors referenced in **Figure 4.1**, are generally those documented within from IPCC Guidelines for National Greenhouse Gas Inventories (*IPCC, 2006*).

Key assumptions and data that have been used in developing the emission inventory for each activity are provided.

4.2 CONSTRUCTION EMISSION INVENTORY

During the construction phase of the Project there will be a requirement for mobile and non-mobile plant, including, for example, bulldozers, loaders, excavators, mobile cranes, pile machines, graders, scrappers, pile driver excavators, dump trucks, and generators, etc.

The detailed construction schedule including locations of individual sources in any given period of time is not known. GHG emissions associated with fuel consumption from onsite mobile and non-mobile plant will be intermittent (and spatially variable) throughout the construction phase period as different activities take precedence. Construction plant GHG emissions will be highly dependable on the operating time of individual mobile and non-mobile plant, which is currently not known to a high level of detail. On this basis it is recognised that the construction phase GHG emission inventories are, in general, difficult to define.

4.2.1 *Combined Cycle Gas Turbine (CCGT) Power Plant Construction*

Notwithstanding the above commentary around construction emissions uncertainty, the activity data for construction of the CCGT Power Plant is reasonably well defined.

Activity data currently available includes a proposed manpower schedule and detailed equipment operation schedule. Construction of CCGT Power Plant is anticipated to involve a maximum of 3,500 workers, and is thus anticipated to be the single largest construction emission.

Three principal activities have been identified in the CCGT Power Plant construction:

- Use of mobile and non-mobile plant (annual fuel consumption estimates provided by the proponent);
- Mobilisation of construction workers (activity data from manpower schedule combined with assumptions around worker transportation mode / average commute distance); and
- Mobilisation of construction equipment and materials (activity data from equipment operation schedule combined with assumptions around average distance travelled to deliver equipment to site)

4.2.2 *Other Construction Activities / Locations*

In view of the granularity of information available for CCGT Power Plant construction, other construction activities / locations have been scaled against the aggregated construction emission estimates, based on information available as to their proposed manpower and / or duration.

The other construction activities / locations that have been quantified in this manner are construction of:

- Transmission lines;
- Pipelines;
- Sub-station; and
- Jetty.

It is acknowledged that there will be other ancillary construction activities taking place (e.g. construction associated with FSRU, construction and access roads and the base camp). However, given the conservatism adopted in the above quantification exercises, it is anticipated that the GHG emissions from such ancillary activities will be accounted for within the total annual estimates.

4.2.3 *Clearing of Land*

The clearing of land needs to be considered in terms of the carbon sink lost in the year of removal of any existing vegetation.

However, information provided by the proponent, and validated from aerial photograph of the region, indicates that a significant proportion of the land clearing required for the Project will require the reclamation of existing paddy fields.

Paddy fields represent a GHG emission source in their own right (associated with CH_4 emissions during the rice growing process). For this assessment, it has been assumed that any GHG emission associated with the clearing of vegetated land would be negated by the GHG-positive activity of paddy field removal.

4.3 OPERATIONAL EMISSION INVENTORY

4.3.1 *Floating Storage and LNG Regasification Unit (FSRU)*

The FSRU will be equipped with a number of diesel generators for operation activities (No.1, No. 2 and No.4 Main Generator Engines).

The post-combustion emissions associated with operation of these diesel generators will be a source of GHG emissions, principally as CO_2.

Based on the Project information provided in **Table 4.1**, the estimated GHG emissions associated with operation of the FSRU Dual Fuel (DF) diesel generators is provided.

Table 4.1 FSRU Diesel Generator GHG Emission Estimates

Regas Capacity	Air emission from main DF generator engines
[mmscfd]	Typical CO_2 [kg/h]
50	1862.1
100	2174.6
150	2741.8
200	2881.8
250	3644.9
300	3823.8
350	4606.1
400	4752.6

Normal operating conditions are considered to be a regas capacity of 300 mmscfd, requiring three sets of main generator engines to be operating. For estimation purposes, under these conditions, the other fuel consumption equipment are not operating (e.g., auxiliary boilers, GCU). Rather, for estimation purposes, normal operating conditions are assumed to occur on a 24 hour basis for the entire year.

4.3.2 *Onshore Receiving facility (ORF)*

During the operation phase of the Project there will be a 70m high pressure cold gas vent located at the ORF. The purpose of the vent is to safely dispose of hydrocarbon to atmosphere under maintenance and emergency relief conditions. The composition of the vented gas is presented in **Table 4.2**. The gas is 'sweet' meaning it is largely free of acidic gases such as carbon dioxide (CO_2) and hydrogen sulphide (H_2S) and consists primarily of CH_4 (~96.66%).

Process design information for the Project details that the vent capacity is 24 mmscfd. Acknowledging that the vent is required for emergency / maintenance only and is expected to be operated infrequently and for short duration, it has been conservatively assumed that the vent is operational for up to a 24 hour period in aggregate annually.

Table 4.2 Feed Gas Composition

Component	Typical Value (% Mol)	Min/Max value (% Mol)
Oxygen	0.00	Max 0.2%
Nitrogen	0.35	Max 1%
Carbon Dioxide	0.00	Max 3%
Methane	96.66	Min 85%
Ethane	2.30	Max 8%
Propane	0.47	Max 4%
i-Butane	0.09	Max 2%
n-Butane	0.11	Max 2%
i-Pentane	0.02	Max 0.1%
n-Pentane	0.00	Max 0.2%
HHV (BTU/SCF)	1036	1000 to 1150

4.3.3 *Combined Cycle Gas Turbine (CCGT) Power Plant*

The combustion of natural gas in the 1,760 MW thermal power plant is anticipated to be the largest single source of GHG during either the construction or operation phase of the Project

The gas consumption by the power plant is estimated to be around 64,000,000 mmBTU/year (~67,523 TJ/year) based on a 60% capacity factor.

Greenhouse gas emissions from this source reference the emission factor contained in **Table 2.2** (Chapter 2. Stationary Combustion) of IPCC, 2006.

4.3.4 *Black Start Diesel Engine-Generators*

The Project will be equipped with thirteen 2 MWe (26 MWe total) diesel powered engine-generators required to start-up the main power plant (i.e. black start). It is understood that for a black start, all thirteen engines will be required at their full power output. Given the relatively small scale (~1% of the CCGT Power Plant) and limited use, their operation is not considered material in terms of the GHG assessment.

4.3.5 *Emergency Power Diesel Engine - Generator*

It is understood that one of the thirteen diesel powered engine-generators discussed in **Section 4.3.4** will be required in case of a station black out and/or emergency power for the safe shutdown of the power plant in the event of loss of mains supply. Per the discussion in **Section 4.3.4**, it is not considered that this will contribute materially to the operational GHG assessment, and this activity is accounted for within the assumptions used to estimate CCGT Power Plant emissions.

4.3.6 *Fugitive Methane Emissions*

Fugitive emissions of methane may occur from multiple sources within the Project boundary during operations, including transmission infrastructure leaks and during LNG transfer at the FSRU. In view of the GWP of methane, it is considered that fugitive emissions may be material in terms of the operational GHG emission inventory.

Based on estimates of GHG emissions specific to the LNG value chain (Worley Parsons, 2011), it has been estimated that fugitive methane may result in a CO_2-e emission of the order of 1.6% of that corresponding to CCGT Power Plant combustion activities (refer **Section 4.3.3** of this Annex**).**

In addition to the above, and acknowledging the potential for double-counting, an estimate of pipeline emissions has been made.

The onshore (7km) and offshore (14 km) pipeline lengths have been referenced within the emission factor provided within DEE, 2017 which provides the natural gas transmission emission factor for high pressure pipelines 0.4 tonnes CO_2-e/km pipeline length.

4.3.7 *Mobilisation of workers*

It has been assumed that all the operational personnel travel an average 10 km per day via gasoline light vehicle (i.e. motorbike). It has been conservatively assumed that up to 350 personnel are required to service the operational requirements of the Project.

4.3.8 *Imported electricity consumption*

Power is anticipated to be imported only when the CCGT Power Plant is completely shut down. It has been estimated that the FSRU will be shut down for an average of 10 days a year. Additionally, it is also assumed there will be four times a year when the power plant is shutdown/tripped. It is estimated that during a normal shutdown the average CCGT Power Plant load is 4 MW and during the FSRU dry dock outages, 3 MW.

The annual total electricity requirement from the grid is estimated to be 1,053 MWh.

An electricity grid emission factor corresponding to Java of 0.9 tCO_2-e /MWh has been adopted (*Institute for Global Environmental Strategies, 2017*).

4.3.9 Scope 3 Emissions

As noted in **Section 3.1.3** of this Annex, IFC Performance Standards require that facilities to quantify Scope 1 and Scope 2, but not Scope 3. However, there are material Scope 3 GHG emission sources associated with the Project, and these are discussed briefly below.

The production and transportation (shipping) of LNG to the FSRU is assumed to be under the operational control of a third party. These potentially significant emissions will be accounted for within the GHG emission inventories of the entities that complete these activities.

An additional, albeit less significant, Scope 3 emission source is associated with the CH_4 generation from the waste generation / management from both construction and operational phases of the Project.

As all waste is assumed to be handled by a third party, this again comprises a Scope 3 activity.

5 *GREENHOUSE GAS EMISSION ESTIMATES*

5.1 *OVERVIEW*

The outputs of the emission inventory calculations for the construction phase, the operation phase, and for the Project life cycle as a whole are discussed in this section.

5.2 *CONSTRUCTION PHASE EMISSIONS*

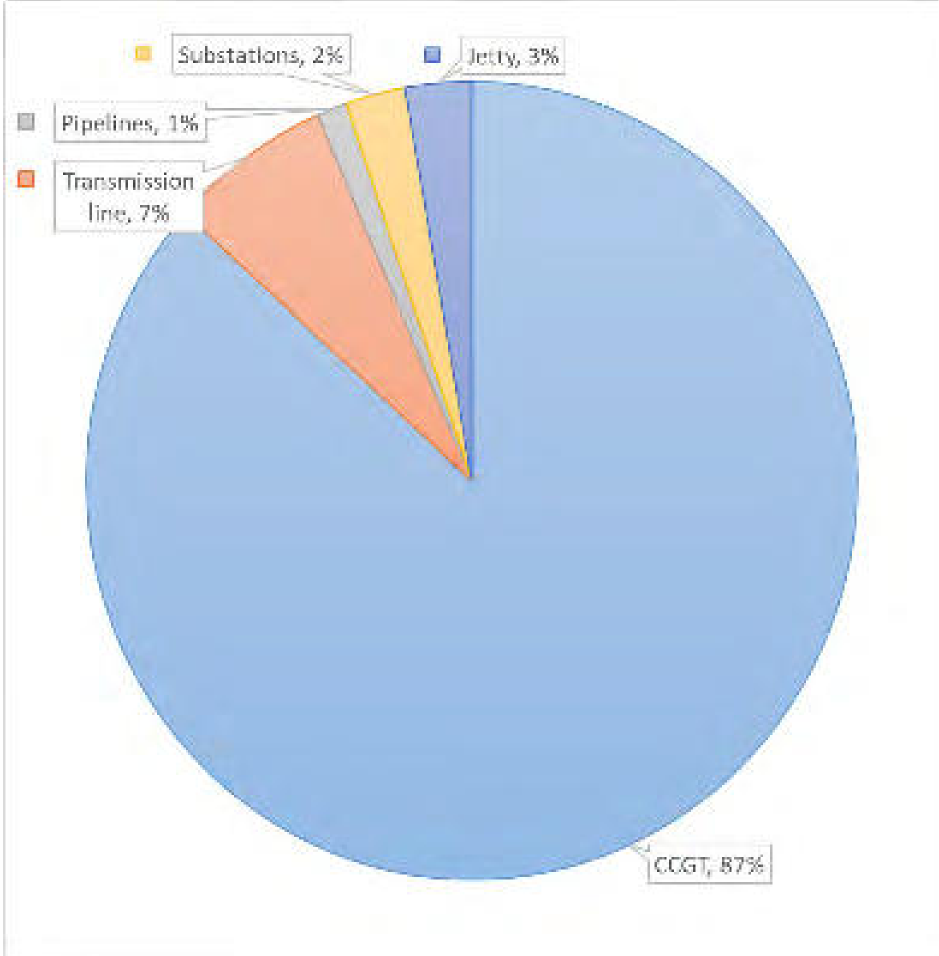
The estimated construction phase GHG emissions, calculated as described in **Section 4.2**, are shown by activity and anticipated year of emission within **Table 5.1**.

The anticipated total construction GHG emissions by facility are shown in **Figure 5.1**.

Table 5.1 Estimated Construction Greenhouse Gas Emissions by Activity and Year

Facility	Activity	Estimated GHG emission (t CO_2-e/year)			
		2018 (Year 1)	2019 (Year 2)	2020 (Year 3)	3 Year Total
CCGT Power Plant	Equipment fuel consumption	30,983	46,203	31,535	108,721
	Manpower mobilisation	3	18	7	28
	Equipment / materials mobilisation	18	96	37	151
	Total	31,004	46,316	31,579	108,899
Transmission line	Total Construction	2,713	5,790	n/a	8,502
Pipelines	Total Construction	n/a	n/a	1,579	1,579
Substation	Total Construction	n/a	n/a	3,158	3,158
Jetty	Total Construction	3,488	n/a	n/a	3,488
Grand Total		**37,205**	**52,106**	**36,315**	125,626

Figure 5.1 ***Contribution to Total Construction Phase Greenhouse Gas Emissions by Activity***



5.3 *OPERATION PHASE EMISSIONS*

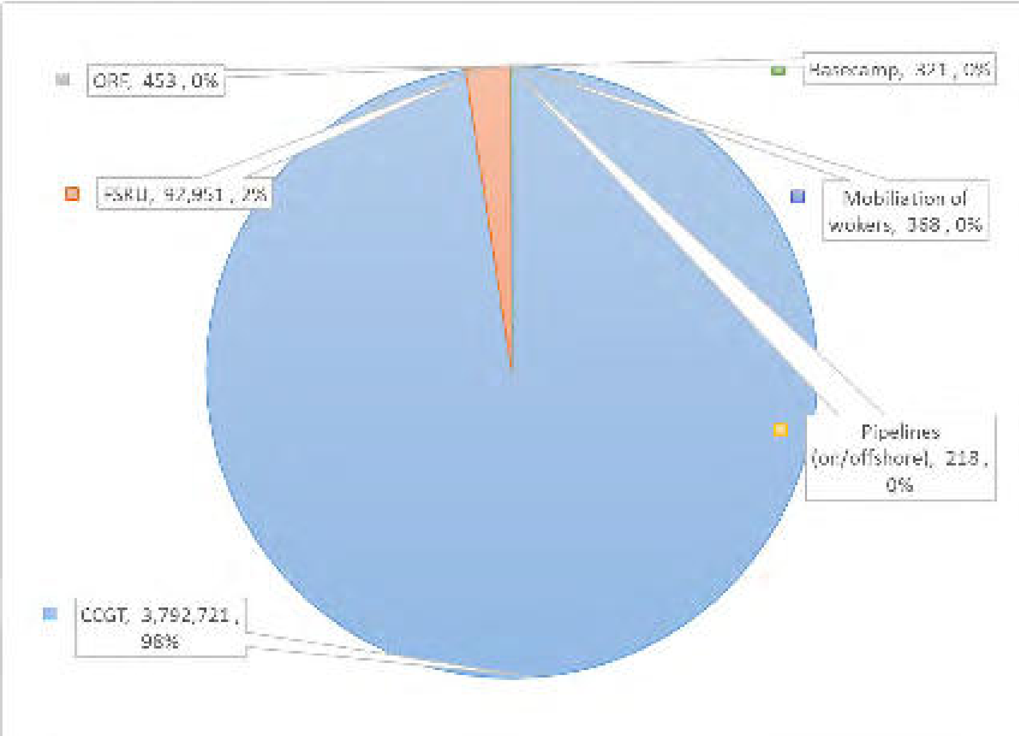
The estimated operation phase GHG emissions, calculated as described in **Section 4.3** of this Annex are shown by activity and anticipated year of emission within **Table 5.2**.

The anticipated total operation GHG emissions by activity / facility are shown in **Figure** 5.2.

Table 5.2 *Estimated Operation Greenhouse Gas Emissions by Activity*

Facility	Activity	Estimated GHG emission (t CO_2-e/year)	Percentage of total operational emissions
CCGT Power Plant	Gas consumption by gas turbines	3,791,773	96.42
	Electricity Purchased	948	0.02
FSRU	Diesel Generator	33,497	0.86
	Fugitive Emissions	59,454	1.53
ORF	Emergency/Maintenance release valve	453	0.01
Pipeline	Fugitive Emissions	218	0.01
Total Operations	Mobilisation of workers	368	0.01
Base Camp	Electricity purchased	321	0.01
Grand Total		**3,887,033**	**100**

Figure 5.2 *Total operation phase greenhouse gas emissions by activity (t CO_2-e/ year, %]*



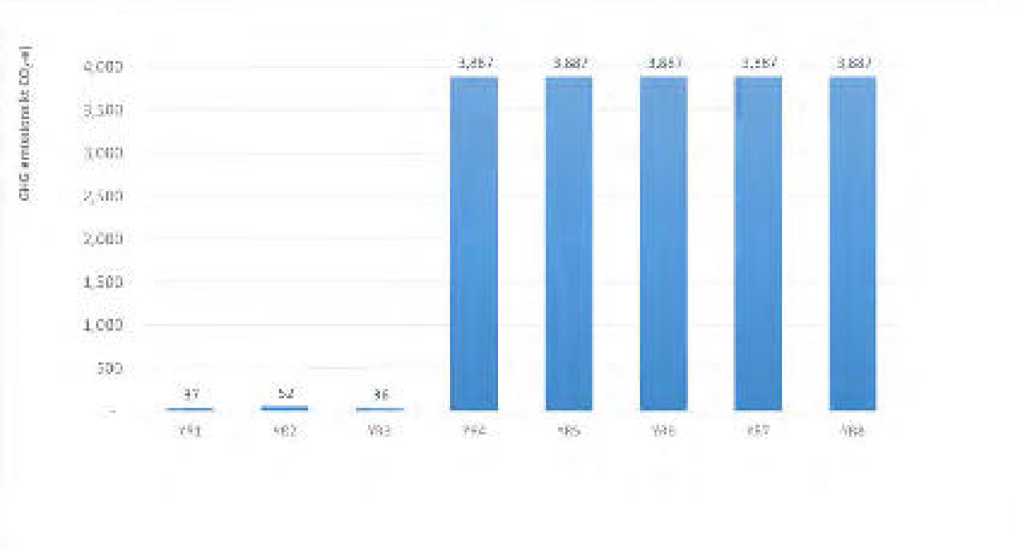
Inspection of **Table 5.2** and **Figure 5.2** indicates that combustion / fugitive emissions from the CCGT Power Plant and FSRU are anticipated to comprise 99.9% of GHG emissions during the operation phase.

5.4 PROJECT LIFE CYCLE EMISSIONS

The anticipated GHG emissions for the first eight years of the Project life cycle are shown in **Figure 5.3.**

It has been conservatively assumed that Year 4 onwards will comprise of full operation year.

Figure 5.3 ***Estimated Greenhouse Gas Emissions for the first eight (8) years of the Project Life Cycle (kt CO_2-e / year)***



Assuming a 20 year asset life from the start of operations, the Project as a whole is anticipated to comprise 77.7 Mt CO_2-e of (Scope 1 and 2) emissions during its total life cycle. Of these, 99.8% of emissions are anticipated to be related to (combustion and fugitive) emissions during the operational phase.

6 IMPACT ASSESSMENT, MITIGATION AND MANAGEMENT

6.1 OVERVIEW

This section seeks to evaluate the Project emissions in terms of their significance at both a National and International level.

The use of LNG within a CCGT Power Plant is benchmarked against other fossil fuel power generation, and appropriate GHG management measures are provided.

6.2 IMPACT ON NATIONAL AND GLOBAL GREENHOUSE GAS EMISSIONS

A traditional impact assessment is conducted by determining how proposed activities will affect the state of the environment compared with the status quo (i.e. baseline conditions).

In the case of GHG emissions, this process is complicated since GHG impacts from a single activity cannot be readily quantified within a defined space and time.

Anthropogenic climate change occurs on a global basis and the emissions of a single point source is irrelevant when considering the future impact on the climate. For example, CO_2 has a residence time in the atmosphere of approximately 100 years – during this period, the emission of a single facility/ Project will combine with other anthropogenic and natural climate forcing emissions and activities to precipitate a global outcome.

The global nature of the impacts of climate change such as temperature increases, sea level rise, ecological impacts, changes in crop productivity, disease distribution etc are well documented. Despite the potential severity of consequences at the national and global level, it is not meaningful to link emissions from single source to particular impacts at this scale.

This specialist study, therefore, looks at the impact of the project on Indonesia's National GHG Inventory, as well as global anthropogenic emissions, and the implications of this rather than the physical impacts of climate change.

In 2014, global emissions of greenhouse gases from anthropogenic activities excluding land use change and deforestation came to 36.14 giga tonnes (Gt) CO_2-e (*CDIAC, 2017*).

For the same year, Indonesia ranked the 14^{th} highest in terms of national GHG emissions, with an estimated 126.6 Mt CO_2-e (*CDIAC, 2017*).

Consistent with the data presented in **Section 5** of this Annex, the annual operational emissions from the Project are anticipated to be of the order of 3.9 Mt CO_2-e.

The Project is therefore anticipated to contribute to 3% of Indonesia's national GHG emissions annually, and 0.01% of global anthropogenic emissions over the same period.

6.3 *BENCHMARKING AGAINST OTHER THERMAL POWER PRODUCTION*

Given that the Project is proposed to meet the future power needs of Java, it is instructive to compare the operation of CCGT Power Plant against other alternative power generation methods.

Given the scale of the Project (1,760MW), and the requirement for baseload power generation, it is appropriate to compare the Project with other thermal (fossil fuel) power generation alternatives.

A comparison of conventional (thermal) baseload electricity generation operations is provided in **Table 6.1.**

Table 6.1 Electricity Generation Greenhouse Gas Intensities (tCO_2-e/MWh)

Operation	Natural Gas		Black Coal		
	OCGT	CCGT	Sub-critical	Super critical	Ultra super critical
Assumed average efficiency (%)	39	53	33	41	43
Extraction and processing	0.14	0.1	0.03	0.02	0.02
Transport	0.02	0.01	0.03	0.03	0.03
Processing and Power Generation	0.59	0.43	0.97	0.78	0.74
Total	**0.75**	**0.55**	**1.03**	**0.83**	**0.79**
Min estimate	0.64	0.49	0.75	0.61	0.58
Max estimate	0.84	0.64	1.56	1.26	1.2

Source: Worley Parsons, 2011

Table 6.1 shows that, compared with other conventional fossil fuel baseload power generation, CCGT Power Plant is the least GHG-intensive option.

Table 4 within the IFC Thermal Power Plant Guidelines (*IFC, 2008*) provides typical CO_2 emissions performance of new thermal power plants. IFC, 2008 further supports that CCGT Power Plant is the least GHG-intensive of all fossil fuel baseload power generation options.

For new CCGT Power Plant facilities, the following CO_2 emissions performance is noted (Table 4 of IFC, 2008):

- 0.40 tCO_2/MWh (gross, LHV) – CCGT, 51% efficiency

The Project's GHG intensity can be estimated referencing a 1,760MW facility operating at a 60% capacity factor and producing 3.79 Mt CO_2-e from the gas combustion. This calculation leads to an estimate of 0.41 tCO_2/MWh, which is commensurate with both Worley Parsons, 2011 and IFC, 2008 estimates.

It is instructive to compare the estimated GHG intensity of Project (0.41 tCO_2-e/MWh for generation alone) with the electricity grid emission factor corresponding to Java of 0.9 tCO_2-e /MWh (*Institute for Global Environmental Strategies, 2017).*

This thus indicates that electricity generated via the Project's CCGT Power Plant has a GHG intensity of approximately 50% compared to the existing power generation mix for the region.

6.4 ASSESSMENT OF SIGNIFICANCE

As noted above, the Project is anticipated to contribute to 3% of Indonesia's national GHG emissions annually, and 0.01% of global anthropogenic emissions.

However, the Project is responding to additional power demands for the region. Therefore, it needs to be queried as to whether there are alternative, lower GHG intensive power generation options available. Discussions in **Section 6.3** of this Annex indicate that CCGT Power Plant is anticipated to have the lowest GHG-intensity compared with other (fossil fuel, baseload) candidate technologies.

To conclude whether this impact is deemed significant or not, a risk classification approach is used. The approach is derived from classic risk assessment nomenclature which involves the expression of risk as the consequence of the event multiplied by the probability of that event. The environmental assessment equivalent is the magnitude of the impact multiplied by the sensitivity/vulnerability/importance of the resource or receptor.

The impact magnitude of the Project, in terms of its contribution to GHG emission inventories, is thus considered to be **Medium** at a National (Indonesian) level, and **Small** in a global context.

The weight of evidence is that anthropogenic climate change will impact multiple resources, human activities and ecological systems on a global scale (i.e. multiple, geographically diverse receptors). The importance of the system subject to impacts is thus **High**.

Application of a conventional risk classification matrix to the Project thus indicates that at a national level, the significance is **Major**, while at a global level the significance is considered **Moderate**.

6.5 *GREENHOUSE GAS MITIGATION*

The key mitigation measures proposed to minimise GHG emissions associated with the Project include:

- Cold venting of gas directly to atmosphere will be avoided where possible. If significant quantities are emitted, the Project should consider flaring, as this converts the CH_4 to CO_2 and thereby reduces the net GHG emissions in terms of CO_2-e emissions; and

- Optimisation of construction schedule and placement of laydown areas/temporary camp sites to reduce overall traffic movements/distance travelled, thus reducing GHG emissions from transport.

Other opportunities exist to further reduce GHG emissions, and should be evaluated for feasibility as the Project progresses further along the Front End Engineering and Design (FEED) and Detailed Design (DD) stages:

- Actual land clearing/disturbance will be minimised to the greatest extent possible. Net GHG emissions could also be reduced by revegetation in many areas that will be cleared only for temporary activities such as laydown areas and temporary camps for construction.

Throughout the design process, assessment of GHG mitigation options should continue. The opportunity exists to continue to optimise energy consumption throughout the Project, where key Project decisions relating to equipment selection have not been made. Technical studies relating to equipment selection (e.g. Best Available Technology studies) will take into account GHG emissions and energy efficiency as factors for consideration.

For construction activities, it is recommended that the following measures be included in the construction management plans for the Project:

- The consideration of energy efficiency and reducing greenhouse gas emissions;

- Strategies to reduce the number of vehicle kilometres travelled as part of construction; and

- Procurement to consider the energy efficiency of all new mobile and fixed equipment.

6.6 *GREENHOUSE GAS MANAGEMENT*

Management, monitoring and auditing provisions should be incorporated in the Environmental Management Plan (EMP) for the Project. Management shall include measurement and recording of:

- Energy use;

- Greenhouse gas emissions;
- Transport activities; and
- Other relevant GHG generating activities (such as land clearance).

As noted in **Section 2.4** of this Annex, for projects > 25,000 t CO_2-e/year (current Project anticipated to comprise 3.9 Mt CO_2-e/year), quantification of direct greenhouse gas emissions is required to be conducted by the client annually.

It is also recommended that GHG management measures incorporate the following with the aim of minimising energy consumption and GHG emissions:

- Establish within the operational and maintenance management systems the controls required to monitor performance of equipment, control emissions and improve energy efficiency; and
- Develop a program to monitor, audit and report on GHG emissions from all relevant activities and the results of emissions mitigation programs.

6.7 RESIDUAL IMPACTS

The combustion of natural gas within the CCGT Power Plant comprises approximately 90% of the annual operational GHG emission, and this contribution will not change significantly under the proposed mitigation measures for the Project.

On this basis, the impact significance is not anticipated to change post-mitigation, as summarised in **Table 6.2**.

Table 6.2 Climate Change Residual Impact

	Impact Significance
Pre-mitigation	Major (Indonesia) Moderate (Global)
Post-mitigation	Major (Indonesia) Moderate (Global)

7 *CONCLUSIONS*

This GHG assessment investigated the sources of GHG emissions associated with the construction and operation of the PLTGU Jawa-1 Project. This involves the development of a 1,760 MW CCGT Power Plant, an LNG FSRU and 500kV power transmission lines and a Substation.

The GHG emissions cover the proposed three years of construction and a nominal 20 year operation period, quantified on an annual basis. Assuming a 20 year asset life from the start of operations, the Project as a whole is anticipated to comprise 77.7 Mt CO_2-e of (Scope 1 and 2) emissions during its total life cycle. Of these, 99.8% of emissions are anticipated to be related to (combustion and fugitive) emissions during the operation phase.

The Project is anticipated to contribute to 3% of Indonesia's national GHG emissions annually, and 0.01% of global anthropogenic emissions.

Given the Project is responding to additional power demands for the region, it is important to contextualise the Project in terms of how GHG intensive the power generation is compared to other options available. It is concluded that CCGT Power Plant is likely to have the lowest GHG-intensity compared with other (fossil fuel, baseload) candidate technologies.

Application of a conventional risk classification matrix to the Project indicates that at a national level, the significance (in the context of GHG emissions) is **Major**, while at a global level the significance is considered **Moderate**.

Mitigation measures to reduce GHG emissions over the life of the Project have been explored and measures have been developed relevant to the requirements of the Project. These measures include high efficiency and high reliability equipment, avoidance of venting where possible, as well as optimisation of construction period to reduce emissions from transport. In addition, mitigation, management and monitoring measures are proposed for consistency with IFC Performance Standards, and to ensure that GHG emissions are managed throughout the life of the Project.

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PLTGU Jawa 1 Independent Power Project

ANNEX N: SALINITY AND THERMAL DISPERSION MODEL

Prepared for:

PT Jawa Satu Power (JSP)

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Chapter VI
Salinity and Waste Water Thermal Dispersion

6.1. Background

This section describes the methodology for waste water dispersion modelling undertaken to assess waste water quality impacts arising from the Jawa 1 project emissions. The Jawa 1 project will be cooled by an indirect wet cooling system using seawater cooling towers. In this type of cooling system the cooling water will be recirculating through the condenser in a closed loop. The heat removed by the cooling water from the condenser will be rejected to atmosphere using mechanical draft cooling towers. As an example, the cooling towers require a supply of make-up water to replace the water that is lost from the circuit. As the water circulates through the system, evaporated water exits the system as pure vapour leaving dissolved solids behind, which begin to concentrate over time. To control solids build-up a portion of the cooling water is bled from the cooling tower basin. Called blowdown, this is usually controlled using a conductivity monitor and is accomplished on a continuous or on a controlled bleed cycle basis. As an example, when enough water is evaporated to increase the concentration of solids to twice their initial value (e.g. 60 parts per million becomes 120 ppm), the newly constituted water is said to have two cycles of concentration.

The Make-up water for the cooling towers shall be drawn from the Java Sea via a submerged offshore intake. The blowdown from the cooling towers, which forms the major part of all waste water from the power plant, will also be discharged to the Java Sea via a submerged offshore discharge.

This chapter presents the results of salinity and thermal dispersion modelling carried out for the waste water discharge to the Jawa Sea.

A waste water dispersion modelling exercise was carried out using the predicted Project emissions. The main purpose of this study is to verify that its chosen intake/outfall positions have been optimised with respect to the following criteria:

a) Potential recirculation is minimised and quantified;
b) Proper mixing of the discharge in order to ensure compliance with relevant environmental standards.

Kwarsa Hexagon has applied the Delft3D-FLOW model to characterise the nearfield mixing effects of the waste water discharge outfall for thermal and salinity dispersion.

Delft3D-FLOW is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing on a rectilinear or a curvilinear, boundary fitted grid.

Waste water modelling dispersion is intended to determine the distribution pattern of the salinity and temperature of the discharge point, so it can be in the know areas that meet quality of Indonesian's standards

6.2. Indonesian waste water quality standards

6.2.1. Indonesian waste water quality standards relating to outfall

The Project shall comply with the Decree of the Ministry of Environment No. 8 of 2009 (Waste Limits of Thermal Power Plant). The applicable limits for temperature and salinity when discharging waste water to the sea are set out in the table below .

Table 6.1. Indonesian limit for temperature and salinity

Parameter	Units	Limit
Temperature	Deg C	< 3°C at edge of mixing zone (note 1)
Salinity	-	Salinity level shall be equal to natural sea salinity within radius 30 meters from discharge to the sea

Note : 100 meters mixing zone is typically applied.

The maximum allowed excess temperatures at the discharge location is +3.0°C. A mixing zone of 100 meters is allowed for around the discharge point, within which water quality standards will not be met. The excess salinity at the discharge location shall have completely dissipated within 30 meters of the discharge point.

6.2.2. Thermal recirculation between outfall and intake

Thermal recirculation between outfall and intake is not such an issue for a power plant with indirect wet cooling system, as it is for a plant using a direct once through cooling system. However for the purposes of this study a ceiling of +1.0°C of the excess temperature at the proposed intake located has been considered.

In terms of salinity it is expected that there will be no excess salinity at the intake location.

6.3. Basic theory

When performing design work and predictive studies on effluent discharge problems, it is important to clearly distinguish between the physical aspects of hydrodynamic mixing processes that determine the fate and distribution of the effluent from the discharge location that intend to prevent any harmful impact of the effluent on the aquatic environment and associated uses.

Mixing processes are an interplay of ambient conditions and the outfall configuration. Different hydrodynamic processes drive and control the system. Most processes are running simultaneously, but with very clear dominance in different temporal and spatial regions, according to their predominant flow characteristics, schematized in **Figure 2** for one specific situation.

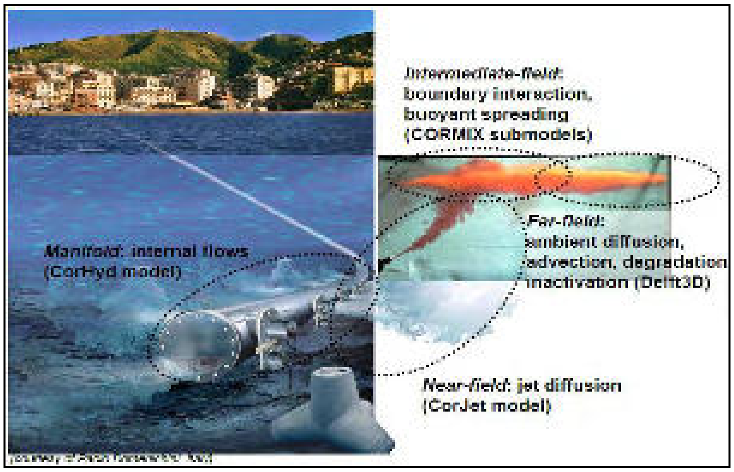


Figure 6.1. Ilustrastion near field and far field model

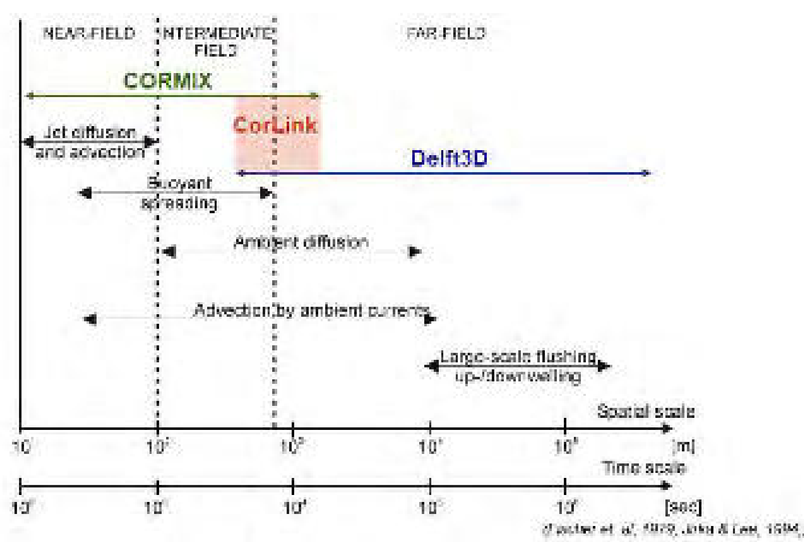


Figure 6.2. Flow classification to choose model and define schematization, coupling position, time and condition

6.4. Hydrodynamic model

Delft3D-FLOW solves the Navier Stokes equations for an incompressible fluid, under theshallow water and the Boussinesq assumptions. In the vertical momentum equation thevertical accelerations are neglected, which leads to the hydrostatic pressure equation. In 3D models the vertical velocities are computed from the continuity equation. The set of partial differential equations in combination with an appropriate set of initial and boundary conditions is solved on a finite difference grid. In the horizontal direction Delft3D-FLOW uses orthogonal curvilinear co-ordinates.

Two co-ordinate systems are supported :

- Cartesian co-ordinates (ξ, η)
- Spherical co-ordinates (λ, ϕ)

The boundaries of a river, an estuary or a coastal sea are in general curved and are not smoothly represented on a rectangular grid. The boundary becomes irregular and may introduce significant discretization errors. To reduce these errors boundary fitted orthogonal curvilinear co-ordinates are used. Curvilinear co-ordinates also allow local grid refinement in areas with large horizontal gradients. Spherical co-ordinates are a special case of orthogonal curvilinear co-ordinates with:

$$\xi = \lambda,$$

$$\eta = \phi,$$

$$\sqrt{G_{\xi\xi}} = R\cos\phi,$$

$$\sqrt{G_{\eta\eta}} = R,$$

in which λ is the longitude, ϕ is the latitude and R is the radius of the Earth (6 378.137 km, WGS84).In Delft3D-FLOW the equations are formulated in orthogonal curvilinear co-ordinates. The velocity scale is in physical space, but the components are perpendicular to the cell faces of the curvilinear grid. The grid transformation introduces curvature terms in the equations of motion.

In the vertical direction Delft3D-FLOW offers two different vertical grid systems: the σ co-ordinate system (σ-model) and the Cartesian Z co-ordinate system (Z-model). The hydrodynamicequations described in this section are valid for the σ co-ordinate system. Theequations for the Z co-ordinate system are similar.

6.4.1. Hydrodynamic equations

The governing equations of hydrodynamics model are derived by continuity equation and momentum equation as follows:

- Continuity equation:

$$\frac{\partial \zeta}{\partial t}+\frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)U\sqrt{G_{\eta\eta}}\right]}{\partial \xi}+\frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)V\sqrt{G_{\xi\xi}}\right]}{\partial \eta}=Q,$$

With Q representing the contributions per unit area due to the discharge or withdrawal of water, precipitation and evaporation:

$$Q=H\int_{-1}^{0}(q_{in}-q_{out})\,d\sigma+P-E,$$

With qinand qoutthe local sources and sinks of water per unit of volume [1/s], respectively, P the non-local source term of precipitation and E non-local sink term due to evaporation. Weremark that the intake of, for example, a power plant is a withdrawal of water and should bemodelled as a sink. At the free surface there may be a source due to precipitation or a sinkdue to evaporation.

The momentum equations in ξ- and η-direction are given by:

- Momentum equation in ξ-component:

$$\frac{\partial u}{\partial t}+\frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial u}{\partial \xi}+\frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial u}{\partial \eta}+\frac{\omega}{d+\zeta}\frac{\partial u}{\partial \sigma}-\frac{v^2}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial \xi}+$$
$$+\frac{uv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\xi\xi}}}{\partial \eta}-fv=-\frac{1}{\rho_0\sqrt{G_{\xi\xi}}}P_\xi+F_\xi+$$
$$+\frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\nu_V\frac{\partial u}{\partial \sigma}\right)+M_\xi,$$

- Momentum equation in η-component:

$$\frac{\partial v}{\partial t}+\frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial v}{\partial \xi}+\frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial v}{\partial \eta}+\frac{\omega}{d+\zeta}\frac{\partial v}{\partial \sigma}+\frac{uv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial \xi}+$$
$$-\frac{u^2}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\xi\xi}}}{\partial \eta}+fu=-\frac{1}{\rho_0\sqrt{G_{\eta\eta}}}P_\eta+F_\eta+$$
$$+\frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\nu_V\frac{\partial v}{\partial \sigma}\right)+M_\eta.$$

The vertical velocity ω in the adapting σ-co-ordinate system is computed from the continuity equation:

$$\frac{\partial \zeta}{\partial t} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \frac{\partial \left[(d+\zeta) u \sqrt{G_{\eta\eta}}\right]}{\partial \xi} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \frac{\partial \left[(d+\zeta) v \sqrt{G_{\xi\xi}}\right]}{\partial \eta} + \frac{\partial \omega}{\partial \sigma} = H\left(q_{in} - q_{out}\right).$$

Density variations are neglected, except in the baroclinic pressure terms, $P\xi$ and $P\eta$ represent the pressure gradients. The forces $F\xi$ and $F\eta$ in the momentum equations represent the unbalance of horizontal Reynold's stresses. $M\xi$ and $M\eta$ represent the contributions due to external sources or sinks of momentum (***external forces by hydraulic structures, discharge or withdrawal of water, wave stresses, etc***.).

6.4.2. Boundary condition and initial condition

Boundary condition consists of an open boundary condition (boundary area with sea models) and closed boundary conditions (border of the model with the island). The initial condition in question is giving the starting price (initialization) to the variable state variable at time t = 0.

At the open boundary velocity gradient is considered very small currents that can be ignored, especially if the depth of water in the open boundary is large enough. This means that the speed at the outermost cells in the open together with the speed limit on the cell next to it. Water level at this boundary is taken from field data measurement tidal elevation by Cubic Spline interpolation for each time step. In the closed boundary, the coastline is considered a vertical wall that does not allow water masses pass through; taken semi-slip boundary condition, the current velocity in a direction perpendicular to the beach is equal to zero, while the current speed tangensialnya should not be zero.

It is assumed that the waters were reviewed at the start of the simulation are in a state of calm that is mathematically written as follows:

$$U = V = \zeta = 0 \quad \text{for} \quad t = 0$$

If the simulation does not start from the beginning, the speed and elevation values are taken from the previous value.

6.4.3. Thermal and salinity dispersion modeling

In this thermal dispersion models used the concept of ocean-atmosphere interactions. The coefficient of heat exchange between the ocean - the atmosphere is determined by empirical methods.In the thermal dispersion models should be added the thermal source. When the thermal output of the source (QT) varies with time, the full model equations are as follows:

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = K_x\frac{\partial^2 T}{\partial x^2} + K_y\frac{\partial^2 T}{\partial y^2} + \frac{A}{\rho C_p h}\left(T - T_E\right) + Q_T$$

While :

T	= actual temperature
T_E	= natural temperature
Q_T	= the rate of temperature change
u,v	= depth averaging velocity *x*, *y* component (ms^{-2})
K_x, K_y	= turbulent diffusion coefficient of the x, and y
A	= (4,48 + 0,049T) + f(1,12 + 0,0180T + 0,00158T^2)
	= coefficient of sea-air heat exchange
f	= 3,6 + 2,5W_3
	= wind factors for the coefficients A
r	= the density of sea water
C_p	= specific heat at constant pressure
h	= Sea depth

For practical purposes it can be assumed that the water area is quite small reviewed the T_E value is taken from the value of the temperature of the sea water in places far from a point source of heat. This equation will be used in thermal dispersion models, for example, which can be applied to the case of waste heat from power plants and the like. Input currents at each grid point used are the result of hydrodynamic model simulations.

6.5. Data collection and model calibration

6.5.1. Data collection

The following data has been collected as part of the this study:

- Bathymetric survey of the study area
- Current and water level measurements using ADCPs (Acoustic Doppler Current Profiler)
- Temperature measurement from CTDs (Current Temperature and Depth)
- Water quality samples

Refer to the separate Bathymetric Survey andSeawater Data Collection Report for further details.

6.5.2. Model calibration

At least two data sets area required to adequately calibrate and validate a numerical model. The general procedure used to calibrated was to first collect field data. For this purpose we area using two station current data to calibrate a numerical model. The location of station observation are in the model domain (**figure 6.5**). this is the resulst of calibration :

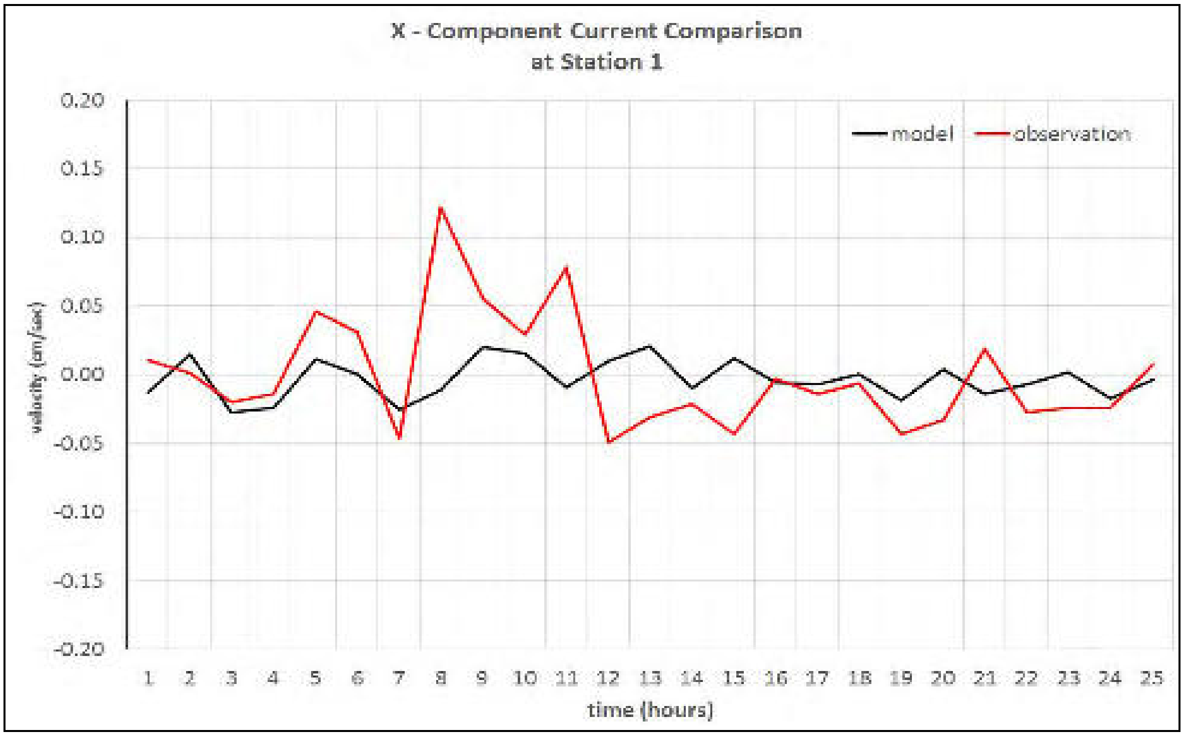


Figure 6.3. **Graphics comparison current velocity x (Vx) Model vs Observation at station 1**

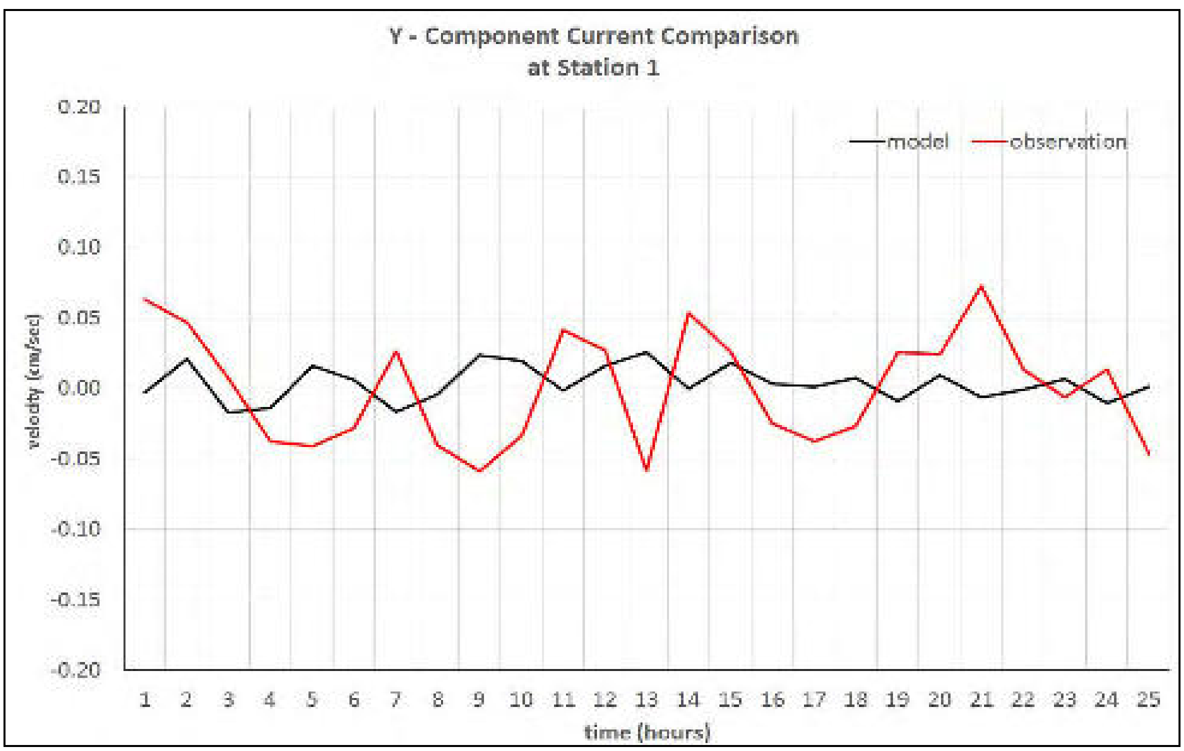


Figure 6.4. Graphics comparison current velocity y (Vy) Model vs Observation at station 1

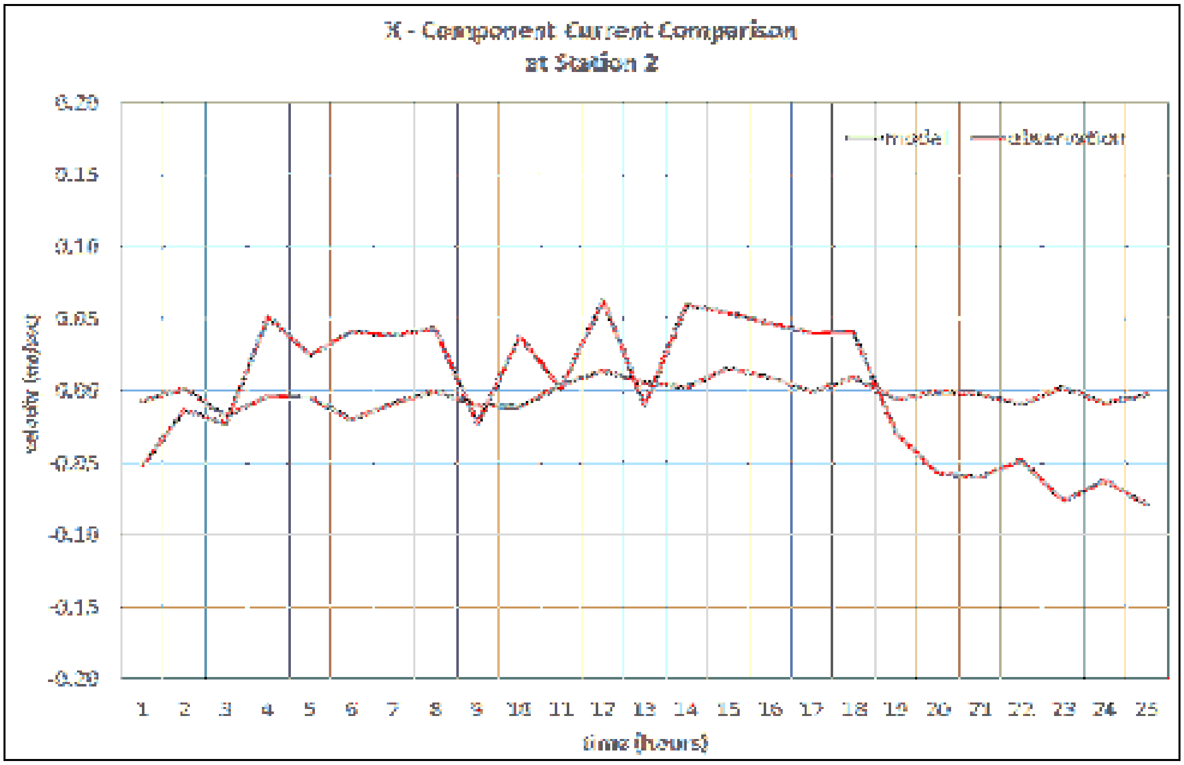


Figure 6.5. Graphics comparison current velocity x (Vx) Model vs Observation at station 2

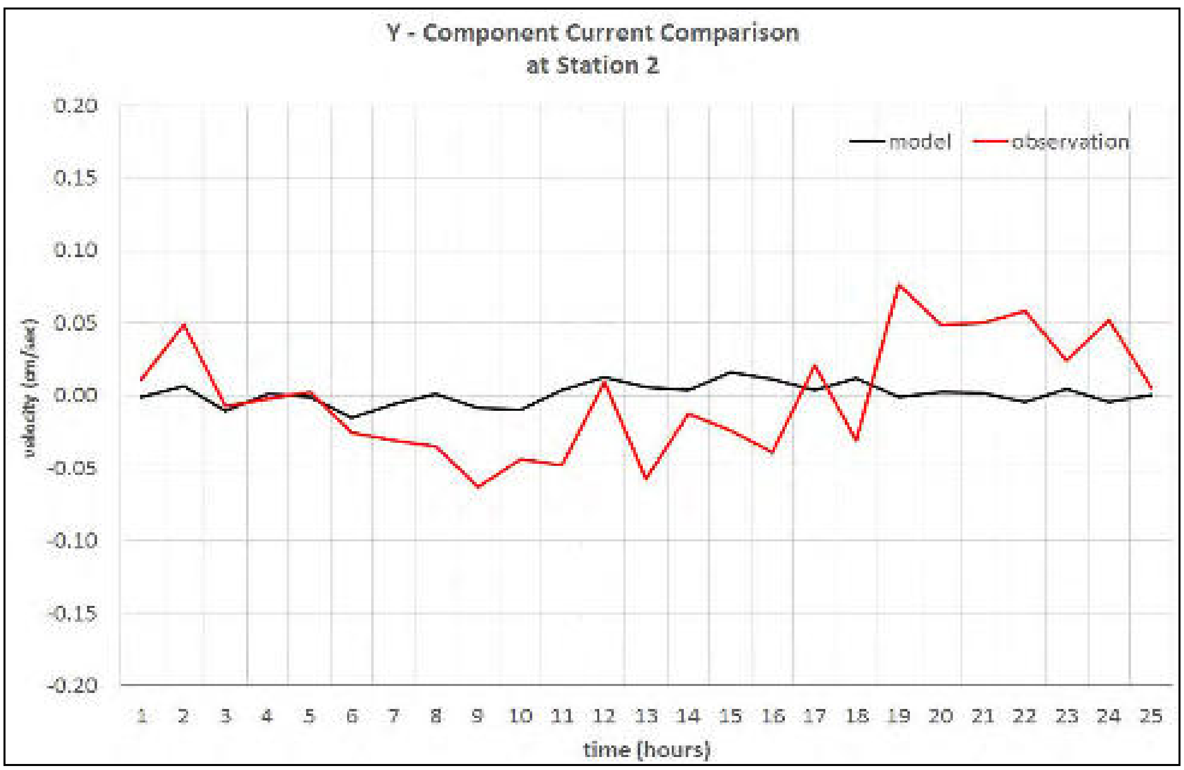


Figure 6.6. Graphics comparison current velocity y (Vy) Model vs Observation at station 2

6.5.3. Model domain

The domain model is based on a curvilinear grid. The spatial resolution in the model varies across the model area, typically increasing resolution towards the project site. The resolution was approximately X m offshore and ranged between X m to Y m at the study area. The vertical resolution layer of the model is defined by Z layers.

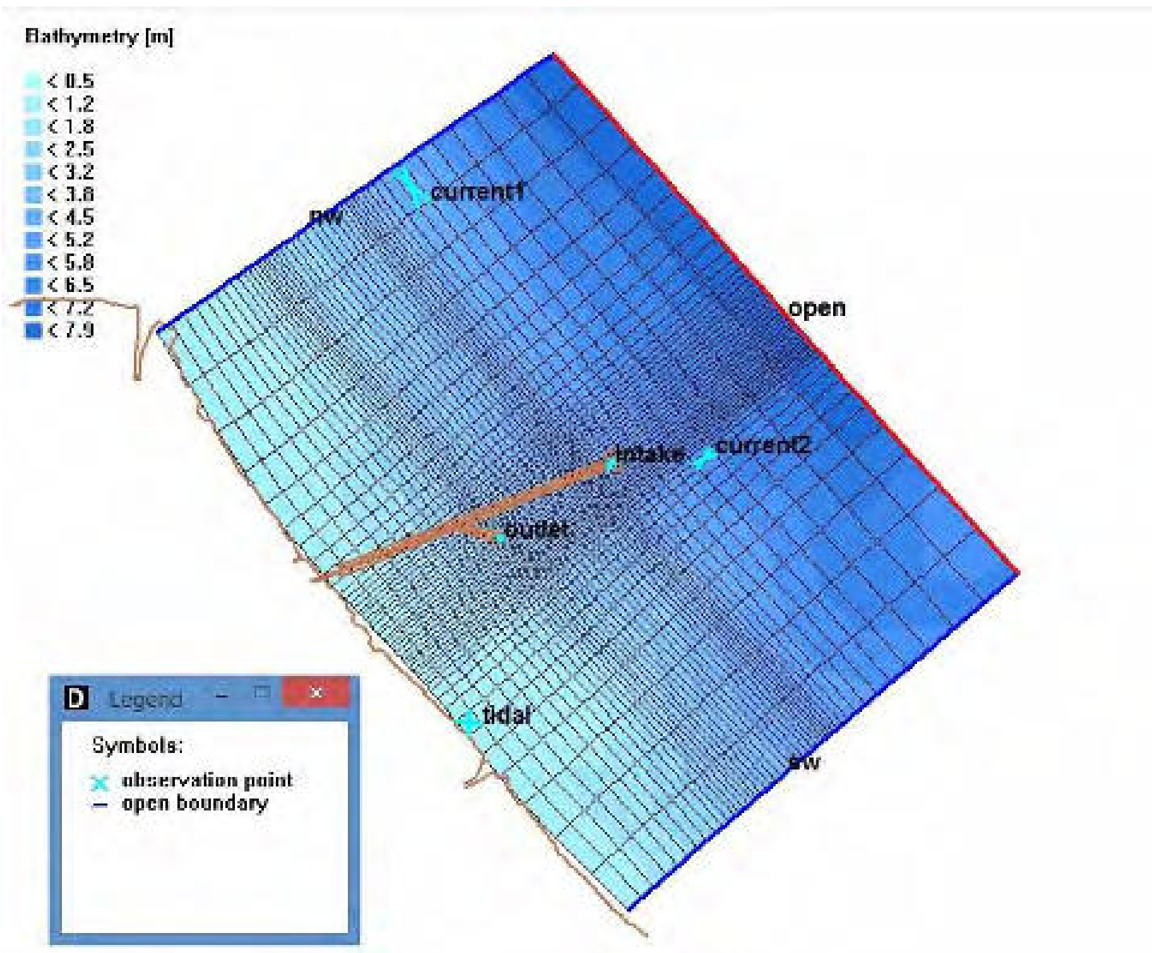


Figure 6.7. Curvilinear grid.

6.5.4. Boundary conditions

The Regional Model is driven by water levels at the open and internal boundaries established from tidal observation.

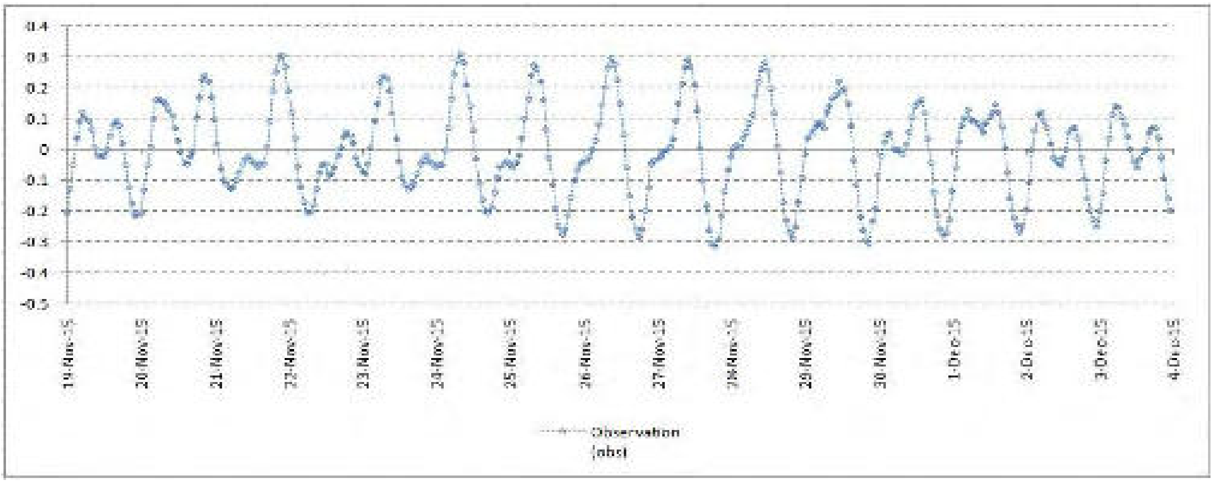
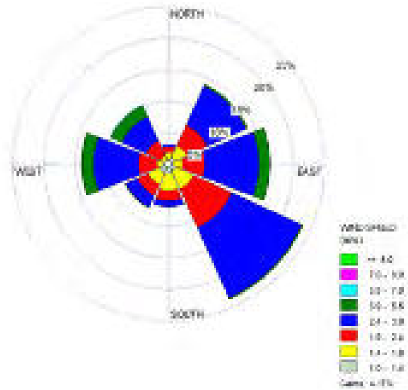


Figure 6.8. Tidal model boundaries

6.5.5. Meteorological forcing (wind set-up)

Three-dimensional modelling is of particular interest in transport problems where the horizontal flow field shows significant variation in the vertical direction. This variation may be generated by wind forcing, bed stress, Coriolis force, bed topography or density differences. Examples are dispersion of waste or cooling water in lakes and coastal areas, upwelling and downwelling of nutrients, salt intrusion in estuaries, fresh water river discharges in bays and thermal stratification in lakes and seas.

The regional pressure and wind fields associated with the monsoon periods are known to drive net currents. The magnitude and direction of the net current varies with the seasons, and for the present limited simulation period, this variation has been included from the simulations. Besides the monsoon variation, the net current may vary due to variations in the regional wind and pressure fields as well as more localized meteorological phenomena.



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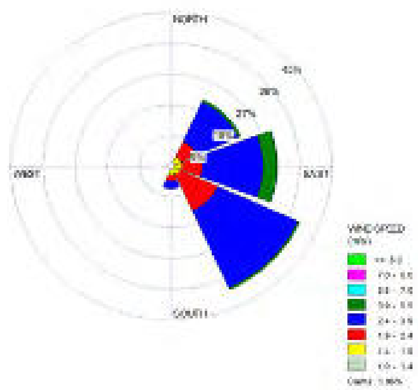
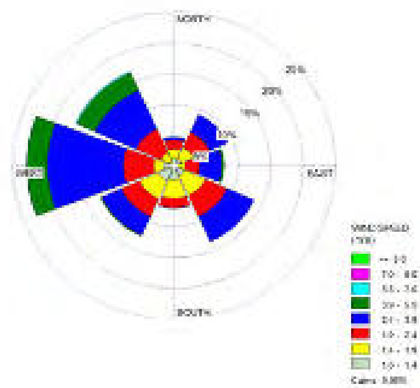




b c

Figure 6.9. a. Wind Rose (blowing from)one year, b. Dry season and c. Rainy season during the Year 2015 (Data from Observation Satellites at coordinates 6.25, 107.6, height of 10 m above the ground)

6.6. Seawater intake and waste water outfall configuration

The intake and outfall configuration that has been considered in this modelling is shown in the figure below.

Figure 6.10. Intake and outfall configuration of Jawa 1 CCGT power plant

For the purposes of this study, it has been assumed the water water will be discharged via a diffuser comprising 5 exit pipes of DN200, each separated by a distance of 5m. The exit pipes release the water 0.5 meters above the seabed. The selected diffuser geometrical features are shown in the Figure below and summarised in the Table below.

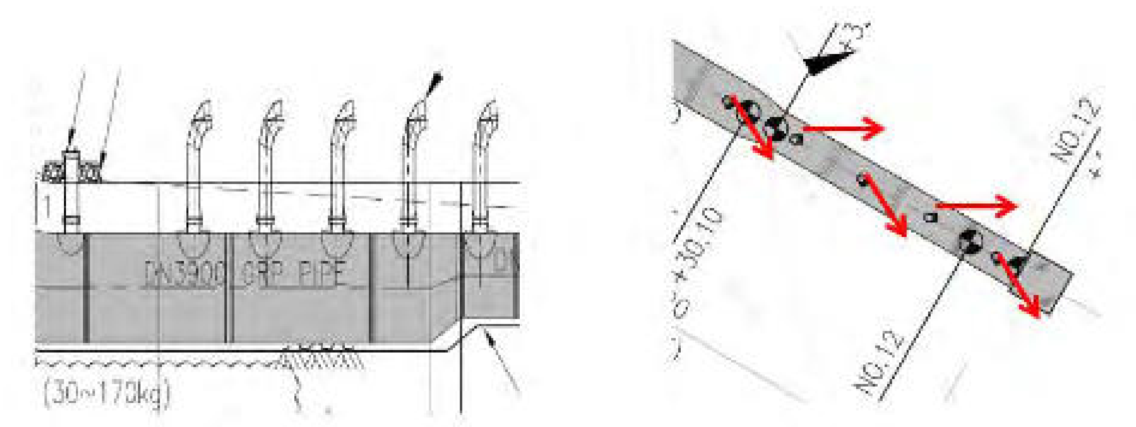


Figure 6.11. Jawa -1 CCGT, water outlet diffuser geometrical features

Table 6.2. Jawa - 1 CCGT water outlet diffuser geometrical features

Parameter	Value
Discharge position	As per Figure above
Length of diffuser	20m
Number of outlet risers	5
Distance between outlet risers (m)	5m
Number of outlet ports per riser	1
Total number of outlet ports on diffuser	5
Distance of port above sea bed (m)	1
Discharge direction	Multi-directional

The modelling has been carried out assuming a temperature of 30.5°C and a salinity of 30 ppt (Design Purpose) to represent background temperature and salinity conditions. These values are based on the measurements taken in the vicinity of intake and outfall which are presented in the separate report entitled "Bathymetric Survey and Seawater Data Collection Report". The salinity value of 30 ppt is lower than typical seawater (around 35 ppt), which is attributed to the freshwater entering the Java Sea from the Cilamaya River in the vicinity of the intake and discharge locations.

The characteristics of the waste water discharge from the Jawa 1 CCGT power plant are presented below

1. **Waste water discharge flowrate**

   Waste water flowrate : 8,250 m^3/h. (worse case)

2. **Waste water discharge temperature**

   waste water discharge temperature : 36^0C (worse case)

3. **Waste water discharge salinity**

   waste water discharge salinity : 42 ppt (1.4 x Design purpose salinity)

The temperature of the waste water discharge will actually vary with ambient temperature and relative humidity as it depends on performance of cooling towers. The temperature of 36^oC reflects the plant operating at 100% load under "worst case ambient conditions". Under normal ambient conditions, the temperature of the waste water should be around four or five degrees lower. Thus in practice the heat release should be lower, with a lower flow rate and/or lower temperature. The modelling may therefore be considered to be conservative.

6.7. Modeling scenarios

The modelling assumed all three units of the power plant operating continuously at 100% load with the waste water release parameters shown in the section above. This is conservative in view of the fact that the Jawa 1 CCGT is expected to be a load following CCGT with capacity factor of 60%.

6.8. Simulation result

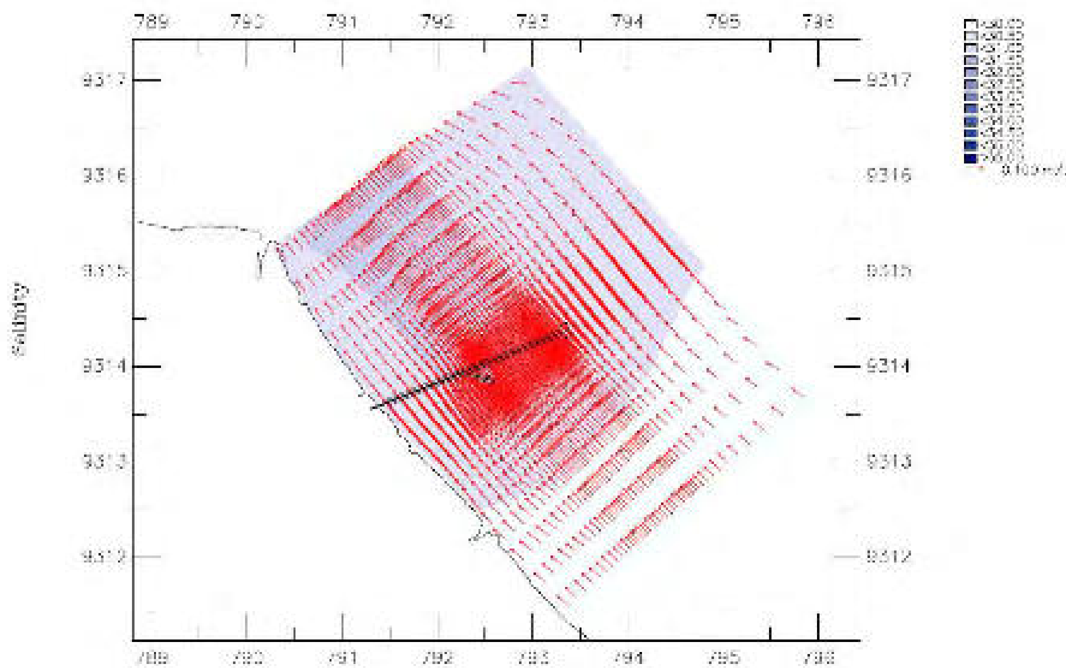
Analysis of salinity dispersion results are conducted in the location area of outfall and water intake location, when the spring tide, minimum and downs, the west and east monsoon season.

Discharges have been simulated operating continuously for at least 14 days in the model, to allow build up of the far field excess temperature over many tidal cycles.

The objective of this simulation is to consider salinity and thermal value at (i) the edge of the relevant mixing zone around the point of discharge and (ii) the water intake location.

6.8.1. Salinity dispersion modeling

1. **Dry Season (East Monsoon)**



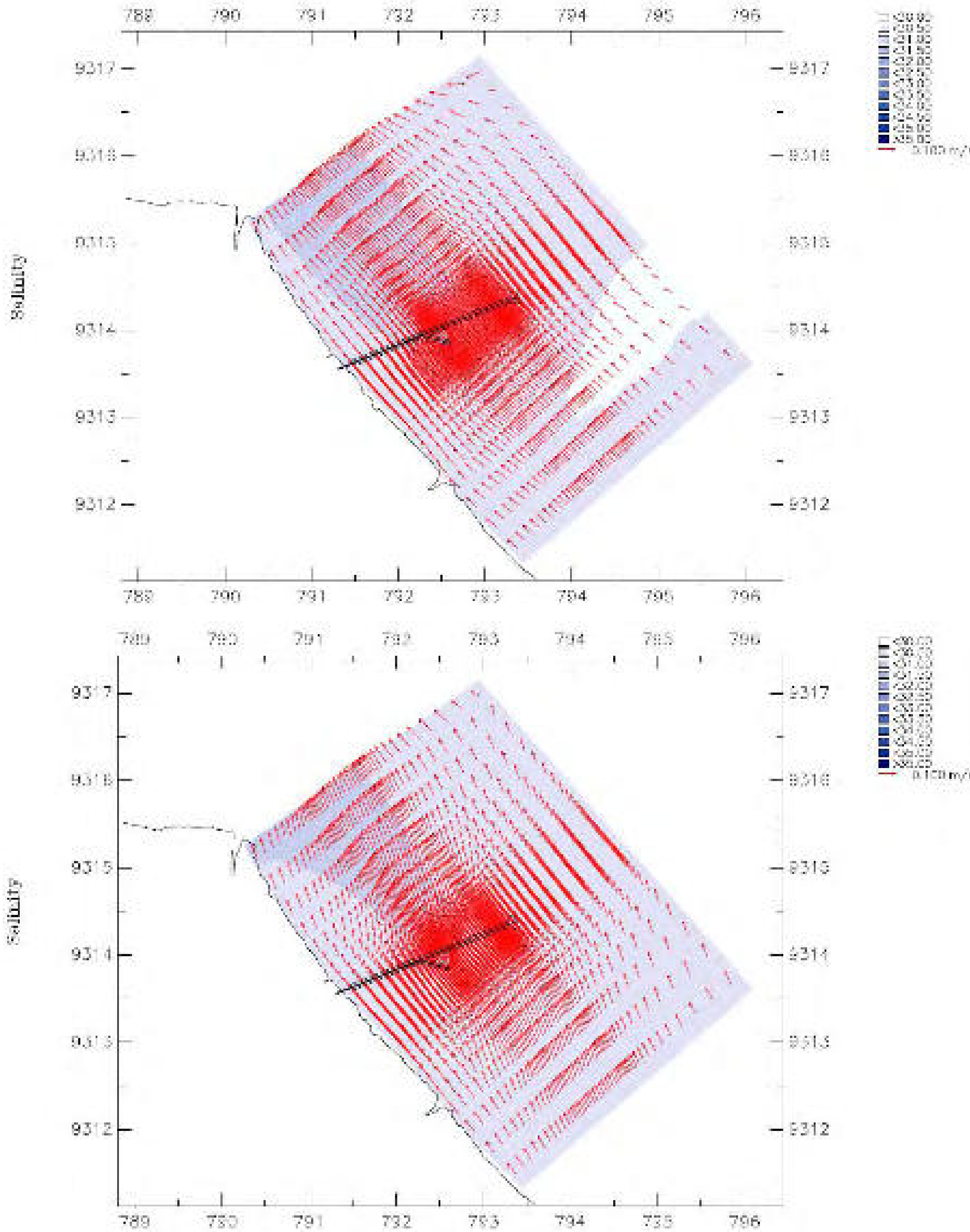
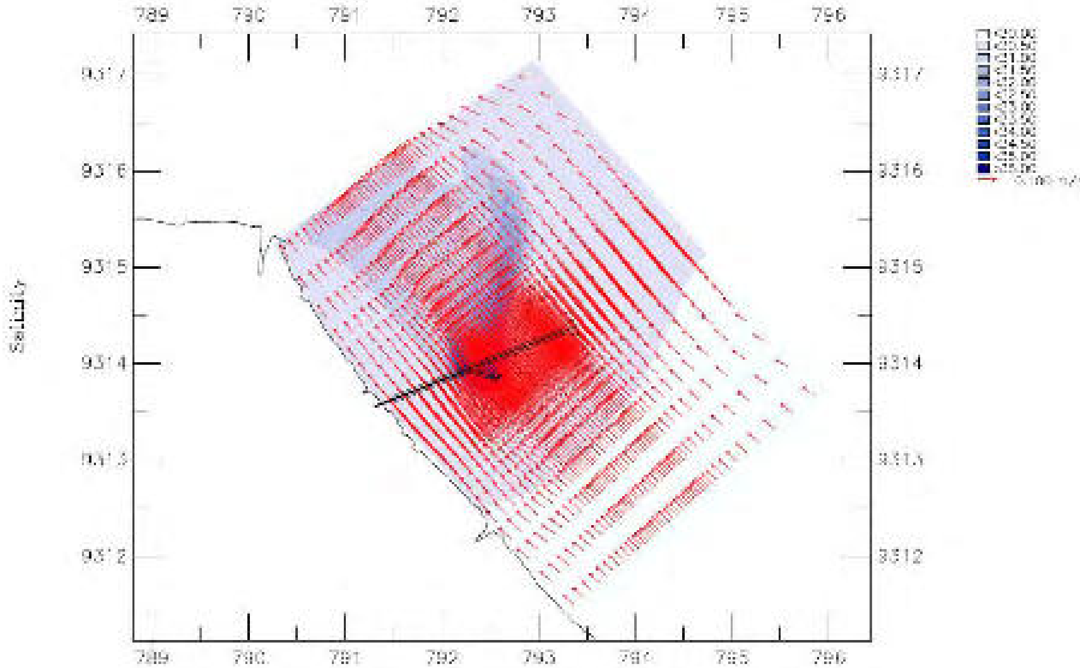


Figure 6.12. Salinity concentration values dispersion on surface (layer 1 model) during East Monsoon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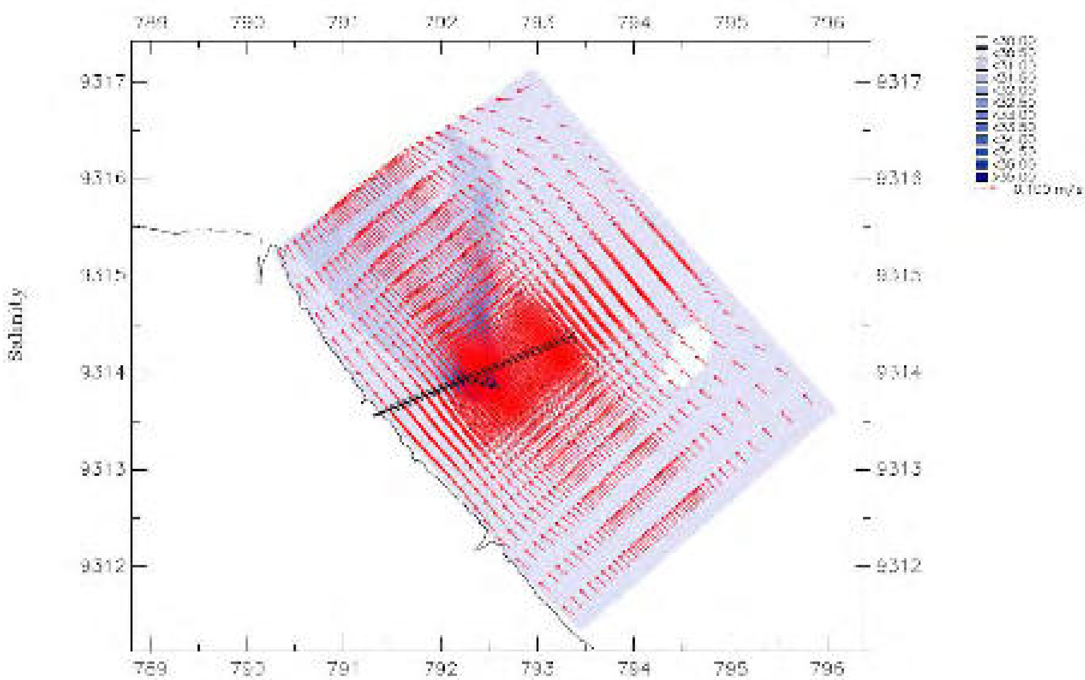
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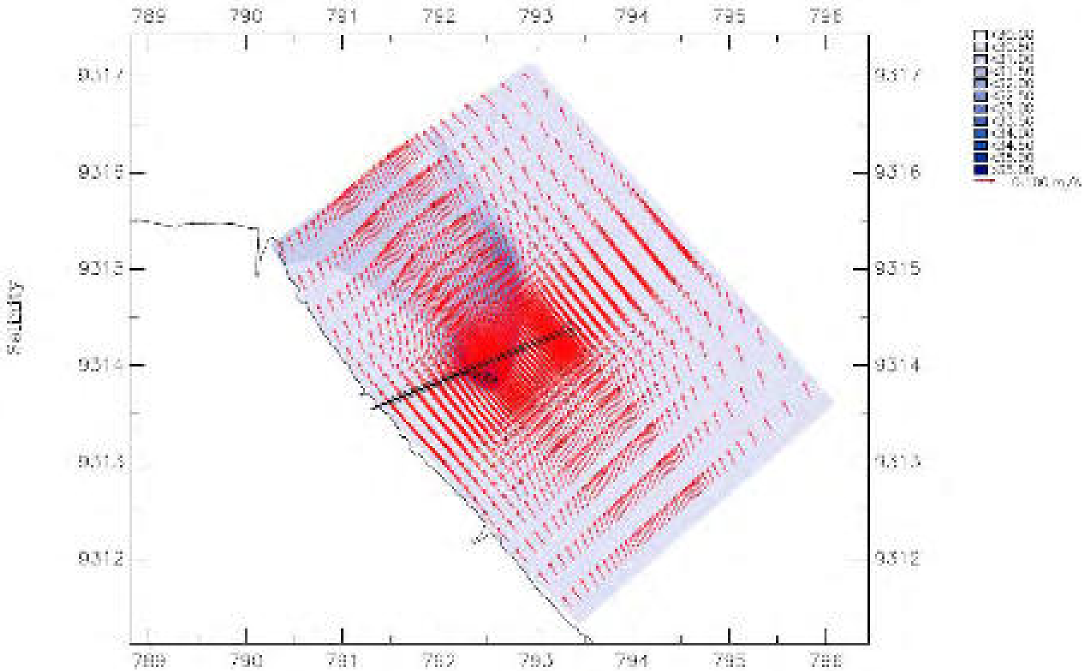
Salinity
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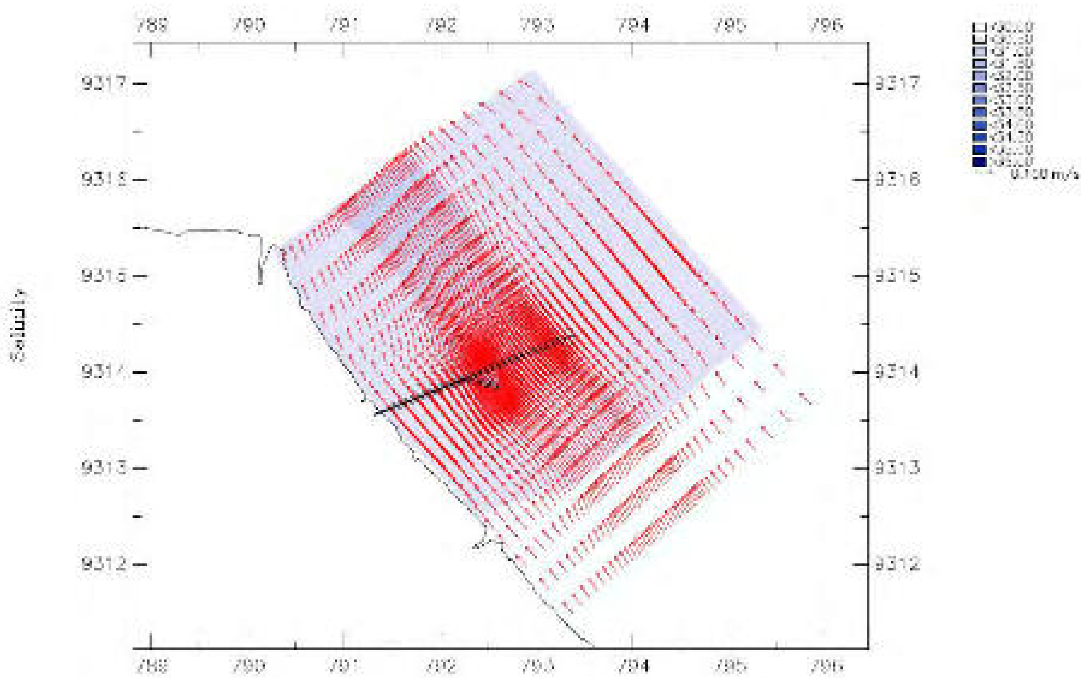
Salinity
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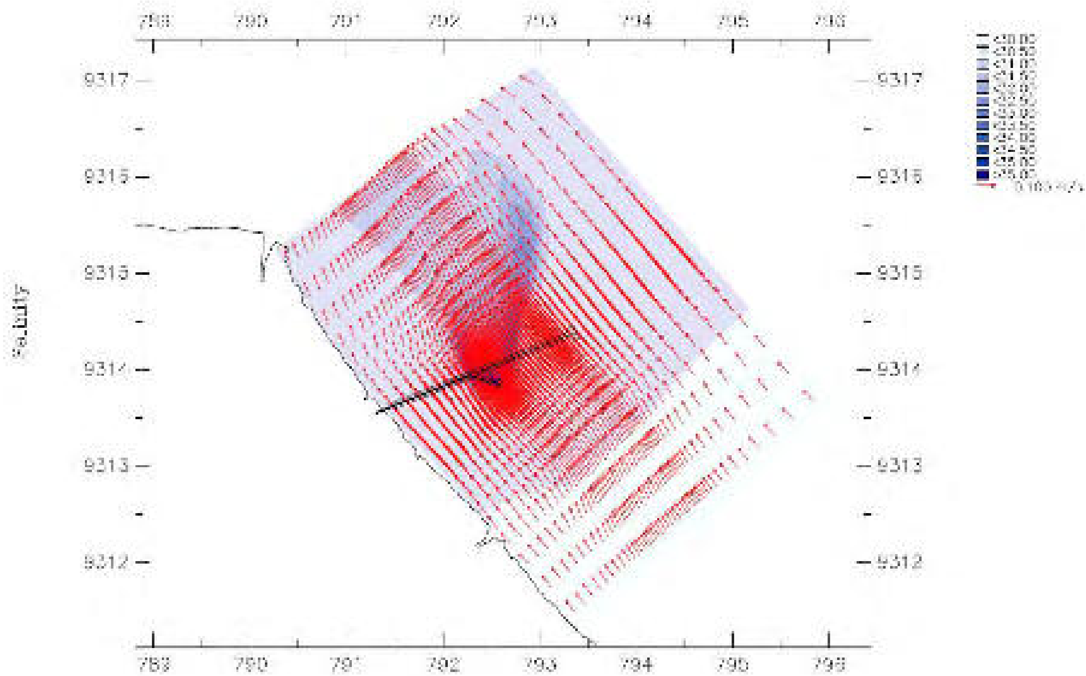


Figure 6.13. Salinity concentration values dispersion on near bottom (layer 3 model) during East Monsoon

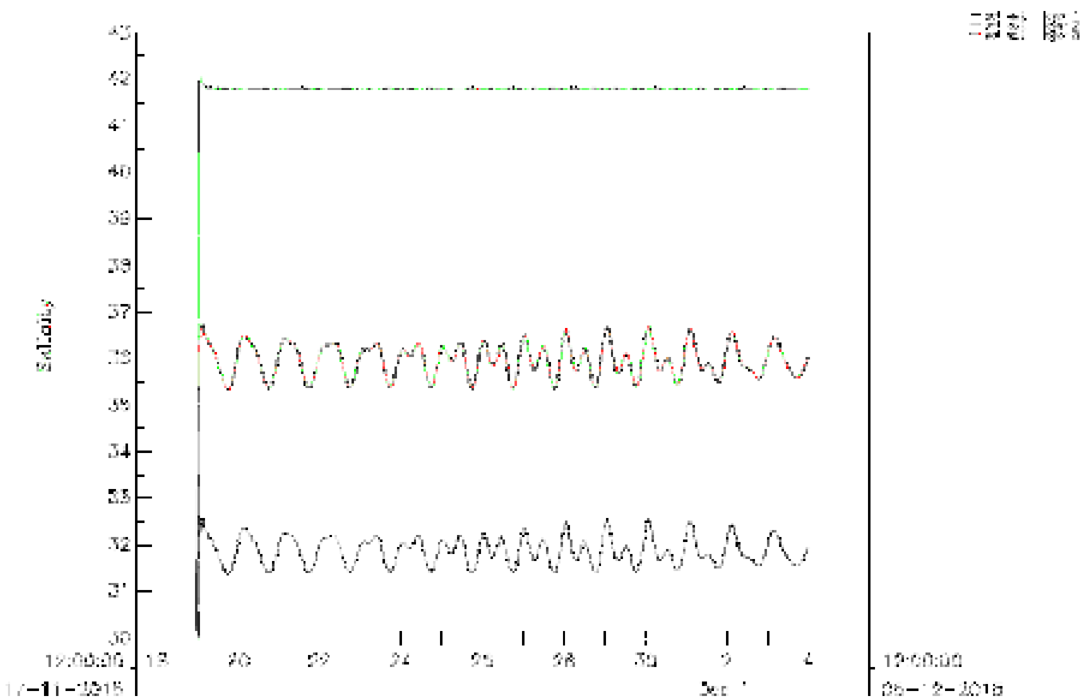


Figure 6.14. Salinity concentration values in water Outlet during East Monsoon

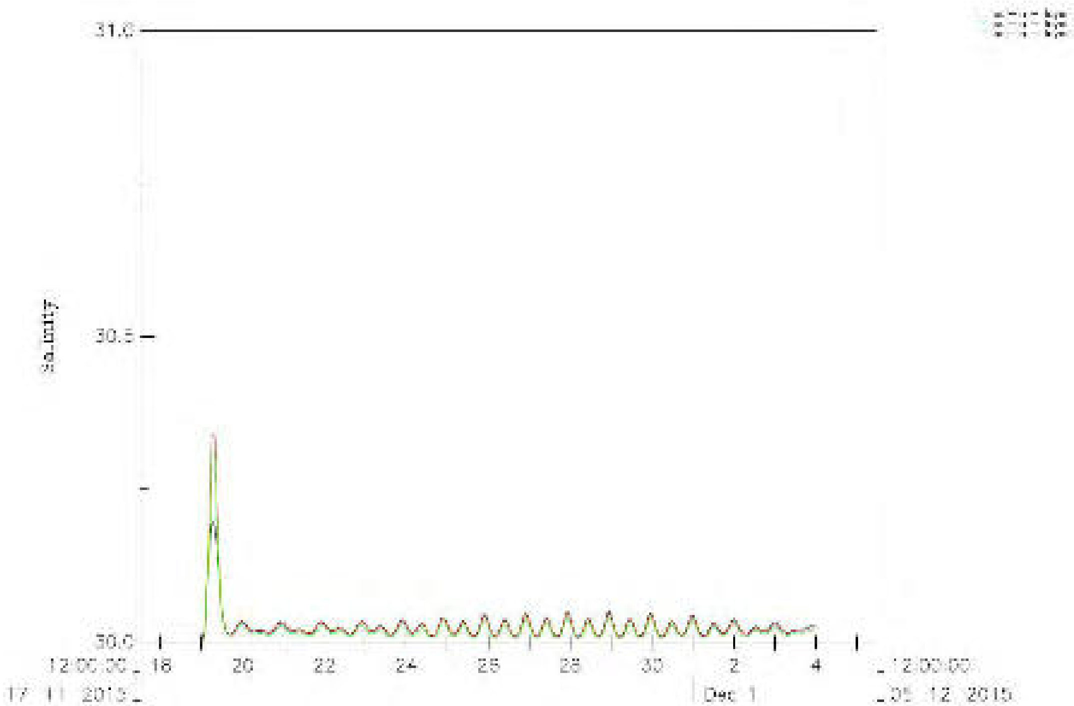


Figure 6.15. Salinity concentration values in water intake during East Monsoon

Figure 6.10. shows salinity dispersion on surface (layer 1 model) during east monsoon. Salinity dispersion in this conditions seen towards dominant to the north and northwest, the diffusion process in east monsoon condition dominant spreading to northwest. In this condition the distribution of salinity distributionis not reach the water intake area with this value. The salinity value 100 meters from outlet (mixing zone area) in the surface is about 32.57 ppt (delta 2.57 ppt from initial condition or ambien salinity):

Excess salinity predictions during the East Monsoon at the water intake location and edge of 100 meters mixing zone are shown in the table below:

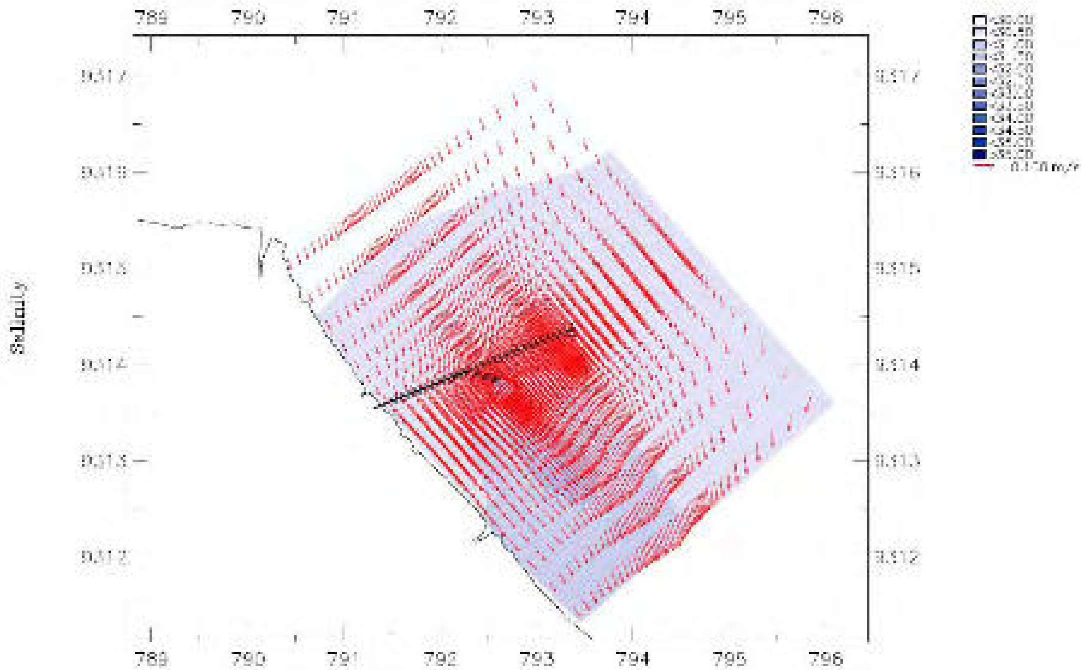
Table 6.3. Predicted Average and Max Excess Salinity (during West Monsoon) in surface (Layer 1 model)

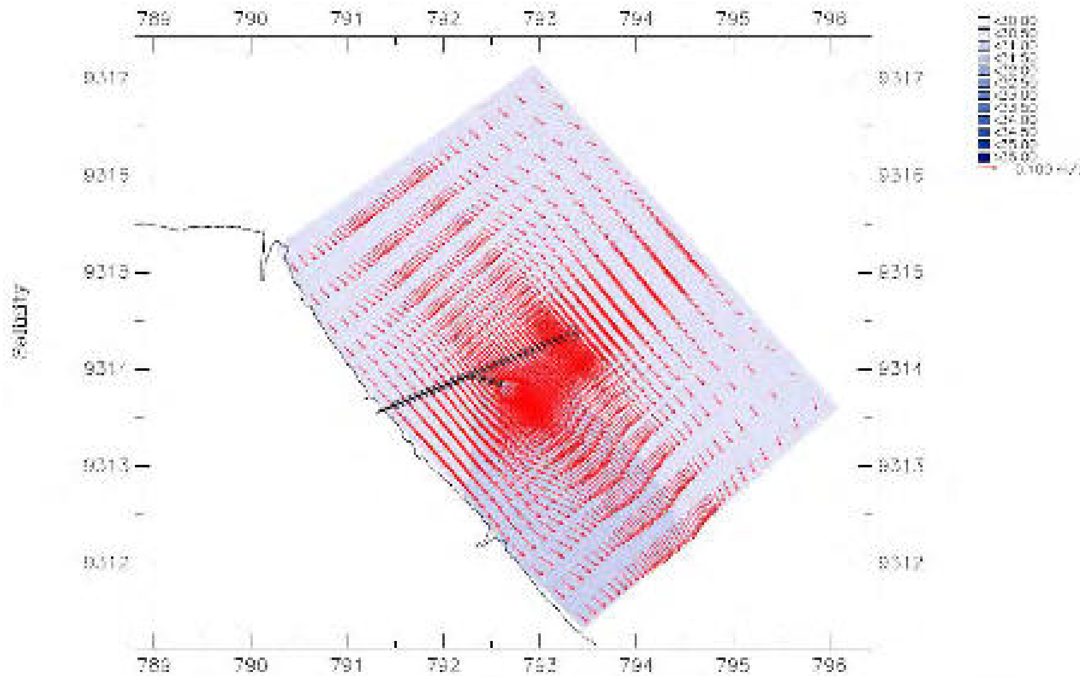
	At intake location	At edge of mixing zone
Max (note 1)	30.2	32.57
Average	30.026	31.87

Note 1 : 95th percentile (i.e. temp exceeded to 5% of time)

With reference to the above it can be concluded that the excess salinity has returned to ambient levels in distance 500 meters - 2000 meters from outlet in east moonson condition.

2. Rainy Season (West Monsoon)

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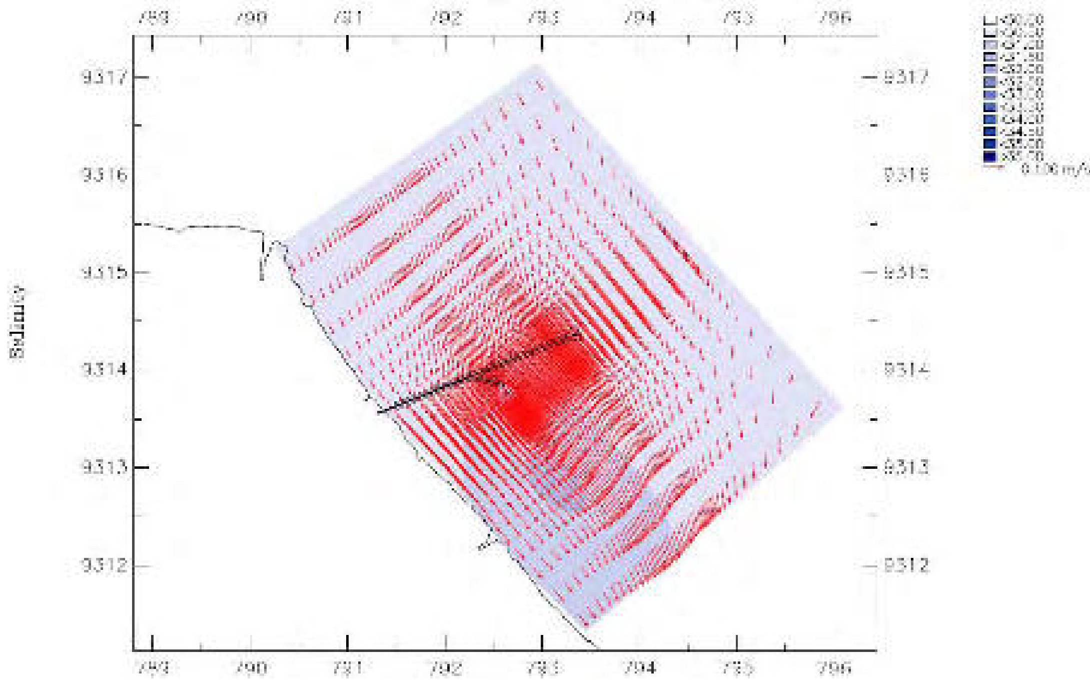
Salinity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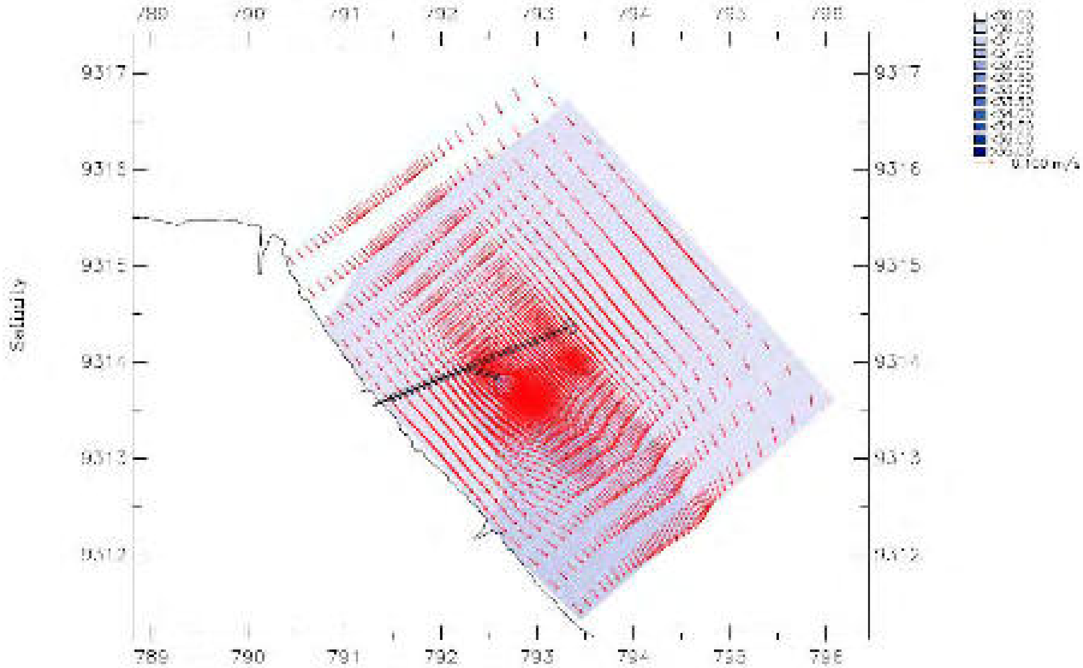
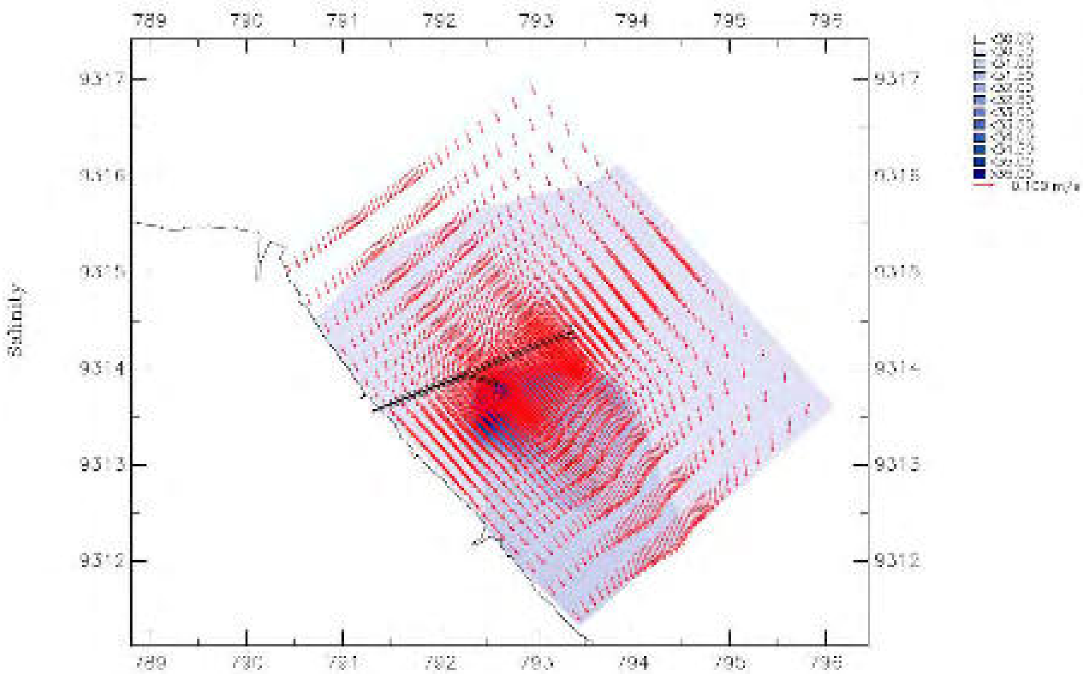
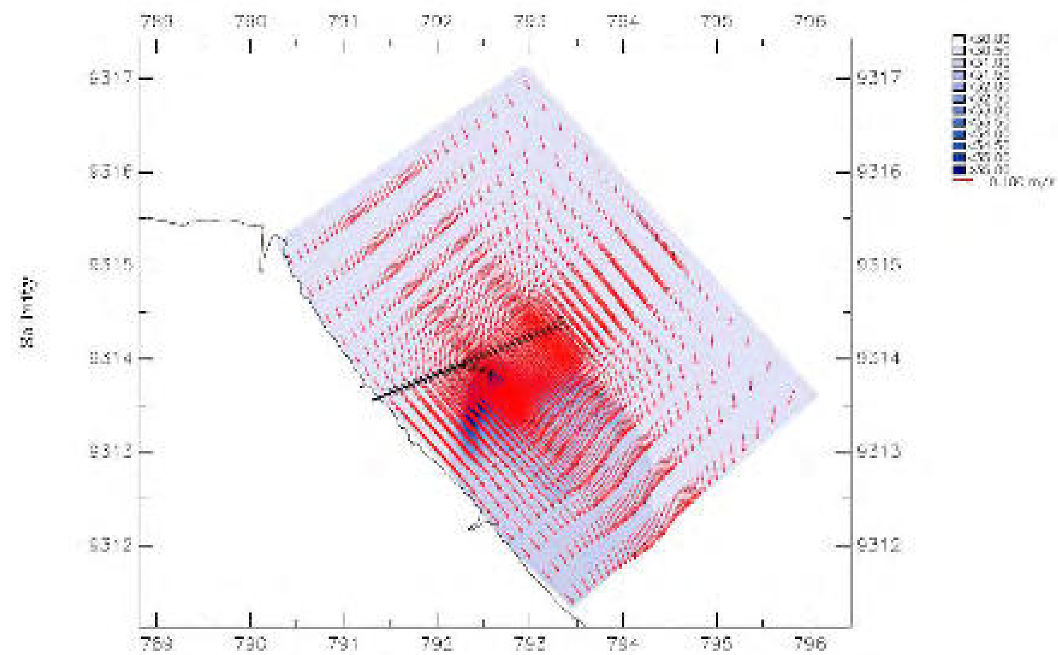
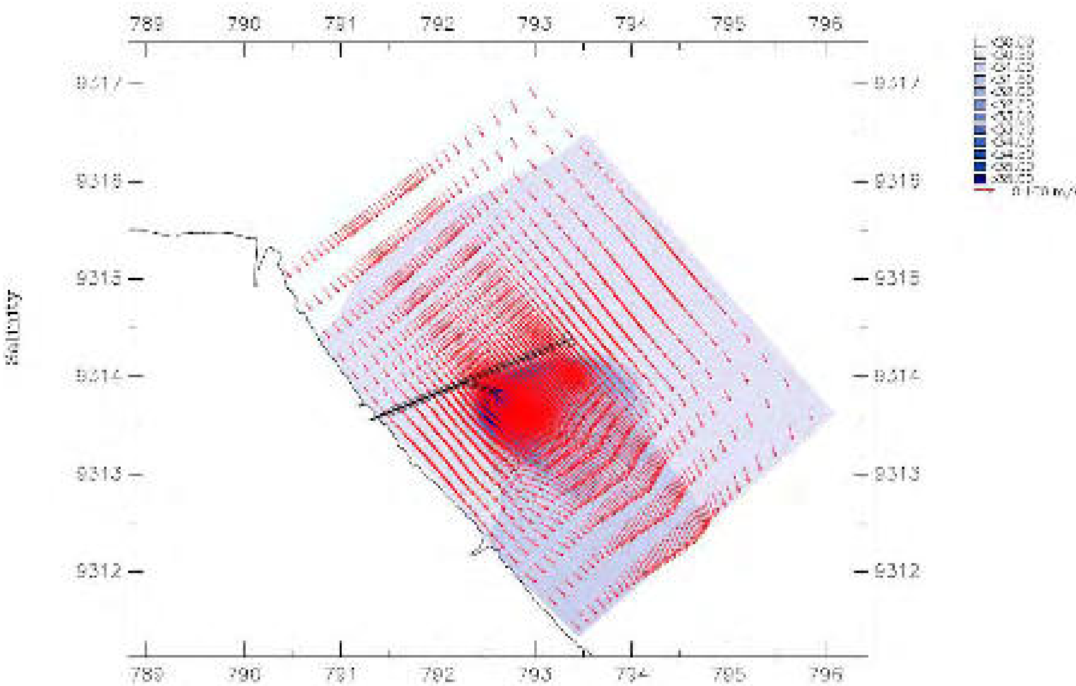


Figure 6.16. Salinity concentration values dispersion on surface (layer 1 model) during West Monsoon




Salinity
0.100 m/s


Salinity

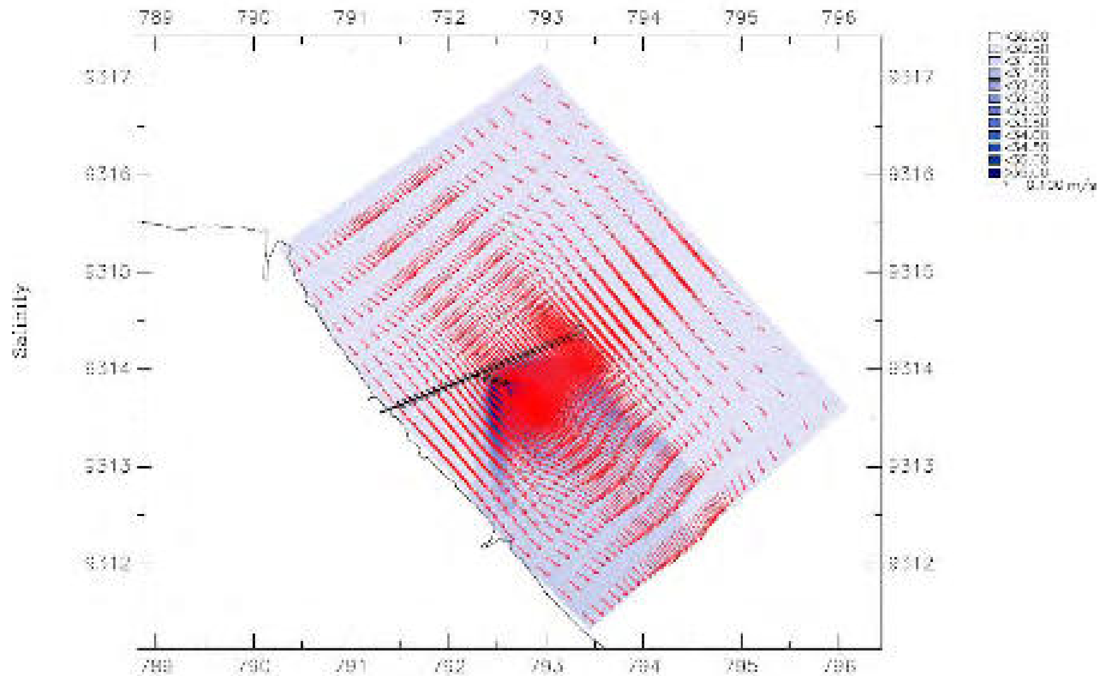


Figure 6.17. Salinity concentration values dispersion on near bottom (layer 3 model) during West Monsoon

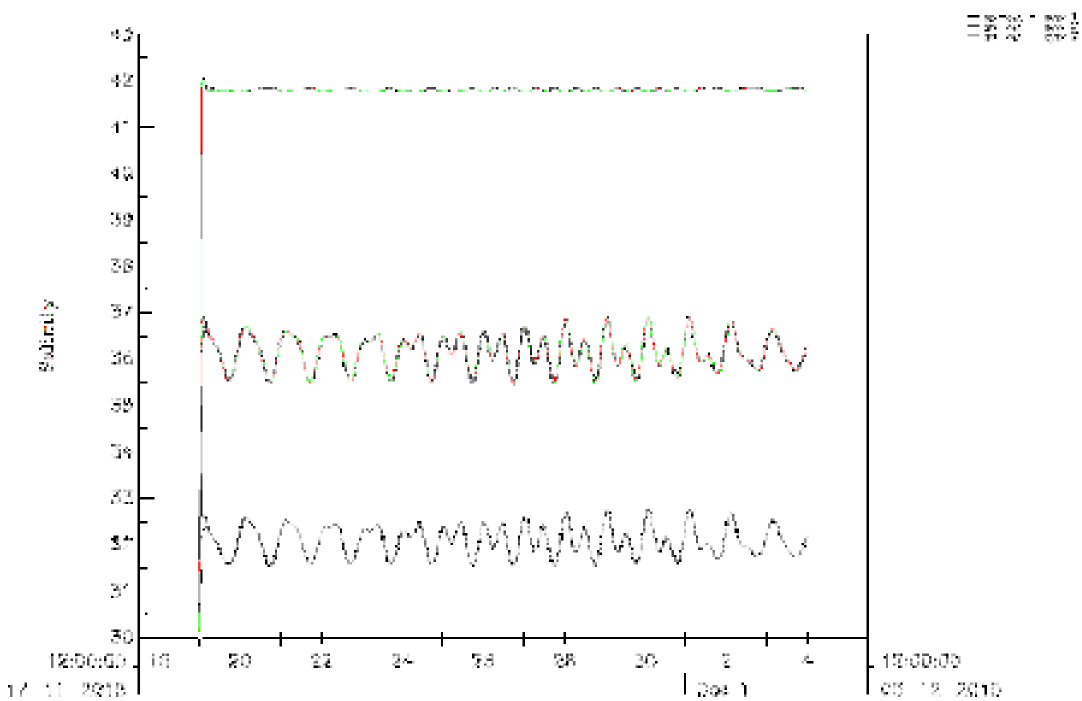


Figure 6.18. Salinity concentration values in water outlet during West Monsoon

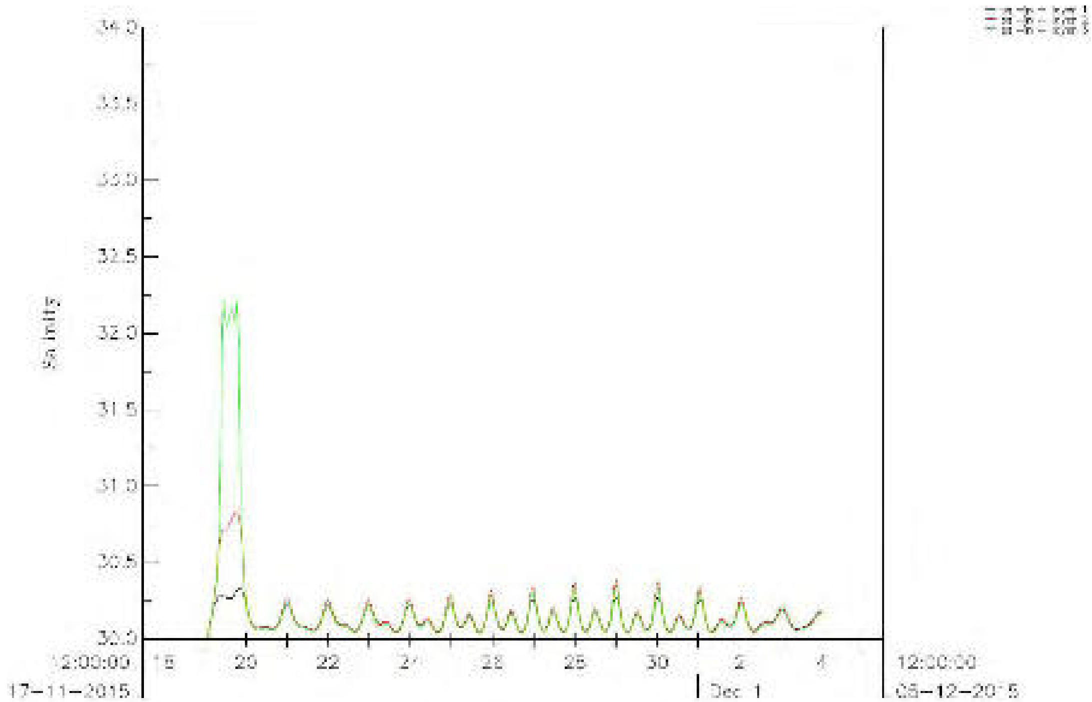


Figure 6.19. Salinity concentration values in water intake during West Monsoon

Figure 6.15. shows salinity dispersion on surface during west monsoon. Salinity dispersion in this conditions seen towards dominant to southwest, the diffusion process is also contributing of spreading salintiy to the other directions. In this condition the distribution of salinity distribution reach the water intake area with this value. Excess salinity predictions during the West Monsoon at the water intake location and edge of 100 meters mixing zone are shown in the table below:

Table 6.4. Predicted Average and Max Excess Salinity (during West Monsoon)

	At intake location	At edge of mixing zone
Max (note 1)	30.33	32.8
Average	30.13	32.08

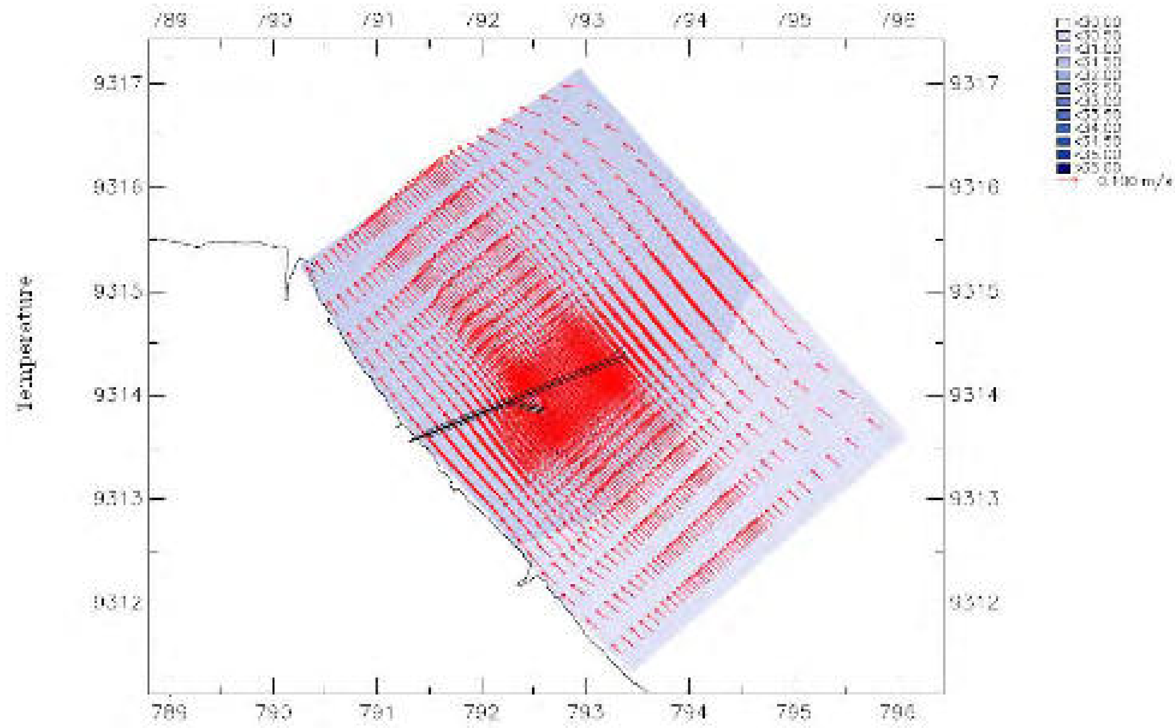
Note 1 : 95th percentile (i.e. temp exceeded to 5% of time)

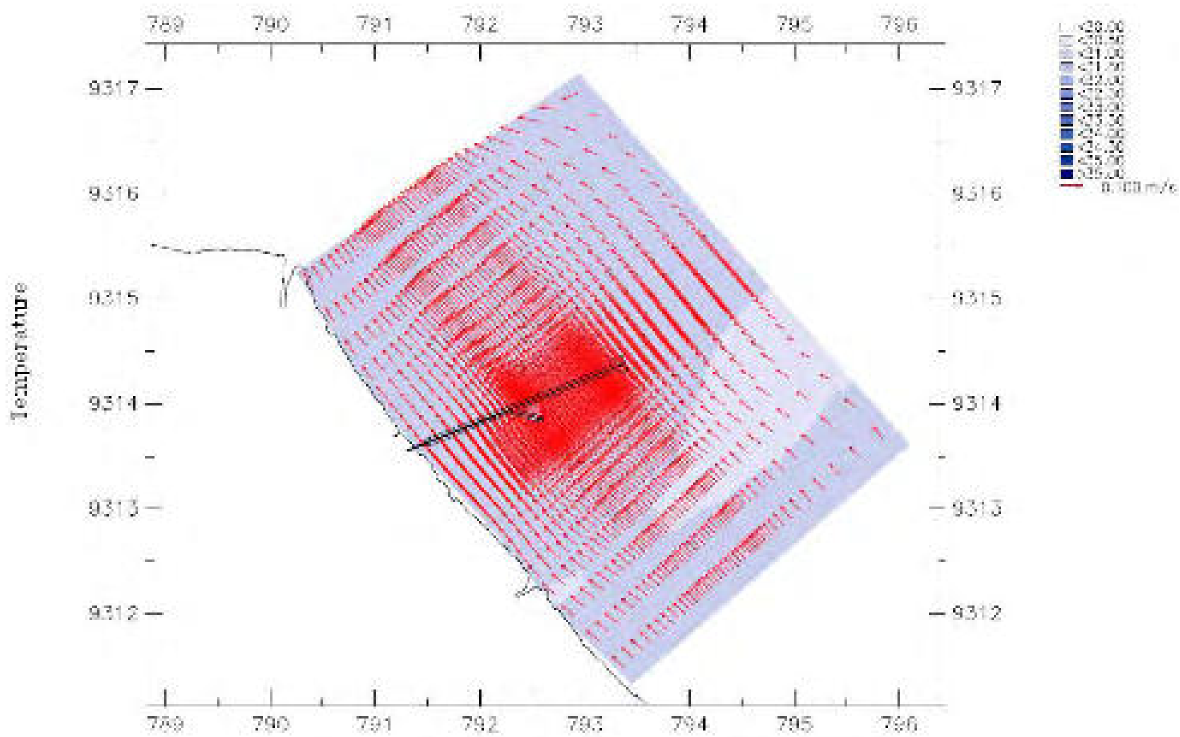
With reference to the above it can be concluded that the excess salinity has returned to ambient levels more than 1000 meters from outlet.

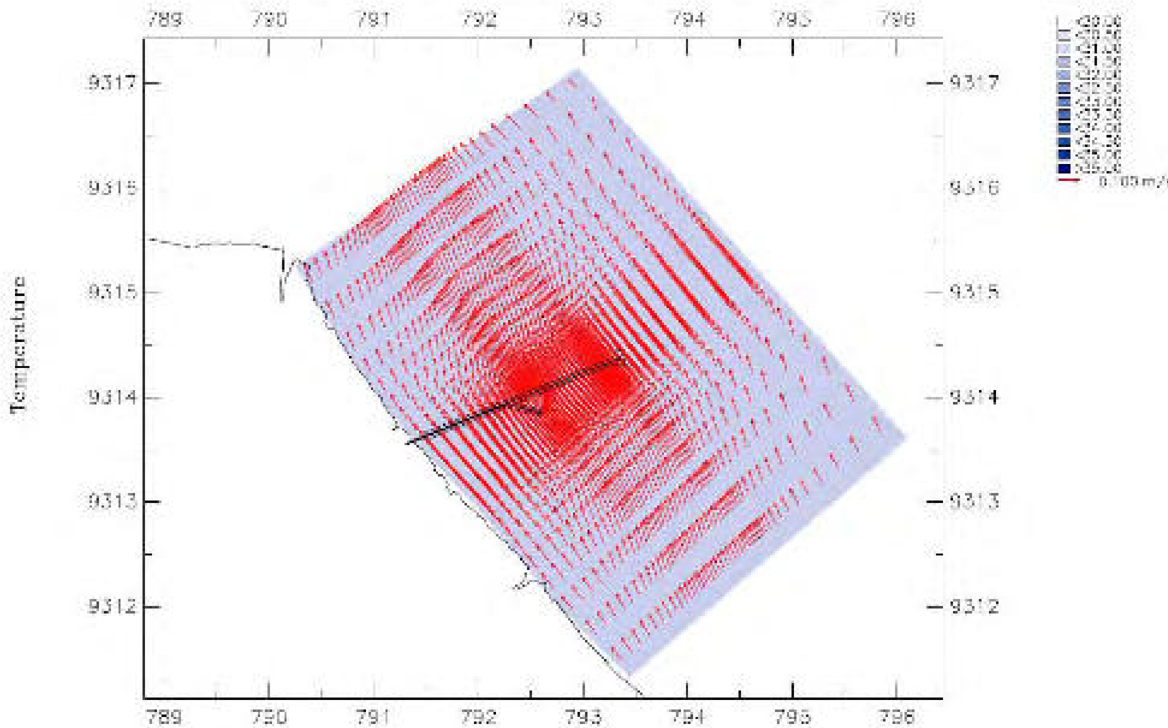
6.8.2. Thermal dispersion modeling

Analysis of thermal dispersion results conducted in the location area of outfall and water intake, For each simulation of thermal dispersion pattern can be explained as follows :

1. **Dry Season (east monsoon)**







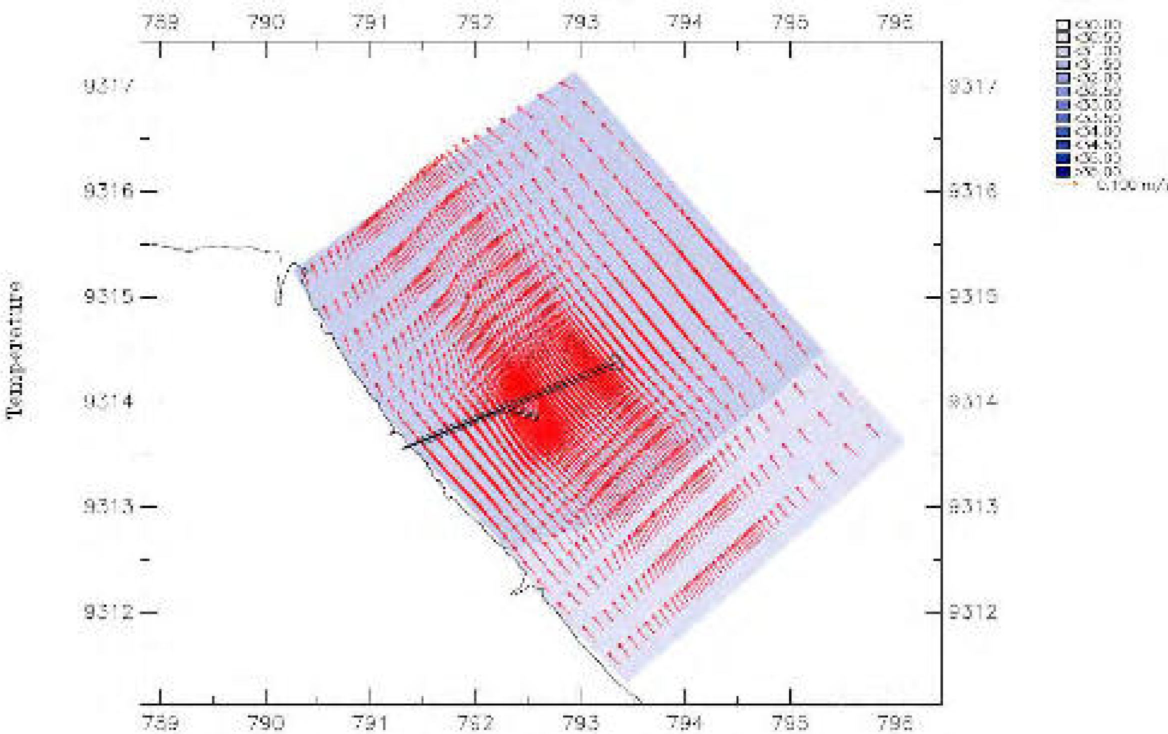
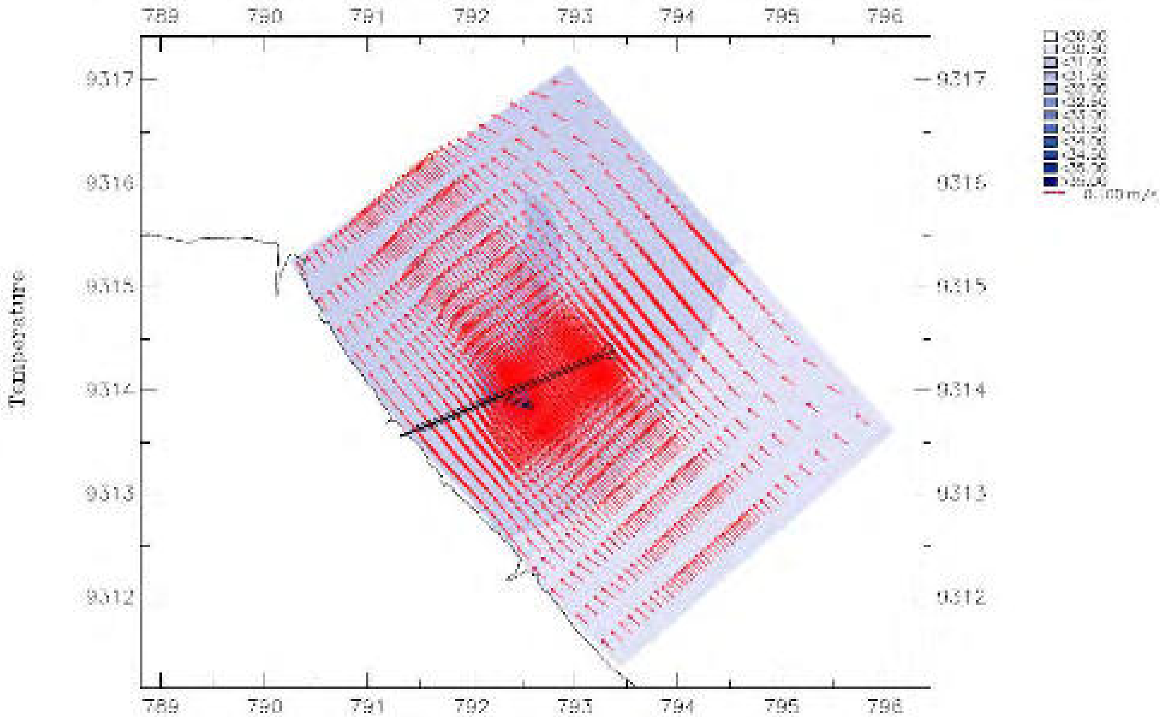


Figure 6.20. Thermal dispersion on surface (layer 1 model) during East Monsoon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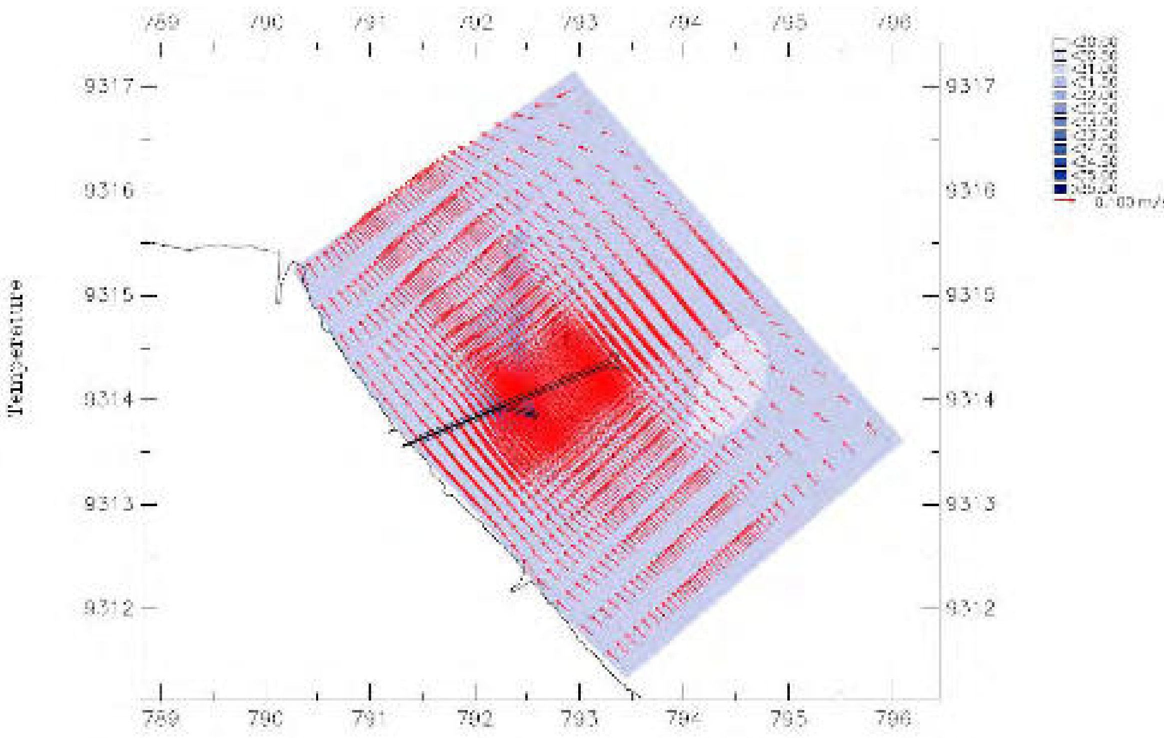
Temperature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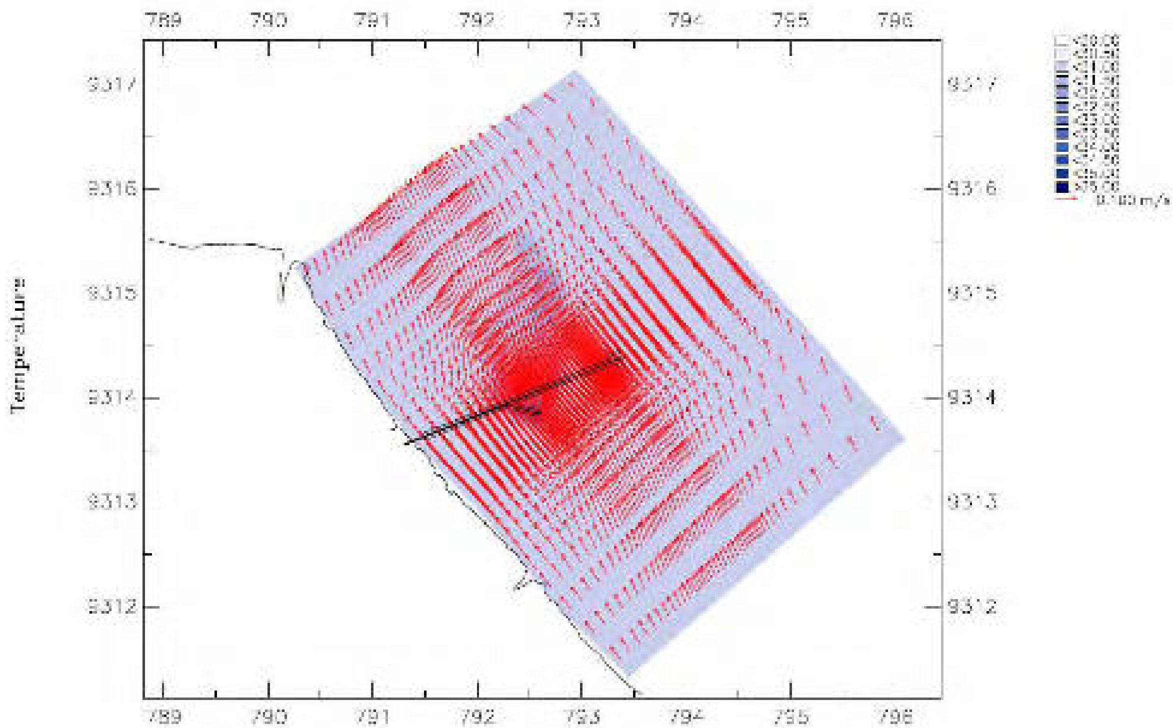
Temperature



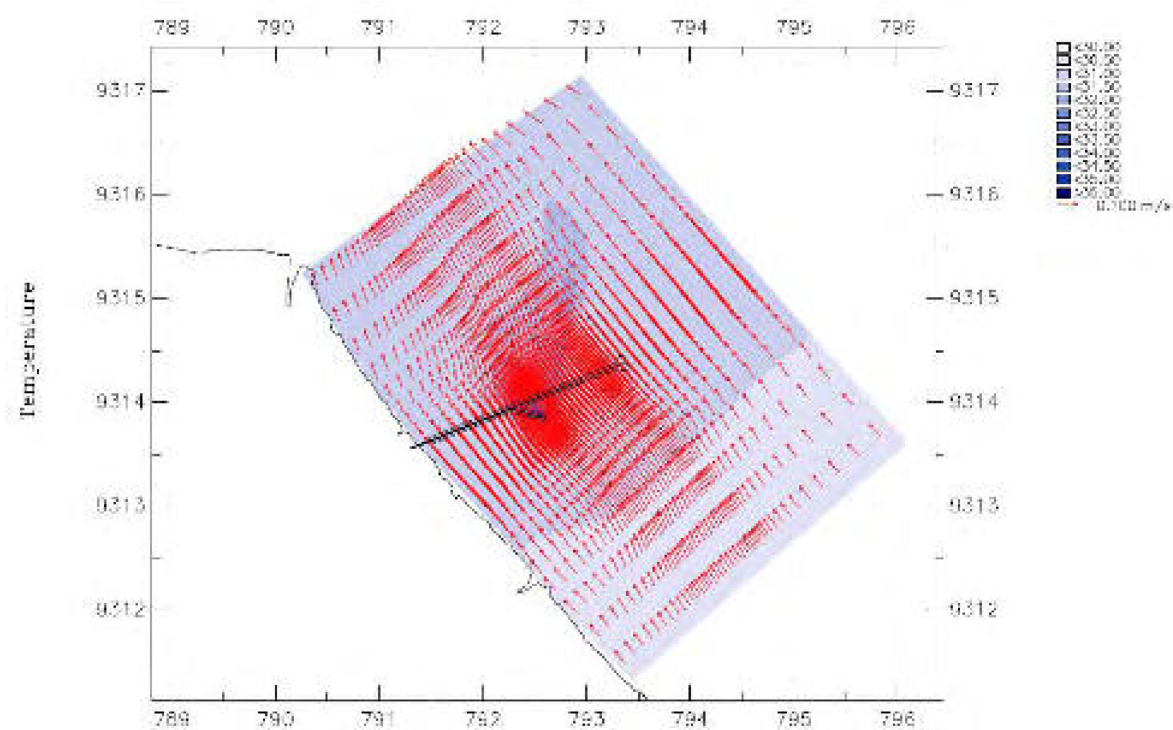


Figure 6.21 .Thermal dispersion near bottom (layer 3 model) during East Monsoon

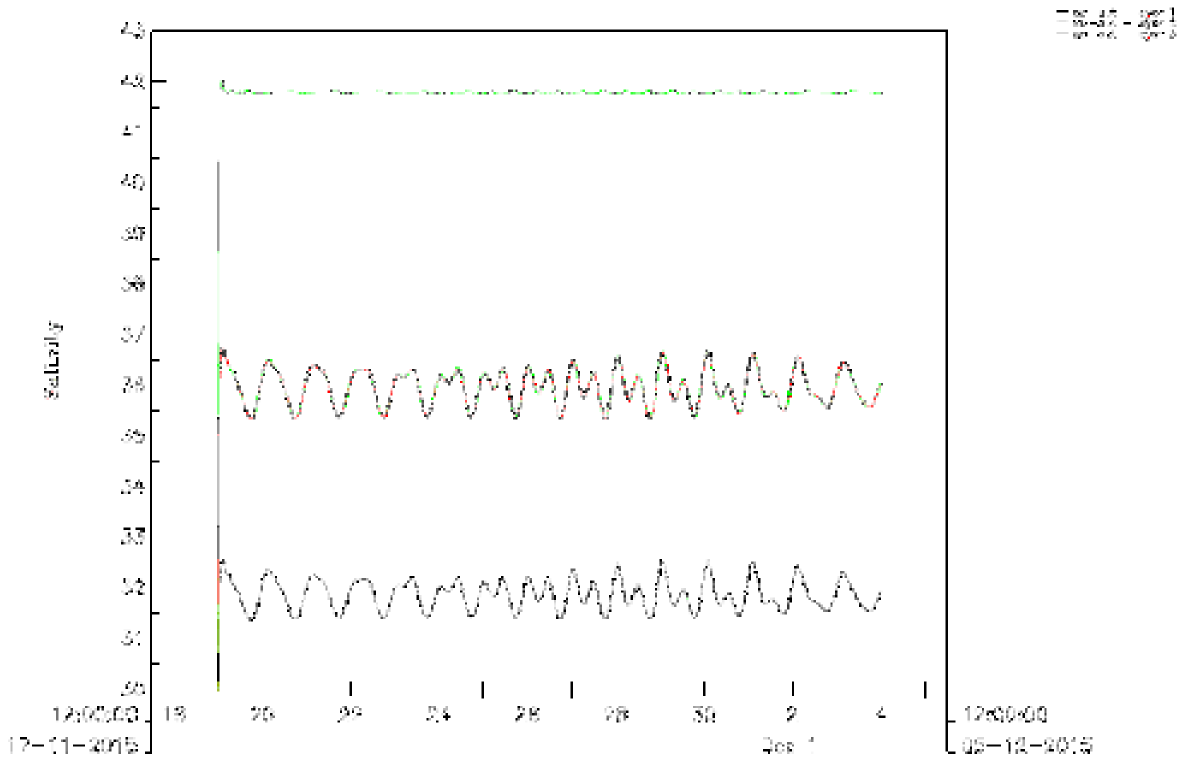


Figure 6.22. Thermal values in water outlet during East Monsoon

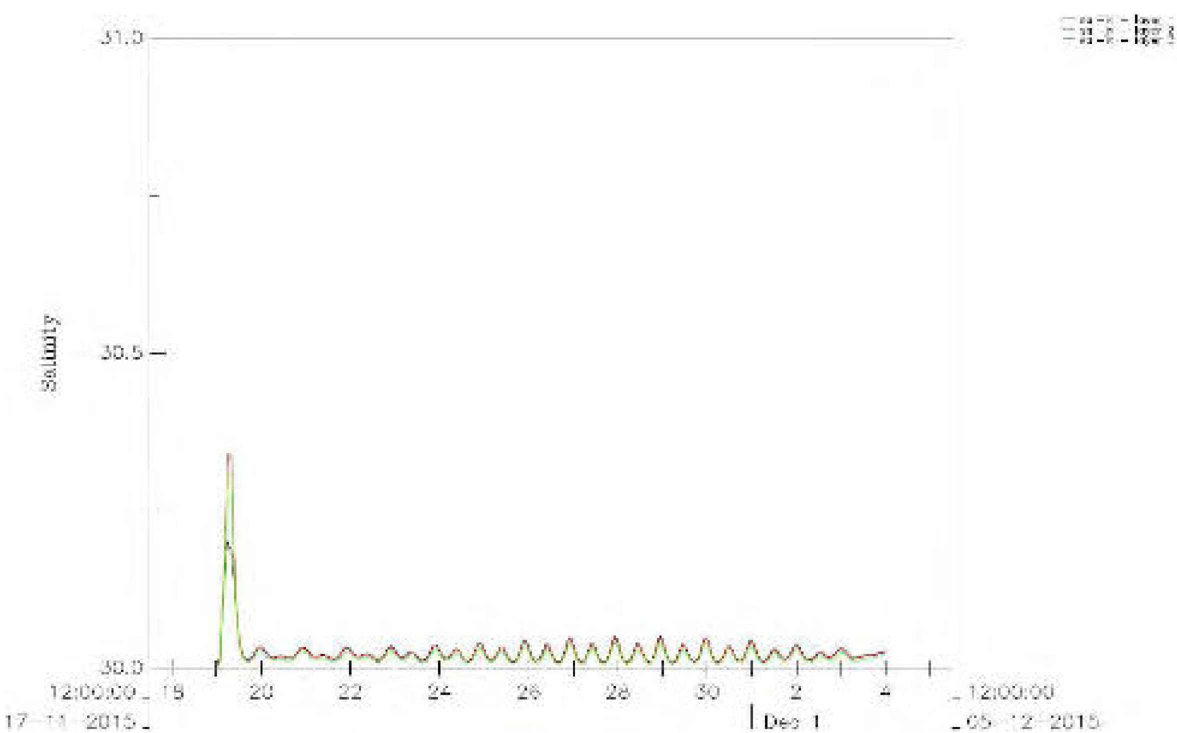


Figure 6.23. Thermal values in water intake during East Monsoon

The thermal dispersion in this condition is seen heading towards northwest. In this condition the distribution of thermal distribution reach the water intake area with maksimum value 30,59 ^{0}C (delta 0.09 ^{0}C from temperature ambient).

Excess temperature predictions during the East Monsoon at the water intake location and edge of 100 meters mixing zone are shown in the table below:

Table 6.5. Predicted Average and Max Excess Temperatures (during East Monsoon)

	At intake location	At edge of mixing zone
Max (note 1)	30.59	31.67
Average	30.51	31.35

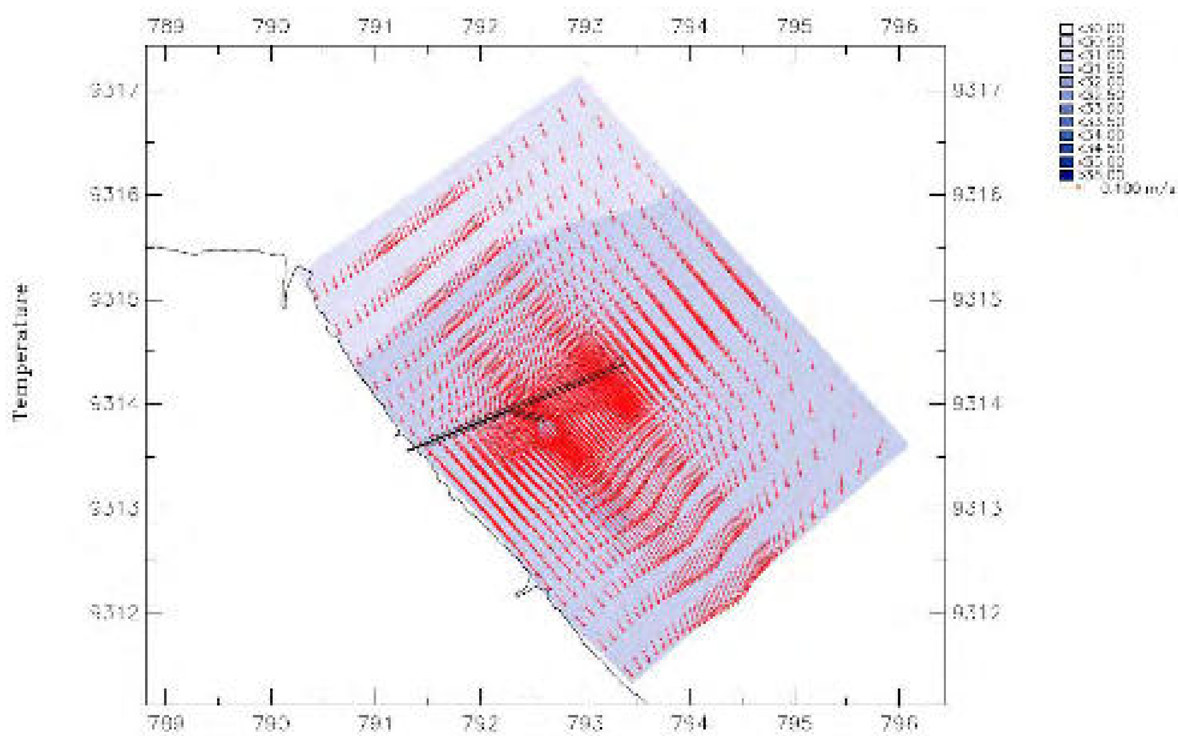
Note 1 : 95th percentile (i.e. temp exceeded to 5% of time)

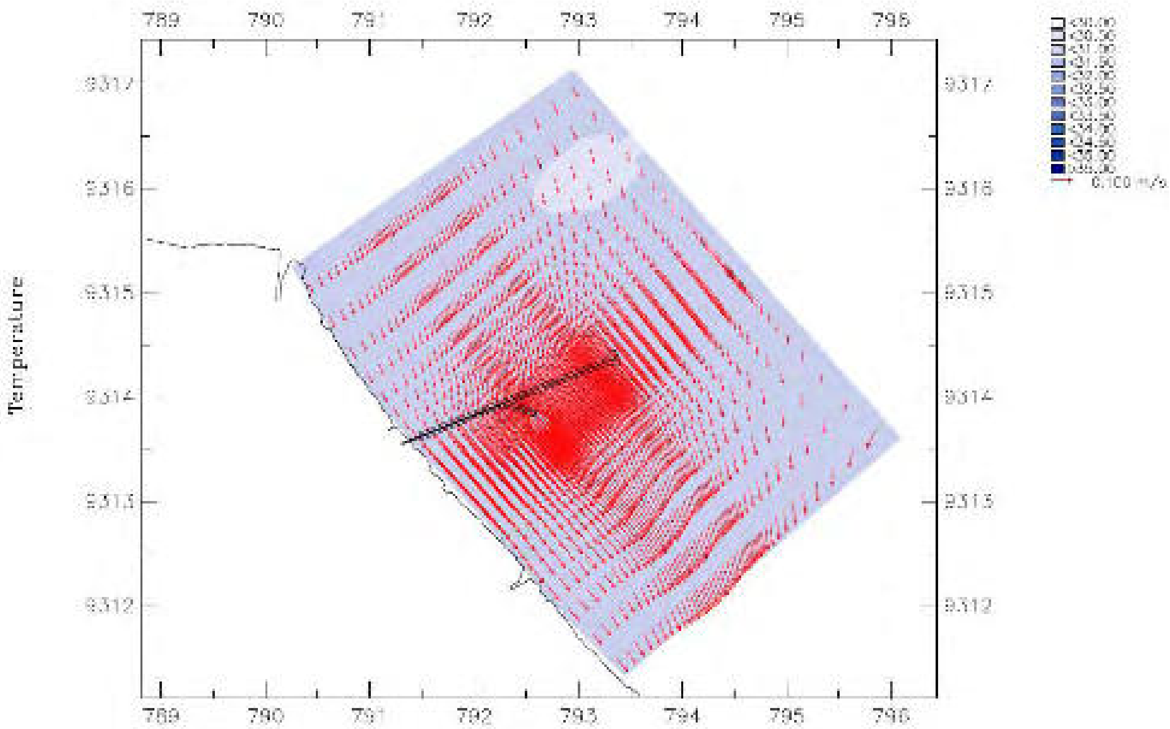
With reference to the above it can be concluded :

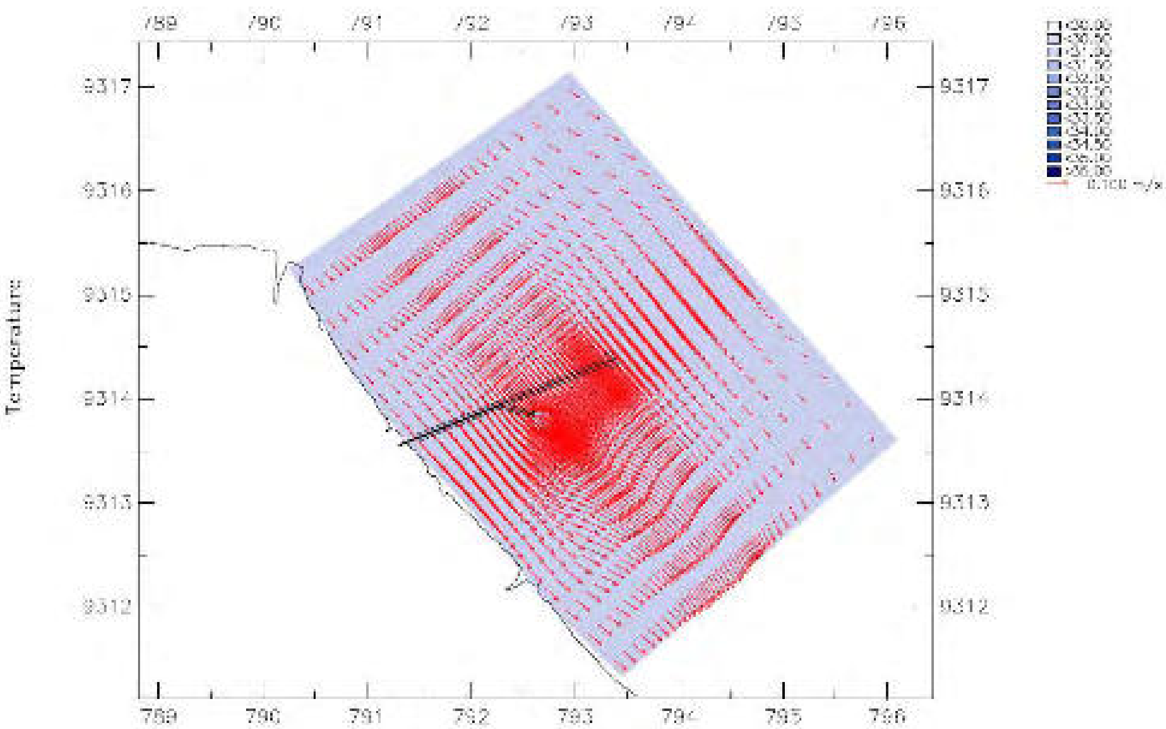
i. The excess temperature is below the required environmental limit of +3°C at the edge of the 100 meters mixing zone.

ii. The excess temperature is below the guideline limit of +1^{0}C at the intake location

2. Rainy Season (West monsoon) :




Temperature
0.100 m/s


Temperature
0.100 m/s

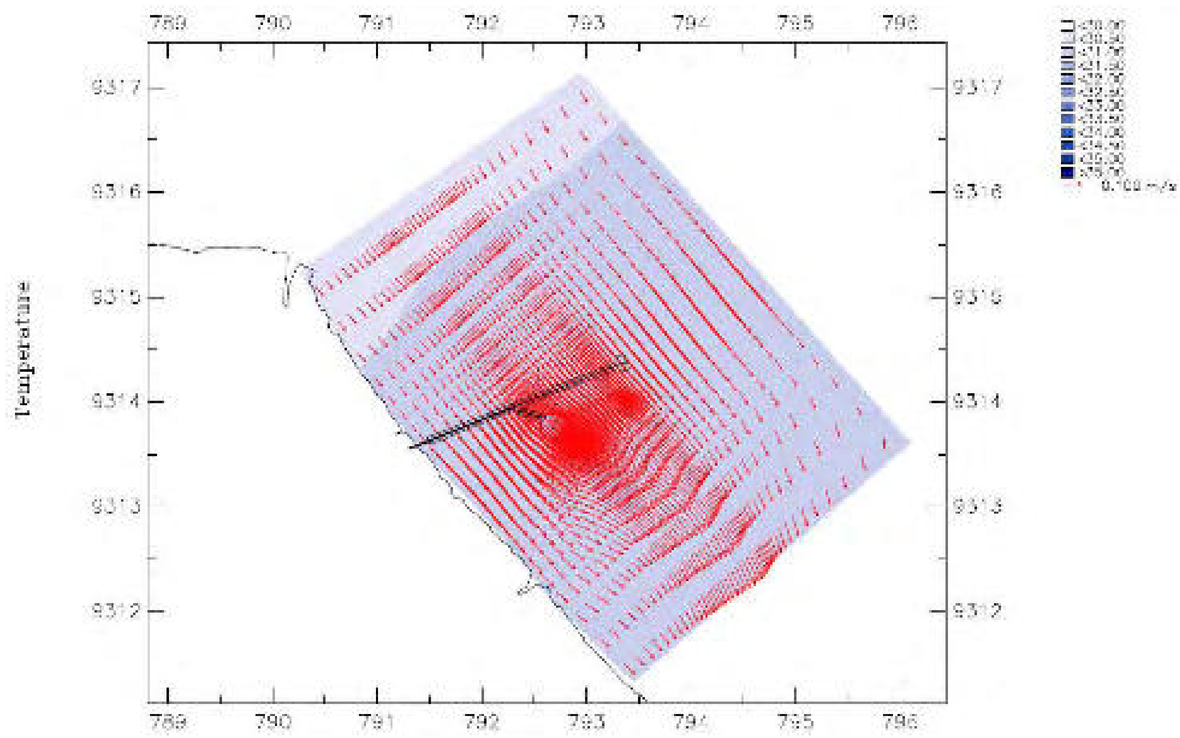
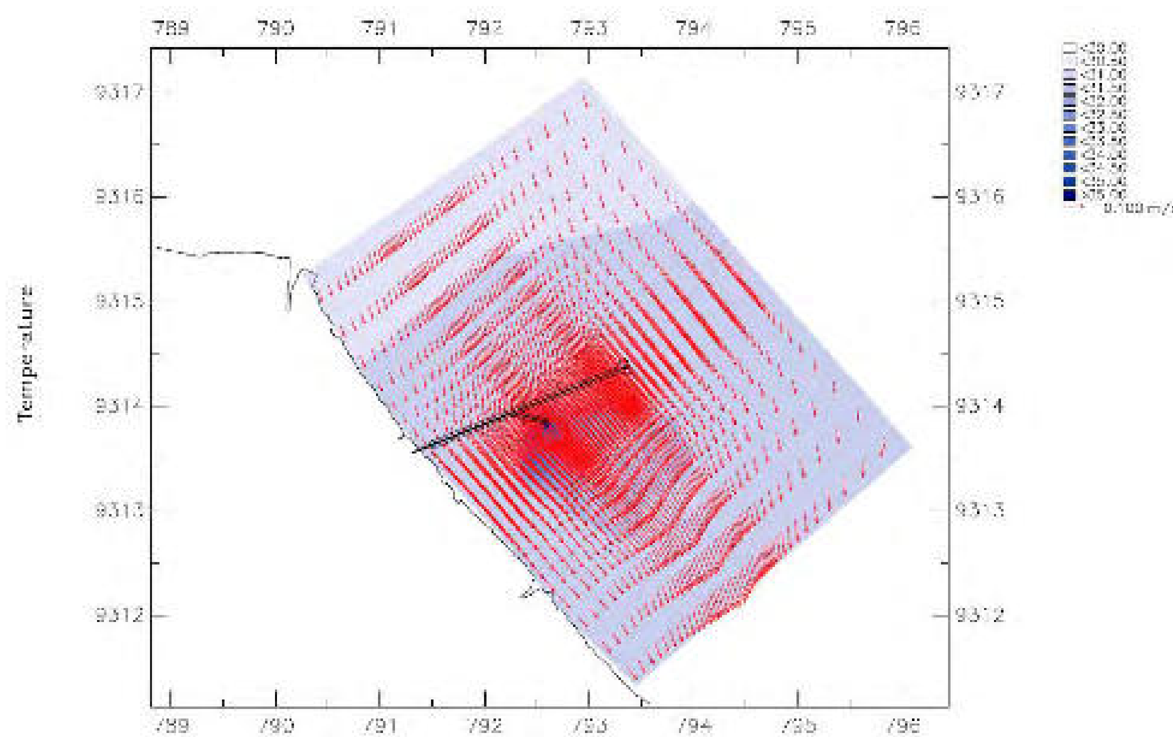
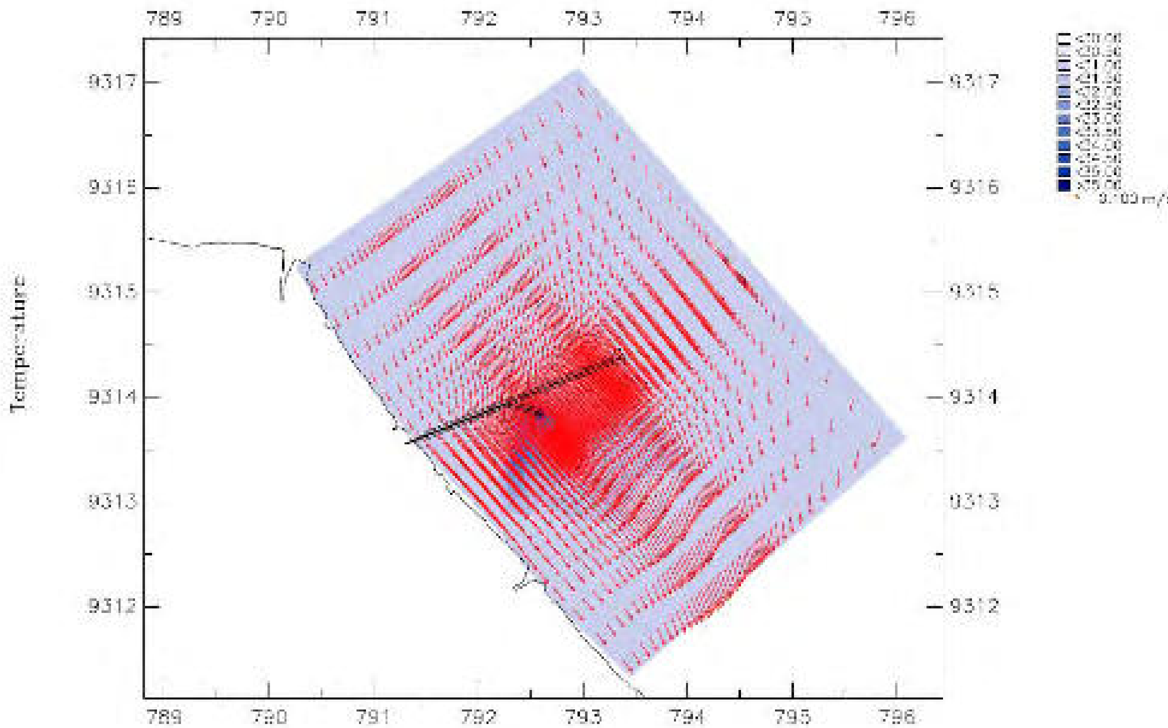


Figure 6.24. Thermal dispersion on surface (layer 1 model) during West Monsoon

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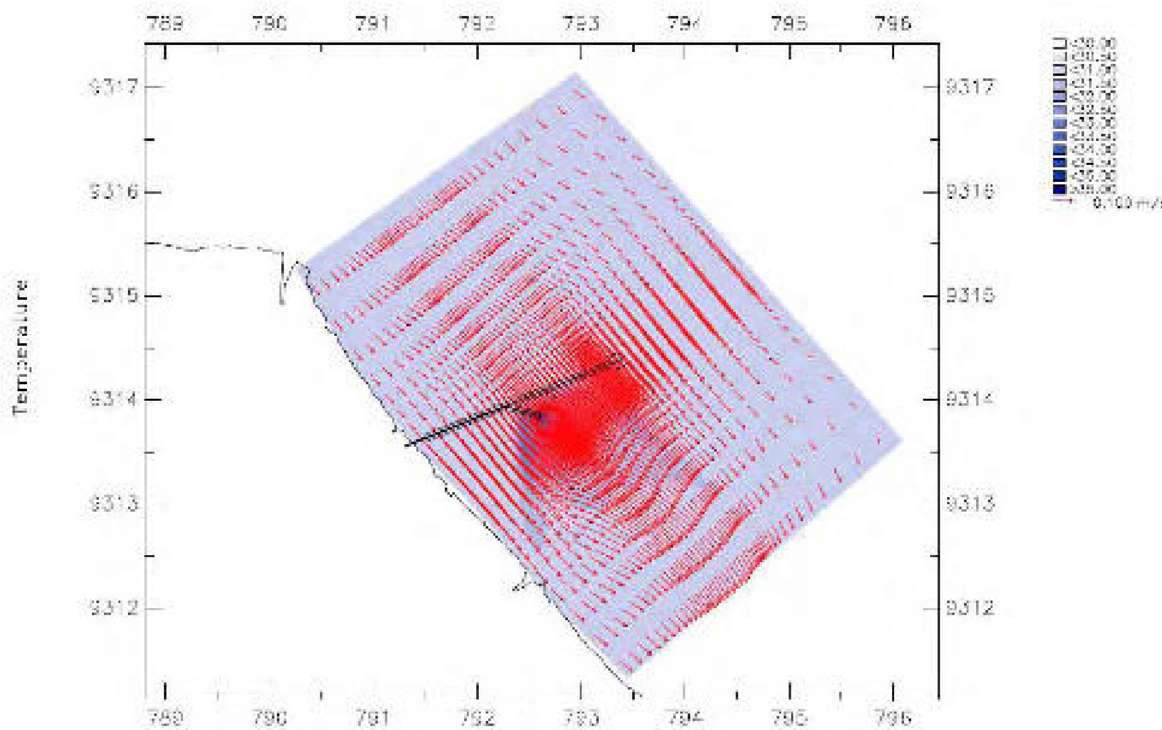
Temperature
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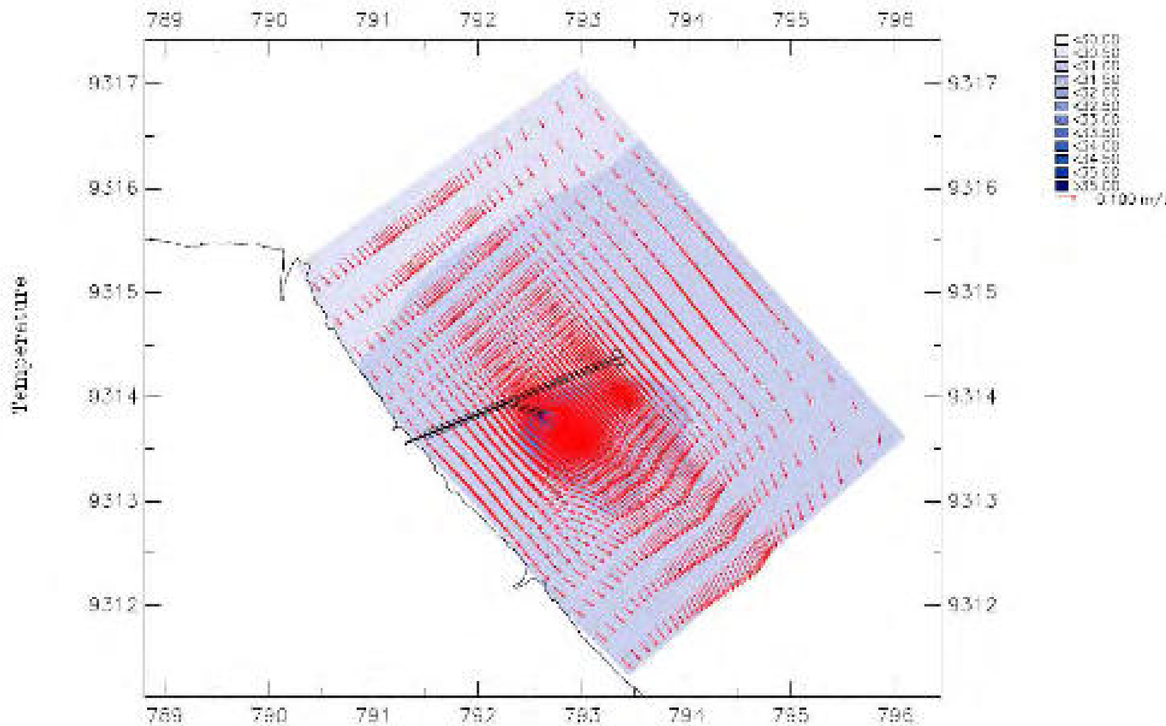

Figure 6.25. Thermal dispersion on near bottom (layer 3 model) during West Monsoon

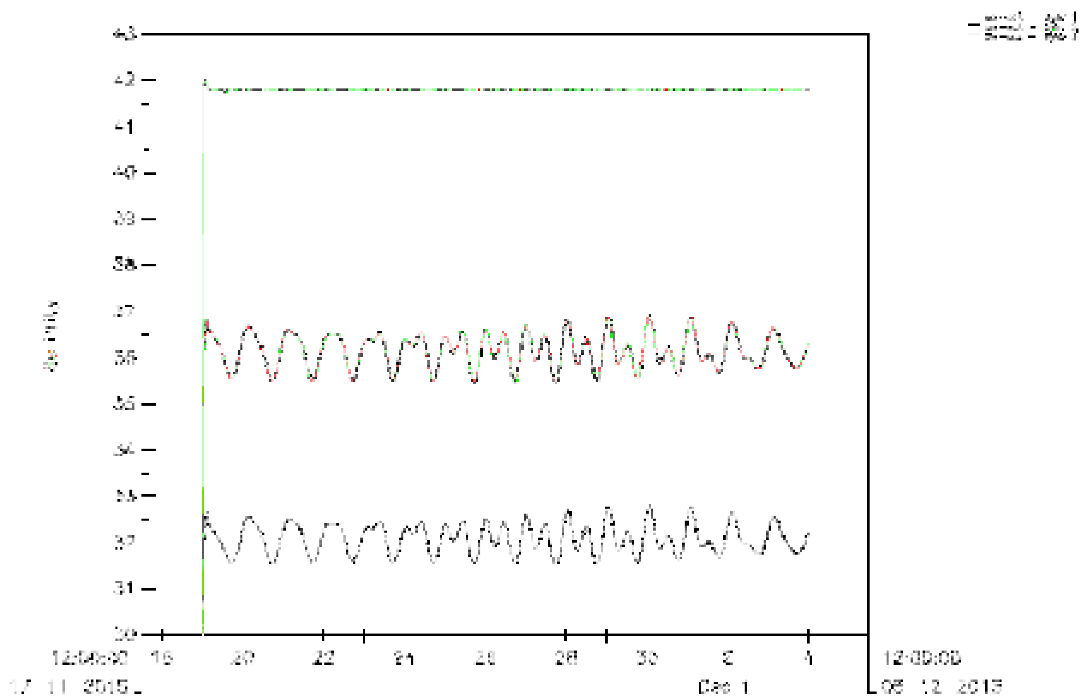

Figure 6.26. Thermal values in water outlet during West Monsoon

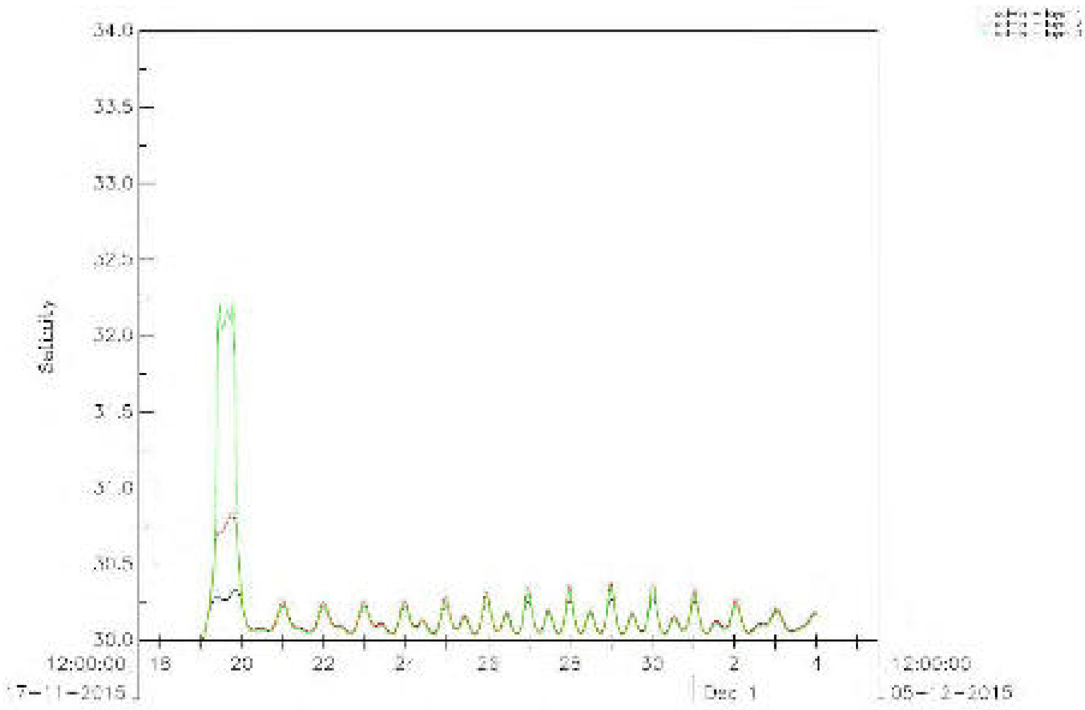

Figure 6.27. Thermal values in water intake during West Monsoon

The thermal dispersion in this condition is seen heading towards northwest. In this condition the distribution of thermal distribution reach the water intake area with this value:

Excess temperature predictions during the West Monsoon at the water intake location and edge of 100 meters mixing zone are shown in the table below:

Table 6.6. Predicted Average and Max Excess Temperatures (during West Monsoon)

	At intake location	At edge of mixing zone
Max (note 1)	30.65	31.78
Average	30.56	31.45

Note 1 : 95th percentile (i.e. temp exceeded to 5% of time)

With reference to the above it can be concluded:-

i. The excess temperature is below the required environmental limit of +3°C at the edge of the 100 meters mixing zone.

ii. The excess temperature is below the guideline limit of +1°C at the intake location.

6.9. Conclusions

1. A three dimensional time-dependent model has been used to simulate the advection, dispersion and dissipation of the proposed discharge as it mixes with the receiving water of the estuary.
2. Environmental Compliance

   The project is fully compliant with the relevant national legislation in terms of both salinity and thermal plume.
3. Thermal Reciculation

   There is no significant (<1°C) recirculation between the intakes and outfall.