Draft Environmental and Social Impact Assessment Report (ESIA)

Project Number: 50330-001
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INO: Rantau Dedap Geothermal Power Project (Phase 2)

Volume VII:

Appendix 13 – Public Consultation (List)
Appendix 14 – Dispersion Modelling of Cooling Tower Plumes at Rantau Dedap Geothermal Power Plant

Prepared by ESC for the Asian Development Bank

6.3 Summary of Past Engagement Activities

No	Date of consultation	Location	Theme	Participants (Number of Participants)	Information Disseminated	Key Issues Raised
1	13 Mar 2008	Dusun IV Yayasan / Rantau Dedap	Project Information	Project affected communities	Information on planned project activities (exploration)	• Purpose of the project • Benefits of the project • Employment opportunities • Electricity black-out and shortage • Land procurement
2	18 Oct 2010	Muara Enim Regency Office	Project information	Regent of Muara Enim Regency and his team	Project activity dissemination as shown in Project Work plan; the contribution of the Project to sustainable development.	• Employment opportunities • Electricity black-out and shortage in Muara Enim • Boundary of the project with other Regency • Regency non tax revenue sharing
3	22 July 2011	Pondok Pesantren Darul Ikhlas, Semende Darat Ulu District, Muara Enim Regency, South Sumatera Province.	Stakeholder consultation meeting	The attendees for the stakeholder consultation meeting were invited by invitation letter. The attendance list of the stakeholder consultation meeting recorded 89 attendees of the meeting	Socialize the project activity. Clean Development Mechanism.	• Question was raised concerning the possibility of accident that would be happened same as in Lapindo • The possibility of profit sharing for the Semende Darat Ulu District • Expectation of road repair in the Semende Darat Ulu District. • Possibility of land damaged by construction of Rantau Dedap Geothermal Power Plant. • An expectation that the project activity would give benefits for local community: Scholarship, mosque renovation, build school.

No	Date of consultation	Location	Theme	Participants (Number of Participants)	Information Disseminated	Key Issues Raised
						• The possibility of cultural shift in society, such as a change from agrarian to industrial community due to the existance of this project.
4	27 Jan 2012	Kota Agung - Lahat	Geothermal Project Socialization	Head of Lahat Regency, Head of Police Resort, Head of sub district, Sub district police, subdistrict army, local goverment apparatus, 5 Village community, public figures (Tokoh Masyarakat), youth groups,Community, and Journalists (more than 100 participants)	Public consultation with respect to planned project activities i.a: • Who is Supreme Energy • What is Geothermal • Project Benefits and contribution • Project legal frame • The construction.	• Expectation of road repair • Question was raised concerning the possibility of accident that would be happened same as in Lapindo • An expectation that the project activity would give benefits for local community
5	02 Feb 2012	Desa Segamit – SDU Muara Enim.	Project information	Head of sub district, Sub district police, subdistrict army, local goverment apparatus, community patron (Tokoh Masyarakat), youth groups, and project affected communities.	Public consultation with respect to planned project activities i.a: • Who is Supreme Energy • What is Geothermal • Project Benefits and contribution • Project legal frame • The construction.	• The possibility of profit sharing for the Semende Darat Ulu District • Expectation of road repair in the Semende Darat Ulu District. • An expectation that the project activity would give benefits for local community: Scholarship, mosque renovation, build school.
6	24 dan 27 Feb 2013	Kota Agung & SDU	Form the Villages Forum	Key stakeholders and affected community members	Villages Forum will bridging the company and community interest, as well as serves as the front liner on the dissemination process.	

No	Date of consultation	Location	Theme	Participants (Number of Participants)	Information Disseminated	Key Issues Raised
7	22 Jul 2012 s/d 15 Sep 2012	Kota Agung Sub district – Lahat Regency	Land acquisition and compensation process dissemination	Land owners, local government/ regency & sub district level	Project background, land requirements, procedure for land acquisition, negotiations, grievance mechanism, potential benefits to the communities including employment opportunities	• Welcomed the project activities, and expressed support for the project and Company. • Clarity on negotiation process and fair compensation for land and crops lost • Concern from coffee planters within the protection area, whether they will be compensated for crops since the land does not belong to them • Tentative timing and schedule of the project • Concerns with respect to land measurement (land owner not in agreement with the size measured by the topographic surveys), age of crops (compensation of coffee is based on age, the decree rates for 20-year-old coffee plants is low) • Potential for employment in the project stage, priority of local labor over outside labor • Impacts during construction and operation, dust, noise, and outside labor conflicts • Clarity on what the process for registering any complaints, grievances regarding the project activities • Need for better infrastructure in the project area, roads and other infrastructure, improvement of school buildings and facilities in schools, improvement to the mosques
8	28 Jul 2012 s/d 02 Sep 2013	Desa Segamit Ke camatan Semende Darat Ulu (SDU) Muara Enim		Affected persons, village head, community representatives		
9	15 Sep 2012 s/d 17 Mar 2013	Desa Tunggul Bute, Kecamatan Kota Agung - Lahat		Affected persons, village head, community representatives		

No	Date of consultation	Location	Theme	Participants (Number of Participants)	Information Disseminated	Key Issues Raised
10	02 Apr 2013	Kota Agung - Lahat	Public Announcement	Project affected communities and wider audience	Public announcement was published	
11	17 December 2013	Serbaguna Hospital, Muara Enim	Public Consultation Meeting for ANDAL	Government officials, community representatives, community leaders, women and youth group representatives and NGOs.	Information on the project and plans for exploration and exploitation	Land acquisition and compensation, expectations for employment, air quality in terms of dust and noise during construction/exploration phase, land clearing of vegetation, and impact on flora nd fauna.
12	02 Feb 2014 03 Feb 2014	Muara Enim Rantau Dedap	Media Gathering Rantau Dedap B-1 Well Spud-in Ceremony	All media in West Sumatra (newspapers & electronics), local government's public relation, 35 participants were involved. All Media Gathering participants plus local villagers.	Project disclosed information, company policy & procedure, and question & answer. Project disclosed information to all stakeholders who are attending the ceremony	• Purpose of the project • Benefits of the project • Employment opportunities • Electricity black-out and shortage • Forestry permit & land procurement • The possibility of accident that would be happened same as in "Lapindo mud"
13	08 Feb 2014	Kota Agung dan SDU	ADB Lender Site Visit (CTF Loan)	Local villagers visiting the local communities	Questions were asked by the ADB Lender about the knowledge of the local community and government officials (*kades* and *kadus* – head of village / hamlet) about the project and the consultation so far as well as land acquisition and compensation process.	• Public awareness • Information disclosure • Social compliance • Land Acquisition & crops compensation process

No	Date of consultation	Location	Theme	Participants (Number of Participants)	Information Disseminated	Key Issues Raised
14	23 Mar 2014	Rantau Dedap - Segamit	Grievance Mechanism (GM) Dissemination	Project affected communities, local government and traditional leaders	GM dissemination including the GM procedure, contact detail and discuss other project issues.	
15	02 – 03 Jul 2014	Kota Agung dan SDU	Lender's Consultant Site Visits	Local villagers visiting the local market	Questions were asked by Lender's Consultants about the knowledge of the local community and government officials about the project and the consultation so far as well as land acquisition and compensation process.	• Environment and social compliance • Land Acquisition & crops compensation process • BAP & CHA
16	10 Okt 2015	Talang Pisang - Rantau Dedap	CSR Stakeholder Meeting	Tunggul Bute and Segamit Village Heads	Socialization of four pillars and program synchronization with the results of the kecamatan Development Planning Consultative Meeting (MUSRENBANG– Musyawarah Perencanaan Pembangunan) accommodating proposed CSR Program.	Need for better infrastructure in the project area, roads and other infrastructure, improvement of school buildings and facilities in schools, improvement to the mosques
17	Maret – Oktober 2015	6 villages	Community Capacity Building (Needs Analysis)	Total of 122 survey respondents	Survey on social data and training needs	Improving life skills, in particular farming, farm animal raising and fishing
18	3 February 2016	Segamit Village	Training Coffee and Vegetable Cultivation (Workshop)	40 participants	Training/Extension Services on farming	Farmers interested to learn more about proper cultivation of coffee
19	3 February 2016	Rantau Dedap Hamlet	Training Coffee and Vegetable Cultivation (Workshop)	40 participants	Training/Extension Services on farming	Farmers have insufficient knowledge of fertiliser application and face pest problems

No	Date of consultation	Location	Theme	Participants (Number of Participants)	Information Disseminated	Key Issues Raised
20	4 February 2016	Tunggul Bute Village	Training Coffee and Vegetable Cultivation (Workshop)	60 participants	Training/Extension Services on farming	Farmers obtain information on how to manage coffee and vegetable plantations better including how to manage pests.
21	5-8 March 2016	Tunggul Bute Village, Rantau Dedap Hamlet and Segamit Village	Training in the field (biopore preparation, fertilizing of coffee)	21 participants (Rantau Dedap/Segamit) 20 participants (Tunggul Bute)	Training/Extension Services on farming	Farmers learn in the field how to do biopore and fertilize coffee.
22	2 May 2016		KA ANDAL presentation			

Figure 6-1 Media gathering SERD

Figure 6-2 Public Announcement

Figure 6-3 Public Consultation Event Q & A Session

PENGUMUMAN
RENCANA KEGIATAN PENGEMBANGAN PANAS BUMI PLTP RANTAU DEDAP DENGAN KAPASITAS PEMBANGKIT 250 MW DI KABUPATEN MUARA ENIM, KABUPATEN LAHAT, DAN KOTAMADYA PAGAR ALAM PROVINSI SUMATERA SELATAN

1. **Deputi Menteri Lingkungan Hidup Bidang Tata Lingkungan**
   Kantor Kementerian Lingkungan Hidup
2. **Badan Lingkungan Hidup (BLH) Provinsi Sumatera Selatan**
3. **Badan Lingkungan Hidup (BLH) Kabupaten Muara Enim**
4. **Badan Pengelolaan Lingkungan Hidup (BPLH) Kota Pagar Alam**
5. **Badan Lingkungan Hidup (BLH) Kabupaten Lahat**
6. **PT Supreme Energy Rantau Dedap**

Jakarta, 5 Desember 2013
PT Supreme Energy Rantau Dedap

Figure 6-4 Notification of AMDAL in Republika Newspaper on 5 December 2013

Dispersion Modelling of Cooling Tower Plumes at Rantau Dedap Geothermal Power Plant

Air Dispersion Modelling Report

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Rantau Dedap Geothermal Project

Quality information

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Stage of Checking	Position	Name	Signature	Date
Review 1	Technical Director - Air Quality	Andrew Curtis		8/23/2016
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Revision history

Revision	Revision date	Details	Name	Position
00	08/26/2016	DRAFT issued for Client Review	Andrew Sembel	Manager, Environment
01	09/02/2016	Revised for Client Comment	Andrew Sembel	Manager, Environment
02	09/08/2016	Final Issue	Andrew Sembel	Manager, Environment
03	27/09/2016	Revised Final – New Accomodation Block Location	Andrew Sembel	Manager, Environment

Table of Contents

List of Tables

List of Figures

Appendices

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INTRODUCTION

01

1 Introduction

1.1 Background

PT. Supreme Energy Rantau Dedap (SERD) is the operation company established by the Joint Venture of Supreme Energy, Engie and Marubeni with the concession for Rantau Dedap awarded in early December 2010. SERD have got the price approval and assignment from the Indonesia Minister of Energy and Mineral Resources through assignment letter No. 5834/26/MEM.L/2011 September 30, 2011, to develop the geothermal field and power plant in Rantau Dedap. The Rantau Dedap geothermal prospect is located in the Muara Enim, Lahat and Pagar Alam Regencies of South Sumatra, approximately 225 km from Palembang.

AECOM has been commissioned by SERD to prepare Air Dispersion Modelling (ADM) to demonstrate compliance with applicable standards. This report therefore provides an assessment of the air quality impact associated with the power plant operation.

The primary air emissions of concern with regards to odour nuisance and health effects from the power plant will be the non-condensable gases (NCG). NCG are gases that are present with range of 0.09-1.6 wt% in the geothermal fluid but are removed during the electricity generation process. The NCG consist predominantly of carbon dioxide (approximately 97%), but also contains hydrogen sulphide (H_2S). The NCG will be released from vents located above the mechanical evaporative cooling towers.

1.2 Purpose of This Report

The purpose of this report is to conduct an ADM using air dispersion modelling to predict potential H_2S impacts at nearby sensitive receptors from emissions associated with the geothermal power plant operation. This report has been undertaken in accordance with the British Columbia Air Quality Dispersion Modelling guidance (BC Ministry of Environment, 2015).

1.3 Project Scope

The ADM for the proposed SERD power plant was based on the air dispersion model Calpuff and assessed the contribution to air quality impacts at nearby sensitive receptors from the power plant. In summary, the report provides information on the following:

- A description of the proposed power plant development;
- Identification of relevant air quality criteria;
- Identifies nearby sensitive receivers which may be impacted by emissions from proposed development.
- A description of the modelling methodology including input parameters including meteorology, terrain and air emissions.
- An assessesement the air quality impact of power plant operations against the relevant ambient air quality criteria;
- A discussion of the potential impacts and recommendations.

PROJECT OUTLINE

02

2 Project Outline

The Rantau Dedap geothermal prospect is located in the Muara Enim, Lahat and Pagar Alam Regencies of South Sumatra, approximately 225 km from Palembang. The contract area covers approximately 35,440 ha (18.56 km x 19.63 km) and is situated at an elevation ranging from 1,000 to 2,600 metres (m) on the Bukit Besar volcanic complex, in which the existence of the geothermal system is indicated by a wide distribution of thermal manifestations, particularly on the flank of it.

SERD is currently undertaking exploratory drilling to investigate the geothermal resource and now intend to undertake the development of the geothermal power project through to commercial operation of a geothermal power plant comprising two units of approximately 46 MW each.

The power plant will use dual pressure condensing steam turbine technology. The steam turbine plant includes 2 x 46 MWe (nominal-gross) condensing steam turbine generators, each with a dual steam inlet. The geothermal fluid is first flashed and separated into high pressure steam and geothermal water components at a specific pressure. The geothermal water is also flashed to produce an additional low pressure steam flow. The separated steam flows are then admitted to steam turbine to drive electricity generators.

After passing through the turbines, the steam is condensed using direct-contact condensers. In direct-contact condensers the cooling water from the cooling tower is sprayed directly into the condenser, mixing with and condensing the incoming exhaust steam. The heated water from the condensers is then cooled in a cooling tower.

Non-condensable gases, which occur naturally in the geothermal steam, are extracted from the steam side of the condenser and piped to the cooling tower for discharge in the cooling tower plume. In direct-contact condensers, a portion of the non-condensable gases is dissolved into the cooling water, while the remainder is extracted and piped to the cooling tower.

The cooling towers for the plant will be induced mechanical-draft, counter flow types. Each cooling tower will consist of five (5) fan cells arranged in a straight line. The dimension of each tower is 80 m long and 16 m wide, with height of 15 m above base level.

ASSESSMENT CRITERIA

03

3 Assessment Criteria

Emission concentrations of the H_2S from the power plant will be compared against the applicable emission standard and for incremental concentrations of H_2S in the ambient air predicted by Calpuff will added to the baseline and compared with ambient air quality standards. These are criteria for assessment in this study. They are intended to minimise the adverse effects of airborne pollutants on sensitive receivers.

3.1 Emission Standards

The State Minister of Environment of the Republic of Indonesia has set Regulation No 21 of 2008 (MENLH, 2008) that stipulate emission standards for stationary sources in thermal power plants including geothermal power plant. In this Regulation, the H_2S emission standard was set to 35 mg/m^3 at normal conditions (temperature of 25°C and pressure of one atmosphere).

The IFC EHS Guideline for Geothermal Power Generation (IFC, 2007) which has been used, as a reference for international guideline, did not establish an emission standard for H_2S. This was because IFC did not consider the H_2S emission from a geothermal power plant is significant. However in the Guideline IFC recommended that H_2S emission "should not result in ambient concentrations above nationally established air quality standards or, in their absence, internationally recognized guidelines".

For this study, the H_2S emission has been compared against the Indonesia Emission Standard as mentioned above.

3.2 Ambient Standards

In Indonesia, H_2S concentration in the ambient air was regulated in the Minister of Environmental Decree No 50 of 1996 regarding Odor Standard (MENLH, 1996). Thus H_2S was considered as an odor. The ambient standard for this gas stipulated in this regulation is 0.02 ppm or equivalent to 28 µg/m^3. The regulation did not mention what the averaging period for the the standard should be. However, since it is for ambient standard, it is believed it is for 24 hour average.

The ambient standard is applicable for residential and general areas only. For industrial areas, another standard is applicable. In 2011, the Minister of Employment and Transmigration of The Republic of Indonesia set forth Regulation Number PER.13/MEN/X/2011 regarding Threshold Values for Physical and Chemical Factors in the Working Environment (MENAKERTRANS, 2011). In this regulation, the H_2S threshold value is 1 ppm which is equivalent to 1,400 µg/m^3. This value should be measured for eight hour averaging time which is normal working duration for a worker.

As international standard for ambient H_2S, WHO's Air Quality Guidelines for Europe (WHO, 2000) was referred to. Here WHO gave concentration of 150 µg/m^3 in a 24 hours average time as guideline for ambient H_2S. Furthermore in order to avoid any substantial complaints on the possible generated odor among the exposed population WHO adds a guideline value of 7 µg/m^3 in 30 minute period of time.

However, as quoted in the Kawerau Geothermal power plant Air Discharge Assessment (Fisher & Heydenrych, 2005), the guideline of 7 µg/m^3 for one hour average is not appropriate for geothermal areas for odor effect. In this report, Fisher & Heydenrych quoted several studies that all assumed 70 µg/m^3 was more appropriate guideline for geothermal power stations in regions affected by natural geothermal emissions. Furthermore they explained for populations that have been adapted to the smell of hydrogen sulphide, 70 µg/m^3 is unlikely to produce complaint. In contrary, for populations that do not experience high natural levels of emissions, levels of above 7 µg/m^3 are likely to be noticed.

The 70 µg/m^3 for one hour average more or less will give the result of 28 µg/m^3 for 24 hour average. Therefore it is equivalent to the Indonesia Odor Standard as explained above. For study in this report, the 28 µg/m^3 for 24 hour average is used as assessment criteria for H_2S ambient concentration.

EMISSION INVENTORY

04

4 Emission Inventory

SERD is proposing that its H_2S emission to meet the emission quality standard from the Government of Indonesia as discussed in Section 3.1. For the purpose of estimating the emission, it is assumed that a steady-state condition. The H_2S will be emitted together with other NCG from vents located above the mechanical evaporative cooling towers.

The SERD geothermal power plant will have two identical units of cooling tower. Each unit will consist of 5 fans. For the purpose of the dispersion modelling with Calpuff, emission rates need to be calculated in units of grams per second (g/s) at the point of emission. Based on the NCG content in the steam and H_2S content in the NCG supplied by SERD (Appendix D), the H_2S emission was calculated 13.25 g/s. With this rate, the emission concentration at normal condition was estimated 30 mg/m^3, still well below the Indonesian Emission Standard of 35 mg/m^3.

For the purpose of modelling, high gas case is used for the calculation. In this case, NCG contents are 1.6% in HP steam and 1.15% in LP steam. As for H_2S concentration content is 5%for both steams. Detailed calculations of H_2S emission are provided in Appendix B. Summary of the calculated emission and other selected parameters are presented in Table 4-1.

Table 4-1 Calculated H_2S Emission Rate and Other Selected Parameters

Item	Value	Unit
NCG content in HP steam	1.6	% weight
NCG content in LP steam	1.15	% weight
H_2S content in HP and LP Steam	5	% weight
Temperature of exit airflow	305.15	K
Pressure of exit airflow	0.8	bar
Specific volume of exit airflow	1.14	m^3/kg
Mass flowrate of exit air	507.5	kg/s
Volume of exit airflow at normal condition (25°C)	449	m^3/s
H_2S concentration at normal condition	30	mg/m^3
H_2S mass flowrate	13.25	g/s

Note: All calculations represent one cooling tower cell (i.e. one fan)

METHODOLOGY

05

5 Methodology

5.1 Dispersion Model

This assessment made use of CALMET meteorological processor and the CALPUFF dispersion model (BC Ministry of Environment, 2015). A summary of the data and parameters used for both the meteorological and air dispersion modelling is presented Table 5-1.

CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. CALMET produces a meteorological file that is used within the CALPUFF model to predict the movement of air pollution.

CALPUFF is a non-steady state, three-dimensional Gaussian puff model developed for the US Environmental Protection Agency (USEPA) for use in situations where basic Gaussian plume models are not effective. These situations include areas where stagnation conditions occur, which are characterized by calm or very low wind speeds with variable wind direction. The CALPUFF modelling system has the ability to model spatially varying winds and turbulence fields that are important in complex terrain, long range transport and near calm conditions. As such, CALPUFF was selected as the appropriate dispersion model for this assessment.

Table 5-1 Summary of CALMET and CALPUFF Input Parameters

Parameter	Input
CALMET (v6.334)	
Meteorological grid domain	12 km x 12 km
Meteorological grid resolution	500 m resolution (24 x 24 grid cells)
Reference grid coordinate of southwest corner	314.852 E, 9529.081 S (Zone: 48)
Cell face heights in vertical grid	0, 20, 40, 80, 160, 300, 600, 1000, 1500, 2200 and 3000 m
Simulation length	3 years (2013-2015)
Surface meteorological stations	CALMET No-Obs Mode: CALMET used Numerical Weather Prediction model outputs.
Upper air meteorological station	No upper air stations. The 3-dimensional gridded prognostic data were used as the initial guess wind-field for CALMET.
Terrain data	Terrain elevations were extracted from the NASA ASTER dataset (ASTER 30 metre, 1-arc sec). Elevations at power plant site were modified using final elevations data.
Land use data	Generic land use based on data from Indonesia Department of Forestry.
CALPUFF (v6.42)	
Modelling domain	**Computation grid:** 12 km x 12 km
Modelling grid resolution for mapping purpose	**Grid resolution:** 500 m
Number of discrete receptors	A total of 89 discrete receptors were added surrounding the plant.
Dispersion algorithm	Turbulence-based coefficients

Parameter	Input
Hours modelled	26,280 hours
Meteorological modelling period	1 January 2013 – 31 December 2015

5.2 Model Input Determination

5.2.1 Source Parameters

For cooling towers, the individual cells were modelled as point sources, mimicking individual stack emission points. The total emissions from the cooling tower cells were divided equally between each individual cell. The stack parameters used for modeling inputs were based on the characteristics of the cooling tower fan, which is assumed to behave like a “stack”.

The vertical velocity was determined by the fan rate (fan blows air at a certain flow rate). The exit diameter was determined by the cross-sectional area of the cooling tower. The stack height would be the actual height of the cooling tower. Summary of the source parameters for individual cells of SERD Cooling Tower is provided in Table 5-2.

Table 5-2 Source Parameters for Individual Cells of Cooling Tower

Specification	Unit	Value
Stack height	m	15
Stack outlet diameter	m	10
Stack volumetric flowrate	m^3/s	580
Stack exit velocity	m	7.4
Flue gas temperature	^oC	32

Source: Supreme Energy Rantau Dedap, 2016

5.2.2 Upset Conditions

As stated in the Original ESIA, upset conditions at the SERD Geothermal Power Plant have not been assessed separately as this operating scenario is considered to represent a lower quality impact than normal operation.

5.2.3 Building Downwash Investigation

The term building downwash is defined as the effect caused by the aerodynamic turbulence induced by a nearby building that may result in high ground-level concentrations in the vicinity of a stack (USEPA, 1992). Thus, the possibility of downwash influences should be investigated.

The effect of building downwash on pollutant dispersion from cooling tower was incorporated in the dispersion model using the PRIME building wake algorithm. Building Profile Input Program for PRIME (BPIPPRM) was used to prepare downwash related input for the PRIME algorithm. BPIPPRM can determine whether a point source is subjected to wake effects from a structure(s), and calculate building heights and projected building widths for cases when the plume is affected by building wakes. Table 5-3 summarizes parameters for buildings investigated for downwash effect based on power plant layout (Appendix E).

Table 5-3 Parameters for Buildings Investigated for Downwash Effect

Notation	Cooling Tower [a]	Turbine Hall
Building length (m)	80 [b]	48 [b]
Building width (m)	16 [b]	37 [b]
Building height above base elevation (m)	15	13 [c]
Building base elevation (m)	1960	1960 [c]

Notes:

a. Parameters for cooling tower are for one of two identical tower units.
b. Building length and width are calculated based on building corner coordinates input into the BPIPPRIME model.
c. The turbine building height is input into the model 2 m lower than its actual height considering that the actual turbine building base elevation is 2 m lower than the cooling tower base elevation. Structures modelled at single elevation to avoid complex terrain model set up.

From the building investigations above, it can be concluded that all buildings are within stack influence areas and they will induce building downwash. As the result, building downwash algorithm is included in Calpuff input files for this study.

5.2.4 Meteorological Conditions

Meteorological conditions determine the direction of movement and dispersion of emissions carried by the wind. Key meteorological parameters include air temperature, wind direction, wind speed, and mixing height. Ideally, this data can be obtained from the nearest meteorological station of the study area. For modeling purposes, the data that is needed is for each one hour interval within a period of three years for each of the key parameters. In Indonesia, this kind of hourly data is not available in all existing meteorological stations.

In 2012 SERD installed a weather station at the project site warehouse. The station has made hourly meteorological observation since February 2012 until now. Parameters observed are wind speed, wind direction, temperature, relative humidity, barometric pressure, rainfall, and evaporation. The weather station is located in 5 km distance from the planned power location. Further data evaluation from this station showed that there is high percentage of missing hours. Therefore the weather station data cannot be used to be accurate for the modelling purposes and data from a meteorological institute is to be obtained.

The forecast meteorological data was then obtained from Lakes Environmental. Lakes Environmental is a company based in Ontario, Canada which provides meteorological modelling for dispersion modelling purpose for any location in the world. For this purpose, Lakes Environmental utilizes WRF (Weather Research Forecasting) model from NCAR (National Center for Atmospheric Research), which is a research and development institute in field of atmosphere in the United States. For this study, meteorological data from Lakes Environmental was obtained for period from January 1, 2013 to December 31, 2015 (three years) with one hour data interval. These data sets were pre-processed with Calmet, the meteorological data pre-processor for Calpuff.

Based on data from the Lakes Environmental, the wind directions at the project site are very scattered. This shows that the wind in the area surrounding the project site is highly affected by terrain. West Southwest direction only dominates with frequency of 13.5%. Yet, the frequency of the wind from the opposite direction is less than 2% different i.e. 11.9%. Third dominant wind comes from the South Southeast with frequency of 11.5%. Number of calm winds is only 1.5%. The average wind speed is 1.68 m/s. The resultant wind rose is presented in Figure 5-1.

A comparison of the CALMET processed meteorological data with climate data collected from the SERD meteorological station is located in Appendix A.

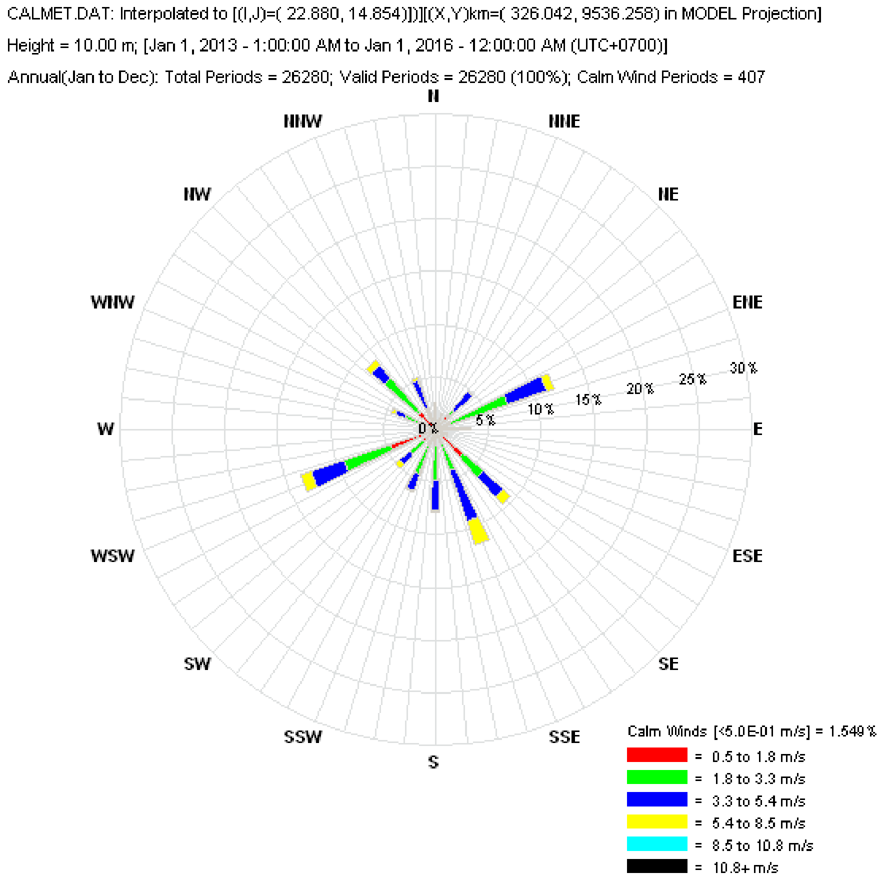

Figure 5-1 Wind Rose Based on Forecast Data from Lakes Environmental (Period of January 1, 2013 - 31 December 2015)

5.2.5 Modelling Domain and Representative Receptor Network

For this study, dispersion is modelled over 12 km x 12 km domain with the power plant cooling tower is in the centre. This domain is considered to have covered all settlements closest to the study area.

For the purpose of input into Calpuff, receptor points are modelled in the form of representative receptor networks. The distribution of concentrations will be calculated based on this receptor network. In this model, the representative receptor is modelled as an arbitrary polar network with power plant cooling tower as its centre point. In this network, the receptor points are placed at 500 m x 500 m grid. This will generate 576 representative receptor points.

5.2.6 Sensitive Receptors

The impact of air emissions on sensitive members of the population is of particular concern. Sensitive receptors include areas such as residences, schools, mosques, churches, marketplaces, clinics, etc. They are selected by identifying rooftops from Google Earth Satellite Imagery and field survey undertaken by SERD. Using this approach, 81 sensitive receptors were selected. For assessing health impact of H_2S to the workers, eight random locations representing workers inside the plant were added to the sensitive receptors. A complete list of sensitive receptors is provided in Appendix C.

5.2.7 Topography

Topography affects the distribution of pollutant concentrations at certain points. Therefore topographic data needs to be entered into the Calpuff model. For this study topographical data were captured from ASTER GDEM. For Indonesia, terrain data are available at approximately 30 m resolution (1-arc seconds).

However since the elevation of the power plant site will be changed because of cut and fills works, final elevation of the site from the design data were incorporated into the Aster GDEM data. The combined data were then processed with ArcGIS software to obtain new elevation data in XYZ. Topography map of the modelling domain is provided as Figure 5-2.

The immediate elevations surrounding the power plant vary between 1,905 m to 1,965 m. In the wider context of the study area, the elevations are lower to the north and higher to the south with the highest points at the southwest area.

5.2.8 Land Use

The latest land use data for the modeling domain were taken from the Department of Forestry. In order to use this data for the model, it was first converted into a generic xyz file. The procedure for creating this xyz file available in the BC Air Quality Modeling Guideline is followed. For simplicity, the land use types from the Indonesian Department of Forestry were changed into equivalent BC types. The result file was then processed using CTGPROG which is the land use processor of Calpuff.

From the processed data, the land use within the modeling domain only consists of protected forest, agriculture of coffee plantation and bush areas. The protected forest is classified as forest area by the CTGPROG as for the coffee plantation is classified by agriculture area. The forest area dominates the modelling domain with more than 50% of coverage. Bushes are spread from west to north as for agricultures are scattered at northwest, northeast and east areas.

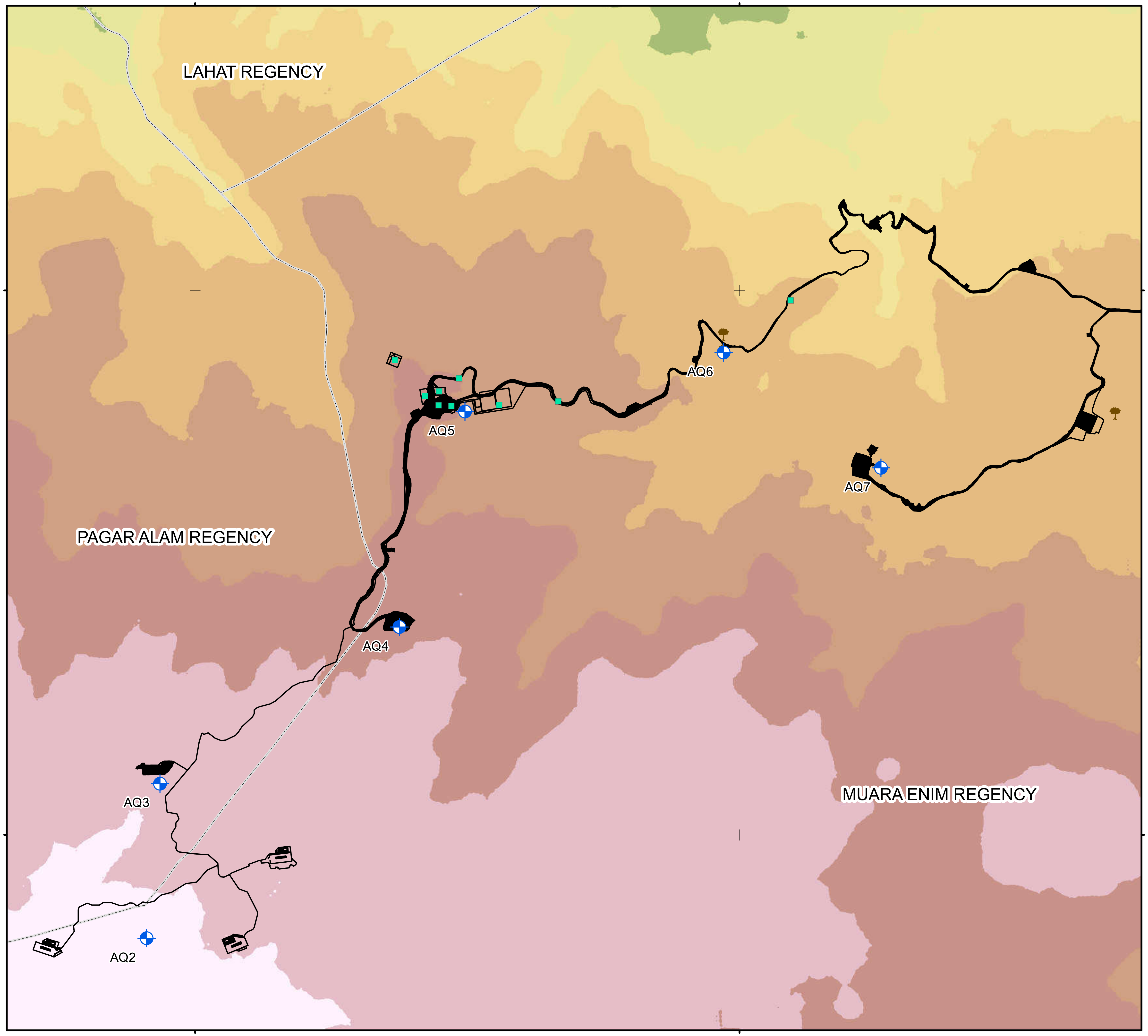

Figure 5-2

CLIENT
supreme energy
PT Supreme Energy Rantau Dedap

Map Title

TOPOGRAPHY MAP

Administrative Details

Regency	Muara Enim, Lahat, and Pagar Alam City
Province	South Sumatra

Scale Map Information

Scale 1:25,000 on A3 Paper

0.25 0.125 0 0.25 0.5 0.75 1
Kilometers

Index Location

Legend

Air Quality Sampling Location

Receptor

- Coffee Farmer Hut
- Household
- Mosque
- Worker
- Road and Wellpad
- Regency Boundary

Elevation (m)

- 895 - 1,200
- 1,200 - 1,300
- 1,300 - 1,400
- 1,400 - 1,500
- 1,500 - 1,600
- 1,600 - 1,800
- 1,800 - 2,000
- 2,000 - 2,200
- 2,200 - 2,500
- 2,500 - 2,722

Data Sources

1. Client Document
2. Modeling results from Calpuff Software
3. Google Earth Imagery Services

Map Information

Datum	World Geodetic System 1984
Projection	Universal Transverse Mercator
Zone	48 South
Unit	Meter

Provided by

AECOM
PT AECOM Indonesia

Drawn	: RAP	Date	: 27 Sept '16
Checked	: MN	Project ID	: JKTD15040

BASELINE CONDITION

06

6 Baseline Condition

Existing H_2S concentrations (baseline) are vital to the assessment of the potential impact from the proposed power plant. Baseline data are added to the predicted incremental concentrations to assess the cumulative impacts likely from the site.

The baseline measurement was carried out on 21 – 22 July 2016. The measurement was carried out only for one hour period at eight sampling points (AQ1 – AQ8). Results of the measurement are presented in Table 6-1.

Table 6-1 Baseline 1-Hr Average H_2S Concentrations

Sampling Location	Concentration ($\mu g/m^3$)	Notes on Location
AQ1	< 2.24	Kampung Yayasan
AQ2	< 2.24	Between Wellpad X, L, M and N
AQ3	8.40	Area of Wellpad I
AQ4	7.00	Area of Wellpad C
AQ5	< 2.24	Area of Wellpad E
AQ6	< 2.24	A hut Belongs to Mr. Rawadi
AQ7	5.60	Area of Wellpad B
AQ8	< 2.24	Tunggul Bute Village

Note: 2.24 $\mu g/m^3$ is limit of detection
Source: Baseline study, SERD, 2016

AQ1, AQ6 and AQ8 are at residential areas and the others are at wellpad areas. It can be seen that H_2S concentrations were not detected at the residential areas. Higher H_2S concentrations were detected at wellpad areas with 8.4 $\mu g/m^3$ as the highest at wellpad I. It can also be seen that the baseline one hour average concentrations of H_2S in the project area are still well below the one hour odor standard of 70 $\mu g/m^3$.

With very low one-hour baseline H_2S, the 24 hour baseline concentrations are believed to be negligible. Therefore in this study baseline 24 hour concentrations are not added to the incremental concentrations predicted by the Calpuff.

MODELLING RESULTS

07

7 Modelling Results

This section presents the dispersion modelling results for the proposed power plant based on expected emission rates as described in Table 4-1 to assess the typical or expected emissions from the proposed power plant. The model predicted concentrations are rounded to one significant value. As such, concentrations of 28.0 to 28.4 µg/m3 would not exceed the standard 28 µg/m3 as those concentrations would round to 28 µg/m3.

7.1 24-Hour Average Incremental Hydrogen Sulphide

The 24-hour average predictions discussed in this section have been undertaken to assess the potential odor nuisance effects, as opposed to the odor standard.

Figure 7-1 shows the predicted 24-hour average hydrogen sulphide concentration within 12km x 12km domain for the expected total hydrogen sulphide emission rate of 133 g/s. Figure 7-2 shows the predicted concentrations within smaller domain (3km x 3km). These figures were made based on spatial interpolation of predicted concentrations at gridded receptors. The interpretation of these figures is as follows:

- The red contour line corresponds to the guideline of 28 µg/m^3 used to assess potential odour nuisance impact, as discussed in Section 3.2. The 28 µg/m^3 concentration contour remains to the east and south of the plant.
- The purple triangles show the locations of existing households based on satellite/field survey identification.
- The brown tree symbols represent coffee farmer huts at coffee plantation.
- The black square symbols represent worker receptors inside the proposed power plant's perimeter fence.
- The highest concentration contour (dark orange) shows the areas within which predicted incremental concentrations exceed 400 µg/m^3. The next two contours show the extent of the areas within which predicted concentrations exceed 300 µg/m^3 and 200 µg/m^3. Predicted incremental concentrations exceeding 400 µg/m^3 are confined within the power plant's perimeter and will be considered in the OSHA of the O&M plan.
- The permanent accommodation facilities (sensitive receptor R90) are located more than 1.5 km to the east of the power plant (emmissions source) and outside the 28 µg/m^3 concentration contour. The predicted maximum concentration at this location is 22 µg/m^3.

Based on Calpuff calculations at discrete receptors (at this case the identified sensitive receptors), the exceedance of the 24-hour incremental concentrations only occurs at one coffee farmer hut i.e. R54 located approximately 1.5 km to the east of the power plant. The predicted maximum concentration at this receptor is 30 µg/m^3. The maximum incremental concentrations predicted at the other sensitive receptors are in the range 5-28 µg/m^3, or less than or equal to the odor standard.

However based on the spatial interpolation as can be seen from the Figure 7-1, the exceedance will also occur at R55. This is note actually the case, as based on the Calpuff calculations for the specific receptors, the maximum concentration at this receptor is 28 µg/m^3 (see Appendix F for reference). The discrepancy may be due to limitation in the spatial interpolation.

Table 7-1 shows frequency distribution of predicted 24-hour average hydrogen sulphide concentrations at R54 within three years period of modelling.

Table 7-1 Frequency Distribution of 24-hour Average H_2S Concentrations at R54

Concentration Range* (µg/m^3)	Frequency (days)	Percentage
0-7	932	85.1%
8-14	119	10.9%
15-21	42	3.8%
22-28	1	0.1%
>28	1	0.1%

* Concentrations are rounded to one significant value

The hydrogen sulphide emissions from the proposed power plant are predicted to cause the R54 to exceed the 28 µg/m^3 odour standard only one time in three years. The exceedance at R54 is only 0.1% of the time. Most of the time (>85%) the H_2S concentrations at this receptor is ranging from zero to seven µg/m^3. Thus the exceedance frequency can be considered insignificant.

In addition the predicted concentrations are well less than the WHO guideline of 150 µg/m3 and will not result in any adverse health effects.

7.2 8-Hour Average Incremental Hydrogen Sulphide

The 8-hour predictions discussed in this section have been undertaken to assess the potential health related effects as opposed to the safety standard, in addition to the potential odour nuisance effects.

Figure 7-2 shows the predicted maximum 8-hour average hydrogen sulphide concentrations at eight representative worker receptors resulting from emissions from the proposed power plant and will be considered in the OSHA of the O&M plan.

Table 7-2 Maximum 8-Hr Average H_2S Concentrations (µg/m^3) at Representative Worker Receptors (Sorted by The Highest)

Receptor Number	Location of Receptor	Maximum Concentration *
86	Near Turbine Hall	1,051
75	Site Access Road 1	696
88	Wellpad Pond Area	689
85	Site Access Road 2	589
87	Wellpad RD-E	536
83	Vent Station	498
84	Separator Station	462
56	Cleared Area (possible temporary facilities area)	267
90	Accomodation Building	47

* Concentrations are rounded to one significant value

Figure 7-3 shows the predicted 8-hour average hydrogen sulphide concentration contributions for the proposed power plant. There is no exceedance of the 8-hour incremental concentrations at representative worker receptors. The highest predicted 8-hr concentration is at receptor number 86 with 1,051 µg/m^3, or 75% of the 1,400 µg/m^3 threshold value in the working environment as stipulated in the Regulation of the Minister of Employment and Transmigration Number PER.13/MEN/X/2011. This receptor is located less than 100 meter from the cooling tower. The incremental concentrations predicted at the other worker receptors are in the range 47-696 µg/m^3, or 3.5-50% of the threshold value.

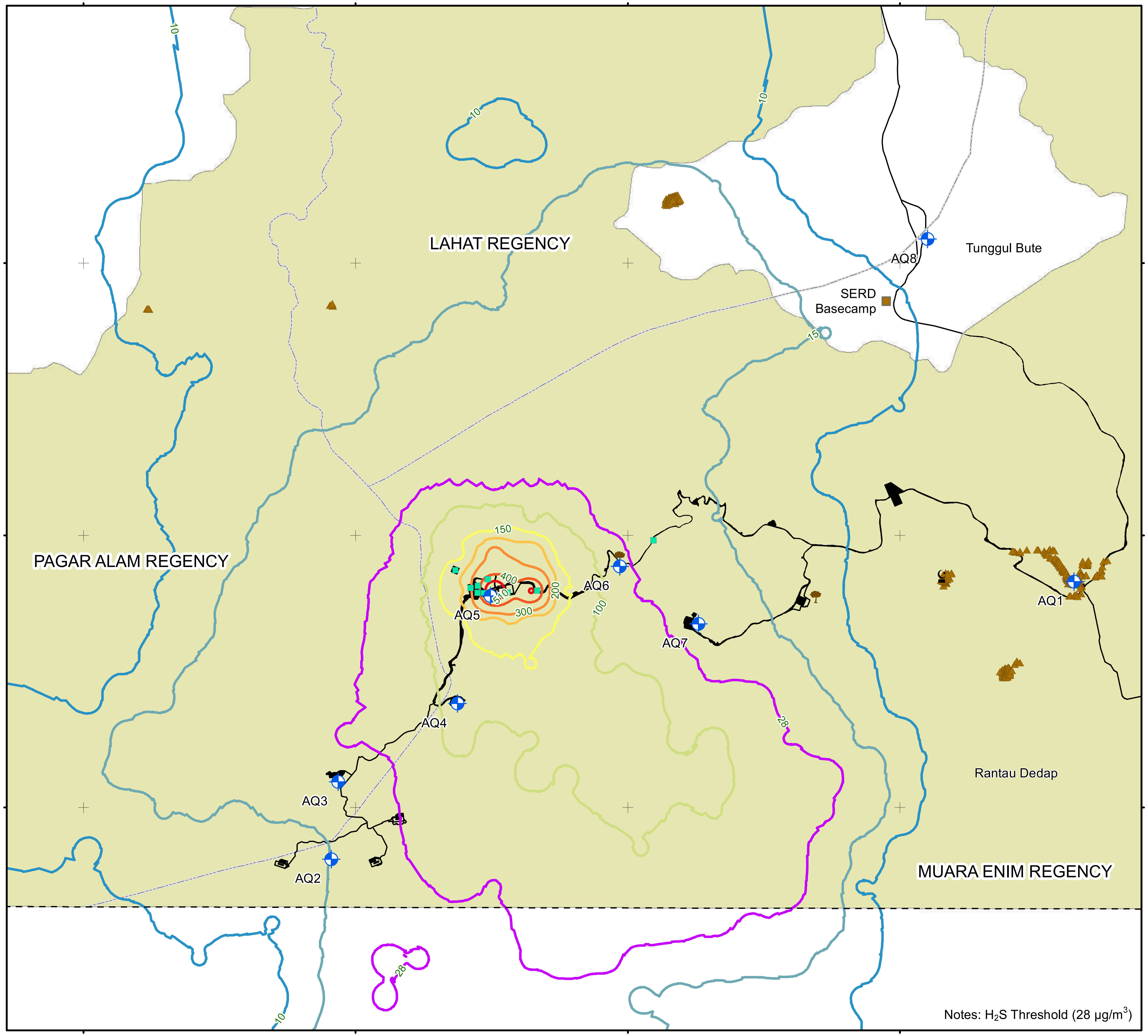

Figure 7-1

CLIENT

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PT Supreme Energy Rantau Dedap

Map Title

H_2S 24 HOURS INCREMENTAL CONCENTRATION

Administrative Details

Regency	Muara Enim, Lahat, and Pagar Alam City
Province	South Sumatra

Scale Map Information

Scale 1:50,000 on A3 Paper

0.5 0.25 0 0.5 1 1.5 2 Kilometers

Index Location

Legend

Air Quality Sampling Location

Forestry Area

Receptor

Coffee Farmer Hut

Household

Mosque

Worker

Road and Wellpad

Regency Boundary

Domain boundary of forestry data availability

H_2S Concentration ($\mu g/m^3$)

10
15
28
100
150
200
300
400
510

Data Sources

1. Client Document
2. Modeling results from Calpuff Software
3. Google Earth Imagery Services

Map Information

Datum	World Geodetic System 1984
Projection	Universal Transverse Mercator
Zone	48 South
Unit	Meter

Provided by

AECOM
PT AECOM Indonesia

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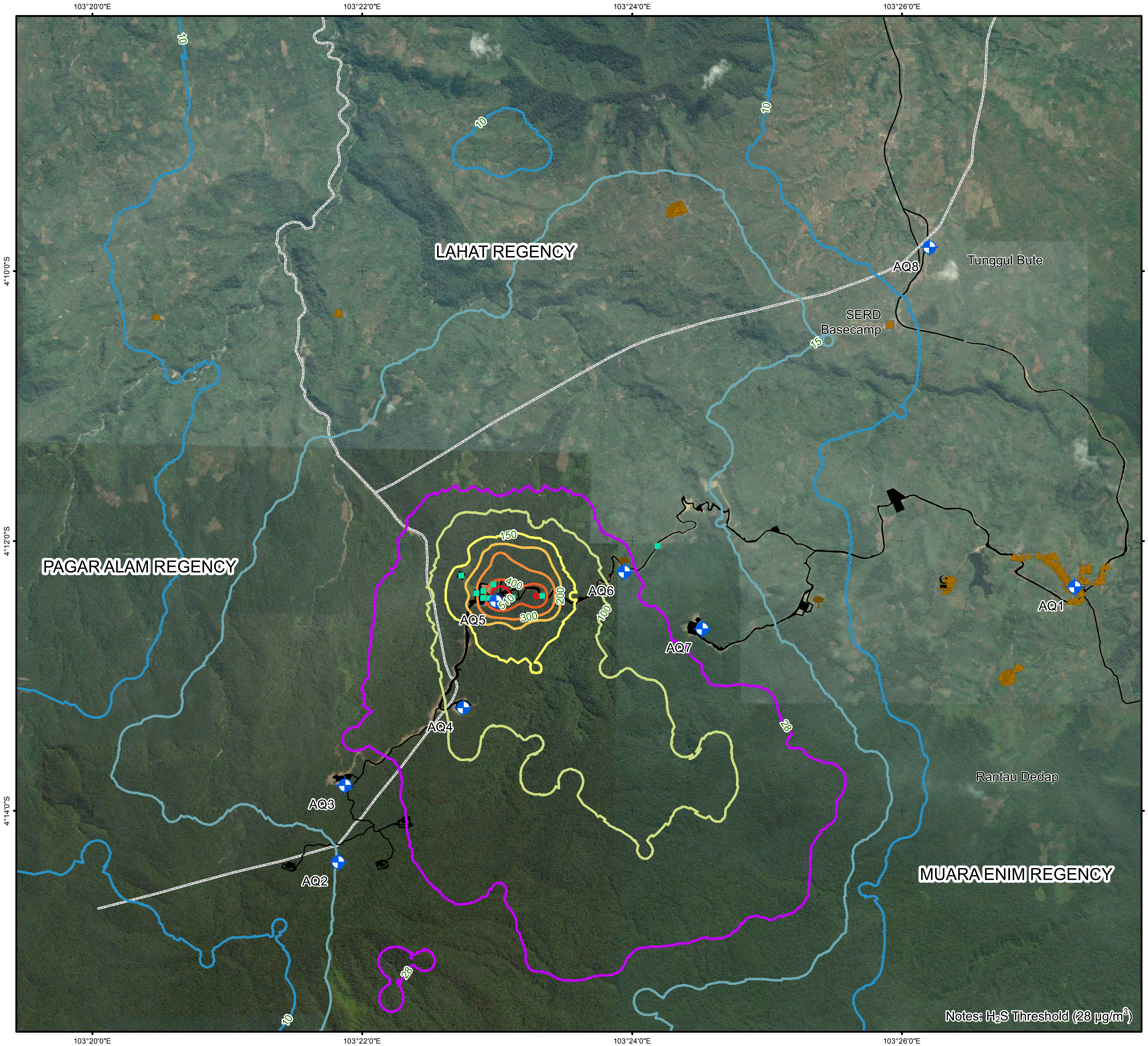


Figure 7-2

CLIENT

supreme energy

PT Supreme Energy Rantau Dedap

Map Title

H_2S 24 HOURS INCREMENTAL CONCENTRATION

Administrative Details

Regency	Muara Enim, Lahat, and Pagar Alam City
Province	South Sumatra

Scale Map Information

Scale 1:50,000 on A3 Paper

0.5 0.25 0 0.5 1 1.5 2

Kilometers

Index Location

Legend

- Air Quality Sampling Location

Receptor

- Coffee Farmer Hut
- Household
- Mosque
- Worker
- Road and Wellpad
- Regency Boundary

H_2S Concentration ($\mu g/m^3$)

- 10
- 15
- 28
- 100
- 150
- 200
- 300
- 400
- 510

Data Sources

1. Client Document
2. Modeling results from Calpuff Software
3. Google Earth Imagery Services (Basemap)

Map Information

Datum	World Geodetic System 1984
Projection	Universal Transverse Mercator
Zone	48 South
Unit	Meter

Provided by

AECOM

PT AECOM Indonesia

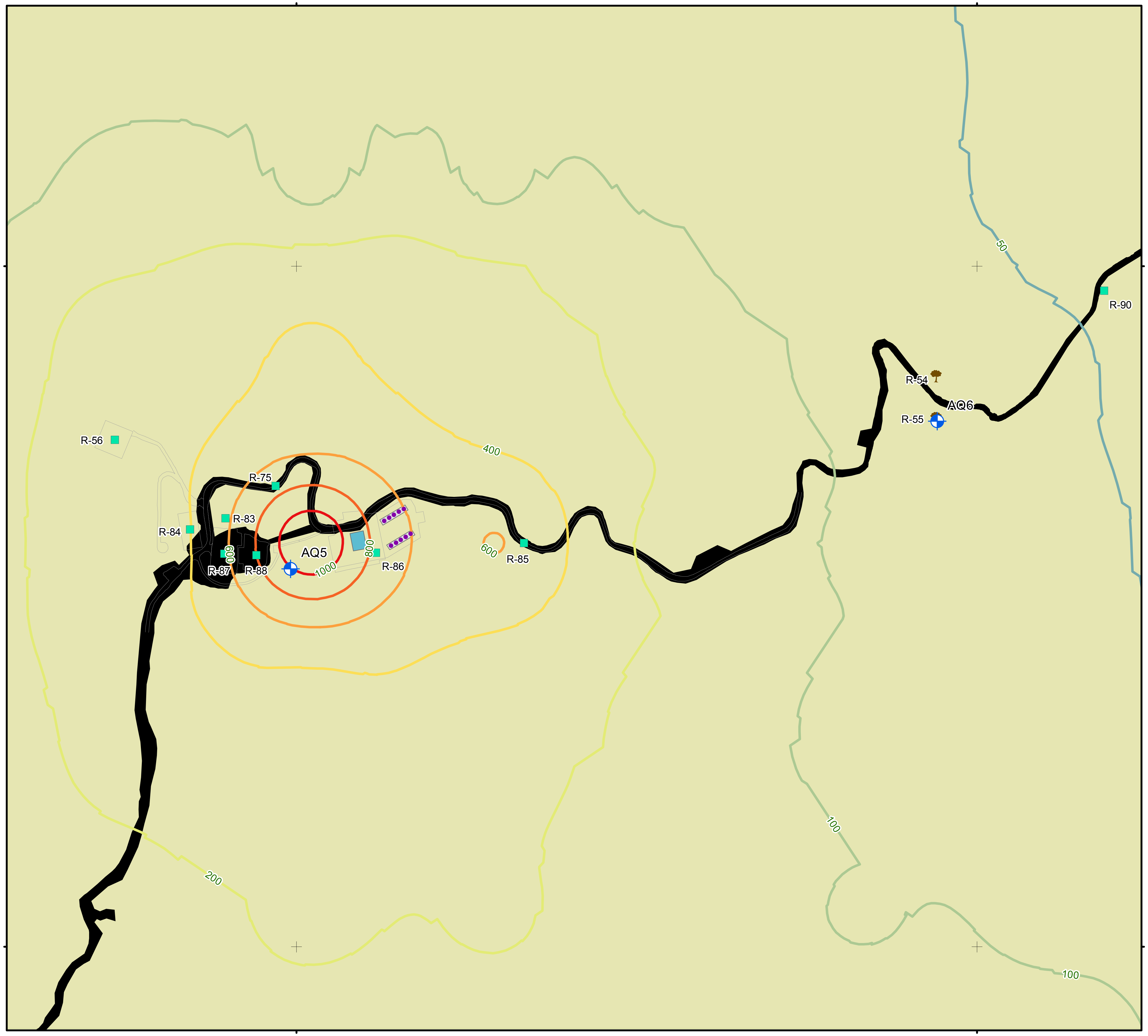
Drawn : RAP	Date : 27 Sept '16
Checked : MN	Project ID : JKTD15040

Figure 7-3

CLIENT

supreme energy

PT Supreme Energy Rantau Dedap



Map Title

H_2S 8 HOURS INCREMENTAL CONCENTRATION

Administrative Details

Regency	Muara Enim, Lahat, and Pagar Alam City
Province	South Sumatra

Scale Map Information

Scale 1:10,000 on A3 Paper

0.1 0.05 0 0.1 0.2 0.3 0.4

Kilometers

Index Location

Legend

- Emission Sources
- Air Quality Sampling Location

Receptor

- Coffee Farmer Hut
- Worker
- Road and Site Boundary
- Road and Wellpad
- Cooling Tower Building
- Turbine Hall
- Forestry Area

H_2S Concentration ($\mu g/m^3$)

28, 50, 100, 200, 400, 600, 800, 1000

Data Sources

1. Client Document
2. Modeling results from Calpuff Software
3. Google Earth Imagery Services

Map Information

Datum	World Geodetic System 1984
Projection	Universal Transverse Mercator
Zone	48 South
Unit	Meter

Provided by

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Drawn : RAP	Date : 27 Sept '16
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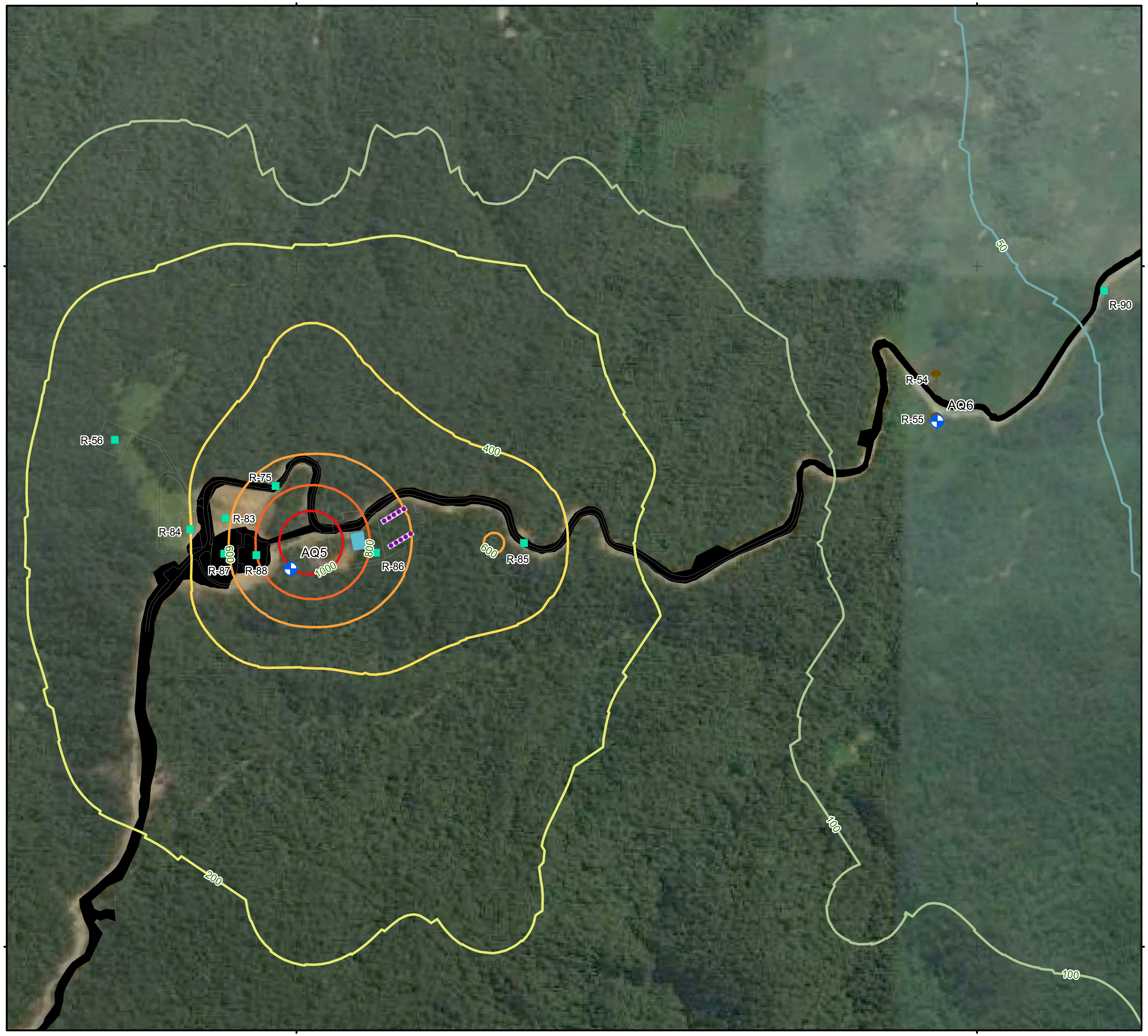

Figure 7-4

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PT Supreme Energy Rantau Dedap

Map Title

H_2S 8 HOURS INCREMENTAL CONCENTRATION

Administrative Details

Regency	Muara Enim, Lahat, and Pagar Alam City
Province	South Sumatra

Scale Map Information

Scale 1:10,000 on A3 Paper

0.1 0.05 0 0.1 0.2 0.3 0.4
Kilometers

Index Location

Legend

- Emission Sources
- Air Quality Sampling Location

Receptor

- Coffee Farmer Hut
- Worker
- Road and Site Boundary
- Road and Wellpad
- Cooling Tower Building
- Turbine Hall

H_2S Concentration ($\mu g/m^3$)

- 28
- 50
- 100
- 200
- 400
- 600
- 800
- 1000

Data Sources

1. Client Document
2. Modeling results from Calpuff Software
3. Google Earth Imagery Services

Map Information

Datum	World Geodetic System 1984
Projection	Universal Transverse Mercator
Zone	48 South
Unit	Meter

Provided by

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PT AECOM Indonesia

Drawn : RAP	Date : 27 Sept '16
Checked : MN	Project ID : JKTD15040

CONCLUSION

08

8 Conclusion

AECOM has been commissioned by SERD to prepare Air Dispersion Modelling (ADM) to demonstrate compliance with applicable standards. This report is therefore to provide an assessment of the air quality impact associated with the power plant operation.

The primary air emissions of concern with regards to odour nuisance and health effects from the power plant will be the non-condensable gases (NCG). NCG are gases that are present with range of 0.09-1.6 wt% in the geothermal fluid. The NCG consist predominantly of carbon dioxide (approximately 97%), but also contains hydrogen sulphide (H_2S). The NCG will be released from vents located above the mechanical evaporative cooling towers.

Based on the NCG content in the steam and H_2S content in the NCG provided by SERD, the H_2S emission was calculated 13.25 g/s. With this rate, the emission concentration at normal condition was estimated 30 mg/m^3, still well below the Indonesian Emission Standard of 35 mg/m^3.

The ADM report for the proposed SERD geothermal power plant was based on the air dispersion model Calpuff and assessed the contribution to air quality impacts at nearby sensitive receptors and representative worker receptors from the power plant. The inputs to the model include source parameters, building dimensions expected to cause downwash effect, meteorological data, topography and land use. For this study, dispersion is modelled over 12 km x 12 km domain with the power plant cooling tower is in the centre.

Based on the Calpuff calculations, the Rantau Dedap geothermal power plant project substantially complies with limits set by the following standards/regulations/guidelines:

- Power plant emissions as set by Republic of Indonesia Regulation No 21 of 2008 (MENLH, 2008)
- Ambient H_2S concentrations, as set by Republic of Indonesia Regulation Minister of Environmental Decree No 50 of 1996 regarding Odor Standard (MENLH, 1996)
- Ambient H_2S concentrations recommended by IFC EHS Guideline for Geothermal Power Generation (IFC, 2007)
- Ambient H_2S Concentrations regarding the working environment, as set by The Republic of Indonesia Minister of Employment and Transmigration Regulation Number PER.13/MEN/X/2011 (MENAKERTRANS, 2011)
- Ambient H_2S concentrations regarding health, as recommended by World Health Organization's Air Quality Guidelines for Europe (WHO, 2000)

Exceedance of the 24-hour incremental concentration limit (MENLH, 1996) occurs at only one identified sensitive receptor (R54), a coffee farmer hut located approximately 1.5 km to the east of the power plant. The predicted maximum concentration at this receptor is 30 µg/m^3 which exceeds the Indonesia Odor Standard. However the exceedance only occurs one time in three year period. This is unlikely to result in adverse impacts on the receptors resulting in odour complaints.

There is no exceedance of the 8-hour incremental concentrations at representative worker receptors. The highest predicted 8-hr concentration is 1,051 µg/m^3 at receptor number 86 located less than 100 meter from the cooling tower. This concentration is below the threshold value of 1,400 µg/m^3 in the working environment as stipulated in the Regulation of the Minister of Employment and Transmigration Number PER.13/MEN/X/2011.

REFERENCES

09

9 References

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WHO. (2000). *Air Quality Guidelines for Europe.* Retrieved August 2016, from World Health Organization Regional Office for Europe: http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

APPENDIX A
Comparison between SERD Observation Meteorological Data and Calmet Simulation

Surface meteorological data were obtained from Meteorological Station installed by Supreme Energy Rantau Dedap (SERD) since 2012 at the project location. Data obtained from this station is from 2012-2015. The parameters obtained include temperature, humidity, wind speed, wind direction and rainfall. Data are available on a hourly basis. However many hours have missing values.

Because of the limitation of the observation data, hourly forecast meteorological data were also obtained from Lakes Environmental (hereinafter referred to as Lakes). Lakes is a company based in Ontario, Canada which provides provides meteorological modelling for air dispersion modelling purpose for any location in the world. Their data were results of running the next-generation Weather Research and Forecasting mesoscale model (WRF).

The meteorological data from Lakes were obtained by request via their website. The request is completed with information regarding domain to be modelled and modelling period. For this study, meteorological modelling was requested for a domain size of 50 x 50 km (with project location in the middle), 12 km grid resolution, and for the period of 2013 to 2015 with one hour data interval. The meteorological data from Lakes were generated in the 3D.DAT format outputs. For air dispersion modelling purpose, these outputs were further simulated with CALMET for a finer grid resolution. CALMET is the meteorological pre-processor for the CALPUFF model. The results of CALMET simulation were then compared to the observation data.

A further evaluation of the reasonableness of the CALMET meteorological output was conducted by comparing the model predicted meteorological parameters with the observed measurements. Note that the extracted data from the CALMET outputs are set up at the surface level, i.e., 10 m above the ground. Tabel 1 summarizes the annual averaged results and the comparisons for wind direction, wind speed and temperature.

Table 1 Comparisons of CALMET Simulation vs. SERD Observation for Annual Average Wind Directions/Speeds and Temperature

Year	Observation			Calmet Simulation			Comparison		
	WD (degree)	WS (m/s)	T (oC)	WD (degree)	WS (m/s)	T (oC)	WD (%)	WS (%)	T (%)
2013	201	2.1	17.9	202.2	2.9	18.4	0.6%	38.1%	2.8%
2014	205	2.2	18.0	188.3	2.9	18.3	-8.1%	31.8%	1.7%
2015	197	2.4	18.5	172.6	3.3	18.4	-12.4%	37.5%	-0.5%

Note: WD = Wind Direction; WS = Wind Speed; T = Temperature

As can be seen in Table 1, the predicted parameter values are very close to those of the observed especially for wind direction and temperature. Only the predicted wind speeds are higher 32% to 38% than those of the observed. However these can be still considered acceptable. It can be seen that the agreement between the measurements and predictions are satisfactory.

Figure 1 and Figure 2 present the wind roses from SERD observation and Calmet simulation for three year period respectively. Comparing with the observations, it is shown that the predicted wind rose is not close to the observed. However, the Calmet simulation does a reasonable job in capturing the distribution of wind directions.

From the observation data, prevailing winds in the study area are primarily from the south southeast. The Calmet simulation tends to under predict the frequency of winds from this direction and over predict the frequency of winds from west southwest and east northeast.

The average wind speeds for the observed and predicted were about 2.4 m/s and 3.3 m/s, respectively. Simulation-predicted wind speeds are slightly higher than the observed values.

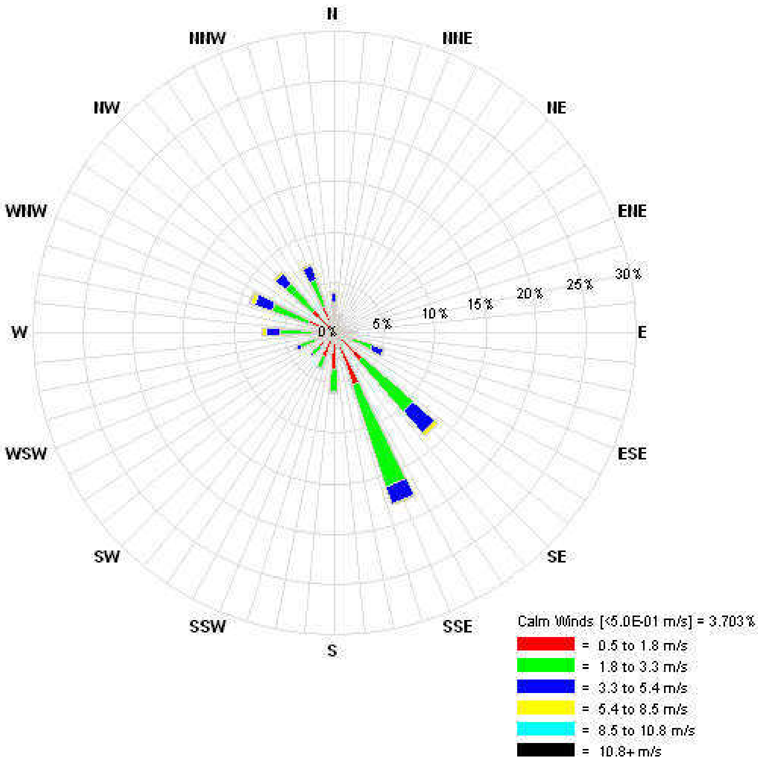


Figure 1 Wind-Rose Depicting Wind Direction Distribution Based on Calmet SERD Observation (Period of 2013-2015)

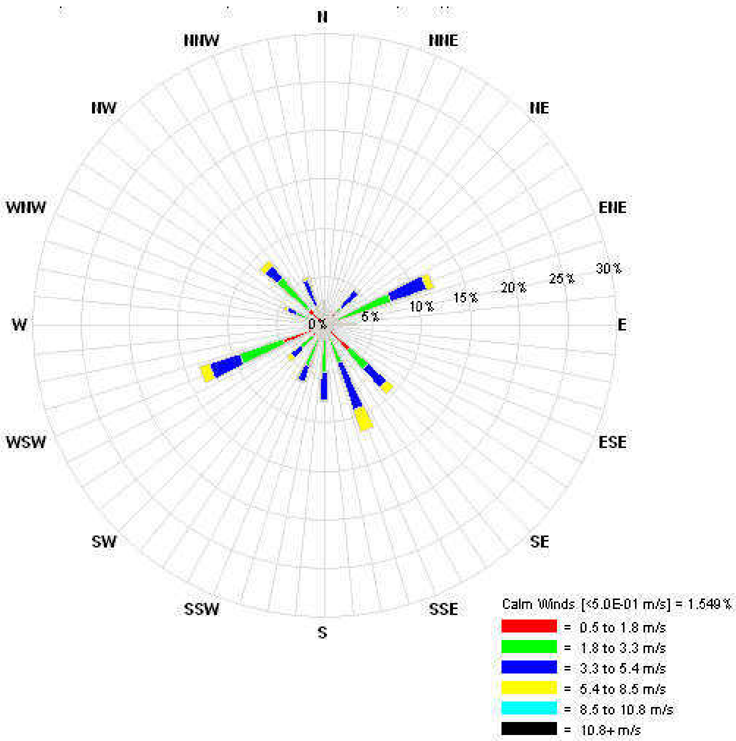


Figure 2 Wind-Rose Depicting Wind Direction Distribution Based on Calmet Simulation (Period of 2013-2015)

APPENDIX B
Calculation of H_2S Emission from Cooling Tower

The most important air quality impact associated with a geothermal power plant will be the release of non-condensable gases (NCG) into the atmosphere. The NCG will be discharged from vents located above the cooling tower fan units and be entrained within the cooling tower discharge, thereby aiding dispersion. The main component of the discharged NCG will be carbon dioxide but hydrogen sulphide (H_2S) and mercury will also be present. The latter two components are those of concerns.

The H_2S emissions from the Supreme Energy Rantau Dedap (SERD) geothermal power plant will originate from the operations of two identical units of cooling tower. Characteristics of the cooling tower per unit at normal operation are presented in Table 1.

Table 1 Characteristic of the Cooling Tower (per Unit)

Item	Unit	Design
Type		COUNTERFLOW
Water flow	t/hr	10,248
Hot water temperature (Tower inlet)	oC	36
Cold water temperature (Tower outlet)	oC	20
Cooling tower size		
Length	m	80
Width	m	16
Height (working level and freeboard)	m	15
Fan		
Number of fans	-	5
Fan diameter	m	10
Exit temperature	C	32
Exit pressure	bar	0.8
Exit relative humidity	%	100
Exit air mass flowrate per fan	t/hr	1,827

Source: Supreme Energy Rantau Dedap, 2016

For this study, the H_2S emission will be calculated based on the NCG content in the steam and H_2S content in the NCG. For the purpose of estimating the H_2S emission, it will be assumed a steady-state condition will be reached. Steps for the calculation of the cooling tower H_2S emission are as follows:

1. Calculate mass flow rate of H_2S emission per fan with equation:

$$EH = [(M_1 * g_1 * f_1) + (M_2 * g_2 * f_2)] / 5 \qquad \text{Equation 1}$$

Where:

EH = Mass flow rate of H_2S emission per fan, g/s

M_1 = Total mass flowrate of high pressure steam to turbine, g/s

M_2 = Total mass flowrate of low pressure steam turbine, g/s

g_1 = Mass fraction of NCG from the high pressure steam flow

g_2 = Mass fraction of NCG from the low pressure steam flow

f_1 = Mass fraction of H_2S in the NCG from the high pressure steam flow

f_2 = Mass fraction of H_2S in the NCG from the low pressure steam flow

5 = number of fans of one unit of cooling tower

Values of M_1, M_2, g_1, g_2, f_1, and f_2 were provided by SERD (Appendix D of this report) for one unit of cooling tower.

2. Calculate volume of air flow at actual condition with equation:

$V_1 = m_{air} \times Sv$, Equation 2

Where:

V_1 = volume of exit airflow at actual condition (T_1 & P_1), m^3/s

m_{air} = mass flowrate of exit air, kg/s

Sv = specific volume of exit airflow at actual condition (T_1 & P_1), m^3/kg

The value of Sv can be obtained from the psychometrics chart according to ANSI/ASHRAE Standard 41.6-1994. This chart shows air-vapour properties including specific volume based on air barometric pressure, dry bulb temperature and relative humidity. The values for these three parameters are provided in Table 1.

3. Calculate volume of airflow at normal condition with equation:

$V_2 = V_1 \times (T_2/T_1) \times (P2/P1)$ Equation 3

Where:

V_2 = Volume of exit airflow at normal condition, m^3/h

T_1 = Temperature of airflow at actual condition, K

T_2 = Temperature of airflow at normal condition, K

P_1 = Pressure of airflow at actual condition, bar

P_2 = Pressure of airflow at normal condition, bar

4. Calculate H_2S emission concentration at normal condition with equation

$ES = EH / V_2$ Equation 4

The result of each step is presented in Table 2.

Table 2 Results of Systematic Estimation of H_2S Emission from Cooling Tower

Item	Value	Unit
M_1	59,917	g/s
M_2	31,889	g/s
g_1	1.60	%
g_2	1.15	%
f_1	5.00	%
f_2	5.00	%
Sv	1.14	m^3/kg
m_{air}	507.5	kg/s
V_1	580	m^3/s
V_2	449	m^3/s
ES	**30**	**mg**/m^3
EH	**13.25**	**g/s**

APPENDIX C
Index of Sensitive Receptors

Receptor ID	Type of Receptor	Easting (km)	Northing (km)	Elevation (m)
R-1	Household	323.081	9540.194	1351
R-2	Household	323.069	9540.189	1351
R-3	Household	323.054	9540.186	1352
R-4	Household	323.040	9540.185	1352
R-5	Household	323.030	9540.179	1356
R-6	Household	323.086	9540.176	1350
R-7	Household	323.012	9540.172	1350
R-8	Household	323.003	9540.171	1348
R-9	Household	322.982	9540.169	1348
R-10	Household	322.965	9540.162	1344
R-11	Household	322.958	9540.162	1344
R-12	Household	323.061	9540.157	1353
R-13	Household	323.053	9540.157	1353
R-14	Household	323.032	9540.155	1350
R-15	Household	323.016	9540.146	1346
R-16	Household	322.924	9540.145	1342
R-17	Household	322.998	9540.144	1344
R-18	Household	322.983	9540.143	1344
R-19	Household	323.068	9540.137	1345
R-20	Household	322.974	9540.136	1344
R-21	Household	323.112	9540.134	1347
R-22	Household	322.925	9540.133	1342
R-23	Household	323.048	9540.131	1349
R-24	Household	323.037	9540.131	1349
R-25	Household	322.959	9540.130	1343
R-26	Household	322.953	9540.127	1343
R-27	Household	323.022	9540.124	1346
R-28	Household	323.107	9540.123	1347
R-29	Household	323.013	9540.122	1346
R-30	Household	322.997	9540.115	1345
R-31	Household	323.096	9540.112	1345
R-32	Household	323.079	9540.109	1345
R-33	Household	322.921	9540.109	1344
R-34	Household	322.976	9540.105	1345
R-35	Household	322.963	9540.103	1343
R-36	Household	323.067	9540.102	1345
R-37	Household	322.945	9540.101	1343
R-38	Household	322.985	9540.087	1345
R-39	Household	322.927	9540.086	1344
R-40	Household	323.003	9540.085	1345

Receptor ID	Type of Receptor	Easting (km)	Northing (km)	Elevation (m)
R-41	Household	322.972	9540.082	1347
R-42	Household	323.045	9540.080	1345
R-43	Household	322.911	9540.069	1348
R-44	Household	322.958	9540.067	1347
R-45	Household	322.931	9540.053	1348
R-46	Household	318.413	9538.701	1240
R-47	Household	318.388	9538.715	1240
R-48	Household	318.357	9538.693	1243
R-49	Household	318.377	9538.693	1243
R-50	Household	318.398	9538.682	1240
R-51	Household	315.891	9538.642	1247
R-52	Household	315.869	9538.639	1249
R-53	Household	315.897	9538.634	1247
R-54	Coffee Farmer Hut	322.302	9535.285	1683
R-55	Coffee Farmer Hut	322.302	9535.171	1692
R-56	Worker	320.070	9535.108	1996
R-57	Household	326.732	9535.088	1595
R-58	Household	326.813	9535.084	1583
R-59	Household	326.766	9535.078	1593
R-60	Household	326.806	9535.074	1588
R-61	Household	326.761	9535.061	1593
R-62	Household	326.698	9535.060	1597
R-63	Household	326.728	9535.048	1594
R-64	Mosque	326.682	9535.042	1599
R-65	Household	326.746	9535.040	1594
R-66	Household	326.756	9535.039	1591
R-67	Household	326.714	9535.025	1597
R-68	Household	326.727	9535.019	1593
R-69	Household	326.789	9535.012	1584
R-70	Household	326.706	9535.009	1596
R-71	Household	326.725	9535.003	1593
R-72	Household	326.735	9534.996	1593
R-73	Household	326.754	9534.994	1587
R-74	Household	326.672	9534.985	1592
R-75	Worker	320.506	9534.984	2000
R-76	Household	326.693	9534.978	1594
R-77	Household	326.704	9534.973	1594
R-78	Household	326.715	9534.968	1594
R-79	Household	326.725	9534.963	1589
R-80	Household	326.735	9534.962	1589

Receptor ID	Type of Receptor	Easting (km)	Northing (km)	Elevation (m)
R-81	Household	326.747	9534.942	1589
R-82	Household	326.704	9534.911	1590
R-83	Worker	320.371	9534.897	2008
R-84	Worker	320.274	9534.866	2023
R-85	Worker	321.182	9534.831	1929
R-86	Worker	320.780	9534.804	1960
R-87	Worker	320.368	9534.801	2012
R-88	Worker	320.455	9534.797	2007
R-89	Coffee Farmer Hut	324.967	9534.756	1687
R-90	Worker	322.759	9535.518	1640

APPENDIX D
SERD Well Field Assumptions

supremeenergy

PT. SE RD

Memorandum

Confidential

To: Novi Ganefianto

From: SERD subsurface team

Copy: Ralph Hoellmann

Victor Van Der Mast

Date: 18 August 2016

Doc Ref: RD-PRD-RPT-0067

Re: **Rantau Dedap Stage-1 Final Wellfield Assumptions- Addendum**

	Position	Name	Signature	Date
Prepared By	Chief Reservoir Engineer	Alfianto Perdana Putra		18 Aug 2016
	Chief Development Geoscience	Herwin Azis		18-08-2016
Reviewed By	VP Explor & SS	Novi Ganefianto		18/08-2016
Approved By	Board Of Director	Victor van der Mast		19/8/2016
		Hisahiro Takeuchi		19/8/2016
		Radikal Utama		19/8 2016

1. Introduction

This memo represents the addendum to the Rantau Dedap Stage-1 Final Wellfield Assumptions issued by SERD subsurface team on 19 November 2015. This addendum prepared to estimate the most likely H_2S flows produced by future production wells, which the outcomes will be used for air dispersion modelling analyses of power plant H_2S emission.

The Wellfield Assumptions presents a wide range of Non-Condensable Gas (NCG) and H_2S concentrations that can be produced during field operation. As for power plant design, the maximum value as high as 3.0 wt. % NCG level in steam can be selected. For environmental compliance, however, the most likely H_2S flows in the produced steam would need to be estimated and presented to make sure field operation will comply with the environmental regulation.

2. NCG in steam (% wt.)-

The Wellfield Assumptions states NCG concentration produced by production wells ranges from 0.1 to 3.0 weight (wt.) % in steam over 30 years. At initial conditions, NCG concentration is in the range of 0.1% - 1% wt., more or less consistent with the actual gas production range measured from the existing exploration wells. After several years of production, steam cap is expected to develop as suggested by both GeothermEx and SERD numerical simulations. As reservoir steam cap develops, NCG production from steam cap could raise up to 3.0 wt. % in steam, increasing by a factor of three (3) out of the highest gas concentration ever found in the field. The chance of the average gas concentration will go that high is small, but this is the number that the plant could be designed for, just in case.

3. H_2S Concentration in the Produced Steam

As for environmental compliance, what matters is the H_2S level in the produced steam. The Wellfield Assumptions documents H_2S content in dry gas (NCG) ranging from 3 to 20%, slightly higher than 1 to 16% range actually measured from six exploration wells. To make an estimate of the most likely H_2S flows will be produced during the field start-up, we reviewed gas chemistry of exploration wells, RD-I2 well flowing characteristics, as well as information from five operating geothermal fields. We recommend the following most likely case of NCG and H_2S concentrations is to be used for H_2S dispersion modelling analyses. We also present other scenarios for comparison. More detailed description of the methodology applied in this prediction is presented in the separate report by Alfiady and Ganefianto, dated 5 August 2016.

	NCG in steam	H_2S level in NCG
Most Likely Case	1.0wt. %	6.71%

Other cases for comparison

	NCG in steam	H2S level in NCG
Low gas Case	0.09wt. %	15.8%
High gas Case	1.6wt. %	5%

Below are the basis and assumptions for the most likely case estimates:

- All future production wells will be drilled deep (2700-2900m measured depth) to target deep hot, low NCG reservoir liquid (<0.09 wt.% in steam) similar to RD-I2
- About 33% of future production wells encounter steam cap. This is the same ratio as of the exploration wells, in which two (2) out of six (6) wells encountered steam cap entries
- Steam entries assumed to contribute 60% to individual well productivity.

- NCG content in steam-cap is assumed ~3.5wt. % based on field analogues (e.g. Salak and Wayang Windu Geothermal Fields), while NCG content of reservoir liquid production is assumed 0.09wt. %, same level as RD-I2 NCG production

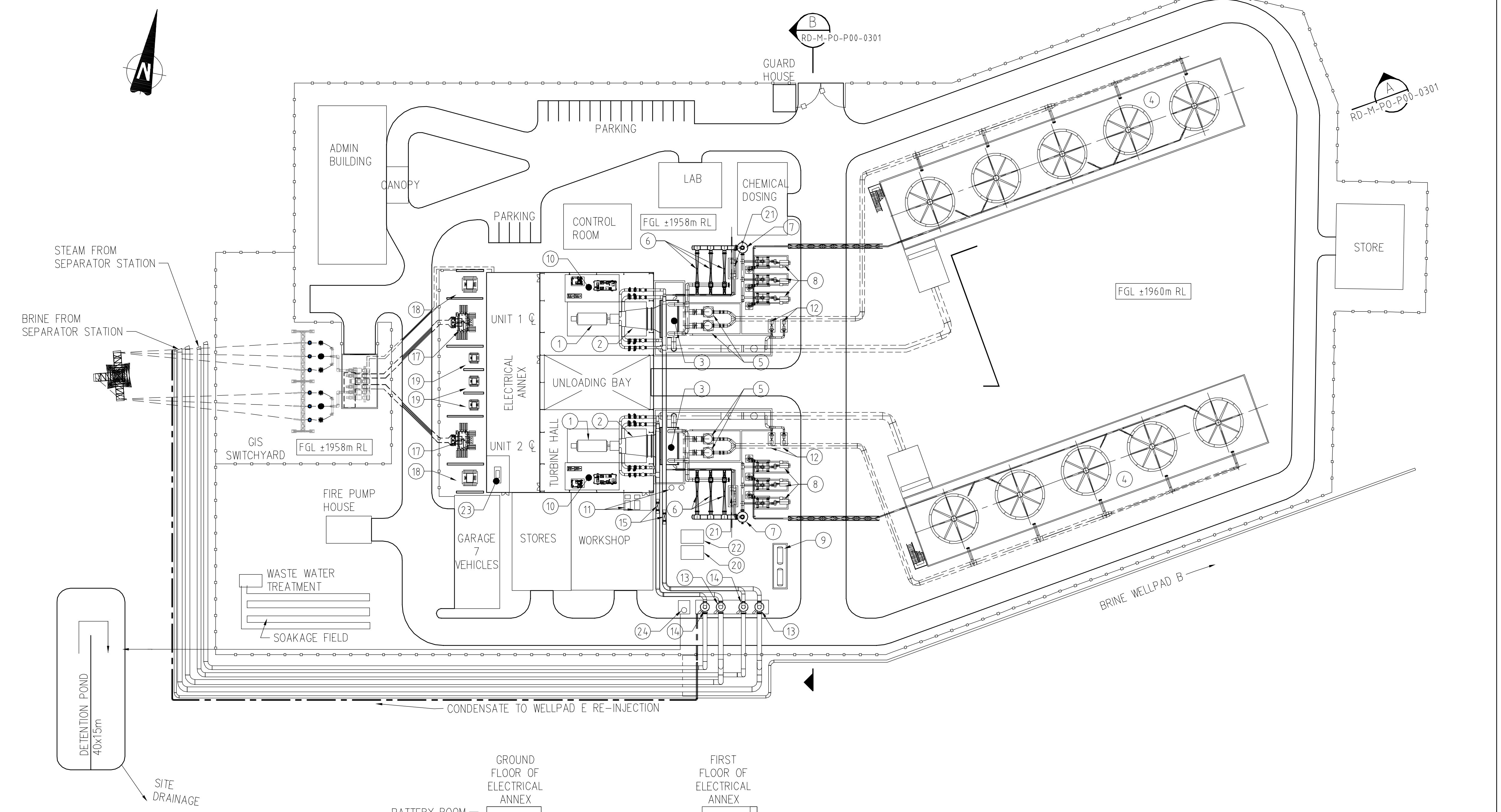
- Due to its high solubility, H_2S content in NCG is enriched in low gas (degassed) steam. This pattern has been observed in many operating geothermal fields. RD-I2 produces very low NCG (0.09wt. % in steam) and high H_2S (16% in dry gas), consistent with the pattern.

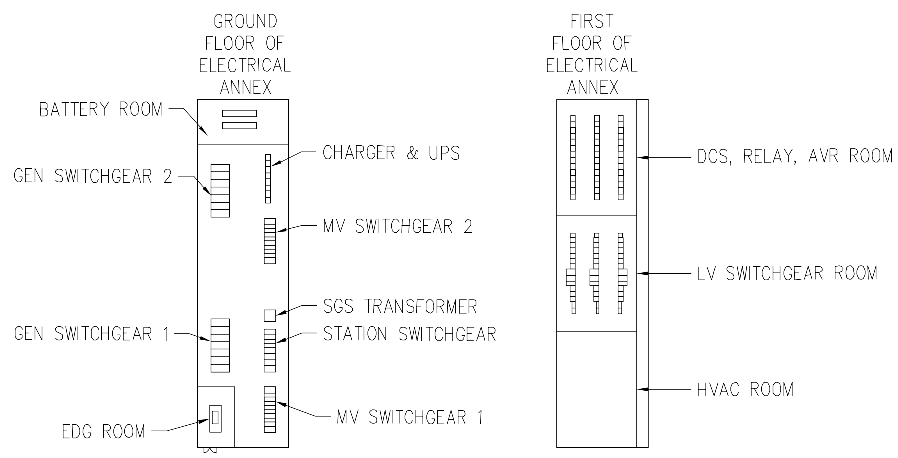
- H_2S proportion in NCG will be depleted when gas increases, due to present of more volatile gases such as CO_2 in NCG. Therefore, when NCG level in steam is predicted to be around 1wt. %, H_2S proportion will likely be closer to what measured at RD-I1, which is 6.71 % in dry gas

4. REFERENCE

Ref.	DESCRIPTION	AUTHOR
1.	Memorandum of "Rantau Dedap – H_2S level prediction", 5 August 2016	Alfiady, Novi Ganefianto
2.	SERD Wellfield Assumption, November 2015	SERD Project and Subsurface team

APPENDIX E
Preliminary Power Plant Layouts





ITEM	DESCRIPTION
1	GENERATOR
2	TURBINE
3	CONDENSER
4	COOLING TOWER
5	HOT WELL PUMPS
6	STEAM EJECTORS
7	INTER CONDENSER
8	LIQUID RING VACUUM PUMPS
9	LUBE OIL STORAGE AREA
10	LUBE OIL & CONTROL OIL SKIDS
11	COMPRESSED AIR FACILITIES
12	AUX COOLING WATER PUMPS
13	LOW PRESSURE SCRUBBER
14	HIGH PRESSURE SCRUBBER
15	VENTURI FLOW METER
16	CHEMICAL DOSING FACILITIES
17	GENERATOR TRANSFORMER
18	UNIT AUX. TRANSFORMER
19	SERVICE TRANSFORMER
20	PLANT SUMP PIT
21	LOOP SEAL PIT
22	CONDENSATE REINJECTION PUMPS
23	EMERGENCY DIESEL GENERATOR
24	SCRUBBER AFT

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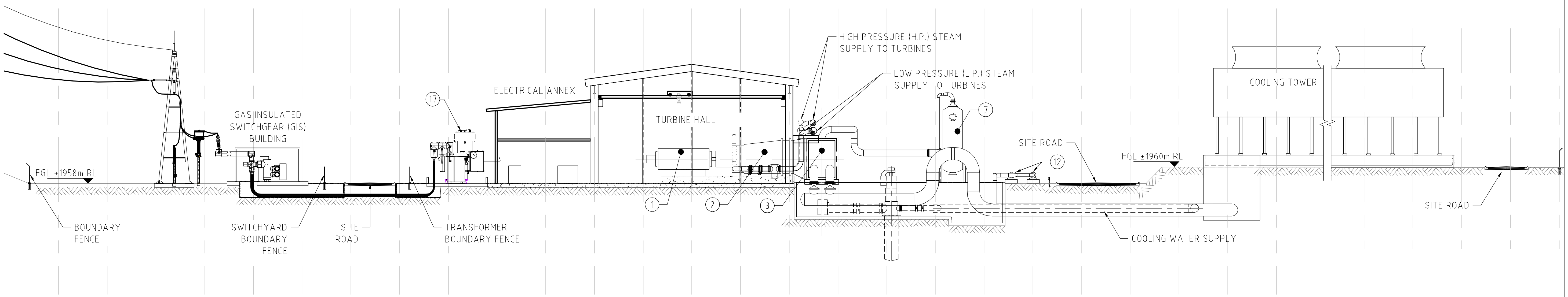
CLIENT: Supreme Energy Rantau Dedap (SERD)
supreme energy

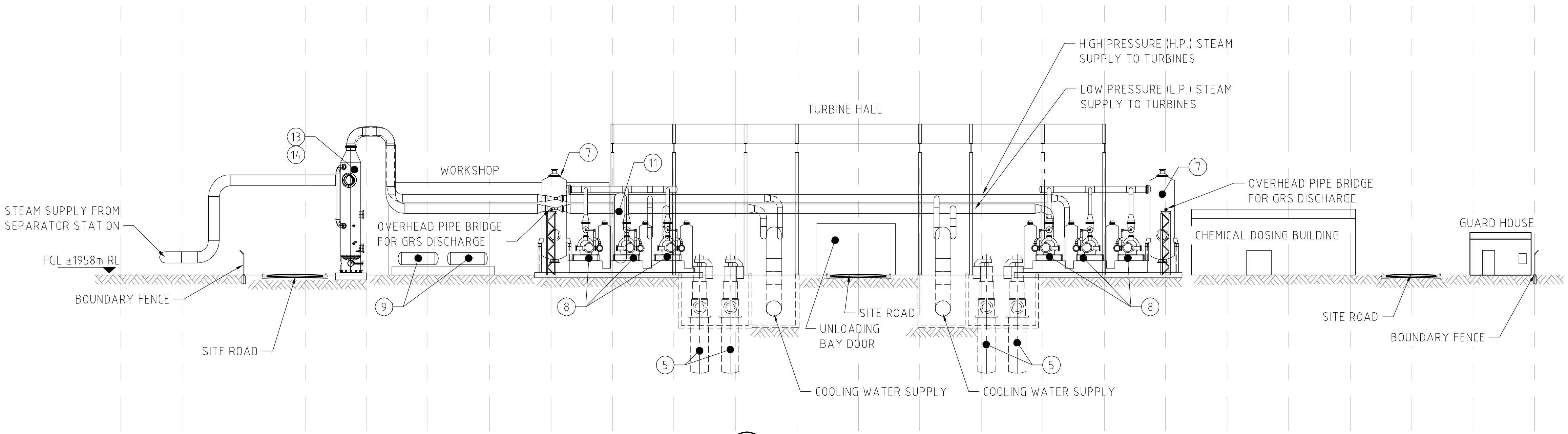
RANTAU DEDAP GEOTHERMAL POWER PROJECT

2x46MW POWER STATION
POWER STATION SITE
EQUIPMENT LAYOUT

A1 | PROJECT NO: | DRAWING NO: RD-M-PO-P00-0300 | REV: 0



SECTION A
RD-M-P0-P00-0300



SECTION B
RD-M-P0-P00-0300

ITEM	DESCRIPTION
1	GENERATOR
2	TURBINE
3	CONDENSER
4	COOLING TOWER
5	HOT WELL PUMPS
6	STEAM EJECTORS
7	INTER CONDENSER
8	LIQUID RING VACUUM PUMPS
9	LUBE OIL STORAGE AREA
10	LUBE OIL & CONTROL OIL SKIDS
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13	LOW PRESSURE SCRUBBER
14	HIGH PRESSURE SCRUBBER
15	VENTURI FLOW METER
16	CHEMICAL DOSING FACILITIES
17	GENERATOR TRANSFORMER
18	UNIT AUX. TRANSFORMER
19	AUX. SERVICE TRANSFORMER
20	PLANT SUMP PIT
21	LOOP SEAL PIT
22	CONDENSATE REINJECTION PUMPS
23	EMERGENCY DIESEL GENERATOR
24	SCRUBBER AFT

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CLIENT: Supreme Energy Rantau Dedap (SERD)

supreme energy

RANTAU DEDAP GEOTHERMAL POWER PROJECT

2x46MW POWER STATION
POWER STATION SITE
EQUIPMENT SECTION

A1 | PROJECT NO: | DRAWING NO: RD-M-PO-P00-0301 | REV: 0

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