Environmental Impact Assessment

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Prepared by ERM for Sarulla Operations Limited (SOL) and Pertamina Geothermal Energy

FINAL REPORT

Volume II: Environmental, Social and Health Impact Assessment (ESIA) Addendum

Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity

North Tapanuli Regency, North Sumatera Province

October 2013

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UNITS AND ABBREVIATIONS

ADB	Asian Development Bank
AIDS	Acquired Immune Deficiency Syndrome
AMDAL	Analisis Mengenai Dampak Lingkungan
ANDAL	Analisis Dampak Lingkungan
BBM	Bahan Bakar Minyak (also known as Fuel in English)
BLH	Badan Lingkungan Hidup (also known as Environmental Agency in English)
BAP	Biodiversity Action Plan
BOMP	Biodiversity Offset Management Plan
BOP	Blow Out Preventer
CBD	Convention on Biological Diversity
CDP	Community Development Program
CR	Critically Endangered
CSMS	Contractor Safety Management System
CSOs	Civil Society Organisations
CSR	Corporate Social Responsibility
dB	Decibel
dBA	Average Decibel
DOA	Deed of Assignment
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESMP	Environmental and Social Management Plan
EN	Endangered
EPC	Engineering Procurement Contracting
EP	Equator Principles
EPFIs	Equator Principles Financing Institutions
ERM	Environmental Resources Management
ERP	Emergency Response Plan
ESC	Energy Sales Contract
ESIA	Environment and Social Impact Assessment
EMP	Environmental Management Plan
EMP	Environmental Management System
ESR	Ecosystem Services Review
FE	Final Evaluation

FGDs	Focus Group Discussions
FI	Financial Intermediary
FPIC	Free, Prior, and Informed Consent
GCCU	Geothermal Combined Cycle Unit
GIIP	Good International Industry Practice
GPM	Gallons per Minute
GPS	Global Positioning System
GRI	Global Reporting Initiative
GTRM	Grievance Tracking and Redress Mechanism
H_2S	Hydrogen Sulfide
H_2SO_4	Hydrogen Sulphate
HIV	Human Immunodeficiency Virus
HR Dept.	Human Resources Department
HSE	Health, Safety and Environmental
ICP	Informed Consultation and Participation
IEC	Information Education Consultation
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IGCCU	Integrated Geothermal Combined Cycle Unit
ILO	International Labour Organisation
IPPs	Independent Power Producers
IPP	Indigenous Peoples Plan
IPs	Indigenous Peoples
IUCN	International Union for the Conservation of Nature
JBIC	Japan Bank for International Cooperation
JOC	Joint Operation Contract
Km	Kilometres
KPIs	Key Performance Indicators
LOI	Letter of Intent
LPM	Litres per Minute
m	Meters
MCK	Mandi Cuci Kakus
MEMR	Minister of Energy and Mineral Resources
MOE	Ministry Of Environment
MSDS	Material Safety Data Sheet
MW	Mega Watt

NIL	Namora I Langit
NGOs	Non-Governmental Organisation
Nm^3	Nano Meter Cubed
NO_X	Nitrogen Oxides
OEC	Ormat Energy Converter
OEM	Original Equipment Manufacturers
OHS	Occupational Health and Safety
ORC	Organic Rankine Cycle
Pb	Lead
PDCA	Plan-Do-Check-Act
PAM	Perusahaan Air Minum
PJA	Pre Job Activity
PLTP	Pembangkit Listrik Tenaga Panas (also known as Geothermal Energy Power Plant in English)
PLN	PT. Perusahaan Listrik Negara
PPE	Personal Protection Equipment
ppm	part per million
PS	Performance Standards
PTWS	Permit-to-Work System
RKL	Rencana Pengelolaan Lingkungan
RPL	Rencana Pemantauan Lingkungan
SFS	Sumatra Fault System
SIL	Silangkitang
SOL	Sarulla Operations Limited
SOP	Standard Operating Procedure
SOx	Sulphur Oxides
SPS	Safeguard Policy Statement
SR	Safeguard Requirements
STIs	Sexually Transmitted Infections
SWP	Specialized Working Procedure
TFT	Tracer Flow Test
TSF	Tor Shibohi Fault
UKL	Upaya Pengelolaan Lingkungan
UNEP	United nation Environmental Program
UNESCO	United Nations Educational, Scientific, and Cultural Organisation
UNSG	Unocal North Sumatera Geothermal
UPL	Upaya Pemantauan Lingkungan

USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
VU	Vulnerable
WC	Water Closet
WHO	World Health Organisation
WIP	Work In Progress

ES EXECUTIVE SUMMARY

ES1 INTRODUCTION

Sarulla Operations Limited (SOL) is the operation company established by the Consortium of Itochu Corporation, Kyushu Electric Power Co., Inc., Ormat International, Inc. and PT. Medco Energi International Tbk. SOL plans to develop the geothermal field and power plant combined capacity of 330 MW in Sarulla, in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province (Figure ES-1). Details of the Project are provided in Table ES-1.

Table ES-1 Summary of the Project for Development of the Geothermal Field and Construction of PLTP Sarulla

Item	Contents	
Project Name	Sarulla Geothermal Power Project	
Location	North Sumatra, Indonesia	
Capacity	320.8 MW, net (1 Unit of 105.4 MW net at Silangkitang ("SIL") and 2 Units of 107.7MW net at Namora-I-Langit ("NIL-1" and "NIL-2"))	
Sponsors	PT Medco Power Indonesia ("Medco") Itochu Corporation ("Itochu") Kyushu Electric Power Co., Inc. ("Kyuden") Ormat International, Inc. ("Ormat")	:37.25% :25.00% :25.00% :12.75%
Project Co.	Sarulla Operations Ltd. ("SOL")	
Commercial Operation Date	SIL: 29 months after financial close NIL-1: 40 months after financial close NIL-2: 46 months after financial close	

In relation to the Regency Spatial Plan, the Government of North Tapanuli Regency issued North Tapanuli Regency Regulation No. 19 of 1994 regarding North Tapanuli Regency spatial planning, which designated the sub districts of Pahae Jae (Silangkitang area or SIL) and Pahae Julu (Namora I Langit or NIL) as areas of geothermal natural resources.

Figure ES-1 Location of the Project for Development of Geothermal Field and Construction of PLTP Sarulla

ES1.1 PROJECT OBJECTIVES AND BENEFITS

The proposed Project has the following objectives:

- To overcome electricity shortage in Indonesia, especially in North Sumatera;
- To support the Government of Indonesia policy in energy diversification and fossil fuel consumption reduction; and
- To optimize the use of geothermal energy that has a high economic and environmental potential.

The Government of Indonesia will benefit from this proposed Project through an increase in electricity supply of 330 MW from geothermal energy which is environmentally friendly compared to traditional sources of electricity generation and is locally available in an area with an increasing energy demand. This project can help to reduce fossil fuel dependency in producing electricity by utilizing the renewable energy of geothermal.

The benefit will also reach local governments and the community in the North Sumatera Region as the direct beneficiary of the power generated from this project. It will help to improve the local economy by providing business and employment opportunities, particularly at the project location.

This project will provide economic, social and technological benefits at national and regional levels. The benefits are as follows:

- Bolsters energy security through use of domestic renewable resource;
    - Limits exposure to fossil fuel market volatility by diversifying the Indonesian power generation profile and reducing reliance on diesel/fuel oil;
    - Reduces critical energy shortage in Sumatra Interconnection System caused by very low reserve margins;
- Improvements in regional industry and economy;
    - Providing multiplier effect to local economy, which is expected to be sustained;
    - An increase in regional incomes at provincial and regency level, through tax and non-tax incomes;
    - Creating job opportunities for local communities, according to Company's requirements and conditions;
- Supports the Indonesian Government's Energy Vision 25/25 through the use of a low-carbon, highly-reliable renewable resource for baseload power;
    - The emissions from power generation from the Sarulla geothermal

development equates to 574,563 tCO_2e per year. Power generation from this additional energy from traditional sources represents 1,946,087tCO_2e (using a 0.748 emission factor for Sumatera). The Project therefore represents a net emissions reduction of 1,371,524tCO_2e per year for 330 MW generation;

- Promotes least-cost generation; and
    - Brings online 330 MW under a highly-competitive tariff, supporting Indonesia in a more sustainable development path.

ES1.2 PURPOSE OF THIS REPORT

The Project has the following approvals under Indonesian environmental regulations:

- ANDAL, RKL/RPL Sarulla geothermal field development (PLN, 2005). Approved November 2005;
- ANDAL, RKL/RPL Sarulla Geothermal 330 MW Capacity. Approved August 2009 (disclosed on ADB's website for 120 days);
- Addendum ANDAL, RKL/RPL 2013 (approval predicted 4Q 2013).

SOL, as part of this development plan is seeking a financial investment from the Japan Bank for International Cooperation (JBIC), Asian Development Bank (ADB) and a group of Equator Principles Financing Institutions (EPFIs). Project proponents seeking financing from JBIC, ADB and EPFIs are required to comply with the applicable bank's environmental, social and health policies, developed for managing the environmental and social risks associated with project finance.

This report presents information on the management of environmental, social and health risks as requested during consultation with the Lenders, which builds upon the information presented in the studies prepared for the aforementioned environmental approval under Indonesian Regulations. As such, this document is not a stand-alone report but represents an Environmental and Social Impact Assessment (ESIA) Addendum that forms part of an overall set of documentation and should therefore be read together with the following reports:

- Environmental Impact Statement (ANDAL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009. This report is available on ADB's website[1];

[1] http://www.adb.org/projects/42916-014/documents

- Environmental Management Plan (RKL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009. This report is available on ADB's website (as per the footnote below);
- Environmental Monitoring Plan (RPL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009. This report is available on ADB's website (as per the footnote below);
- Addendum to ANDAL, RKL-RPL, Relocation Activities of Wellpad Sites in Namora I Langit (NIL), Power Plant in Silangkitang (SIL), Transmission Line, Development of Geothermal Field and Construction of the 330 Mw Capacity PLTP Sarulla. Sarulla Operations Limited, in North Tapanuli District North Sumatra Province; July 2013. At the time of writing, these reports are currently undergoing review under the Indonesian regulatory approval process.

This study presents the ESIA Addendum. This report forms part of five (5) Volumes for the proposed development of the Sarulla Geothermal Field and Power Plant of 330 MW Capacity, North Tapanuli Regency, North Sumatera Province. All Volumes are as follows:

- Volume I: Environmental Compliance Audit Report and Corrective Action Plan;
- Volume II: Environmental and Social Impact Assessment (ESIA) Addendum (this report);
- Volume III: Indigenous Peoples Plan (IPP);
- Volume IV: Social Safeguards Compliance Audit Report and Corrective Action Plan; and
- Volume V: Resettlement Plan.

ES1.3 REPORT CONTENTS

This ESIA Addendum presents additional information, assessment and findings for the following areas requested in consultation with the Lenders:

- Supplemental Environmental Studies, comprising:
  - Seismic risks and geohazards;
  - Flood Risk Assessment;
  - Steam Field Piping Network Review;
  - Biodiversity assessment and Ecosystem Services Review;
  - Water resource use and balance study;
  - H2S modelling; and

    - Cumulative impacts.
- Information Disclosure, Consultation and Participation;
- Grievance Mechanism;
- Environmental Management Plan; and
- Monitoring and Verification.

Updates are provided on the description of the Project and updated environmental baselines (2008-2013), to put the above into context of any new information since the regulatory approval documents.

ES2 PROJECT DEVELOPMENT OVERVIEW

The project was initiated by Unocal North Sumatera Geothermal (UNSG) in 1993. An extensive exploration activity was conducted in geology, geochemistry, geophysics investigations, and certain infrastructure development including well pad and its access road and followed by drilling activity starting from 1994 to 1998.

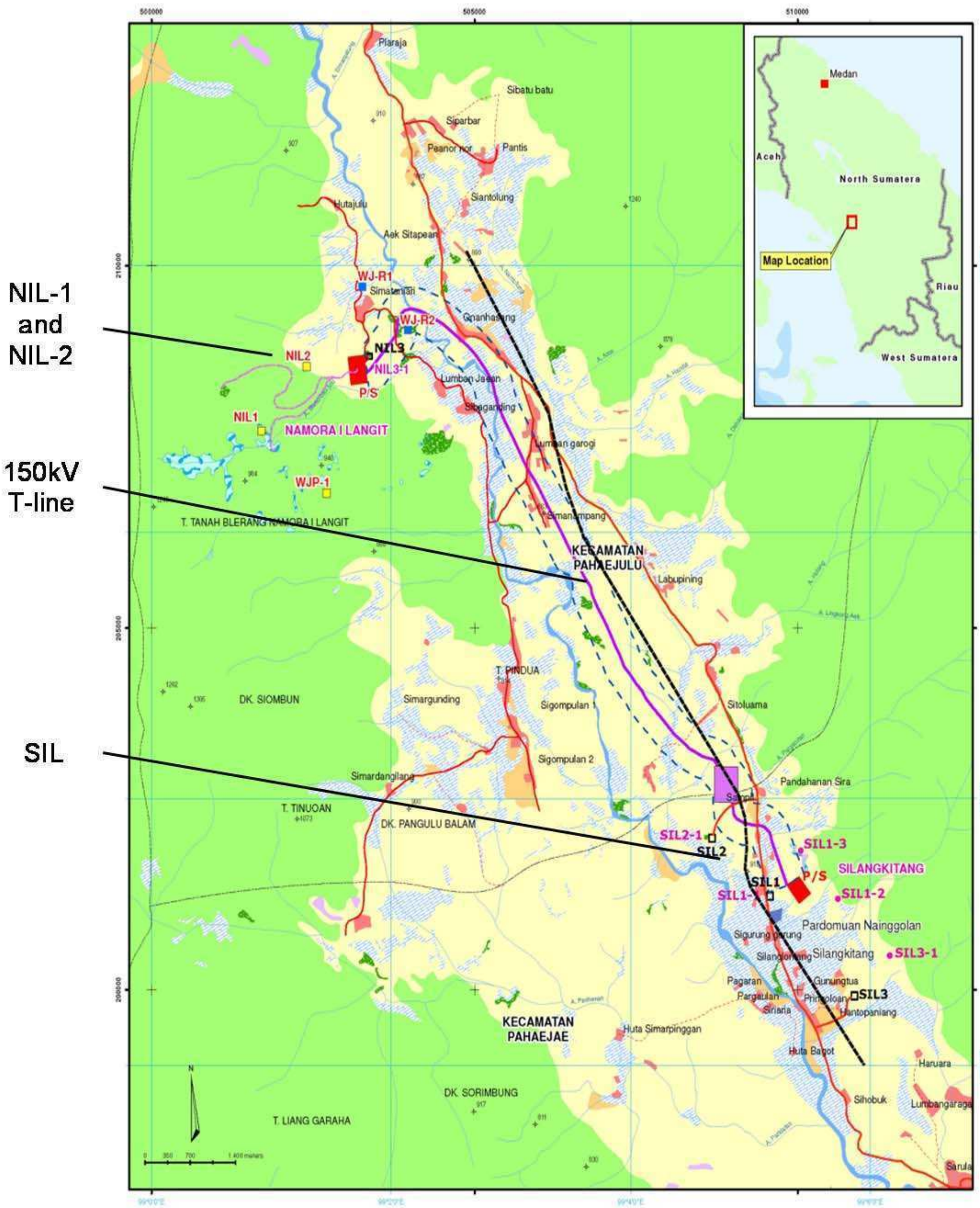
SOL's development of Sarulla geothermal field and 330 MW power plant includes the following activities:

- The development of Sarulla geothermal field i.e. Silangkitang (SIL) field and Namora I Langit (NIL) field;
- The construction and operation of a combined capacity of 330 MW geothermal power plant, one unit at SIL and two units at NIL each with a nominal capacity of 110 MW;
- The construction of a combined length of approximately 14kms of 150 kV (high voltage) overhead transmission line from Silangkitang field (SIL 1) to PLN Substation and from Namora I Langit field (NIL 1) to PLN substation.

Drilling activities for new production and injection wells in SIL are to take place at the existing well pads previously developed by UNSG. For NIL, all are planned to be on new well pad locations. A total of 23 production wells, 11 reinjection wells will be developed from 2 well pads at SIL and 5 well pads at NIL. The NIL new well pads are located on farmland and mixed forest areas.

The Project development overview is illustrated in Figure ES-2.

Figure ES-2 Project Development Overview



ES3 ESIA FINDINGS

The following subsections summarise the findings of the ESIA Addendum.

ES3.1 SEISMIC RISKS AND GEOHAZARDS

Geothermal power in Indonesia is an increasingly significant source of renewable energy. Due to its volcanic geology, Indonesia has 40% of the world's potential geothermal resources and is the world's third largest geothermal electricity producer after the United States and the Philippines. The country is also surrounded by multiple tectonic plates causing it to be highly exposed to earthquake risk in both frequency and intensity. It ranks 11th for its economic exposure to earthquakes and 3rd out of 153 countries for the number of people present in earthquake hazard zones.

Pahae Julu and Pahae Jae Districts have been determined as areas of geothermal natural resources. The Sarulla power plant construction is located in these districts in the Tapanuli Utara, North Sumatra, Indonesia. The Sarulla Geothermal Power Plant will have an installed capacity of 330MW which will be constructed in three phases of 110MW each. The plant will be fuelled by two steam production and injection reservoirs, Silangkitang (SIL) and Namora I Langit (NIL).

The seismic hazard desk study identifies the tectonic setting, seismicity and geology of Indonesia and the Project; it highlights the potential seismic hazards which need to be remediated through risk management. The seismic assessment was performed for the project area and the seismic soil class was determined according to factual ground investigation data. The seismic design criteria were established and recommendations are made for the use of appropriate seismic code.

ES3.1.1 FINDINGS

The area is located in a complex tectonic regime. It is likely to be affected by near source earthquakes. This implies that seismic design should be incorporated in all the structures built within the power plant site. This risk can be mitigated by the EPC Contractor following the latest international seismic design codes and the updated version of the local seismic code.

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The study found that not all the seismic risks have been eliminated completely. However they are considered manageable provided additional fault trenching activities are carried out before the detailed design phase and facilities in the vicinity of the rupture zone are designed to accommodate the possible predicted movement from the rupture of the fault (if the fault is deemed active). The key seismic hazard mitigations are:

- Further field trenches need to be performed in order to test fault activity prior to construction. Further field investigations should be accompanied by related studies during detailed design.
- The use of International Building code (IBC) is recommended in the design for those cases where the local seismic code is unconservative. However it is acknowledged that the Uniform Building Code (UBC) is still used in several countries outside the US and can be used for elements of the seismic design.
- Monitoring of micro tremoring activities should be continued in order to associate the relation with induced seismicity and injection of fluids in the wells.
- It is reminded that a detailed liquefaction assessment should be carried out for the area by using the laboratory test Plasticity Index results and internationally accepted liquefaction assessment techniques in order to estimate the possible liquefaction hazard by the EPC contractor. If liquefaction is deemed to be a problem then the EPC contractor should consider proper mitigation measures as mentioned in Table 10.1 for the plant design.
- Seismic slope stability assessments should be performed by the EPC contractor during detailed plant design. Slope stability remedial work can be carried out by EPC contractor after the contract is awarded, prior to construction. It is recommended that such analysis should possibly be based on displacement based methods.

ES3.2 FLOOD RISK ASSESSMENT

The Sarulla Geothermal plant is located south of Lake Toba in North Sumatra Province, Indonesia. The project area consists of two power plant sites, Namora I Langitand (NIL) and Silangkitang (SIL), which are approximately 15 km apart. Each site has its own power plant and a network of above-ground pipes that connect the extraction wellpads with the power plant and the reinjection wellpads.

Flooding is a regular phenomenon in low-lying areas of Indonesia and causes significant damage to property, agriculture and infrastructure. Flooding can pose a critical risk to infrastructure, in particular to the flood vulnerable equipment in the power plant and the wellheads and separator pads. Flood risks in Indonesia are likely to increase in the future due to the impacts of climate change.

The scope of the flood risk assessment for the Sarulla Geothermal Project included:

- Estimating the magnitude of flow in a severe flood event;
- Assessing the risk these flood flows could pose to the project site in relation to the site topography and levels; and
- Considering the effects of climate change on extreme rainfall occurrence (from tropical storms/typhoons) and the subsequent implications on flood risk to the site.

ES3.2.1 FINDINGS

Based on annual maximum rainfall data for local rainfall stations flood flow estimates were derived for key locations using the US SCS Approach for the 1 in 100 year and 1 in 500 year return periods. Climate change projections were considered and incorporated into the assessment to derive equivalent return period flows for the 2060's. Hydraulic calculations were undertaken to derive flood levels for these key locations.

The main conclusions of this assessment is that there is a very low risk of flooding from the Batang Toru River to the Namora I Langitand (NIL) and Silangkitang (SIL) wellpad and power plant sites, with all calculated flood levels significantly below design levels both currently and in the future as a result of climate change.

The majority of the tributaries that pass close to the NIL and SIL sites also pose a very low flood risk both currently and in the future as a result of climate change.

However, there are three small watercourses which pose some limited risk to the NIL Power Plant, SIL Power Plant and SIL 1 Wellpad. For the NIL and SIL Power Plants it will be necessary to undertake stream diversions to mitigate this risk and in the case of the SIL 1 Wellpad there is some limited risk from overland flow. In this case appropriate site drainage would mitigate this risk.

ES3.3 STEAM FIELD PIPING NETWORK REVIEW

The Sarulla geothermal project consists of two power plant site locations. There is the Silangkitang development (SIL), preliminary assessed to be a 110 MW development. The second steam field and power plant is roughly 15 km (by road) to the north, called Namora-I-Langit (NIL). The field is assessed to be capable of producing 220 MW. It is the intention to develop the Project in three (3) phases. The first phase is for a 110 MW capacity from SIL, followed by NIL-1 phase at 110MW and NIL-2 phase at 110MW. Planned commercial operation dates of each phases are 30, 40 and 46 months reckoned from the Project's successful achievement of financial closing. Conceptual studies, field modelling and initial engineering/design, including those for the steam field separation and pipe gathering systems have been prepared. This includes heat mass balance, process flow diagram, conceptual layout of pipe gathering and in NIL, a relatively detailed pipe routing have been prepared. Although the final pipe size dimensions have not been finalized, the approach to the design and standards used are acceptable. The pipeline corridors identified for both the NIL and SIL fields for the brine and steam pipe lines from the separation plants to the power plants follow the local contours, has relatively few changes in the vertical direction, which results in simplifying the venting and drainage equipment needed. It also reduces the visual impact of the field piping.

The well heads have motor controlled main valves, so can be closed remotely if something unexpected does go wrong.

Unexpected failure of either steam or brine pipe lines will result in clearly visible steam plumes, which will be picked up by field staff, and appropriate measures will be taken to limit the impact of those failures. At the same time, control room staff will notice the reduction in plant output due to pipe failure, and will also contact steam field staff to check what is happening. It is our expectation that any unexpected failure of steam field piping will be discovered and any discharges to the surface be controlled well within 24 hrs.

ES3.4 BIODIVERSITY ASSESSMENT AND ECOSYSTEM SERVICES REVIEW

ES3.4.1 BIODIVERSITY ASSESSMENT

The Project comprises two geothermal fields (Namora I Langit (NIL) field and Silangkitang (SIL) field), each consisting of a power station (two at NIL), production and reinjection wells, and connecting pipeline as well as a transmission line to the Perusahaan Listrik Negara (PLN) power substation. The transmission line will be suspended by a series of transmission towers. In addition, the Project will involve upgrade to existing transport corridors and development of new routes as well as development of accommodation and waste disposal facilities. The Project is located between the East and West Batang Toru Forest, located in the valley of Sarulla in North Tapanuli District. The Batang Toru River meanders north/south through the forest blocks with modified forest, agricultural and settlement areas lining the watercourse.

As part of an ADB review of the Project ANDAL, information gaps relating to impacts to biodiversity were identified, in particular impacts to IUCN listed species in the context of International Finance Corporation (IFC) Performance Standard 6 (PS6). The biodiversity assessment used available information (from desktop and preliminary field surveys) to describe the biodiversity values in accordance with the requirements of IFC Performance Standard 6 and ADB Environmental Safeguard Policy. Primarily this involves the identification and assessment of habitats that may be directly and/or indirectly impacted by the Project infrastructure. As such, for the purposes of this assessment the Project footprint is defined as the area of land to be disturbed for the infrastructure installation. The Project area is defined as the area within a 500 metre buffer of the Project footprint.

The majority (approximately 97%) of the Project footprint is located within modified habitat (mixed plantation landuse and paddy field) with direct and indirect impacts to natural habitat mainly associated with footprints of the NIL1 and WJP1 production well sites and connector pipeline. The Project footprint is relatively small for a project of this nature, at approximately 86 hectares (ha), with only 2.7 ha within natural habitats.

A preliminary field survey was undertaken at NIL and SIL in April 2013 to identify dominant habitat types within the Project area. Opportunistic records of fauna species present were recorded during the survey and a number of vegetation plots measured. In addition, geospatial mapping was undertaken to map modified and natural habitats that may be impacted by the project and a literature review provided additional species and community information to understand the local biodiversity values. An additional survey was undertaken in September 2013 to identify habitat suitability for threatened species in the area identified as natural habitat in the preliminary field survey and geospatial mapping. Results from these field surveys, in combination with information obtained from desktop sources, were used to inform a biodiversity impact assessment.

Although the majority of the Project area contains modified habitats, some small areas of natural habitat were identified to provide potential habitat to a variety of flora and fauna species listed under the IUCN Red List of Threatened Species. In many cases, species information is limited and the confirmation of presence of microhabitat features that contribute to the survival of the species (for example nest locations or breeding areas) and/or locations of populations within the Project area is not available. Therefore, the precautionary principle has been applied and it has been assumed that 'potential critical habitat' may occur in the Project area for the purposes of undertaking an impact assessment. The likelihood of 'actual critical habitat' occurring in the Project area is low. However, due to the lack of information at this stage of assessment and in the absence of more detailed field survey data and information from consultation with recognised candidate species experts, there remains uncertainty in making a final determination.

An impact assessment was undertaken for seven species. The species included the Sumatran tiger (*Panthera tigris sumatrae*), Sumatran orangutan (*Pongo abelii*), agile gibbon (*Hylobates agilis*), Malayan pangolin (*Manis javanica*), mitred leaf monkey (*Presbytis melalophos*), siamang (*Symphalangus syndactylus*) and Asian tapir (*Tapirus indicus*). Following an assessment against

Tier 1 and Tier 2 sub-criteria (according to the IFC PS6 Guidance Note 6) 'potential critical habitat' was considered for only six of these species - Sumatran tiger, Sumatran orangutan, agile gibbon, siamang, Malayan pangolin and Asian tapir.

The significance of the potential impacts to the seven IUCN Red List endangered and critically endangered species was considered very low. According to the Biodiversity Decision Framework (IFC, ADB Sourcebook 2012), the Project will not lead to a reduction in population size, will not impact on ecosystem function and will not compromise the persistence of a representative host community for each of the threatened species.

Despite a key finding of this assessment that there is no significant impact to any of the CR or EN IUCN listed species that may occur in the Project Area, and due to the uncertainty associated with the determination of critical habitat (as described above), there are three key actions that will be implemented so that the Project avoids, minimises and offsets impacts associated with Project development and determines the extent of critical habitats in the Project area. These actions are:

- The implementation of a targeted field survey for IUCN listed species within the Project area. The more detailed investigations will also allow for 'potential' critical habitat areas (as determined by this assessment) to be confirmed (or not) as 'actual' critical habitat.
- Development of a Biodiversity Action Plan (BAP) based on the species specific habitat and population information for IUCN listed species obtained from the targeted field survey that outlines specific mitigation and compensatory measures.

  SOL commit to conducting the targeted survey and development of the BAP prior to disturbance activities associated with the potential critical habitat.
- The development of a Biodiversity Offset Management Plan (BOMP). Given the anticipated small area to be offset (2.7 ha of natural habitat), a land-based offset (i.e. creation of an equivalent or greater area of new habitat) is not considered the most appropriate mechanism for achieving a conservation benefit for the greater Batang Toru Forest region. Indirect offsets, such as research, education and enhancement of existing habitat, and investment in improved management of adjacent areas are considered to provide greater conservation benefits to the target species than a small land based direct offset.

  Overall the BOMP will document the offset design, intended conservation outcomes, and identify the implementation process. Due to the reliance on completion of the BAP, engagement with relevant stakeholders and the determination of appropriate offsetting mechanisms, the BOMP is not likely to be completed until mid-2014.

These actions are interrelated, with the outcomes of each required to be considered in the development of the other.

ES3.4.2 ECOSYSTEM SERVICES REVIEW

A review of Project documentation by the Asia Development Bank (ADB) identified a need for further investigations relating to International Finance Corporation (IFC) Performance Standards (PS). The Ecosystem Services Review (ESR) supports conformance with IFC PS6 (Ecosystem Services) by identifying Priority Ecosystem Services relevant to the Project, potential and existing impacts to Priority Ecosystem Services and measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

The ESR included desktop review of the Project ANDAL (ERM 2009), the Addendum ANDAL (ERM 2013a) and biodiversity impact assessment report (ERM 2013b). The ESR also drew upon preliminary findings of community consultation, undertaken as part of a separate social impact assessment. Based on information from these sources, three priority Ecosystem Services were identified: Cultivated Crops; Non-wood Fibres and Resins; and Freshwater.

An impact assessment based on findings from the desktop review, and preliminary findings from community consultation, assessed impacts to Cultivate Crops and Non-wood Fibres and Resins as Minor. These services will be impacted by land acquisition and clearing within the Project footprint (approximately 86 hectares). In the context of the Pahae Julu and Pahae Jae sub-districts, the area of impact is small. However, in some cases individual farmers within the footprint may have substantial portions of their land acquired, which could affect incomes and livelihoods. A Land Acquisition Process is currently underway, which aims to manage impacts to land owners.

ES3.5 WATER RESOURCE USE AND BALANCE STUDY

The Government of North Sumatera supports the availability of clean water for all communities in a sustainable manner. This is mandated via the Regional Government regulation No. 6 Year 2002 regarding Tax for Collection and Utilization of Surface Water and Groundwater. In this regulation, the Government restricts the use of groundwater; obligating industry that utilises ground water to construct infiltration wells. SOL is committed to comply with this regulation.

Consultation findings with villagers, village heads, and clan and community leaders in both sub-districts indicated they are anxious about the potential Project impacts on groundwater. At present the community have no water access or availability issues (even in the dry season), however given the

Project's water requirements fears exist that the groundwater quality and abundance may change.

SOL will not use spring water, which is the main community source of freshwater (Pahae Jae: 43 households and Pahae Julu: 20 households). The Project's drinking water requirements will be purified bottled water sourced through a local vendor. Water for the workforce camp site will be sourced from water wells and the highest water demand, which occurs during drilling, will be drawn from the Batang Toru River.

It is acknowledged that the community have concerns over Project water demands despite the use of groundwater being less common. Six households in Pahae Jae and nine households in Pahae Julu rely on this source. Community wells range from 4-6 m depth. The estimated depths of the Project's planned groundwater wells are in the range of 50 to 100 m which targets the groundwater supply far below the community wells. SOL conducted pumping tests and tested yields are very low and not predicted to affect community wells >100m from the site. SOL has conducted initial modelling to understand better potential abstraction impacts on the communities' water wells.

SOL will engage with the community around this issue and ensure all appropriate measures are implemented to safeguard the communities' use of local water resources.

SOL is committed to further monitoring of river water and groundwater extraction, particularly during peak demand to illustrate that the supply is not affected. Part C of this ESIA (the Indigenous Peoples Plan (IPP)) will consider the potential social impacts of these activities in more detail.

ES3.6 H_2S MODELLING

Hydrogen Sulfide (H_2S) was remodelled to assess whether refinements in project design resulted in a change in the projected H_2S emissions assessment. In addition it was considered whether there had been an increase in the local population in proximity to the Project since the regulatory EIA.

The H_2S modelling aimed to update the Project's air quality impact assessment, monitoring and management in respect to the expected Hydrogen Sulfide (H_2S) emissions from the Project in line with the Policy Standards of the Project Lenders. The Indonesian standard for H_2S is an odour standard of 0.02 ppm (approximately 30 µgram/m3) specified in Minister of Environment Decree No. 50 of 1996 (Kep-50/MENLH/11/1996).

The WHO guideline is 150 μgram/m^3 (approximately 0.1ppm) time weighted average over 24hours[2]. The WHO guideline is a health impact threshold and is based on the avoidance of eye irritation. Table III-6 shows the established dose–effect relationships for H_2S.

A review of the affected people was also updated. Based on the surveys made, there was no increase in the number of households around the immediate vicinity of the Power Plant, especially at the NIL site receptor point where the highest concentration of H_2S emission is projected to occur.

The findings of the H_2S modelling are:

- The maximum annual average emission is predicted at 0.014ppm.
- There are 129 occasions by which the Indonesian Standard of 0.02ppm is exceeded.
- Compared to the total receptor-days of 160,965 (441 receptor points read each daily for 365 days), this occurs 0.080142% in a year.
- Predicated highest concentration will be below the WHO guidelines in all instances for all receptor points
- There is no predicted health hazard from H_2S emissions on ambient air from the project operation.
- Nuisance impacts from odour may be reported by communities where H_2S temporarily exceeds 0.02ppm (NIL).
- Monitoring will be conducted to assess need for a commercially available abatement system such as LO-CAT.

ES3.7 CUMULATIVE IMPACTS

The Project assessed the potential for cumulative impacts. To date, there are no major industries existing or planned in the project area. Therefore, consequently cumulative impact with other projects is not predicted.

However, during the construction and operation phases, cumulative impact may occur from concurrent activities of the Project. The main consideration for cumulative impact is noise.

ES3.7.1 NOISE

Noise assessment typically includes a quantitative process in which future noise levels are modelled and compared against baseline and/or impact

[2] http://www.euro.who.int/data/assets/pdf_file/0005/74732/E71922.pdf

threshold levels. It is widely understood that humans respond to different types of noise in different ways. Hence, different standards are used to assess different types of noise.

Environmental Resources Management Pty Ltd (ERM) on behalf of Sarulla Operations Ltd. (SOL) has completed a noise impact assessment for the SOL Project Sarulla Geothermal Plant (the Project), a 330 MW power plant at Silangkitang (SIL) and Namora I Langit (NIL) in Indonesia.

Construction and operational noise levels have been predicted utilising internationally recognised methods and compared to applicable noise criteria.

The findings of the assessment indicate compliant (Project criteria) noise levels for operational activities and aspects of the project, with negligible impact anticipated. Construction noise levels are also compliant at the majority of noise receptors, but exceed the Project criteria at a limited number of noise receptors during certain high noise level generating activities. These exceedances warrant noise control mitigation and management measures to be considered and ERM has provided a set of project specific recommendations.

There are no further recommendations for noise control mitigation, management measures or monitoring options to those presented in this report (specific to construction), or those already incorporated into the project design.

ES3.8 INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION;

SOL's Information Disclosure, Consultation and Participation activities conducted have been undertaken to meet the requirements set out in the ADB SPS, the IFC PS and applicable laws and regulations of the Indonesian Government. In addition to complying with lender requirements SOL's objectives for consulting and disclosing Project information are to:

- Carry out meaningful consultation with the Project's affected people and facilitate their informed participation;
- Ensure women's participation in consultation;
- Involve stakeholders, including affected people and concerned Non-governmental organisations (NGOs), early in the Project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account; and
- Continue consultations with stakeholders throughout Project implementation as necessary.

SOL's Information Disclosure, Consultation and Participation activities have involved:

- Provision of information education consultation (IEC) materials;
- Agreement of communication protocols with village heads; and
- Consultation activities from 2008 until 2013.

To date SOL has undertaken consultation in a culturally sensitive manner using both Indonesian and Batak languages to conduct meetings with the local communities. Consultation activities were conducted, where possible, in a venue closest to the local communities. Where this was not possible SOL provided transportation for the community.

Meeting participants consisted of men, women and youth who were given equal opportunities to voice their concerns and expectations during the question and answer sessions. Key stakeholders consulted to date by SOL have included:

- Head of the impacted villages and sub-districts;
- Representatives of local communities;
- Land owners;
- Representatives of Local Government (sub district and regency);
- Youth groups;
- Community elders;
- Church leaders;
- NGOs; and
- BPN (Land Agency Office).

During the consultations undertaken between 2008 and 2013 a series of Project topics were discussed including:

- Explanations on the Project plan and activities;
- The Project plan for the re-injection line route;
- The Project impacts on community life and the environment;
- Ceremony events prior to commencing the well work over activity;
- Discussions related the Project's community development program; and
- Socialisation and negotiations on the land acquisition process and compensation price for land and crops.

Community concerns and issues discussed with SOL during these sessions were focussed on environmental impacts of the Project (such as ground and surface water pollution), Project employment and business opportunities, community development through the Project's CSR program and SOL's land acquisition process and compensation offered. In the sessions held with the Project's stakeholders, where possible, SOL responded to each of the concerns raised.

Aside from the consultation and participation activities that have been conducted to date, SOL will continue to conduct public consultation and disclosure activities in various forms. Throughout the Project, regular meetings and co-ordination with stakeholders will be planned and scheduled. This will include disclosure of the ESIA and ESMP.

ES3.9 GRIEVANCE MECHANISM

The Lenders emphasise specific requirements for establishing a grievance mechanism that receives and facilitates the resolution of affected people's concerns, complaints, and grievances about a Project's environmental and social performance. Therefore SOL has established and implemented a Grievance Mechanism in order to adhere to these requirements and also to ensure that affected community grievances are managed in a fair and timely manner.

SOL's grievance mechanism has been designed as a locally based, Project specific design that assesses and resolves community complaints and concerns related to all Project activities. The Project grievance mechanism offers a package of widely understood and effective processes to address affected communities' concerns and complaints.

The Project Grievance Tracking and Redress Mechanism (GRTM) that is triggered the instance a community complaint is received in a five step process:

- Step 1: Receipt of grievance record;
- Step 2: Assessment and fact finding;
- Step 3: Resolution or appeal;
- Step 4: Feedback; and
- Step Close-out.

Grievances are communicated by the community to SOL orally via community representatives in each sub-district or written to SOL's External Relations Department. Details of the mechanism were disclosed to the local communities during the land acquisition socialization activities between April and May 2013. As the Project progresses, disclosure of the grievance mechanism will continue with other key stakeholders including municipal and central government offices and NGOs.

ES3.10 ENVIRONMENTAL MANAGEMENT PLAN

SOL commits to incorporate the mitigation findings into the Project Environmental and Social Management Plan (ESMP). The ESMP provides information and instructions on how Environmental, Social, Health and Safety (ESHS) aspects of the Project will be managed from pre-construction through the completion of the construction, operation and decommissioning phases. The ESMP is a living document which:

- Incorporates the EHS and social measures identified as a result of the EIA process into a comprehensive framework to facilitate and ensure appropriate management throughout the Project cycle;
- Provides a framework for procedures and plans specifically for activities that have 'high' risks, including an emergency response plan;
- Presents responsibilities for meeting ESMP requirements including the provision of training;
- Defines the monitoring and reporting program; and
- Provides a framework for the implementation of specific management plans by construction contractors and facility operators.

SOL commits to the development of the following plans which will be implemented through the Environmental and Social Management System (ESMS).

Table ES-2 Specific Management Plans and Policies

Management Plan	*Objective / Content*
Stakeholder Engagement and Communication	Develop a comprehensive engagement and communications framework for key stakeholders and relevant communities that: • results in the distribution of timely information about the Project; and • provides a formal process by which grievances can be raised
Labour and Working Condition	Address potential labour issues such as equity in employment benefits. The plan will include: • Labour practices policy for non-discrimination, anti-child labour, anti-forced labour, freedom of union/association, minimum wages, social/medical insurance, and right for capacity building; • Local labour recruitment policies; and • Local procurement plan; and • A formal process by which grievances can be raised by the workforce, and allow structured investigation by SOL.
Workforce Environmental Training	Ensure that all personnel responsible for the implementation of the ESMP are competent and are provided with environmental and social aspects training appropriate to their scope of activity and level of responsibility.

Management Plan	*Objective / Content*
Contractual Workers Decommissioning Plan;	Ensure that decommissioning of contractual workers runs smoothly and as much as possible to minimise any potential impacts to the workers
Community Health and Safety	• Management of labour influx; • Avoid or minimize transmission of communicable diseases associated with the influx of the Project migrant workers within its area of influence; • Protocols for migrant workers interaction with local communities; • Camp follower and camp habitation management; and • Health outreach program (e.g. support improvement of public health facilities, monitoring community health, HIV/AIDS awareness program for community and workers).
Occupational Health and Safety	Provide a safe working environment through implementation of procedures to address: • Violation & Infringement • Appreciation Award • Working within Company Premises • Employee Requirements • Emergency Preparedness & Evacuation • Roles Played by Everybody • Safety Induction • Smoking • Alcohol and/or Controlled Drugs • Safety Signs • Environmental Control • Permit-to-Work • Worksite Visit • House keeping In addition, SOL will develop Standard Operating Procedure (SOP) which is a routine step-by-step task instruction or a sequence of task to operate and maintain the equipment & facility.
H_2S Monitoring Plan	Describe the programme for monitoring H2S in ambient air and collection of data on health effects.
Emergency Response Plan	Ensure processes are in place to effectively manage the response to emergency events and minimise risk to the workforce and environment. Emergency response may include: • Oil spill response plan; • H^2S release monitoring and response plan; • Drills; • Fire • Community Emergency response plan.
Water Management	Monitor surface and ground water quality Implement measures to stop contamination if identified and provide alternate water source.
Brine Management	Minimise and control brine discharges during well production tests or in case of re-injection failure during operation.

Management Plan	Objective / Content
Effluent Disposal Management Plan	Minimise and control effluent discharges.
Erosion Management Plan	Implement measures to reduce erosion and enhance rehabilitation.
Spoils And Drill Cuttings Disposal Management Plan	Appropriate storage, handling, testing, transport and reuse of drilling mud or cuttings onsite or disposal.
Solid and Hazardous Waste Management Plan	Identify measures for minimisation of waste. Appropriate storage, handling, transport disposal of waste.
Spill Response Plan	Appropriate storage, transfer and use of chemicals on site. Identify responsibilities and equipment required to deal with a spill.
Land Contamination Management Plan	Implementation of processes to prevent soil contamination. Implementation of processes to remediate previously contaminated land disturbed by Project activities.
Traffic Management Plan	Minimise the impact of Project activities in regulating and managing traffic.
Ambient Air And Noise Management Plan	Reduction of Project impacts on ambient air quality and noise. Optimising best methods of technology to reduce greenhouse gases
Heritage Management	The procedure will include: • A definition of cultural resources; • Recognition and ownership of artefacts; and • Procedures upon discovery including stopping work and reporting requirements.
Biodiversity Action Plan	Provide a strategy for refining the mitigation and management approach to conservation of biodiversity values, including specific measures for the IUCN listed threatened species with potential to occur in the Project area.
Biodiversity Offsets Management Plan	Provide a plan for the design and implementation of biodiversity offsets, to support the Biodiversity Action Plan.
Well Abandonment Plan	Outline a procedure for well decommissioning and rehabilitation.
Facilities Decommissioning Plan	Project's plan for facilities decommissioning activities after the 30-year term of contract as agreed in ESC/JOC, including the following elements: • Closure of production and reinjection wells; • Reclamation of well pads; • Reclamation of geothermal pipe gathering system; • Reclamation of power plant facility; • Road system including bridges; • Disposal area for drilling; • Disposal area for drilling; • Abandonment facilities decommissioned prior to Project transfer;

Management Plan	*Objective / Content*
	• 150 KV transmission line of SIL-PLN sub-station and NIL-PLN sub-station; • Reclaimed land.

ES4 CONCLUSION

This Report has been prepared as an Environmental and Social Impact Assessment (ESIA) Addendum for the development of the geothermal field and power plant combined capacity of 330 MW in Sarulla, in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province (the Project). This report presents information on the management of environmental, social and health risks as requested during consultation with the Lenders, which builds upon the information presented in the studies prepared for environmental approvals under Indonesian Regulations. As such, this document is not a stand-alone report but forms part of an overall set of documentation for the Project.

The conclusions of the ESIA Addendum are as follows:

- No insurmountable impacts have been identified;
- Project benefits outweigh the potential impacts identified;
- Environmental and social impacts can be mitigated to acceptable levels on the adoption of the ESMP;
- Substantial commitments during construction will be implemented by contractors, requiring effective management controls from SOL;
- Ongoing commitments during operations will be implemented by SOL through the Project ESMS; and
- The Project ESMS supported by Management Plans and KPIs are key for the effective management of predicted impacts.

1 INTRODUCTION

1.1 PROJECT PROPONENT

Sarulla Operations Limited (SOL) is the operation company established by the Consortium of Itochu Corporation, Kyushu Electric Power Co., Inc., Ormat International, Inc. and PT. Medco Energi International Tbk. SOL plans to develop the geothermal field and the power plant in Sarulla, in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province. Project proponent contact details can be found below:

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In the development of the Sarulla geothermal field and power plant at a combined 330 MW capacity, the Consortium and SOL signed a DOA with PT. PLN (Persero); a JOC with PERTAMINA Geothermal Energy; and an ESC 1 with PERTAMINA Geothermal Energy - and PT. PLN (Persero).

1.2 REPORT CONTEXT

The Indonesian electricity business is largely conducted by the State and carried out by The State own enterprise (PLN). Indonesia's energy demand is increasing with a growth of electricity demand estimated at 7.1% annually (2006-2026) and there is currently a shortage of electricity supply in several provinces, particularly in Java and Sumatera. Operative, private sector and local enterprises have an opportunity to participate in the electricity business as Independent Power Producers (IPPs).

Indonesia is estimated to hold approximately 40% of the World's estimated geothermal resource. These resources are concentrated within tectonic areas in Sumatera, Java and Sulawesi, in the same areas where electricity demand is under met. With traditional fossil fuels widely developed, the Indonesia Government has placed a priority on alternative energy development including renewable energy to enhance energy security.

SOL is proposing the Sarulla Geothermal Field and Power Plant Development Project to further develop the geothermal potential in Sumatera, commenced in 1993 by Unocal North Sumatera Geothermal (UNSG). As part of this development plan, SOL is seeking a financial investment from the Japan Bank for International Cooperation (JBIC), Asian Development Bank (ADB) and a group of Equator Principles Financing Institutions (EPFIs). Project proponents seeking financing from JBIC, ADB and EPFIs are required to comply with the applicable bank's environmental, social and health policies, developed for managing the environmental and social risks associated with project finance.

JBIC, ADB and the EPFIs recognise the specific issues associated with private sector projects and manage these through the JBIC Guidelines for Confirmation of Environmental and Social Considerations, ADB Safeguard Policies and Equator Principles. These are further discussed in Section 1.3.

This report presents information on the management of environmental, social and health risks as requested during consultation with the Lenders, which builds upon the information presented in the studies prepared for environmental approval under Indonesian Regulations. As such, this document is not a stand-alone report but represents an Environmental and Social Impact Assessment (ESIA) Addendum that forms part of an overall set of documentation and should therefore be read together with the following reports:

- Environmental Impact Statement (ANDAL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009. This report is available on ADB's website[3];
- Environmental Management Plan (RKL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009. This report is available on ADB's website (as per the footnote below);
- Environmental Monitoring Plan (RPL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009. This report is available on ADB's website (as per the footnote below);
- Addendum to ANDAL, RKL-RPL, Relocation Activities of Wellpad Sites in Namora I Langit (NIL), Power Plant in Silangkitang (SIL), Transmission Line, Development of Geothermal Field and Construction of the 330 Mw Capacity PLTP Sarulla. Sarulla Operations Limited, in North Tapanuli District North Sumatra Province; July 2013. At the time of writing, these

[3] http://www.adb.org/projects/42916-014/documents

reports are currently undergoing review under the Indonesian regulatory approval process.

This study presents the ESIA Addendum. This report forms part of five (5) Volumes for the proposed development of the Sarulla Geothermal Field and Power Plant of 330 MW Capacity, North Tapanuli Regency, North Sumatera Province. All Volumes are as follows:

- Volume I: Environmental Compliance Audit Report and Corrective Action Plan;
- Volume II: Environmental and Social Impact Assessment (ESIA) Addendum (this report);
- Volume III: Social Impact Assessment and Integrated Social Program;
- Volume IV: Social Safeguards Compliance Audit Report and Corrective Action Plan; and
- Volume V: Resettlement Plan

1.3 STRUCTURE OF THE ESIA ADDENDUM

This Environmental and Social Impact Assessment (ESIA) Addendum is structured to address ADB requests for additional Project information on the management of environmental and social risks. This report is structured as follows:

- Executive Summary
- Chapter 1: Introduction and context of the ESIA study;
- Chapter 2: Project Description;
- Chapter 3: Supplemental Environmental Baseline Assessments;
- Chapter 4: Information Disclosure, Consultation and Participation;
- Chapter 5: Grievance Mechanism;
- Chapter 6: Environmental Management Plan; and
- Chapter 7: Monitoring and Verification.

1.4 BACKGROUND

The development of geothermal energy is a priority for the Government of Indonesia in securing alternative energy sources. This is in line with the Government's policies in energy diversification, fuel oil (Bahan Bakar Minyak or BBM) consumption reduction and anticipating the rise in electricity demand in Indonesia, especially in North Sumatera.

The development of the Sarulla geothermal field and the construction of Sarulla power plant in Pahae Julu and Pahae Jae Districts, North Tapanuli Regency, North Sumatera Province (Figure I-1) commenced in 1993 by UNOCAL North Sumatera Geothermal (UNSG, as awarded by PERTAMINA. The owner of the Sarulla Geothermal Working Area, through a Joint Operation Contract (JOC) and direct right (through PERTAMINA), has access to sell electricity to PT. Perusahaan Listrik Negara (PLN, the State Utility Company) according to Energy Sales Contract (ESC). UNSG conducted a number of technical engineering and environmental studies covering the exploration and development of Sarulla geothermal resources and related infrastructure from 1994 to 1997. According to the JOC, all infrastructure and assets were properties of PERTAMINA and UNSG had the right to use them.

In 2002, UNSG decided to sell their rights as contractor to PLN. In February 2004, PLN acquired the entire concession ownership from UNSG. The acquisition was approved by PERTAMINA and the Minister of Energy and Mineral Resources (MEMR). At the same time, the tender process to transfer PLN ownership as the PERTAMINA contractor to a third party was also approved.

In 2004, PLN started an international tender process to transfer the concession ownership for the development and the operation of a 330 MW power plant at the Sarulla geothermal field. It was stated in the Request for Proposal, that the winning company would have the right to fund, design, build, test, operate and maintain the field, and also to have the right as the contractor of PERTAMINA to develop the Sarulla geothermal field through a DOA (Deed of Assignment).

After three rounds of a tendering process, in June 2005 PLN issued a Letter of Intent (LOI) for PT. Geo Dipa Energi (a joint venture between PLN and PERTAMINA) as the tender winner based on the lowest offered electricity price ($4.445 cent/kWh). PLN and PERTAMINA gave over a year for PT. Geo Dipa Energi to present their financial plan as a basis to approve the changes of the ESC and JOC. However, PT. Geo Dipa Energi could not meet the deadline and hence the LOI was cancelled in July 2006.

On 25 July 2006, PLN awarded the LOI to a Consortium of Medco-Ormat-Itochu (subsequently Kyushu joined in October 2007) as the second lowest bidder on electricity price ($4.642 cent/kWh). The Consortium was awarded the right from PLN to develop the Sarulla geothermal field and power plant.

The Head of Agreement authorization to develop the Sarulla geothermal field in North Tapanuli Regency, North Sumatera Province, was signed by PERTAMINA, PLN and the Consortium at the Indonesia–Japan Business Forum on 20 August 2007, as witnessed by the Prime Minister of Japan, Mr. Shinzo Abe, and the President of the Republic of Indonesia, Mr. Soesilo Bambang Yudhoyono.

By early 2008, in the context of rising raw materials prices, costs of power plant equipment, and well drilling costs, it became apparent that the Consortium’s tariff originally bid in 2005 was no longer viable. In fact, many other power projects in Indonesia that had been delayed for various reasons faced the same problem, leading to requests by many companies to adjust the tariff to offset increased construction costs.

The Consortium presented its tariff adjustment proposal to PLN in July 2008. The Consortium and PLN held several rounds of negotiations on the basis for the tariff increase, with support from relevant ministries and government agencies, until the approaching presidential elections (held in June 2009) meant a temporary inability to bring the discussions to a conclusion.

Following President Susilo Bambang Yudhoyono’s re-election and a cabinet reshuffle, momentum resumed to the negotiations in September 2009 and the parties finally agreed a revised base tariff of 6.79 cents per kWh (calculated on a levelled basis with 3 step-down tariff stages) which were memorialized in a “Principle Agreement” dated 1 April 2010.

Following the tariff negotiation, the Consortium discussed with PLN and relevant parties on the resolution of any remaining bankability issues. Finally the amended ESC and JOC were signed on 4 April 2013.

Figure I-1 Location of the Project for Development of Geothermal Field and Construction of PLTP Sarulla

1.5 *Project Purpose and Benefits*

1.5.1 *Purpose*

The proposed Project has the following objectives:

- To overcome electricity shortage in Indonesia, especially in North Sumatera;
- To support the Government of Indonesia policy in energy diversification and fossil fuel consumption reduction; and
- To optimize the use of geothermal energy that has a high economic and environmental potential.

1.5.2 *Benefits*

The Government of Indonesia will benefit from this proposed Project through an increase in electricity supply of 330 MW from geothermal energy which is environmentally friendly compared to traditional sources of electricity generation and is locally available in an area with an increasing energy demand. This project can help to reduce fossil fuel dependency in producing electricity by utilizing the renewable energy of geothermal.

The benefit will also reach local governments and the community in the North Sumatera Region as the direct beneficiary of the power generated from this project. It will help to improve the local economy by providing business and employment opportunities, particularly at the project location.

This project will provide economic, social and technological benefits at national and regional levels. The benefits are:

- Bolsters energy security through use of domestic renewable resource
    - Limits exposure to fossil fuel market volatility by diversifying Indonesia power generation profile and reducing reliance on diesel/fuel oil
    - Reduces critical energy shortage in Sumatra Interconnection System caused by very low reserve margins
- Improvements in regional industry and economy:
    - Providing multiplier effect to local economy, which is expected to be sustained;
    - An increase in regional incomes at provincial and regency level, through tax and non-tax incomes;
    - Creating job opportunities for local communities, according to Company's requirements and conditions;
- Supports the Indonesian Government's Energy Vision 25/25 through the

use of a low-carbon, highly-reliable renewable resource for baseload power:

- The emissions from power generation from the Sarulla geothermal development equates to 574,563 tCO_2e per year. Power generation from this additional energy from traditional sources represents 1,946,087tCO_2e (using a 0.748 emission factor for Sumatera). The Project therefore represents a net emissions reduction of 1,371,524tCO_2e per year for 330 MW generation; and

- Promotes least-cost generation
  - Brings online 330 MW under a highly-competitive tariff, supporting Indonesia in a more sustainable development path.

1.6 *APPLICABLE STANDARDS*

There are two levels of regulatory provisions applicable to the Project. The first is the Indonesian assessment and approvals process (Chapter 1.5.1); the second are applicable International Standards. SOL is applying for funding from JBIC, ADB and EPFIs and as such, SOL is committed to meeting the ADB Safeguard Policy Statement (SPS, 2009) and Strategies and the 2012 IFC Performance Standards 1- 8 (IFC PS) and IFC EHS guidelines during the lifetime of the project (Chapter 1.5.2).

1.6.1 *Indonesian Regulatory Process Outline*

1.6.1.1 *Environmental Assessment and Approvals*

Indonesia's Environmental Law requires a project proponent to undertake an Environment Impact Assessment (Analisis Mengenai Dampak Lingkungan or AMDAL) where it is considered that the project has the potential to result in potential significant environmental or social impacts. The Indonesian government imposes a "positive list" for a project and/or activity that requires AMDAL according to the type, scale and location of the proposed activity.

Projects not listed are not believed to result in significant impacts. These projects are required to prepare Environmental Management Effort (termed Upaya Pengelolaan Lingkungan or UKL) and Environmental Monitoring Effort (Upaya Pemantauan Lingkungan or UPL) documents. The UKL/UPL details the implementation of environmental management and monitoring activities for the proposed project.

The size of the Project required an AMDAL under Indonesian regulations which results in the submission of an Environmental Statement referred to as an ANDAL Report. In addition, an Environmental Management Plan and Environmental Monitoring Plan (UKL/UPL) is required for such a Project.

The proposed Project has been through a number of stages in the Indonesian

Regulatory approvals, as follows:

- Environmental Impact Statement (ANDAL), Environmental Monitoring and Management Plan (RKL/RPL), Sarulla geothermal field development (PLN, 2005). The AMDAL was approved in November 2005 by the Governor of Sumatera Utara;
- Environmental Impact Statement (ANDAL), Environmental Monitoring and Management Plan (RKL/RPL), Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity North Tapanuli Regency, North Sumatera Province; August 2009[4]. The AMDAL revised the 2005 version to incorporate the following:
- Change of project proponent from PT PLN (Persero) to Sarulla Operations Ltd. (SOL),
- Inclusion of additional activities of production well operation and drilling;
- Change in the vapour and brine cooling system from water to air, which is more environmentally friendly; and
- Construction and operations of internal electricity transmission from Silangkitang (SIL) to Namora I Langit NIL.

The revised Sarulla Geothermal Field and Power Plant Project AMDAL, RKL/RPL was approved in 2009. Subsequent to this a number of design changes necessitated an Addendum ANDAL. These related to changes in the Project siting for wellpad Sites in Namora I Langit (NIL), the Power Plant in Silangkitang (SIL) and transmission line route. At the time of writing, the Addendum ANDAL is under review and is expected to receive approval in 4Q 2013.

1.6.1.2 *Other National and Regional Regulatory Provisions*

In addition to the overarching requirements to manage environmental, social and health impacts through the AMDAL or UKL/UPL processes, there a range of other regulatory provisions that apply to the Project:

- Indonesian Laws;
- Government Regulations;
- Presidential Decrees;
- Ministerial Regulations;
- Regency Regulations (Decrees of Head of Environmental Impact Management Agency and National Land Agency); and
- Local Regulations and Governor Decrees.

[4] http://www.adb.org/projects/42916-014/documents

The Project AMDAL, RKL/RPL details valid Indonesian Government Legislations and Regulations pertaining to the project (Chapter 1.3) and these are not repeated here.

1.6.2 *International Processes and Standards*

The following subsections provide a summary of the applicable International standards that apply to the proposed Project.

1.6.2.1 Asian Development Bank (ADB) Safeguard Policies

ADB's Safeguard Policy Statement (SPS) 2009[5], governs the environmental and social safeguards of ADB's operations and articulates the safeguard policy principles for three key safeguard areas:

- Environmental safeguards (SPS, Appendix 1);
- Involuntary resettlement safeguards (SPS, Appendix 2); and
- Indigenous Peoples safeguards (SPS, Appendix 3).

The SPS 2009 applies to all ADB-supported projects reviewed by ADB's management after 20 January 2010. The objective of the SPS is to ensure the environmental and social soundness and sustainability of projects and to support the integration of those considerations into the project decision-making process.

The overarching SPS statement on ADB's Commitment and Policy Principles states that the ADB's safeguards have the following objectives:

- Avoid adverse impacts of projects on the environment and affected people, where possible;
- Minimise, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and
- Help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

ADB adopts a set of specific safeguard requirements that borrowers/clients are required to meet in addressing environmental and social impacts and risks. The Safeguard Requirements (SR) are described in the following:

- Safeguard Requirements 1 (SR1): Environment Safeguards. A Good Practice Sourcebook (Draft Working Document November 2012)[6];
- Safeguard Requirements 2 (SR2): Involuntary Resettlement Safeguards. A Planning and Implementation Good Practice Sourcebook (Draft Working

[5] http://www.adb.org/documents/safeguard-policy-statement?ref=site/safeguards/publications
[6] http://www.adb.org/documents/environment-safeguards-good-practice-sourcebook

Document November 2012)[7];

- Safeguard Requirements 3 (SR3): Indigenous Peoples Safeguards. A Planning and Implementation Good Practice Sourcebook (Draft Working Document Revised June 2013)[8], and
- Safeguard Requirements 4 (SR4): Special Requirements for Different Finance Modalities (Appendix 4). SR4 is not applicable to the Project and is not further discussed in this ESIA Addendum.

The SPS uses a categorisation system to reflect the significance of a project's potential environmental impacts. A project's category is determined by the category of its most environmentally and socially sensitive component, including direct, indirect, cumulative, and induced impacts in the project's area of influence.

Table I-1 describes the environmental and social category definitions for proposed projects (financial intermediary (FI) category projects are not discussed).

Table I-1 Project Screening under the Safeguard Categories

Safeguard	*Category*		
	A	*B*	*C*
Environment	Project is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment (EIA), including an environmental management plan (ESMP), is required.	Project's potential adverse environmental impacts are site-specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination (IEE), including an ESMP, is required.	Project is likely to have minimal or no adverse environmental impacts. An EIA or IEE is not required, although environmental implications need to be reviewed.
Involuntary Resettlement	Project is likely to have significant involuntary resettlement impacts. A	Project includes involuntary resettlement impacts that are not	Project has no involuntary resettlement impacts. No further action is required.

[7] http://www.adb.org/documents/involuntary-resettlement-safeguards-planning-and-implementation-good-practice-sourcebook-d?ref=site/safeguards/publications

[8] http://www.adb.org/documents/indigenous-peoples-safeguards-planning-and-implementation-good-practice-sourcebook?ref=site/safeguards/publications

Safeguard	*Category*		
	A	*B*	*C*
	resettlement plan, which includes assessment of social impacts, is required9.	deemed significant. A resettlement plan, which includes assessment of social impacts, is required10.	
Indigenous Peoples	Project is likely to have significant impacts on indigenous peoples. An indigenous peoples plan (IPP), including assessment of social impacts, is required.	Project is likely to have limited impacts on indigenous peoples. An IPP, including assessment of social impacts, is required.	Project is not expected to have impacts on indigenous peoples. No further action is required.

In 2008, ADB's Chief Compliance Officer approved the following safeguard category rankings for the Sarulla Geothermal and Power Plant Development Project:

- Environment: Category A due to the potential for significant adverse environmental impacts associated with the proposed development;
- Involuntary Resettlement: Category B/C. There is no associated involuntary resettlement; however considering that this project requires the acquisition of land currently used for livelihood and other purposes by the local people, a resettlement plan is required.
- Indigenous Peoples: Interim Category A in 2008 with a note that during due diligence the Project Team is required to determine whether the project will have economic, social and cultural impacts to Batak communities (refer *ESIA Addendum Volume IV Social Impact Assessment and Integrated Social Program, Chapter 2 Social Baseline*) living within the vicinity of the project and whose customary lands will be acquired.

The Project Data Sheet (PDS) and above safeguard category rankings are provided on the ADB's website, project reference 42916-014: SARULLA

[9] A project is considered to have a significant IR impact if 200 or more persons will experience major impacts, which are defined as (i) being physically displaced from housing, and (ii) losing 10% or more of their productive assets (income generating).

[10] A project has limited significant IR impact if less than 200 or more persons will experience major impacts, which are defined as (i) being physically displaced from housing, and (ii) losing 10% or more of their productive assets (income generating).

GEOTHERMAL POWER GENERATION PROJECT[11].

In May 2013, an ADB Safeguards Specialist team visited the proposed Project location. Following an extensive site visit and meetings with the local community, ADB issued revised safeguard category rankings and explanation, as follows:

- Environment – Category A (no change);
- Involuntary Resettlement – Elevated to Category A due to:
  - People losing 10% or more of productive assets;
  - Potential feeling of other landowners that they may have no choice but to sell because the surrounding areas have been bought by the Project (UNOCAL, SOL);
  - Potential feeling that remaining land at the project site is no longer viable;
  - Potential for economic displacement of ethnic minorities
- Indigenous Peoples (IP) – Category A due to the Batak people in the project area who meet ADB's "distinctiveness" criteria to be classified as IP:
  - Batak people have their own distinct language different from national language;
  - Batak people have their own distinct customs and traditions, which they continue to display;
  - Batak self-identify and are identified by others as a distinct ethnic group.
  - The Batak are considered vulnerable (currently in poor condition) and may become more vulnerable as a result of the project, as a result of the following:
  - Collective attachment to land. The project lands are closely related to and identified with particular clans;
  - People feel strong collective attachment to land of their ancestors in each affected villages.
- There is no physical displacement of IP from traditional or customary lands from Project land acquisition. Associated impacts however, may include:
  - Acquisition of land and asset that may affect the Batak's vulnerability in terms of their economic status and their cultural identity.
  - Feeling of vulnerability brought about by uncertainties about project

[11] http://www.adb.org/projects/42916-014/details

impacts.

The revised safeguard category rankings for the Sarulla Geothermal and Power Plant Development Project have not been updated on the ADB website, however the ESIA Addendum will be made available, together with the Addendum ANDAL and existing project documents disclosed previously.

In addition to the ADB Safeguard Policy Statement (2009) discussed above, the following ADB policies and strategies have been considered as part of this assessment:

- Social Protection Strategy (2001) – which stipulates ADB expectations for compliance with applicable labour laws (e.g. the relevant conventions of the International Labour Organisation [ILO]) in relation to a Project, The strategy specifically discusses expectations with respect to forced or compulsory labour, child labour, discrimination in respect of employment and occupation, and freedom of association and the effective recognition of the right to collective bargaining.
- Policy on Gender and Development (1998) - supports mainstreaming as a key strategy in promoting gender equity in ADBs projects. The key elements of this policy include gender sensitivity, analysis and planning as well as mainstreaming and agenda setting.
- Public Communications Policy (2011) - which aims to enhance stakeholders' trust in and ability to engage with ADB. It recognizes the right of people to seek, receive, and impart information about ADB operations and supports knowledge sharing and enables participatory development with affected people. The policy is based on a presumption in favour of disclosure unless there is a compelling reason for nondisclosure.

1.6.2.2 *Japan Bank for International Cooperation (JBIC) Guidelines for Confirmation of Environmental and Social Considerations*

JBIC adopted the Guidelines for Confirmation of Environmental Considerations on 1st October 2009 through the Japan Finance Corporation (referred to as the JFC Guidelines). In 2002, they were revised as the JBIC Guidelines for Confirmation of Environmental and Social Considerations (The Guidelines), to include detailed provisions. The Guidelines were revised in 2007 and 2012 to take account of global developments and trends on environmental matters and broad opinions from stakeholders. The current version of the Guidelines is available on JBIC's website and is dated April 2012[12].

The Guidelines state that Project proponents are responsible for "undertaking

[12] http://www.jbic.go.jp/en/about/environment/guideline/index.html

appropriate environmental and social considerations, through various measures, so as to prevent or minimize the impact on the environment and local communities which may be caused by the projects for which JBIC provides funding, and not to bring about unacceptable effects."

Environmental and social considerations refer not only to the natural environment, but also to social issues such as involuntary resettlement and respect for the human rights of indigenous peoples. It is important to confirm that adequate measures have been taken to mitigate adverse environmental impacts proactively and that understanding has been obtained from all the stakeholders regarding environmental effects, especially when significant environmental impact is foreseen from the proposed project. These are crucial points for proceeding with the proposed project or approving a loan for the project.

Information on the project is disclosed proactively in order to obtain the understanding of all the stakeholders. JBIC makes information available to the public on environmental and social considerations in regard of a project proposed for JBIC financing, including category classification of the project when it is in the screening process and results of its environmental review. A framework has also been created in which JBIC takes on objections regarding any non-compliance with the Guidelines.

While encouraging appropriate consideration of the environment and social aspects in projects subject to funding, it is JBIC's policy to provide active support to projects that promote environmental conservation and to projects that contribute to the protection of the global environment, such as projects to reduce greenhouse gas emissions, as in the case of the Sarulla Geothermal Field and Power Plant Development.

Consistent with the approach of the ADB and EP/IFC, JBIC conducts screening and environmental reviews of projects for which it intends to provide funding before it makes decisions on funding, first classifying the project into one of the categories:

- Category A: Projects likely to have significant adverse impact, complicated impact or unprecedented impact which are difficult to assess on the environment. The impact of Category A projects may affect an area broader than the sites or facilities subject to physical construction. Category A, in principle, includes projects in sensitive sectors (i.e., sectors that are liable to cause adverse environmental impact) or with sensitive characteristics (i.e., characteristics that are liable to cause adverse environmental impact) and projects located in or near sensitive areas. JBIC provide an illustrative list of sensitive sectors, characteristics and areas.
- For Category A projects, borrowers must submit EIA reports and environmental permit certificates issued by the host governments or other

appropriate authority for Category A projects. For projects that will result in large-scale involuntary resettlement, resettlement plans are required. For projects that will require measures for indigenous peoples, indigenous peoples plans must also be submitted.

JBIC undertakes its environmental reviews based on the EIA and other reports prepared by the project proponents and submitted through the borrower.

- Category B: A proposed project with potential adverse environmental impact less adverse than that of Category A projects. Typically, this is site-specific, few if any are irreversible, and in most cases normal mitigation measures can be designed more readily. The environmental reviews for Category B projects are similar to those of Category A in that they examine potential negative and positive environmental impact and evaluate measures necessary to prevent, minimize, mitigate or compensate for the potential negative impact, and measures to promote positive impact if any such measures are available. The EIA report and environmental permit certificates issued by the host governments or other appropriate authority may be referred to.
- Category C: A proposed project likely to have minimal or no adverse environmental impact. Projects that correspond to one of the following are, in principle, classified as Category C, with the exception of projects with sensitive characteristics and projects located in sensitive areas as indicated by JBIC. For Category C projects, environmental reviews do not proceed beyond screening.
- Category FI: A proposed project that satisfies all of the following:
    - JBIC's funding of the project is provided to a Financial Intermediary;
    - The selection and assessment of the actual sub-projects is substantially undertaken by such an institution only after JBIC's approval of the funding and therefore the sub-projects cannot be specified prior to JBIC's approval of funding (or assessment of the project); and
    - Those sub-projects are expected to have potential impact on the environment.

  JBIC checks through the Financial Intermediary to see whether appropriate environmental and social considerations as stated in the Guidelines are ensured for projects in this category.

During the screening process for a project, JBIC discloses the project's environmental impact category and the progress status of EIA reporting on its website, and after reaching loan agreements, also publishes the results of the project's environmental reviews. JBIC's official decision on the ranking of the

Project, released on 17th July 2013, is Category A[13], as "*the project includes sensitive characteristics and is located in or near sensitive areas under the Environmental Guidelines*."

The relevant finance section and JBIC's Environment Analysis Department also identify all environmental and social considerations through the use of detailed environmental checklists. Further, even after a loan agreement is reached, projects are monitored, and dialogue with project proponents is conducted as occasion demands to ensure that appropriate environmental and social considerations continue to be observed. The environmental checklists of relevance to the Project are:

- Environmental Checklist 11: Thermal Power; and
- Environmental Checklist 15: Power Transmission and Distribution Lines.[14]

The Environmental Guidelines state broadly in Part 1.3.(4) that "In addition, where appropriate, JBIC also uses, as reference points or benchmarks, examples of standards and/or good practices regarding environmental and social considerations established by other international financial institutions and developed countries such as Japan, or recognized internationally" If new standards are internationally established in the future, JBIC intends to use them as reference points as well.

Regarding World Bank Safeguard Policy and IFC Performance Standards, the Environmental Guidelines stipulates "JBIC also ascertains whether a project meets the relevant aspects of World Bank Safeguard Policy regarding environmental and social considerations. On the other hand, for private sector limited or non-recourse project finance cases, or for where appropriate, JBIC ascertains whether the project meets the relevant aspects of International Finance Corporation Performance Standards". Therefore further reference to IFC Performance Standards in this document also represent meeting JBIC standards.

1.6.2.3 The International Finance Corporation (IFC) Performance Standards

In April 2006, the International Finance Corporation (IFC), a member of the World Bank Group, released a set of Performance Standards (PSs) based upon the original World Bank Group Safeguard Policies, which recognised further the specific issues associated with private sector projects. EP Three: Applicable Social and Environmental Standards requires that projects in non-OECD countries be undertaken in accordance with IFC Performance Standards,

[13] http://www.jbic.go.jp/en/about/environment/guideline/projects/classify/detail.php?qid=2013-0092

[14] http://www.jbic.go.jp/en/about/environment/guideline/confirm/

General EHS Guidelines and Industry Specific Guidelines. The IFC PSs have been broadened to include issues such as greenhouse gases, human rights, community health, and safety and security. A revised set of Performance Standards came into force on January 1, 2012. The complete list of PS's is provided in Figure I-2.

Figure I-2 IFC Performance Standards

The requirements for whether an ESIA is required under IFC PS depend upon the nature and complexity of the project and prediction of impacts that are likely to occur. These are embodied within Equator Principle Number One – Review and Categorisation. Projects are generally categorized as:

- Category A: Projects with potential significant adverse social or environmental impacts that are diverse, irreversible or unprecedented, with attributes such as direct pollution discharges large enough to cause degradation of air, water or soil, large scale physical disturbance of the site or surroundings, conversion of substantial amounts of forest and other natural resources, measurable modification of hydrologic cycles, use of hazardous materials in more than incidental quantities, and involuntary displacement of people and other significant social disturbances. A Category A project will require a full ESIA to be undertaken;
- Category B: Projects with potential limited adverse social or environmental impacts which are few in number, generally site specific, largely reversible and readily addressed through mitigation measures. Typically Category B projects entail rehabilitation, maintenance or upgrading rather than new construction. Whilst a full ESIA is not required, some environmental and socio-economic analysis is required;
- Category C: Projects with negligible or minimal social or environmental

impacts. These typically include projects with a focus on education, family planning, health and human resources development. No ESIA or any other form of environmental analysis is required.

The Sarulla Geothermal and Power Plant Development Project has not been given an official category ranking at the time of writing. Due to the scale of the Project and potential environmental impacts, it may be classified as a Category A project. This is primarily determined on the basis that land acquisition, clearing and habitat disturbance required for the Project, as well as operational wastes, emissions and discharges location may result in diverse potential significant adverse impacts when considered in context with the environmental and social characteristics in the project location.

PS1: A Social and Environmental Assessment and Management System is the key driver behind the development of an ESIA and associated management plans. In particular, the following key steps as outlined within PS1 are identified as basic principles within an ESIA:

- Project definition;
- Initial screening and risk assessment of the project;
- Scoping of the assessment process based upon the outcomes of the initial screening and risk assessment;
- Stakeholder identification;
- Gathering of social and environmental baseline data;
- Impact identification and analysis;
- Generation of mitigation or management measures; and
- Development of management action plans.

As discussed in Chapter 1.1, this report is an ESIA Addendum and should be read in context of the wider document support package referenced (Section 1.2).

1.6.2.4 IFC Environmental, Health and Safety (EHS) Guidelines

ADB SPS refers to internationally recognized standards such as World Bank Group’s EHS General Guidelines. Supplementing the IFC PS's are the IFC General Environmental Health and Safety (EHS) Guidelines that were released in April 2007. The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP), as defined in IFC's Performance Standard 3: Resource Efficiency and Pollution Prevention.

The EHS Guidelines contain performance levels and management measures that are generally considered to be achievable by new facilities using existing technology at a reasonable cost. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets with an appropriate timetable for achieving them.

The following IFC EHS Guidelines are applicable to the Project:

- Environmental, Health, and Safety (EHS) Guidelines. General EHS Guidelines.

The General EHS Guidelines contain standards relating to:

- Environment: air, energy, waste, hazardous materials management, noise and contaminated land.
- Occupational Health & Safety.
- Community Health & Safety.
- Construction & Decommissioning

The General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors.

Industry-Specific Guidelines describe Impacts and Management, with Performance Indicators and Monitoring:

- Environmental, Health, and Safety Guidelines. Geothermal Power Generation;
- Environmental, Health, and Safety Guidelines. Electric Power Transmission and Distribution

1.6.2.5 Comparison of ADB Safeguards and IFC Performance Standards

The ADB Safeguard Policies and IFC PS have similar scope in their application to the Sarulla Geothermal and Power Plant Development Project, as illustrated in Table I-2. ADB's safeguards do not contain numerical limits or standards for emissions or discharges but stipulate that the project proponent is required to apply pollution prevention and control technologies and practices consistent with international good practice, such as the World Bank Group's Environment, Health and Safety Guidelines.

Table I-2 Comparison of ADB Safeguards and IFC Performance Standards (adapted from World Bank, 2011)[15]

	Asian Development Bank Safeguard Policy Statement (July 2009)	*IFC Performance Standards on Social and Environmental Sustainability (2012)*
E&S	SR4: Special Requirements for Different Financing Modalities	PS1: Assessment and Management of Social and Environmental Risks and Impacts
Environment	SR1: Environment	PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources PS3: Resource Efficiency and Pollution Prevention PS8: Cultural Heritage
Social	SR2: Involuntary resettlement SR3: Indigenous Peoples safeguards	PS5: Land Acquisition and Involuntary Resettlement PS7: Indigenous Peoples PS2: Labour and Working Conditions PS4: Community Health, Safety and Security
Pollution prevention	SPS SR1: Environment (references IFC EHS Guidelines for numerical limits/standards)	PS 3: PS3: Resource Efficiency and Pollution Prevention General EHS Guidelines EHS Guidelines Geothermal Power Generation

1.6.2.6 Comparison of Indonesian and IFC Standards

Annex A provides a comparison of Indonesian regulatory standards against the IFC EHS guidance for specific effluents, emissions and discharges, where available. It can be seen from the tables that there are differences between parameters that are regulated under national legislation and the guidance values of the IFC. There are also common parameters that have different standards between the two systems. The more stringent standard is highlighted for clarity.

When host country regulations differ from the levels and measures presented in the IFC EHS Guidelines, the expectation of ADB and IFC is for projects to achieve whichever is the more stringent. If less stringent levels or measures than those provided in the EHS Guidelines are appropriate in view of specific project circumstances, a full and detailed justification must be provided for any proposed alternatives through the environmental and social risks and impacts

[15] http://go.worldbank.org/FQNLBGXG40

identification and assessment process. This justification must demonstrate that the choice for any alternate performance levels is consistent with the objectives of Performance Standard 3.

The applicable standards are further discussed in the relevant Chapters of this report.

2 PROJECT DESCRIPTION

2.1 DEVELOPMENT HISTORY

The project was initiated by UNSG, after ESC and JOC were signing in 1993. An extensive exploration activity was conducted in geology, geochemistry, geophysics investigations, and certain infrastructure development including well pad and its access road and followed by drilling activity starting from 1994 to 1998.

There are nine exploratory wells (5 in SIL, 4 in NIL) were drilled in the contract area followed by well completion and production testing to prove the quality and quantity of the resource.

After receiving the right to develop the Sarulla project, the Consortium has re-evaluated the all of the Sarulla exploration data (geo scientific and exploration drilling) in order to undertake next strategy for field development stage of the Sarulla Contract Area.

New development plan including future drilling plan by utilizing reservoir forecast simulation were established in 2011 and reflected to the well pad design and so on.

2.1.1 SOL project location

The proposed activity is located ± 40 km south of Tarutung at the side of the Trans Sumatera Highway (Tarutung – Sipirok). Administratively, the project is located in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province.

In relation to Regency Spatial Plan, the Government of North Tapanuli Regency issued North Tapanuli Regency Regulation No. 19 of 1994 regarding North Tapanuli Regency spatial planning, which designated the sub districts of Pahae Jae (Silangkitang area or SIL) and Pahae Julu (Namora I Langit) as areas of geothermal natural resources.

The Silangkitang field (SIL) has three (3) existing well pads developed by the former project proponent, UNSG in 1994. The pads are SIL 1, SIL 2 and SIL 3 and located around the periphery of these coordinates:

- SIL 1 - N201,374 and 510,500;
- SIL2 - N202,126 and E508,614; SIL 3 - N199,925 and E510,910.

SIL is located in Pahae Jae District, North Tapanuli Regency. The pad locations can also be described as follows:

- SIL 1 - located in Silangkitang Village, about 50 m from Sumatera Highways (Tarutung – Sipirok);
- SIL 2 - located at the north-west of SIL 1, on the side of Aek Batang Toru which is part of Sigurung-gurung Village;
- SIL 3 - located at the south of SIL 1, in Pardomuan Nainggolan Village.

SIL 1 has three (3) existing wells, SIL 1-1, 1-2 and 1-3 drilled in 1994 through 1997 at the depth of around 2,000m. SIL 1-2 and 1-3 are planned to be used as permanent production wells for SIL PLTP. In 2008, these two wells underwent work-over to remove existing well plugs and in case of SIL1-3 repair a portion of the casing at 13-3/8" layer to prepare them for production testing and usage as permanent production wells. SIL 1-1 is not intended to be utilised as permanent well in the operation of SIL PLTP. It is intended to be used as a temporary reinjection well during the production flow testing of SIL 1-2 and SIL 1-3 (supplemental to SIL 2-1) and afterwards, the wells will continue to be used as monitoring point of reservoir. Three (3) additional production wells (allowing 1 as allocation for failure) are planned to be drilled in this SIL 1 pad to obtain the geothermal fluid quantity needed for SIL PLTP operations. Two (2) reinjection wells are also planned to be drilled in this SIL-1 pad.

SIL 2 pad has one (1) existing well, SIL 2-1. SIL 2-1 drilled in 1995 at the depth around 2,100m is not intended to be used as permanent part of the wells during operation of SIL PLTP. This is to be used as temporary reinjection (as the primary with SIL 1-1 and 3-1 as supplemental) well during the production flow testing of SIL 1-2 and 1-3 and afterwards, the wells will continue to be used as monitoring point of reservoir. Three (3) new reinjection wells are planned to be drilled in this SIL-2 pad.

SIL 3 pad has one (1) existing well, SIL 3-1 drilled in 1995 at the depth around 2,100m. SIL 3-1 is not intended to be used as permanent part of the wells during operation of SIL PLTP. This is to be used as temporary reinjection (as the supplemental to SIL 2-1) well during the production flow testing of SIL 1-2 and 1-3 and afterwards, the wells will continue to be used as monitoring point of reservoir.

Namora I Langit (NIL) field has three (3) existing well pads developed in 1997. The pads are NIL 1, NIL 2 and NIL 3 located around the periphery of these coordinates:

- NIL 1 - N207,509 and E501,941;
- NIL 2 - N208,245 and E501,131;
- NIL 3 - N208,745 and E503,328.

The pad locations can also be described as follows:

- NIL 1 - located in Sibaganding, Lumban Jaean, and Simataniari Villages (there is one investigation well);
- NIL 2 - located in Sibaganding, Lumban Jaean, and Simataniari Villages (there are two investigation wells); and
- NIL 3 - located in Sibaganding, Lumban Jaean, and Simataniari Villages (there is one investigation well).

In order to mitigate significant static pressure differences between power plant and well pads, the most recent updates of the development strategy for the NIL geothermal field was developed, none of the 3 existing well pads will be utilised as locations for drilling the permanent (or initial/start-up) production wells, and consequently, none of the 4 investigation wells drilled in 1997 through 1998 at the depth of around 1,700m that exist therein. The existing well in NIL-3 pad will be used as temporary reinjection well during the early stage of drilling the new production wells in NIL for well testing purposes until such time that permanent reinjection wells are drilled, afterwards, the well will continue to be used as monitoring point of reservoir.

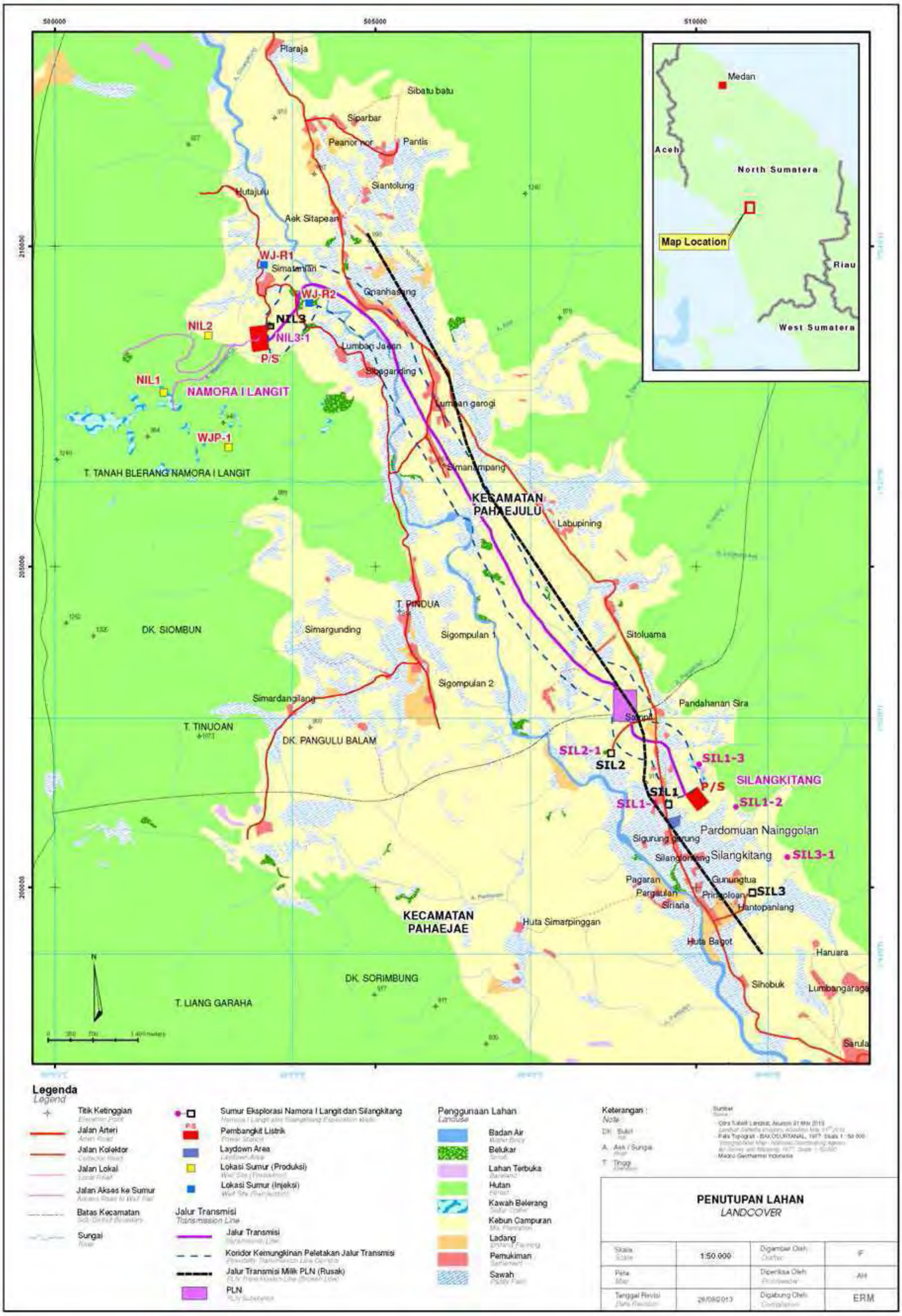
The permanent wells will be drilled on the following new well pads:

Table II-1 Number of Wells to be Drilled on New Well Pads

No	*Location*	*Number of wells to be drilled*
1	NIL-1n	7 production wells (1 allocation for failure)
2	NIL-2n	8 production well (1 allocation for failure)
3	WJP-1n	5 production wells
4	WJR-1n	3 reinjection wells
5	WJR-2	3 reinjection wells

A map illustrating the development plan for Silangkitang (SIL) and Namora I Langit (NIL) geothermal fields is shown in **Map II-1**.

Map II-1 **Development plan for Silangkitang (SIL) and Namora I Langit (NIL) geothermal fields**



2.1.2 *Stages of project activity*

The development of Sarulla geothermal field and 330 MW power plant includes the following activities:

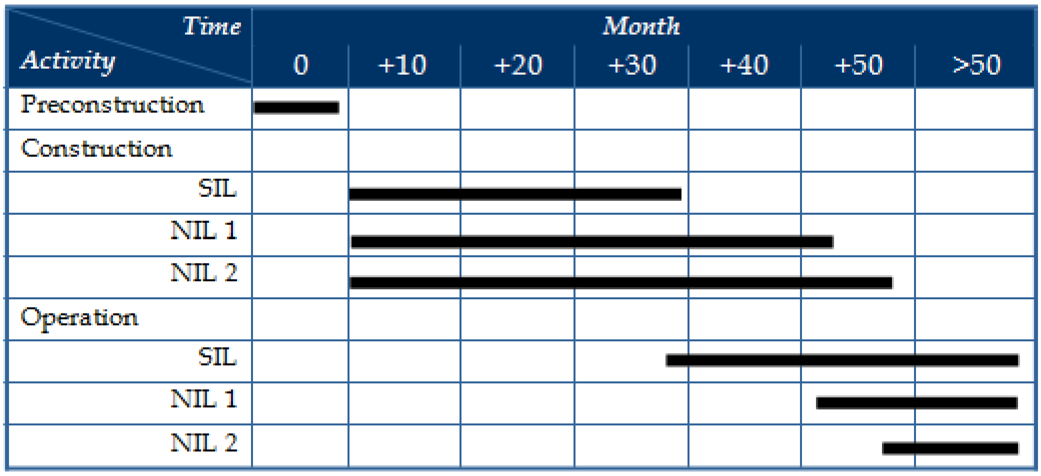
- The development of Sarulla geothermal field i.e. Silangkitang (SIL) field and Namora I Langit (NIL) field;
- The construction and operation of 330 MW geothermal power plant, one unit at SIL and two units at NIL each with a nominal capacity of 110 MW;
- The construction of a combined length of approximately 14kms of 150 kV (high voltage) overhead transmission line from Silangkitang field (SIL 1) to PLN Substation and from Namora I Langit field (NIL 1) to PLN substation.

Drilling activities for new production and injection wells in SIL are to take place at the existing well pads previously developed by UNSG. For NIL, all are planned to be on new well pad locations. The NIL new well pads are located on farmland and mixed forest areas.

The power plant locations for both SIL and NIL will be at mixed plantation areas. SIL is situated approximately 500 meter from the nearest residential area whilst NIL is located at least 1km far from a residential area.

The project schedule for the development of Sarulla 330 MW power plant at SIL and NIL is displayed in **Table II-2**.

Table II-2 Project schedule for the development of Sarulla 330 MW power plant at Silangkitang (SIL) and Namora I Langit (NIL)



2.1.2.1 Pre-construction Stage

2.1.2.1.1 The Development of Sarulla Geothermal Field

This activity consists of preliminary study, detailed construction design, and land acquisition. Those activities are taken into consideration of complying with ADB safeguard policy and IFC performance standard.

1) Preliminary study

a. Technical planning

Technical planning includes:

- Well characteristics study by well testing for existing two (2) wells to be utilised as production wells;
- Planning of equipment for geothermal fluid production such as wells, separators, brine accumulators, distribution valves, and safety devices for geothermal field;
- Planning of equipment to anticipate abnormal conditions in steam production process;
- Planning to distribute geothermal fluid to power plants and reinjection from power plants to reinjection wells.

b. Topographic measurement

This is to designate positions, area and determination of the subsequent construction boundaries including supporting facilities at the proposed well locations i.e. pipelines, roads, and transmission line.

c. Project socialization

The following consultation activities were conducted to socialize the development of Sarulla geothermal field and 330 MW power plant:

- Project socialization at Silangkitang on 5th February 2008;
- Public consultation in relation to AMDAL preparation in Pahae Julu on 28th March 2008;
- Project socialization with government institutions in Tarutung on 6th May 2008;
- Project socialization regarding land acquisition process for reinjection route on 6th June 2008;
- Socialization/Seminar of Sarulla project to local NGOs groups, local communities and local Governments representatives, 25th June 2008;
- Socialization of well work over activity in Silangkitang on 15th July 2008;
- Well work over ceremony in Silangkitang on 15th August 2008;

- Dialogue forum with local communities and local NGO – IMARUPA & IARRP on 11th Jan 2011;
- Discussion/Meeting with local communities, representatives of North Tapanuli Local Government and IMARUPA/ IARRP on 24th March 2011;
- Project and AMDAL socialization/explanation in 11 villages on 23 March 2011, 15 -18 April 2011;
- Project and AMDAL socialization to land owners in Pahae Jae & Pahae Julu on 6th -7th May 2013.
- While for socialization activities related land with land acquisition, SOL has conducted the following activities:
- Socialization on land acquisition to brine Injection line land owners on 25th November 2009;
- Negotiation meetings for Brine Injection line on 9th December 2010, 19th January 2011, and 24th March 2011;
- Socialization meeting for land acquisition to land owners in Pahae Jae and Pahae Julu on 30th April 2013, 1-2 May 2013 and 6-7th May 2013.

2) *Construction design*

This stage consists of a feasibility study and technical design on the development of Sarulla geothermal field which will supply geothermal fluid to power plants. Those activities are taken into consideration of complying with ADB safeguard policy and IFC performance standard.

Geotechnical investigation includes field investigations, laboratory testing, analysis and recommendations to understand the subsurface conditions for design and construction planning for the preparation of project location and civil engineering work. These investigation results are reflected to the design consideration such as landslide, erosion.

3) *Land acquisition*

Land required for the Project will be procured on a willing buyer-willing seller basis. It will be undertaken in stages as the construction of the geothermal field progresses. The process will be conducted using direct negotiations and agreements between land owners and SOL. A total of 127 ha of land located in the districts of Pahae Jae and Pahae Julu, North Tapanuli Regency will be needed for the land use plan for the development at SIL and NIL is shown in Table II-3. To date, SOL has acquired approximately 4.3 ha of land in SIL for Brine Injection Line and it will be used for the Well test activity. While for the remaining estimated required land as listed in the table II-3 is still in the process and is expected to be completed within 2013.

Table II-3 Land use plan and area required for SIL and NIL

NO	*LAND USE PLANNING*	*Estimated REQUIRED AREA (m^2)*	*CURRENT LAND USE*
NAMORA I LANGIT (NIL)			
1	Main Access Road	33,883	Mainly rice/paddy field
2	Well Pad NIL 2n & Access Road	57,231	Wild plantation area, Rice field area
3	Disposal 1 & 2 & Access Road	176,050	Wild plantation area, Rice field area
4	Borrow Area	91,468	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
5	WJR 1n & Access Road	35,513	Wild plantation area, Rice field area
6	Power Plant & Access Road	226,177	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
7	Lay down	80,000	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
8	Road 5	120,000	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
9	WJP 1	80,000	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
10	NIL1 Exp & Access Road	80,000	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
11	WJR 2n & Access Road	40,000	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
	Sub Total NIL	**1,020,322**	
SILANGKITANG (SIL)			
1	Disposal For Power Plant	12,340	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
2	Borrow Area	20,880	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
3	Well Pad SIL 1	13,344	Bushes, rice field area
4	Power Plant	65,465	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
6	SIL 2 Expansion & Access Road	30,000	Wild plantation area (various trees such as rubber, incense *(Kemenyan)*, cacao, coffee and bushes)
7	Lay down 1	28,000	Rice field area
8	Lay down 2	20,000	Various (bushes & wild trees)
9	Transmission Line 150 Kv	60,000	Majority rice field area, Wild trees, bushes
	Sub Total SIL	**250,029**	
	TOTAL NIL & SIL	**1,270,351**	

2.1.2.1.2 *Construction of geothermal power plant*

SOL will construct, operate and maintain a power plant at 330 MW total installed capacity. To fulfil the capacity, three unit power plants will be constructed where each will generate approximately 110 MW. The first unit will be built at SIL and another two units at NIL.

1) *Preliminary study*

Based on the geothermal conditions of each well and wells spread rate curve (wellhead pressure vs. flow rate and enthalpy), separator pressure is calculated to obtain the most effective power generation configuration in order to minimize project cost.

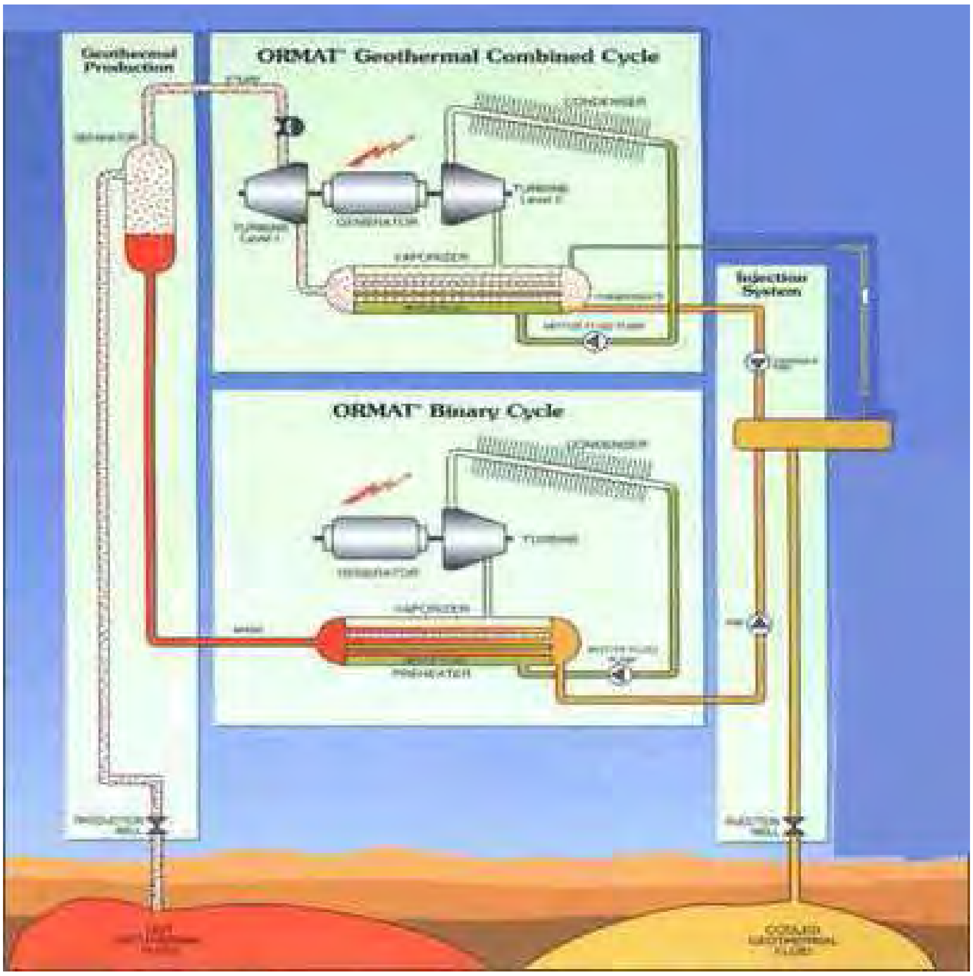
This stage consists of three phases of power plant construction, one plant at SIL and two plants at NIL. Each power plant has a capacity of 110 MW (a total of 330MW) and each consists of one Integrated Geothermal Combined Cycle Unit (IGCCU). A unit of IGCCU is comprised of:

- 1 steam back pressure turbine
- 4 bottoming Organic Rankine Cycle (ORC) units operating on steam
- 2 Organic Rankine Cycle (ORC) units operating on brine

The IGCCU will be using air cooled system. Hence, Sarulla power plant will not require make up water. All brine water and steam condensate will be injected into the ground through reinjection wells. Based on the expected characteristics of the geothermal fluid, pH modification through the addition of H_2SO_4 may be implemented to prevent scaling formation. The actual chemical properties of geothermal fluid once discharged from the wells will eventually determine if such pH control will be needed or not.

A diagram of Integrated Geothermal Combined Cycle Unit (IGCCU) system is shown in Figure II-1.

Figure II-1 Typical Diagram of Geothermal Combined Cycle Unit (GCCU) and Ormat Energy Converter (OEC) Technology



2) Land acquisition

The land required for the power plant construction is already taken into account in the land acquisition process for the development of geothermal field and construction of access roads. In the construction plan, one power plant unit will be built at SIL and two units will be built at NIL where each will have a capacity of 110 MW (a total of 330 MW). The amount of land required for the power plants is approximately 6.5 ha for SIL and 22.6 ha for NIL.

2.1.2.1.3 Transmission line construction between SIL and NIL

1) Land acquisition

The process will be conducted using direct negotiations and agreements between land owners and SOL, facilitated by the government of North Tapanuli Regency. The land required to build the transmission towers is not yet purchased. The plan is not to use productive land, cemetery or residential areas.

The purchased land will be used as platforms for transmission towers and not for transmission lines. Approximately 47 towers will be built with an estimated distance of approx. 300 m between each of the towers. It is estimated that each transmission tower will require 900 m2, and therefore the total of land required for 47 towers is 4 ha.

2.1.2.2 *Construction stage*

2.1.2.2.1 *Sarulla geothermal field development*

This stage involves construction of new well pads, access roads, improvement of existing well pads, drilling of new wells, and installation of associated well pad equipment such as separators, accumulators, pipelines for well production testing. The geothermal field development construction is scheduled for approximately 3 years.

1) Workforce recruitment

The estimated number of workforce at the peak who will be involved in the geothermal field development activities is as shown in **Table II-3**.

Table II-3 Workforce Numbers

Activity	*Estimated Workforce Required*				
	Expatriate	*Manager/ Engineer/ Supervisor*	*Skilled/ Semi-skilled*	*Unskilled*	*Total*
Infrastructure Construction	3	10	50	50	113
Well drilling operations (3 rigs operating simultaneously)	5	10	150	60	225
Central logistics		2	2	12	16

2) Mobilization of equipment and materials

Construction activities start with mobilization of equipment and materials that will be used in the project. Construction equipment typically used in the roads and wellpad construction and those for geothermal well drilling are to be mobilized including the following:

- Earth-moving equipment such as dozers, loaders, dump trucks, excavators;
- Drilling equipment and its associated facilities such as cementing units, diesel generators, pumps;
- Mechanical construction equipment such as cranes, welding machines, cutting torches, etc.

Other equipment and materials required in the geothermal field development activities will also include:

- Drill pipes and casing;
- Cementing material;
- Additional drilling materials;
- Commonly used construction materials, i.e. lumber, reinforcing and structural steel, concrete;
- Pipes, insulation materials, isolation materials etc.

Whenever possible, materials used in this project will be supplied locally. If not, the materials will be supplied from the nearest area. Materials will be transported inland by trucks using the route Medan–Tarutung – Sarulla towards storage facility around project location in SIL and NIL. Specialty materials such as casing and wellhead valves for the well drilling are expected to be imported

3) Land preparation

The land preparation consists of two main activities as follows:

- Vegetation clearing;
- Land clearance and removal; and
- Site restoration work.

Considering that the current land use is a combination of farmland, plantation or dry land (*tegalan*), and bushes, tree cutting will be at a minimum. Typically, the tree species that will be cut down after completion of the compensation process include rubber, pines, coffee, fruit, and small tree grades.

Stripped soil from the project site will be placed in the project's designated disposal areas. Re-vegetation of the soil disposal site will be done after the construction stage of the project aside from some portions that will continuously be used as spaces for project's supporting facility area during the stage of operation.

4) Civil engineering construction

i) Improvement of Sumatera Highway and Project roads and bridges

The main entry point of the power plant equipment to the Island of Sumatra is through the port of Belawan, near Medan. The plant equipment will then be transported through the Trans-Sumatra highway from Belawan to the Sarulla Project Site. A number of the plant equipment (i.e. turbines, generators, transformers, heat exchangers, containerized items) are of notable heavy loads and requires proper transportation planning.

Based on preliminary road survey made by the contractor, certain improvements of bridges along the Trans Sumatra Highways will be needed. No actual replacement of bridges has been identified needed during this preliminary survey. Most of the improvements seen needed are reinforcement of bridges, some widening of roads along tight curves, and temporary removal of certain low lying overhead structures (i.e. ad posters). As part of the standard methodologies in transporting heavy load on public roads, multi-axle trucks designed to minimize point loading to the permissible limits will be utilised. More detailed survey will be performed prior to actual transportation activities to make definitive plans.

The existing roads in the project sites that were previously built to access the existing well pads are mostly going to be utilised. Refurbishment, expansion and extension of these existing roads combined with constructing new ones are part of the project activity under the Infrastructure Construction scope of work. The existing steel truss bridge in NIL (called Hamilton Bridge) will undergo rehabilitation by adding various struts, cross members and other of stiffeners to match the heaviest transport load expected to travel on it. A detailed design for this reinforcement procedure has already been conducted. These roads and bridges will be built as part of the permanent structures usable through the period of project operation.

ii) Well pads for well drilling

The work includes construction of pads (to the designed size and elevations) where drilling activities will be performed. System for geothermal fluid separation will also be built on the well pads containing production wells.

Table II-4 Numbers of wells to be drilled at SIL and NIL

Well pad	*Numbers of wells*			*Output Capacity Target (Mwe)*	*Average Well Capacity (Mwe/Well)*
	Existing	*New*	*Total*		
SIL					
Production	2	3 (includes 1 failure)	5	110	28
Reinjection	0	5	5	For total liquid to be injected	-
NIL					
Production	0	20 (includes 2 failures)	20	220	13
Reinjection	0	6	6	For total liquid to be injected	-

Source: West JEC Table 3.1.1-1, updated June 2013
Note: Numbers of wells may change subject to well testing results

Basic designs for access road are shown in Table II-5 and Table II-6.

Table II-5 Civil engineering work for access roads

NO	Description	Approximated Width (m)	Approx. Length (m)	Note
1	Road from Sumatra highway to SIL Power Plant	6	750	New
2	Existing access road (Main road – SIL 2)	5	1,050	Over existing road structure
3	Main road to P/P (NIL)	6	4,000	Over existing road structure + bridge
4	P / S (NIL) to NIL-1n	5	1,200	Partly over existing road structure, others
5	P / S (NIL) to NIL-2n		1,100	Partly over existing road structure
6	P/S (NIL) to NIL WJP-1n	5	2,500	all new road + new bridge
7	P/S (NIL) to NIL WJR-1n	5	1,750	partly over existing road structure, other new + bridge
8	To WJR-2		0	To main access road

P/S = Power Station
Source: WestJEC, 2007, updated June 2013

Table II-6 Civil engineering work for well pads

No	Pad	Size (m2)	Note
1	SIL 1	160 x 90	New pad
2	SIL 2	160 x 90	expand existing pad
3	NIL 1n	160 x 150	New pad
4	NIL 2n	160 x 150	New pad
5	WJP-1n	160 x 150	New pad
6	WJR-1n	160 x 90	New pad
7	WJR-2n	160 x 90	New pad

Source: WestJEC, 2007

iii) Construction of temporary facilities – worker accommodation area and working area

Contractor will provide all temporary facilities, including offices, worker accommodation area, storage materials area, and working area and also meet with the requirements of IFC performance standard. As per ADB requirements the EPC camp site will have adequate fencing and 24 hour, security.

iv) Disposal area

All unused or excess materials during construction activity will be collected and deposited in a landfill by the contractor. Soil for disposal for the general site excavation (ICW and Power Plant) is estimated at:

- NIL: approximately 1,500,000 m^3; and
- SIL: approximately 450,000 m^3.

In the case of drilling mud, it will be collected in a pit with a liner sheet and treated as industrial waste. Drill cutting volumes (estimated as 50% of the hole size) are:

- NIL: approximately 13,000 m^3; and
- SIL: approximately 3,000 m^3.

v) Temporary drainage during site preparation

Temporary drainage system will be provided by the contractor during the site preparation construction work. The system will include temporary ditches, collection pits and sedimentation basins for mud water treatment.

5) Drilling and production test

Drilling is conducted to prepare production and reinjection wells. It is anticipated that up to 34 wells will be drilled at SIL and NIL. The drilling will be performed using the conventional drilling rig, equipped with essential safety features such as blowout preventer (BOP). H_2S detection tools will also be provided, while the drilling targets are planned drill maximum depth of 2,000 m (directional), the minimum of 1,500 hp rig planned to drill in the project can handle more than 3,500 m.

The drilling activities will utilise water from Batang Toru River. Estimated usage of water during drilling is at an approximate rate of 200 GPM (equivalent to 4 LPM).

The drilling process will use water based mud to prevent the borehole walls from caving during drilling. At certain depths, well casing will be installed to prevent caving of the borehole, and to prevent leakage from or to soil and rock formations. After the drilling is completed, wellhead will be equipped with tools to control fluid flow rate from the well. The chemicals used will have MSDS (Material Safety Data Sheet). The procedures to manage drilling mud, mud waste and cuttings will refer to applicable regulation including Regulation of Minister of Energy and Mineral Resources No. 45 of 2006.

After the drilling is completed, production tests will be carried out at each drilled well to determine its specific characteristic. The option to use the separator type test facility or the tracer flow test (TFT) type are both acceptable in conducting the discharge tests of the newly drilled wells. During production test, steam will be discharged through a steam muffler, while separated brine will be re-injected to reinjection wells.

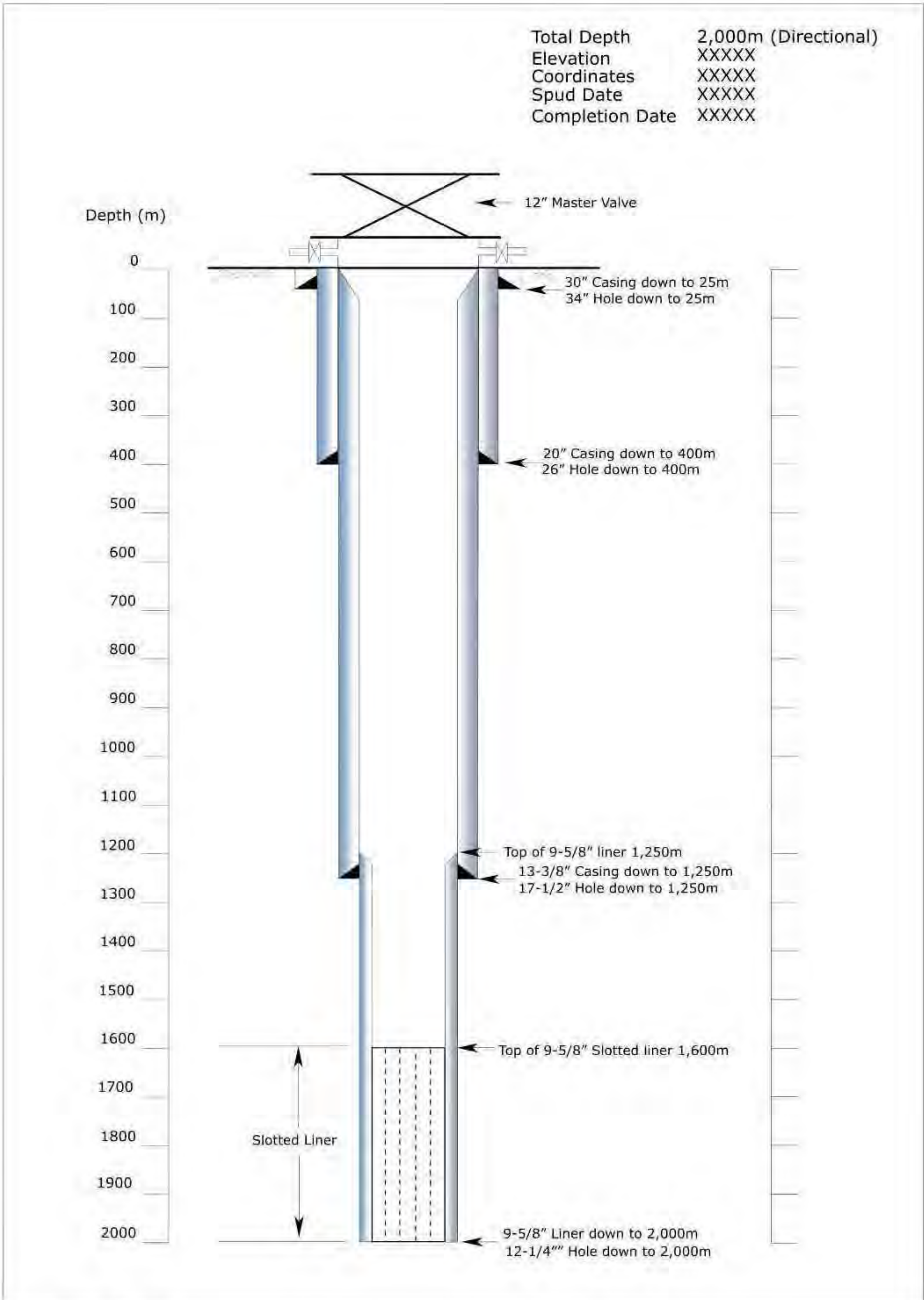
Figure II-3 and Figure II-4 illustrate types of casing for production and reinjection wells respectively. Based upon the records of wells drilled by the former developer of the project, the specific studies made by the Sarulla team, and discussion held with experienced drilling contractors, it is estimated that each well may require 38 drilling days for production wells (which has bigger hole sizes) and 32 drilling days for reinjection wells.

Chemicals required for drilling activity consist of water based mud and cementing materials. The types and the amounts of the chemicals required depend on the depth and the characteristics of the drilled formations. The typical chemicals required are as follows:

- Barite;
- Bentonite;
- Caustic soda;
- Sodium bicarbonate;
- High temp deflocculant;
- High temp fluid (control additive).

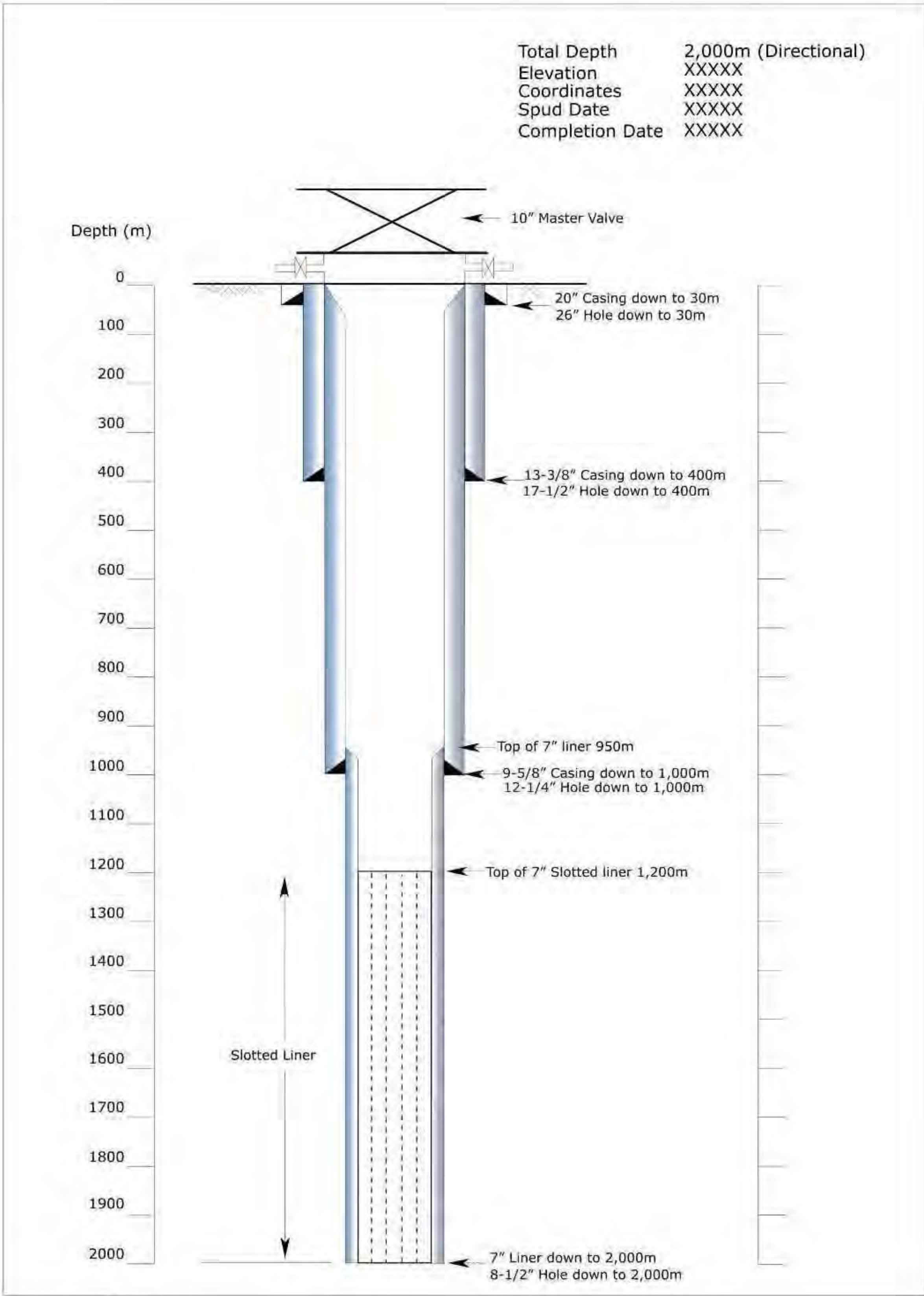
Each chemical has its own MSDS and most of the chemicals are categorized as non-hazardous and non-toxic (non-B3) based on a list published by the United States Environmental Protection Agency (US- EPA). Storage and treatment of these chemicals and their residuals will refer to the associated MSDS.

Figure II-3 Typical Casing for Production Well (at SIL and NIL)



Sumber.WestJEC, 2007

Figure II-4 Typical Casing for Reinjection Well (at SIL and NIL)



Sumber.WestJEC, 2007

2.1.2.2.2 Construction of geothermal power plant

1) Workforce recruitment

The estimated number of workforce at the peak projected to be involved for the construction of the Power Plant is shown in the table II-7 below:

Table II-7 Workforce recruitment

No	*Activity*	*Estimated workforce required*				
		Expatriate	*Manager/ Engineer/ Supervisor*	*Skilled/ Semi Skilled*	*Unskilled*	*Total*
I	Power Plant construction	20	50	500	700	1,270

It was acknowledged that contractor shall best endeavour to use local labour and local contractor. The detail plan including local recruitment and accommodation will be developed at the later stage taken into consideration of IFC performance standard.

2) Mobilization of equipment and materials

The power plant equipment that are imported such as the turbines and generators, heat exchanges, electrical components are planned to be off-loaded at the port of Belawan. They will then be transported from Belawan to the project site via land trucking through the Trans Sumatra highway. Various multi-axle trailers are to be utilised to keep the road loading to within the permissible limits. Based on initial transport surveys made most probable route would be through Belawan Port –Medan – Deli Serdang – Serdang Bedagai – Tebing Tinggi – Pematang Siantar – Parapat – Balige – Tarutung – Sarulla project locations (Pahae Julu and Pahae Jae). It is estimated that construction traffic will range from approximately 3-4 truck movements a day during the peak. The maintenance of access roads will be conducted by the Project.

Certain construction equipment such as those used for earthmoving (dump trucks, dozer, loaders) were identified available from within the North Tapanuli area. Others are planned to be sourced within North Sumatra Island and other parts of Indonesia.

Construction materials for civil, buildings and architectural are expected to be sourced locally and within Indonesia.

3) Land preparation for power plant and employee residential area

The sites will be prepared by removing all the top soil, grading and levelling to the required elevations. At NIL, an inventory of trees already undertaken, and the land clearing including tree cutting and levelling will be carried out according to the applicable regulations. The development platform of the Power Plant area:

- SIL (see Figure II-5)

  Area: about 210m x 305m

  Elevation: 530 and 525 m above sea level (bi-level)

  The EPC camp will be located at Lay Down 2 approximately 1 km away from the nearest houses (3-4 houses) which are close to the SIL-1 well pad.
- NIL (see Figure II-6)

  Area: about 500 x 435m

  Elevation: 823 and 813 m above sea level (bi-level)

  The EPC camp will be located adjacent to WJR 2 approximately 1 -2 km away from residential areas.

Figure II-5 SIL Development Plan

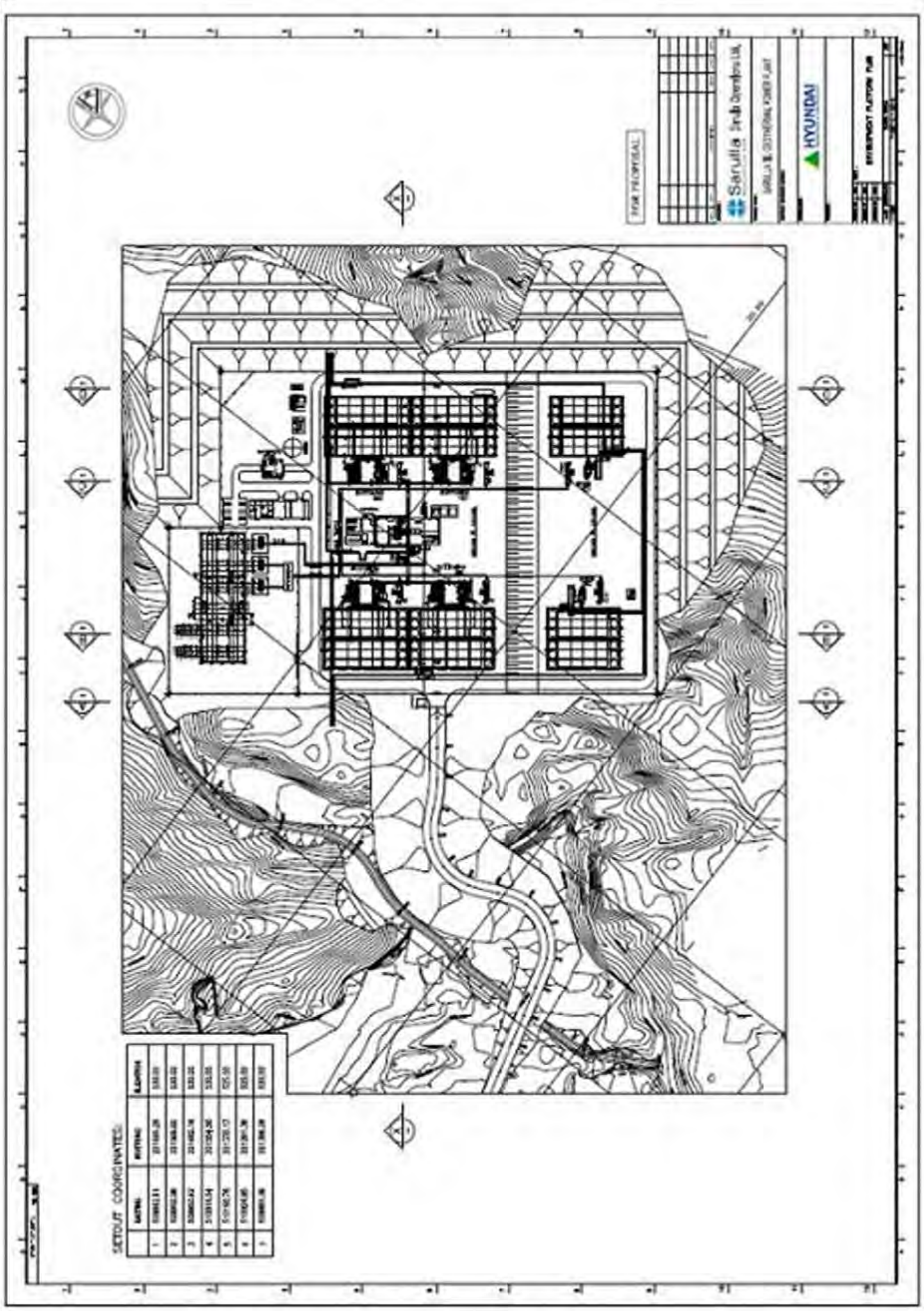
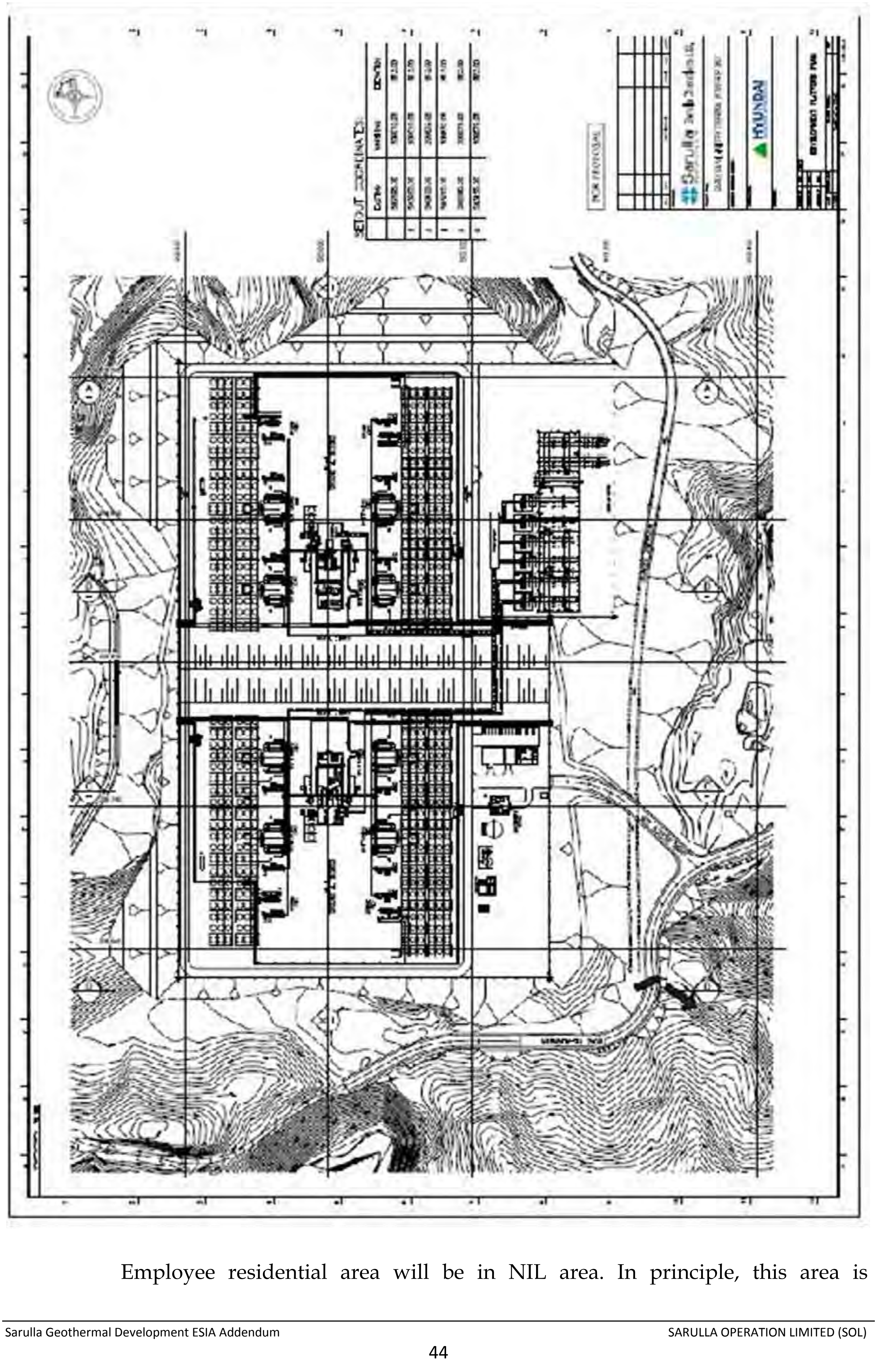


**Figure II-6	NIL Development Plan**



Employee residential area will be in NIL area. In principle, this area is designed to be separated with local community area. Details such as size, adequate security will be determined at the later stage.

4) Power plant construction - Civil

The construction stage will include civil works and building construction and shall include activities such as:

- Power plant area final grading;
- Improvements of existing and new access roads to the power plant locations and well pads;
- Constructions of the power plant office buildings and supporting facilities.

The construction will be designed and built according to guidelines for earthquake resistance buildings (SNI 03-1726-2002) or other international standards.

5) Power Plant Construction - Electromechanical

Mechanical construction includes installations of power plant equipment such as steam turbine generator and supporting tools, OEC units, condenser with air cooler, overhead crane, etc.

Electrical construction includes assembly and installation of generator, control system and relays, transformers, switchgears, and lighting facility.

Other activities include painting and installation of pipe insulator. The insulator will be used to stabilize the temperature and pressure of steam and brine from wells to power plants.

2.1.2.2.3 *Construction of Transmission Line between SIL and NIL*

This subsection provides an overview of the construction of transmission lines between SIL & NIL related aspects including associated facility.

1) Workforce recruitment

Quantity of Workforce is included in the Power Plant construction projected workforce requirement.

2) Mobilization of equipment and materials

The mobilization will be using existing road network. Whenever possible, materials used in this project will be supplied locally. If not, the materials will be supplied from the nearest area. Materials will be transported inland by trucks using the route Medan – Tarutung – Sarulla towards storage facility around project location.

3) Land preparation

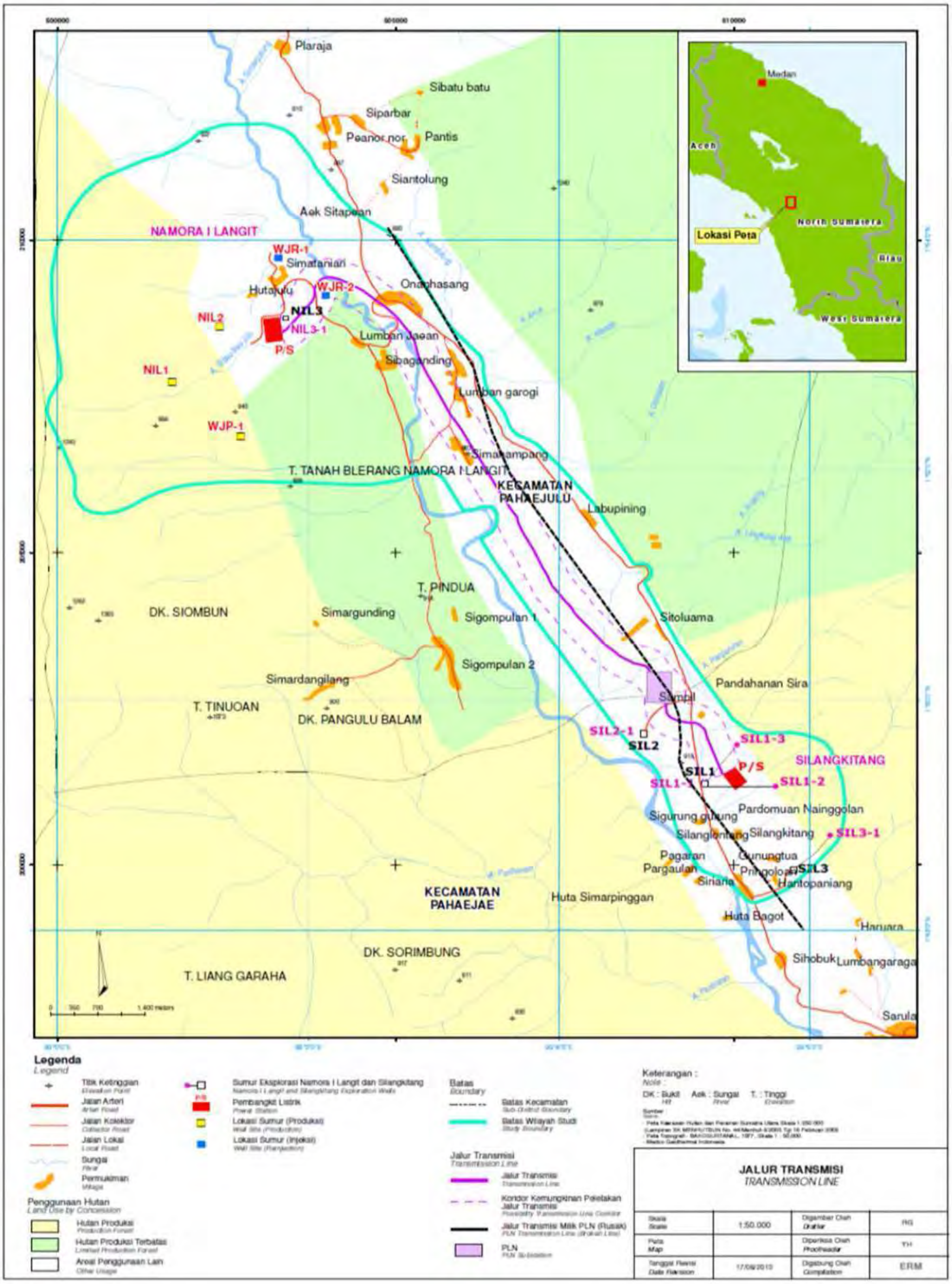
The land preparation consists of two main activities i.e. vegetation clearing, and land clearance and removal.

Land will be prepared for the locations of the transmission towers. SOL will not prepare the whole section of land; however some high trees will be cut.

4) Installation of transmission tower

This activity consists of constructions of towers for the 150KV Transmission Line. The towers will be constructed at approximately 300 meter intervals. The combined approximate length of the transmission line from SIL to PLN substation and from NIL to PLN substation is approximately 14 km (Figure II-7).

Figure II-7 Transmission Lines from SIL to PLN Substation and from NIL to PLN Substation



5) Associated Facility – PLN 275 kV Transmission line

The 150 kV Transmission Lines will interconnect the Electricity Generation Facilities to PLN's 275 kV transmission line. PLN is responsible for the construction of the 275 kV T/L and current activities that are being undertaken by PLN to complete the construction of this facility is land acquisition and also some construction work for tower foundation. Based on information given by PLN, EIA (AMDAL) document for this facility has been completed and has been approved.

2.1.2.3 *Operation stage*

2.1.2.3.1 *Workforce*

The planned quantity of workforce to be utilised during the operation of both SIL and NIL is described in table II-8 below:

Table II-8 Workforce during operation stage

No	*Activity*	*Estimated workforce required*				
		Expatriate	*Manager/ Engineer/ Supervisor*	*Skilled/ Semi Skilled*	*G&A/ Support*	*Total*
I	Sarulla Jakarta Head office support	5	8	12	1	26
2	Site Operations and Maintenance Team	3	5	91	101	200

It is expected that local labour can be used as G&A/Support during operation stage. The detailed hiring plan will be developed at later stage. During annual maintenance activities, third party contracted services will also add number of workforce at the site. Depending on the actual maintenance activities being performed, between 50 to 75 people are expected to be involved. The crafts vary from labour force, skilled workers (i.e. welders, mill wright), consultants and representatives from the Original equipment manufacturers (OEM).

2.1.2.3.2 *Geothermal Field operation*

The operation stage is to operate the steam production system to generate electricity. The system consists of production sources, well heads, safety valves, pipe lines, separators and brine accumulator units, and control tools.

Geothermal fluid from reservoir will be channelled to separators in order to separate steam and brine at the designed system operating pressure. Both steam and brine are used to generate electricity to achieve the 330 MW capacity. Separator systems are equipped with safety valves and rupture disks to prevent over-pressurization risks in cases of emergency situation. Mufflers to vent the steam and brine storage pond are also available for the relief system.

The operation shall also include standard monitoring system used in similar geothermal projects to monitor and assess the behaviour of the geothermal resource and wells. The detailed monitoring plan will be developed at later stage.

Allocation for drilling make-up wells through the operation period is allocated. Other forms of well maintenance such as work over and acidizing are also included in the program. This project was modelled on the basis that productivity of the resource can sustain the 30 years life of the project with make-up and work-overs considerations.

2.1.2.3.3 *Power plant operation stage*

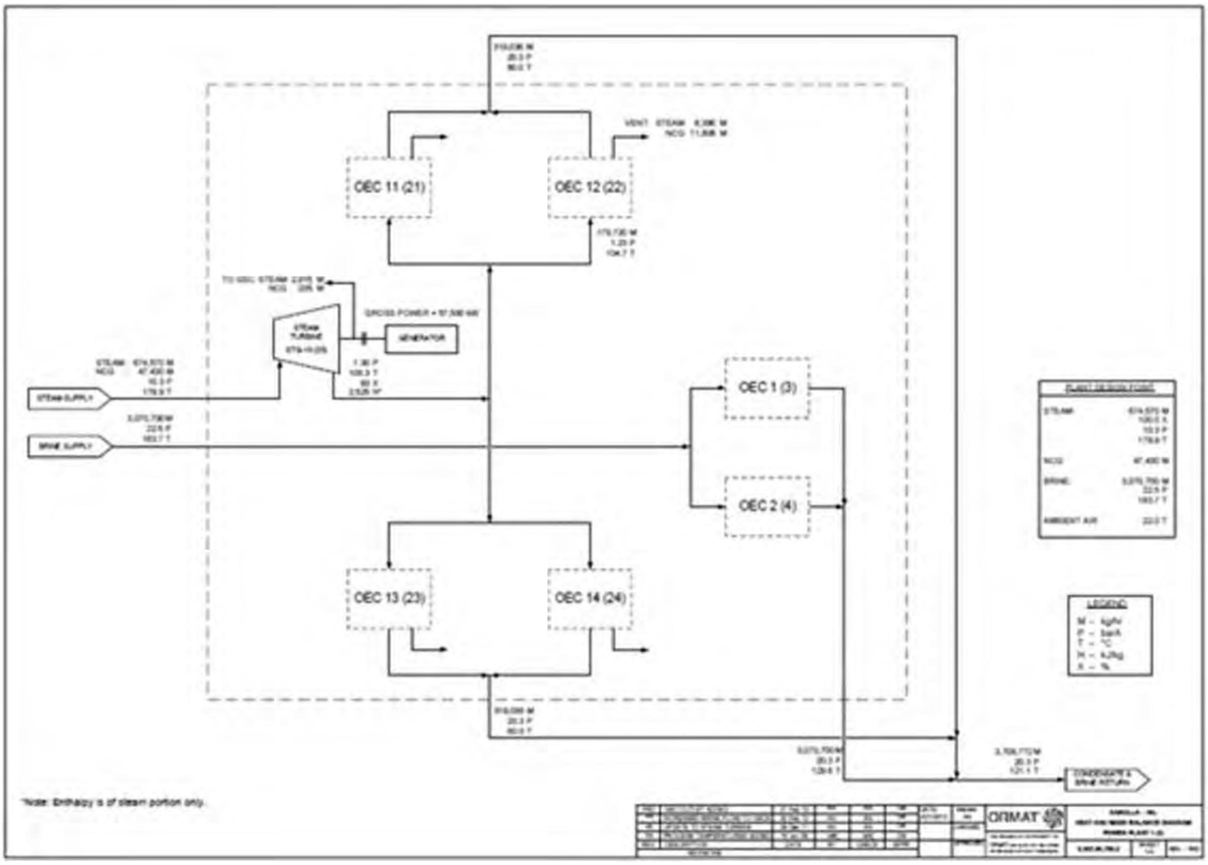
The Power Plant will be operated as base load with electricity generated dispatched to PLN grid. The geothermal fluid in the form of separated steam and brine from the production wells in various well pads are delivered to the power plant. Pipe gathering system serves to convey the geothermal fluid to the power plant. The energy of the geothermal fluid is converted into electric energy through the IGCCU.

The IGCCU – each of the IGCCU are comprised of 1 back pressure steam turbine and 4 bottoming ORC units plus 2 brine ORC units.

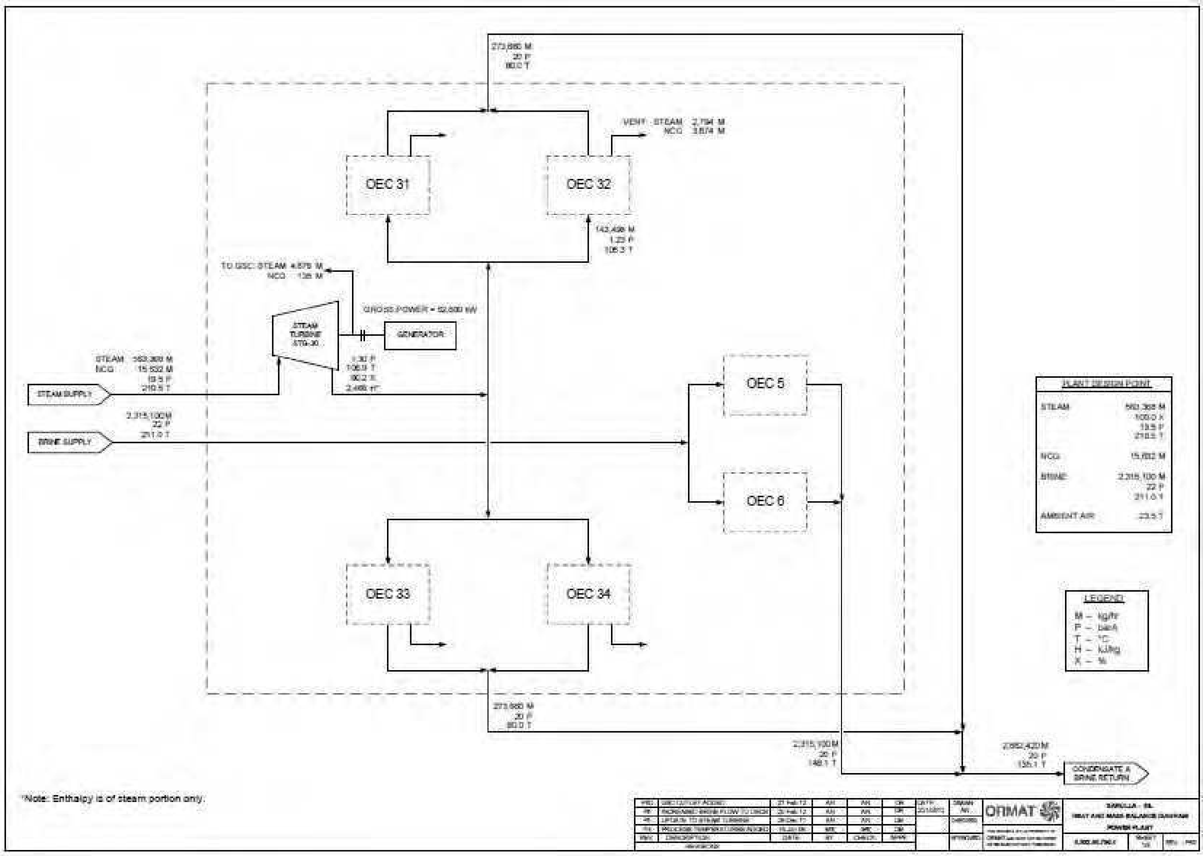
Expected Design operating conditions of the IGCCU:

Parameter		*SIL*	*NIL (Total of both NIL-1 and NIL-2)*
Steam Supply	Steam Pressure	19.5 Bara	10.3 Bara
	Steam Flow Rate	579 Ton/hour	1,444 Ton/hour
	Steam NCG Content	2.7 Weight %	6.57 Weight %
Brine Supply	Brine Flow Rate	2,315.1 Ton/hour	6,141,4 Ton/hour
	Brine Temperature	211 °C	183.7 °C
Re-Injection	Water Temperature	135.1 °C (*)	121.1 °C (*)

The typical diagram of an IGCCU is shown below



OEC 11 (21)
OEC 12 (22)
OEC 1 (3)
OEC 2 (4)
OEC 13 (23)
OEC 14 (24)
ORMAT
*Note: Enthalpy is of steam portion only.



OEC 31
OEC 32
VENT STEAM 2,794 M
NCG 3,874 M
142,498 M
1.23 P
105.3 T
GROSS POWER = 52,800 kW
STEAM TURBINE STG-30
GENERATOR
STEAM SUPPLY
BRINE SUPPLY
OEC 5
OEC 6
OEC 33
OEC 34
LEGEND
M – kg/hr
P – barA
T – °C
H – kJ/kg
X – %
CONDENSATE & BRINE RETURN
ORMAT
*Note: Enthalpy is of steam portion only.

Main Equipment Specification is described in table II-9 below:

Table II-9 Main Equipment Specification

Parameter	*Back pressure steam turbine*	*Bottoming OEC units*	*Brine OEC units*
Type	Axial, impulse	Axial, impulse organic turbine	Axial, impulse organic turbine
RPM	3000	1500	1500
Nominal Capacity	SIL – 59MW NIL – 62MW	SIL – 6.75MW NIL – 7.80MW	SIL – 13.89MW NIL – 15.45MW
Organic Fluid	N/A	Pentane	Pentane
Nominal Voltage	11kV	11kV	11kV

2.1.3 *Summary of Project Components*

Table II-10 summarises the Project Components and also shows the status of those components.

Table II-10 Project Components

SIL

Component	*Existing*	*Plan*
Power Plant	-	To be constructed - Steam turbine - OEC - BOP etc.
Well pad (SIL-1) (for production and reinjection)	- Pad - 1 (one) sump pit - 1 (one) rock muffler	To be repaired and used - Pad - existing sump pit - existing rock muffler To be constructed - 1 (one) new sump pit - separator station
	- 3 (three) wells	To be drilled - 3 (three) wells for production - 2 (two) wells for reinjection To be used - existing 2 (two) wells for production - existing 1 (one) well for monitoring

Component		*Existing*	*Plan*
Well pad (SIL-2) (for reinjection)		- Pad - 1 (one) sump pit	To be repaired and used - Pad - existing sump pit
		- 1 (one) well	- 3 (three) wells to be drilled - existing 1 (one) well to be utilised for monitoring
Well pad (SIL-3) (for reinjection)		- Pad - 1 (one) sump pit	- Pad to be repaired and used - 1 (one) sump pit to be abandoned
		- 1 (one) well	existing 1 (one) well to be utilised for monitoring
Access roads	to Power plant	-	To be constructed
	to SIL-2	Road	To be repaired and used
	to SIL-3	Road	To be maintained and used
Pipeline		-	To be constructed between well pad and power plant
Transmission line		-	To be constructed - transmission tower - conductor - bays in PLN substation
Water intake station (temporary)		-	To be constructed
Site office		- Site office - Container house - Casing pipes	To be repaired to the some extent - Site office - Container house To be utilised or maintained - Casing pipes
Well pad (SIL-D)		1 (one) disposal area	- Existing area to be repaired and used as drilling disposal area
Lay down area		-	2 (two) area to be constructed
Water well (operation use)		-	1 (one) well to be drilled

NIL

<table>
<tr><th colspan="2">Component</th><th>Existing</th><th>Plan</th></tr>
<tr><td colspan="2">Power Plant</td><td>-</td><td>To be constructed
- Steam turbine
- OEC
- BOP etc.</td></tr>
<tr><td colspan="2" rowspan="2">Well pad (NIL-1)</td><td>- Pad
- 1 (one) sump pit
- 1 (one) rock muffler</td><td>To be maintained
- Pad
To be abandoned
- existing sump pit
- existing rock muffler</td></tr>
<tr><td>- 1 (one) wells</td><td>existing 1 (one) well to be utilised for monitoring well</td></tr>
<tr><td colspan="2" rowspan="2">Well pad (NIL-2)</td><td>- Pad
- 1 (one) sump pit</td><td>To be repaired and used
- Pad
- existing sump pit</td></tr>
<tr><td>- 1 (one) well</td><td>existing 1 (one) well to be utilised for monitoring well</td></tr>
<tr><td colspan="2" rowspan="2">Well pad (NIL-3)</td><td>- Pad
- 1 (one) sump pit</td><td>To be maintained</td></tr>
<tr><td>- 1 (one) well</td><td>existing 1 (one) well to be utilised for monitoring well</td></tr>
<tr><td colspan="2">Well pad (NIL-1n)</td><td>-</td><td>- Pad to be constructed
- 7 (seven) wells to be drilled</td></tr>
<tr><td colspan="2">Well pad (NIL-2n)</td><td>-</td><td>- Pad to be constructed
- 8 (eight) wells to be drilled</td></tr>
<tr><td colspan="2">Well pad (WJP-1n)
(for production)</td><td>-</td><td>- Pad to be constructed
- 5 (five) wells to be drilled</td></tr>
<tr><td colspan="2">Well pad (WJR-1n)
(for reinjection)</td><td>-</td><td>- Pad to be constructed
- 3 (three) wells to be drilled</td></tr>
<tr><td colspan="2">Well pad (WJR-2n)
(for reinjection)</td><td>-</td><td>- Pad to be constructed
- 3 (three) wells to be drilled</td></tr>
<tr><td rowspan="6">Access roads</td><td>to Power plant</td><td>- Road
- Bridge</td><td>To be repaired
- Road
- Bridge</td></tr>
<tr><td>to NIL-1n</td><td>- Road</td><td>To be repaired</td></tr>
<tr><td>to NIL-2n</td><td>- Road</td><td>To be repaired</td></tr>
<tr><td>to WJP-1n</td><td>-</td><td>To be constructed
- Road
- Bridge</td></tr>
<tr><td>to WJR-1n</td><td>- Road</td><td>Road to be repaired
Bridge to be constructed</td></tr>
<tr><td>to WJR-2n</td><td>- Road</td><td>To be repaired</td></tr>
<tr><td colspan="2">Pipeline</td><td>-</td><td>To be constructed between well pad and power plant</td></tr>
</table>

Component	Existing	Plan
Transmission line	-	To be constructed - transmission tower - conductor - bays
Disposal area	-	2 (Two) area to be constructed
Lay down area	Land	1 (one) area to be constructed
Camp site	Land	1 (one) area to be constructed
Water well (operation use)	-	1 (one) well to be drilled

3 SUPPLEMENTARY ENVIRONMENTAL STUDIES

This Chapter provides additional information to that provided in the Project AMDAL 2009[16] and AMDAL Addendum 2013. It described the results of additional baseline data and impact analyses required to address the comments received from ADB for compliance with the ADB SPS 2009. Where JBIC/IFC standards apply, these are also discussed in the individual subject-specific sections. The following subject-areas are discussed:

- Updated baselines 2008-2013;
- Seismic risks and geohazards;
- Flood Risk Assessment;
- Steam Field Piping Network Review;
- Biodiversity assessment and Ecosystem Services Review;
- Water resource use and balance study;
- H_2S modelling; and
- Cumulative impacts.

3.1 UPDATED BASELINES 2008-2013

A number of baseline measurements were made for the purposes of the Indonesian regulatory approvals process. These were presented in the 2009 ANDAL with additional data presented for some parameters in the 2013 Addendum ANDAL, which is currently under review. For those parameters that were revisited in 2013, sample locations and data are represented in the following subsections with reference to the applicable Indonesian and IFC standards (refer Annex A for full list of the standards and comparison between Indonesian and IFC numerical standards).

Regarding Project compliance with applicable standards, at the time of writing this ESIA Addendum, there is a lack of definition on the levels of wastes, emissions and discharges that are predicted from the Project due to the current status and the need to finalise equipment selection.

As discussed in the main ESIA Addendum text, when host country regulations differ from the levels and measures presented in the IFC EHS Guidelines, there is an expectation that projects will achieve whichever is more stringent. If less stringent levels or measures than those provided in the EHS Guidelines are appropriate in view of specific project circumstances, a full and detailed justification must be provided for any proposed alternatives through the environmental and social risks and impacts identification and assessment

[16] 2009 ANDAL, UKL/UPL available for download at http://www.adb.org/projects/42916-014/documents

process. This justification must demonstrate that the choice for any alternate performance levels is consistent with the objectives of Performance Standard 3.

The applicable IFC and Indonesian regulatory standards for the Project are provided in Annex A. The most stringent standard is highlighted for ease of reference.

3.1.1 Air Quality

Sulfur oxides and nitrogen oxides emissions from geothermal power generation are significantly less than are associated with fossil fuel power generation. However, emissions from potential gases require study, particularly hydrogen sulfide (H_2S) (refer Section 3.7). Other gases potentially emitted from geothermal energy are ammonia (NH_3) and a number of particulates in steam.

Baseline study measurements of SOx, NOx, NH_3, H_2S, P and dust (TSP) were undertaken at location UK-1, UK-2, UK-3 and UK_4 on 27 and 28 March 2008. These 4 locations represent conditions characteristic of the study area. One point (UK-4) was at the nearest residential area i.e. Simataniari Village (Figure III-1). The results of the ambient air sampling are show in Table III-1 against the applicable standards.

Ambient air quality parameters in the Project area identified that the overall air quality parameters in the project location is lower than the quality standard found in PP No. 41 of 1999 Concerning Air Pollution Control and KEP-50/MENLH/11/1996 Concerning Odour Level Standards, when they were sampled in 2008. Recorded levels are also below the IFC EHS Guidelines (and WHO Air Quality Guidelines for H_2S).

Table III-1 Ambient Air Quality in the Study Area (2009)

Parameter	Units	Results				Standard	
		UK-1	UK-2	UK-3	UK-4	Indonesian	IFC
SOx	μg/Nm³	38.35	36.95	22.50	39.88	900	-
NOx	μg/Nm³	28.55	20.60	16.75	29.20	400	200
Pb	μg/Nm³	0.105	nd	nd	0.195	1	-
Dust	μg/Nm³	28.75	16.75	15.15	30.55	230	-
NH_3	ppm	0.605	0.570	0.515	0.810	*2.0	
H_2S	ppm	nd	nd	0.0095	nd	*0.02	0.1

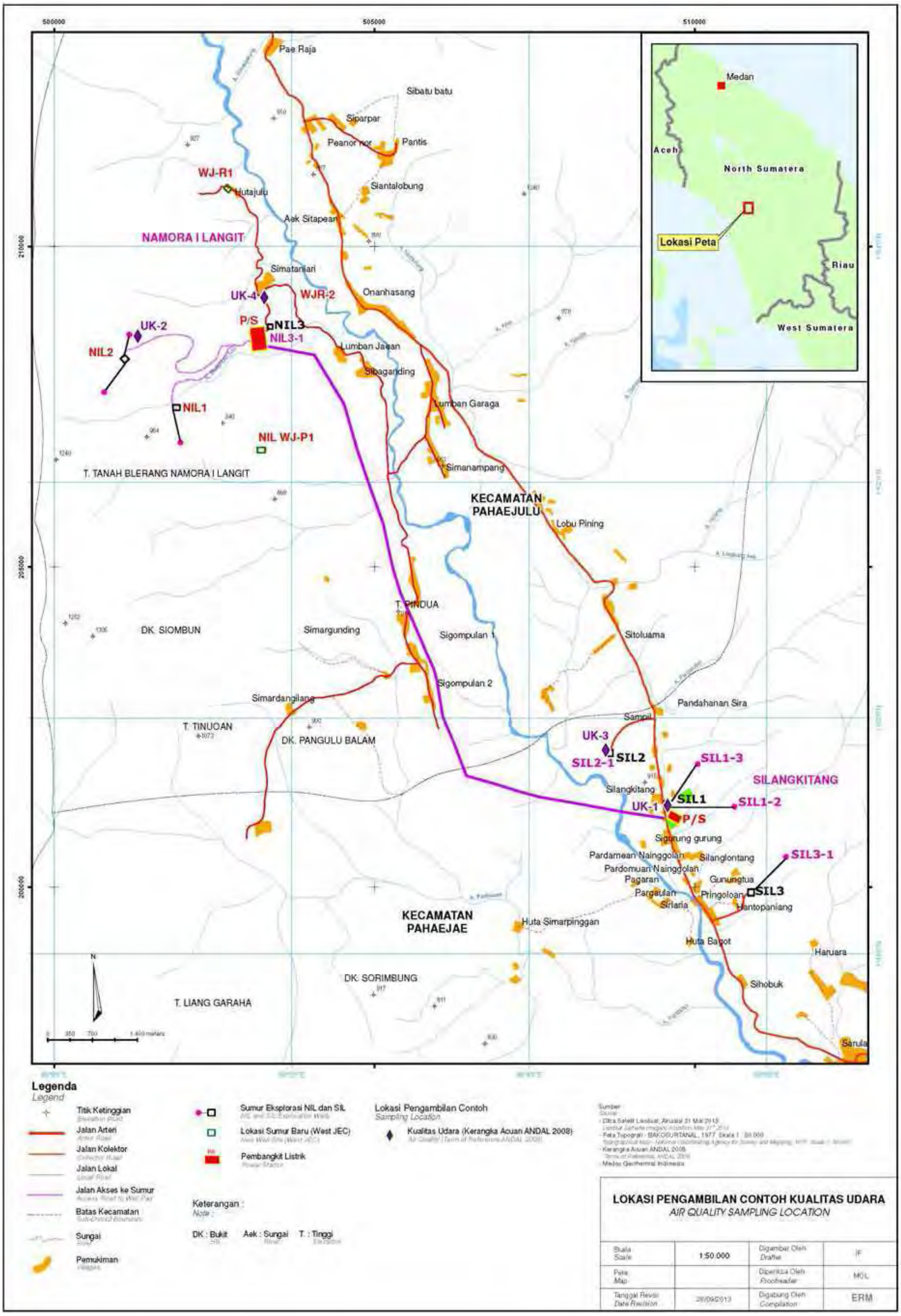
Source: Laboratory analysis results from the Center of Natural Resources and Environmental Research, University of North Sumatera (2008)

Note:
X-Y Coordinates of sample points:
UK-1: 509580 201280
UK-2: 501309 208604
UK-4: 503281 209211
UK-3: 508613 202144

Limit Values from Indonesian Regulations are as follows:
National Ambient Air Quality Standard according to Government Regulation No. 41 of 1999
* Odour Level Standard according to: KEP-50/MENLH/11/1996. 0.02 ppm H_2S equivalent to 28 μg/m3; WHO 150 μg/m³ (24 hour) equivalent to 0.1 ppm.
Results standardised to normal temperature and pressure (N)

nd: not detected

Figure III-1 Air Quality Sampling Locations 2008



When comparing the data on air quality parameters in 2009 measurements and the data on air quality parameter measurement in 2013 (Table III-2), there was a decline in NO_2 concentration at the project location, whereas SO_2 and H_2S parameters increased. It should be noted that he sampling locations for the 2013 measurements were changed to take account of revised locations for project facilities which required the Addendum ANDAL submission (Figure III-2). As with the 2008 sample results, none exceeded the limit values.

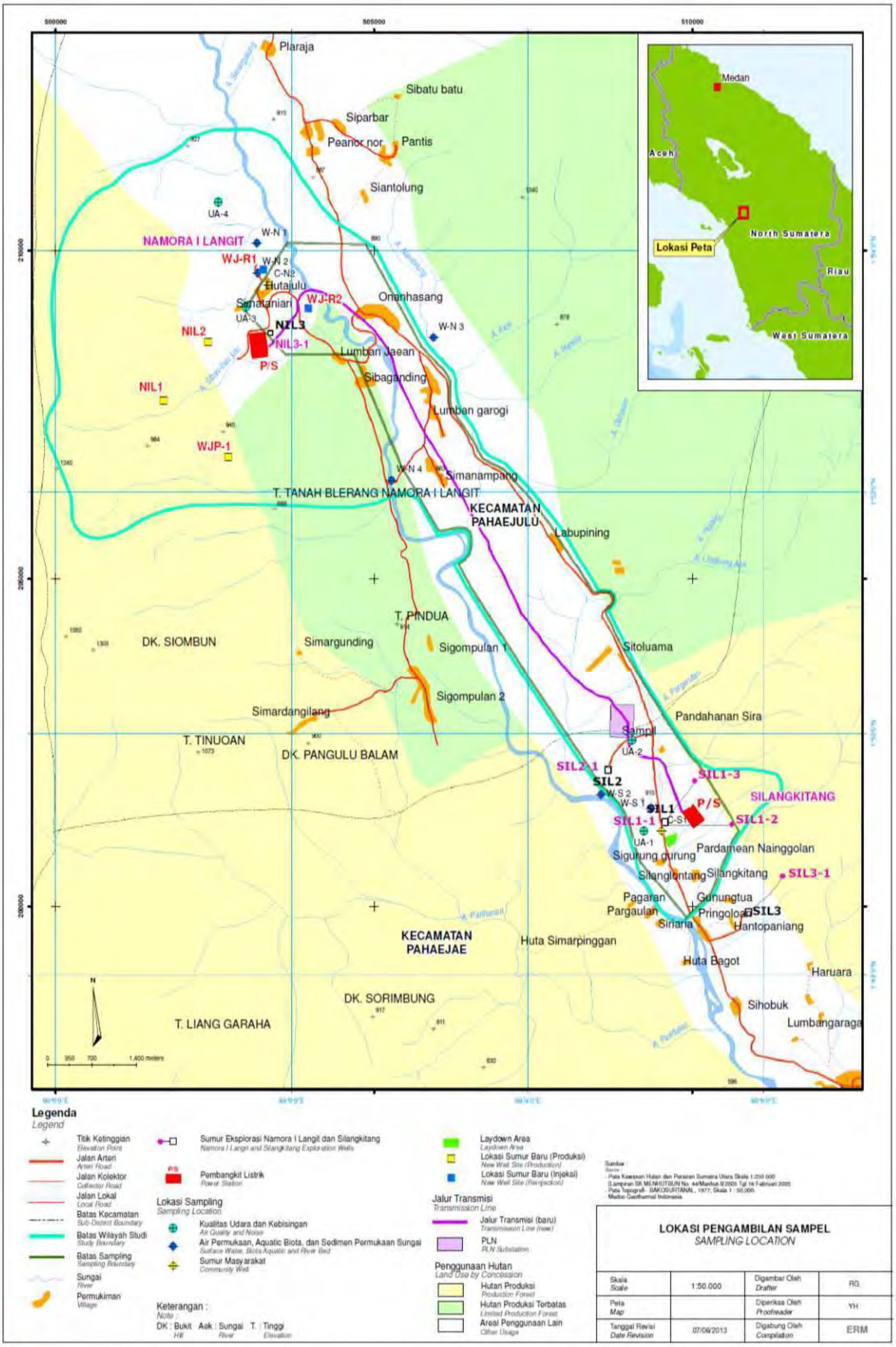
Table III-2 2013 Ambient Air Quality Analysis Results

Parameters	*Unit*	*Laboratory Test Results*				*Standard*	
		UA-1	*UA-2*	*UA-3*	*UA-4*	*Indonesian**)*	*IFC*
SO_2*)	µg/Nm³	1.40	1.22	1.03	1.05	900	-
NO_2*)	µg/Nm³	5.80	4.68	3.82	4.60	400	200
Dust (TSP)	µg/Nm³	53.42	60.14	68.34	69.7	230	-
CO	µg/Nm³	804	723	632	467	30,000	-
H_2S*)	µg/Nm³	0.28	0.28	0.82	0.57	28	150
O_3	µg/Nm³	3.74	3.81	3.83	5.01	50	-
Hydrocarbon (HC)	µg/Nm³	<0.2	<0.2	1.8	<0.2	160	-

Note :
*) SEAMEO Biotrop Laboratory : Accredited by KAN:LP-221-IDN
**) Quality Standard According to Government Regulation No.41/1999
#) Quality Standard according to KEPMENLH No. KEP-50/MENLH/11/1996 concerning Odour Level Standards. 0.02 ppm H_2S equivalent to 28 µg/m3; 150 µg/m3 (24 hour) equivalent to 0.1 ppm.
Results standardised to normal temperature and pressure (N)

UA-1 = Area A-S2 (N: 01° 49′ 11,7″ E: 099 ° 04′ 59,1″)
UA-2 = Area A-S1 (N: 01° 49′ 56,9″ E: 099 ° 04′ 53,1″)
UA-3 = Area A-N-1 (N: 01° 53′ 32,1″ E: 099 ° 01′ 36,9″)
UA-4 = Area A-N-2 (N: 01° 54′ 24,0″ E: 099 ° 01′ 22,7″)

Figure III-2 2013 Sampling Point Locations



3.1.2 *Noise*

Noise measurements were taken during the 2008 and 2013 surveys from the sample locations shown in Figures III-1 and III-2. Results from the points sampled in 2008 were below the applicable Indonesian and IFC standards. The 2013 noise measurement results as found in Table III-3, they indicate that the environmental setting for noise level in the project location for noise range value and average noise level value is under the Indonesian standard (KEP-48/MENLH/11/1996). According to the measurement results in locations UA-1, UA-2, UA-3, UA-4, the continuous noise values obtained from day-night ranged between 47.1 – 50.9 dB(A) or met the applicable Indonesian quality standard but showed exceedances with the night time (22:00-07:00) standard of IFC for residential areas of 45 dbA.

Table III-3 Noise Level Analysis Results

i) 2008

Parameter	Unit	*Result*					
		UK-1	*UK-2*	*UK-3*	*UK-4*	*Indonesian*	*IFC*
Range	dBA	40-42	34-36	32-34	42-44	55	45-55
Average	dBA	41	35	33	43	55	45-55

Note:
Laboratory analysis results from the Center of Natural Resources and Environmental Research, University of North Sumatera (2008)
Ministry of Environment Decree No. 48 Year 1996 regarding Noise Level. Residential standard

ii) 2013

Measurement time	*Unit*	*Results*				*Standard*	
		UA-1	*UA-2*	*UA-3*	*UA-4*	*Indonesian*	*IFC*
07.00 (06.00-09.00)	dBA	45.4	41.0	46.3	46.9	55	55
10.00 (09.00-11.00)	dBA	49.1	43.1	47.0	44.9	55	55
15.00 (14.00-17.00)	dBA	43.5	42.4	45.8	42.5	55	55
20.00 (17.00-22.00)	dBA	45.4	49.5	53.8	48.9	55	55
23.00 (22.00-24.00)	dBA	45.6	50.4	49.0	46.6	55	45
01.00 (24.00 – 03.00)	dBA	41.6	51.5	49.0	43.7	55	45
04.00 (03.00 – 06.00)	dBA	48.6	45.8	43.0	39.1	55	45
L noon	dBA	45.0	45.6	49.8	46.1	55	55
L night	dBA	46.2	49.8	47.5	43.7	55	45
L sm	dBA	48.1	50.9	50.9	47.1	55/24 hour	-

Note:
Ministry of Environment Decree No. 48 Year 1996 regarding Noise Level. Residential standard

3.1.3 *Surface Water Quality*

The IFC does not establish numerical standards for ambient surface water quality but states:

"Discharges of process wastewater, sanitary wastewater, wastewater from utility

operations or stormwater to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria."

Indonesian standards are established by Government Regulation (PP) #82/2001 on Water Quality Management and Water Pollution Control, which includes different classes according to use. Class I is not applicable to the Project as it relates to standards for drinking water (Class I). Classes II-IV apply as water is used for recreational, fresh water fish cultivation, livestock and irrigation.

3.1.3.1 2008 Water Sampling Results (2009, ANDAL)

Surface water samples were taken on 28 and 29 March 2008 at the following locations:

- KA-1. Batang Toru River before SIL;
- KA-2 Batang Toru River after SIL;
- KA-3 Batang Toru River before NIL; and
- KA-4 Batang Toru River after NIL.

The samples were analysed by Centre of Natural Resources and Environmental Researches, University of North Sumatera (PPSDAL USU) and in Intertek Laboratory at Jakarta (for dissolved metals). The results are provided in Tables III-4.

Generally, water quality in the study area is considered in good conditions as it meets the majority of established criteria specified in Government Regulation No. 82 of 2001, with the exceptions being dissolved oxygen, one location for COD, nitrite and phosphate levels.

Table III-4 Surface water quality in the study area, 2008

Parameter	*Unit*	*Results*				*Standard* Indonesia*
		KA-1	*KA-2*	*KA-3*	*KA-4*	
PHYSICAL						
Conductivity	Umhos/cm	286	296	205	190	-
Dissolved Solid	mg/L	36	40	30	34	50
Hardness	mg/L	87.5	82.5	89.5	81.0	-
Suspended Solid	mg/L	128	138	114	124	1000
Temperature	°C	29	29	27	27	3° change
Turbidity	NTU	3.27	3.38	2.63	2.86	-
CHEMICAL						
Ammonia (N-NH³)	mg/L	1.27	1.33	0.97	1.14	-
BOD	mg/L	2.06	2.27	1.85	1.91	3
Chloride	mg/L	10.22	25.84	8.81	10.99	-
COD	mg/L	22.56	25.44	19.88	20.67	25
Dissolved Oxygen	mg/L	5.55	5.53	5.92	5.65	4
Nitrate (N-NO3)	mg/L	4.14	4.20	3.52	3.89	10

Parameter	Unit	Results				Standard* Indonesia
		KA-1	KA-2	KA-3	KA-4	
Nitrite (N-NO2)	mg/L	0.078	0.082	0.075	0.078	0.06
pH		6.8	6.8	7.1	6.9	6 – 9
Phosphate	mg/L	0.60	0.64	0.43	0.45	0.2
Sulfate	mg/L	48.50	54.20	38.25	39.75	-
Sulfide	mg/L	nd	nd	nd	nd	0.002
Arsenic (As)	mg/L	0.0005	0.0007	<0.0005	<0.0005	1
Barium (Ba)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	-
Boron (B)	mg/L	0.1	0.1	< 0.1	< 0.1	1
Cadmium (Cd)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.01
Calcium (Ca)	mg/L	9.67	9.76	9.52	9.39	-
Chromium Hexavalent (Cr^{6+})	mg/L	< 0.002	0.002	0.003	< 0.002	0.05
Cobalt (Co)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	0.2
Copper (Cu)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	0.02
Iron (Fe)	mg/L	0.16	0.31	0.15	0.18	-
Lead (Pb)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.03
Magnesium (Mg)	mg/L	2.25	2.25	2.25	2.21	-
Manganese (Mn)	mg/L	0.02	0.04	0.02	0.03	-
Mercury (Hg)	mg/L	0.00025	0.00037	0.00008	0.00009	-
Nickel (Ni)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	-
Potassium (K)	mg/L	4.84	4.85	4.78	4.90	-
Selenium (Se)	mg/L	<0.0005	< .0005	< .0005	<0.0005	0.05
Sodium (Na)	mg/L	8.49	8.91	6.61	6.61	-
Zinc (Zn)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.05

Notes:
1 PPSDL USU laboratory analysis result; 2 Intertek laboratory analysis result
*) Standards based on Government Regulation No. 82 of 2001 concerning Management and Control of Water Quality Class II: Water used for infrastructure / water recreation facilities, freshwater fish farming, livestock, water for irrigating crops or other uses that require similar water quality

3.1.3.1.1 Physical parameters

Temperature

Water temperature of the Batang Toru River before SIL and after SIL was 29˚C, while of Batang Toru River before and after NIL was 27˚C. There were no significant difference between sampling locations and the temperature was considered as normal.

Total Suspended Solids (TSS)

Total suspended solids (TSS) concentrations ranged from 114 to 138 mg/L, which could be considered as high. The highest concentration was found at Batang Toru River after SIL whilst the lowest was at Batang Toru River before NIL. All measured TSS concentrations were below the maximum permitted level of 1000 mg/L according to Government Regulation No. 82 of 2001.

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) concentrations show the amount of colloid particles in the river. The measurements indicated that the TDS concentrations ranged from 30 to 40 mg/L. The highest TDS was found at Batang Toru River after SIL and the lowest was found at Batang Toru River before NIL. The TDS concentrations at all sampling locations were below the standard of 50 mg/L.

Turbidity

Turbidity levels in 4 locations in the study area ranged from 2.63 to 3.38 NTU. The highest level of turbidity was found at Batang Toru location after SIL while the lowest levels were at Batang Toru location before NIL. There is no turbidity standard for water Class II in Government Regulation no. 82 of 2001.

According to Lloyd (1985), increased turbidity levels up to 5 NTU in lakes may decrease primary productivity by 75% whilst in rivers by 3to 13% (AMDAL, 2009).

3.1.3.1.2 Chemical Parameters

Acidity (pH)

pH of surface water in the study area ranged from 6.8 to 7.1, which were within the standard for Class II Water as prescribed in Government Regulation No. 82 of 2001 i.e. 6 - 9.

Biochemical Oxygen Demand (BOD)

BOD is defined as the amount of oxygen needed by bacteria to modify organic matters aerobically. According to Boyd (1979), BOD in water is affected by temperature, plankton density, organic matter concentration and several other factors. Center and Hill (1979) suggested that rivers with low flow rate, 5 mg/L BOD represents low water quality but for rivers with high flow rate, 30 mg/L BOD does not represent significant disturbance (AMDAL, 2009).

BOD in the study area ranged between 1.85 – 2.27 mg/L, which were below the standard of 3 mg/L.

Chemical Oxygen Demand (COD)

COD describes total oxygen required to oxidize organic materials completely. Thus, COD increases as organic material concentration increases. Laboratory analysis showed that the highest COD i.e. 25.44 mg/L was at Batang Toru River after SIL which was slightly above the standard of Class II water quality of 25 mg/L. At other locations, COD were in the range of 19.88 to 22.56 mg/L.

Dissolved Oxygen (DO)

Dissolved Oxygen is essential for respiration and is one of the main components for aquatic biota metabolism. DO in the study area ranged from 5.53 to 5.92 mg/L where the highest DO was measured at Batang Toru River before NIL and the lowest was at Batang Toru River after SIL. This indicated good condition and compliance with the standard of > 4 mg/L specified in Government Regulation No. 82 of 2001.

Phosphate

Phosphate is an important nutrient for aquatic biota growth. Total phosphate contents in the study area ranged from 0.43 to 0.64 mg/L. The highest phosphate content was measured at Batang Toru River after SIL and the lowest was at Batang Toru River before NIL. Phosphate contents in the study area were higher than the standard of 0.2 mg/L prescribed in Government Regulation No. 82 of 2001.

Nitrate and nitrite

Nitrogen is the main component of protein for growth of organism. In water, nitrogen exists in the forms of gas (N2), nitrite (NO2-N), nitrate (NO3-N) and ammonia (NH3-N). These compounds, within nature, are found as dissolved, suspended, and precipitated salts.

Nitrate concentrations in the study area ranged from 3.52 to 4.2 mg/L which were below the standard of 10 mg/L. Nitrite concentrations ranged from 0.075 to 0.082 mg/L, which were slightly higher than the standard of 0.06 mg/L.

Ammonia contents (NH3-N)

Ammonia is the main product of protein destruction in anaerobic conditions, which is toxic for water organisms. High level of ammonia may be generated by household activities, farming, and industry. Ammonia contents in the study area ranged from 0.97 to 1.33 mg/L. The highest was measured at Batang Toru River after SIL whilst the lowest was at Batang Toru River before NIL. There is no ammonia standard specified in Government Regulation No. 82 of 2001 for Class II water quality.

3.1.3.1.3 Dissolved metals

Dissolved metals were all below the Indonesian standards. Barium (Ba), cadmium (Cd), cobalt (Co), copper (Cu), lead (Pb), nickel (Ni), selenium (Se) and zinc (Zn) contents in the study area were below the detection limits indicating very low concentrations. Iron (Fe) concentrations ranged from 0.15 to 0.31 mg/L. The highest concentration was detected at Batang Toru River after SIL whilst the lowest was at Batang Toru River before NIL. Government Regulation No. 82/2001 does not specify a standard for iron.

Arsenic (As) concentrations in Batang Toru River before and after SIL were very small i.e. 0.0005 and 0.0007 mg/L respectively and under the detection limit in Batang Toru River before and after NIL. Boron (B) concentrations at Batang Toru River before and after SIL were detected 0.1 mg/L whereas at Batang Toru River before and after the NIL the concentrations were under the detection limit (< 0.1).

Very low hexavalent chrome (Cr^{6+}) contents were measured at Batang Toru River after SIL and before NIL i.e. 0.002 and 0.003 mg/L respectively. At Batang Toru River before SIL and after NIL, the concentrations were not detected by the analytical instrument or were under the detection limit.

The lowest content of Calcium (Ca) was at Batang Toru River after NIL (9.39 mg/L) and the highest was found at Batang Toru River after SIL (9.76 mg/L).

Magnesium (Mg) concentration of 2.25 mg/L was measured in almost all study areas except at Batang Toru River after NIL where a concentration of 2.21 mg/L was measured.

Manganese (Mn) concentration was found to be very small in all study areas as follow 0.02 mg/L at Batang Toru River before SIL and NIL, 0.04 mg/L at Batang Toru River after SIL, and 0.03 mg/L at Batang Toru River after NIL.

Mercury (Hg) contents were also very small. The highest concentration was at Batang Toru River after SIL i.e. only 0.00037 mg/L whereas the lowest concentration was measured at Batang Toru River before NIL (0.00008 mg/L).

Batang Toru River after NIL recorded the highest potassium (K) concentration i.e. 4.9 mg/L. Whereas Batang Toru River before the NIL recorded the lowest concentration i.e. 4.78 mg/L.

Sodium (Na) concentrations at Batang Toru River before and after SIL respectively were 8.49 and 8.91 mg/L. This was higher than in Batang Toru River before and after NIL i.e. 6.61 mg/L.

3.1.3.1.4 Soluble Salts, Hardness and Electrical Conductivity

Soluble salts in water bodies are chloride and sulfate salts. The higher the salt concentrations, the higher the hardness and the conductivity in the water bodies. Government Regulation No. 82 of 2001 does not specify the quality standards for soluble salts contents, hardness, and electrical conductivity for Class II water quality.

Laboratory analysis showed high level of soluble salts in the study area. The lowest level of chloride salt (Cl) was 8.81 mg/L (in Batang Toru River before the NIL) and the highest was 25.84 mg/L (in Batang Toru River after SIL). The lowest content of sulfate salt was 38.25 mg/L (in Batang Toru River before NIL) while the highest was 54.20 mg/L (in Batang Toru River after SIL).

Therefore, the hardness and conductivity in the study area were considered high. The highest hardness was at Batang Toru River before NIL i.e. 89.5 mg/L and the lowest was at Batang Toru River after NIL (81.0 mg/L). The lowest conductivity was found at Batang Toru River after NIL whilst the highest was found at Batang Toru River after SIL.

3.1.3.2 *Surface Water Quality Analysis, 2013 Update*

The sampling of river/surface water quality was conducted in April 2013 in six locations, which were Pametaran River (W-N1), Aek Alimun River (W-N2), Aek Sibao Bao River (W-N3), Batang Toru River (W-N4), Batang Toru Estuary (W-S1) and Kapesong River (W-S2) (Figure III-2).

The samples were then analysed and results were compared to the quality standard requirements according to the Government Regulation as presented in Table III-5.

Table III-5 Results of Surface Water Quality Analysis in 2013

Parameter	Unit	Result						Standard** Indonesia
		W-N1	W-N2	W-N3	W-N4	W-S1	W-S2	
PHYSICAL								
Dissolved Solid	mg/L	82	80	68	74	96	66	50
Suspended Solid	mg/L	30	15	10	26	8	20	1000
Temperature	°C	25	24,6	27,9	25,6	23,4	24,2	3° change
CHEMICAL								
Ammonia (NH_3-N)*)	mg/L	0.05	0.222	0.271	0.029	0.024	0.069	-
BOD_5	mg/L	2.5	2.3	3.1	4.2	4.1	2.6	3
Chloride (Cl)*)	mg/L	8.62	11.4	11.67	11.4	11.4	8.89	0.03
Chlorine (Cl_2)	mg/L	0.02	0.01	0.03	0.02	0.02	0.02	-
COD*)	mg/L	12.83	<4.99	<4.99	<4.99	<4.99	6.29	25
Cyanide (CN)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02
Detergent	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.2
Dissolved Oxygen	mg/L	5.4	6.2	5.2	6.5	6.4	5.8	4
Fluoride (F)*)	mg/L	0.076	0.126	0.276	0.335	0.3	0.33	1.5
Nitrate (NO_3-N)	mg/L	0.054	0.729	0.06	0.082	0.049	0.105	10
Nitrite (NO_2-N)*)	mg/L	0.006	<0.004	<0.004	0.02	<0.004	0.004	0.06
Oil and Fat	mg/L	<1	<1	<1	<1	<1	<1	1
pH	-	7.58	7.4	2.86	7.34	8.11	7.64	6-9
Phenol	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.001
Phosphate*)	mg/L	0.09	0.052	0.047	0.081	0.043	0.083	0.2
Sulfate (SO_4)*)	mg/L	7.12	12.01	299.71	10.06	7.75	11.12	-
Sulfide (H_2S)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
DISSOLVED METALS								
Arsenic (As)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	1
Cobalt (Co)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.2
Barium (Ba)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Boron (B)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	1
Selenium (Se)	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.05
Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
Hexavalent Chromium (Cr^{6+})*)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Copper (Cu)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.02
Iron (Fe)*)	mg/L	0.639	3.281	5.242	0.62	0.105	0.653	-

Parameter	Unit	Result						Standard** Indonesia
		W-N1	W-N2	W-N3	W-N4	W-S1	W-S2	
Lead (Pb)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.03
Manganese (Mn)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-
Mercury (Hg)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.002
Zinc (Zn)	mg/L	<0.005	<0.005	0.024	<0.005	<0.005	<0.005	0.05
MICROBIOLOGY								
Total Coliform	MPN/ 100mL	1600	140	14	220	350	430	5000
Fecal Coli		540	110	0	130	39	430	1000

Notes:
Environmental Water and Productivity Laboratory, IPB (2013)
*) Accredited Parameters
**) Quality Standard according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control
W-N1 N : 01°54'03,6" E : 099°01'42,3" (Pametaran River)
W-N2 N : 01°53'49,0" E : 099°01'42,7" (Aek Alimun River)
W-N3 N : 01°53'16,8" E : 099°03'12,1" (Aek Siabao Bao River)
W-N4 N : 01°52'06,1" E : 099°02'50,8" (Batang Toru River)
W-S1 N : 01°49'23,1" E : 099°05'02,7" (Batang Toru Estuary)
W-S2 N : 01°49'30,0" E : 099°04'37,2" (Kapesong River)

3.1.3.2.1 *Physical parameters*

Temperature

The results of temperature measurement in the field (*in situ*) indicate that the values ranged between 23.4 °C and 27.9 °C. The temperature of Batang Toru 1 river water showed the highest values compared to the temperature of other rivers. This range value indicates that existing conditions do not show any actual differences in temperature and are still within the normal limits for life.

Total Suspended Solids (TSS)

The concentration of Total Suspended Solids (TSS) for water taken from locations W-N1, W-N2, W-N3, W-N4, W-S1 and W-S2 indicated a range between 8 – 30 mg/L which met the quality standard according to the enforced regulation.

Total Dissolved Solids (TDS)

The concentration of Total Dissolved Solids (TDS) was classified as low, ranging between 66 – 96 mg/L. The highest value of Total Dissolved Solids (TDS) was found in Batang Toru Estuary (W-S1) with 96 mg/L and the lowest in Kapesong River (66 mg/L). TDS parameter values for all samples taken in the field met the quality standard (1000 mg/L) set in Government Regulation No. 82 of 2001, which is 1000 mg/L.

3.1.3.2.2 *Chemical Parameters*

Acidity (pH)

The results for the river water pH analysis for water taken from locations W-N1, W-N2, W-N3, W-N4, W-S1 and W-S2 ranged between 2.86 – 8.11. The lowest pH value (pH = 2.86) was indicated for the water sample taken from Aek Siabao Bao River (W-N3). The lowest pH value for sample W-N3 may possibly be caused by the oxidation of sulfur (S) into sulfate indicated by the high content of sulfate at 299.71 mg/L. The pH value for the samples taken from W-N1, W-N2, W-N4, W-S1 and W-S2 ranged between 7,4 – 8,11 or met the quality standard required by Government Regulation No 82 of 2001 (pH = 6 – 9).

Biochemical Oxygen Demand (BOD)

The BOD5 value of the river water taken from the project area (W-N1, W-N2, and W-S2) ranged between 2.3 – 2.6 mg/L or met the quality standard (3 mg/L). Other BOD values ranged between 3.1 – 4.1 mg/L for river water samples taken from W-N3, W-N4 and W-S1.

Chemical Oxygen Demand (COD)

From the results for the laboratory analysis, it was identified that the total dissolved oxygen is the total O_2 dissolved in water. In general, good quality water has a minimum of 5 mI\L dissolved oxygen. COD values for all river water samples taken from locations W-N1, W-N2, W-N3, W-N4, W-S1 and W-S2 ranged between < 4.99 and 12.83 or met the quality standard requirements.

Phosphate

The total phosphate content in the river water taken from locations in the project site ranged between 0.047 – 0.090 mg/L. The highest phosphate content was in location W-N1 (Pametaran River), whereas the lowest was found in location Aek Siabo-Bao River (W-N3). The phosphate level in the project area is still under the quality standard set in Government Regulation No 82 of 2001, which is 0.2 mg/l.

Nitrate

Nitrate content in the river water samples taken from locations W-N1, W-N2, W-N3, W-N4, W-S1 and W-S2 indicate a nitrate value range of 0.049 – 0.729 mg/L and nitrite ranging between <0.004 – 0.020 mg/L. The range of nitrate and nitrite content is still under the quality standard of class II water set in Government Regulation No 82 of 2001, which is 10 mg/L (Nitrate) and 0,06 mg/L (Nitrite) respectively.

Ammonia contents (NH3-N)

From the analysis results, ammonia content in the river water samples taken from locations W-N1, W-N2, W-N3, W-N4, W-S1 and W-S2 ranged between 0.024 – 0.271 mg/L. The highest ammonia content was found in location W-N2 and the lowest in W-S1. Government Regulation No. 82 of 2001 does not set any quality standards for Ammonia content for the use of class II water.

3.1.3.2.3 *Dissolved Metals*

The results for the analysis on dissolved metals (As, Ba, B, Co, Se, Cd, Cr, Cu, Fe, Pb, Mbn, Hg, and Zn) for all surface water samples taken from Pametaran River, Aek Alimun River, Aek Siabo Bao River, Batang Toru River, Batang Toru Estuary and Kapesong River meet the required quality standards set in Government Regulation Number 82 of 2001 for the classification of Class II water quality standards. Several dissolved metals such as (As, Co, Ba, B, Se, Cd, Cr6+, Cu, Pb, Mn, and Hg) indicate a concentration of anion below the detection limit of analysis tools used by the Testing Laboratory each at <0.0002 mg/L (Arsenic), <0.005 mg/L (Cobalt), 0.001 mg/L (Barium), <0.002 (Selenium), <0.001 mg/L (Cadmium), <0.001 mg/L Chromium) <0.005 mg/L (copper, lead and manganese) and <0.0002 mg/L (Mercury).

The concentration of dissolved metals indicates a value ranging between 0.620 to 5.242 mg/L. The lowest concentration value of dissolved metals was only obtained from the results of the analysis on river water samples taken from Batang Toru River. The high level of dissolved metal concentration in sampling points may be due to quite high natural metal content in the ground. Next, these metals naturally react with organic compounds (humic acid), which react with metal, forming dissolved metals.

3.1.3.2.4 *Hardness and Electric Conductivity*

From the laboratory analysis results, it was identified that the content of dissolved salts in the water sample taken from Pametaran River, Aek Alimun River, Siabo Bao River, Batang Toru River, Batang Toru Estuary, and Kapesong River was quite high. The lowest content of chloride salts (C1) was 8.62 (in Pametaran River) and the highest was 11.67 mg/L (in Aek Siabo Bao River). The lowest content of sulfate salts was 7.12 mg/L (in Pametaran River) and the highest was 299.71 mg/L (in Aek Siabao Bao River). Government Regulation No. 82 of 2001 does not set any quality standards for these dissolved salts, for the classification of class II water.

In general, the quality of water from Pametaran River, Aek Alimun River, Batang Toru River and Batang Toru Estuary as well as Kapesong River is quite good, except for water from Aek Siabao Bao River because the level of acidity is extremely low, almost reaching a pH value of 3,0.

3.1.4 *Ground Water Quality*

3.1.4.1 *2008 Groundwater Sampling Results (2009, ANDAL)*

Ground water analysis results from 2008 showed that all measured parameters were in compliance with the standards stipulated in Minister of Health Regulation No.416/PER/MENKES/IX/1990 regarding Clean Water Quality Criteria. **Table III-6** presents the analytical results.

Table III-6 Groundwater quality in the study area, 2008

Parameter	*Unit*	*Result*		*Indonesian Standard *)*
		AT-1	*AT-2*	
PHYSICAL[1]				
Taste and smell	-			No Taste or smell
Total Dissolved Solid (TDS)	mg/L	142	94	1500
Total Suspended Solid (TSS)	mg/L	18	14	-
Turbidity	NTU	1.32	1.31	25
Temperature	^oC	27	29	Dev 3
Color	TCU	6.2	5.8	50
CHEMICAL[1]				
pH	-	6.7	6.9	6. 5 – 9.0
Cyanide (CN)	mg/L	nd	nd	01
Sulfide	mg/L	nd	nd	-
Nitrate (N-NO3)	mg/L	2.07	2.36	10
Nitrite (N-NO2)	mg/L	0.81	0.52	1.0
Sulfate	mg/L	88.25	70.10	400
Chloride	mg/L	16.88	12.78	600
Total Hardness	mg/L	137	81	500
Ammonia (N-NH^3)	mg/L	0.24	0.25	-
Phosphate	mg/L	nd	nd	-
ORGANIC CHEMICAL				
Organic Matter s KMnO4	mg/L	3.10	2.12	10
MICROBIOLOGY				
Total Coliform	Jlh/100 ml	50	42	1000
Fecal Coliform	Jlh/100 ml	12	10	1000
DISSOLVE METALS[2]				
Arsenic (As)	mg/L	<0.0005	<0.0005	0.05
Barium (Ba)	mg/L	< 0.01	< 0.01	-
Boron (B)	mg/L	< 0.01	0.01	-
Cadmium (Cd)	mg/L	< 0.005	< 0.0005	0.005
Calcium (Ca)	mg/L	38.2	15.3	-
Chromium Hexavalent	mg/L	< 0.002	< 0.002	0.05
Cobalt (Co)	mg/L	< 0.02	< 0.02	-
Copper (Cu)	mg/L	< 0.01	< 0.01	-
Iron (Fe)	mg/L	< 0.05	< 0.05	1
Lead (Pb)	mg/L	< 0.001	< 0.001	0.05
Magnesium (Mg)	mg/L	2.76	3.45	-
Manganese (Mn)	mg/L	0.04	< 0.01	0.5
Mercury (Hg)	mg/L	0.00007	0.00024	0.001
Nickel (Ni)	mg/L	< 0.02	< 0.02	-
Potassium (K)	mg/L	4.7	8.35	-
Selenium (Se)	mg/L	<0.0005	<0.0005	0,01
Sodium (Na)	mg/L	7.27	14.1	-
Zinc (Zn)	mg/L	0.031	0.005	15

Notes:
Description:
1 PPSDL USU laboratory analysis result; 2 Intertek laboratory analysis result
*) Standards based on Minister of Health Regulation No. 416/PER/MENKES/IX/1990 regarding Clean Water Quality Criteria

3.1.4.2 *Groundwater Quality Analysis, 2013 Update*

Ground water (well water) analysis results in 2013 indicate that all parameters measured still meet the water quality standards according to Indonesian Minister of Health Regulation No. 416/PER/MENKES/IX/1990 concerning Clean Water Quality Requirements. From the analysis results (Table III-7), no parameters were found to have concentrations exceeding the quality standard. From the analysis results of physics and chemistry properties in the water, it can be concluded that the water meets the requirements as raw drinking water.

Table III-7 Results for Ground Water Quality Analysis in the Study Location of Sarulla PLTP and Geothermal Development Activities, 2013

Parameter	Unit	Results		Indonesian Standard**)
		C-N1	C-S2	
PHYSICS				
Temperature	^{o}C	26.4	26.8	Dev. $\pm$ 3^{o}C
Color	Pt, Co	1	1	15
Turbidity*)	NTU	0.45	0.13	25
Dissolved Solids (TDS) *)	mg/L	138	38	1500
Odor	-	tb	tb	tb
Taste	-	tb	tb	tb
CHEMISTRY				
Mercury (Hg)	mg/L	<0.0002	<0.0002	0.001
Arsenic (As)	mg/L	<0.0002	<0.0002	0.05
Iron (Fe) *)	mg/L	0.114	0.162	1.0
Fluoride (F) *)	mg/L	0.081	0.136	1.5
Cadmium (Cd)	mg/L	<0.001	<0.001	0.005
Total Hardness*)	mgCaCO3/L	25.63	34.43	500
Chloride (Cl) *)	mg/L	8.89	11.95	600
Hexavalent Chromium (Cr^{6+})*)	mg/L	<0.001	<0.001	0.05
Manganese (Mn)	mg/L	<0.005	<0.005	0.5
Nitrate (NO_3-N)	mg/L	0.010	1.229	10
Nitrite (NO_2-N) *)	mg/L	<0.004	<0.004	1.0
pH *)	-	6.83	5.80	6.5 - 9.0
Selenium (Se)	mg/L	<0.002	<0.002	0.01
Zinc (Zn)	mg/L	<0.005	<0.005	15
Cyanide (CN)	mg/L	<0.001	<0.001	0.1
Sulfate (SO_4) *)	mg/L	7.04	9.80	400
Lead (Pb)	mg/L	<0.005	<0.005	0.05
Detergent	mg/L	<0.005	<0.005	0.5
Permanganate Value (TOM)	$mgKMnO_4/L$	6.95	6.00	10
Sulfide (H_2S)	mg/L	<0.001	<0.001	-
Copper (Cu)	mg/L	<0.005	<0.005	-

Parameter	Unit	Results		Indonesian Standard**)
		C-N1	C-S2	
MICRO BIOLOGY				
Total Coliform	MPN/100ml	38	25	0
Fecal Coli	MPN/100ml	17	6	0

Source: Environmental Waters and Productivity Laboratory, IPB (2013)

Description :
*) Accredited Parameters
**) Clean Water Quality Standard Based on Indonesian Minister of Health Regulation No. 416 /MENKES/PER/IX/1990 (Appendix II)
Tb, odorless/tasteless
C-S1 = N : 01°49'11,8" E : 099°05'08,1" Well of Citizen Mr. M,Sitompul (Ds,Sigurung gurung Kec,Pahajae)
C-S2 = N : 01°53'42,9" E : 099°01'48,3" Water Source (Ds,Simataniari)

3.2 *Seismic Risks And Geohazards*

Geothermal energy resources predominate in seismically active areas. The development of geothermal resources therefore needs to assess the risks of geohazards, as well as the potential for geothermal development to result in induced seismicity risks.

The issues to be examined include the type and history of volcanism, definition of characteristics of areas of active fault movements, earthquake activity including microseismicity, slope stability and possibility of flash floods. Hazards involved with exploitation of low and high temperature geothermal systems where hosted in areas of restricted recharge drawdown of reservoir fluid may cause ground subsidence and damage to buildings and roads[17].

3.2.1 *Seismic Hazard desk Study*

SOL commissioned Mott-MacDonald to conduct a Seismic Hazard Desk Study for the Sarulla Geothermal and Power Plant Development Project. The full report is provided as Annex B, and summarised below.

Pahae Julu and Pahae Jae Districts have been determined as areas of geothermal natural resources. Sarulla power plant construction is located in those districts in Tapanuli Utara, North Sumatra, Indonesia. The Sarulla Geothermal Power Plant will have an installed capacity of 330MW which will be constructed in three phases of 110MW each. The plant will be fuelled by two steam production and injection reservoirs, Silangkitang (SIL) and Namora I Langit (NIL).

The seismic hazard desk study identifies the tectonic setting, seismicity and

[17] Saemundsson, K (2008). Geohazards In Geothermal Exploitation. Presented at Short Course III on Exploration for Geothermal Resources, organized by UNU-GTP and KenGen. Lake Naivasha, Kenya, October 24 - November 17, 2008.

geology of Indonesia and Sarulla project and highlights potential seismic hazards which need to be remediated through risk management. The seismic assessment was performed for the project area and the seismic soil class was determined according to the factual ground investigation data from SOL. The seismic design criteria were established and recommendations are made for the use of appropriate seismic code.

3.2.1.1 *Study Findings*

The study key findings and recommendations are as follows:

- The area is located in a complex tectonic regime. It is likely to be affected by near source earthquakes. This implies that seismic design should be incorporated in all the structures built within the power plant site. This risk can be mitigated by the EPC Contractor following the latest international seismic design codes and the updated version of the local seismic code.
- The area is located within the vicinity of the Sumatra fault system (SFS) which forms a zone up to 10km wide along the length of the study area. One active strand of the fault, the Tor Shibohi Fault (TSF) extends along the entire distance and in exposed in the northern limit of the contract area.
- Comprehensive fault identification activities have been performed in previous investigations in the site to understand the potential of future rupture of the faults. This has mitigated the risks to a certain extent and additional fault trenching activity is recommended for the next stage.
- An extensive fracture zone has been identified in the plant locations. The effect of this fracture zone on the performance of the substructure infrastructure needs to be assessed carefully. This may involve additional analyses of facilities located in this zone.
- The U.S. Geological Survey (USGS) global shear-wave velocity maps web application (USGS, 2010) has been used for obtaining a first-order estimate of the average shear-wave velocity values over the top 30meters of ground (Vs,30). According to the USGS web tool, within the North Sumatra regionVs,30 values range from 360-490m/sec and raise up to >760m/sec at some areas. This implies that correct seismic spectra as proposed in the report should be used for design.
- The Indonesian Seismic Design Code follows site classification based on the following generic site classes: Based on the Indonesian Seismic Design Code and using the Vs,30 values estimated from the soil around Sarulla region would be classified as "Hard soil".
- The geotechnical information in the site was critically reviewed. The weighted average of the SPT values indicates that the seismic site class should be classified as 'Medium soil' based on Indonesian seismic code. Site class C should be used for Eurocode site classification.

- A historical and instrumental earthquake catalogue was developed for the area around the Sarulla region. In the last ten years there has been an average of about 45 events between magnitude 4-6 and approximately very few events greater than 6 to 8 in the last ten years in the vicinity of the site area. The biggest event is a 6.8 event magnitude with its epicentre located at 200km SW from the proposed plant.
- A review of regional seismic hazard maps show that the peak ground acceleration (PGA) for the rock site in the Sarulla region vary between 0.33g to 0.25g.
- The Indonesian seismic code provides values for PGA which can be considered unconservative compared to other specific studies. The map for PGA at bedrock was developed by averaging values from four seismic hazard maps developed by four different research groups in Indonesia. Thus it is recommended that the revised maps should be used for design (Asrurifak, M. et al. 2010). The PGA in the region is likely to be in the range of 0.5 to 0.6g.
- Liquefaction risk cannot be eliminated completely. Liquefaction assessment from geological criteria cannot eliminate the risk completely as the expected PGA is high. This should be mitigated by further analysis by the EPC contractor.
- There is pronounced fault activity in the area since imminent vertical and horizontal movements are studied and Tor Sibohi fault is described as active by Hickman et al. (2004). Slip partitioning and subduction of Indian Ocean lithosphere produce high levels of seismicity in the Barisan Mountains, in the forearc basin and along the forearc ridge. The potential for extremely destructive earthquakes was most recently demonstrated by the Magnitude 9 event near Simeule in December 2004 and a future earthquake hazard is considered as possible for the plant area.
- The current method suggested by the designers relies on using a pseudo static coefficient for the slope stability analysis. This method is extremely conservative for high values of acceleration.
- The risk due to lateral spreading is considered minimal as wide scale liquefaction is not envisaged in the current site.

3.2.1.2 *Conclusions and Recommendations*

The Mott MacDonald Seismic Hazard Desk Study concludes that the project can proceed as designed currently provided additional fault trenching activities are carried out before detailed design phase and facilities in the vicinity of the rupture zone are designed to accommodate the possible predicted movement from the rupture of the fault if the fault is deemed active.

The key recommendations are summarised as:

- According to previous studies faults GNZ1 to GNZ4 cross the SIL plant plan while fault GNZ5 and the fracture zones are very close to the plant location. Potentially faults GNZ1 to GNZ4 are not active but fault GNZ5 and fracture zone are potentially active. It is noted that Fault No. GNZ5 is outside the footprint of the current SIL plant area. It is recommended that further field trenches need to be performed in order to test those faults activity prior to construction. Further field investigations should be accompanied by related studies during detailed design. This may include
  - Interpretation of large-scale stereo aerial photographs and/or LiDAR imagery of the site and surrounding areas;
  - Tectonic geologic and geomorphic field mapping of the area surrounding the site (± 3 km radius);
  - Radiometric dating, where possible, of soil and organic materials collected from natural or manmade exposures with clear association to the faults mapped or inferred within the SIL site; and
  - Reference studies of the nearby Sumatran fault where its location and rate of Holocene activity are well constrained.
- The use of International Building code (IBC) is recommended in the design for those cases where the local seismic code is unconservative. However it is acknowledged that the Uniform Building Code (UBC) is still used in several countries outside the US and can be used for elements of the seismic design.
- Monitoring of micro tremoring activities should be continued in order to associate the relation with induced seismicity and injection of fluids in the wells.
- It is reminded that detailed liquefaction assessment should be carried out for the area by using the laboratory test Plasticity Index results and internationally accepted liquefaction assessment techniques (like Idriss and Boulanger, 2008) in order to estimate the possible liquefaction hazard by the EPC contractor. If liquefaction is deemed to be a problem then the EPC contractor should consider proper mitigation measures for the plant design.
- It is reminded that the seismic slope stability assessments should be performed by the EPC contractor during detailed plant design. Slope stability remedial work can be carried out by EPC contractor after the contract is awarded, prior to construction. It is recommended that such analysis should possibly be based on displacement based methods.

3.3 *FLOOD RISK ASSESSMENT*

Sarulla Operations Ltd has commissioned Mott MacDonald to undertake a flood risk assessment for the Sarulla Geothermal Project. This assessment includes consideration of the potential impacts of climate change over the project design lifespan. The full report is provided in Annex C.

3.3.1 *Background*

The Sarulla Geothermal plant is located south of Lake Toba in North Sumatra Province, Indonesia. The project area consists of two power plant sites, Namora I Langitand (NIL) and Silangkitang (SIL), which are approximately 15 km apart. Each site has its own power plant and a network of above-ground pipes that connect the extraction wellpads with the power plant and the reinjection wellpads.

Flooding is a regular phenomenon in low-lying areas of Indonesia and causes significant damage to property, agriculture and infrastructure. Flooding can pose a critical risk to infrastructure, in particular to the flood vulnerable equipment in the power plant and the wellheads and separator pads. Flood risks in Indonesia are likely to increase in the future due to the impacts of climate change.

3.3.2 *Study Scope*

The scope of this assessment includes:

- Estimating the magnitude of flow in a severe flood event for return periods of 1 in 100 and 1 in 500 years;
- Assessing the risk these flood flows could pose to the project site in relation to the site topography and levels; and
- Considering the effects of climate change on extreme rainfall occurrence (from tropical storms/typhoons) and the subsequent implications on flood risk to the site.

It is noted that the scope specifically referred to the consideration of typhoons. Typhoons are mature tropical cyclones that develop in the northwestern part of the Pacific Ocean. The equivalent term for those that develop in the South Indian Ocean is 'severe tropical cyclone'. It is also noted that tropical cyclones rarely form within 5° of the equator. Given the location of the site within this equatorial zone it has been assumed for the purposes of this assessment that this aspect of the scope should relate to the incidence of storm events that result in extreme rainfall, and not specifically tropical cyclones. Consideration of extreme rainfall events both currently and as a result of climate change is an integral part of the analysis adopted in this assessment.

3.3.3 *Approach*

A field visit to visually assess the potential flood risk to the sites was completed on 5 September 2013. An assessment of the site topography in relation to local watercourses was undertaken to inform this assessment. Meetings were held with local meteorological and hydrological authorities to identify and collect rainfall and flow data.

Based on annual maximum rainfall data for local rainfall stations flood flow estimates were derived for key locations using the US SCS Approach for the 1 in 100 year and 1 in 500 year return periods. Climate change projections were considered and incorporated into the assessment to derive equivalent return period flows for the 2060's. Hydraulic calculations were undertaken to derive flood levels for these key locations.

As part of this flood risk assessment the following activities were undertaken in order to address the Project objectives:

- Preliminary site visit to assess the locations of watercourses and site topography in relation to the Nil and SIL sites;
- GIS assessment of catchment areas and river characteristics in the vicinity of the sites using supplied topographic information;
- Analysis of extreme rainfall data (annual maximum daily rainfall) and flow data to derive predicted flood flows;
- Estimation of flood magnitudes using the US SCS method;
- Extract basic channel and floodplain dimensions from available topographic information upstream and downstream of the site, and estimate roughness coefficients, so that basic hydraulic calculations can be made to estimate flood levels from the calculated flood flows;
- Sensitivity studies to review the potential impact of uncertainties in the data;
- Consideration of the regional effects of climate change on typhoon occurrence and rainfall in this part of Sumatra and impact on the flood flows and flood levels estimated as part of the study.

The level of detail of the assessment has been limited to the project timeframe of one month and the availability of climatological and topographic information.

In light of this the following uncertainties need to be emphasised:

- Flood risk has not been considered in relation to the road network, bridges or other infrastructure associated with the sites;
- Land use change, in particular deforestation in the catchments, may increase flood flows;
- Annual maximum rainfall data that has been supplied by Badan

Meteorologi, Klimatologi, dan Geofisika (Meteorological Department) in Medan is a partial record for all of the identified stations and cannot be verified;

- Available rainfall records for stations within or close to the catchment are very limited (about 7 years); this means that estimates of 100-year and 500-year rainfalls are subject to substantial uncertainty.
- There is not enough reliable flow gauged data to be able to undertake any statistical analysis of recorded flood flows on the Batang Toru. The assessment is therefore based on the SCS approach with adjustment of the Curve Number to provide the closest match to the Flood Design Manual estimates for Java and Sumatra;
- The topographic survey is limited in its extent and has not considered the river channels in detail. Hydraulic calculations have been undertaken where adequate topography of the channel and floodplain exists;
- The hydraulic calculations are basic steady state assessments and no detailed modelling has been undertaken;
- The climate change analysis is based on a summary of observed data and the results of climate model experiments, rather than a summary of the existing literature on projected climate change. Any decision-making based on this analysis should be used with reference to other studies which make use of alternative techniques and information; and
- Modelled data for the future are not predictions of climate, but model simulations of future climate under a range of hypothetical emissions scenarios. Further research or analysis should take account of the accuracies and uncertainties associated with these projections.

Whilst these uncertainties need to be recognised in this case, the extent to which the sites are raised from these watercourses suggests that the uncertainties involved in the analysis would have little impact on the overall conclusions.

3.3.4 Findings

The report findings are provided in detail in Annex C. The report provides an assessment of the Project, with details presented on:

- Characterisation of the area with an assessment of the topography of the area in relation to local watercourses, summarising the flood risks;
- Estimation of flood flow and flood risks of the catchment areas at the project locations;
- Assessment of the projected impact of climate change on the future precipitation patterns, as determining flood risks for the Project locations; and
- Flood inundation probability assessment, using hydraulic calculations to establish estimated flood levels based on the flood hydrology of the area

The findings of the study are that there is a low risk of flooding to the Project sites of NIL and SIL. The majority of the tributaries that pass close to the NIL and SIL sites also pose very low flood risk. However, there are three tributaries which pose some risk to three sites:

- NIL Power Plant - Tributary draining North West catchment: Whilst the site is raised by at least 2.8m from the calculated flood levels it will be important to ensure there is adequate stream diversion as the site will block the NIL North West catchment valley and this has the potential to cause flooding.
- SIL 1 Wellpad might be at risk from overland flow from the overtopping of small drainage ditch to the NE but this risk is low and volumes of water would be limited. Depending on the chosen level and location of the additional SIL 1 Wellpad there may be some limited flood risk from overland flow.
- Appropriate site drainage would mitigate this risk as the site is located in a sloping area.
- SIL Power Plant site is at risk of flooding from the small tributary which drains the catchment covering the east side of the site. Adequate stream diversion will be required as the SIL Power plant site will block this small catchment valley.

Overall it is considered that with appropriate stream diversion and on site drainage this low level of flood risk can be mitigated. It should be emphasised that these risks are from small catchments that would contribute runoff to the site locations. This should be considered as part of the site drainage design.

3.3.5 *Conclusions*

The main conclusions of this assessment is that there is a very low risk of flooding from the Batang Toru River to the Namora I Langitand (NIL) and Silangkitang (SIL) wellpad and power plant sites, with all calculated flood levels significantly below design levels both currently and in the future as a result of climate change.

The majority of the tributaries that pass close to the NIL and SIL sites also pose very low flood risk both currently and in the future as a result of climate change.

However, there are three small watercourses which pose some limited risk to the NIL Power Plant, SIL Power Plant and SIL 1 Wellpad. For the NIL and SIL Power Plants it will be necessary to undertake stream diversions to mitigate this risk and in the case of the SIL 1 Wellpad there is some limited risk from overland flow. In this case appropriate site drainage would mitigate this risk.

These drainage requirements should be considered as part of the site drainage design.

Various uncertainties exist in this type of assessment but the extent to which the sites are raised from these watercourses suggests that the uncertainties involved in the analysis would have little impact on the overall conclusions.

3.4 *STEAM FIELD PIPING NETWORK REVIEW*

Mott MacDonald was commissioned to conduct a high level review of the Project steam field piping. The results of the review are provided in the following subsections. The full report is provided in Annex D.

3.4.1 *Project Overview*

The Sarulla geothermal project consists of two power plant site locations. There is the Silangkitang development (SIL), preliminary assessed to be a 110 MW development. The second steam field and power plant is roughly 15 km (by road) to the north, called Namora-I-Langit (NIL). The field is assessed to be capable of producing 220 MW. It is the intention to develop the Project in three (3) phases. The first phase is for a 110 MW capacity from SIL, followed by NIL-1 phase at 110MW and NIL-2 phase at 110MW. Planned commercial operation dates of each phases are 30, 40 and 46 months reckoned from the Project's successful achievement of financial closing. Conceptual studies, field modelling and initial engineering/design, including those for the steam field separation and pipe gathering systems have been prepared. This includes heat mass balance, process flow diagram, conceptual layout of pipe gathering and in NIL, a relatively detailed pipe routing have been prepared.

3.4.2 *Process Overview*

The production wells produce hot, pressurized fluid called a two-phase fluid because it contains both liquid and steam. The two-phase fluid pipelines from well head to separation plant have been kept short, and the separation stations are located close to the wellheads. This is good practice, as two-phase fluids can form slugs of liquid (as opposed to the flow regime where the liquid flows along the pipe walls and steam on the inside) which results in undesirable water hammer.

Within the separation stations, the two-phase fluid is separated into steam and brine. One separation station generally handles the fluid of several production wells (see process flow diagram (PFD) attached in Annex D).

The brine and steam are piped (within the same corridor) to the power plant, where the thermal energy is converted to electrical energy. The resulting condensate and (colder) brine waste streams are combined piped to the reinjection wells. Reinjection has two principal advantages.

- It avoids disposing of the geothermal liquid to surface water (geothermal liquid may contain bromide, mercury, boron, silicate etc., which at high concentrations are not permitted to dispose to surface waters as it would affect flora and fauna detrimentally).

- Re-injecting the fluid into the field helps in maintaining the field production levels for longer, i.e., helps to maintain field pressure and liquid levels.

Within the power plant the geothermal energy is converted into electrical energy. The steam expands in the (back pressure) steam turbine and exits the back pressure turbine at just above atmospheric pressure. It than enters the bottoming Ormat Energy Converters (OEC) where more electricity is generated. Steam leaves the bottoming OEC's as condensate. The brine converts part of its thermal energy into electricity in a different set of OECs. A simplified process flow diagram is included in Annex D.

The plant is equipped with a turbine bypass system that allows the steam (after pressure reduction) to divert directly to the bottoming OECs.

The plant is also equipped with a vent system for the steam (both high pressure and low pressure) in case for some reason the steam cannot be used within the power plant, but the production wells have not been shut down yet. The steam is vented to the atmosphere, and mufflers are used to reduce noise levels during venting (but venting is still a very noise event, only done during emergencies).

The colder brine exits the OEC units at a temperature of around 120 °C (down from around 185 °C). At those temperatures scaling is not expected to be a major issue, as minerals remain in solution.

Condensate and used brined are combined together and piped to the designated re- injection wells.

3.4.3 *Steam field piping review*

The NIL power plant geothermal fluid supply is shown to come from 3 production wellpads namely NIL-1n, NIL-2n and WJP-1n. Used geothermal fluid from the NIL power plant is to be re-injected via two (2) reinjection wellpads namely WJR-1n and WJR-2. The geothermal fluid from each of the wellpad will be transported to the power plant via pipelines. The estimated quantities of geothermal fluid that will be flowing in each section of the pipeline connecting the wellpads to the power plant are shown in the table below. The values indicated in the table below reflect the changes in the wellpad configurations adapted by the Project. The heat mass balance diagram and the process flow diagram still need to be updated to reflect those changes. It is noted however that the design pressure and temperature are still the same, the only variation relates to the flowrates. This may have an impact on the pipe sizes, but the pipeline corridors and position of pipe supports and expansion loops is not expected to change significantly.

The estimated quantities of the geothermal fluid flowing through such pipelines are:

From	To	Steam		Brine		Mixed Brine and Condensate		Pipe Length (m)
		Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	
NIL-1n	PLTP	551	11.5 - 10.3	2,250	14-22			~2,000
NIL-2n	PLTP	550	11.5 - 10.3	2,445	14-22			~1,000
WJP-1n	PLTP	410	11.5 - 10.3	1773	14-22			~3,200
PLTP	WJR-1n					3,940	20	~2,000
PLTP	WJR-2					3,940	20	~2,000

PLTP = Power Plant

In the SIL power plant geothermal fluid supply is from the SIL-1 wellpad. Used geothermal fluid from the SIL power plant is re-injected into two (2) reinjection wellpads namely SIL-1 and SIL-2. The SIL power plant has the same concept as the NIL power plant. Similarly, the SIL steamfield piping will adhere to the same principles as NIL, i.e. pipe corridors to follow the natural contours of the land as much as possible to reduce the number of vertical changes of direction and keep visual impact minimal.

The estimated quantities of the geothermal fluid flowing through the pipelines are as follows:

From	To	Steam		Brine		Mixed Brine and Condensate		Pipe Length (m)
		Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	
SIL-1	PLTP	579	19.9-19.5	2,315	19			
PLTP	SIL-1					1,146	~16	600
PLTP	SIL-2					1,720	~16	1,800

PLTP = Power Plant

A review of the available information regarding the steam and brine pipes from separation plants NIL-1 and NIL-2 to the power plant showed that the pipelines follow the contour of the field. The steam and brine pipes follow the same corridor. The pipes are arranged at grade, which makes them easily accessible for inspection and maintenance purposes. There are fixed anchors on average between 70 and 100 m apart, with an expansion loop in between. Where there is no expansion loop as such, the pipes have a change in direction which serves as an expansion loops. Sliding supports are provided to accommodate the pipe movement. This design is acceptable.

When shutting down the pipelines, the temperature will drop over time, and especially for the brine pipes, dissolved solids will come out of solution and tend to deposit within the pipe as scale. This reduces the pipeline capacity and increases the pressure drop along the pipeline, both undesirable effects. The pipe gradient is generally above 1%, which means that draining of the pipes should not be a problem. There are also few changes of grade, which makes the operational procedures for draining the pipelines much easier.

The material used for the piping is in accordance with ASTM A53 or ASTM A106, with a corrosion allowance of 3mm. Given the temperature and pressure range of the steam and brine in question, the proposed materials are acceptable.

Although the steam field piping design is in accordance with typical steam field piping standards and practices, things can go wrong. Geothermal fields, by their very nature, are often located within seismically active areas. Even though the design standards take this seismic activity into account, there is always a risk that the actual seismic activity is more severe than anticipated (point in case the earthquake in Christchurch, NZ, where a previously inactive fault moved).

Catastrophic pipe ruptures of field lines will result in a very visible steam cloud, which is likely to be noticed by the steam field operators. This is self-explanatory for steam lines. If a two-phase flow or brine line ruptures, the pressure loss results in the brine flashing into steam and boiling water. The steam cloud will alert field staff that something is wrong. At the same time, the resulting loss of pressure of the incoming fluid into the power plant alerts the plant operators that something is wrong in the field, and they will contact the steam field staff to check it out. The steam field operators will isolate the affected pipeline, close the separation plant and/or the associated wells, if needed.

Small leakages will occur during the operational phase of the project, such as leaks on pipe fittings, flanges, gaskets, condensate traps etc. Those leakages are generally small, and will be picked up by the steam field operators during their regular inspections of the field installations.

A third possible area of leaks could be the result of the corrosive action of the liquids on the pipe material. The composition of fluids from each well differs, and is likely to change over time as well. Some well samples have a pH as low as 2.3, but the average pH is (based on available fluid characteristics for the wells) is expected to be only slightly acidic for NIL and neutral to slightly alkaline for SIL. The pipe material has been selected taking into account the geothermal nature of the fluids, and a 3mm corrosion allowance has been included in the pipe specifications. But it is possible that the geothermal fluid composition changes over time.

Steamfield piping will be subject to regular operations and maintenance (O&M) inspections, during which the pipes will be assessed for corrosion damage (expected to occur say every three to five years, depending on actual experience during operations). If this corrosion damage is not picked up during O&M inspections, and severe pipeline corrosion actually results in pipe leakage, this initial leakage is likely to be small. However, the evidence of pipeline leakage is expected to be picked up by field operators.

Geothermal fluids are also prone to scaling, where dissolved solids deposit within pipes, especially on cooling. Scaling is generally easier to detect, as the pressure drop along the pipeline increases and the mass flow decreases. Those parameters are monitored over time, and trend analysis will indicate if scaling is affecting the field pipes or not. Appropriate steps will have to be taken to remedy this, either cleaning of the pipes (mechanically and/or chemically), or replacement. These activities are not expected to result in any major fluid spills.

Both issues (scaling and corrosion) require that pipelines will need to be inspected on a regular basis to assess their condition. This is recognized and part of normal steamfield operating practice.

Any steam that escapes will be dispersed into the atmosphere. The steam contains a small amount of non-condensable gases such as CO_2, H_2S, N_2, NH_3 and CH4. Concentrations of those gases is sufficiently low (total about 2.7% for SIL and 6.5% for NIL, of which CO2 is the main constituent at 95% and 97% respectively) as not considered to be harmful to health in case of a steam pipe rupture.

In case of a brine pipeline rupture, the brine will follow the contours and eventually drains itself into the surface water within the area or seeps into the groundwater. The fields are within a narrow valley, drained by the Batung Toru River. This river is a substantial river, with an estimated flowrate of around 100 m^3/s. The total brine flow from NIL is around the 1.5 m^3/s, and hence from a thermal dispersion point of view the impact on the main river is likely to be acceptable. However, the effect on much smaller contributory rivers is likely to be more extensive, depending on where the actual rupture occurred.

3.4.4 Conclusions

Although the final pipe size dimensions have not been finalized, the approach to the design and standards used are acceptable. The pipeline corridors identified for both the NIL and SIL fields for the brine and steam pipe lines from the separation plants to the power plants follow the local contours, has relatively few changes in the vertical direction, which results in simplifying the venting and drainage equipment needed. It also reduces the visual impact of the field piping.

The well heads have motor controlled main valves, so can be closed remotely if something unexpected does go wrong.

Unexpected failure of either steam or brine pipe lines will result in clearly visible steam plumes, which will be picked up by field staff, and appropriate measures will be taken to limit the impact of those failures. At the same time, control room staff will notice the reduction in plant output due to pipe failure, and will also contact steam field staff to check what is happening. It is our expectation that any unexpected failure of steam field piping will be discovered and any discharges to the surface be controlled well within 24 hrs.

3.5 BIODIVERSITY ASSESSMENT AND ECOSYSTEM SERVICES REVIEW

The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, is an international legally binding treaty to which Indonesia is a signatory. Biodiversity often underpins ecosystem services. The ADB SPS and IFC PS6 address how project proponents can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle. Both ADB and IFC define biodiversity according to CDB 1992, as:

"Biological Diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems."[18]

IFC PS6 defines ecosystem services as:

The benefits that people, including businesses, derive from ecosystems. Ecosystem services are organized into four types:

(i) Provisioning services, which are the products people obtain from ecosystems;

(ii) Regulating services, which are the benefits people obtain from the regulation of ecosystem processes;

(iii) Cultural services, which are the nonmaterial benefits people obtain from ecosystems; and

(iv) Supporting services, which are the natural processes that maintain the other services.

ADB SPS describes the requirements for Biodiversity Conservation and Sustainable Natural Resource Management (including ecosystem services) in Appendix 1 Safeguard Requirements 1: Environment, Section D.8. Further details are provided in ADB Environment Safeguards, A Good Practice Sourcebook; Chapter V.

[18] http://www.cbd.int/convention/text/default.shtml

IFC introduces biodiversity and ecosystem services in PS1. PS4 addresses a project's direct impacts on priority ecosystem services as having a potential to result in adverse health and safety risks and impacts to Affected Communities; thereafter referring to PS6 where biodiversity and ecosystem services are addressed in depth.

Both ADB SPS and IFC PS6 contain specific requirements for the identification of habitat types that relate to their likely conservation value and support to valuable biodiversity, including endemic or threatened species. In addition, ADB and IFC outline the objective of no net loss of biodiversity in natural and modified habitats and a net gain of biodiversity in Critical Habitats, where feasible. There is also a need to consider use of offsets to compensate for residual impacts to biodiversity as a result of the Project, but only after the mitigation hierarchy has been applied to the fullest extent practicable.

The proposed Project is located in Sumatra, an area of Indonesia with recognised abundant biodiversity and where many local communities rely on ecosystem services, such as forest products, soils for agriculture and natural fresh water supply from rivers or groundwater. There are also existing pressures from illegal logging and legal forest conversion for industries such as palm oil plantations. A review of the 2009 ANDAL for the Project identified gaps with these specific requirements in the information provided about biodiversity, habitats and ecosystem services; in particular, information on the possible presence of species of concern, critical habitats, an assessment of potential impacts from proposed Project activities specific to biodiversity and ecosystem services, and detailed mitigation (where required).

SOL commissioned ERM to conduct a Biodiversity Assessment and Ecosystem Services Review (ESR). The full reports describing approach, methodology and findings are presented in Annexes E and F. The following subsections summarise the main findings.

3.5.1 Biodiversity Assessment

The Sarulla Geothermal Field and Power Plant of 330W Capacity Project (the Project) incorporates geothermal fields at Namora I Langit (NIL) and Silangkitang (SIL). Each location will include a power station (two at NIL), production and reinjection wells, connecting pipeline and aerial transmission line to the Perusahaan Kistrik Negara (PLN) power substation. The Project will require upgrades to existing transport corridors, new access roads and development of accommodation and waste disposal facilities.

In 2009 Sarulla Operation Ltd (SOL) prepared an Environmental Impact Statement (ANDAL) for the Project. A detailed Project description and background to the Project is found in the ANDAL and updated in Chapter 2 of this Report.

In 2012 the ANDAL was reviewed by the Asia Development Bank (ADB) in the context of corporate safeguard policy. Specific to biodiversity, the ADB review identified two issues for clarification:

- Identification of measures to avoid, minimise or mitigate potentially adverse impacts and risks to biodiversity; and
- Consideration of protected species under IUCN including hairy nosed otter or berang berang (*Lutra sumatrana*), black-handed/agile gibbon or ungko (*Hylobates agilis*), and Malayan pangolin or trenggiling (*Manis javanica*). Underground bees should also be considered in the vicinity of WJP-1n and NIL-1.

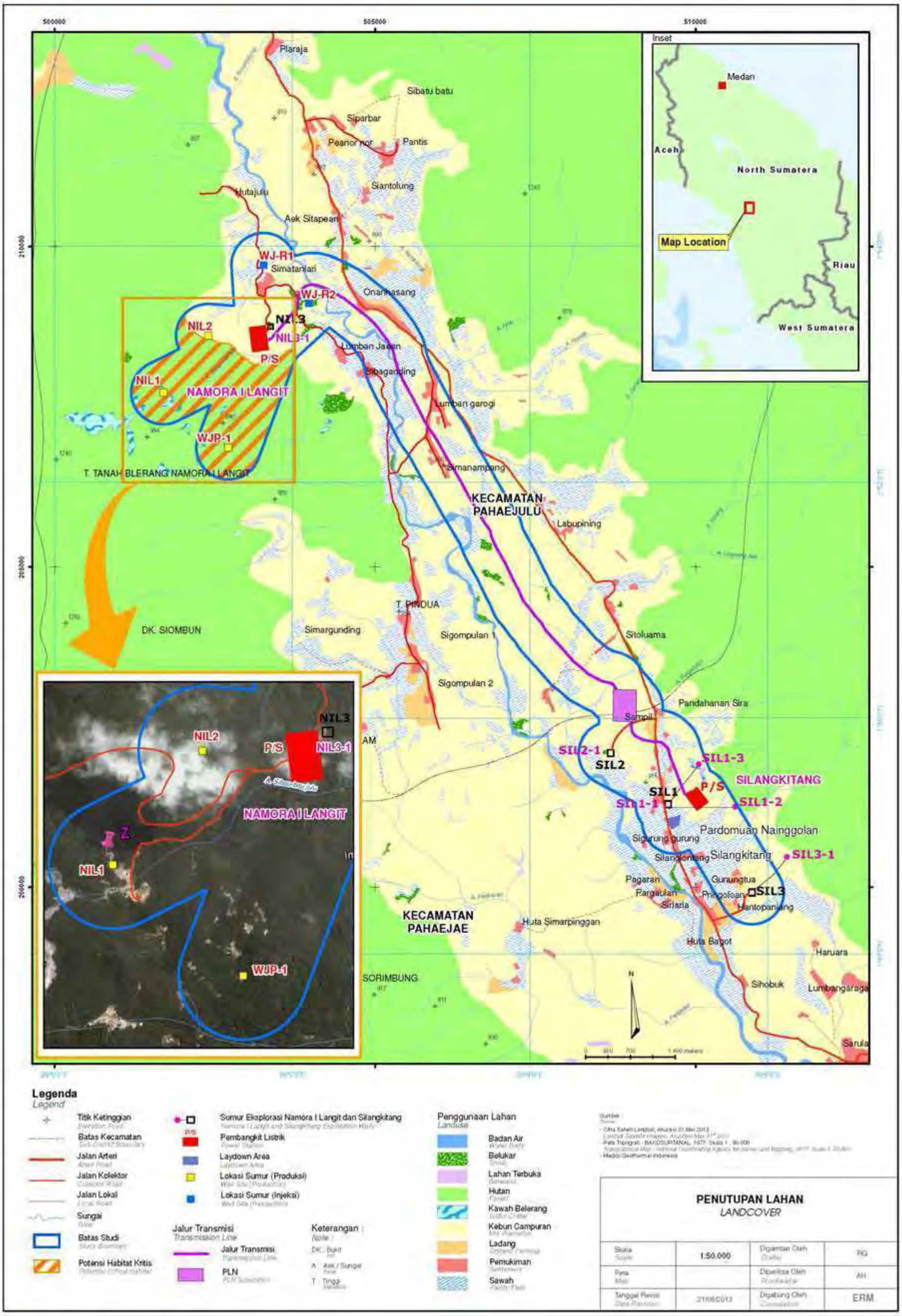
Following reviews from the ADB, SOL proceeded with further investigation of the potential impacts to biodiversity values associated with the Project. An Addendum ESIA is currently being prepared for the Project. This biodiversity impact assessment report will provide supporting information specific to the ADB and International Finance Corporation (IFC) biodiversity related standards. A biodiversity survey was undertaken in April 2013, and an additional site visit in September 2013, to obtain some detail of on-ground biodiversity conditions at NIL, WJP1 and SIL fields, the information gathered has been summarised to inform this impact assessment specific to IFC and ADB requirements.

3.5.1.1 *Purpose of the Report*

The purpose of the biodiversity assessment is to identify the potential impacts to biodiversity in relation to the requirements of the IFC Performance Standard 6 and relevant ADB environmental safeguard policies.

The biodiversity impact assessment considers the potential direct and indirect impacts of the Project infrastructure. As such, for the purposes of this assessment the Project footprint is defined as the area of land to be disturbed for the infrastructure installation. The Project area is defined as the area within a 500 metre buffer of the Project footprint (Figure III-3).

Figure III-3 Project Area Overview



3.5.1.2 *Findings*

Development of geothermal energy is a priority of the Government of Indonesia, in efforts to seek alternative sources of energy. The development of Sarulla geothermal field and the construction of the Sarulla power plant in Pahae Julu and Pahae Jae districts, North Tapanuli Regency, commenced in 1993 and investigations and negotiations have progressed to the current status whereby SOL completed an ANDAL (2009) and are currently preparing an Addendum to the ANDAL.

The Project comprises two geothermal fields (Namora I Langit (NIL) field and Silangkitang (SIL) field), each consisting of a power station (two at NIL), production and reinjection wells, and connecting pipeline as well as a transmission line to the Perusahaan Listrik Negara (PLN) power substation. The transmission line will be suspended by a series of transmission towers. In addition, the Project will involve upgrade to existing transport corridors and development of new routes as well as development of accommodation and waste disposal facilities. The Project is located between the East and West Batang Toru Forest, located in the valley of Sarulla in North Tapanuli District. The Batang Toru River meanders north/south through the forest blocks with modified forest, agricultural and settlement areas lining the watercourse.

As part of an Asian Development Bank (ADB) review of the Project ANDAL, information gaps relating to impacts to biodiversity was identified, in particular impacts to IUCN listed species in the context of International Finance Corporation (IFC) Performance Standard 6 (PS6). This report uses available information (from desktop and preliminary field surveys) to describe the biodiversity values in accordance with the requirements of IFC Performance Standard 6 and ADB Environmental Safeguard Policy. Primarily this involves the identification and assessment of habitats that may be directly and/or indirectly impacted by the Project infrastructure.

The majority (approximately 97%) of the Project footprint is located within modified habitat (mixed plantation landuse and paddy field) with direct and indirect impacts to natural habitat mainly associated with footprints of the NIL production well sites and connector pipeline. The Project footprint is relatively small for a project of this nature, at approximately 86 hectares (ha), with only approximately 2.7 ha within natural habitats.

A preliminary field survey was undertaken at NIL and SIL in April 2013 to identify dominant habitat types within the Project area. An additional field inspection was undertaken in September 2013 to further investigate threatened species habitat condition and suitability in areas identified as natural habitat as a result of the initial survey. The additional field inspection identified that the majority of the Project footprint is within modified habitats, with the only exception being WJP-1 and associated access and infrastructure. The outcome from the assessment of habitat suitability and condition indicated that the majority of habitats within the Project footprint where secondary or marginal habitats.

Results from these preliminary field surveys, in combination with information obtained from desktop sources, were used to inform a biodiversity impact assessment. Opportunistic records of fauna species present were recorded during the surveys and a number of vegetation plots measured. In addition, geospatial mapping was undertaken to map modified and natural habitats that may be impacted by the project and a literature review provided additional species and community information to understand the local biodiversity values.

Although the majority of the Project area contains modified habitats, some small areas of natural habitats were identified to provide potential habitat to a variety of flora and fauna species listed under the IUCN Red List of Threatened Species. In many cases, species information is limited and the confirmation of presence of microhabitat features that contribute to the survival of the species (for example nest locations or breeding areas) and/or locations of populations within the Project area is not available. Therefore, the precautionary principle has been applied and it has been assumed that 'potential critical habitat' may occur in the Project area for the purposes of undertaking an impact assessment. The likelihood of 'actual critical habitat' occurring in the Project footprint is low. However, due to the lack of information at this stage of assessment and in the absence of more detailed field survey data and information from consultation with recognised candidate species experts, there remains uncertainty in making a final determination. This can be addressed by implementing a range of actions that have been identified by this study (refer below).

An impact assessment was undertaken for seven species. The species included the Sumatran tiger (*Panthera tigris sumatrae*), Sumatran orangutan (*Pongo abelii*), agile gibbon (*Hylobates agilis*), Malayan pangolin (*Manis javanica*), mitred leaf monkey (*Presbytis melalophos*), siamang (*Symphalangus syndactylus*) and Asian tapir (*Tapirus indicus*). Following an assessment against Tier 1 and Tier 2 criteria (according to the IFC PS6 Guidance Note 6) 'potential critical habitat' was considered for only six of these species.

The significance of the potential impacts to the seven IUCN Red List endangered and critically endangered species was considered very low. According to the Biodiversity Decision Framework (IFC, ADB Sourcebook 2012), the Project will not lead to a reduction in population size, will not impact on ecosystem function and will not compromise the persistence of a representative host community for each of the threatened species.

Despite a key finding of this assessment that there is no significant impact to any of the CR or EN IUCN listed species that may occur in the Project area, and due to the uncertainty associated with the determination of critical habitat (as described above), there are three key actions that will be implemented so that the Project avoids, minimises and offsets impacts associated with Project development and determines the extent of critical habitats in the Project area. These actions are:

- The implementation of a targeted field survey for IUCN listed species identified as likely to occur in the Project area. The more detailed investigations will also allow for 'potential' critical habitat areas (as determined by this assessment) to be confirmed (or not) as 'actual' critical habitat.
- Development of a Biodiversity Action Plan (BAP) based on the species specific habitat and population information for IUCN listed species obtained from the targeted field survey that outlines specific mitigation and compensatory measures.

  SOL commit to conducting the targeted survey and development of the BAP prior to disturbance activities associated with the potential critical habitat.
- The development of a Biodiversity Offset Management Plan. Given the anticipated small area to be offset (2.7 ha of natural habitat), a land-based offset (i.e. creation of an equivalent or greater area of new habitat) is not considered the most appropriate mechanism for achieving a conservation benefit for the greater Batang Toru Forest region. Indirect offsets, such as research, education and enhancement of existing habitat, and investment in improved management of adjacent areas are considered to provide greater conservation benefits to the target species than a small land based direct offset.

  Overall the BOMP will document the offset design, intended conservation outcomes, and identify the implementation process. Due to the reliance on completion of the BAP, engagement with relevant stakeholders and the determination of appropriate offsetting mechanisms, the BOMP is not likely to be completed until mid-2014.

These actions are interrelated, with the outcomes of each required to be considered in the development of the other. Further detail on the objectives, timing, responsibilities and key outputs of these actions are provided in the Biodiversity Impact Assessment Report.

3.5.1.2.1 Targeted Field Survey – IUCN listed Species and Habitats

A targeted field survey is planned which will target the listed IUCN species identified as likely to occur in the Project area. The targeted field survey will aim to determine the suitability of habitat throughout the Project area for candidate species; confirm the presence or absence of endangered and critically endangered species identified as potentially occurring in the Project area; and assess the value of the habitat for endangered and critically endangered species known to occur in the Project area. Primarily, the more detailed investigations will allow for 'potential' critical habitat areas (as determined by this assessment) to be confirmed (or not) as 'actual' critical habitat.

3.5.1.2.2 *Biodiversity Action Plan*

Based on the findings of the targeted survey, a Biodiversity Action Plan (BAP) will be developed to document a strategy for refining the mitigation and management approach to conservation of biodiversity values in the Project area. The Biodiversity Action Plan will outline any opportunities identified through the targeted surveys to implement additional avoidance measures (for example, realignment of the pipeline to avoid a breeding feature), refine mitigation measures, determine an appropriate monitoring program and define offsetting and compensatory measures through the development of a Biodiversity Offset Management Plan (BOMP). It is on this basis that the three actions are linked.

Management measures specific to managing impacts to biodiversity are currently required to be implemented and are in the EMP. These measures include (but are not limited to):

- Maintain construction vehicles appropriately to minimise unnecessary noise generation;
- Implement speed limits to maximum of 40 km/hr for construction vehicles to limit noise and dust generation and minimise potential for fauna strike;
- Utilise or upgrade existing roads to minimise additional clearing requirements;
- Clearly demarcate areas to be cleared to limit unnecessary or accidental clearing of habitat;
- Manage construction and domestic waste to avoid attracting native and alien species to the construction areas;
- For adjacent areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and maintained until vegetation replanting can occur to stabilise disturbed surfaces;
- All chemicals to be stored and treated according to the requirements of each material safety data sheet (MSDS);
- Directional drilling technology will be employed to allow efficient use of drilling well pads and avoid the requirement for additional pad area;
- Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors;
- Condensate and brine generated during the power plant production testing and operation will be injected into reinjection wells;
- For construction and operation areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible; and
- Any replanting of disturbed areas will be done using native plant species, and where possible those common to the area.

These general environmental management measures will assist in reducing the potential for degradation of habitat, behaviour disturbance, fauna mortality and habitat fragmentation for native species. Management measures specific to IUCN listed species are also included within the EMP. Species specific management measures for potential IUCN listed species are provided in Table III-8. These measures will be refined in the BAP following input from the targeted field surveys.

Table III-8 Summary of species specific management measures

Species	*Species specific management measures*
Sumatran Tiger	• Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Sumatran Orangutan	• Pre-clearing survey for presence of individuals prior to tree felling • Pre-clearing survey for presence of nests prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Malayan Sun Bear	• Pre-clearing survey for presence of individuals prior to tree felling and clearing • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Agile Gibbon	• Pre-clearing survey for presence of individuals prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Malayan Pangolin	• Pre-clearing survey for presence of individuals prior to clearing • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Mitred Leaf Monkey	• Pre-clearing survey for presence of individuals prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Siamang	• Pre-clearing survey for presence of individuals prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Asian Tapir	• Pre-clearing survey for presence of individuals prior to clearing

Species	Species specific management measures
	• Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss

3.5.1.2.3 Biodiversity Offsets Management Plan

For the purposes of this assessment report, an area of approximately 2.7 ha of potential critical habitat was identified to be directly impacted. The loss of this habitat area is not considered to lead to a reduction in population size, will not impact on ecosystem function and will not compromise the persistence of a representative host community for each of the threatened species (according to the Biodiversity Decision Framework (IFC, ADB Sourcebook 2012).

In accordance with IFC requirements and the Business and Biodiversity Offsets Programme Standard on Biodiversity Offsets (2012), a Biodiversity Offset Management Plan (BOMP) will be developed to document the design and implementation of biodiversity offsets, in order to achieve at least no net loss to biodiversity as a result of the Project. The design of the offset will require input from the BAP, as it will document the extent of residual impact requiring offsetting.

Given the anticipated small area to be offset, a land-based offset (i.e. creation of an equivalent or greater area of new habitat) is not considered the most appropriate mechanism for achieving a conservation benefit for the greater Batang Toru Forest region. Indirect offsets, such as research, education and enhancement of existing habitat, and investment in improved management of adjacent areas are considered to provide greater conservation benefits to the target species than a small land based direct offset. Potential offset measures that have been identified for further investigation during the offset design process include:

- Rehabilitation of an area of modified habitat directly adjacent to the natural habitat area of the Batang Toru Forest to achieve natural habitat characteristics;
- Actions to improve the biodiversity values of the adjacent Batang Toru Forest, including investment by the proponent into the development of management programs, facilitating stakeholder workshops or establishing long-term conservation mechanisms for selected high value areas within the forest;
- Activities relating to threat abatement for the species for which habitat will be impacted. For example:
    - community education activities regarding threatened species poaching and illegal pet trade

- pest species management or population reduction activities including provision of funds and/or employment for local residents to assist in management;

- Support for existing protected area network for the species for which habitat will be impacted;
- Support for species research in the Batang Toru Forest to contribute to enhancing the knowledge of the species and addressing species data deficiencies and contributing to conservation information; and
- Contribution to existing conservation programs.

The BOMP requires multiple inputs from targeted field surveys, the BAP, various stakeholders including research institutions, governments, local communities and as a result will take some time to develop.

3.5.2 *Ecosystem Services Review (ESR)*

The ESR was prepared to support conformance with IFC PS6 by identifying: Priority Ecosystem Services relevant to the Project; potential and existing impacts to Priority Ecosystem Services; and measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

To achieve these objectives, a five step process was undertaken. This included:

1. Review of baseline data, including the Project ANDAL (ERM 2009); Addendum ANDAL (ERM 2013a) and biodiversity impact assessment (ERM 2013b);
2. Screening of Ecosystem Services potentially occurring within the Project area;
3. Scoping to refine the list of Ecosystem Services;
4. Prioritisation to identify the services of importance to beneficiaries; and
5. Impact assessment.

The full ESR is provided in Annex F, detailing scope, coverage, methodology and results. These are summarised in this Section.

The purpose of the ESR is to identify:

- Priority Ecosystem Services in the Project area;
- Potential and existing impacts to Priority Ecosystem Services; and
- Measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

This ESR considers Ecosystem Services that occur within the Project footprint, or in the Project area (defined as a 500 m buffer from the infrastructure/footprint). The impact assessment addresses potential impacts which may occur as a result of construction activities, and throughout the operational phase of the Project.

Ecosystem Services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economic activities, the fulfilment of people’s potential, and enjoyment of life. In order to provide a uniform basis to assess the status of all major global habitats across all of the world’s bioregions, the United Nation’s Millennium Ecosystem Assessment (UN 2005) combined these diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of Ecosystem Services defined in the Millennium Ecosystem Assessment, as adopted in IFC PS6:

- Provisioning services - those services that can be extracted from ecosystems to support human needs. This term is more or less synonymous with the term “ecosystem goods” that was used in some prior classification schemes, including such tangible assets as freshwater, food, fibre, timber and medicinal plants;
- Regulating services – the benefits obtained from an ecosystem’s control of the natural environment, including the regulation of surface water purification, carbon storage and sequestration, climate regulation, protection from natural hazards, air quality, erosion and pests;
- Cultural services - nonmaterial benefits including diverse aspects of aesthetic, spiritual, recreational, and other cultural values; and
- Supporting services – the natural processes essential to the maintenance of the integrity, resilience, and functioning of ecosystems, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling and primary production.

The concept of Ecosystem Services highlights the fact that humans are reliant upon the benefits provided by ecosystems, and that impacts to ecosystems can subsequently impact human health and quality of life. Project Affected Communities therefore perform an important role in the identification and prioritisation of Ecosystem Services within this review.

IFC PS6 has the following requirements regarding Ecosystem Services:

- Where a project is likely to adversely impact Ecosystem Services, as determined by the risks and impacts identification process, the client will conduct a systematic review to identify Priority Ecosystem Services. Priority Ecosystem Services are two-fold: (i) those services on which project operations are most likely to have an impact and, therefore, which result in adverse impacts to Affected Communities; and/or (ii) those services on which the project is directly dependent for its operations (e.g., water).

- When Affected Communities are likely to be impacted, they should participate in the determination of Priority Ecosystem Services in accordance with the stakeholder engagement process as defined in Performance Standard 1.
- With respect to impacts on Priority Ecosystem Services of relevance to Affected Communities and where the client has direct management control or significant influence over such Ecosystem Services, adverse impacts should be avoided. If these impacts are unavoidable, the client will minimize them and implement mitigation measures that aim to maintain the value and functionality of priority services.
- With respect to impacts on Priority Ecosystem Services on which the project depends, clients should minimize impacts on Ecosystem Services and implement measures that increase resource efficiency of their operations, as described in Performance Standard 3.

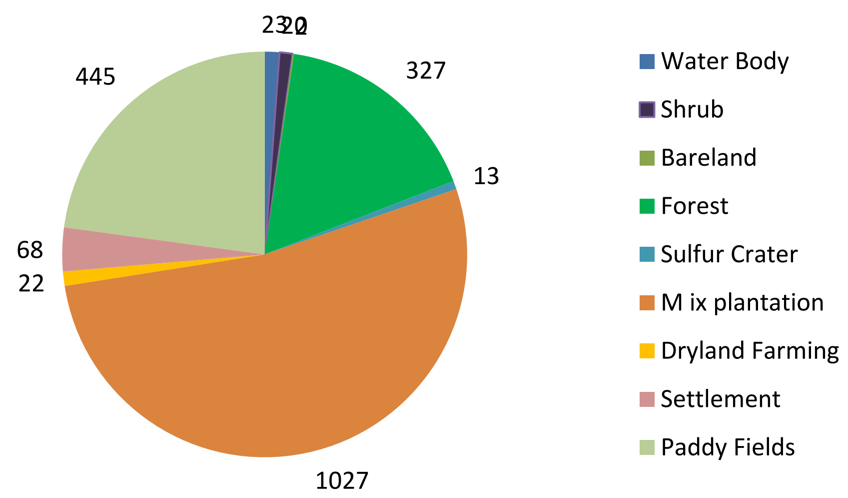
Additional provisions for Ecosystem Services are included in Performance Standards 4, 5, 7, and 8.19.

3.5.2.1 Study Findings

3.5.2.1.1 Habitats

The Project area used for this ESR covers an area of 1948 ha. The area (ha) of each type of land cover is shown in Figure III-4.

Figure III-4 Land Cover in the Project Area (Hectares)



The Project footprint is estimated to cover an area of approximately 86 ha (ERM 2013b). Of this, 83.3 ha (97%) consists of modified habitats and approximately 2.7 ha (3 %) consists of natural forest. These habitats are discussed in more detail below.

Modified Habitats

Modified habitats are represented by four vegetation communities: yard vegetation, field vegetation, rubber plantation, and mixed plantation vegetation. These communities are usually cultivated to meet basic community needs and represent sources of economic value.

Yard vegetation is found around residential areas and the borders of rubber plantations and fields. It is commonly made up of fruit, agricultural, ornamental and medicinal plant species. Field vegetation is generally paddy field, occasionally peanuts, coconut or areca nut.

Rubber plantation is an agricultural land use which is extremely intensive. The vegetation is not monoculture as traditional management includes several other crops species planted in between rubber plants. Mixed plantation is intensive agricultural vegetation that is planted with various annual plant species.

Modified habitats provide values for native and non-native fauna species. Monoculture communities or communities with limited structural diversity represent the lowest biodiversity values with open areas lacking forage resources and cover and as such exposing individuals that may be moving through the area to predation. Communities with greater structural diversity, such as mixed plantation, although modified, may provide foraging and breeding habitat for some native fauna species. These areas play a role in the landscape mosaic of fauna habitat, connecting the large tracts of the Batang Toru Forest. The modified nature of these habitats can present a higher incidence of weed and pest species that will compete with native species for resources.

Natural Habitats

The natural habitat of the Project area is the forest vegetation which is dominated by cantagi species from the Ericaceae family and woody plant species from the Fagaceae family. These habitats adjoin or are part of the wider Batang Toru Forest (east and west lots) which spans approximately 148,000 ha. Only 340 ha (0.2%) of the Batang Toru Forest is located within the Project area.

Field surveys identified two broad natural habitat types: forests and bushes. The forests grow around the crater of NIL and are behind the mentigi bush formations from the sulphur crater. Bushes habitat is usually in open areas, particularly around the geothermal wells in NIL. The flora species represented are pioneer species.

The natural habitats represent the highest quality habitat in the Project area. These habitats are expected to provide foraging, breeding and dispersal habitat for a range of native flora and fauna, including species listed on the Red List, as discussed in the biodiversity assessment (Section 3.3.1).

3.5.2.1.2 *Ecosystem Service Screening*

The screening process used a template list of Ecosystem Services developed by the World Resources Institute, which is based upon the Millennium Ecosystem Assessment Reports (2005). Each of the services in this table was assessed for its likelihood to occur in the Project area based on two criteria:

- The habitats present in the Project area were known to provide this service or were similar to habitats elsewhere that provide this service; and
- People were believed to benefit from the service, either at the local, national or global level and /or the Project was expected to benefit from this service.

The review also considered whether the Project would be likely to be dependent on any services (such as water, flood protection, etc.) in the Project area.

Community consultation is being undertaken as a separate study to support the development of a Social Impact Assessment and Integrated Social Program (ERM 2013c). Consultation topics included:

- Income from farming and forests;
- Income from livestock;
- Non-timber forest products, such as orchid, ornamental plants, bamboo, incense bark, traditional medicines;
- Wild pigs or other wild animals for consumption or sale;
- Clean water sources for cleaning, bathing and washing clothes;
- Drinking water sources;
- Housing construction materials, such as concrete, wood and bamboo;
- Disease vectors, such as rats, flies, mosquitos; and
- Impairment or loss of access to public facilities, including: cultural heritage, hunting, grazing, the use of traditional natural resources.

General information about the use of Ecosystem Services gained from consultation has been used to inform this ESR.

3.5.2.1.3 *Ecosystem Service Scoping*

The scoping exercise was undertaken in order to refine the list of Ecosystem Services to include only those services that:

- Were identified as occurring in the Project area;
- Had human beneficiaries; and
- Were potentially impacted by the Project.

The goal of the scoping exercise was to identify a list of Ecosystem Services to be assessed during through the prioritisation stage.

The scoping exercise considered the following parameters:

- Potential Beneficiaries: Known and potential beneficiaries for a service were identified and where possible identifying people at the local, national, and/or global level.
- Sources of Impact: Potential sources of impact were considered based on the Project description (Chapter 1.6); and
- Project Dependence: IFC PS6 requires that the Ecosystem Services assessment take into consideration any services that the Project may rely upon during construction, operation and/or decommissioning. Therefore all services for which there is a potential project dependency were scoped into the prioritisation stage.

Based on these parameters, the services that may be impacted or depended on by the Project were scoped into the prioritisation process.

3.5.2.1.4 Ecosystem Service Prioritisation

IFC PS6 requires that Priority Ecosystem Services are identified, and impacts to those services are assessed (IFC 2012). The prioritisation process was aimed at identifying those services for which Project impacts would be most likely to result in adverse impacts on Project Affected Communities and other beneficiaries. Using the information collected through the baseline data collection and stakeholder engagement processes, Ecosystem Services were prioritised according to a Priority matrix ranking two criteria:

- Importance of the Ecosystem Service to the beneficiary which considers the intensity of use, degree of dependence and the importance expressed by the Project Affected Communities; and

- Irreplaceability of the Ecosystem Service, which refers to the availability of alternatives, the accessibility, cost and appetite for those alternatives as discussed with the beneficiary.

After compiling baseline information on the importance and irreplaceability of each service, these ratings were combined to assign a priority rating to the service grading from Low to Major. Ecosystem Services identified as High Priority or Major Priority were considered Priority Ecosystem Services. The weight given to each of these components varied slightly depending upon the service, but stakeholder values were given precedence over other criteria where the rating was not clear.

In addition to the above, according to the IFC definition of Priority Ecosystem Services, all services for which project dependencies are identified are considered priority services. The importance and irreplaceability of services relied upon by the Project was assessed through the same prioritisation process outlined above, with the Project filling the role of the beneficiary.

In addition to the prioritisation exercise, the baseline data collection process provided the opportunity to collect information on the status, trends and sustainability of resource use as they pertain to the habitats and species that support Ecosystem Services. This information is important for the assessment of impacts on Ecosystem Services and therefore on local people as the final receptors of these changes.

3.5.2.1.5 *Impact Assessment*

Impacts were assessed based on the vulnerability of beneficiaries and the magnitude of potential or realised impacts, as described below.

Assessing Level of Vulnerability

Determination of the vulnerability of beneficiaries included consideration of the following questions:

- Are beneficiaries heavily dependent on a particular resource, with few alternatives available?
- Are resource shortages frequent and serious?
- Are key species or areas depended upon for goods or services legally protected and use is illegal?
- Are key resources controlled by an influential receptor and access is not guaranteed?
- Is there a low availability of alternatives for a number of important of Ecosystem Services?

Beneficiaries were considered vulnerable in the context of their immediate surroundings and were considered against existing pre-project baseline levels. Because of this there are always some vulnerable receptors within the receiving environment.

Rating Magnitude of Impacts

Magnitude of social and health impacts is understood as a reflection of the 'size' of change caused by social impacts. Magnitude is a function of the extent, duration, scale, and frequency. Impacts on human receptors as a result of changes in Ecosystem Services were assessed according to the four magnitude criteria listed above and ranked from negligible to large.

Evaluating Significance

The significance of the impact was determined by combining the magnitude of predicted impact with the value of the receptor, to produce a significance rating from Negligible to Significant. Positive impacts were also considered.

Each of the Ecosystem Services considered in this study was evaluated to determine whether it should be considered for elevation to a Priority Ecosystem

Service based on the following four criteria:

- Potential Project impact;
- Dependence of the Project on the Ecosystem Service;
- The importance of the service to the affected community; and
- The irreplaceability of the Ecosystem Service if it was to be completely removed from the region.

Ecosystem Services with a priority ranking of High or Critical were assigned as Priority Ecosystem Services.

Impacts

In summary, the Priority Ecosystem Services identified for the Project are:

- Food: cultivated crops;
- Non-wood fibres and resins; and
- Freshwater.

Impacts to two Ecosystem Services were assessed as being Minor: Cultivated Crops, and Non-wood Fibres and Resins. Potential impacts to Freshwater (Groundwater) are discussed in Section 3.3.2. No significant impacts were identified at this stage.

3.5.2.1.6 Recommendations

The ESR found that whilst the potential impacts from the Project are considered minor. The recommendations for the Project are:

Cultivated Crops and Non-Wood Fibres and Resins

Acquisition of productive land will affect farmers within the Project footprint that are dependent on agriculture for livelihoods. A Land Acquisition Process is currently underway, which aims to manage impacts to land owners, including those directly impacted. Land has been acquired in Pahae Jae Sub-district, and land owners have been compensated. Land Acquisition in Pahae Julu Sub-district is currently being negotiated. The Land Acquisition Process should:

- Involve baseline data collection on the uses and incomes derived from land to be acquired;
- Identify households that are vulnerable to Project impacts, whether due to the proportion of land to be acquired, or the current level of household income;
- Provide appropriate compensation, whether financial or land-based; and
- Include a grievance mechanism. The Project grievance mechanism is discussed in detail in Chapter 4 of this report.

A land acquisition audit has been prepared for the Project to assess the level of compliance with ADB's social safeguards. Further assessment is provided in ESIA Addendum Volume IV: Social Safeguards Compliance Audit Report and Corrective Action Plan.

Freshwater (Groundwater)

The Project has produced a water balance study and impacts to groundwater are not predicted. This will be supported by monitoring during use. This is provided in Section 3.6. Further assessment of Social Impacts from resource use by the Project is provided in ESIA Addendum Volume III: Social Impact Assessment and Integrated Social Program.

3.6 WATER BALANCE STUDY

This section provides a summary of the Project's water usage from planned construction and operational activities discussed in the Project description. An overview of the affected communities water resources and usage is also presented based on recent consultation findings.

At this stage accurate Project consumption levels of water and specific disposal measures have not been defined therefore this section provides a high level discussion of potential community impacts which will be further investigated in Part C (the social impact assessment) when further Project data is available.

3.6.1 *Summary of Project Water Requirements*

The average and total requirement for water usage during the construction and operation phases are presented in Table III-9 below. From this data it is clear that the Project's usage of water will be highest during drilling activities in the NIL area. At this point in the Project, planning and design estimates for the Project's total water consumption are unknown.

Table III-9 Project Water Consumption

Stage	*Average Consumption Rate (m^3/day)*		*Estimated Total Requirement (m^3)*	
Construction Stage				
	SIL	NIL	SIL	NIL
EPC Contractor Construction Operation	70	75	63,000	86,000
Drilling Contractor	600	1200	200,000	635,000
Operation Phase				
	90	180	n/a	n/a

Source: SOL 2013

3.6.1.1 *Construction Stage*

3.6.1.1.1 *EPC Contractor Construction Use*

About 60% of the water needs of the EPC Contractor will be utilised for the camp site, office operation and other similar requirements for workers such as toilets and shower usage, and general cleaning purposes. Drinking water provided to the Project workforce will be in the form of purified bottled water sourced through local vendors.

The duration of water use will be approximately 30 months at the SIL area and 47 months in NIL area. Approximately 20% will be utilised for construction activities; preparing concrete, watering for soil compaction, dust control, construction equipment clean-up and maintenance. Water will also be required for vessel and pipe hydro-testing.

3.6.1.1.2 *Source*

Water for the workforce camp site will be sourced from water wells that will be drilled within the site area. Source points in the NIL and SIL areas have been surveyed; the EPC Contractor will undertake drilling of such wells pre construction activities commencing. The number of wells to be drilled is expected to be two (2) wells for each SIL and NIL. Final number will be determined at the later stage. The estimated depths of the wells could be in the range of 50 to 100 m. The anticipated locations of the wells are indicated in Figure III-5. The quantity of each well will meet with the consumption quantity as described in Table III-9.

Figure III-5 Groundwater Well Location

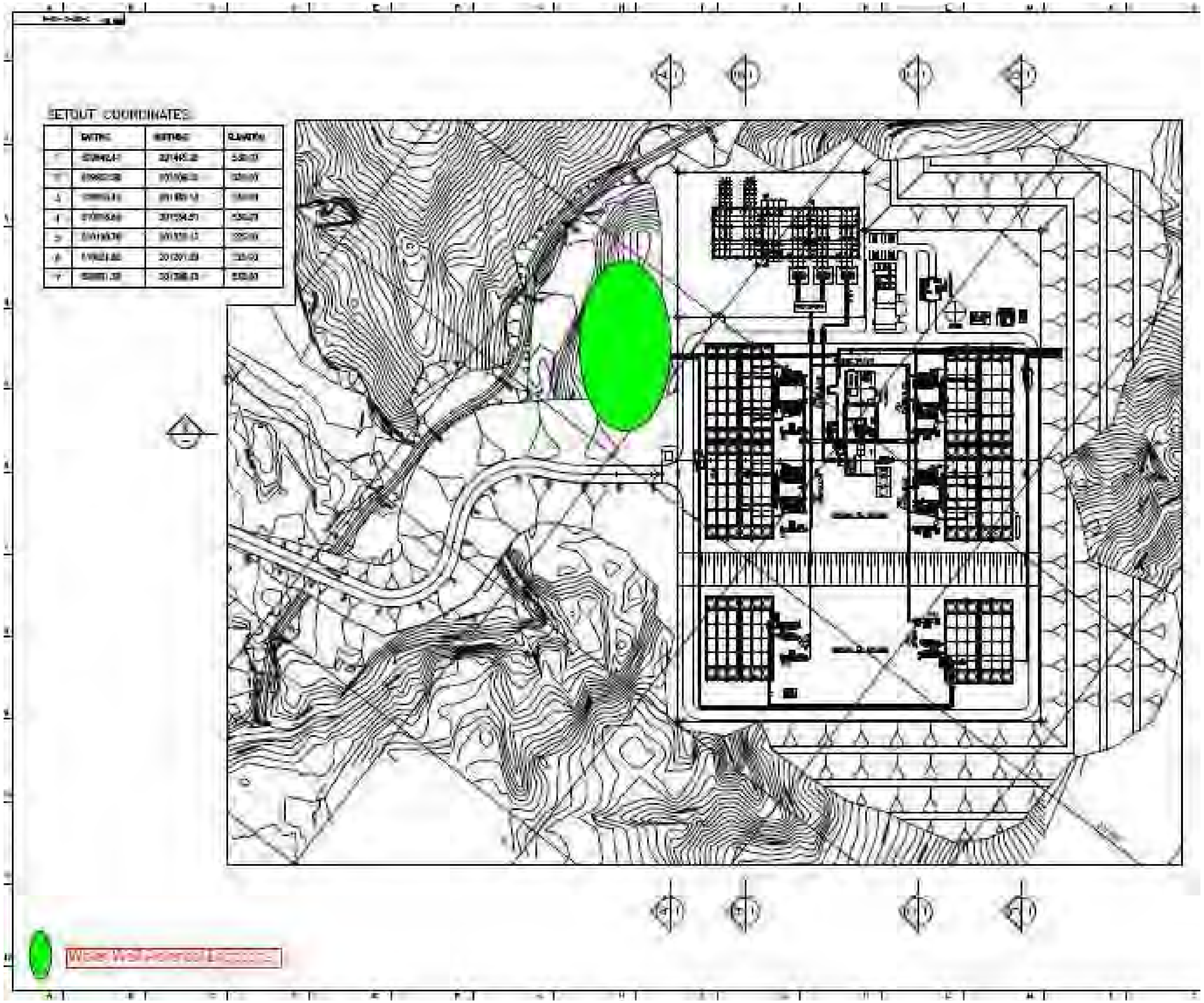
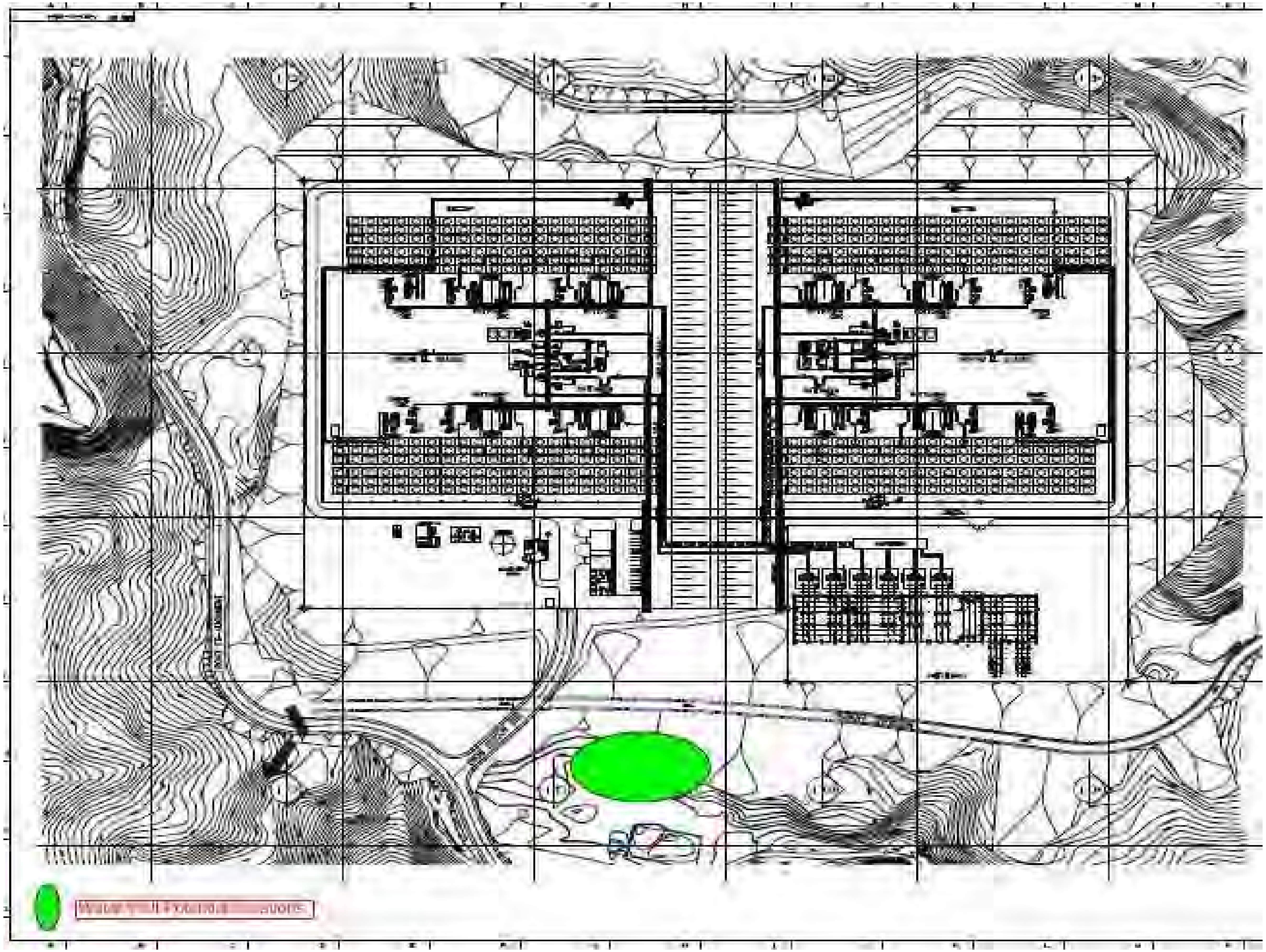


Figure III-5 Continued



Water for construction and hydro-testing will be sourced from Project water wells and the Batang Toru River, with the majority of the water sourced from the Batang Toru Rivers. This river is a substantial river, with an estimated flowrate of around 100 m^3/s (Section 3.3). Specific abstraction volumes are unknown at this point however initial modelling has been undertaken to understand better potential abstraction impacts on the communities' water wells. Further modelling tests on ground and surface water will be undertaken when abstraction volumes are better understood.

3.6.1.1.3 Disposal of used water

SOL and its EPC Contractor will ensure that the disposal of used water is in line with Indonesian government regulations and international lender standards to avoid any adverse impacts to the environment or local communities surrounding the Project area.

SOL plans to dispose of the Project's used water in the following manner:

- Waste water from the camp and workforce will be disposed via a suitable treatment process prior being drained to local water channels;
- Construction waste water will be reused during construction activities where possible;
- Water used for hydro-testing will be treated and then drained to local water channels; and

Specific treatment system will be determined at the later stage. Initial planning is consisted of contact oxidation process for sanitary waste water, EPS (egg plate separator) equipment for oily water, and pH adjustment for chemical waste water. For hydro-test water, the water will be filtered by providing mesh or running through sand/gravel filter pits to collect particulate matters such as rust, metal slugs and other forms of debris like dust and sand and prevent them from running into the drainage canals around the project area..

3.6.1.2 Drilling of Wells Use

Based on the size and depth of the geothermal wells to be drilled and the characteristics of the subsurface condition where wells are to be drilled, an approximate quantity of 150,000 barrels (approximately 18,000m^3) of water is needed to do each well. This constitutes the biggest portion of the water required for drilling.

Aside from the water needed for the actual drilling operation, water is needed for associated drilling activities including constructing the civil facilities such as foundations, sumps, kelly holes, in addition to general construction clean-up purposes.

The base camp and rig camps will also be utilising water for toilets, showers and other workforce related requirements. Water usage will be for an approximate duration of 12 months in SIL and 18 months in NIL.

3.6.1.2.1 *Source*

All water intended for drilling will be drawn from the Batang Toru River. Water for the workforce base and rig camps will be filtered before use.

3.6.1.2.2 *Disposal of used water*

The mechanism for disposal of used water from the above activities is described as follows:

- Water used for drilling will be left in the drilled hole;
- Water used for workforce purposes will be treated and then drained to local water channels;
- A septic system with leaching and digestive chambers will be employed for treating domestic sewage. Liquid passing through the septic tank will percolate underground; and
- Construction waste water will be reused by suitable Project facilities where possible.

3.6.1.3 *Operation Stage*

Based on the number of operators and plant water requirements, SIL's requirement rate is calculated at 90m^3/day and NIL is 180m^3/day. This geothermal power plant does not require water for its cooling process as it uses an air-cooled technology. However, water is still required for the plant operation for general clean-up and regular maintenance, and during annual preventive maintenance period.

It is projected that future drilling of wells will require a similar rate of water usage (150,000 barrels or approximately 18,000 m^3 per well). This estimated rate of usage takes into account these ad hoc activities but not continuous requirement for water.

3.6.1.3.1 *Source*

Water for the plant's operation will be sourced from the water wells that will be drilled during the construction phase. As discussed previously, source points in NIL and SIL have been surveyed and wells will be drilled by the EPC Contractor prior to construction.

3.6.1.3.2 *Disposal of used water*

Disposal of used water in this phase includes:

- Water used for workforce purposes will be treated and then drained to local water channels;

- A septic system with leaching and digestive chambers will be employed for treating domestic sewage. Liquid passing through the septic tank will percolate underground;
- Water used for plant clean-up works will pass through oil-interceptors to separate the oil and the water; the separated water will then be directed to water channels around the site; and
- Specific treatment system will be determined at the later stage. Initial planning is consisted of contact oxidation process for sanitary waste water, EPS (egg plate separator) equipment for oily water, and pH adjustment for chemical waste water.

3.6.2 *Delineation of Water Source Areas*

3.6.2.1 Surface Water

3.6.2.1.1 River

The Batang Toru River is located in the South Tapanuli Regency; it originates from Lake Toba and flows south west, ending in the Indian Ocean after it first divides the waters of Lake Sias. The Batang Toru River Basin covers four Regencies in the North Sumatera Province (which includes the South and North Tapanuli Regencies) and has a watershed of 234,000 acres. This river is a substantial river, with an estimated flowrate of around 100 m^3/s (Section 3.3). The river is utilised daily by the local communities who reside alongside it for activities such as drinking, bathing, washing, irrigation and other farming activities. It is also used for catching freshwater fish (Figure III-6 and III-7).

Figure III-6 Batang Toru River

Figure III-7 Community use of River for Bathing And Washing

3.6.2.1.2 Spring Water

The communities in the Pahae Jae and Pahae Julu sub-districts use spring water as the main source of community life for bathing, washing and cooking. Based on a recent social survey conducted by ERM in 2013 there were 43 households in the Pahae Jae sub-district who used spring water located near their villages. There were 20 households identified as using spring water located in the forest near the villages in the Pahae Julu sub-district.

In addition to household usage the majority use spring water for farming purposes where spring water is considered indispensable for rice paddy cultivating. The spring water is piped or hosed from the wells to the rice-paddy fields- see Figures III-6 and III-7.

Figure III-8 Fish Pond Supplied by Water From Spring Water in Silangkitang Village

Figure III-9 Rice Paddy Field Obtaining Water from Spring Water and Rain Water

3.6.2.2 Groundwater

The community also use groundwater as a water source. In Pahae Jae, it was identified that 6 households had a well. In Pahae Julu, there were 9 households using wells. Well depths range from 4-6 m depth (Figure III-10). Well water is largely used for activities, such as bathing, cooking and washing.

Figure III-10 Gambar Community Well in Silangkitang Village, Pahae Jae Sub District

3.6.3 Summary of Community Water Use and Disposal

Currently the community uses both surface water and ground water for daily household and farming activities. An initial assessment based on a community social survey (ERM 2013) indicates the water source for clean drinking water in the Pahae Julu and Pahae Jae sub-districts are via shallow wells, PAM (water agency) and springs- see Table III-10. In Pahae Julu 64% of people and in Pahae Jae 86% use spring waters as a clean water source and 64% in Pahae Julu and 95% in Pahae use spring water to drink. Less than 5% of people use the river as clean water and drinking water resource.

Table III-10 Sources of Clean Water and Drinking Water in Pahae Julu and Pahae Jae Sub-districts

No.	Sources of Clean Water and Drinking Water	Sub-district		Total
		Pahae Julu	Pahae Jae	
Clean Water Source				
1.	Pump/shallow well/excavated well	9 (29%)	6 (7.9%)	15 (14%)
2.	PAM	1 (3.2%)	2 (2.6%)	3 (2.8%)
3.	River water/other surface water	20 (3.2%)	2 (2.6%)	22 (20.6%)
4.	Springs (mountain water)	1 (64.5%)	66 (86.9%)	67 (62.6%)
Drinking water sources				
1.	Pump/shallow well/gali	9 (29%)	1 (1.2%)	10 (9.3%)
2.	PAM	1 (3.2%)	3 (3.8%)	4 (3.7%)
3.	River water/other surface water	20 (3.2%)	0	20 (18.7%)
4.	Springs (mountain water)	1(64.5%)	72 (95%)	73 (69.3%)
	Total	**31 (100%)**	**76 (100%)**	**107 (100%)**

Source: ERM Primary Data, July 2013

Table III-11 shows Availability of MCK Facilities and Methods of Human Waste Disposal in Pahae Julu and Pahae Jae Sub-Districts. This shows that approximately 26% of people use river for bathing and washing in the Pahae Julu sub-district and 56% of people use the river for bathing and washing in Pahae Jae sub-district.

Table III-11 Availability of MCK Facilities and Methods of Human Waste Disposal in Pahae Julu and Pahae Jae Sub-Districts

No.	MCK Facilities and Methods of Disposing of Human Waste	Sub-district		Total
		Pahae Julu	Pahae Jae	
MCK Facilities				
1.	Inside the house	16 (51.6%)	26 (34.2%)	42 (39.3%)
2.	River/lake/spring	9 (26%)	43 (56.6%)	52 (48.6%)
3.	Public MCK /neighbour	6 (19.4%)	7 (9.2%)	13 (12.1%)
Method of Sanitation Effluent Disposal				
1.	Swan-neck toilet	13 (41.9%)	9 (11.8%)	22 (20.6%)
2.	River	1 (3.2%)	48 (63.2%)	49 (45.8%)
3.	Pit toilets	6 (19.4%)	18 (23.7%)	24 (22.4%)
4.	Public WC	0	1 (1.3%)	12 (22.4%)
5.	Arbitrarily	11 (35.5%)	0	
	Total	31 (100%)	76 (100%)	107 (100%)

Source: Primary Data, July 2013

Table III-12 indicates that 48% of people in the Pahae Jae Sub District dispose of their household waste water in the river via manmade ditches and channels to the river.

Table III-12 Household Wastewater Disposal in Pahae Jae Sub-District

No.	Household Wastewater Disposal	Sub-district		Total
		Pahae Julu	Pahae Jae	
1.	SPAL	3 (9.7%)	3 (4%)	6 (3.7%)
2.	River	0	37 (48.7%)	53 (65.4%)
3.	Drain	16 (51.6%)	29 (38.1%)	41 (15.9%)
4.	Behind the House	12 (38.7%)	7 (9.2%)	19 (15%)
Total		**31 (100%)**	**76 (100%)**	**107 (100%)**

Source: Primary Data, July 2013

3.6.4 Conclusion

The Government of North Sumatera supports the availability of clean water for all communities in a sustainable manner. This is mandated via the Regional Government regulation No. 6 Year 2002 regarding Tax for Collection and Utilization of Surface Water and Groundwater. In this regulation, the Government restricts the use of groundwater; obligating industry that utilises ground water to construct infiltration wells. SOL is committed to comply with this regulation.

Consultation findings with villagers, village heads, and clan and community leaders in both sub-districts indicated they are anxious about the potential Project impacts on groundwater. At present the community have no water access or availability issues (even in the dry season), however given the Project's water requirements fears exist that the groundwater quality and abundance may change.

SOL will not use spring water, which is the main community source of freshwater (Pahae Jae: 43 households and Pahae Julu: 20 households). The community has no current water access or availability issues (even in the dry season). The Project's drinking water requirements will be purified bottled water sourced through a local vendor. Water for the workforce camp site will be sourced from water wells and the highest water demand, which occurs during drilling, will be drawn from the Batang Toru River.

It is acknowledged that the community have concerns over Project water demands despite the use of groundwater being less common. Six households In Pahae Jae and nine households in Pahae Julu rely on this source. As discussed, community wells range from 4-6 m depth. The estimated depths of the Project's planned groundwater wells are in the range of 50 to 100 m which targets the groundwater supply far below the community wells. SOL conducted pumping tests and tested yields are very low and not predicted to affect community wells >100m from the site. As discussed above, SOL has conducted initial modelling to understand better potential abstraction impacts on the communities' water wells.

SOL will engage with the community around this issue and ensure all appropriate measures are implemented to safeguard the communities' use of local water resources.

SOL is committed to further monitoring on river water and groundwater extraction, particularly during peak demand to illustrate that the supply is not affected. Part C of this ESIA (the social impact assessment) will consider the potential social impacts of these activities in more detail.

3.7 *H_2S MODELLING*

This section aims to update the Project's air quality impact assessment, monitoring and management in respect to the expected Hydrogen Sulfide (H_2S) Emission from the Project in line with the Policy Standards of the Project Lenders. The Indonesian standard for H_2S is an odour standard of 0.02 ppm (approximately 30 μgram/m^3) specified in Minister of Environment Decree No. 50 of 1996 (Kep-50/MENLH/11/1996).

The WHO guideline is 150 μgram/m^3 (approximately 0.1ppm) time weighted average over 24 hours[19]. The WHO guideline is a health impact threshold and is based on the avoidance of eye irritation. Table III-13 shows the established dose–effect relationships for H_2S.

Table III-13 H_2S Established Dose–Effect Relationships (WHO, 2000)[14]

Hydrogen Sulfide Concentration (ppm)	*Effect*
1,000-2,000	Immediate collapse with paralysis of respiration
530-1,000	Strong central nervous system stimulation, hyperpnoea followed by respiratory arrest
320-530	Pulmonary oedema with risk of death
150-250	Loss of olfactory sense
50-100	Serious eye damage
10-20	Threshold for eye irritation

[19] http://www.euro.who.int/data/assets/pdf_file/0005/74732/E71922.pdf

3.7.1 *Introduction*

Emission of H_2S from geothermal project development is one of the usually anticipated air contaminants. In a number of geothermal fields around the world, due to the naturally occurring venting of geothermal gasses, either in the form of fumaroles, or hot springs that flashes upon exposure to atmosphere, H_2S concentration on air is usually present even before the development of the geothermal project. Depending on the extent of H_2S emission contributed by the Project activities, an increase in H_2S on ambient air maybe experienced around the project surroundings. Ambient air measurements of H_2S are discussed in Section 3.1 and are either non detectable or of negligible magnitude. As a result, no baseline contours have been produced as the potential cumulative effect of H_2S is considered negligible if the Project adds to these background concentrations.

3.7.2 *H_2S Dispersion Modelling Updates*

This sub section presents the updates of the H_2S modelling dispersion and its results. Based on these updates, impact and significance is further elaborated in the following subsection.

3.7.2.1 *H_2S Dispersion Modelling*

The basis of the model used in this H_2S study is the straight-line, steady-state Gaussian plume equation, with some modifications to model emissions from point and non-point sources. Emission sources are categorized into five basic types of sources, i.e., point sources, line sources, volume sources, area sources, and open pit sources. The model uses hourly meteorological data records to define the conditions for plume rise, transport, diffusion, and deposition. The model can be used to estimate the concentration or deposition value for each source and receptor combination for each hour of input meteorology, as well as calculate selected short-term averages.

The H_2S dispersion modelling was updated to cover matters related to:

- The effect of the change of the point source location at SIL as described in Section 2.4.2.b Construction of the Geothermal Energy Power Plant (PLTP) in the AMDAL Addendum (ERM, 2013);
- Reflect the updated characteristics of the air flow per fan according to more recent design information of the air-coolers; and
- The variances of the results between the whole year, dry season and wet, both for the 24 hour average and annual average.

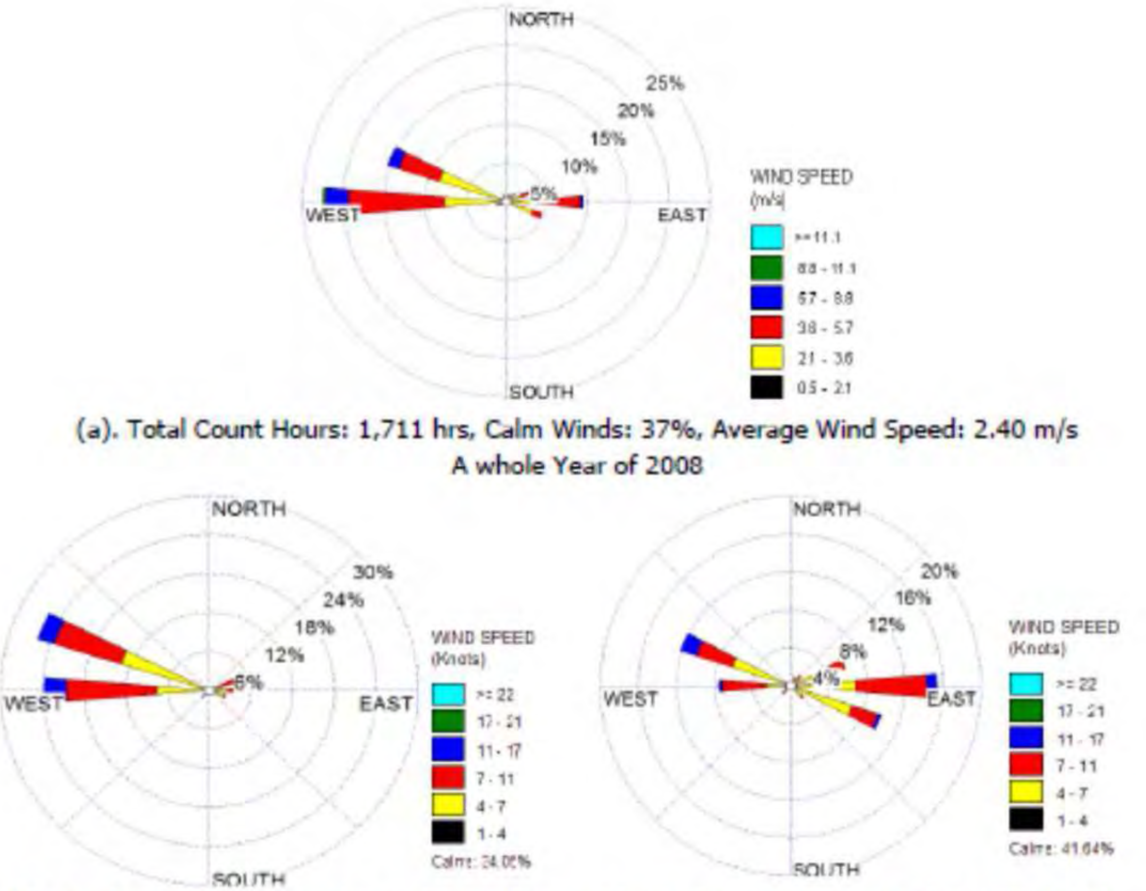
The updated input data for the model is summarized in Table III-14.

Table III-14 Updated input data

No.	Item	Unit	SIL	NIL	Remark
1	Air flow per fan	m^3/s	108.80	118.00	Data Input, cross sectional area * ejection speed per fan $((\pi *(d/2)^2)*v)$
2	Exhaust air temp per fan	^oC	39.2	38.9	Data Input
3	H_2S density	gram/m^3	1,326.54	1,327.81	Data Input, At exhaust air temperature condition
4	Ejection speed per fan (v)	m/s	5.817	6.3088	Data Input, Used as H_2S velocity when emitted from the point source
5	Outlet diameter (d)	m	4.88	4.88	Data Input, Typical for all outlet
6	Outlet height	m	7.5	7.5	Data Input, Typical for all outlet
7	Outlet position above mean sea level	m	530	813/823	530m: Level of Bottoming OEC in SIL, which exhausts H2S gas 813m: Level of NIL-II plant 823m: Level of NIL-I plant
8	H_2S emission volume	m^3/s	0.020	0.143	Data Input, Based on H_2S premises calculation data
9	Number of emission sources		240	504	Data Input, number of point sources is equal to number
10	H_2S emission volume per emission source	m^3/s	8.33E-05	2.84E-04	Data Input, H_2S emission volume / number of emission sources
11	H_2S emission rate per emission source	gram/s	0.11055	0.3767	Data Input, H_2S emission volume per emission source * H_2S density

WPRPIOT View program was used to generate the frequency distribution of wind speed and direction and plotted in the form of wind roses as shown in Figure III-11. The average wind direction is shown as one of sixteen compass points, each point separated by 22.5°, measured from true north. The bar plotted for a given direction indicates the percentage of time of the wind came from that direction. Since wind direction is constantly changing, the time percentage for a specific compass point actually includes those time for wind directions 11.25° on either side of the point. The percentage of time for a given velocity range is shown by the length of the direction bar. A wind rose proves good estimates of local pollutant dispersion patterns.

Figure III-11 Wind Rose for the Study Area



(a). Total Count Hours: 1,711 hrs, Calm Winds: 37%, Average Wind Speed: 2.40 m/s
A whole Year of 2008

(b). Total Count Hours: 279 hrs, Calm Winds: 34.05%, Average Wind Speed: 2.58 m/s
Dry Season, May to June 2008

(c). Total Count Hours: 281 hrs, Calm Winds: 41.64%, Average Wind Speed: 2.15 m/s
Wet Season, February to March

3.7.2.2 The H_2S Dispersion Modelling Result

The modelling result shows the prediction of H_2S dispersion for whole year (Figures III-10 to III-11), wet & dry season which can be seen in Figures III-12 to III-15, which present the isopleths of the H_2S emissions.

Figure III-12 Predicted H_2S Concentration (Annual Average) for the Whole Year

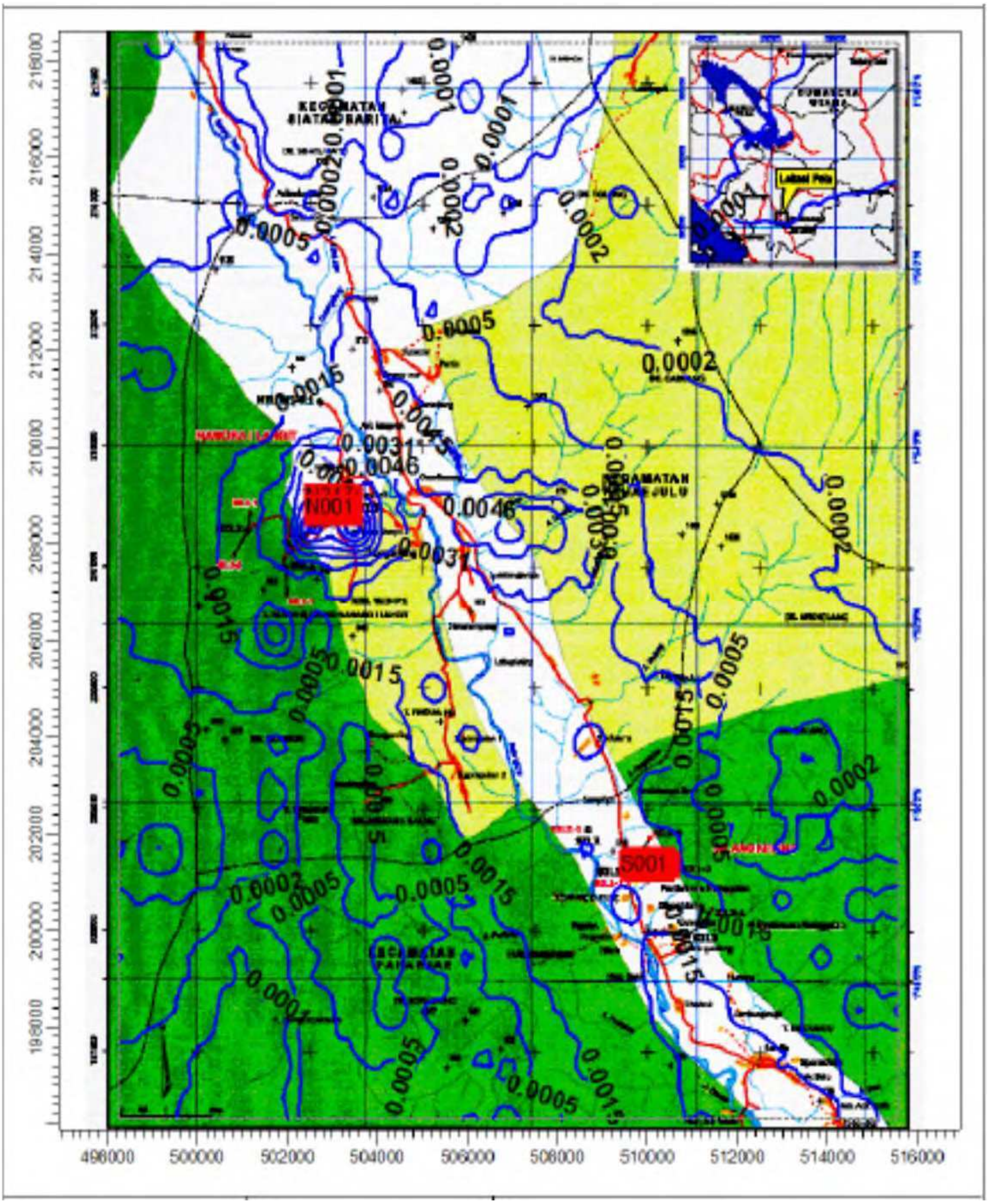


Figure III-13 Predicted H_2S Concentration (24hr Average) for the Whole Year

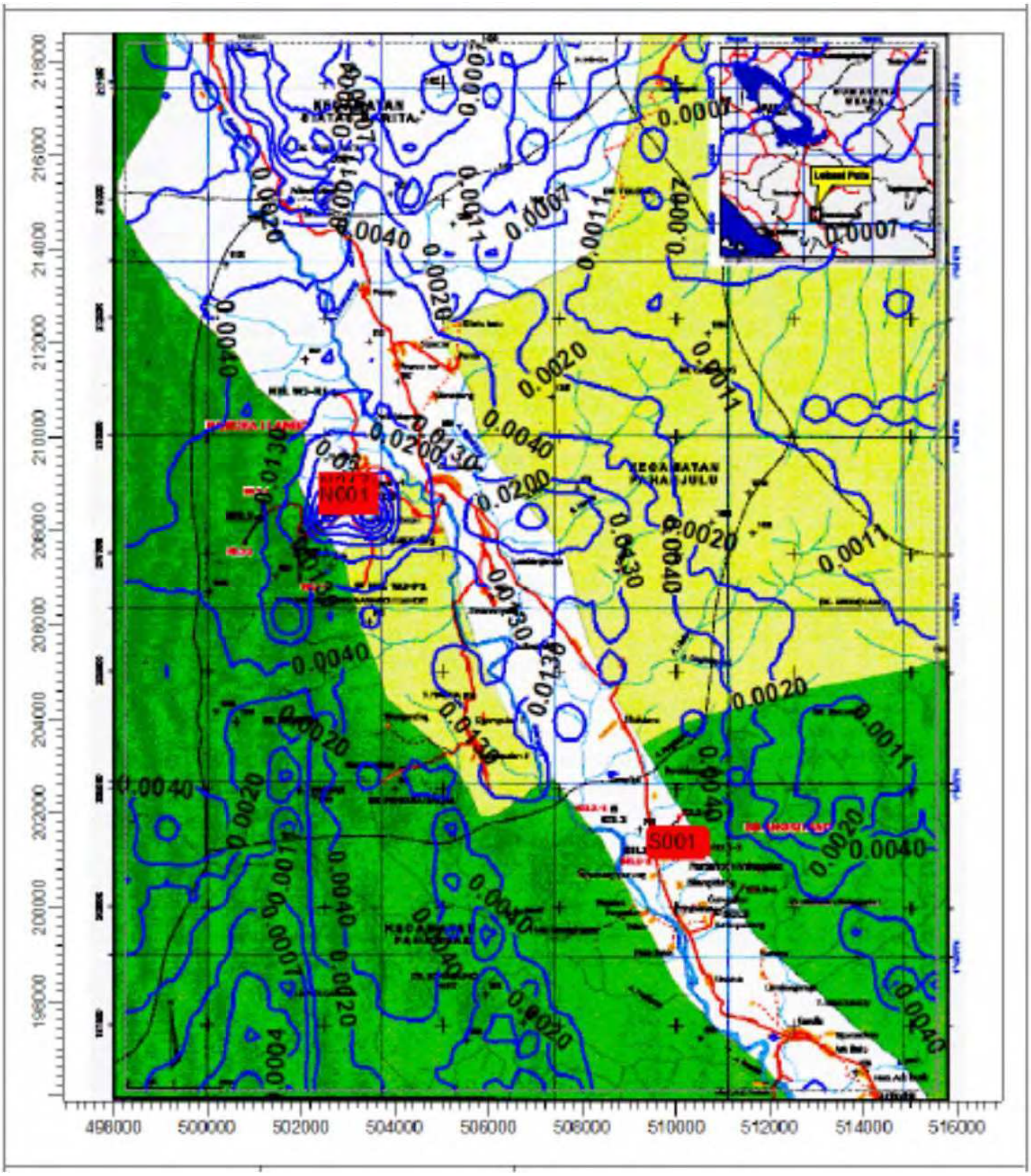
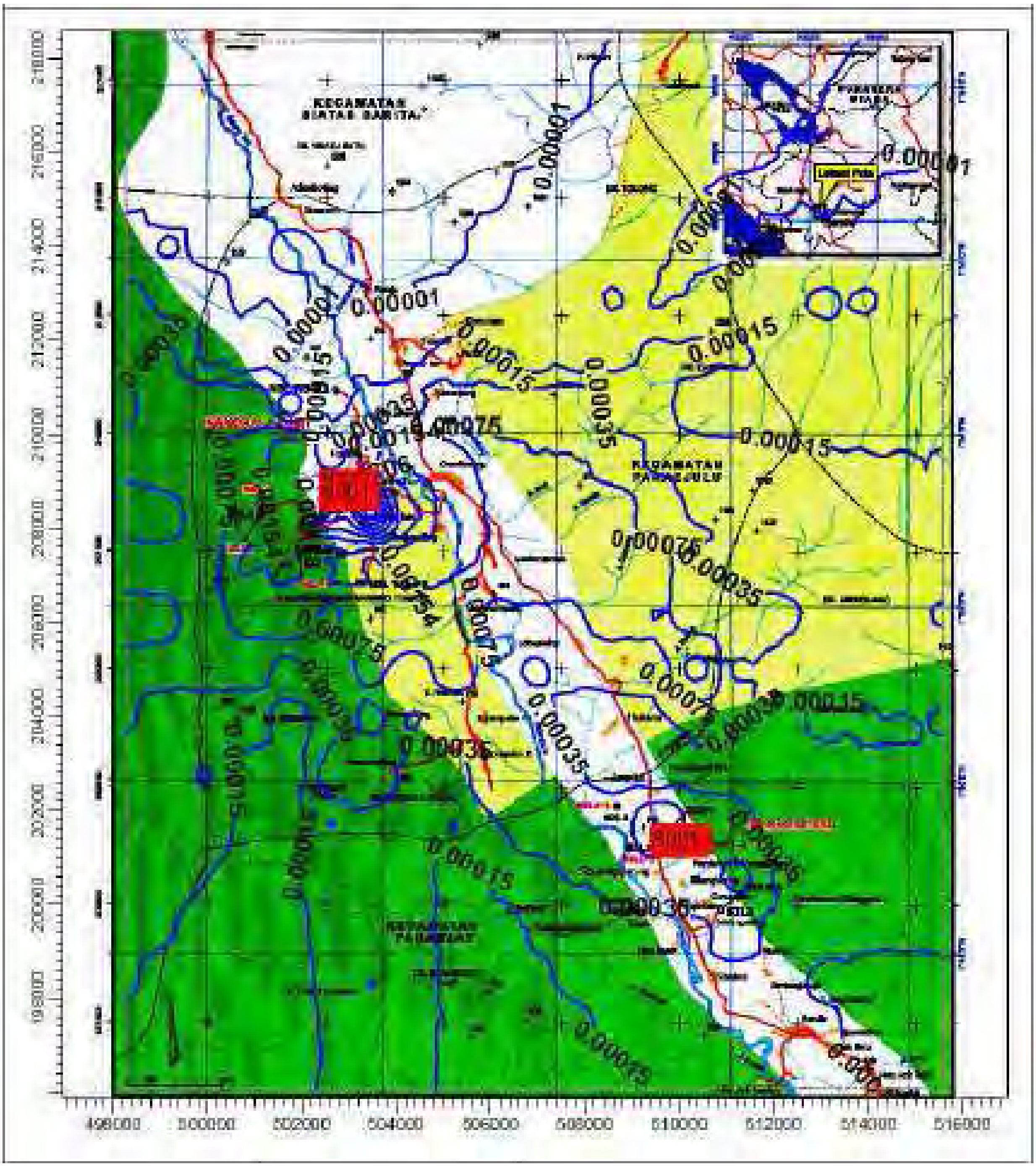


Figure III-14 Predicted H_2S Concentration, Periodic Average (Dry Season)



Note: Periodic Average means the average during the extreme dry season which is between the months of May to June

Figure III-15 Predicted H_2S Concentration, 24 Hr Average (Dry Season)

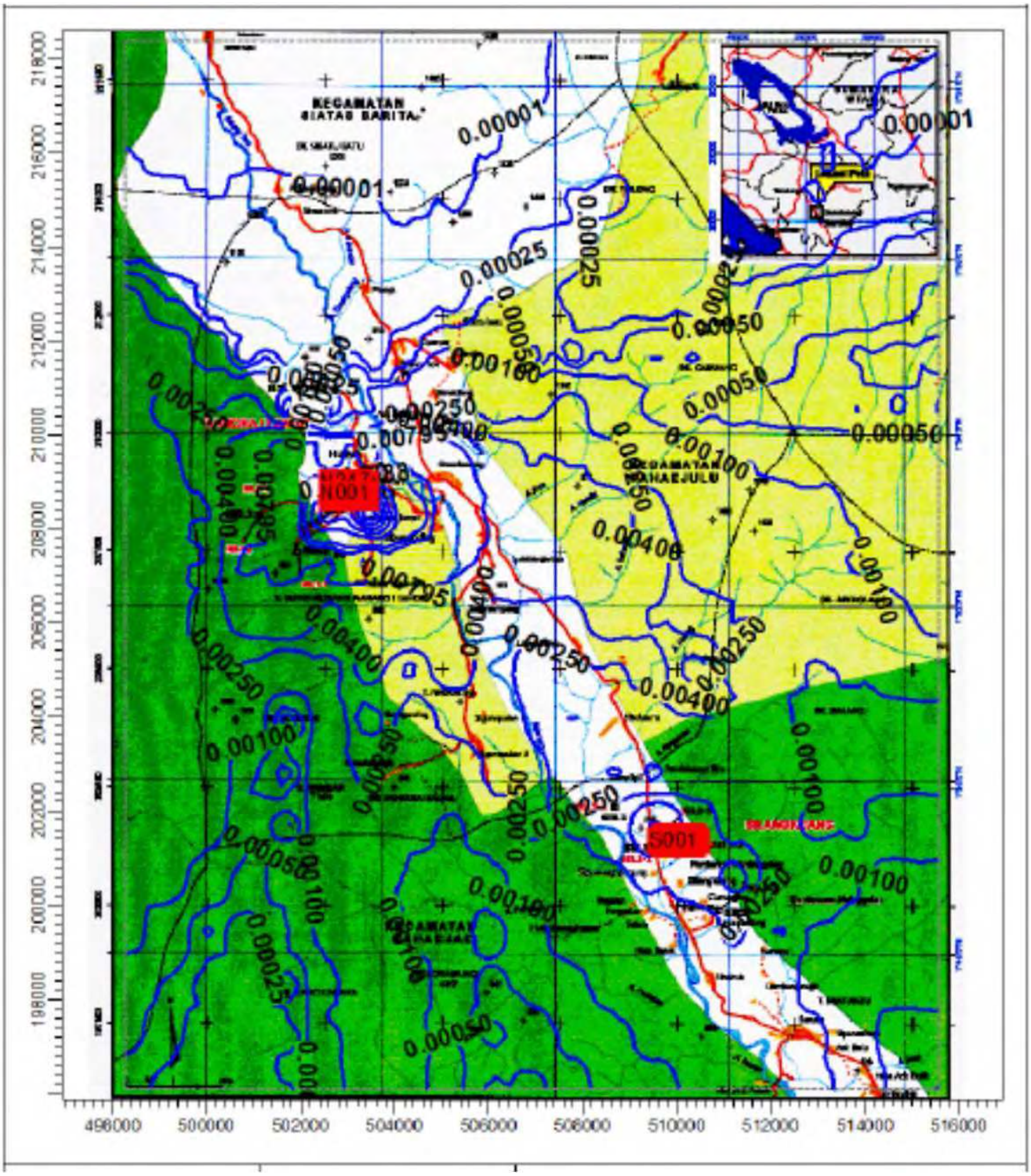
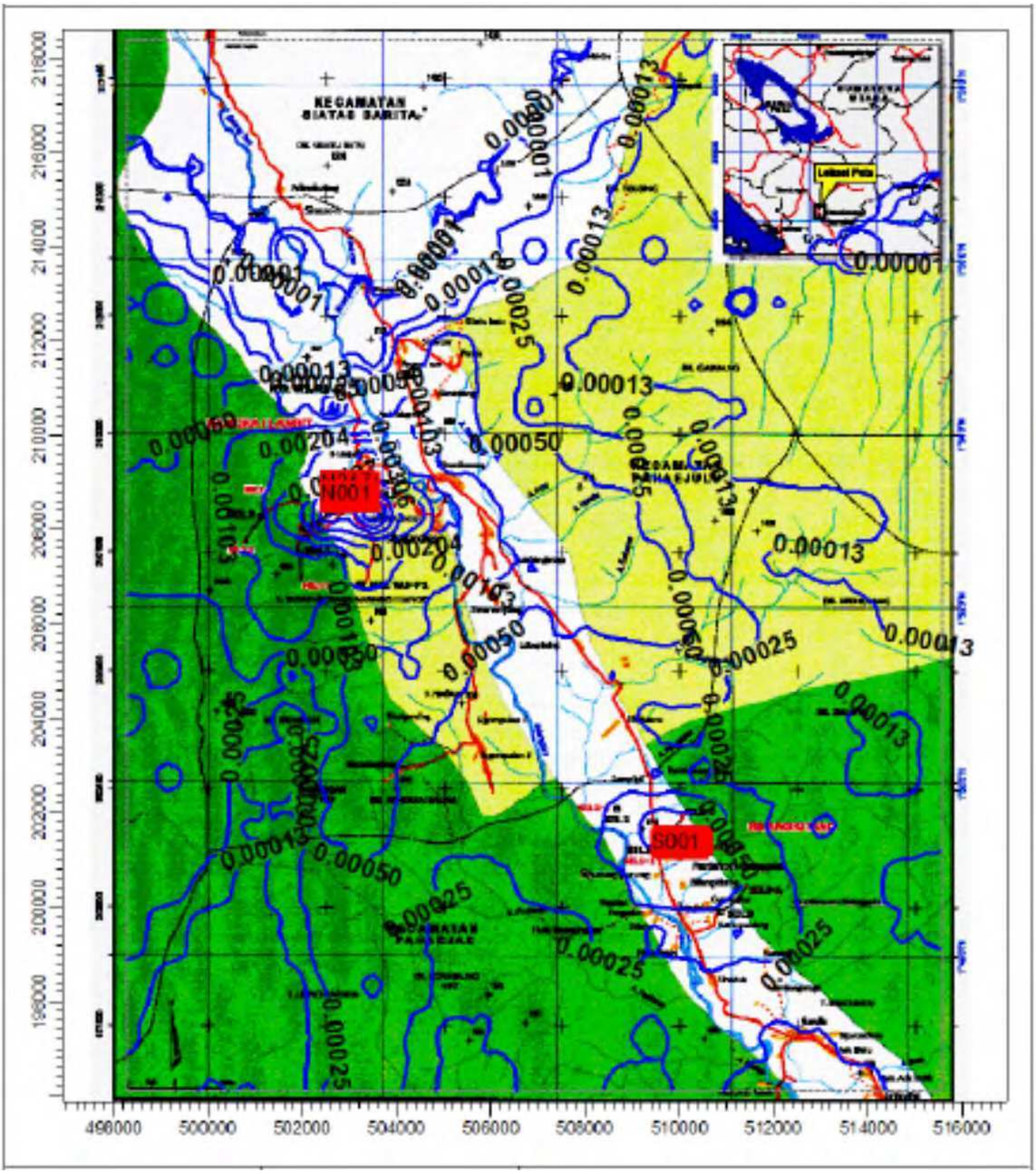
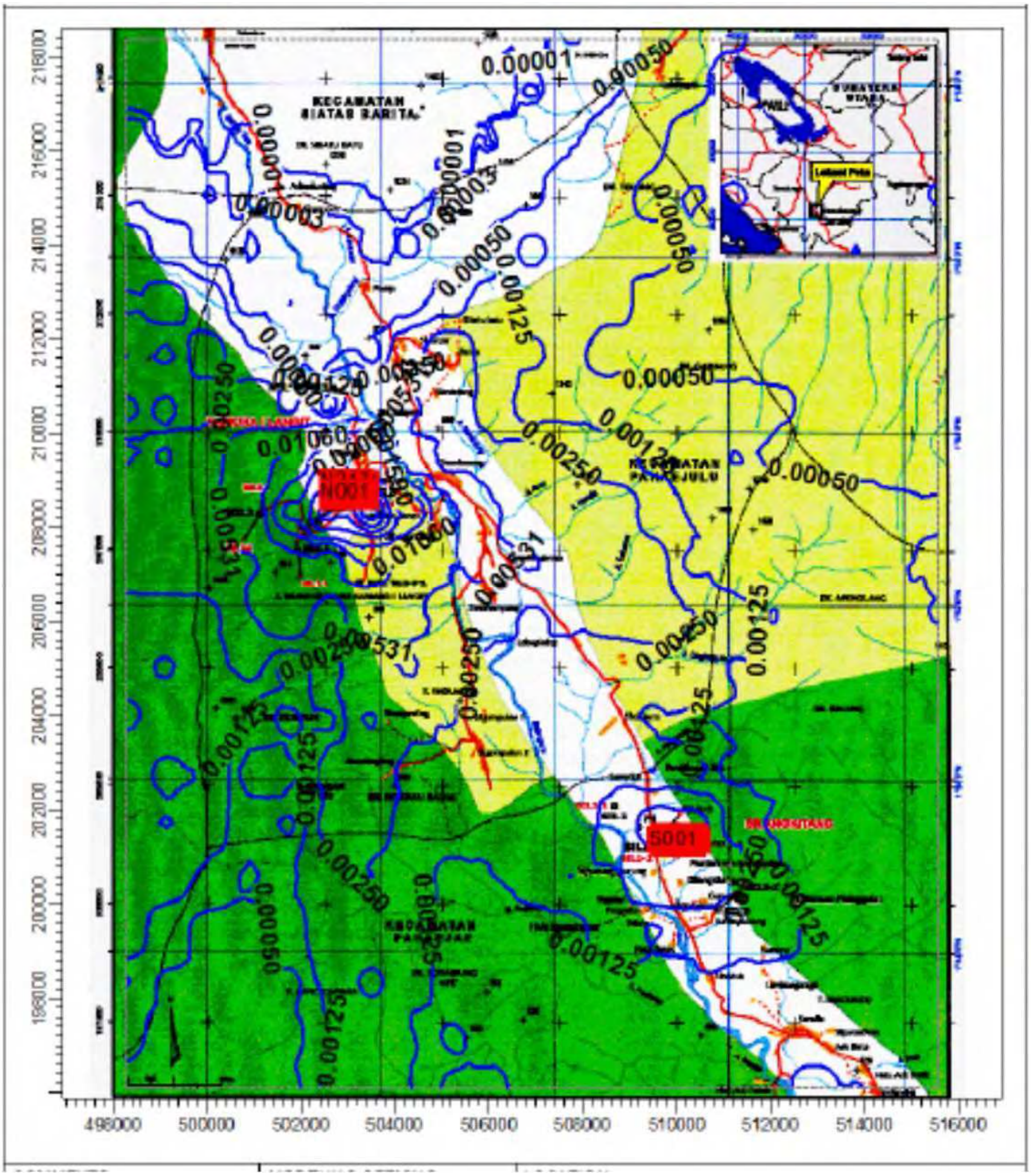


Figure III-16 Predicted H_2S Concentration, Periodic Average (Wet Season)



Note: Periodic Average means the average during the extreme wet season which is between the months of February to March.

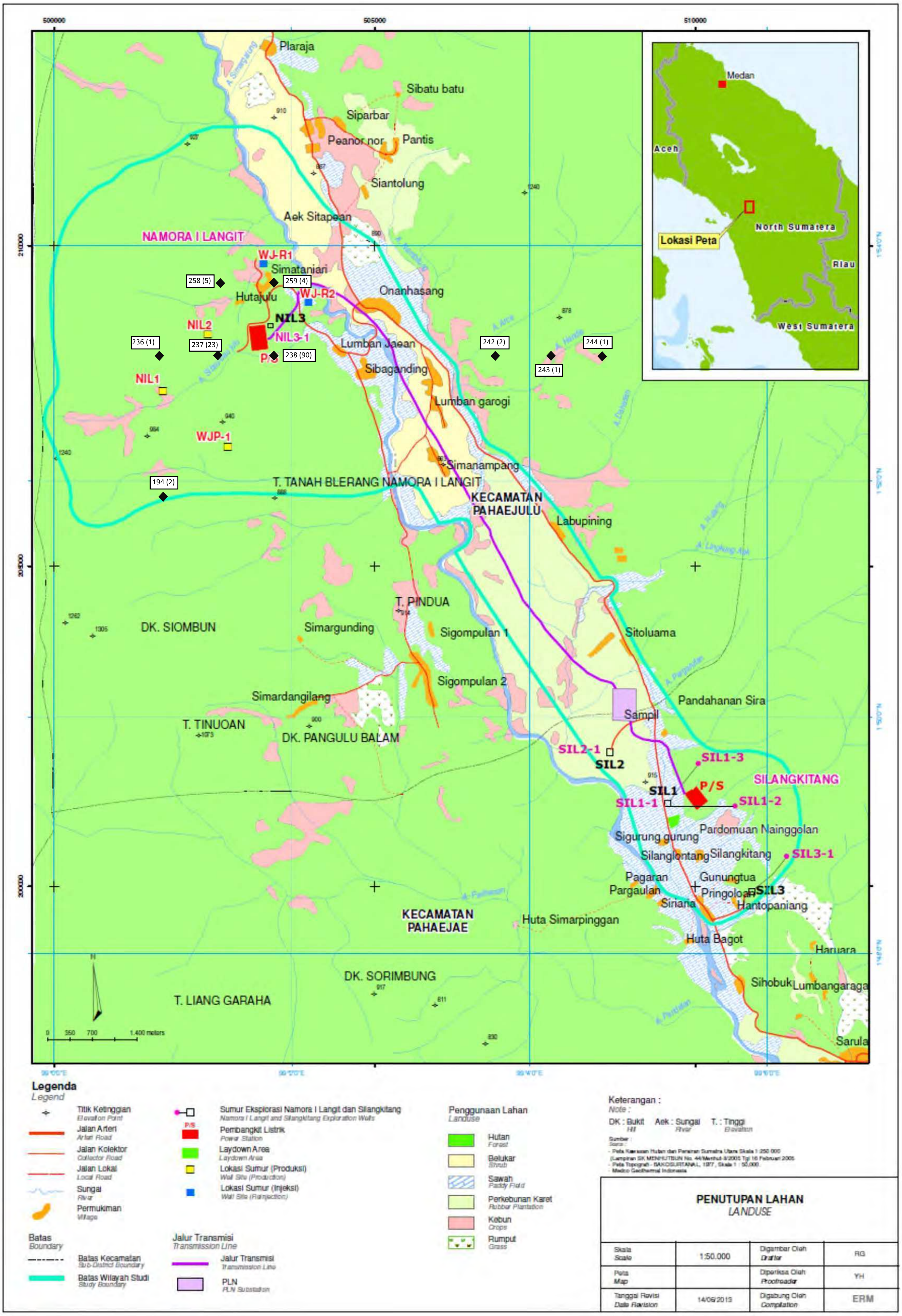
Figure III-17 Predicted H_2S Concentration; 24 Hr Average (Wet Season)



3.7.2.3 Updates on the number of households surrounding the project facilities

A review of the affected people was also updated. Based on the surveys made, there was no increase in the number of households around the immediate vicinity of the Power Plant, especially at NIL site receptor point 238 where the highest concentration of H_2S emission is projected to occur. Receptor 259 is located near a village but the number of occasions where H_2S exceeds the standard is low (4). Receptors 237/238 are located in forest area. Other receptors exceeding 0.02ppm are not located in residential area and the number of occasions are low (Figure III-18, Table III-15).

Figure III-18 H$_2$S Emission Receptor Points Exceeding 0.02ppm (30 µgram/m^3)



236 (1) First number denotes receptor point; Number inside brackets denotes number of times H$_2$S 24hr average emission exceeds 0.02ppm

Table III-15 Predicted Highest Concentration of H_2S Emission, 24 Hr Average

Coordinate		Receptor number Description of Location	Occurrence Period (no)	Date	Elevation (masl)	Concentration (ppm)
Easting	Northing					
504,323.5625	208,350.2969	Receptor 238	1	12 - Jan	824	0.053
504,323.5625	208,350.2969		2	02 - Feb	824	0.048
504,323.5625	208,350.2969		3	25 - Feb	824	0.048
504,323.5625	208,350.2969	Approximately 600	4	28 - Feb	824	0.021
504,323.5625	208,350.2969	meters souteast of	5	01 - Feb	824	0.038
504,323.5625	208,350.2969	NIL PLTP	6	10 - Mar	824	0.036
504,323.5625	208,350.2969		7	22 - Mar	824	0.025
504,323.5625	208,350.2969		8	26 - Mar	824	0.025
504,323.5625	208,350.2969	* Occassions = 90	9	27 - Mar	824	0.033
504,323.5625	208,350.2969		10	09 - Apr	824	0.021
504,323.5625	208,350.2969		11	11 - Apr	824	0.056
504,323.5625	208,350.2969		12	14 - Apr	824	0.025
504,323.5625	208,350.2969		13	16 - Apr	824	0.039
504,323.5625	208,350.2969		14	18 - Apr	824	0.045
504,323.5625	208,350.2969		15	23 - Apr	824	0.028
504,323.5625	208,350.2969		16	28 - Apr	824	0.022
504,323.5625	208,350.2969		17	30 - Apr	824	0.021
504,323.5625	208,350.2969		18	03 - May	824	0.029
504,323.5625	208,350.2969		19	04 - May	824	0.036
504,323.5625	208,350.2969		20	07 - May	824	0.031
504,323.5625	208,350.2969		21	08 - May	824	0.030
504,323.5625	208,350.2969		22	09 - May	824	0.038
504,323.5625	208,350.2969		23	11 - May	824	0.023
504,323.5625	208,350.2969		24	13 - May	824	0.030
504,323.5625	208,350.2969		25	19 - May	824	0.025
504,323.5625	208,350.2969		26	29 - May	824	0.021
504,323.5625	208,350.2969		27	30 - May	824	0.031
504,323.5625	208,350.2969		28	31 - May	824	0.060
504,323.5625	208,350.2969		29	06 - Jun	824	0.035
504,323.5625	208,350.2969		30	09 - Jun	824	0.048
504,323.5625	208,350.2969		31	10 - Jun	824	0.025
504,323.5625	208,350.2969		32	13 - Jun	824	0.030
504,323.5625	208,350.2969		33	15 - Jun	824	0.072
504,323.5625	208,350.2969		34	17 - Jun	824	0.020
504,323.5625	208,350.2969		35	21 - Jun	824	0.057
504,323.5625	208,350.2969		36	22 - Jun	824	0.024
504,323.5625	208,350.2969		37	30 - Jun	824	0.027
504,323.5625	208,350.2969		38	09 - Jul	824	0.025
504,323.5625	208,350.2969		39	26 - Jul	824	0.030
504,323.5625	208,350.2969		40	27 - Jul	824	0.040
504,323.5625	208,350.2969		41	01 - Aug	824	0.022
504,323.5625	208,350.2969		42	06 - Aug	824	0.033
504,323.5625	208,350.2969		43	12 - Aug	824	0.039
504,323.5625	208,350.2969		44	24 - Aug	824	0.047
504,323.5625	208,350.2969		45	08 - Sep	824	0.028

Coordinate		Receptor number Description of Location	Occurrence Period (no)	Date	Elevation (masl)	Concentration (ppm)
Easting	Northing					
504,323.5625	208,350.2969		46	09 - Sep	824	0.035
504,323.5625	208,350.2969		47	14 - Sep	824	0.022
504,323.5625	208,350.2969		48	15 - Sep	824	0.024
504,323.5625	208,350.2969		49	19 - Sep	824	0.034
504,323.5625	208,350.2969		50	22 - Sep	824	0.039
504,323.5625	208,350.2969		51	25 - Sep	824	0.038
504,323.5625	208,350.2969		52	27 - Sep	824	0.041
504,323.5625	208,350.2969		53	29 - Sep	824	0.028
504,323.5625	208,350.2969		54	30 - Sep	824	0.047
504,323.5625	208,350.2969		55	09 - Oct	824	0.055
504,323.5625	208,350.2969		56	31 - Oct	824	0.062
504,323.5625	208,350.2969		57	02 - Nov	824	0.032
504,323.5625	208,350.2969		58	10 - Nov	824	0.055
504,323.5625	208,350.2969		59	05 - Nov	824	0.031
504,323.5625	208,350.2969		60	11 - Nov	824	0.028
504,323.5625	208,350.2969		61	17 - Nov	824	0.048
504,323.5625	208,350.2969		62	22 - Nov	824	0.030
504,323.5625	208,350.2969		63	23 - Nov	824	0.023
504,323.5625	208,350.2969		64	24 - Nov	824	0.026
504,323.5625	208,350.2969		65	25 - Nov	824	0.025
504,323.5625	208,350.2969		66	26 - Nov	824	0.048
504,323.5625	208,350.2969		67	28 - Nov	824	0.026
504,323.5625	208,350.2969		68	29 - Nov	824	0.056
504,323.5625	208,350.2969		69	05 - Dec	824	0.062
504,323.5625	208,350.2969		70	06 - Dec	824	0.049
504,323.5625	208,350.2969		71	07 - Dec	824	0.028
504,323.5625	208,350.2969		72	11 - Dec	824	0.026
504,323.5625	208,350.2969		73	23 - Dec	824	0.023
504,323.5625	208,350.2969		74	25 - Dec	824	0.027
504,323.5625	208,350.2969		75	30 - Dec	824	0.021
504,323.5625	208,350.2969		76	12 - Jan	666	0.022
504,323.5625	208,350.2969		77	27 - Mar	666	0.026
504,323.5625	208,350.2969		78	04 - May	666	0.026
504,323.5625	208,350.2969		79	07 - May	666	0.024
504,323.5625	208,350.2969		80	08 - May	666	0.022
504,323.5625	208,350.2969		81	31 - May	666	0.025
504,323.5625	208,350.2969		82	15 - Jun	666	0.027
504,323.5625	208,350.2969		83	21 - Jun	666	0.022
504,323.5625	208,350.2969		84	19 - Sep	666	0.022
504,323.5625	208,350.2969		85	31 - Oct	666	0.025
504,323.5625	208,350.2969		86	05 - Nov	666	0.023
504,323.5625	208,350.2969		87	26 - Nov	666	0.023
504,323.5625	208,350.2969		88	29 - Nov	666	0.023
504,323.5625	208,350.2969		89	30 - Nov	666	0.021
504,323.5625	208,350.2969		90	11 - Dec	666	0.028

Coordinate		Receptor number Description of Location	Occurrence Period (no)	Date	Elevation (masl)	Concentration (ppm)
Easting	Northing					
502,592.9063	208,350.2969	Receptor 237	1	19 - Jan	874	0.044
502,592.9063	208,350.2969		2	26 - Jan	874	0.031
502,592.9063	208,350.2969		3	06 - Feb	874	0.032
502,592.9063	208,350.2969	near Sibau-bau Julu	4	10 - Feb	874	0.028
502,592.9063	208,350.2969		5	05 - Mar	874	0.029
502,592.9063	208,350.2969		6	13 - Mar	874	0.032
502,592.9063	208,350.2969	* Occasions = 23	7	21 - Mar	874	0.036
502,592.9063	208,350.2969		8	23 - Mar	874	0.024
502,592.9063	208,350.2969		9	27 - Apr	874	0.042
502,592.9063	208,350.2969		10	23 - May	874	0.021
502,592.9063	208,350.2969		11	27 - May	874	0.046
502,592.9063	208,350.2969		12	28 - May	874	0.021
502,592.9063	208,350.2969		13	26 - Jun	874	0.038
502,592.9063	208,350.2969		14	07 - Jul	874	0.036
502,592.9063	208,350.2969		15	16 - Jul	874	0.021
502,592.9063	208,350.2969		16	09 - Aug	874	0.044
502,592.9063	208,350.2969		17	16 - Aug	874	0.044
502,592.9063	208,350.2969		18	25 - Aug	874	0.023
502,592.9063	208,350.2969		19	31 - Aug	874	0.031
502,592.9063	208,350.2969		20	01 - Sep	874	0.039
502,592.9063	208,350.2969		21	01 - Oct	874	0.038
502,592.9063	208,350.2969		22	02 - Oct	874	0.060
502,592.9063	208,350.2969		23	24 - Oct	874	0.027
502,592.9063	209,464.1072	Receptor 258	1	22 - Apr	881	0.029
502,592.9063	209,464.1072	West of Simatniari	2	11 - Jul	881	0.033
502,592.9063	209,464.1072	*Occasions = 5	3	12 - Jul	881	0.026
502,592.9063	209,464.1072		4	15 - Jul	881	0.022
502,592.9063	209,464.1072		5	21 - Jul	881	0.036
503,458.2188	209,464.1719	Receptor 259	1	18 - Mar	746	0.023
503,458.2188	209,464.1719	At Simatniari	2	11 - Aug	707	0.024
503,458.2188	209,464.1719	*Occasions = 4	3	07 - Oct	746	0.027
503,458.2188	209,464.1719		4	05 - Sep	746	0.021
506,919.5625	208,350.2969	Receptor 242 (*A)	1	12 - Dec	752	0.037
506,919.5625	208,350.2969		2	12 - Dec	646	0.033
507,727.5625	206,122.5313	Receptor 194 (*B)	1	02 - Oct	886	0.030
507,727.5625	206,122.5313		2	20 - Nov	886	0.026
508,650.2188	208,350.2969	Receptor 244 (*C)	1	12 - Dec	889	0.020
507,784.8750	208,350.2969	Receptor 243 (*D)	1	12 - Dec	785	0.032
501,727.5625	208,350.2969	Receptor 236 (*E)	1	09 - Mar	992	0.021

* Occasion means the number of instances that 24hr average emission exceeds 0.02ppm

*A: Receptor 242; Northeast of Lumbang Garogi; Occasion = 2

*B: Receptor 194; West of T.Tanah Blerang; Occasions = 2

*C: Receptor 244; Northeast of Lumbang Garogi; Occassions = 1

*D: Receptor 243; Northeast of Lumbang Garogi; Occassions = 1

*E: Receptor 236; West of Sibau-bau Julu; Occassions = 1

3.7.2.4 *Comparison of the updated H_2S Dispersion Modelling results to the modelling results in the Project AMDAL.*

Parameter	*Updated H2S Dispersion Modelling Result*	*H2S Dispersion Modelling Result in the AMDAL*
Number of receptor-day points observed in each study	160, 965 receptor-day (441 receptor points x 365 days/year)	36,600 receptor-days 100 receptor points x 366 days/year
Annual Average Concentration of all receptor-day points	0.014 ppm	0.02067 ppm
Number of occasion that H_2S emission will not exceed the 0.02ppm level	160,836 receptor-days	36,301 receptor-days
Number of occasion that H_2S emission will exceed the 0.02ppm level	129 receptor-days	299 receptor-days
Percentage of occasions that the 0.02ppm level is exceeded compared to the total receptor-day points	0.080142 % (129 / 160,965)	0.81694 % (299/36,600)
Average emission of the receptor points that exceed the 0.02ppm level	0.03267 ppm	0.0467ppm
Occasion that the 150µg/m³ time weighted average on 24-hour averaging by WHO Standard is exceeded	None	None

3.7.3 *Impacts and Significance*

3.7.3.1 *Health Impact*

Based on the modelling result, the maximum annual average emission is predicted at 0.014ppm.

In respect to the 24hr average, aside from the occasions shown, the maximum predicted H_2S concentration for all receptors points are predicted not to exceed 0.02ppm. Table III-15 presents the dates and the values of the maximum emission on 24hr average that may exceed the 0.02ppm. There are 129 number of occasions by which the 002ppm is exceeded. Compared to the total receptor-days of 160,965 (441 receptor points read each daily for 365 days), this occurs 0.080142% in a year.

Even considering the highest concentration presented in Table III-15, the predicated highest concentration will be below the WHO guidelines of

150 µgram/m^3 (approximately 0.1 ppm) in all instances for all receptor points. Under this condition there is no predicted health hazard through the effects of H_2S emissions on ambient air quality from the project operation.

In respect to the odour limit set by Indonesian standard of 0.02ppm, in view of the non-continuous and very few days per year occasions that the odour limit is exceeded as tabulated in Table III-15, the impact is considered to be insignificant negative impact.

3.7.3.2 *Flora and Fauna*

Elevated H_2S levels can have positive and negative effects on vegetation, depending on the concentration. In low concentrations, H_2S has been researched as a potential fertiliser. Sulphur is a key ingredient in chlorophyll and helps maintain proper photosynthesis. Research has provided evidence that low doses (30 ppb) of hydrogen sulphide can actually increase crop yield and plant size.

Vegetation may display leaf damage and stunted growth at high doses of H_2S (100 to 500 ppm)[20]. The baseline studies illustrate that these levels of hydrogen sulphide have not been measured in the local environment and modelling predicts that these emission levels are not predicted from the Project. Therefore this type of plant damage is not predicted from Project levels of H_2S emissions.

The effect of H_2S on animals is very similar to humans and can be acute and/or chronic depending on exposure level. Evidence from human and animal studies suggests that the effects of H_2S are dose-dependent and the inhalation of high concentrations of H_2S (greater than 2000 ppm or 2780 mg/m^3) can be fatal within seconds or minutes[21]. No modelled results show this level of emission.

Whilst H_2S is a known neurotoxic hazard however, only a limited number of experimental animal studies have examined its neurochemical or behavioural effects[22]. Studies are laboratory based (predominantly on small mammals such as rodents) and may not be representative of conditions or species at the proposed Project site.

Concentrations illustrated by SOL's model (Figure III-18) are low. No data has been found for concentrations producing health impacts/behavioural effects for these levels of emissions in the natural environment or for species specific

[20] Thompson, R., Kats, G. (1978). Effects of continuous hydrogen sulfide fumigation on crop and forest plants. Environ. Sci. Technol., 1978, 12 (5), pp 550–553. DOI: 10.1021/es60141a001. May 1978
[21] USEPA (2003). Toxicological Review of Hydrogen Sulfide. www.epa.gov/iris/toxreviews/0061tr.pdf
[22] CIIT Centers for Health Research, USA (2013).

to the project area.

3.7.4 *Monitoring of H_2S Emissions*

The dispersion modelling utilised various assumed input data that are obtained through studies, simulations, correlations and historical data which during the stage of Project Operation and Construction, may differ than the actual ones. While the modelling had shown the expected level of H_2S contaminants on air to be well below the standards that may cause health hazard of odour nuisance, actual monitoring is still essential to ensure that actual results are reflective of the modelling results.

The Environmental Monitoring Plan (RPL) of the Project AMDAL shall be implemented to monitor the actual emission of H_2S from the Project (ERM, 2009).

3.7.5 *Management Plan*

Due to the expected low emission of H_2S from the Project, as shown by the dispersion modelling and being lower than the standards that may cause health hazard or odour nuisance, no major mitigation is steps are seen necessary.

In the project socialization, residents will continue to be educated and explained of the circumstances that the smell of H_2S may become present in the surrounding but are at the levels that are low enough not to cause health hazard to the environment.

In the event that the monitoring will show results exceeding the standards, as presented in the Environmental Management Plant (RKL), steps will be taken to reduce the emission level not to exceed the permitted Standards. Such step may include the installation of a commercially available abatement system such as LO-CAT system.

3.8 *CUMULATIVE IMPACT ASSESSMENT*

This Section will present explanation on the cumulative Impact Assessment.

To date, there are no major industries existing or planned in the project area. Therefore, consequently cumulative impact with other project is not predicted.

However, during the construction and operation phases, cumulative impact may be occurred from concurrent activities of the Project. The determination of impacts significance is discussed in the following subsections.

3.8.1 *H_2S*

Predicted H_2S concentration is as described in Section 3.5. On the condition that SIL and NIL are operated simultaneously, H_2S prediction is lower than the applicable regulation. Consequently it is categorized as insignificant negative impact.

3.8.2 *Noise*

Noise assessment typically includes a quantitative process in which future noise levels are modelled and compared against baseline and/or impact threshold levels. It is widely understood that humans respond to different types of noise in different ways. Hence, different standards are used to assess different types of noise.

SOL commissioned ERM to conduct a noise assessment of the Project with the following objectives:

- Review project data and/or information as relevant to the assessment;
- Identify noise generating activities associated with construction and operational stages of the project;
- Identify the closest and/or potentially most affected noise receptors located in the vicinity of noise generating activities;
- Predict project noise levels (via 3d modelling) at all identified noise receptors, for construction and operational aspects of the project;
- Compare the predicted project noise levels to local and international policy, standards and guidelines and identify any exceedances of criteria; and
- Provide preliminary noise control mitigation, management measures and/or monitoring options design to minimise noise levels, and potential impacts, at applicable noise receptors.

The noise assessment study is provided in full in Annex G and summarised in the following subsections.

3.8.2.1 *Relevant Policy, Standards and Guidelines*

In the case when applying both jurisdictional and lender standards, the more stringent of the two is used in the assessment. In all cases the assessment should still evaluate compliance with jurisdictional requirements.

This noise impact assessment has been completed with due regard to and in accordance with the following national legislation and international policy, standards and guidelines:

- Indonesian National – The Minister of Environment Decree No. 48 Year 1996 (Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard);
- International Finance Corporation - World Bank Group (IFC) - Environmental, Health and Safety (EHS) Guidelines - General EHS Guidelines: Environmental Noise Management, Section 1.7 Noise (IFC 1.7

Noise); and

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

Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard and IFC 1.7 Noise were referred to develop the project-specific noise criteria. Standards or guidance provided in Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard are minimal and as such the criteria presented in IFC 1.7 Noise have been adopted for use in this project.

The project-specific noise criteria are outlined in Table III-16.

Table III-16 Project-Specific Noise Criteria

Receptor	*Maximum Allowable (free field) Noise Levels LAeq, 1hr dB(A)*	
	Daytime 07:00 – 22:00	*Night-time 22:00 – 07:00*
Residential, institutional, educational	55	45
Industrial, commercial	70	70

In addition the fixed values described above, IFC states that "*impacts should not exceed the levels presented in* Table III-16, *or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site*". In this case, ambient noise level measurements were taken for the project, over a period of 24 hours, during the daytime and night time assessment periods. Noise levels ranged between 41 dB(A) and 51 dB(A). 41 dB(A) is adopted here to represent an approximate Assessment Background Level (ABL) for all receptors during both daytime and night time periods. Thus a permissible level of 44 dB(A) specified for this project.

3.8.2.2 *Evaluating Impact Significance*

Predicted noise levels are compared to criteria to determine and exceedances and to evaluate the magnitude and extend of any impacts. Typical impact assessment methodologies require an approach that combines impact magnitude with receptor sensitivity to determine impact significance, thus:

Receptor Sensitivity X Impact Magnitude >> Impact Significance

For most environmental impact aspects this allows a significance matrix to be used that combines receptor sensitivity with impact magnitude. For noise, however, we can predict noise levels quantitatively and compare them against impact assessment standards that are receptor specific taking into account receptor sensitivity.

This is standard practice for ERM, who are experienced globally at the assessment of potential noise impacts. Furthermore, many numerical noise standards are source specific (e.g. industrial noise is different to aircraft noise), some refer to baseline levels, and there can be a number of other factors that determine impact significance. For noise impact significance, the assessment considers the type of receptor, draw on relevant standards or guidance to determine impact magnitude, and then consider any other factors to determine significance. The impact assessment methodology is explained in detail in Annex G.

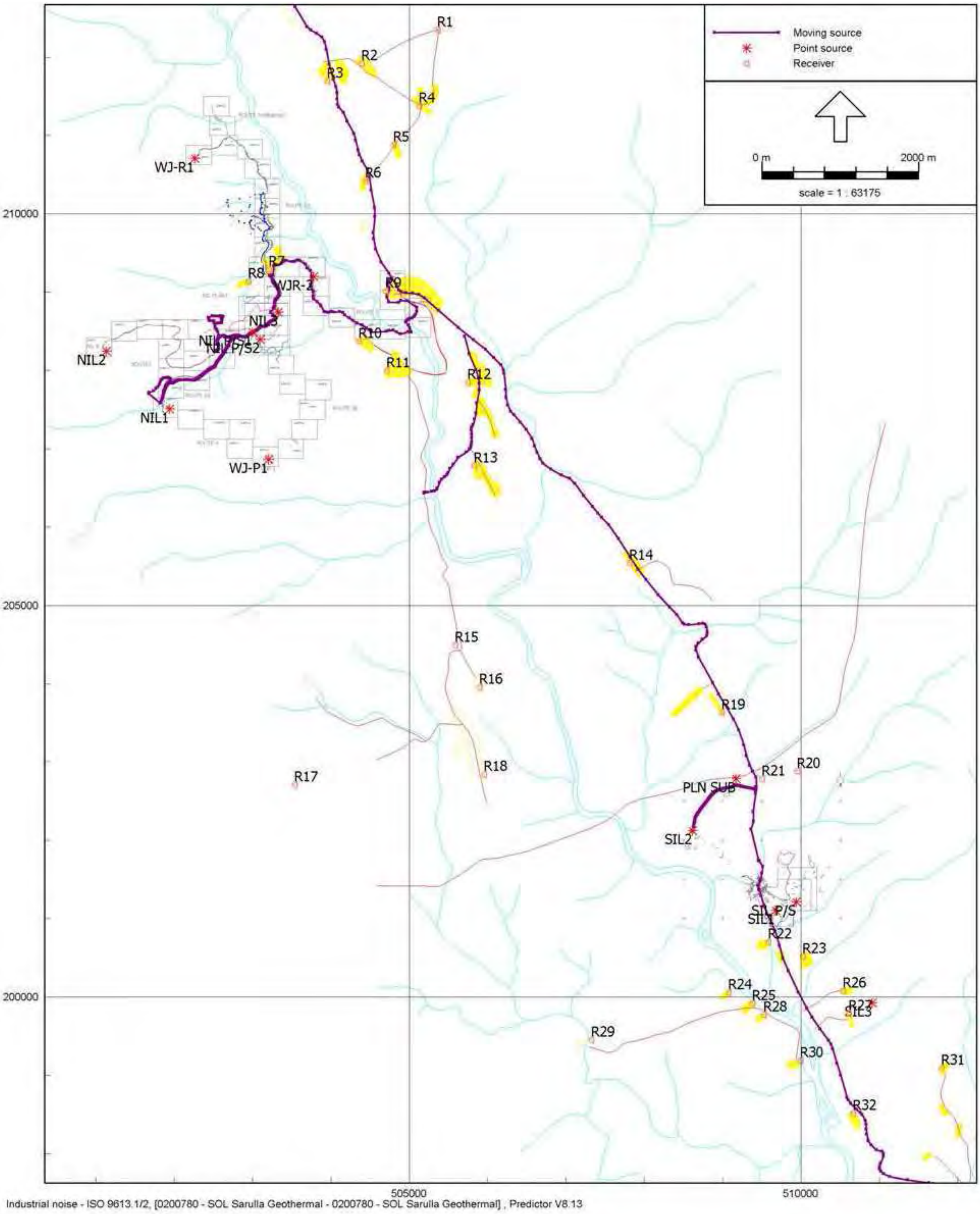
3.8.2.3 Noise Modelling

3D noise modelling is used to predict representative worst-case noise levels for construction and operational aspects of a project. In this case the predicted noise levels are then to local and international noise criteria; to identify any exceedances and to inform any noise control mitigation, management and/or monitoring options.

Construction and operational noise is modelled separately, except for in this case, one scenario where a potential overlap of construction and operational noise is considered to assess the potential cumulative noise impact. The Project schedule (Chapter 2) identifies an extended (~14 month) overlap of construction and operational activities where operations at SIL commence with construction works at NIL continuing.

Modelling was conducted for 32 noise receptors (assessment locations) nominated to be representative of the closest and/or potentially most affected noise receivers located in the vicinity of project noise generating areas (detailed in Annex G and illustrated in Figure III-19).

Figure III-19 Noise Modelling Assessment Receptor Locations



Based on ERM's detailed review of project data and/or information as relevant to the assessment and in consultation with SOL the following noise assessment scenarios were developed for construction and operational aspects.

- Construction Assessment Scenario (CASc01) presents the type of plant and equipment, their location and likely quantity during general construction works;
- Construction Assessment Scenario (CASc02) presents the same scenario as CASc01 with the inclusion of drill rigs in use;
- Construction Assessment Scenario (CASc03) presents the same scenario as CASc01 with the inclusion of steam blowing tests in progress;
- Construction Assessment Scenario (CASc04) presents the type of plant and equipment, their location and likely quantity during transmission line construction works;
- Operational Assessment Scenario (OASc01) using operation noise source data from SOL; and
- Combined Construction and Operational Assessment Scenario (COASc01) – inputs as above with addition of operation noise source data from SOL;

All data inputs and assumptions are detailed in Annex G. It should be noted that ERM used a "moving point source" to represent project vehicle movements on the local area road network; all other noise emission sources are represented by point sources.

3.8.2.4 Predicted Noise Levels

This section presents the resultant noise levels predicted via 3D modelling and comparison to the project-specific noise criteria, any exceedances are highlighted in bold typeset. All data inputs presented in Section 2of this noise impact assessment report were relied upon for the purposes of this modelling.

3.8.2.4.1 Construction Noise

Predicted construction noise levels are presented in Tables III-17 to III-20 and illustrated in location maps in Annex G.

Table III-17 Construction Assessment Scenario (CASc01)

Noise Receptor		*Predicted Project Noise Level*	*Project Specific Noise Criteria*	
ID	*Description*	*LAeq, 1hr dB(A)*	*Daytime 07:00 – 22:00*	*Night-time 22:00 – 07:00*
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	31	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	33	55	45
R7	Hutajulu	42	55	45
R8	Simataniari	41	55	45
R9	Onanhasang	36	55	45
R10	Lumbanjaean	30	55	45
R11	Sibaganding	30	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	39	55	45
R20	Pandahanan Sira	42	55	45
R21	Sampil	32	55	45
R22	Sigurung-gurung	**47**	55	45
R23	Silangkitang	44	55	45
R24	Pagaran	36	55	45
R25	Pargaulan	36	55	45
R26	Gunungtua	39	55	45
R27	Rantopanjang	38	55	45
R28	Siriaria	35	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	33	55	45

Table III-18 Construction Assessment Scenario (CASc02)

Noise Receptor		*Predicted Project Noise Level*	*Project Specific Noise Criteria*	
ID	*Description*	*LAeq, 1hr dB(A)*	*Daytime 07:00 – 22:00*	*Night-time 22:00 – 07:00*
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	33	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	33	55	45
R7	Hutajulu	**46**	55	45
R8	Simataniari	44	55	45
R9	Onanhasang	37	55	45
R10	Lumbanjaean	31	55	45
R11	Sibaganding	32	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	39	55	45
R20	Pandahanan Sira	43	55	45
R21	Sampil	32	55	45
R22	Sigurung-gurung	**52**	55	45
R23	Silangkitang	**47**	55	45
R24	Pagaran	40	55	45
R25	Pargaulan	41	55	45
R26	Gunungtua	**48**	55	45
R27	Rantopanjang	**47**	55	45
R28	Siriaria	39	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	37	55	45
R31	Hariara	35	55	45
R32	Sihobuk	36	55	45

Table III-19 Construction Assessment Scenario (CASc03)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
ID	*Description*	*LAeq, 1hr dB(A)*	*Daytime 07:00 – 22:00*	*Night-time 22:00 – 07:00*
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	33	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	33	55	45
R7	Hutajulu	43	55	45
R8	Simataniari	42	55	45
R9	Onanhasang	37	55	45
R10	Lumbanjaean	30	55	45
R11	Sibaganding	31	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	39	55	45
R20	Pandahanan Sira	42	55	45
R21	Sampil	32	55	45
R22	Sigurung-gurung	**49**	55	45
R23	Silangkitang	45	55	45
R24	Pagaran	39	55	45
R25	Pargaulan	39	55	45
R26	Gunungtua	43	55	45
R27	Rantopanjang	42	55	45
R28	Siriaria	38	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	34	55	45
R31	Hariara	30	55	45
R32	Sihobuk	34	55	45

Table III-20 Construction Assessment Scenario (CASc04)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
ID	Description	LAeq, 1hr dB(A)	Daytime 07:00 – 22:00	Night-time 22:00 – 07:00
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	31	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	36	55	45
R7	Hutajulu	**54**	55	45
R8	Simataniari	44	55	45
R9	Onanhasang	39	55	45
R10	Lumbanjaean	34	55	45
R11	Sibaganding	36	55	45
R12	Lumbang garoga	41	55	45
R13	Simanam pang	**51**	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	33	55	45
R20	Pandahanan Sira	37	55	45
R21	Sampil	30	55	45
R22	Sigurung-gurung	47	55	45
R23	Silangkitang	42	55	45
R24	Pagaran	37	55	45
R25	Pargaulan	37	55	45
R26	Gunungtua	39	55	45
R27	Rantopanjang	39	55	45
R28	Siriaria	36	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	33	55	45

3.8.2.4.2 *Operational Noise*

Predicted operational noise levels are presented in Table III-21.

Table 11-21 Operational Assessment Scenario (OASc01)

Noise Receptor		*Predicted Project Noise Level*	*Project Specific Noise Criteria*	
ID	*Description*	*LAeq, 1hr dB(A)*	*Daytime 07:00 – 22:00*	*Night-time 22:00 – 07:00*
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	<30	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	<30	55	45
R7	Hutajulu	30	55	45
R8	Simataniari	30	55	45
R9	Onanhasang	<30	55	45
R10	Lumbanjaean	<30	55	45
R11	Sibaganding	<30	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	<30	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	<30	55	45
R20	Pandahanan Sira	<30	55	45
R21	Sampil	<30	55	45
R22	Sigurung-gurung	34	55	45
R23	Silangkitang	32	55	45
R24	Pagaran	<30	55	45
R25	Pargaulan	<30	55	45
R26	Gunungtua	<30	55	45
R27	Rantopanjang	<30	55	45
R28	Siriaria	<30	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	<30	55	45

3.8.2.4.3 Combined Construction and Operational Noise

Predicted construction and operational noise levels are presented in Table III-22.

Table III-22 Construction and Operational Assessment Scenario (COASc01)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
ID	Description	LAeq, 1hr dB(A)	Daytime 07:00 – 22:00	Night-time 22:00 – 07:00
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	<30	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	<30	55	45
R7	Hutajulu	41	55	45
R8	Simataniari	41	55	45
R9	Onanhasang	32	55	45
R10	Lumbanjaean	<30	55	45
R11	Sibaganding	30	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	<30	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	<30	55	45
R20	Pandahanan Sira	<30	55	45
R21	Sampil	<30	55	45
R22	Sigurung-gurung	34	55	45
R23	Silangkitang	32	55	45
R24	Pagaran	<30	55	45
R25	Pargaulan	<30	55	45
R26	Gunungtua	<30	55	45
R27	Rantopanjang	<30	55	45
R28	Siriaria	<30	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	<30	55	45

3.8.2.5 *Findings*

The above model results are discussed in terms of disturbance and amenity impacts.

3.8.2.5.1 *Disturbance Impacts*

Disturbance impacts from Project modeled noise levels are as follows:

- General construction noise levels (*Construction Assessment Scenario (CASc01))* are below the project specific noise criteria at the majority of noise receptors. *Negligible* impacts are predicted for the daytime period. *Moderate* impacts are predicted during the night time period for a very limited number of noise receptors (one location) located in near proximity to areas of potential project noise emission;
- General construction noise levels including well drilling activities (*Construction Assessment Scenario (CASc02))* are typically below the project specific noise criteria at the majority of noise receptors. *Negligible* or *Minor* impacts are predicted for the daytime period. *Moderate* and *Major* impacts are predicted for a limited number of noise receptors (five locations: one *Major*; four *Moderate*) located in near proximity to area of potential project noise emission;
- General construction noise levels including steam blowing activities (*Construction Assessment Scenario (CASc03))* are below the project specific noise criteria at the majority of noise receptors. *Negligible* or *Minor* impacts are predicted for the daytime period. *Moderate* impacts are predicted during the night time period for a very limited number of noise receptors (one location) located in near proximity to area of potential project noise emission;
- General construction noise levels including transmission line activities (*Construction Assessment Scenario (CASc04))* are below the project specific noise criteria at the majority of noise receptors. *Negligible* or minor impacts are predicted for the daytime period. *Major* impacts are predicted during the night time period for a limited number of noise receptors (two locations) located in near proximity to area of potential project noise emission;
- Operational noise levels (*Operational Assessment Scenario (OASc01))* are predicted to be below the project specific noise criteria at all noise receptors. *Negligible* impacts are predicted for both the daytime and night time periods; and
- Combined construction and operational noise levels (*Construction and Operational Assessment Scenario (COASc01)*) are predicted to be below the project specific noise criteria at all noise receptors. *Negligible* impacts are predicted for both the daytime and night time periods.

3.8.2.5.2 Amenity Impacts

As discussed, 41 dB(A) was selected to represent an approximate Assessment Background Level (ABL) for all receptors during both daytime and night time periods. On consideration of the applicable regulations and standards, ERM adopted a permissible level of 44 dB(A) for this project in accordance with the more stringent standards of IFC.

To provide comparison to this supplementary criterion the previously predicted noise levels ($L_{Aeq,\ 1hr}$) must first be converted from the L_{Aeq} parameter (which represents ambient or average noise levels) to the L_{A90} parameter (which represents background or constant noise levels). To do this ERM has applied a 5 dB(A) reduction to predicted construction noise levels, which are typically dynamic in nature and a 3 dB(A) reduction to operational noise levels, which are typically constant in nature.

Doing this results in maximum construction noise levels of between 44 dB(A) (general construction) and 51 dB(A) (transmission line works) indicating a temporary increase in background noise levels. Maximum operational noise levels of 31 dB(A) indicating no increase in background noise level and maximum combined construction and operational noise level 38 dB(A) also indicating no increase in background noise levels.

These temporary noise level increases during representative worst-case construction works noted here are consistent with the findings of the disturbance impacts assessment, which associated exceedances during the works to the closest and/or potentially most affected noise receptors in near proximity to works.

3.8.2.6 Recommendations

This section presents the recommendations and conclusions based on the findings of the noise impact assessment.

3.8.2.6.1 Operational Noise

ERM makes no further recommendations for noise control mitigation, management measures or monitoring options to those already scheduled for the project or incorporated into the design plans.

3.8.2.6.2 Construction Noise

Based on the limited number of exceedances and temporary increase in background noise levels, assessed in accordance with IFC, it is recommended that:

- High noise level generating construction works (including drilling and steam blowing activities) be limited to the daytime (07:00 to 22:00) period, if they are to be undertaken in near proximity to noise receptors;

- Prior to construction and during design of the construction methodology, equipment with lower sound power levels than those specified in this report are selected. This may extend to include the installation of silencers for fans, suitable mufflers on engine exhausts and compressor components if considred a more achievable approach to reducing nosie emissions;
- Installing acoustic barriers/screens or utilising site objects or topography to block direct line of site between high noise level generating activities and potentially impacted noise receptors. Where acoustic barriers or screens are preferred, they should be constructed without gaps or cracks and with a continuous minimum surface density of 10 kg/m^2 in order to minimise the transmission of sound through the barrier. Barriers should be located as close as possible to the source or to the receptor location to be effective;
- Noise sources are re-located to less sensitive areas to take advantage of distance and shielding. This may extent to siting permanent construction facilities as far away from community areas as is possible;
- Project traffic routing through community areas is reduced wherever possible; and
- The Project grievance mechanism is used to record and respond to complaints.

3.8.2.6.3 Construction Noise Management Plan

Detailed procedures for the management of construction noise across the project should be developed as part of the project Environmental Management System (EMS) with documented procedures included in the Construction Noise Management Plan (CNMP). These procedures should include those presented above and may extend to inlcude general good practice requirements, such as:

- Establish permanent signage around the site e.g. At site offices, that is visible to all personnel, which identifies the need to limit noise e.g. 'please respect our neighbours and keep noise to a minimum';
- Provide relevant personnel with training in noise control procedures and equipment operation; and
- Establish a project complaints register and manage community complaints, as required.

The CNMP should include the following broad objectives:

- Manage construction in a way that minimises noise impacts to environment and neighbours, and limits interference to production; and
- To keep the local community and regulators informed of activities where required and to respond quickly and effectively to issues and complaints.

To ensure that the CNMP remains a reliable and robust noise control, mitigation and management tool, it should be regularly reviewed and updated during construction. The review of the CNMP should also coincide with any major infrastructure or procedural changes within the project site. Remedial measures should be noted in the CNMP, where required to be implemented to reduce noise impacts to levels below that of the project-specific noise criteria.

3.8.2.7 Residual Construction Noise Impacts

Following adequate implementation of the recommended noise control mitigation measures as described in this report, it is anticipated that noise levels would be reduced significantly (approximately 5 dB(A) to 10 dB(A)), and impacts, if any, should be reduced to be at a Negligible or Minor level. Development of a suitable CNMP will assist to maintain lower noise levels and where elevated levels are noted, to determine appropriate actions to mitigate the source of the emission.

3.8.3 Water Quality

The locations of SIL re-injection wells are different from NIL's. Consequently based on the cumulative nature of impacts, it is considered as insignificant negative impact.

3.8.4 Exposure of Electromagnetic Field

SIL and NIL transmission line are planned to the PLN substation respectively. And the route of 275 kV line of PLN is around 1 km far from SIL and NIL transmission line. Consequently based on the cumulative nature of impacts, it is considered as insignificant negative impact.

4 INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

4.1 OVERVIEW

This Section presents the Information Disclosure, Consultation and Participation activities conducted by SOL. These are requirements set out in the Asian Development Bank's (ADB) Safeguard Policy Statement (SPS) 2009 and in the International Finance Corporation's (IFC) Performance Standards (PS) 2012. This Chapter specifically discusses Information Disclosure, Consultation and Participation requirements, activities undertaken with the identified Project communities, government agencies and representative groups (e.g. farming) and planned future activities.

4.2 INTERNATIONAL CONSULTATION REQUIREMENTS

4.2.1 *Asian Development Bank (ADB)*[23]

The ADB's SPS and Public Communications Policy emphasise the importance of consultation and public participation in development projects, particularly with those people who are likely to experience social impacts as a result. The consultation and public participation process must be substantive and meaningful. It should be performed at the initial phase of the project, through open and transparent procedures and without coercion. The ADB also emphasise the importance of involving stakeholders in the decision-making stages of the project. Stages may include the design, impact assessment, mitigation planning, and implementation phases.

As discussed in Chapter 1, the ADB SR defines clients' roles and responsibilities for project management—including requirements for information disclosure. There are a total of four Safeguard Requirements, three of which contain specific requirements for public consultation and disclosure:

- Safeguard Requirements 1: Environment;
- Safeguard Requirements 2: Involuntary Resettlement; and
- Safeguard Requirements 3: Indigenous People.

Details of consultation and disclosure requirements for each of these SR are as to:

- Carry out meaningful consultation with affected people and facilitate their informed participation;

[23] http://www.adb.org/documents/safeguard-policy-statement

- Ensure women's participation in consultation;
- Involve stakeholders, including affected people and concerned Non-governmental organisations (NGOs), early in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account; and
- Continue consultations with stakeholders throughout project implementation as necessary to address issues related to the environmental assessment.

4.2.2 *International Finance Corporation (IFC)*[24]

4.2.2.1 *IFC Performance Standard (PS)*

The IFC has adopted policy requirements and guidelines (IFC PS) relevant to public consultation and disclosure to ensure projects are implemented in an environmentally and socially responsible manner.

The IFC's Policy on Social and Environmental Sustainability highlights the need for community engagement and broad community support. Specifically, it states that the *IFC is committed to working with the private sector to put into practice processes of community engagement that ensure the free, prior, and informed consultation of the affected communities … leading to broad community support for the project within the affected communities…* The IFC's definition of broad community support is *a collection of expressions by the affected communities, through individuals or their recognized representatives, in support of the project.*

The IFC PSs on Social and Environmental Sustainability define clients' roles and responsibilities for project management—including requirements for information disclosure. There are a total of eight PSs, six of which contain specific requirements for public consultation and disclosure:

- PS 1: Assessment and Management of Environmental and Social Risks and Impacts;
- PS 2: Labour and Working Conditions;
- PS 5: Land Acquisition and Involuntary Resettlement;
- PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;

[24] http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Sustainability+Framework+-+2012/Performance+Standards+and+Guidance+Notes+2012/

- PS 7: Indigenous Peoples; and
- PS 8: Cultural Heritage.

These relevant PSs are summarised briefly, with respect to public consultation and disclosure, as follows:

PS 1 establishes the importance of effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them. Community engagement is defined as *an on-going process involving the client's disclosure of information, free of external manipulation, interference, or coercion, and intimidation, and conducted on the basis of timely, relevant, understandable and accessible information*.

IFC articulates three general topics within the framework of community engagement:

1) Disclosure;

2) Consultation; and

3) Grievance Mechanisms.

Disclosure refers to the public disclosing key project documents; importantly the assessment document. The information disclosed will detail the purpose, nature and scale of the project, the duration of proposed project activities and the nature of potential risks and impacts.

Consultation refers to a process undertaken by the client that provides the affected communities with an opportunity to express their views on project risks, impacts and mitigation measures. Such consultation should also allow the client to consider and respond to community inputs. It should also be tailored to the language preferences and decision-making process of the affected communities and to the needs of disadvantaged or vulnerable groups. For projects with significant adverse impacts on affected communities, Informed Consultation and Participation (ICP) must be undertaken capturing men and women's views, concerns and priorities. Such consultation must be documented—particularly the measures taken to avoid or minimize risks to, and adverse impacts on, the affected communities.

Reporting refers to the formal process for compiling and presenting written information about technical aspects of project design, as well as for project action and implementation plans. The IFC requires clients to disclose to affected communities an Action Plan describing specific mitigation measures and actions necessary for the project to comply with applicable laws and regulations as well as with the requirements of the PSs. Clients must also provide periodic reports that describe progress against the Action Plan implementation. Reported issues should include on-going risks to, or impacts on, affected communities and on issues of concern identified via the consultation process or grievance mechanism. Reports must be accessible to the affected communities and distributed regularly (not less than annually).

PS 2 requires consultation in cases of large-scale retrenchment. In such cases, the client must ensure consultation with employees, their representative organisations and the government (where appropriate) in a manner that is absent of discrimination.

PS 5 requires consultation on matters associated with land acquisition and involuntary resettlement and evidence of informed participation with the affected persons and communities in the decision-making processes. It stipulates that consultation *will continue during the implementation, monitoring, and evaluation of compensation payment and resettlement*.

In **PS 6** the need for community consultation is understood as integral to defining an appropriate system of independent certification for the sustainable management of natural living resources.

Under **Performance Standard 7**, when a project initiative affects Indigenous Peoples (IPs), the client must work to establish an on-going relationship with the IPs. Projects with adverse impacts require a process of Free, Prior, and Informed Consent (FPIC) with affected IPs to facilitate their informed participation and consent on matters that affect them directly. The engagement process must be culturally appropriate and commensurate with the risks and potential impacts to the IPs. To ensure these aims are met, the IFC mandates the following steps:

- Involve IP representative bodies (e.g. councils of elders or village councils, etc.) as well as members of the affected IP communities;
- Be inclusive of both women and men and of various age groups in a culturally appropriate manner;
- Provide sufficient time for IP collective decision-making processes;
- Facilitate the IPs views, concerns, and proposals in the language of their choice, without external manipulation, interference, or coercion, and without intimidation; and
- Ensure that the grievance mechanism is culturally appropriate and accessible.

The IFC also requires clients to identify opportunities for culturally appropriate development benefits that are commensurate with the degree of project impacts. The aim of which is to improve the standard of living and livelihoods of IPs in a manner that fosters the long-term sustainability of the natural resources upon which indigenous communities rely.

Performance Standard 8 states that where a project may affect cultural heritage, the proponent must consult with affected communities who use, or have used within living memory, the cultural heritage for longstanding cultural purposes. A project must also incorporate the views of the affected communities on such cultural heritage into its decision-making process. Consultation will also involve the relevant national or local regulatory agencies that are entrusted with the protection of cultural heritage.

4.2.2.2 *Policy on Disclosure of Information*

The 2012 IFC *Policy on Disclosure of Information* is a 13-page document outlining the scope of materials that the IFC makes publically available—either on a routine basis or upon request. This disclosure policy is intended to reflect the IFC's commitment to transparent business practices in-line with its Policy on Social and Environmental Sustainability and the PSs.

In accordance with the prescripts of IFC's PSs, the disclosure policy requires that IFC clients self-disclose information to project-affected parties about all types of adverse environmental and social impacts that could potentially result from the project, as well as the client's plan to mitigate or eliminate these impacts.

4.3 *NATIONAL CONSULTATION REQUIREMENTS*

SOL is committed to enforce all applicable laws and regulations of the Indonesian Government. The below summarises the relevant articles and paragraphs in the laws and regulations in relation to public consultation and disclosure that SOL will comply with:

- Act No. 32 Year 2009 regarding Environmental Protection and Management:
- Outlines requirements for public involvement and information disclosure during the AMDAL process.
- Outlines the importance of social and environmental resources and values and delegates responsibility to project proponents to protect and preserve these values.
- Requires project proponents to conduct stakeholder engagement during project scoping.
- Requires project proponents to obtain community input into the project risk assessment process and definition of the project social zone of impact.
- Minister of Environment Regulation No. 17 Year 2012 regarding Guidelines for Community Involvement in the Process of Environmental Impact Assessment and Environmental Permits

- Outlines requirements for community involvement and information disclosure during the AMDAL process and Environmental Permits.
- Requires all development projects to involve the community - providing information in a transparent and accountable manner, equality among parties, resolving problems fairly and wisely, coordinating and communicating across all parties.

4.4 CULTURALLY SENSITIVE CONSULTATION AND PARTICIPATION ACTIVITIES

4.4.1 *Identification of Stakeholders*

Stakeholders are defined *as people or entities that are affected or may have an interest in the Project*. SOL's key stakeholders were identified through a stakeholder analysis process at the beginning of the Project. During this process stakeholders were categorised by identity, roles and interest in and influence on the Project. The key stakeholders were categorized into three groups (Figure IV-1):

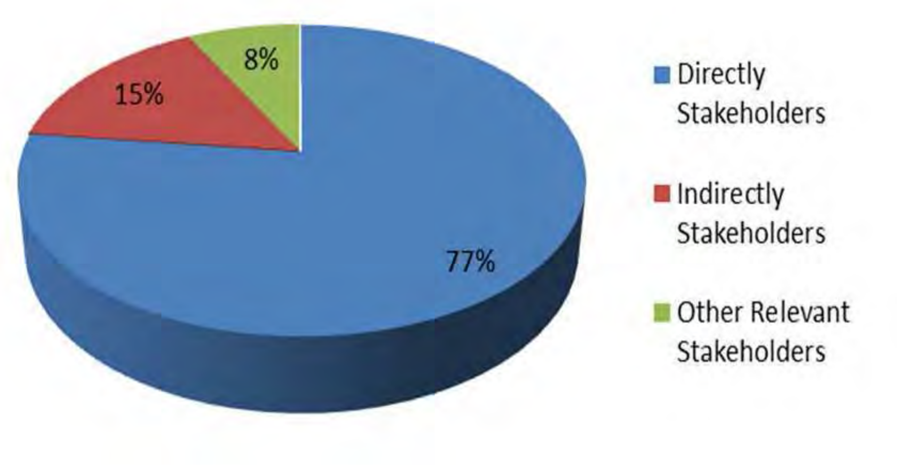
1) Directly Impacted Stakeholders: People or entities that are directly affected by the Project and/or have been identified as most vulnerable to changes due to Project. They require engaging when identifying impacts, stakeholder's significance and during mitigation and management measure discussions. Direct stakeholders include land owners, village heads, community and religious leaders and the sub-district head as well as villagers in project affected communities.

2) Indirectly Impacted Stakeholders: People or entities that are could be indirectly affected by the Project. Indirect stakeholders include NGOs, Civil Society Organisations (CSOs).

3) Other Relevant Stakeholders: People or entities who are interested in the Project.

Tables IV-1 and IV-2 present the concerns, issues and perceptions of the communities in the Pahae Jae and Pahae Julu Sub Districts.

Figure IV-1 Project Stakeholders by Category



Source: ERM and SOL Primary Data, 2013

Table IV-1 Key Concerns, Issues and Perceptions of the Communities in the Pahae Jae Sub District

Community	*Key concerns, issues and perceptions*
Pardamaean Nainggolan	**Environment**
	▪ Environmental damage concerns due to land clearing
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	Employment and Business Opportunities
	▪ Prioritise job opportunities for local people
	CSR Program
	▪ Improve the bridge in the sub-village (*dusun*)
	▪ Provide support for church and school equipment
	▪ Increase the social welfare of the community
	▪ Improve the public health services
	▪ Provide scholarships for local students
	▪ Raise awareness of environment and community safety
	▪ Build junior and senior high school buildings
	▪ Build a hospital
	Information, Disclosure and Grievance Mechanism
	▪ Inform the community clearly on relocation and compensation process
Pardomuan Nainggolan	**Environment**
	▪ Concerns regarding a reduction of irrigation water
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	▪ The project may result in pollution that could impact crop plantations
	▪ As the project is located in an earthquake prone area there are concerns this may impact project activities
	▪ The project may impact the quality of drinking water
	▪ The project may cause a landslide
	Health
	▪ Concerns regarding the production and disposal of project wastes

Community	*Key concerns, issues and perceptions*
	Employment and Business Opportunities
	▪ Prioritize Project employment for local people e.g. construction labourers, catering, security and administration
	▪ The recruitment process should be open and transparent involving the village head (not via email or SOL's website).
	▪ Provide opportunities for local people to set up businesses to support the project ego an auto workshop, laundry and cleaning service
	CSR Program
	▪ Provide donations to disaster victims
	▪ Provide Christmas gifts for community
	▪ Improve the local road access
	▪ Establish a health program for local elderly people
	▪ Provide English and Mathematic courses for local students
	▪ Provide aid/donations for all local people
	▪ Provide scholarships for high performing students and those from poor families
	Information, Disclosure and Grievance Mechanism
	Inform the community about SOL's grievance mechanism - how it works and who they contact to make a complaint etc.
Silangkitang	**Environment**
	▪ Concerns about impacts to their plantations and crops
	▪ The waste water from the project may contaminate the hot spring water
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	▪ As the project is located in an earthquake prone area there are concerns this may impact project activities
	▪ The project may impact the quality of drinking water and amount of irrigation water available
	▪ Agricultural activities will be reduced due to the land acquisition process
	▪ Potentially the project may increase air pollution, noise and waste water resulting in negative environmental impacts
	Health
	▪ The project may result in community health impacts e.g. due to a high level radiation from the transmission lines
	Employment and Business Opportunities
	▪ Provide opportunities for local people to set up businesses to supply to the Project such as transportation, laundry and cleaning services
	▪ Employ local labourer during the construction phase
	▪ Recruitment process should be open and transparent; it should be informed to village head, not via email or website.
	CSR Program
	▪ Develop a water pipeline from the spring to community houses
	▪ Provide scholarships for high performing students and those from poor families
	▪ Improve the school building
	▪ Improve the church building and also provide support for church activities and equipment
	Information, Disclosure and Grievance Mechanism
	Inform the community of the grievance mechanism including who is responsible with in SOL

Community	Key concerns, issues and perceptions
Sigurung-gurung	**Environment**
	▪ The project may increase water, air and noise pollution
	▪ Project activities may impact the communities clean water source
	▪ A toxic gas blow out caused by the project may harm the community
	▪ The project may impact plants in the forest
	Health
	▪ The transmission tower should be built away from residential areas to minimise community health impacts
	Employment and Business Opportunities
	▪ Train and capacity build the local workforce
	▪ Prioritize local job opportunities
	▪ Provide opportunities for local people to set up businesses that service the project such as provision of agricultural crops (vegetables, rice paddy, fruit, etc.) to SOL, transportation, laundry and cleaning services
	CSR Program
	▪ Increase the quality of life and social welfare of the local communities
	▪ Implement a community development plan
	▪ Provide school equipment for students in the villages surrounding project
	▪ Provide scholarships for students between elementary and senior high school level
	▪ Provide electricity to Sugurung-gurung free of charge
	▪ Improve the dam used to irrigate the local rice paddy fields
	Information, Disclosure and Grievance Mechanism
	▪ Inform the community clearly regarding relocation due to project
	▪ Inform the community transparently regarding negative project impacts

Table IV-2 Key Concerns, Issues and Perceptions of the Communities in the Pahae Julu Sub District

Community	*Key concerns, issues and perceptions*
Lumban Jaean	**Environment**
	▪ The project could harm plants such as *Petai* (*Parkia Speciosa*), cocoa and rubber resulting in crop failures
	▪ The project could impact water availability for rice paddy fields
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	▪ Project activities may trigger landslides which could impact the community's rice paddy fields and plantations
	▪ SOL's activities may decrease the quality of clean water
	▪ The project may result in an increase in air pollution, noise and traffic accidents
	Social Culture
	▪ In migration as a result of the project could impact the Batak's tradition and culture
	Health
	▪ The project may increase diseases within the local population and crops due to its activities
	▪ The transmission tower could result in health impacts within the community
	Employment and Business Opportunities
	▪ New jobs for local people will be created
	▪ Employment of local youth will be a priority
	▪ Business opportunities within the local villages will increase
	CSR Program
	▪ Establish a conservation program
	▪ Provide vocational training for the community on IT, automotives, cooking, etc.
	▪ Improve the community infrastructure and health facilities
	▪ Provide school supplies for students
	▪ Provide church supplies, such as tables and chairs
	Information, Disclosure and Grievance Mechanism
	▪ Conduct socialization activities regarding project impacts as the community have not received enough information about project
	▪ Inform the community about SOL's grievance mechanism and ensure complaints are dealt with in a timely manner
	▪ Inform the community about the projects use of local roads verses the construction of new access roads
Onan Hasang	**Environment**
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	▪ The project may harm plants such as *Petai* (*Parkia Speciosa*), cocoa and rubber resulting in crop failure
	▪ Potential environmental damage due to SOL's activities
	Health
	▪ The transmission tower should be built far from residential areas
	▪ SOL's activities have the potential to cause health issues in the community
	Employment and Business Opportunities
	▪ Increase business opportunities in the village e.g. in transportation, workshops, canteen/restaurants, laundry and materials supplier

Community	*Key concerns, issues and perceptions*
	▪ Prioritize the employment of local people in catering, housekeeping and administration
	CSR Program
	▪ Provide school equipment for students
	▪ Provide agricultural support such as provision of fertilizer and rice paddy seeds
	▪ Build new access roads to the rice paddy fields
	▪ Provide scholarships for high performing students
	▪ Provide access to medical facilities such as a clinic or hospital and allow community to have access to project doctors and paramedic staff during an emergency
	▪ Provide sporting facilities for local youth
	Information, Disclosure and Grievance Mechanism
	▪ Inform the community transparently and clearly about the project's negative impacts
	▪ Conduct socialization activities regarding project impacts
Sibaganding	**Environment**
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	▪ The project may reduce the quality of the mountain spring water which is used as a clean water resource
	▪ The project may increase air pollution and dust from project vehicles
	▪ Potentially the project may increase traffic accidents
	▪ Potentially it will reduce soil fertility due to project activities
	▪ Potentially it will cause water pollution
	Social Culture
	▪ Anxious of social inequalities due to in migration and also the impact this may have on the Batak's tradition and culture
	Employment and Business Opportunities
	▪ Prioritize employment for skilled and educated local people
	▪ Provide opportunities for local people to set up business activities such as opening a convenience store to sell goods to the workers
	CSR Program
	▪ Increase the social welfare of the community
	▪ Provide the school equipment for students
	▪ Provide scholarships for high performing students and those from poor families
	▪ Provide support to the local agricultural sector (e.g. provision of fertilizer and rice paddy seeds)
	▪ Provide vocational training for local youth according to project needs e.g. English language, electronics, automotive training.
	▪ Provide sporting facilities for local youth
	Information, Disclosure and Grievance Mechanism
	▪ Inform the community regarding the projects negative impacts before activities commence
	▪ Change the company name from Sarulla Operation Limited to Pahae Operation Limited (POL)
Simataniari	**Environment**
	▪ The project may cause landslides that may impact the community's rice paddy fields and plantations

Community	*Key concerns, issues and perceptions*
	▪ Anxious of a well blow-out, such as in the case of LAPINDO in the East Java Province (this was due to a well failure during drilling)
	▪ As the project is located in an earthquake prone area project activities may be impacted
	Health
	▪ The transmission tower should be built far away from residential area
	Employment and Business Opportunities
	▪ Provide opportunities for local people to set up business activities such as opening a convenience store to sell goods to the workers
	▪ Provide employment opportunities for local people in catering, housekeeping, manual labour and drivers
	▪ Prioritize employment for local people depending on their skills
	CSR Program
	▪ Provide school equipment villages
	▪ Improve road access in the village
	▪ Build the junior and senior high school
	▪ Provide scholarships for high performing students and those from poor families
	▪ Improve health facilities in the villages
	▪ Provide church supplies such as tables and chairs
	▪ Improve the village government office
	▪ Provide sporting facilities for local youth
	Information, Disclosure and Grievance Mechanism:
	▪ Inform the community regarding the projects negative impacts and details of the relocation process
	▪ Inform the community how the project will manage its negative impacts and provide compensation

4.4.2 *Consultation*

This section provides an overview of the Information Disclosure, Consultation and Participation process that has been implemented to date by SOL. This includes:

- Information education consultation (IEC) materials;
- Dissemination protocols;
- Consultation activities from 2008 until 2012;
- Consultation conducted to date in 2013; and
- Planned future consultation including disclosure of the ESIA.

4.4.2.1 *IEC Materials*

ADB's SPS states that consultation and participation are central to the achievement of the safeguard policy objectives. It explicitly requires the borrower/client to carry out meaningful consultation with affected persons and communities within the vicinity of the project location. Thus, in order to achieve this objective, SOL is required to ensure that all information related to the Project is well informed and communicated to the communities, groups, or peoples affected by the Project.

This also implies that information disclosure is not merely a one off process but that it is conducted continuously throughout the Project cycle allowing for an effective flow of information. One of the most important aspects of information disclosure is the preparation and establishment of IEC materials.

SOL has prepared numerous forms of IEC materials including brochures/leaflets, Project location maps, pictures/photos and video presentations etc. Preparation of such materials considers:

- Culturally appropriate and effective: The materials are presented in a language that is understood by the local communities; the IEC materials consider all local customs and values. Even though the Indonesian language is widely spoken and understood by the local communities, the Batak (the majority ethnic group in the project location) speak the Batak language therefore Batak is used when producing IEC materials for this group.
- Clear and understood by the communities: SOL recognises the importance of providing concise and clear information in the IEC materials. Materials are presented in a structured format and are as informative as possible but not in an exhaustive way.
- Accessible: The Project needs to ensure that all affected people have access to the information concerning the Project and its impacts. Therefore SOL's IEC materials are made accessible to all affected communities as well as other related stakeholders.

Information and issues covered in the IEC materials range from Project information (project footprints, village settlements, etc.), the Environmental Impact Assessment (EIA) related information, job vacancies, grievance forms, etc. SOL understands the importance of sharing Project information with its local communities. This is demonstrated through the provision of the EIA executive summary document in eight affected villages, namely:

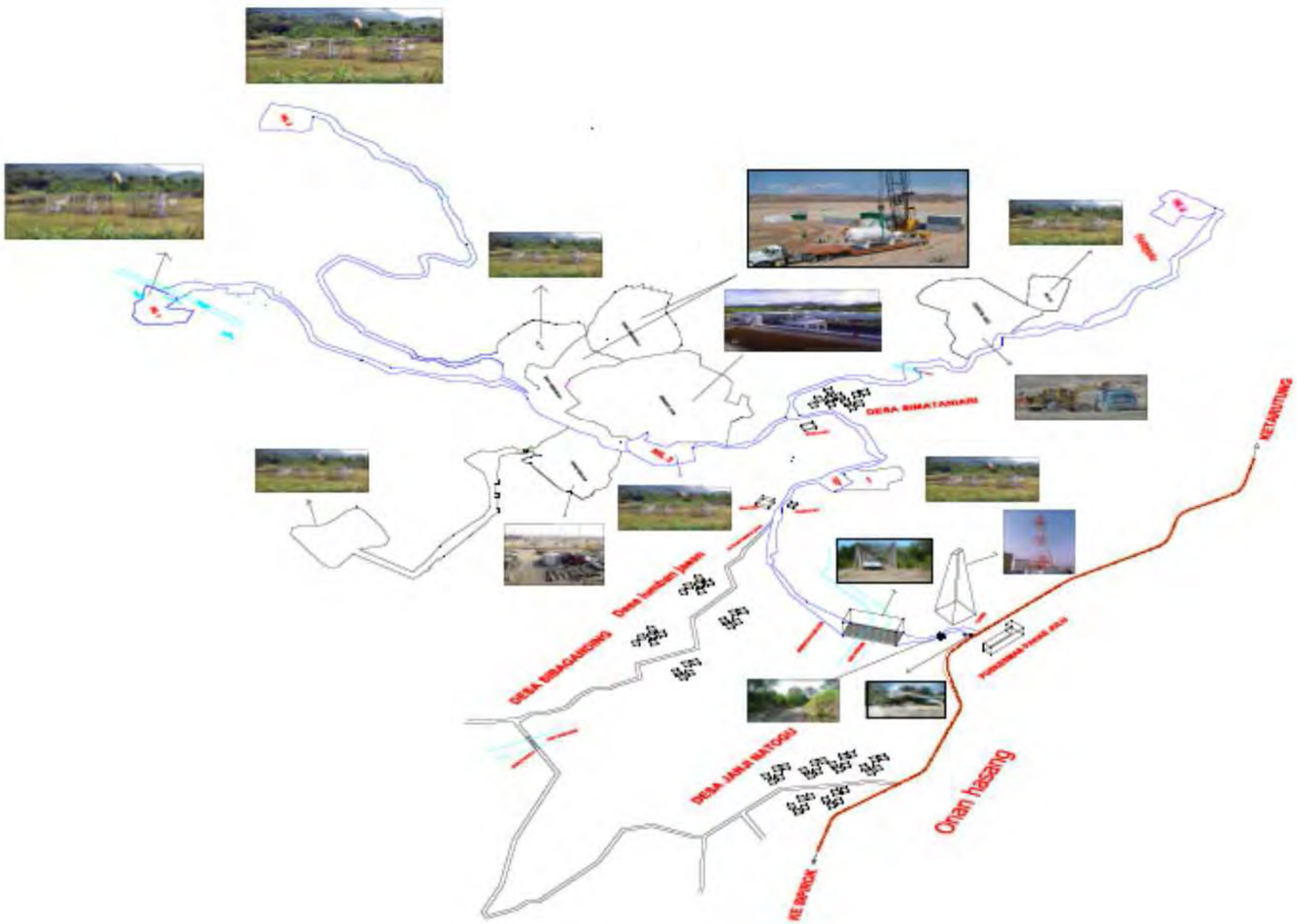
SIL Area:	NIL Area:
1. Silangkitang	1. Simataniari
2. Sigurung-gurung	2. Lumban Jaean
3. Pardamean Nainggolan	3. Sibaganding
	4. Onan Hasang

The documents have been made available in each village administration office. The complete EIA (ANDAL, RKL/RPL) documents are available in the sub-district offices in Pahae Jae (Silangkitang Area) and Pahae Julu (Namora I Langit Area).

Aside from the provision of the EIA summary to the local communities, other forms of materials are being developed by SOL including pictures/maps of the Project footprint (Figure IV-2). This provides an overview of all Project facilities and their location. These materials will be finalised prior to undertaking further public consultation in the villages.

Figure IV-2 Example of Project Map Being Prepared For Project Disclosure and Silangkitang (SIL) Area

a) NIL Location



b) SIL Location

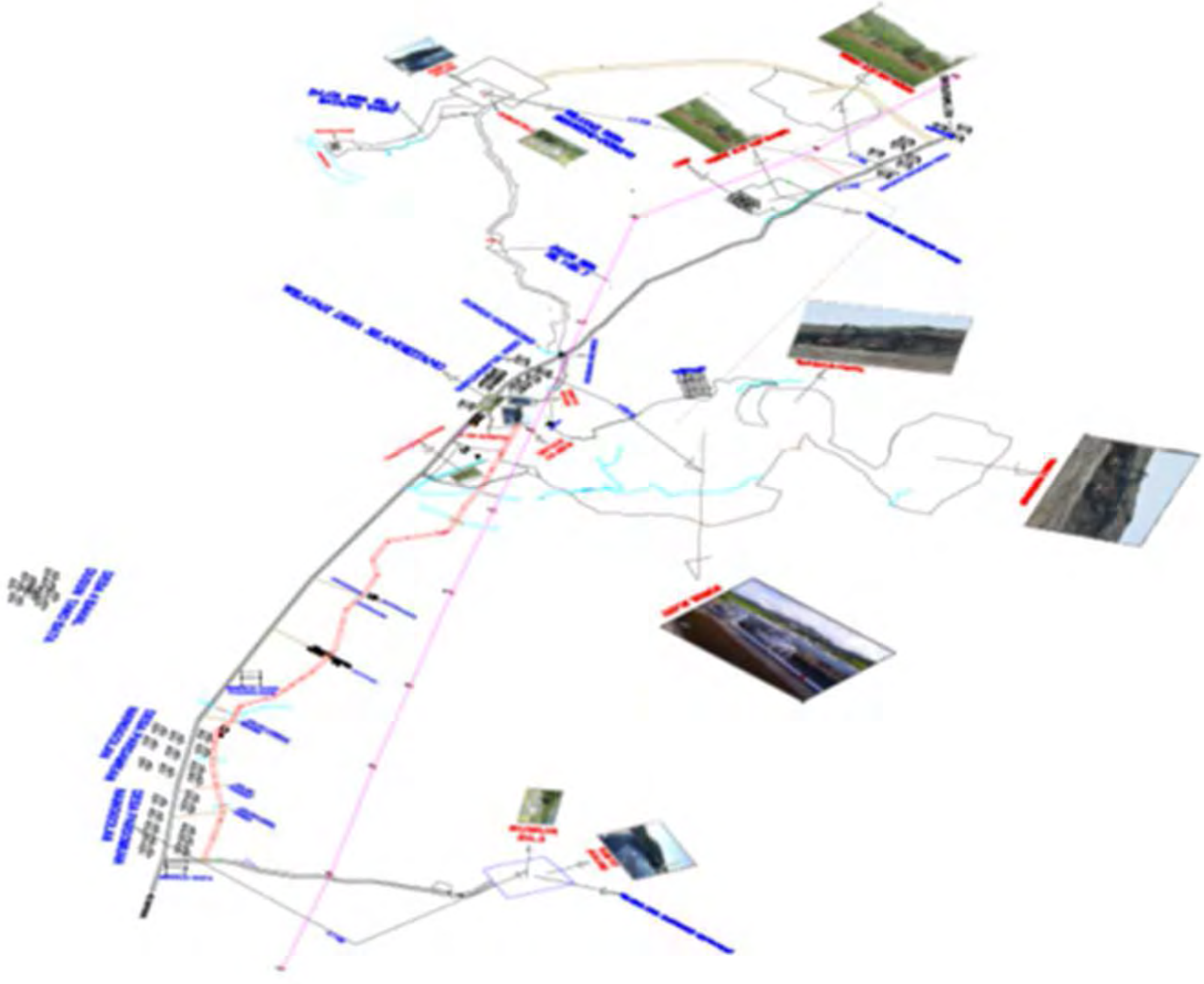


Figure IV-3 provides a further example of a typical Project brochure that SOL will share with the communities.

Figure IV-3 How geothermal works as sustainable source of Energy and typical situation of a geothermal power plant built and operated by Ormat

SOL also plans to develop materials that will be presented and explained to the local communities/affected communities during consultation activities which will be conducted in the latter part of 2013. The materials will consist of the following information:

- Introduction of the Project proponent/management;
- Explanation on the Project and its related activities;
- Location of Project facilities and boundaries and facilities closest to local communities;
- Potential impacts from the Project (positive and negative) and how they will be managed;
- Important environmental components to be understood; and
- SOL's grievance mechanism.

As the consultation process is not a one-off activity the IEC materials will be developed throughout the Project lifecycle as one of the tools for information disclosure to the local communities.

4.4.2.2 *Distribution of IEC materials*

In order to ensure that IEC materials are accessible to the general public, especially the affected people, SOL will establish locations where disclosure and the distribution of materials will take place.

4.4.2.2.1 *Village Level*

At the village level, distribution of IEC materials will be shared via the:

- Head of village and local communities leaders/informal leaders;
- Village board information;
- Village administration staff; and
- Representatives from community group.

4.4.2.2.2 *Sub District Level*

At the Sub district level materials will be distributed through the:

- Sub district administration staff; and
- Information board.

4.4.2.2.3 *Project Office Level*

At the Project level, the IEC materials will be communicated and presented by SOL's Project field team and management. This task will be managed by SOL's Project external relations officer, Mr Industan Sitompul and his team. The team will be divided into two coverage areas, one for the SIL area and the other for the NIL area.

4.4.2.3 *Information Dissemination Protocols*

This section explains the information dissemination protocols which SOL has and will continue to apply for the Project. The purpose of these protocols is to ensure that all related stakeholders participate in and are well informed of Project meetings or activities conducted in their area.

Considering the national, ADB and IFC information dissemination requirements and local customs in the Sarulla area, SOL will undertake information dissemination in the following forms:

4.4.2.3.1 *Direct Communication*

Verbal

Where information is communicated face to face with the intended individuals. Verbal communication to disseminate information to local communities in the Project area is accepted locally as most villagers communicate in this manner.

Written/invitation or notification letter

This is conducted by sending/distributing notification/invitation letters to the individuals/villagers.

4.4.2.3.2 *Indirect Communication*

This would be undertaken in the form of a notification through the village information board, brochures, and also newspapers or electronic media, such as radio and television.

4.4.2.3.3 *Protocol and Implementation*

The guidelines on public consultation, as stipulated by the Government of Indonesia in Minister of Environmental Number 17 year 2012, do not explain in detail the protocols for information dissemination. However the Project will use the regulation as a reference in the implementation, and it will also refer to local culture and practices so information can be well disclosed to the local communities and the public. Therefore, the following protocols will to be carried out by SOL for disseminating information:

Initial Communication with the Heads of the Sub Districts and Villages

Prior to conducting any meetings or activities, the SOL field team/external relations will first coordinate and communicate the planned activity with the heads of the sub districts and villages. In these initial discussions the schedule will also be agreed to ensure the timing is suitable and does not conflict with other key community activities or events. In addition the location of the venue will be agreed. Where possible meetings will take place in the evening to allow the community to carry out their farming activities as normal.

Invitation – written and verbal

After the schedule is agreed with the head of the villages or sub-districts SOL will then prepare a formal invitation letter to be sent to all intended persons/individuals or groups. This invitation will then be distributed to all the intended individuals via the head of each village by SOL's external relation officers.

In addition to the written invitation, as the external relation officers are locally recruited, they will also disseminate information on planned meetings and discussions verbally.

SOL's intent is to ensure that communication on proposed consultation events is undertaken as early as possible to the villagers/participants. This should be at least one week before any activity takes place.

Follow up on invitations

The SOL field team (i.e. the external relation officers) will then follow up with the head of each village to confirm attendees. If the intended person is unable to attend SOL will encourage them to nominate a representative to attend in their place. (This also occurred during the land acquisition socialisation/negotiation process in instances where land owners reside outside of the Project area).

4.4.2.3.4 *Execution of activities*

Agenda of Meetings/Activities

In general the agenda for the above stakeholder meetings follows the below:

- Prayer followed by a welcome speech by SOL and other attendees; Explanation and presentation on current Project activities by SOL. This will also include a two way discussion on the identified potential impacts and risks, and the proposed measures and actions to mitigate the impacts;
- Open discussion in a Question and Answer format;
- Documentation including minutes, attendee list and photos; and
- Closing prayer.

When the majority of villagers are Christian the meeting will be opened and closed with a prayer, performed by the community leader or S*intua* (church minister).

Language

Local communities in the Pahae Jae and Pahae Julu sub districts are predominantly Batak and use both Indonesian and Batak in their daily communication. They understand Indonesian very well and use it in their daily conversation.. However, older people in the communities prefer to use Batak. Thus meetings and activities conducted to date by SOL have been in both languages to accommodate all generations. During informal meetings Batak is and will continue to be used to build a closer relationship with the local communities.

For certain activities, such as land surveying and staking, the process will be slightly different as the meetings will involve less people:

- Coordination with the village head to explain the activity and identify the affected land owners;
- Contact the intended person/land owner directly (accompanied by the village head) to set up the meeting;
- Meet with the land owner (or small group of land owners) to explain land surveying activities; and
- Based on whether consent is obtained from the land owner and village head the survey is conducted.

This protocol will continue to be used when disseminating information to the local communities; adjustments will be made in accordance with the local communities' needs.

4.4.2.4 *SOL Consultations up to 2012*

This section presents an overview of public consultation activities undertaken by SOL between 2008 and 2012.

4.4.2.4.1 *Consultation Activities*

The Project commenced consultation activities in 2008 with stakeholders including local government and related agencies, affected communities/groups, local NGOs and other related stakeholders. The objectives of these activities were to:

- Commence the consultation process early in the Project planning phase with affected communities and other related stakeholders;
- Disclose information on Project related information; and
- Establish a relationship with local communities, understand their concerns and discuss how the Project could address the issues raised.

Consultation activities were conducted, where possible, in a venue closest to the local communities. However, in some villages, where no sufficient venues were available, it was agreed with the village heads to hold the meetings in a church or school classroom located close to the village (due to their larger capacity). Some meetings were also held at SOL's Project office meeting hall in Silangkitang. In instances where this occurred SOL provided transportation for the community.

Meeting participants consisted of both men and women who were given equal opportunities to voice their concerns and expectations during the question and answer sessions. A summary of consultation activities conducted between 2008 and 2012 is described in Table IV-3.

Table IV-3 Public Consultations Activities Undertaken Between 2008 and 2012

Activities	*Date*	*Stakeholders/ attendees*	*Description*
Project socialization at Silangkitang	5th February 2008	Head of villages, Representatives of local communities, Representatives of Local Government	Explanation on Project plan and activities
Public consultation in relation to AMDAL preparation	28th March 2008	Local communities from seven affected villages, Head of Villages, Communities' leaders, Youth groups, Church leaders from both Pahae Jae & Pahae Julu, North Tapanuli Local Government	Information disclosure and discussion on project plan and activities, discussion on communities' concerns and inputs
Project socialization with government institutions in Tarutung	6th May 2008	Bupati of North Tapanuli, Head of Local Government Offices/ agencies, Head of Sub District of Pahae Julu and Pahae Jae	Information disclosure on project plan and activities
Project socialization regarding land acquisition process for re-injection route	6th June 2008	Local communities, Head of villages, Head of Sub District	Explanation and discussion on land acquisition process and plan for re-injection line route
Socialization/ Seminar of Sarulla project to local NGOs groups, local communities and local Governments representatives	25th June 2008	Church Associations and NGOs -JPIC HKBP, JPIC UEM,KSPPM, NINDJA JAPAN, Local Government Agencies (BAPPEDA, North Tapanuli Bupati Office), representative of local communities, Head of Villages	The impact of PLTP Sarulla towards community life and the environment
Socialization of well work over activity in Silangkitang	15th July 2008	Local communities, head of villages, Head of Sub Districts, Representative of Local Government	Information disclosure on well work over plan and activity
Well work over ceremony in Silangkitang	15th Aug 2008	Local Government of North Tapanuli, local communities, Head of Villages, Communities' elders, Head of Sub districts	Ceremony event prior to commencing the well work over activity
Dialogue forum with local communities and	11th Jan 2011	member of local House of Representatives of North	Discussions related to concerns on

Activities	Date	Stakeholders/ attendees	Description
local NGO – IMARUPA & IARRP		Tapanuli, IMARUPA NGO, IARRP NGO, Head of Villages, Local communities' representatives	environmental impacts and the project's community development program
Discussion/Meeting with local communities, representatives of North Tapanuli Local Government and IMARUPA/ IARRP	24th March 2011	Head of villages, village elders, Chairman of IMARUPA NGO and staff, Chairman of IARRP NGO and staff, Representative of Local Government, Head of Sub districts, representatives of local communities	Discussion on the project's CSR program and stakeholders (local communities, SOL, Local NGOs (IMARUPA & IARRP), local government) commitment to support the implementation of the project
Project and AMDAL socialization/explanation (in 13 villages) of Pahae Jae and Pahae Julu	23th March 2011, 15 – 18th April 2011	Head of villages, villagers and community leaders	Explanation on geothermal project, environmental impact and project's AMDAL document, communities concerns
Socialization on land acquisition to brine Injection line land owners	25th Nov 2009	Land owners, Head of Villages, Head of Sub district, BPN (Land Agency Office), Agricultural Office	Explanation and discussion on project's land acquisition plan/activities for brine injection line route
1st negotiation meeting for Brine Injection line – land owners	9th Dec 2010	Land owners, Head of Villages, Head of Sub district	Meeting/negotiation on land price
2nd negotiation meeting for Brine Injection line – land owners	19th Jan 2011	Land owners, Head of Villages, Head of Sub district	Same as above
3rd negotiation meeting for Brine Injection line – land owners	24th March 2011	Land owners, Head of Villages, Head of Sub district	Meeting/negotiation on final agreement on land price

4.4.2.4.2 *Communities' concerns and SOL's responses*

In general, the stakeholders consulted, especially local communities, expressed their support towards the Project during the above meetings; welcoming the Project in their area. However, various concerns/issues were raised throughout the 2008 to 2012 consultation period (Table IV-4).

Table IV-4 Summary of Key Concerns and Issues (2008 -2012)

Key concerns and issues	*SOL's responses*
Environment:	
- Effects of the hot steam/vapour on the plantation - What if there is a leak in the gas pipe? - Concerns on mud flooding as in Lapindo case - Water, air and noise pollution	- The project is using new technology so that the hot steam will not cause any harm to the plantation surrounding the project area. - The project has assessed and has taken counter measures for any related risks including pipe leaking and also mud flooding. This has been considered as part of the project design. Should such a case happen the project will take full responsibility.
- Further explanation on impacts of the transmission line (SUTET)	- The project is not going to build SUTET (275- 500 kV) but a SUTT 150 kV line which is different –the project will have another meeting to discuss the transmission line issue.
- Project should be transparent on the impacts and further explanation on positive and negative impacts are required	- The project will conduct further socializations to local communities to address all the questions and concerns and having this meeting is part of communities' involvement in the preparation and discussion of AMDAL.
- Involvement of local communities on AMDAL document preparation and discussion - There should be a clear agreement and meeting on environmental managements	- The project will comply with the applicable regulations in Indonesia when conducting its activities.
Employment and business opportunities:	
- Prioritize the local man power and local resources such as local contractors, businesses and services	- The project will absorb local man power in accordance with their skills and capacity and based on project's need. The project will also work with local contractors and businesses.
- Training for local man power, to ensure the community are work ready and skilled appropriately as most of the local people are farmers - Do not treat local people differently, all people must be given same opportunities - Request the project to conduct survey on available local man power data so that it could be used for recruitment process - To establish a simpler tender process for small scale contracts so that local contractors could participate	- The project noted this and plans to conduct training for local manpower - this still needs to be further assessed and discussed. - The project noted the inputs and will discuss these further with the management. - Mechanism for recruitment and the tender process will be communicated and coordinated with local communities through Head of Villages. - Mechanism for recruitment and the tender process will be communicated and coordinated with local communities through Head of Villages.

Key concerns and issues	*SOL's responses*
CSR program:	
- The project should allocate budget for a CSR program - Commitments for a CSR program must be made in a written statement/agreement	- The project fully understands and acknowledges its responsibilities to conduct CSR activities and this issue will be followed up and discussed with the project management team.
Land Acquisition process:	
- Land owners should be informed of their rights and land acquisition should be done based on agreement and consent from the land owners' themselves - Negotiation should be undertaken on a group basis not individually and should be free from intimidation or force. - Land owners who release their land should be prioritized for Project employment opportunities	- The project noted all these concerns and inputs; the land acquisition process will be conducted accordingly with no intimidation or force and it will comply with the applicable regulations in Indonesia.

The following section provides a series of photos taken during the consultation activities (Figures IV-4 to IV-7).

Figure IV-4 Public consultation with local communities in Sibaganding, Simataniari & Lumban Jaean village

Figure IV-5 Public consultation with local communities in Sitolu Ompu and Siopat Bahal

Figure IV-6 Public Consultation with Local Communities in Sigurung-gurung Village

Figure IV-7 Public consultation with local communities in Silangkitang village

4.4.2.5 *SOL Consultations in 2013*

During 2013 the Project has conducted two phases of consultation activities in seven impacted villages as discussed below.

4.4.2.5.1 *Socialization on the Land Acquisition Process (April and May 2013)*

Socialisation was undertaken on the acquisition of land required for some project facilities; this included confirmation of the land boundary survey and calculation on the number of plantations (conducted by SOL's field team). The meetings were held with land owners from the SIL area (Silangkitang and Sigurung-gurung village) and NIL area (Sibaganding, Simataniari, Onan Hasang, Lumban Jaean village). The aim of these meetings was to gain land owner consent and agreement before negotiations take place.

Consultation Process

The meeting schedules were first coordinated with the village heads with invitations distributed a week before the meeting. Where land owners were unable to attend, representatives were nominated, with SOL then undertaking a verification process to ensure these nominated persons had the appropriate documentation.

Participants were generally limited to related land owners and their family members and land owner representatives (confirmed by the village head). During these meetings SOL explained the purpose of the meeting and the stages of land acquisition to be undertaken before payment takes place. SOL also stated that attendance did not mean that the land owner would have to sell their land, that the final decision was the land owners' decision and that no coercion or force would be placed on the land owners to make a decision. Figures IV-8 and IV-9 show some of the socialisation consultation meetings that took place during this period.

Figure IV-8 Socialization on Land Acquisition to Land Owners in Silangkitang Area

Figure IV-9 Socialization on Land Acquisition to Land Owners in NIL Area

The meetings were conducted in Indonesian and Batak by SOL's External Relations team. Following the Project presentation a question and answer session was initiated with the land owners where comments and queries were raised. Some of which SOL responded to immediately others required follow up. The question and answer session was then followed by the signing of the situation map and plantation inventory by each land owner or their representative. Land owners comments and queries along with SOL's responses during these sessions are summarized in Table IV-5. Furthermore, Figures IV-10 to III-23 show some of the land acquisition meetings that took place.

Table IV-5 Summary of Comments and Queries from Land Owners During Land Acquisition Socialization

Land Owners/ Village	*Comments/Queries*	*SOL's Responses*
Janton Simatupang / Simataniari	- EIA (AMDAL) needs to be explained to villagers in Simataniari. - During UNOCAL era, some community members claim activities caused damages to their water line. They are requesting SOL fix it.	- Socialization on AMDAL document had been conducted in 2011. The project is fully committed to disseminate the AMDAL document throughout the project area. - SOL noted this issue and will further investigate the location because this is from UNOCAL era. Best solution will be sought by SOL's team.
Volwin Sitompul(Sibaganding Village)	When the project operates, will the water from Aek Acimun river keeps running to Sibaganding village?	Yes, water will still run from Aek Acimun to Sibaganding village.
Novada Sitompul (Sibaganding Village), Rudi (Simataniari Village)	- The local recruitment process should involve candidates from Sibaganding and Simataniari village. The process should be fair and positions should not only be temporary but permanent. - Results of the plantation inventory, calculations and the situation map should be shared with the village after the price is agreed and payments made.	- The project will recruit local man power based on their skills and information from the Jakarta office, within the near future; the project will have socialization on recruitment of workers in the Sarulla area. - SOL noted this and it will be shared after the price is agreed and payments are made to all land owners.

Land Owners/ Village	*Comments/Queries*	*SOL's Responses*
Dimpos Tambunan (Sibaganding Village)	- Access road to the village needs to be improved - Waterline to the rice field needs to be improved - Local people to be recruited in accordance with their skill	- SOL noted this and will further study the condition of the access road and the waterline. The presence of the project in this area will not cause any harms to the local communities.
Basirun Sinaga	- Propose that his land located on the right side is not to be wholly acquired by the project	- This request had been addressed and responded as per Mr Basirun's request as this was discussed during the land survey and measurement
Doharman Sitompul	- A situation map for each land to be acquired to be prepared - Invitation for land negotiation to be prepared at least a week before the event so that owners residing outside of Sarulla area may have time to prepare and attend the meeting. - AMDAL document should be available at the village	- SOL has prepared and made situation maps for all land to be acquired - SOL noted this and all activities will be informed well in advance and ensure that land owners residing outside of Sarulla attend the negotiation. - It will be shared with the Head of Village and available at the village office
Rajin Sihombing	- What if the land doesn't belong to me?	- As long as there is power of attorney letter from the land owner, then it will not be an issue.
Sadahari Hutabarat	- Represents Mr Hattus Sihombing asked SOL to also acquire the remaining land that he has including one grave area	- SOL could not acquire the grave area but will check the location for the remaining land.
Tunggul Sihombing, Samarida Sianturi, Parinton Sihombing	- Requested SOL to acquire their remaining land	- SOL will first check and study the location of the remaining land
Herto Sihombing	- After signing the situation map and plantation inventory today, do we lose our right on the land?	- No, because no payment is made and after the signing of situation map and plantation inventory, land owners still have full rights to their land.

Figure IV-10 One Land Owner Signing of the Situation Map and Plantation Inventory

Figure IV-11 Landowner Requesting SOL to Purchase her Remaining Land

4.4.2.5.2 *Project Awareness Meetings (June and July 2013)*

Focus Group Discussions (FGDs) have been recently undertaken to discuss the local communities' awareness of the Project, as well as their concerns, expectations and needs. The key points discussed in these sessions included:

- Local community perceptions both positive and negative and assistance provided by SOL to date;
- The potential of available local man power;
- Expectations and recommendations for SOL; and
- Short, medium and long term programs to advance the development and welfare of the local communities in the Project area.

The villages included in the above FGDs were located in the Pahae Julu sub-district: Onan Hasang, Sibaganding, Lumban Jaean, and Simataniari; while from Pahae Jae Sub District were conducted in Silangkitang, Pardamean Nainggolan, Pardomuan Nainggolan and Sigurung-gurung village.

The FGDs were grouped into three categories: local community leaders (men); women; and youth. Invitations were communicated through the village head to the intended groups about a week before the activity took place and discussions were mostly conducted in the evening because the local communities were busy with harvesting during the day.

Discussion Results

Discussions were led by a SOL facilitator with meeting notes recorded. The results of the FGDs are discussed in the subsequent sections of this Chapter.

Summary of Local Communities Perception

Local communities in both Pahae Jae and Pahae Julu have similar Project perceptions, the positives include:

- Proud the Project is located in their area and that it will advance local development;
- Supportive of the implementation of a geothermal project;
- Provides new hopes for the advancement of the area and welfare of the local communities; and
- SOL will provide employment and business opportunities to local communities that will trigger local development.

Concerns or negative perceptions towards the Project were mainly focused on potential environmental impacts – these are summarised in Table IV-6.

Table IV-6 Local Communities' Concerns on the Project

No	Concerns/Negative Perception
1	Impacts from drilling activities: 1. Mud – concerns around mud flooding due to uncontrolled drilling as occurred in Sidoarjo (LAPINDO case). 2. Gas- Drilling will produce natural gas which and will affect communities' health 3. Reduce the productivity/ amount of production of plantation such as rubber, incense trees, and petai tree.
2	Water: - Reduction of irrigation water which will cause damage to the communities' rice fields /farming which is the main livelihood of the local communities. - Reduction in available clean water
3	Pollution: - Waste from the project may pollute the environment if not managed - Air and noise pollution caused by project's activities
4	- Tower of transmission line may disturb the production of farming and plantation and also communities' health
6	- Since the area is prone to earthquakes, the project presence may worsen the situation or earthquake condition in the area
7	- Landslides that may happen due to deforestation for project activities
8	- Influence on local culture/custom from the workers/employees of the project who come from other areas/outside of the Sarulla area.

Source: ERM Primary Data, 2013

Discussions took place on community expectations and suggestions – these are summarized below. During the FGDs the communities identified a number of expectations (Table IV-7).

Table IV-7 Local Communities 'Expectations

Expectations and Suggestions
Employment Opportunities: -A number of employment opportunities have been identified by the communities. These roles include computer/administration, accounting, skilled construction workers, drivers and operators of heavy equipment, welders, cooks, tailors and security.
Business Opportunities: -A number of local business opportunities have been identified by the communities. These include laundry and cleaning services, catering, car and heavy rental equipment and production of uniforms for workers and /employees.
Environmental Management: -Wastes from the project should be managed so no pollution occurs -The local communities should be informed about the negative impacts and the management.
Agricultural Capacity Building: - Provide agricultural training/ workshops/ guidance to improve the communities' knowledge and skills in agricultural activities including farming in accordance with the land condition in the area - Improvement of irrigation systems and provision of clean water to household - Improvement and development of access roads to the villages, to the rice fields and also to plantation areas.

Expectations and Suggestions
Investment in Education Services: - Provide scholarships for high performance children - Construction of public schools and a school for children with special needs
Investment in Health Services: - Construction/ improvement of health facilities (such as hospitals and public health centres) - Facilitate the visit of specialist doctors/physicians periodically to the public health centre
Cultural Heritage and Values - The project and the workers/employees should respect and preserve the local custom/culture.
Other CSR suggestions: - Improvement of church and mosque buildings - Assistance for elderly people - Assistance for sports' activities such as football, volley ball etc.

Source: ERM Primary Data, 2013

The communities have indicated their desire SOL to prioritize employment and business opportunities for local people in accordance with their skills and capabilities. In doing so opportunities are not only disclosed/announced through the internet but also through each village head office and where necessary the Project establishes training centres and programs. The community has requested this focus on the following areas:

- For women/housewives: special skills such as cookery (culinary), tailoring/sewing, beauty salon; and
- For men/young people: automotive/electronics.

Community Development Expectations

The FGD activities captured inputs on what kind of development program would be needed in each village. This approach was adopted to enable SOL to establish the foundations for a Community Development Program (CDP) via a grass roots/bottom up concept. This approach provides the local communities with a say in the kind of program that is best suited for their village. In addition, by taking this approach SOL aims to build the communities sense of ownership in the CDP to enable it to be sustainable and successful. Thus this initial step is taken to incorporate the needs and relevant views of the affected communities into the CDP plan. This is also in line with the ADB's SPS policy on consultation and participation which sees *meaningful consultation* process as a process that:

- Begins early in the project preparation stage and is carried out on an on-going basis throughout the project cycle;
- Provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people;

- Is undertaken in an atmosphere free of intimidation or coercion;
- Is gender inclusive and responsive, and tailored to the needs of disadvantaged and vulnerable groups; and
- Enables the incorporation of all relevant views of affected people and other stakeholders into decision making, such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.

A brief summary of the local communities' inputs/ recommendations for the CDP is presented in Table IV-8.

Table IV-8 Local Communities Inputs and Recommendations on Development Programs

Short term (1 year)	*Mid-term (2-5 years*	*Long term > 5 years*
- Training/workshops sessions for agricultural matters; - Training for special skills - Assistance for starting a business (capital assistance); - Assistance for provision of seeds for agricultural activities; - Improve local communities' capability to start a business/or entrepreneurship,	- Improve access roads to the villages, rice fields, and plantation; - Training for special skills: automotive, electronics, culinary, beauty salon; - Scholarships for students with achievement and also poor families; - Improve the supply of clean water to the houses and sanitation facilities; - Improve the irrigation; - Improve the schools and health facilities and also churches & mosques; - Provide assistance for additional teachers on English and computer subjects; - Provide assistance on providing specialist doctor's visit periodically to the Public Health Centres.	- Improve access roads to the villages, rice fields, and plantation; - Improve the supply of clean water to the houses and sanitation facilities; - Build school for junior and senior high schools, school for children with special needs, training centres/ workshop; - Build hospitals and other health facilities

Source: ERM Primary Data, 2013

4.4.3 *Consultation and Participation Activities During Pre-Construction, Construction and Operation Phase*

Aside from the consultation and participation activities that have been conducted to date, SOL will continue to conduct public consultation and disclosure activities in various forms. This is not only to comply with ADB, IFC or other international finance standards, but also to establish good communication and relationships with all SOL's stakeholders - especially the affected communities and the communities living in the vicinity of the Project area. Throughout the Project, regular meetings and co-ordination with various stakeholders will be planned and scheduled. This will include disclosure of the ESIA and ESMP.

Key known activities for planned future consultation and participation are summarized in Table IV-9.

Table IV-9 Key Activities for Planned Future Consultation and Participation

Phase	*Issues to be discussed*	*Planned schedule*	*Responsibility*
Pre-construction	Disclosure of project activities and its impact	Aug 2013	SOL
	Grievance mechanism and settlement process	Aug 2013	SOL
Construction	Disclosure of recruitment and opportunities for local man power/contractors	2 Months before activity commences	SOL's EPC contractor/ sub-contractor
	Disclosure of project CSR program planning and implementation	First when construction starts and continually thereafter based on agreement with the related affected communities	SOL
	Disclosure of ESMP monitoring report through Head of Village and local communities focal points	Every six months	SOL
Operation	Socialization to all related stakeholders on the commencement of the project operation	1 month before commissioning	SOL
	Disclosure of ESMP monitoring reports	Every six months	SOL
	Discussion with affected local communities on any issues/concerns during project operation	Once in three months	SOL
Decommissioning	Public announcement on decommissioning of the plant & facilities, potential impacts and how they will be managed	2 months before decommissioning	SOL

Phase	*Issues to be discussed*	*Planned schedule*	*Responsibility*
	Consultation and socialization to the affected communities, local workers/employees and all employees affected	2 months before decommissioning	SOL

5 Grievance Mechanism

5.1 OVERVIEW

This Chapter focusses on the Project Level Grievance Mechanism as required by the ADB's SPS 2009 and IFC PSs. Establishing and implementing a Grievance Mechanism is an important requirement in meeting both lenders requirements as well as ensuring that affected community grievances are managed in a fair and timely manner.

5.2 INTERNATIONAL REQUIREMENTS

5.2.1 Asian Development Bank (ADB)[25]

The ADB's Safeguard Policy Statement (2009) emphasises requirements for establishing a grievance mechanism that receives and facilitates the resolution of affected people's concerns, complaints, and grievances about a Project's environmental and social performance. The grievance mechanism should be scaled to Project risks and adverse impacts, address affected people's concerns and complaints promptly. It should also ensure the process is understandable and transparent, gender responsive, culturally appropriate and readily accessible to all segments of affected people. It should also not impede access to judicial or administrative remedies. The grievance mechanism should be delivered to the affected people in appropriate manner. There are a total of four Safeguard Requirements, three of which contain requirements for a grievance mechanism:

- Safeguard Requirements 1: Environment;
- Safeguard Requirements 2: Involuntary Resettlement; and
- Safeguard Requirements 3: Indigenous People.

5.2.2 International Finance Corporation (IFC)[26]

The IFC views a grievance mechanism as one of the pillars of the stakeholder/community engagement process for all projects. A grievance mechanism should inform and complement, but not replace other forms of stakeholder engagement. Companies across multiple sectors and through all stages of a project's development can benefit from understanding community concerns and complaints and addressing them.

The IFC's Performance Standards (PS) require the need for community engagement. They state that the IFC is committed to working with the private

[25] http://www.adb.org/documents/safeguard-policy-statement
[26] http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Sustainability+Framework+-+2012/Performance+Standards+and+Guidance+Notes+2012/

sector to put into practice processes of community engagement that ensure the free, prior, and informed consultation of the affected communities.

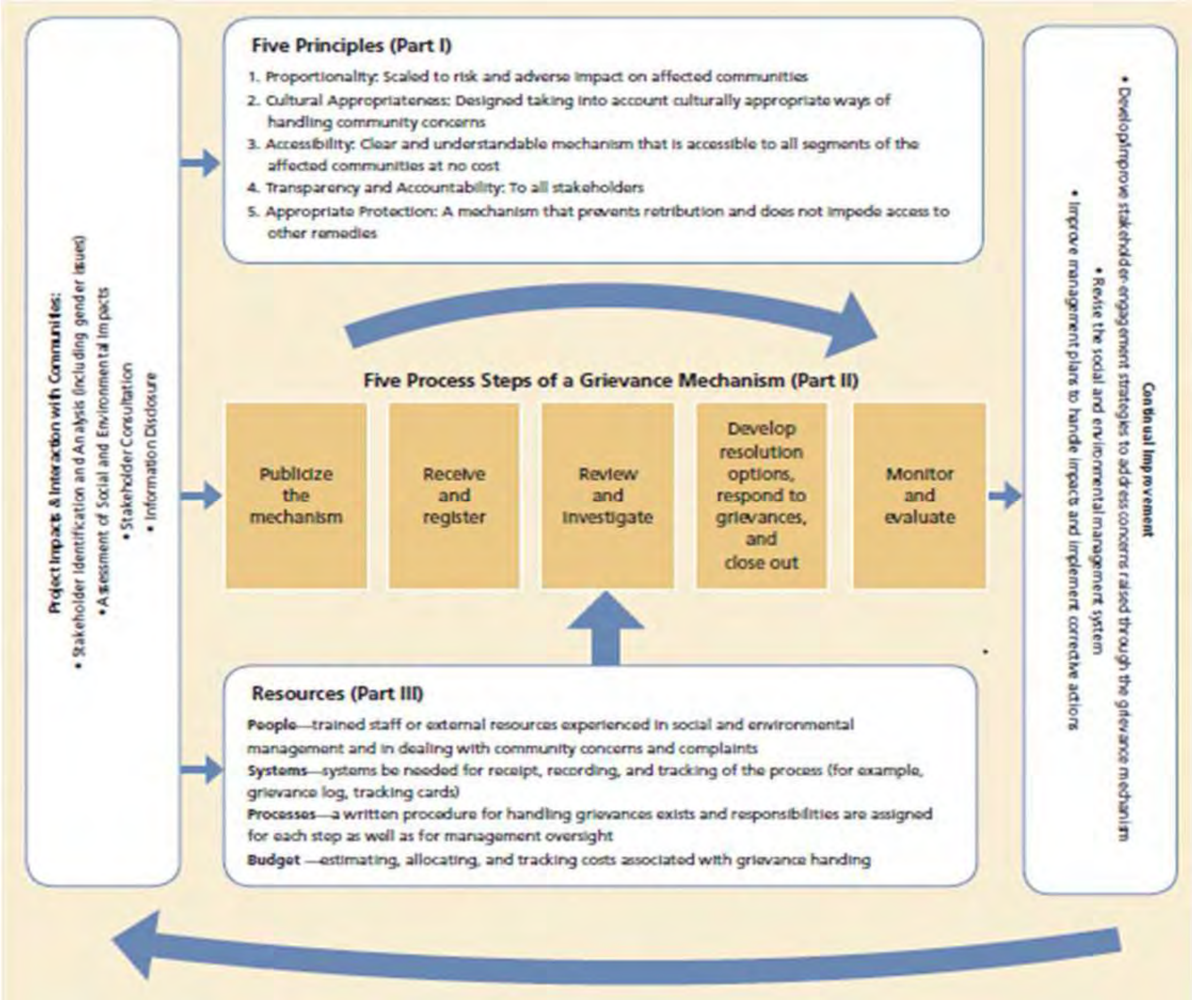
To summarise these requirements briefly:

A grievance mechanism is an important part of the IFC's approach to community engagement by a project under the PSs. The IFC's PSs require a project to establish a grievance mechanism to receive and facilitate resolution of the affected communities' concerns and complaints about its environmental and social performance. The grievance mechanism should be scaled to risks and adverse impacts of the project, address concerns promptly, use an understandable and transparent process that is culturally appropriate and readily accessible to all segments of the affected communities, and do so at no cost to the community and without retribution. The mechanism should not impede access to judicial and administrative remedies. The client will inform the affected communities about the mechanism early in the course of its community engagement process. (**Performance Standard 1 Paragraph 35)**.

A grievance mechanism should be able to deal with most community issues that are covered by the PSs. Grievance mechanism requirements, in relation to affected communities, are explicitly stated with regard to security personnel (**Performance Standard 4, Paragraph 12**) and Land Acquisition (**Performance Standard 5, Paragraph 11**).

The basic design elements of a grievance mechanism based on the IFC are illustrated in Figure V-1.

Figure V-1 Basic Design Elements of a Project Level Grievance Mechanism



Source: IFC Good Practice Note (#7) – Addressing Grievances from Project-Affected Communities, 2009

To ensure that the grievance mechanism is accepted by affected communities, the Project will follow the five principles recommended in Part I of the IFC's Good Practice Note. The steps that have been described in Part II of the Good Practice Note define the generic process that a Project can adapt to their specific situation. The factual process behind the steps should show the assessment results of the project's scale and impacts, and appoint appropriate resources for implementation. Appropriate allocation of resources will ensure that a management system for handling each step of the grievance procedure exists and has clearly defined objectives, assigned responsibilities, timelines, budget, senior management oversight, and regular reporting.

5.3 SOL'S GRIEVANCE MECHANISM

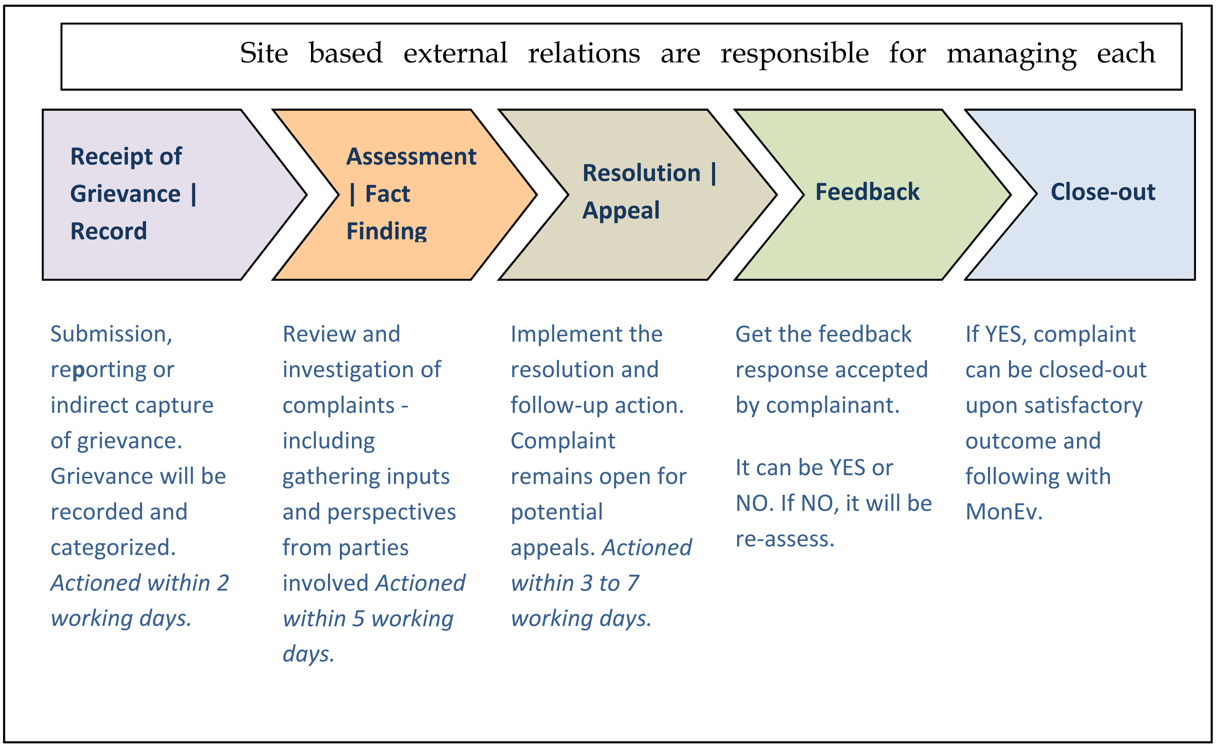
5.3.1 *Overview*

Although the Project seeks to minimise potential negative impacts arising from the project activities and to operate responsibly, it is inevitable that queries, and grievances will arise throughout the construction and operation phases. Therefore SOL's grievance mechanism has been designed as a locally based, Project specific design that assesses and resolves community complaints and concerns related to all Project activities. The Project grievance mechanism offers a package of widely understood and effective processes to address affected communities' concerns and complaints. To date community grievances received by the Project have been verbal, without any recorded documentation therefore further work is required to develop and implement the grievance mechanism in accordance with ADB and IFC requirements (i.e. via written documentation). Details of the current grievance mechanism are provided in the following sections of this Chapter.

5.3.2 *Grievance Tracking and Redress Mechanism*

The Project Grievance Tracking and Redress Mechanism (GRTM) that is triggered the instance a community complaint is received is illustrated in Figure V-2. This is a five step process based on international lender guidance.

Figure V-2 Summary Overview of the Project Grievance Tracking and Redress Mechanism



In general, grievances are communicated by the community to SOL through two primary channels:

- Oral communications such as to community representatives in each sub-district. These representatives appointed by SOL are Bapak Alden Sitompul (a religious leader in Sigurung-gurung village) and Bapak Marlan (the village head in Lumban Jaean); and
- Written communications to SOL's External Relations Department; this includes grievances registered with the village head (*Kepala Desa*) and/or at village community centres.

5.3.3 Receipt of Grievances

The initial procedure for grievance redress involves a entering the grievance information into the GTRM database—a grievance log and tracking system that will equip SOL management to identify, understand and address vulnerabilities in Project implementation. The GTRM database will be utilised to: a) register, track and recall information about specific grievances and b) categorise reports of grievances by type and frequency.

The original grievance form is kept in the village head office or by the community representative.

A generic report of the grievance is generated from the initial GTRM database that is entered by the External Relations Department in coordination with an appointed manager. This report includes all details known at the time the grievance is registered, and indicates what, if any, information is needed before a full account of the grievance can be logged. This initial report also serves to provide context and guidance for the fact-finding investigation. Timelines for fact-finding and implementation of possible actions will be established as appropriate for the type and severity of the grievance. The time period to receive a grievance is within 2 working days.

5.3.4 Assessment and Fact-Finding Investigation of Grievance Redress

The External Relations Department reviews and undertakes a fact-finding investigation of each grievance received by SOL. These investigations shall seek to establish a clear picture of the circumstances surrounding a particular grievance. Investigations shall verify the information contained in the initial grievance report specifically:

- Identity of the complainant and nature of the complaint;
- Identify the status of the complaint, including if it has been resolved by any immediate remedial actions, if the aggrieved expects that any particular actions need to be implemented, if no action toward resolution is known or expected, etc.; and

- Review supporting evidence for any disputed claims.

For grievances that involve a large number of people or entire villages, community meetings will be held with both open sessions for people to air their complaints and facilitated sessions to help collaboratively identify potential redress actions. Fact-finding investigations undertaken by SOL will rely on consultation that is free of discrimination and coercion.

The review and fact-finding investigation may result in the grievance being resolved; or follow-up actions being required with further coordination within SOL. Following this the External Relations Department can decide who is responsible for responding to the grievance and overseeing redress. The time period to assess the grievance is within 5 working days.

5.3.5 Resolution and Appeal on Grievance Redress

Resolution will be undertaken with the hope that agreement on a grievance resolution is achieved at the Project level (i.e. preventing complainants from proceeding to higher levels, such as government authorities). In some cases, redress actions may necessitate coordination with the local authorities. Resolution processes and approaches will rely, whenever possible, on local approaches to conflict resolution. Local authorities and/or respected leaders will be consulted for their insights and advice on the grievance and its proper resolution.

Resolution involves decision-making about grievance redress actions. Through co-ordination with other SOL departments, the External Relations Department is able to handle the communities' grievances and decide on how SOL will respond to the grievance with suitable resolution and a follow-up action plan. SOL will respond in the following ways:

- Written. Upon reaching agreement with the aggrieved, all such understandings shall be put in writing and a statement signed by both SOL and the complainant will be distributed to all sides involved in the grievance.
- Verbal. Meeting with complaints or dialogue/open meeting with groups – External Relations will ensure the effective and timely communication of grievance notifications, fact-finding inquiries, and will facilitate forums for remediation and restitution decisions.

If a complainant is not satisfied with the implementation outcomes of an agreed-upon grievance resolution measure, he/she may appeal the outcome. Written appeals may be registered with SOL's External Relations Department directly, or complainants may express their desire for an appeal to their Kepala Desa, community representative, or village community relations. When an appeal is registered, SOL will investigate the cause of dissatisfaction associated with the implemented resolution measure and identify follow-up actions that are agreeable to the aggrieved party. No grievance shall be considered closed if an appeal process is pending or active. The time period to respond is between within three and seven working days.

5.3.6 Feedback of Grievance

Once a grievance has been resolved, the complainant shall be invited to give feedback about the resolution process. They may be asked to indicate their level of satisfaction with the mitigation measures once such measures have been implemented. In all cases, the aggrieved must be aware of the outcome of his/her complaint. If the complainant is anonymous, information on resolution of the complaint shall be posted on the relevant village bulletin boards.

Following the resolution decision, the GTRM database shall be updated to reflect the status, on-going redress measures and the perception of the aggrieved in regard to these measures.

5.3.7 Close-out

Close-out reports are generated upon completion of the grievance resolution process. Reviewing the information logged in the GTRM database, External Relations—working with the SOL field team and other managers engaged in the grievance resolution process—generate a summary write-up of the resolution process. Close-out reports will:

- Contain details of the duration of time it took for each step of the grievance resolution process;
- List resolution measures agreed-upon and describe the implementation process;
- Provide an evaluation of the resolution process by External Relations;
- Provide feedback from the aggrieved on the resolution process;
- If appeals were registered, indicate the cause for dissatisfaction with the implementation of the initial resolution measures and explain what was done differently during the appeals resolution process; and
- Reflect on lessons learned.

5.3.8 Resources and Responsibilities

The External Relation Department are responsible for managing grievances - the key individual within the department is Bapak Hindustan Sitompul who is responsible for each step of SOL's Grievance Mechanism. Should the grievance be escalated beyond site decision makers SOL's senior management will take responsibility for closing out the grievance.

5.3.9 Grievance Mechanism Disclosure

SOL has prepared a simple grievance mechanism and provided contact details and information material to the affected communities. The details of the mechanism were disclosed to the local communities during the land acquisition socialization activities between April 30 and May 7 2013.

Future disclosure of the grievance mechanism will be integral to effective public consultation and strategic engagement. This will include disclosing to the following stakeholders:

- Local Community Centres;
- Village Heads Offices;
- Municipal and Central Government Offices;
- Local Universities or Academic Research Centres; and
- Offices of Local NGOs and Community-Based Organisations.

6 ENVIRONMENTAL MANAGEMENT PLAN

6.1 OVERVIEW

This Environmental and Social Management Plan (ESMP) chapter provides information and instructions on how Environmental, Social, Health and Safety (ESHS) aspects of the Project will be managed from pre-construction through the completion of the construction, operation and decommissioning phases. The ESMP is a living document which:

- Incorporates the EHS and social measures identified as a result of the EIA process into a comprehensive framework to facilitate and ensure appropriate management throughout the Project cycle;
- Provides a framework for procedures and plans specifically for activities that have 'high' risks, including an emergency response plan;
- Presents responsibilities for meeting ESMP requirements including the provision of training;
- Defines the monitoring and reporting program; and
- Provides a framework for the implementation of specific management plans by construction contractors and facility operators.

6.1.1 *Content of the ESMP*

The remains of this chapter are structured as follow:

- *Section 6.2* defines roles and responsibilities for the Project and outlines specific measures for construction management that bind contractors to safeguard the environment, health, safety, and social/community in line with commitments within this ESMP. Where relevant, various capacity building program are identified to ensure that the measures are implemented.
- *Section 6.3* outlines the specific management plans required to be prepared for the Project.
- *Section 6.4* presents the framework for management measures to be applied from pre-construction through the completion of the construction phase of the Project.
- *Section 6.5* presents the framework for management measures to be applied during the operation of the Project.
- *Section 6.6* outlines other management plans relevant to the Project.
- *Section 6.6.5.6* outlines the training requirements for the Project.

6.2 *KEY ROLES AND RESPONSIBILITIES*

6.2.1 *Overview*

The key parties and their primary roles in implementing the ESMP are as follows:

- SOL – as the Project Proponent is responsible for overall Project monitoring, ensuring compliance with environmental policy and obligations in the ESMP;
- EPC Contractors – responsible for complying with ESMP requirements set out by SOL; and
- Drilling contractors – responsible for complying with ESMP requirements set out by SOL.

6.2.2 *SOL EHS Management*

6.2.2.1 *SOL EHS Policy*

SOL is responsible to protect the environment, the health and safety of its employees, its contractors and the public affected by its operation. Health, safety and environment protection performance are core values of SOL and will be managed as an integral part of its business to benefit SOL's stakeholders. This objective can only be accomplished when all of SOL and its contractors' employees are responsible for the SOL's achievement of continuous and measurable improvement.

SOL has developed structured a HSE (Health, Safety and Environment) guideline which describes protocols related with health, safety and environment during project duration. Accordingly, a HSE procedure will be developed to outline a detailed procedure in line with applicable Indonesian Legislation and Industry Codes and Standards and ADB safeguard and social policy requirements, for the following fundamental objectives:

- *Line Management Responsibility, Compliance and Continuous Improvement*; all employees and contractors' personnel will actively promote SOL' HSE guideline as an integral part of everyone's work responsibilities. SOL' Management will set annual HSE performance objectives – with targets to achieve continuous performance improvements – and will implement a structured contractor selection process;
- *Risk Assessment*; the project will identify the inherent hazards in all activities and the level of associated risks. Appropriate control measures will be developed and implemented to ensure the protection of health and safety of all employees, contractor personnel, communities and other people as well as environment affected by SOL' operations. The integrity of

assets will be monitored and maintained;

- *Accident/Incident Reporting and Investigation*; the project management will immediately report all accidents or incidents. Line Management must investigate such events and promptly implement corrective actions;
- *Communications and Quality Assurance*; SOL recognizes the value of consultation between management, employees and communities. The project will implement internal and external inspections and audits to ensure that the required HSE performance targets are achieved;
- *Environmental Management*; SOL will continually monitor and reduce the impacts on water, land, and air by implementing Environmental Management System (EMS) that consists of: (i) Environmental Management Plan (RKL) and Environmental Monitoring Plan (RPL) approved by the North Sumatera Governor and fulfilling lenders' ESIA requirements to be used as a basis of preparing an environmental program, (ii) its implementation, (iii) its monitoring and evaluation/ correction, and (iv) regular reports to North Sumatera Environmental Agency (BLH) and lenders. In essence, EMS refers to the management of environmental programs in a comprehensive, systematic, planned and documented manner; SOL follows a Plan-Do-Check-Act (PDCA) Cycle and focuses in a continual improvement of the system;
- *Resourcing, Competency and Training*; the project will ensure that competent people, the correct equipment and appropriate procedures are available. The training needs of employees will be assessed and the necessary training conducted to enable them to do their jobs safely.

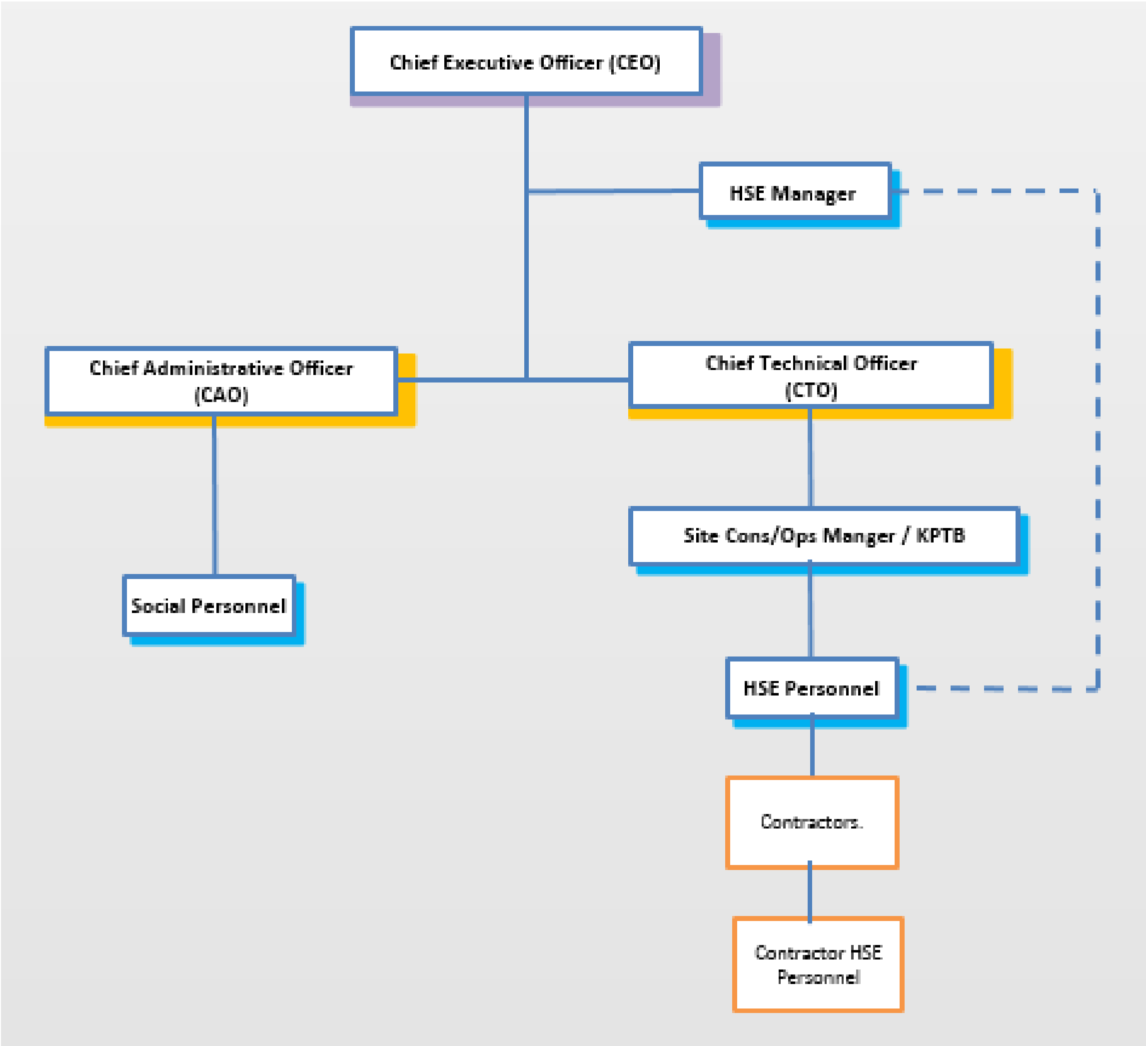
6.2.2.2 *Organisational Structure and Responsibilities*

Table VI-1 describes the duties and responsibilities of each personnel within the Project organisation structure in order to ensure that Environmental and Social Management (ESM) programs/system are well implemented.

Table VI-1 Officers' Roles and Responsibilities

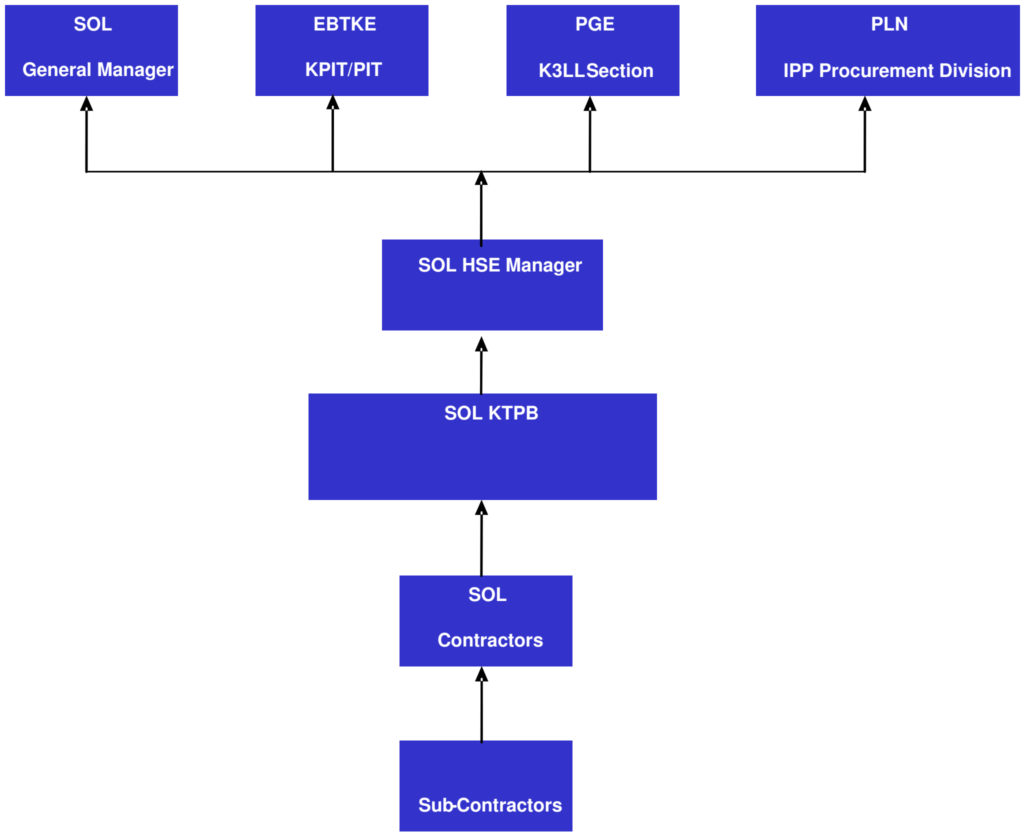
Function	*Responsibility*
CEO	Highest ranking officer of the company, responsible to: • All the day to day management decisions and implement long and short term plans. • Ensure a fully complying ESMS (Environmental and Social Management System) to the applicable environmental and social policies and standards • Ensure full implementation of the ESM program • Approval of company's HSE policy
HSE Manager	• Report to CEO • Develop, implement and monitor Project's Health, Safety and Environment Policy, Programs, and Procedures • Supervision of HSE personnel • Coordination among company's department managers for their respective contribution to the Company's ESMS • Perform audit
Chief Administration Officer	• Responsible for administration of the company • Ensure compliance of the whole administration department to the project's ESMS • Supervision of the social personnel • Promulgation of social programs
Social Personnel	• Report to the CAO • Implement, Execute and monitor social programs
Chief Technical Officer	• Responsible for all the technical aspect of the company's management • Ensure compliance of the whole technical department to the project's HSE • Ensure contractors' compliance to the project's HSE
Site Construction & Operation Manager/ KPTB	• Reports to the CTO • Ensure compliance of the technical department at the site to the project's HSE • Monitor contractors' performances on HSE • Support social programs implementation
HSE personnel	• Administratively under the supervision of the HSE Manager • Functionally under the supervision of the Site Construction and Operation Manager • Day to day supervision and monitoring HSE programs • Coordination with contractors
SOL' s Contractors	• Comply with the project's HSE program • Develop its own program based upon the project's HSE
Contractors' HSE personnel	• Implement the contractors' HSE program • Coordination with HSE personnel

Figure VI-2 HSE Management System



The structured HSE (Health, Safety and Environment) Management System will be implemented by SOL at all operating units/facilities and HSE training will be provided to all employee and also project contractors. In order to manage and monitor the implementation of HSE management system, the project establishes the following monitoring and reporting structure.

Figure VI-3 Institutional HSE Reporting



<u>Notes</u>:

K3LL: Keselamatan, KesehatanKerja&LindunganLingkungan (Health, Safety & Environment Protection

IPP : Independent Power Producer

KTPB KepalaTeknikPanasBumi (Head of Technical Geothermal)

WaKTPB : WakilKepalaTeknikPanasBumi (Deputy Head of Technical Geothermal)

KPIT : KepalaPelaksanaInspeksi Tambang (Head of Geothermal Inspection Execution)

PIT : PelaksanaInspeksi Tambang (Geothermal Inspection Executor)

EBTKE: EnergiBaru & Terbarukan&KonservasiEnergi (New & Renewable Energy & Energy Conservation)

HSE Reporting Line | Operational Reporting

6.2.3 *Capacity Building*

6.2.3.1 *SOL personnel for Health, Safety and Environment (HSE)*

SOL aims to provide a continuous capacity building to improve and enhance the capability of its personnel in the HSE division in executing their respective responsibilities towards health, safety and environment.

The management will undertake the following capacity buildings steps for the members of the HSE which shall include the following:

- Comprehensive orientation to be performed by the HSE Manager on the rest of HSE members on the SOL HSE policies
- Comprehensive orientation to be performed by the HSE Manager on the rest of HSE members on the HSE policies of the SOL Contractors
- Attend seminars, symposiums and workshops sponsored by EBTKE relating to HSE specific to implementation of geothermal projects. Proper scheduling of the members turn to attend seminars shall be done to ensure the continuous presence of SOL HSE personnel at the work site at all times
- Attend conferences, seminars and workshops on health, safety and environment organized by the government and certain selected private entities, especially those with great relevance to the geothermal industry. Specific geothermal industry HSE program is quite important to enhance the understanding of the HSE members on dealing with specific HSE matters that may not exist in other industries or activities. At the same token, there are certain HSE matters that may not necessarily be relevant to the geothermal industry and it is equally worth for HSE members to understand such extent for better execution of their work responsibilities
- The HSE Manager shall provide updates and relevant Indonesian environment regulations
- The Management shall perform audits at least annually of the performances of all members of the HSE personnel to further determine the needs for improving their expertise in HSE.
- Conduct a quarterly meeting of all members of the HSE to be conducted by the HSE Manager together with other key managers of SOL for SOL's in house monitoring of the respective performance of the subject personnel and updates of the project activities as a whole.

Under the SOL organisation, the HSE Manager has the direct responsibilities towards the HSE members. The HSE Manager role shall include not only the assessment and evaluation of the HSE execution activities but also the assessments of the welfare of the HSE members themselves.

The HSE members of SOL, functionally, will be in close coordination with the

Contractors performing works for SOL. A proper endorsement of these members to the Contractors shall be done by SOL and definitions of their functions in interfacing with the Contractors. Participation of the HSE member on certain Contractors safety meetings shall be arranged by SOL management. This will allow the HSE member to obtain continuous comprehensiveness of the Contractors' HSE plans and activities.

SOL includes recognition and incentive programs to the SOL HSE team members for upholding the highest quality of HSE performances.

6.2.3.2 *SOL Personnel for Social Matters*

Under the SOL organisation, the social staff are under the Administration Division and report to the Administration Manager.

Execution of work by the social staff is often surrounded by difficulties attributed to the complexity of dealing with social communities. The variations in behaviours of the society, political and cultural differences, mixed legal, regulatory and moral constraints are just few of the factor that can pose pressures on social staffs undertaking such work.

Capacity building is essential to ease responsibilities placed onto such staff that are brought under pressure arising out of their work responsibilities.

SOL provides a comprehensive explanation of the company's policies and rules on social matters to social staff, including:

- Aims and objectives;
- Explain the do's and don'ts; and
- Policy on limitations or boundaries of the company.

Expression of Management support:

- Management adapt policies of providing comprehensive support to the programs implemented by the Social Staff. Due to the nature of variability of dealing with society, the management shall equally adapt policies for flexibilities in supporting the activities of the social staff to maintain the harmonious relation of the social staff with the society. This also enhances the level of confidence of the Social Staff in performing their function if they are comfortable that the management has full support to implementation of the social activities.

Training:

- Similar to the HSE, the social staff will be given the opportunities to undergo trainings, attends seminars and workshops to enhance their capabilities in respect to social matters.

Reinforcement of Social Programs:

- SOL for its CSR program also intends to adapt the use of consultants (such a non-profit organisation and foundation sponsors) to come up with the effective CSR programs. The Social Staff shall be at all times be involved during such process of discussion with the consultants. Input from the SOL Social Staff shall be given adequate attention in the formulation of these programs.

Regular and periodic audits:

- The management, via the General Manager, shall perform periodic audits of the Social Staff to ascertain that they do not go beyond the policies of the Company in respect to implementing Social Programs. The close coordination of Social Staff to the community can in a number of instances cause intimate relationship with the society prompting Social Staff to act beyond the policies and standards of the Company. Period audits and review of the Staff's undertaking could deter from happening.

Social Staff is part of the whole team:

- Regular updates of project status
- Work with the rest of the project teams – exchange ideas; active and joint participation with the other team
- Close coordination with the subcontractors' community relation officers to know each of the entities programs.

6.2.4 Contractor Management

SOL as a Company has developed HSE Management System to protect its people at work, the environment and the community. SOL also has committed to protect its contractors, their subcontractors and their workers, vendors and customers with the same priority as well as Company employees through the Contractor Safety Management System (CSMS) implementation. All project contractors performing work are expected to have developed and implemented a comprehensive HSE program for managing the specific daily activities of their workforce, in accordance with the requirements set forth in the CSMS.

While performing work, the contractor shall follow the standards of conduct included in these guidelines to safely and environmentally friendly perform their work activities. Contractors shall refer to SOL's environmental impact assessment report ("AMDAL") and lenders' safeguard and social documents contractors should follow identical standards for work as well as labour and working conditions compliant with national laws and ILO core labour standards in their own facilities.

The Decision from the Minister of Energy & Geothermal Resources *No. 555.K/26/M.PE/1995,* The Decision of the Minister of Energy & Geothermal Resources *No. 02.P/20/M.PE/1990,* ADB's Social Protection Strategy 2001, and ADB's Policy on Gender and Development 1998 shall be used as references.

In order to help SOL to do better management of the risks of Contractors works at sites, in the HSE guidelines it is explained that there are two phases that consist of the following steps each in the CSMS procedure:

- Administration Phase:
  - Risk Assessment; the objective is to describe and assess the work and risk. This is the responsibility of SOL to prepare.
  - Pre – Qualification; it is intended to evaluate whether the contractors are experienced and capable to undertake the activities safely in accordance with the HSE standard requirements. SOL will also evaluate the capacity of the contractors to provide labour and working conditions compliant with national laws and ILO core labour standards (CLS);
- Field Implementation Phase:
  - Pre - Job Activity (PJA) consists of two steps: Pre-mobilization and Mobilization activities; HSE Manager or Line Managers shall lead the pre-job activities.
  - Work In Progress (WIP); the objectives of this phase are to ensure that the work performed is conducted according to the HSE requirements and that any additional HSE requirements identified during the work are properly addressed. SOL will also monitor contractors and subcontractors engagement of workers and their compliance with the national labour standards and the ILO's CLS.
  - Final Evaluation (FE); the objectives of this phase are to conduct a joint evaluation of the contractor's performance on HSE and compliance with national labour laws and CLS and to provide feedback to the contractor and Company as a reference for future work.

6.3 *PLANS, POLICIES AND PROCEDURES*

In addition to the EMP a set of specific management plans will be required to manage key issues for the Project. These constitute the Project approach in managing its impacts. These plans are intended as framework documents which will be developed by SOL to complement its existing EMS specifically for the Project. These plans will be applied for both construction and operation stage.

As minimum, specific plans will include:

- Stakeholder Engagement and Communication (includes grievance management);
- Occupational Health and Safety;
- Community Health and Safety;
- H_2S Monitoring Plan;
- Emergency Response Plan;
- Labour and Working Condition;
- Workforce Environmental Training Programme;
- Contractual Workers Decommissioning Plan;
- Water Management;
- Brine Management;
- Effluent Disposal Management Plan;
- Erosion Management Plan;
- Spoils And Drill Cuttings Disposal Management Plan;
- Solid And Hazardous Waste Management Plan;
- Spill Response Plan;
- Land Contamination Management Plan;
- Traffic Management Plan;
- Ambient Air And Noise Management Plan;
- Biodiversity Action Plan;
- Biodiversity Offsets Management Plan;
- Heritage Management;
- Well Abandonment Plan; and
- Facilities Decommissioning Plan.

Table VI-2 Specific Management Plans and Policies

Management Plan	*Objective / Content*
Stakeholder Engagement and Communication	Develop a comprehensive engagement and communications framework for key stakeholders and relevant communities that: • results in the distribution of timely information about the Project; and • provides a formal process by which grievances can be raised
Labour and Working Condition	Address potential labour issues such as equity in employment benefits. The plan will include: • Labour practices policy for non-discrimination, anti-child labour, anti-forced labour, freedom of union/association, minimum wages, social/medical insurance, and right for capacity building; • Local labour recruitment policies; and • Local procurement plan; and • A formal process by which grievances can be raised by the workforce, and allow structured investigation by SOL.
Workforce Environmental Training	Ensure that all personnel responsible for the implementation of the ESMP are competent and are provided with environmental and social aspects training appropriate to their scope of activity and level of responsibility.
Contractual Workers Decommissioning Plan;	Ensure that decommissioning of contractual workers runs smoothly and as much as possible to minimise any potential impacts to the workers
Community Health and Safety	• Management of labour influx; • Avoid or minimize transmission of communicable diseases associated with the influx of the Project migrant workers within its area of influence; • Protocols for migrant workers interaction with local communities; • Camp follower and camp habitation management; and • Health outreach program (e.g. support improvement of public health facilities, monitoring community health, HIV/AIDS awareness program for community and workers).
Occupational Health and Safety	Provide a safe working environment through implementation of procedures to address: • Violation & Infringement • Appreciation Award • Working within Company Premises • Employee Requirements • Emergency Preparedness & Evacuation • Roles Played by Everybody • Safety Induction • Smoking • Alcohol and/or Controlled Drugs • Safety Signs • Environmental Control • Permit-to-Work

Management Plan	*Objective / Content*
	• Worksite Visit • House keeping In addition, SOL will develop Standard Operating Procedure (SOP) which is a routine step-by-step task instruction or a sequence of task to operate and maintain the equipment & facility.
H_2S Monitoring Plan	Describe the programme for monitoring H2S in ambient air and collection of data on health effects.
Emergency Response Plan	Ensure processes are in place to effectively manage the response to emergency events and minimise risk to the workforce and environment. Emergency response may include: • Oil spill response plan; • H^2S release monitoring and response plan; • Drills; • Fire • Community Emergency response plan.
Water Management	Monitor surface and ground water quality Implement measures to stop contamination if identified and provide alternate water source.
Brine Management	Minimise and control brine discharges during well production tests or in case of re-injection failure during operation.
Effluent Disposal Management Plan	Minimise and control effluent discharges.
Erosion Management Plan	Implement measures to reduce erosion and enhance rehabilitation.
Spoils And Drill Cuttings Disposal Management Plan	Appropriate storage, handling, testing, transport and reuse of drilling mud or cuttings onsite or disposal.
Solid and Hazardous Waste Management Plan	Identify measures for minimisation of waste. Appropriate storage, handling, transport disposal of waste.
Spill Response Plan	Appropriate storage, transfer and use of chemicals on site. Identify responsibilities and equipment required to deal with a spill.
Land Contamination Management Plan	Implementation of processes to prevent soil contamination. Implementation of processes to remediate previously contaminated land disturbed by Project activities.
Traffic Management Plan	Minimise the impact of Project activities in regulating and managing traffic.
Ambient Air And Noise Management Plan	Reduction of Project impacts on ambient air quality and noise. Optimising best methods of technology to reduce greenhouse gases
Heritage Management	The procedure will include: • A definition of cultural resources; • Recognition and ownership of artefacts; and • Procedures upon discovery including stopping work and reporting

Management Plan	*Objective / Content*
	requirements.
Biodiversity Action Plan	Provide a strategy for refining the mitigation and management approach to conservation of biodiversity values, including specific measures for the IUCN listed threatened species with potential to occur in the Project area.
Biodiversity Offsets Management Plan	Provide a plan for the design and implementation of biodiversity offsets, to support the Biodiversity Action Plan.
Well Abandonment Plan	Outline a procedure for well decommissioning and rehabilitation.
Facilities Decommissioning Plan	Project's plan for facilities decommissioning activities after the 30-year term of contract as agreed in ESC/JOC, including the following elements: • Closure of production and reinjection wells; • Reclamation of well pads; • Reclamation of geothermal pipe gathering system; • Reclamation of power plant facility; • Road system including bridges; • Disposal area for drilling; • Disposal area for drilling; • Abandonment facilities decommissioned prior to Project transfer; • 150 KV transmission line of SIL-PLN sub-station and NIL-PLN sub-station; • Reclaimed land.

6.4 *CONSTRUCTION ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN*

This section outlines the construction ESMP. Table VI-3 to Table VI-15 present the framework for each management issue, which is to be elaborated in the EPC and drilling contractor's ESMP and implemented during construction. These tables detail minimum requirements for mitigation measures that will be implemented during construction to avoid, or mitigate environmental or social impacts as a result of the Project. SOL will review and approve contractor ESMPs prior to implementation.

Table VI-3 Labour and Working Conditions

Aspect	*Impact*	*Mitigation Measure / Enhancement*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Employment generation	Discrimination and potential conflict amongst locals	Preparation of recruitment policy, which will include prioritisation of local employment taking into account skills.	HR Department	To be applied immediately and ongoing	Disclosed recruitment policy Village committee meeting minutes Monitoring of compliance with national labour laws	Included in normal human resources and site management budget
	Local skills development	Local employment (especially women and people belonging to ethnic groups) to be prioritised, with additional specialised training provided where required.	EPC and Drilling Contractor	To be applied immediately and ongoing	Contractor contract review Contractor records on workers diversity: number of workers by job responsibility (management, skilled labour, unskilled labour), age, gender and ethnicity, locality Training records (records to show sex-disaggregated data)	Included in the cost of EPC and Drilling contract
	Ineffective communication resulting in mismanaged community expectations for employment	Project affected communities will be consulted with regularly, to communicate the progress of Project activities and the number of workers that will be employed throughout the construction period.	HR Department	To be applied immediately and ongoing	Maintenance of complaints log	Included in normal human resources and site management budget
	Remuneration and conditions of work will affect the quality of life of workers.	All workers will receive written contracts of employment that contain terms required by Indonesian law including medical / social insurance and will be paid at least the minimum wage as	HR Department	To be applied immediately	Employment contracts, payroll system	Included in normal human resources and site management budget

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
		defined in Indonesian law.				
	Retrenchment - unfair distribution in jobs losses and resentment within local communities.	A Retrenchment Procedure based on the principle of non-discrimination and Indonesian law will be established to guide job cuts.	HR Department	To be applied immediately	Maintenance of complaints log	Included in normal human resources and site management budget
Labour Management	Poor conditions resulting in employee grievance	Develop and implement a formalised grievance mechanism for complaints about unfair treatment.	HR Department and EPC and Drilling Contractor	To be applied immediately and ongoing	Maintenance of complaints log	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
	Poor camp conditions	An audit programme of workers camps with corresponding penalties for noncompliance	HR Department and EPC and Drilling Contractor	Ongoing – once a quarter or upon complaint	Audit reports, records of fines and penalties imposed and corrective action plans	Included in the site management budget and the cost of EPC and Drilling contract
		Ensure the housekeeping procedures outlined are implemented.	EPC and Drilling Contractor	To be applied immediately and ongoing		Included in the cost of EPC and Drilling contract
	Poor worker behaviour	Implement an Employee Code of Conduct (with corresponding penalties for noncompliance) and Camp Management Plan for the Project	HR Department	To be applied immediately	Employee records	Included in the site management budget

Table VI-4 Occupational Health and Safety

Aspect	*Impact*	*Mitigation Measure / Enhancement*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Occupational Health and Safety	Workplace accidents and injuries	Ensure compliance with the general HSE rules and requirements as detailed in SOL HSE Policy and Procedure including: • Violation & Infringement • Appreciation Award • Working within Company Premises • Employee Requirements • Emergency Preparedness & Evacuation • Roles Played by Everybody • Safety Induction • Smoking • Alcohol and/or Controlled Drugs • Safety Signs • Environmental Control • Permit-to-Work • Worksite Visit • House keeping	All personnel	Throughout construction	Training records Incident records	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
		Develop a Standard Operating Procedure (SOP) for the operation and maintenance of equipment & facilities. The SOP may refer to the instruction manual provided by Original Equipment Manufacturer (OEM) or facility start up manual and engineering manual or assessment. Specialized Working Procedure (SWP) will be also developed contain a step by step task instruction or	Project Manager and OHS Manager EPC and Drilling contractor	To be applied immediately and ongoing	Plan development	Included in normal human resources and site management budget and the cost of EPC and Drilling contract

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
		sequence of task to conduct critical one time job i.e. tie in procedure to existing facility, etc. Both SOP and SWP shall be written in both English and Indonesian languages.				
		Provide all SOL and contractor employees with access to healthcare and treatment at the main camp.	SOL, EPC and Drilling Contractor	To be applied immediately and ongoing	Camp records	Included in the cost of EPC and Drilling contract
		Conduct regular spot checks regarding drug and alcohol consumption in particular amongst those working with heavy machinery, vessels or vehicles.	EPC and Drilling Contractor	To be applied immediately and ongoing	Audit reports	Included in the cost of EPC and Drilling contract
		Regularly patrol all construction areas to ensure that any health and safety incident is quickly identified and appropriate actions are taken.	EPC and Drilling Contractor	To be applied immediately and ongoing	Audit reports	Included in the cost of EPC and Drilling contract
		Ensure the injury management and rehabilitation procedures are in place, including: • injury management processes; • basic first aid facilities; • emergency response mechanisms for significant injuries; and • rehabilitation processes.	EPC and Drilling Contractor	To be applied immediately and ongoing	Incident reports/ log Audit reports	Included in the cost of EPC and Drilling contract
		Provide workforce with required personal protective equipment (PPE).	EPC and Drilling Contractor	To be applied immediately	PPE register	Included in the cost of EPC and Drilling contract

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
				and ongoing		
		Ensure a Work Permit System is in place, and that all site personnel operate within the basic types of permit processes, as listed below: • Confined Space Entry Permit; • Working At Heights Permit; • Hot work and Cold work Permit; • Workbox Approval; • Burning Permit; and • Isolation Permit.	EPC and Drilling Contractor	To be applied immediately and ongoing	Work permit records	Included in the cost of EPC and Drilling contract
Geothermal Gases	Occupational exposure to geothermal gases, mainly hydrogen sulfide gas	Where there is a potential for exposure to hazardous levels of hydrogen sulfide the following management measures will be implemented: • Development of a H_2S Monitoring Plan including installation of H_2S monitoring and warning systems; • Development of a contingency plan for H_2S release events including facility emergency response teams • Provision of personal H_2S monitors, self-contained breathing apparatus and emergency oxygen supplies, and training in their safe and effective use for workers in locations with high risk of exposure; • Provision of adequate ventilation of occupied buildings to avoid accumulation of H_2S gas; and	Project Manager, OHS Manager and EPC and Drilling Contractor	To be applied immediately and ongoing	H_2S monitoring data Training records PPE Register Incident records	Estimated cost of environmental monitoring such as air quality, noise is US$ 86,000 per year. For the related to the contractor's matter, included in the cost of EPC and Drilling contract

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
		• Providing workers with a fact sheet or other readily available information about the chemical composition of liquid and gaseous phases with an explanation of potential implications for human health and safety.				
	Mercury vapours have also been recorded in some geothermal facilities and it would be useful for SOL to comment on the potential for mercury release based on analysis of geothermal fluids from exploration activities and a commitment to monitor periodically.	Geothermal characteristic of Sarulla do not indicate presence of mercury vapour in the fluid. As wells are tested, geothermal fluid samples will be taken and will be analysed for chemical and physical properties including determination if mercury vapours present.	OHS manager and Drilling Contractor	During Well testing	Lab test record	Included in normal human resources and site management budget and the cost of Drilling contract
Confined Spaces	Potential fatal accident	Develop and implement confined space entry procedures including a development and implementation of a confined space entry program for areas designated as 'Confined Spaces'.	OHS Manager and EPC and Drilling Contractor	To be applied immediately and ongoing	Training records Incident records	Included in normal human resources and site management budget and the cost of EPC and Drilling contract

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
Heat	Occupational exposure to heat, including non-routine exposures such as blowout accidents	Prevention and control measures to address heat exposure include: • Reducing the time required for work in elevated temperature environments and ensuring access to drinking water; • Shielding surfaces where workers come in close contact with hot equipment; • Use of personal protective equipment (PPE) as appropriate, including insulated gloves and shoes; • Implementing appropriate safety procedures during the exploratory drilling process.	OHS Manager and EPC and Drilling Contractor	To be applied immediately and ongoing	H_2S monitoring data Training records PPE Register Incident records	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
Communicable disease	Transmission of HIV/AIDS, STIs and PIDs	Provision of HIV/AIDS, STIs and PIDs awareness and prevention briefings.	OHS Manager and EPC and Drilling Contractor and also in collaboration with local health units or related NGOs working on health areas	To be applied immediately and ongoing	Training records	Included in normal human resources and site management budget and the cost of EPC and Drilling contract

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
Disease Vector	Transmission of mosquito-borne and other infectious diseases	Provision of awareness and prevention briefings	OHS Manager and EPC and Drilling Contractor	To be applied immediately and ongoing	Training records	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
		Provide workers with personal protection (e.g. insecticide impregnate bed nets) and regular fumigation of camp site.	EPC and Drilling Contractor	To be applied immediately and ongoing	PPE records	Included in the cost of EPC and Drilling contract
		Provide trained medical staff support onsite who can conduct malaria rapid diagnostic tests to workers, provide effective treatment.	EPC and Drilling Contractor	To be applied immediately and ongoing	Medical records	Included in the cost of EPC and Drilling contract
		Maintain camp sites free of stagnant pools.	EPC and Drilling Contractor	To be applied immediately and ongoing	Audit reports	Included in the cost of EPC and Drilling contract

Table VI-5 Social Management

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
Community Health, Safety and Security	General project impacts resulting in community grievance	Develop and implement a formalised grievance mechanism for complaints recognition, investigation and resolution.	HR Department and EPC and Drilling Contractor	To be applied immediately and ongoing	Maintenance of complaints log	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
	Community accident, injury or health impacts	Restrict access to site using fencing and security personnel as required.	EPC and Drilling Contractor	To be applied immediately and ongoing	Incident reports/ log Audit reports	Included in the cost of EPC and Drilling contract
		Prepare a labour In-migration Management Plan to cover the following issues: • avoid or minimize transmission of communicable diseases associated; • protocols for migrant workers interaction with local communities; • camp habitation management; and • pre-employment medical exams or health screening.	HR Department and EPC and Drilling Contractor	To be applied immediately and ongoing	Plan review Maintenance of complaints log	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
		Develop a community health outreach program (e.g. to support improvement of public health facilities, monitoring community health, HIV/ AIDS awareness program).	HR Department and EPC and Drilling Contractor and also in collaboration	To be applied immediately and ongoing	Program reporting	Included in normal human resources and site management budget and the cost of EPC and Drilling contract

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
			with local health units or related NGOs working on health areas			
		Avoid or minimize the potential community exposure to water-borne, vector-borne diseases, and any communicable diseases resulting from Project activities. Where specific diseases are identified as endemic in the Project area of influence, opportunities to improve environmental condition to minimize their incidence will be explored.	HR Department and EPC and Drilling Contractor	To be applied immediately and ongoing	Maintenance of complaints log	Included in normal human resources and site management budget and the cost of EPC and Drilling contract
		Ensure compliance with Traffic Management Plan. Traffic safety sessions for children and distribution of traffic awareness information.	EPC and Drilling Contractor	To be applied immediately and ongoing	Incident reports/ log Audit reports	Included in the cost of EPC and Drilling contract
Land acquisition	Loss of land, assets, common property income and impact on livelihoods.	Continue using current willing buyer / willing seller practices.	Project Manager and land Acquisition Team	Ongoing throughout construction	Land acquisition report Compensation data Payment date Date of transfer	Included in normal land acquisition budget

Table VI-6 Seismicity Management

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
Seismicity	Infrastructure damage	Undertake further field trenches need to test the activity in faults located near plan facilities.	Project Manager / Engineering Manager EPC Contractor	During construction	Seismicity activity testing Seismicity monitoring Liquefaction assessment review Slope stability assessment review	Included in normal project management budget and the cost of EPC contract
		The International Building code will be used for the design of buildings where the local seismic code is un-conservative.	Project Manager / Engineering Manager EPC Contractor	Prior to construction		
		A detailed Liquefaction Assessment will be undertaken for the area by using the laboratory test Plasticity Index results and internationally accepted liquefaction assessment techniques in order to estimate the possible liquefaction hazard.	Project Manager / Engineering Manager EPC Contractor	Prior to construction; integrated part of engineering/design works		
		Slope Stability assessments will be performed using displacement based methods.	Project Manager / Engineering Manager EPC Contractor	Prior to construction		

Table VI-7 Water Management

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
River Abstraction	Altered water flows and reduced water quality.	Identify water users downstream prior to abstraction.	Project Manager	Prior to abstraction	Identification records	Included in normal project management budget
		Choose a flow rate and timing to minimise impacts on the water course and maintain stream flow. Where this cannot be achieved a new water supply pipeline is to be constructed from an alternative source to ensure community water supply is unaffected.	Environmental Engineer / EPC and Drilling Contactor	Throughout construction	Record water quality at the time of abstraction Record quantity of water abstracted and timing of abstraction River flow monitoring before and after abstraction Audit reports Complaints log	Included in normal project management budget and the cost of EPC and Drilling contract
Clearing and grading works	Contamination of surface water by stormwater runoff containing suspended sediment.	Implement erosion control measures as set out in the Erosion Management Plan.	EPC Contactor	Throughout construction	Quarterly Water quality Monitoring – no deterioration in pre-project river water quality Audit reports	Included in the cost of EPC contract
		Construct diversion drains and bunds to divert clean runoff away from construction areas and prevent contaminated water entering local water sources.	EPC Contactor	Throughout construction		
		Reuse treated stormwater on site where possible to meet some of the water needs of the Project.	EPC Contactor	Throughout construction		
		Creation of a buffer zone around waterways to reduce the potential for	EPC Contactor	Throughout construction		

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		erosion and sedimentation entering waterways.				
	Impacts to groundwater resources.	Provide baseline of current spring discharge and quality to ensure any potential new springs created by excavation can be identified as such.	EPC Contactor	Throughout construction	Survey of well to be undertake prior to works	
		If community water supply wells are affected by the Project, either deepen the affected w ell provide an alternate water supply.	EPC Contactor	Throughout construction	Quarterly monitoring of community supply wells.	
Drilling and testing	Pollution from drilling muds or test waters	Use water based drilling muds rather than oil based.	Drilling Contactor	Throughout construction	Quarterly Water quality Monitoring – no deterioration in pre-project river water quality Site inspection (daily) and Audit (quarterly) reports Incident report – no discharges of untreated water.	Included in the cost of Drilling contract
		Recycle drilling muds where possible.	Drilling Contactor	Throughout construction		
		Design adequate capacity treatment ponds / water filters to manage waste water. Ponds to have impermeable lining, and be regularly checked for rips and tears. Ponds will be regularly cleared of silt.	Environmental Engineer/ Drilling Contactor	Throughout construction		
	Contamination of groundwater	Well designs to employ deep set surface casing to prevent blowouts (the uncontrolled discharge of deep aquifer water/steam into the upper aquifer or surface.	Drilling Manager /Engineer/ Contractor	Throughout construction	Daily site inspections Audit reports Incident logs	
Well blow out / Overflow of settling pond	Reduced water quality	Provide drains from wells to route effluent fluid to settling ponds.	OHS Engineer/ Environmental Engineer Drilling	Throughout construction	Design plans	Included in normal project management budget and the cost of Drilling contract

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
			Contractor			
		Where downstream users are affected by an overflow construct a new water supply pipeline from an alternative source to ensure community water supply is unaffected.	Environmental Engineer/ Drilling Contractor	Throughout construction	Water quality monitoring following event. Monitoring locations to include upstream, immediate downstream and nearest community.	Included in normal project management budget and the cost of Drilling contract
Spill of hazardous materials	Contamination of surface water and groundwater.	Ensure compliance with the Spill Prevention Plan. Mitigation measures to prevent water contamination may include: • Any potentially hazardous materials on site will be kept in a secure and bunded area. Bunds will be designed to enable containment of 110% of the largest container volume, or 25% of the total storage capacity (whichever is greater). • Locate hazardous material stores away from surface waters. • Provide spill kits on site. • Stormwater runoff will be diverted away from hazardous materials stores. • Runoff from refuelling areas, fuels storage, and containment areas will be diverted through oil water separators and grease traps prior to going to the treatment pond.	EPC and Drilling contractor	Throughout construction	Daily site inspection and audit reports	Included in the cost of EPC and Drilling contract

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Discharge of effluent wastewater	Reduced water quality	An Effluent Management Plan will be prepared and will include details on the collection, treatment and reuse or discharge of effluent wastewater.	EPC Contactor	Throughout construction	Treated effluent will be tested prior to discharge. Daily site inspections Audit Reports	Included in the cost of EPC contract
Collection and Storage of Brine	Reduced water quality	Minimise and control brine discharges during well production tests or in case of a reinjection failure during operation. Prepare the secondary containment and procedure to reroute the brine, brine treatment prior to discharge if required, community warning	Project Manager Drilling Contractor	Prior to construction	Plan review	Included in normal project management budget and the cost of Drilling contract
		Storage of brine in lined ponds until potential future re-injection.	EPC and Drilling Contractor	Throughout construction	Daily site inspection Audit reports	Included in the cost of EPC and Drilling contract

Table VI-8 Erosion Management

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
Clearing and grading	Soil erosion	Design construction works to avoid erosion prone areas such as weak soils, tributary headwalls along ridges and over-steepened slopes in gorges, previous areas of instability and reduce the number of watercourse crossings.	EPC Contractor	Prior to construction	Design plans	Included in the cost of EPC contract
		Stage works to ensure areas are not disturbed until necessary for the following works.	EPC Contractor	Throughout construction	Design plans	
		Restrict site clearing to areas that require development.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
		Retain cleared vegetation and use as mulch and/or erosion control and rehabilitation.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
		Install erosion and sediment control structures to prevent erosion or intercept sediment-laden surface runoff and reduce sediment delivery to watercourses.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
		Maintain erosion and sediment control structures until adequate slope stabilization, sediment control and subsidence control has been achieved.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
		Construct diversion drains to divert clean runoff away from construction areas.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
		Reduce disturbance of natural drainage and avoid blocking channels with graded material.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
		Revegetate disturbed areas (no longer required for construction) as soon as possible to stabilise soil. Rehabilitation will be conducted progressively and as soon as possible to return the land to as close as, or better than, prior to disturbance.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	
Soil and Stockpile	Soil erosion	The following erosion and sediment control measures will be implemented before stripping or	EPC Contractor	Throughout construction	Daily site inspection and audit reports	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
Management		stockpiling of any material. Stockpiles must be: • Located in pre-designated areas. • Constructed at least 10m from hazard areas and likely areas of concentrated water flows, e.g. waterways, roads, slopes steeper than 10%, etc. Where rainfall events within the catchment are likely to cause the waterway to swell then this distance will be need to be increased up to 50m. • No greater than 2m high if the stockpile material is topsoil, to avoid excessive heat being generated and composting. • Protected from run-on water by installing water diversion structures upslope. • Formed with sediment fences placed immediately down slope to protect other lands and waterways from pollution. • Stabilised if they are expected to be in-situ for extended periods and receive extended periods of potentially erosive rain (e.g. sprayed with a chemical stabiliser; covered, grassed, etc.). • Stabilised if they are located near sensitive receptors (e.g. waterways, water bodies, wetlands, etc.) and contain materials with appreciable fines contents that pose a pollution risk following a rainfall event.				
		Topsoil will be conserved in designated topsoil stockpile areas for later reuse.	EPC Contractor	Throughout construction	Daily site inspection and audit reports	

Table VI-9 Solid and Hazardous Waste Management

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Inappropriate waste management and disposal	Soil, groundwater and surface contamination and ambient air quality impact	Ensure waste minimisation through prior planning and accurate estimation of material required.	EPC Contractor	Throughout construction	Waste tracking and reporting is required to provide data on all waste amounts from generation through to disposal. Daily site inspections Audit reports	Included in the cost of EPC contract
		Provide appropriate facilities/containers for segregation and temporary storage of general wastes on site.	EPC Contractor	Throughout construction		
		Identify and approve licensed landfill and recycling facilities and waste disposal contractors to be used for the Project.	EPC Contractor	Throughout construction		
		Establish site specific processes for material, handling (receipt, unloading), storage, transportation and disposal (including recycling/ reuse options).	EPC Contractor	Throughout construction		
		Reuse or recycle all wastes where possible.	EPC Contractor	Throughout construction		
		Develop a waste inventory for the Project.	EPC Contractor	Throughout construction		
		• Drilling mud will be regularly removed from settling ponds and: • re-injected into total loss wells where available; or • Stored and/or disposed of in accordance with Indonesian regulation.	Drilling Contactor	Throughout construction		Included in the cost of Drilling contract

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Hazardous waste	Soil, groundwater and surface contamination and ambient air quality impact	Use of materials that will produce hazardous or restricted waste will be avoided.	EPC Contractor	Throughout construction		Included in the cost of EPC contract
		Hazardous wastes must be collected in designated containers including classification and labelling as hazardous waste. Hazardous waste storage areas must be lined and capable of containing any potential spills.	EPC Contractor	Throughout construction		
		Hazardous waste must be disposed of by a licensed third party.	EPC Contractor	Throughout construction		
		Prepare a Hazardous Waste Report for hazardous wastes generated during the Project lifecycle. The report will describe in site-specific detail how these wastes will be controlled and managed including the storage location, methods of storage and handling and identify relevant design specifications, drawings, construction methods, implementation plans, and operational procedures.	EPC Contractor	Throughout construction		

Table VI-10 Land Contamination Management

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Collection, storage and transport of drilling muds and cuttings	Soil contamination	Use water based drilling muds rather than oil based.	Drilling Contactor	Throughout construction	Daily site inspection Audit reports	Included in the cost of Drilling contract
		Store muds in lined ponds and cuttings in dedicated housing.	Drilling Contactor	Throughout construction	Daily site inspection Audit reports	
		Drilling mud will be regularly removed from settling ponds and: • re-injected into total loss wells where available; or • stored and subsequently treated in accordance with Indonesian regulation.	Drilling Contactor	Throughout construction	Toxicity texting of drilling muds required for disposal Daily site inspection Audit reports	
Spill of hazardous materials	Contamination soil	Construction of appropriate spill containment facilities for all chemicals and fuel storage areas.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	Included in the cost of EPC contract
		Material Safety Data Sheets (MSDS) for all stored substances will be held at each storage site.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Spill kits including appropriate spill containment and response equipment will be made available and all personnel appropriately trained in their use.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Waste will be managed in accordance with the Waste Management Plan, including discarded oil filters and used spill response equipment.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Investigation, remediation and validation	EPC	Throughout	Daily site inspection	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		procedures will be developed and used to establish the site as 'clean' in the event of a spill.	Contractor	construction	Audit reports	
		Develop and maintain a contaminated soils register which lists all known and suspected areas of land contamination at sites associated with the Project.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
Collection and Storage of Brine	Soil contamination	Storage of brine in lined ponds until potential future re-injection. Develop Brine Management Plan to minimise risk of brine discharges.	EPC Contractor Project Manager	Throughout construction Prior to construction	Daily site inspection Audit reports Plan review	 Included in normal project management budget

Table VI-11 Traffic Management

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Delivery Traffic	Congestion and damage to road infrastructure	Predefined access routes will be used for abnormal loads (long, wide or heavy loads). Routes will be agreed with local authorities in advance and the police will be notified.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	Included in the cost of EPC contract
		Abnormal loads will require use of a pilot escort at the front and rear to warn oncoming vehicles. The escort will also be responsible for pulling the convoy over at predefined locations to allow a build-up of traffic to pass. All vehicles will be in contact via two-way radio.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	
		Additional traffic management staff will be employed with pedestrians are present.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	
		Develop a contingency plan, in consultation with police to cover an event where an abnormal load becomes immovable on a public road.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	
		Develop driver induction for abnormal load vehicles including: • Safety briefing; • Appropriate care and speed control; • Identification of sensitive areas; and • Clarification of identified route.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	
Site Traffic	Congestion and damage to road infrastructure	Drivers to be made aware of predefined route.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	
		Construction traffic will operate in	EPC	Throughout	Daily site inspection	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		accordance with site working hours.	Contractor	construction	Audit reports Incident reports	
		Erect temporary signage indicating local routes to site and site entrances. Signing arrangement will be agreed with the local municipality and police.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	
		Wherever possible, arrangements will be made for site workers to be transported to site via shared transport.	EPC Contractor	Throughout construction	Daily site inspection Audit reports Incident reports	

Table VI-12 Noise Management

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Construction activities, equipment and vehicles	Nuisance impacts to local communities	Affected persons will be notified prior to any loud works that may have adverse impacts.	EPC Contractor and Drilling Contractor	Throughout construction	Weekly (or on complaint) noise monitoring using sound level m at the nearest sensitive receptor. Complaints log Audit reports	Included in the cost of EPC contract
		Establish permanent signage around the site e.g. At site offices, that is visible to all personnel, which identifies the need to limit noise e.g. 'please respect our neighbours and keep noise to a minimum'	EPC Contractor and Drilling Contractor	Throughout construction		
		Construction machinery and vehicles will be located within designated working areas and away from residential areas where practical.	EPC Contractor and Drilling Contractor	Throughout construction		
		Construction equipment will be placed in a position that provides the most acoustic shielding from buildings and topography.	EPC Contractor and Drilling Contractor	Throughout construction		
		High noise activities will be undertaken over short periods and where possible scheduled to avoid simultaneous operation of high noise generating plant.	EPC Contractor and Drilling Contractor	Throughout construction		
		Machinery s is to be shut down when not in use, and not left idling unnecessarily.	EPC Contractor and Drilling Contractor	Throughout construction		
		All engine exhausts and compressor components will be maintained	EPC Contractor	Throughout construction		

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		regularly. Equipment that meets industry good practice will be selected.	and Drilling Contractor			
		Maintain noise suppression devices (e.g. rock muffler) on construction vehicles and equipment.	EPC Contractor and Drilling Contractor	Throughout construction		
		Minimise reversing movements by vehicles with reversing alarms in sensitive areas.	EPC Contractor and Drilling Contractor	Throughout construction		
		Pneumatic tools will be fitted with a silencer if used within a sensitive environment.	EPC Contractor and Drilling Contractor	Throughout construction		
		High noise level generating construction works (including drilling and steam blowing activities) be limited to the daytime (07:00 to 22:00) period, if they are to be undertaken in near proximity to noise receptors. Where night work may be required, it will follow World bank Guidelines and Indonesian regulation	EPC Contractor and Drilling Contractor	Throughout construction		
		If construction activities cause breaches of Indonesian or World Bank standards noise barriers will be put in place. Where acoustic barriers or screens are preferred, they should be constructed without gaps or cracks and with a continuous minimum surface density of 10 kg/m^2 in order to	EPC Contractor and Drilling Contractor	Throughout construction		

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		minimise the transmission of sound through the barrier. The barrier must ensure that the noise source is entirely hidden from the receptor.				
		Avoid well column clearing/ vertical well testing.	EPC Contractor and Drilling Contractor	Throughout construction		
Construction Traffic	Nuisance impacts to local communities	Schedule traffic movements to avoid sensitive periods. Project traffic routing through community areas is reduced wherever possible.	EPC Contractor and Drilling Contractor	Throughout construction		
		Use modern (not less than 5yrs old) vehicle / construction fleet equipped with exhaust silencers.	EPC Contractor and Drilling Contractor	Throughout construction		

Table VI-13 Biodiversity Management

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
Site clearing and grading activities	Destruction of flora/fauna, habitat loss and edge effects. Fauna injuries and fatality.	Locate facilities within or adjacent to existing disturbed areas, and avoid biological features of significance, as identified in a targeted field survey and outlined in the Biodiversity Action Plan, where practicable.	EPC Contractor	Prior to construction	Ecology survey Design plans	Included in the cost of EPC contract Included in the land acquisition budget Included in the cost of EPC contract
		Ensure areas to be cleared during construction are kept to a minimum. Mark the extent of vegetation to be	EPC Contractor	Throughout construction	Daily site inspection Audit reports	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		cleared on all technical drawings and mark in the field.				
		Utilise or upgrade existing roads to minimise additional clearing requirements.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Ensure access roads and transmission line right of ways are kept at the minimum width necessary.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Directional drilling technology will be employed to allow efficient use of drilling well pads and avoid the requirement for additional pad area.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		All cleared vegetation will be stockpiled (away from water ways) and kept for rehabilitation, landscaping and erosion control work.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Clearance and felling methods that retain trees and allow fauna to escape will be employed where possible.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		If fauna species are found in areas to be cleared, immediately prior to clearing activities, fauna will be relocated by a qualified ecologist to suitable habitat as close as possible to the area in which they were found.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Habitat features and resources for native fauna (such as hollow-bearing trees, hollow logs and bush rocks), identified by a qualified ecologist, will be relocated in a manner to limit damage to existing vegetation, where practicable.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
	Loss of habitat with potential critical habitat values	Confirm presence (or not) of habitat values for IUCN listed species through targeted survey program for candidate species (Sumatran tiger, Sumatran orang-utan, agile gibbon, siamang, Malayan pangolin and Asian tapir).	EPC Contractor	Prior to clearing and construction	Daily site inspection Audit reports	
	Unavoidable loss of habitat	Biodiversity Offsets Management Plan will be developed specific to the biodiversity values of the Project area that will be disturbed. Offset or compensatory measures may include: • Rehabilitation of modified habitat adjacent to Batang Toru Forest to reinstate natural habitat characteristics; • Improving the biodiversity values of the adjacent Batang Toru Forest through investment into the development of management programs or establishing long-term conservation mechanisms for high value areas within the forest; • Threat abatement for impacted species. For example community education activities regarding threatened species poaching and illegal pet trade • Support for existing protected area network for impacted species; • Support for conservation research in	EPC Contractor	Prior to construction	Strategy review	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		the Batang Toru Forest; and • Contribution to existing conservation programs.				
General construction activities	Introduction of invasive flora and fauna species	Avoid damage to other trees, not scheduled for felling, by machinery. Vehicles or other plant or machinery will not be permitted to enter areas of intact vegetation.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Avoid use of herbicides to clear vegetation unless absolutely necessary to remove noxious weeds.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Intact vegetation areas will not be inadvertently used for stockpiling or as lay down areas.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Any replanting of disturbed areas will be done using native plant species, and where possible those common to the area. Replanting or any stabilisation will occur as soon as practicable after ground disturbance to limit erosion potential.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
		Identify existing areas of non-native plant species and their extent within the project boundary and develop specific management plans where required.	EPC Contractor	Throughout construction	Ecology survey	
		Hygiene measures for construction machinery and workforce will be undertaken, including: • disinfection and wash down of plant and machinery prior to its arrival at the Project Area;	EPC Contractor	Throughout construction	Daily site inspection Audit reports	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		• containment of the material washed from machinery/equipment for appropriate disposal. • containing and treating wash down water (as required); • locating wash areas away from water bodies; and • inspection of plant and machinery when moving between work stations.				
General construction activities		Possession of cats and dogs in camp or on work sites will be prohibited.	EPC Contractor	Throughout construction	Training records Daily site inspection Audit reports	
		Manage construction and domestic waste to avoid attracting native and alien species to the construction areas.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
	Light and noise causing behavioural disturbances	Maintain construction vehicles appropriately to minimise unnecessary noise generation.	EPC Contractor Drilling Contractor	Throughout construction	Daily site inspection Audit reports	
		Implement speed limits to maximum of 40 km/hr for construction vehicles to limit noise and dust generation and minimise potential for fauna strike.	EPC Contractor Drilling Contractor	Throughout construction	Daily site inspection Audit reports	
		For construction and operation areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible.	EPC Contractor Drilling Contractor	Throughout construction	Daily site inspection Audit reports	
	Erosion impacts	For adjacent areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and	EPC Contractor	Throughout construction	Daily site inspection Audit reports	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		maintained until vegetation replanting can occur to stabilise disturbed surfaces.				
	Hazardous materials spills	All chemicals to be stored and treated according to the requirements of each material safety data sheet (MSDS).	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
	Waste impacts	Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
	Brine discharge impacts	Condensate and brine generated during the power plant production testing and operation will be injected into reinjection wells.	EPC Contractor	Throughout construction	Daily site inspection Audit reports	
Hunting /fishing by project workers and contractors	Reducing numbers of vulnerable animals	Hunting / fishing or possession of fauna by Project personnel will be prohibited.	EPC Contractor Drilling Contractor	Throughout construction	Training records Daily site inspection Audit reports	
Collection of flora by project workers and contractors	Reduction in numbers of flora species near camp sites.	Harvesting / cultivating of forest products and deforestation by Project personnel will be prohibited.	EPC Contractor Drilling Contractor	Throughout construction	Training records Daily site inspection Audit reports	
Ecosystem services	Loss of cultivated crops and non-wood fibres and resins	The Land Acquisition Process will: • involve baseline data collection on the uses and incomes derived from land to be acquired; • identify households that are vulnerable to Project impacts, whether due to the proportion of land	Project Manager and land Acquisition Team	Prior to and ongoing throughout construction	Baseline studies Land acquisition report Compensation data	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		to be acquired, or the current level of household income; • provide appropriate compensation, whether financial or land-based; and • include a grievance mechanism.				
	Impact to freshwater supply (groundwater)	Undertake an assessment which: • models the impact of water extraction and discharge on groundwater supply to determine if depletion will occur; • assesses the impacts of a potential well blow out on aquifers used for community water supply; and • identify measures to manage the risk of impact to groundwater system.	EPC Contractor Drilling Contractor	Prior to construction	Model review	

Table VI-14 Air Quality Management

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Drilling, clearing and construction	Dust emissions creating nuisance, aesthetic and health impacts.	Construction activities and site layouts will be planned so that the duration of exposure to potential wind erosion is minimised. This may include staging construction activities.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	Included in the cost of EPC and Drilling contract
		Avoid dust generating activities during windy conditions. (i.e. winds greater than 35km/hr)	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
		Stabilize exposed areas susceptible to wind erosion using industry good practice measures such as water (non-saline) for active stockpiles, or agglomerating agents, temporary grass/hydromulch or mulch for longer term stockpiles.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
		Locate soil stockpiles away from sensitive receivers and ensure they are adequately protected from the elements using sheeting, water damping or vegetation as required.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
		Cutting, grinding or sawing equipment will be fitted or used in conjunction with suitable dust suppression techniques such as water sprays or local extraction and collection.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
Traffic and vehicle movements	Dust emissions creating nuisance, aesthetic and health impacts.	Unsealed roads will be regularly maintained and damped down in dry (i.e. less than 0.25mm/24hr rainfall) and windy conditions (i.e. winds greater than	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	

Aspect	Impact	Mitigation Measure	Responsibility	Timing	Monitoring	Cost Estimate
		35km/hr).				
		Control speed limits via posted speed limit signs on unsealed roads. Keep vehicles to marked trafficable areas that will be maintained in a damp and compacted condition.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
Air emissions from fuel combustion	Reduced air quality	Select construction equipment with low emissions based on industry good practice.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
		Locate fixed and mobile equipment with consideration of local people (a minimum distance of 150 m from residences or other sensitive receptors, where practicable).	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
		Implement a monitoring and maintenance regime for construction vehicles and equipment in order to limit emissions, and remove from service any equipment producing excessive emissions.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	
		The engines of all vehicles and plant on site will not be left running unnecessarily.	EPC and Drilling contractor	Throughout construction	Daily site inspection Audit reports	

Table VI-15 Heritage Management

Aspect	*Impact*	*Mitigation Measure*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*

Excavation works	Disturbance of items of cultural heritage.	Establish a chance finds procedure which is to include:
		• definitions of 'chance find' and 'cultural resources';
		• determining ownership;
		• providing tools for works to recognize items of heritage;
		• procedures upon discovery including;
		  o suspension of work;
		  o preparation of a chance find report;
		• role of the Cultural Authority;
		• resumption of work; and
		• review.
			EPC Contractor	Prior to construction	Reporting and notification of finds	Included in the cost of EPC contract

6.5 *OPERATIONAL ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN*

This section outlines environmental and social management to be undertaken during the operational phase of the Project ESMP. The majority of the management measures outlined in the Construction ESMP are applicable and therefore to be carried over in tot eh operational phase. This operational ESMP therefore addresses issues and management measure applicable only to the operational phase.

Table VI-16 to VI-21 present the framework for each management issue, which is to be elaborated in SOL work procedure's and ESMP. These tables detail minimum requirements for mitigation measures that will be implemented to avoid, or mitigate environmental or social impacts as a result of Project operation.

Table VI-16 Social Management

Aspect	*Impact*	*Mitigation Measure / Enhancement*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Labour Management	Improve employee management Improve capability of staff Work opportunities extended to local people especially women and people belonging to ethnic groups Improve management attention to SOL employee and operations stage contractors' workers issues Impact on livelihoods of any workers retrenched.	Establish human resources department to manage HR issues and develop human resources policies and procedures based on international best practice; Prepare learning and development program for staff Maintain records on employees diversity: number of employees by job responsibility (management, skilled labour, unskilled labour), age, gender and ethnicity. Develop employee/workers grievance procedure Develop and implement a retrenchment plan for permanent staff	Project Manager and HR Department	Prior to operation Within 1st year of operation and throughout operation Within 1st year of operation	HR policies and procedures, learning and development Program disclosed to staff Included in regular monitoring reports Grievance redress records Plan review Plan disclosure to staff	Included in normal human resources and site management budget
Community health and safety	Community accident or injury due to tampering with steam pipes.	Provide awareness brochures for communities living or working near pipes to discourage tampering.	HSE Manager	Prior to operation	Community signatures acknowledging receipt of brochure	

Table VI-17 Geothermal Activity Management

Aspect	*Impact*	*Mitigation Measure / Enhancement*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Steam field operation	Movement of natural geothermal activity	Direct observation and mapping of surface activity and comparison with baseline (pre-Project) environment.	Project Manger	Throughout operation	Annual monitoring of surface activity (including flow rates and water chemistry). Annual sampling of production wells for fluid chemistry, steam fraction and well pressure. Daily monitoring of production wells.	Included in normal site management budget

Table VI-18 Water Management

Aspect	*Impact*	*Mitigation Measure / Enhancement*	*Responsibility*	*Timing*	*Monitoring*	*Cost Estimate*
Reinjection	Surface water impacts	Develop Brine Management Plan to minimise risk of brine discharges.	Project Manager	Prior to operation	Plan review	Included in normal site management budget
		Develop and implement a re-injection system including • provision of adequate sized and lined storage ponds; and • system shut down in case of reinjection failure. In the event of emergency discharge of brine/ condensate, treatment of effluent will be undertaken prior to discharge to comply with Indonesian geothermal effluent standards.	Operations Manager/ HSE Manager	Throughout operation	Quarterly surface water monitoring.	
Groundwater abstraction	Impact to groundwater supply	Provide baseline of current community supply wells. If community water supply wells are affected by the Project, either deepen the affected well provide an alternate water supply.	HSE Manager	Throughout operation	Annual survey of community well locations Quarterly sampling of community wells Record quantity of abstraction Maintain complaints log	

Table VI-19 Noise Management

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
Operational activities, equipment and vehicles	Nuisance impacts to local communities	Noise source of power plant is operated 24 hours continuously. Employ noise mitigation measures including • selecting low noise design; • absorption material in building design; • acoustic and insulation enclosures; • inlet and exhaust silencers; • duct mounted attenuators; • acoustic louvers; • vibration isolation systems; and • three sided pens or low noise trims (for generators).	HSE Manager	Throughout operation	Quarterly (or on complaint) noise monitoring using sound level m at the nearest sensitive receptor. Maintain complaints log Audit reports	Included in normal site management budget
		Maintain equipment and acoustic enclosures to ensure noise levels do not increase over time. Hours of maintenance will be restricted to avoid sensitive periods and night works.	HSE Manager	Throughout operation		
		If operational activities cause breaches of Indonesian or World Bank standards, noise barriers will be put in place. The barrier must ensure that the noise source is entirely hidden from the receptor.	HSE Manager	Throughout operation		

Table VI-20 Air Quality Management

Aspect	Impact	Mitigation Measure / Enhancement	Responsibility	Timing	Monitoring	Cost Estimate
Air emissions plant operation	Reduced air quality	Develop and implement a H_2S and Air Quality Monitoring Programme including identification of emission limit standards.	Operations Manager and HSE Manager	Throughout operation	Monthly monitoring of steam line for H_2S in NCGs. Biannual monitoring of H_2S emissions from cooling towers Air quality (including meteorological monitoring) – timing TBC	Estimated cost of environmental monitoring such as air quality, noise is US$ 86,000 per year. Other things, included in normal site management budget
		Where monitoring indicates H2S levels above national regulations, implement additional mitigation measures such as: • Partial re-injection of gases with geothermal fluids; or • Use of abatement systems to remove H_2S emissions from non-condensable gases, e.g. wet or dry scrubber systems or a liquid phase reduction / oxidation system.	Operations Manager and HSE Manager	As required	Monthly monitoring of steam line for H_2S in NCGs. Biannual monitoring of H_2S emissions from cooling towers Air quality (including meteorological monitoring) – timing TBC	
		Develop and implement a Health Data Collection Programme.	Operations Manager and HSE Manager	Throughout operation	Health Data Collection – timing TBC	
		Ensure Compliance with the Emergency response Plan.	Operations Manager and HSE Manager	Throughout operation	Plan review	
		Abatement of emissions from cooling towers using integrated removal technology.	Operations Manager and HSE Manager	Throughout operation	Biannual monitoring of H_2S emissions from cooling towers	

6.6 OTHER MANAGEMENT PLANS

6.6.1 Occupational Health and Safety

6.6.1.1 Introduction

Sarulla Operations Ltd. (SOL) is responsible to protect the environment, the health and safety of its employees, its contractors and the public affected by its operation. Health, safety and environment protection performance are core values of SOL and will be managed as an integral part of its business to benefit SOL's stakeholders. This objective can only be accomplished when all of SOL and its contractors' employees are responsible for the SOL's achievement of continuous and measurable improvement.

6.6.1.2 Objective

SOL is going to develop & implement structured HSE (Health, Safety and Environment) management system in line with applicable Indonesian Legislation and Industry Codes and Standards in the form of HSE guideline which will describe the procedure & protocols related with Health, safety and Environment during project operation/activities, which includes the following fundamental objectives:

- **Line Management Responsibility, Compliance and Continuous Improvement.** All employees and contractors' personnel will actively promote SOL' HSE guideline as an integral part of everyone's work responsibilities. SOL' Management will set annual HSE performance objectives – with targets to achieve continuous performance improvements – and will implement a structured contractor selection process
- **Risk Assessment.** The project will identify the inherent hazards in all activities and the level of associated risks. Appropriate control measures will be developed and implemented to ensure the protection of health and safety of all employees, contractor personnel and other people as well as environment affected by SOL' operations. The integrity of assets will be monitored and maintained.
- **Accident/Incident Reporting & Investigation.** The project management will immediately report all accidents or incidents. Line Management must investigate such events and promptly implement corrective actions.
- **Communications and Quality Assurance.** SOL recognizes the value of consultation between management, employees and communities. The project will implement internal and external inspections and audits to ensure that the required HSE performance targets are achieved.
- **Environmental Management.** SOL will continually monitor and reduce the impacts on water, land, and air by implementing Environmental

Management System (EMS) that consists (i) of Environmental Management Plan (RKL) and Environmental Monitoring Plan (RPL) approved by the North Sumatera Governor and fulfilling lenders' ESIA requirements to be used as a basis of preparing an environmental program, (ii) of its implementation, (iii) of its monitoring and evaluation/ correction and (i) regular report to North Sumatera Environmental Agency (BLH) and lenders. In essence, EMS refers to the management of environmental programs in a comprehensive, systematic, planned and documented manner; SOL follows a Plan-Do-Check-Act (PDCA) Cycle and focuses in a continual improvement of the system.

- **Resourcing, Competency and Training.** The project will ensure that competent people, the correct equipment and appropriate procedures are available. The training needs of employees will be assessed and the necessary training conducted to enable them to do their jobs safely.

6.6.1.3 *Contractor Safety Management System (CSMS)*

SOL as a Company has developed HSE Management System to protect its people at work, the environment and the community. SOL also has committed to protect its contractors, vendors and customers with the same priority as well as Company employees through CSMS implementation. All project contractors performing work are expected to have developed and implemented a comprehensive HSE program for managing the specific daily activities of their workforce, in accordance with the requirements set forth in the Contractor Safety Management System (CSMS).

While performing work, the contractor shall follow the standards of conduct included in these guidelines to safely and environmentally friendly perform their work activities. Contractors shall refer to SOL's environmental impact assessment report ("AMDAL") and lenders' safeguard documents and contractors shall follow identical standards for work in their own facilities.

The Decision from the Minister of Energy & Geothermal Resources No. 555.K/26/M.PE/1995, The Decision of the Minister of Energy & Geothermal Resources No. 02.P/20/M.PE/1990, ADB's Social Protection Strategy 2001, and ADB's Policy on Gender and Development 1998 shall be used as references.

In order to help SOL to do better management of the risks of Contractors and subcontractor works at sites, in the HSE guidelines it is explained that there are two phases that consist of six steps each in the CSMS procedure:

A. Administration Phase

1. Risk Assessment

The objective is to describe and assess the work and risk. This is the responsibility of SOL to prepare.

2. Pre - Qualification

It is intended to evaluate whether the contractors are experienced and capable to undertake the activities safely in accordance with the HSE standard requirements. SOL will also evaluate the capacity of the contractors to provide labour and working conditions compliant with national laws and ILO core labour standards (CLS)

B. Field Implementation Phase

1. Pre - Job Activity (PJA) consists of two steps: Pre-mobilization and Mobilization activities. HSE Manager or Line Managers shall lead the pre-job activities.

2. Work In Progress (WIP). The objectives of this phase are to ensure that the work performed is conducted according to the HSE requirements and that any additional HSE requirements identified during the work are properly addressed. SOL will also monitor contractors and subcontractors engagement of workers and their compliance with the national labour standards and the ILO's CLS..

3. Final Evaluation (FE). The objectives of this phase are to conduct a joint evaluation of the contractor's performance on HSE and to provide feedback to the contractor and Company as a reference for future work.

6.6.1.4 *General HSE rules and requirements*

General HSE rules and requirements will be detailed out in SOL HSE guidelines document and all employee and contractors shall comply to the rules and requirements set out the in the HSE guidelines. Rules that explained and detailed out in the HSE guidelines include the following issues:

- Violation & Infringement
- Appreciation Award
- Working within Company Premises
- Employee Requirements
- Emergency Preparedness & Evacuation
- Roles Played by Everybody

- Safety Induction
- Smoking
- Alcohol and/or Controlled Drugs
- Safety Signs
- Environmental Control
- Permit-to-Work
- Worksite Visit
- House keeping

6.6.1.5 Line of Management Duties and Responsibilities

This section describes the duties and responsibilities of each personnel within the project organisation structure in order to ensure that HSE program/system are well implemented.

6.6.1.5.1 Site Manager

In his capacity as the appointed by EBTKE Head of Technical Geothermal, he has the overall responsibility for the on-going safety of all operations under his control, including the Permit-to-Work System.

6.6.1.5.2 Area Authority

The Site Manager is responsible for PTWS implementation within his area of responsibility. In this capacity he will:

- Appoint the senior personnel in charge of each site or sub area as the Area Authority and Site Authority to ensure the safe implementation of the PTWS. (The Area Authority will, in certain situations, be the Site Authority).
- Ensure that the Site Authority and Performing Authority are properly briefed and that the work is to be completed by competent personnel.
- In certain situation the area authority must visit the site and check the conditions himself.

6.6.1.5.3 Site Authority

The Site Authority is responsible for the safety of all work conducted in his site and to ensure that all applicable Permit-to-Work conditions are met. The Site Authority may be appointed from Company HSE personnel. In this capacity he will:

- Discuss the safety requirements in Permit-to-Work with the Performing Authority/Job. Isolate and prepare the equipment. Arrange for any required testing and confirm that the results are within acceptable safety limits.

- Advise all affected site personnel that the Permit-to-Work conditions have been met and that it is safe to commence the work. Obtain their signatures of understanding.
- Obtain the signature of the Performing Authority/Job Executor of his understanding and acceptance of the Permit-to-Work conditions.
- Regularly monitor the workplace while the job is taking place, Inspect the work upon completion and confirm that it is safe to return to normal operations.

6.6.1.5.4 Performing Authority

The Performing Authority is responsible for the work performance indicated in the Permit-to-Work. The Performing Authority may be a contractor and the Job Executor. In the capacity as Performing Authority he will:

- Prepare TRA before conducting the specific job.
- Discuss the safety requirements with the Site Authority that will be applied to any Permit-to-Work application.
- Review the completed Permit-to-Work for hazards precautions.
- Inspect the work as considered appropriate and at the completion of the work.
- Report to the Site Authority at the completion of the work and sign off the Permit-to-Work.

Figure VI-5 SOL Work Permit System

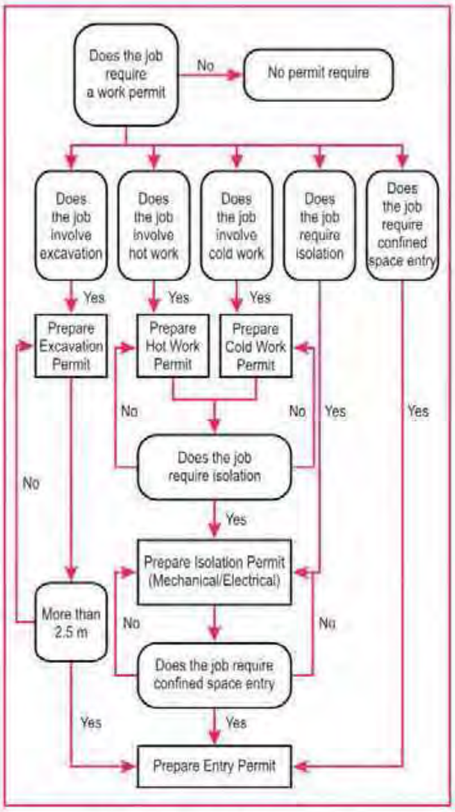


Figure 2. Work Permit Selection Diagram

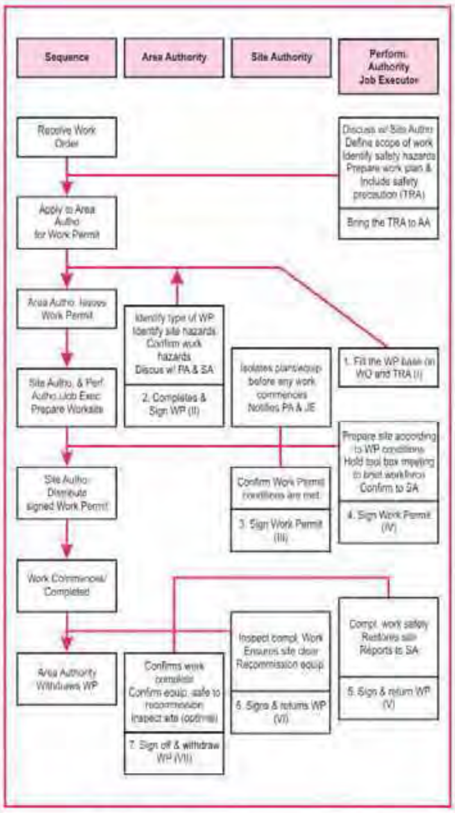


Figure 3. Work Permit Authorization & Sequence

Source: SOL HSE guidelines

6.6.1.6 *Standard Operating Procedure (SOP) & Specialized Working Procedure (SWP)*

Standard Operating Procedure (SOP) is a routine step-by-step task instruction or a sequence of task to operate and maintain the equipment & facility. The SOP may refer to the instruction manual provided by Original Equipment Manufacturer (OEM) or facility start up manual and engineering manual or assessment.

Specialized Working Procedure (SWP) is a step by step task instruction or sequence of task to conduct critical one time job i.e. tie in procedure to existing facility, etc. Both SOP and SWP shall be written in both English and Indonesian languages.

SOL fully realizes that HSE guidelines as SOL's standard for project operation is not merely the only source used for managing and controlling any emerging situations and it cannot answer all questions related to project operation and activities that may arise. Therefore discussions/meetings and agreements among stakeholders are encouraged to find the best solutions to response to the issues.

6.6.1.7 *Specific issues in geothermal plant*

Followings are specific issues in geothermal plant with respect to occupational health and safety. SOL will develop the detailed management plan based on the HSE guideline.

6.6.1.7.1 *Hydrogen Sulfide (H2S)*

It can be found during drilling, well testing, and plant operation. H2S is heavier than natural air; consequently it will be concentrated at the lower place, confined space.

SOL will install H2S detection system where concentration is predicted, in order to prevent the workers from the exposure. And also SOL will inform the workers the location of hazardous area.

If concentration level is exceeded the threshold of health and safety limit, emergency response plan shall be applied.

6.6.1.7.2 *Confined space*

During the operation and maintenance activities, confined space hazards will be placed. Entry to confined space shall be managed such as entry permit, when personnel enter a vessel or an enclosed space, which could contain flammable or toxic gas/material, or be oxygen deficient.

6.6.1.7.3 *Heat*

During the construction, operation, and maintenance activities, heat hazards will be placed. In order to prevent the heat exposure, preventive equipment such as shielding, PPE shall be used.

6.6.2 ***Monitoring Of Compliance with National Labour Laws and Internationally Recognized Core Labour Standards***

6.6.2.1 *Introduction*

The prohibited workers condition is internationally recognized, such as the use of child and forced labour, discrimination and unequal opportunities.

SOL will not comply with such prohibited condition. The specific plans will be prepared based on this policy at the implementation stage.

6.6.2.2 *Compliance with legislation and international requirements*

6.6.2.2.1 *Legislation*

The following international environmental agreements and conventions have been ratified by Indonesia and are applicable to this project:

- IFC PS2 Labour and Working Conditions and ILO Fundamental Human Rights Conventions;
- Elimination of Forced and Compulsory Labour (Conventions 29/105) – ratified 1950/1999;
- Elimination of Discrimination in respect of Employment and occupation (Conventions 100/111) – ratified 1958/1999;
- Abolition of Child Labour (Conventions 138/182) ratified – 1999/2000; ILC Core Labour Standard; and
- Law No. 13 year 2003 regarding Manpower.

6.6.2.3 *International requirements*

In order to protect the workers, SOL will comply with the following requirements.

- ADB Safeguard Policy Statement 2009;
- ADB's Social Protection Strategy 2001; and
- IFC Performance Standard 2 – Labour and Working Conditions.

6.6.2.4 *Monitoring and Reporting*

6.6.2.4.1 *Monitoring*

In order to ensure the implementation of the project commitments to worker's rights, monitoring items shall be as follow, but not limited to:

- Recruitment policies, job descriptions, contracts;
- Implementation of plans, procedures;
- Not to use child labour and forced labour;
- Non-discrimination and equal opportunity;
- Minimum wage payment;
- Not to prevent employees from exercising their right of association and their right to organize and bargain collectively;
- Use of the labour grievance mechanism;
- Training activities.

Particularly during the construction period, SOL will instruct EPC contractor and Drilling contractor to integrate the workers conditions requirements into their management plan.

6.6.2.4.2 *Reporting*

Semi-annual reporting will be developed based on monitoring results. Reporting will comply with the Global Reporting Initiative (GRI), which is the world's most widely used framework for annual sustainability reporting. SOL will ensure that such reporting is aligned with the reporting requirements under the IFC Performance Standards and ADB's safeguard and social requirements. Monitoring reports will be publicly disclosed on ADB website as required under ADB's 2011 Public Communications Policy.

6.6.3 *Contractual Workers Decommissioning Plan*

This subsection presents the plan for decommission of contractual workers to be implemented by the project. There are several stages in the project where contractual workers position will be decommissioned.

The following actions will be undertaken by the project to ensure that decommissioning of contractual workers run smoothly and as much as possible to minimize any potential issues to the workers:

- Employees will be separated from the project following the policies of the company, the applicable labour laws and regulations of Indonesia
- Part of SOL employees' orientation is to make them understand that this project has a specific duration and at that period of time, employees shall be accordingly separated from the Project.
- SOL CSR will adapt program relating to livelihood so that family members of the employees can be trained for other forms of sources in income in order to cushion the families need in the event of the separation of the employees from the Project
- The company shall endeavour to make recommendation and endorsements to the eventual owners of the project to consider qualified deserving employees to continue working with them

6.6.4 *Emergency Response Plan ("ERP")*

6.6.4.1 *Introduction*

This plan is providing a high-level overview of the procedures to mitigate and control the impacts on both of project and local community in the event of emergency conditions. The ERP must be accessible to all project personnel involved in implementing appropriate and effective emergency response procedures. The specific plans including detailed command and response actions will be prepared based on this plan.

6.6.4.2 *Objectives*

The primary objectives of this plan are to:

- Protect and preserve human lives of personnel and local community residents
- Protect project asset from further damage
- Control and contain any emergency situation including implementation of post-emergency actions

6.6.4.3 *Scope*

This plan defines standards for management plans for:

- Construction phase
- Operation phase.

In each phase, management plans are prepared that address health and safety, environmental, and social aspects.

During the Construction phase, the plan shall be covered emergency situations associated with construction work. Where responsibilities fall to the EPC contractor and Drilling contractor, these will be implemented under the contractor's Health, Safety, and Environmental management system.

6.6.4.4 *Standards*

The following standards for Emergency Preparedness and Response are applicable to project activities.

Applicable Indonesian regulations including but not limited to:

- The Decision from the Minister of Energy & Geothermal Resources No. 555.K/26/M.PE/1995
- The Decision of the Minister of Energy & Geothermal Resources No. 02.P/20/M.PE/1990

The IFC Environmental, Health and Safety General Guideline has a following requirement with regard to emergency responses.

- All projects should have an Emergency Preparedness and Response plan that is commensurate with the risks of the facility and that includes the following basic elements:
- Administration (policy, purpose, distribution, definitions, etc.)

- Organisation of emergency areas (command centres, medical stations, etc.)
- Roles and responsibilities
- Communication systems
- Emergency response procedures
- Emergency resources
- Training and updating
- Checklists (role and action list and equipment checklist)
- Business Continuity and Contingency

ADB Safeguard Policy Statement and IFC performance standard also define Emergency Preparedness and Response expectations.

6.6.4.5 *Roles and responsibilities*

The Project detailed organisation is under preparation. The General Manager, will coordinate with all aspects of Emergency Preparedness and Response, will report on progress to SOL's management and has overall responsibility for the implementation of ERP for the period of both Construction phase and Operation Phase.

6.6.4.6 *Construction Phase*

The Health, Safety, and Environmental (HSE) Manager is responsible for HSE matters and will be the main point of contact with EPC contractor and drilling contractor.

The EPC Manager and Drilling Manager is responsible for the integration of these procedures and requirements into each work plan and management procedure.

The EPC contractor and Drilling contractor are responsible for the integration of these procedures and requirements into their plans and procedures including specific roles, responsibilities and lines of communication.

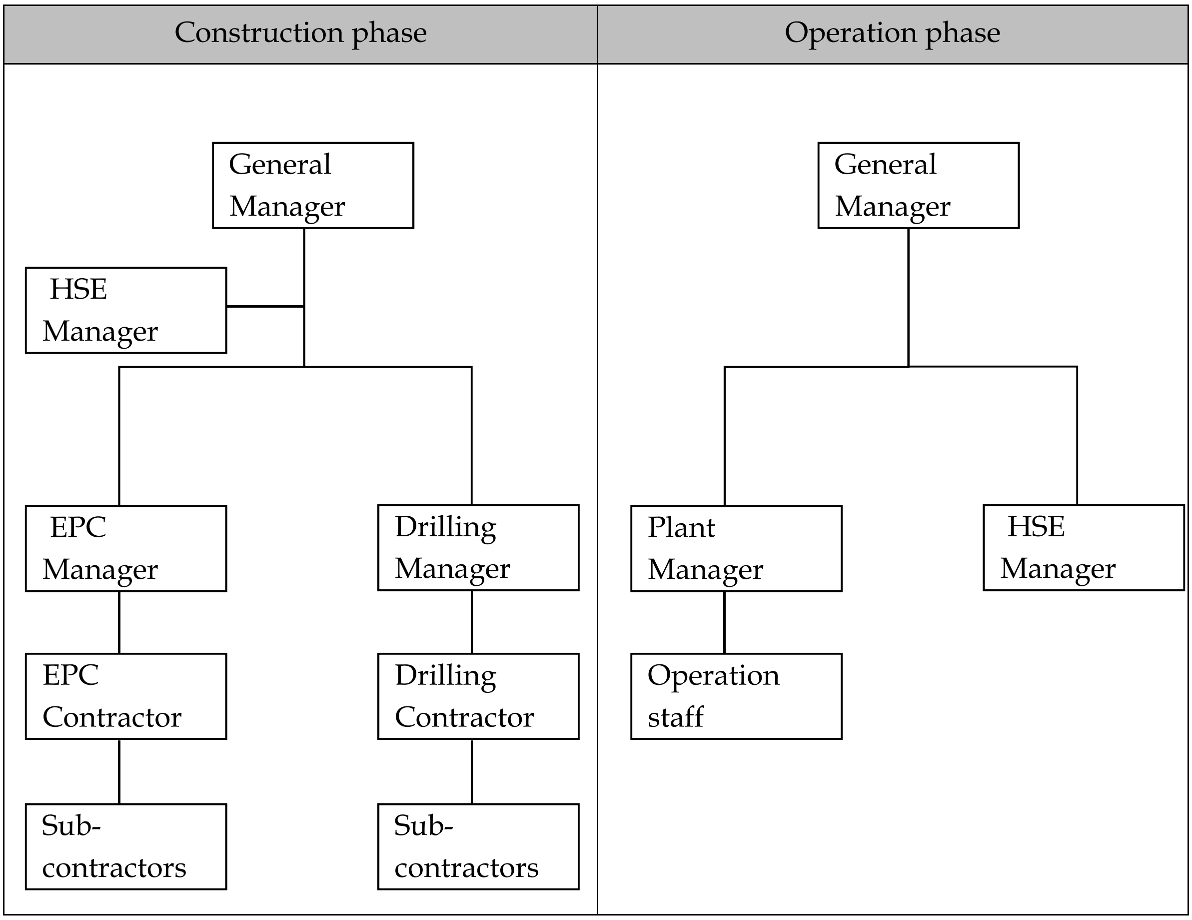
6.6.4.7 *Operation phase*

The Plant Manager is responsible for the integration of these procedures and requirements into the operation plan and act as a leader for operation staff in case of an emergency.

The HSE manager is the main point of contact with employees and local communities with respect to HSE and maintaining the ERP.

The following are expected structures with regard to Emergency Preparedness and Response. Further details will be prepared at the implementation stage.

Figure VI-6 Expected Structure with regard to Emergency Preparedness and Response



6.6.4.8 Communication systems

In the event of an emergency, immediate notice and reporting is required to power plant employee and also the local community.

The following table shows the basis of communication measures.

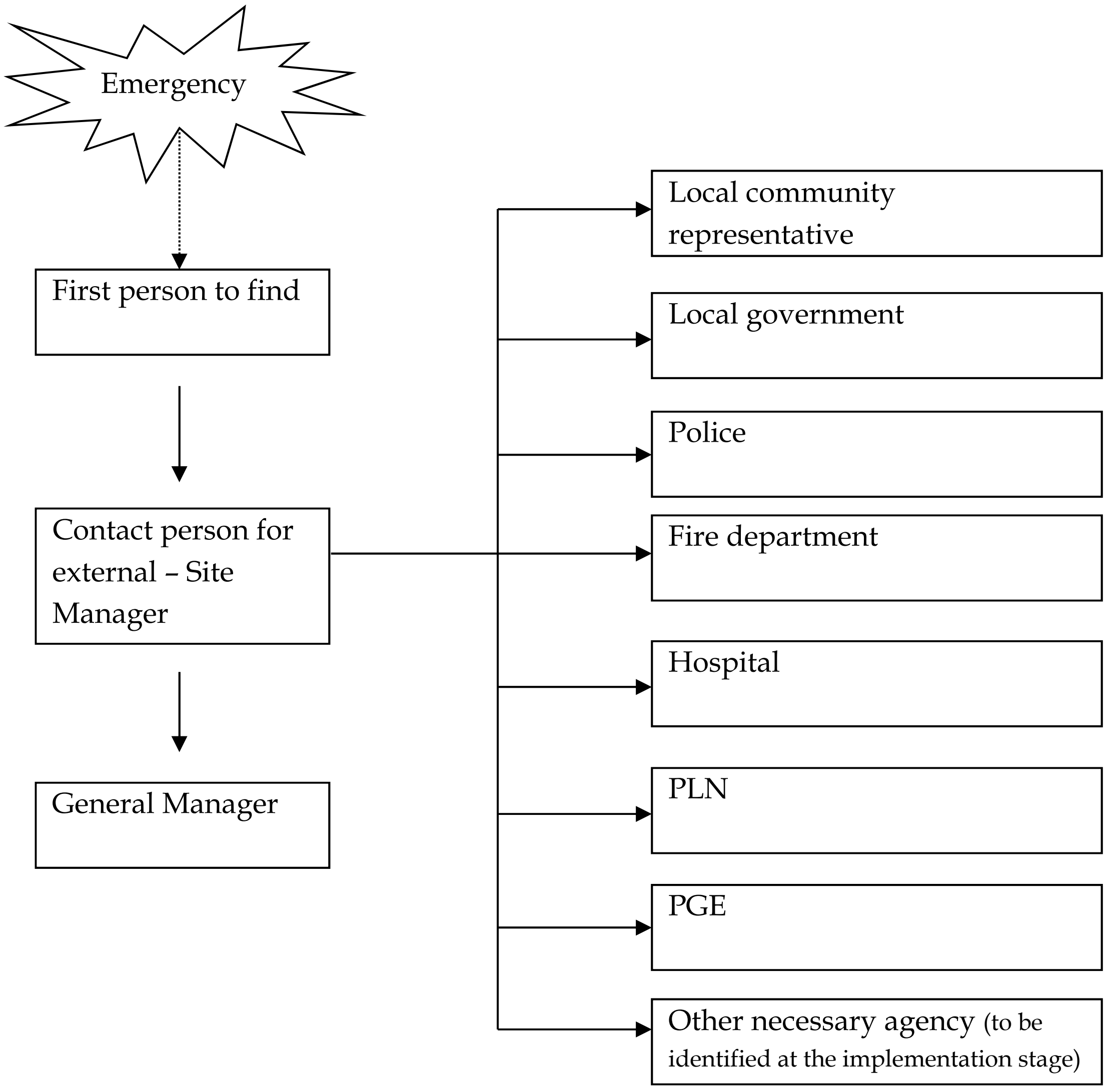
Table VI-21 Basis of Communication Measures

For	*Communication measure*	*Remarks*
Employees	Warning system • Siren • Alarm indication • Announcement	• Warning system shall be maintained and tested at least bi-annually subject to applicable regulation. • Reliable system such as duplicate system to be considered in the event of malfunction.
Communities	Warning system • Siren • Speakers Communication tool • Telephone call • Sound truck	• Warning system shall be maintained and tested at least bi-annually subject to applicable regulation. • The representative of each community shall be appointed and communicating method shall be registered. • Contact list shall be checked and updated at least bi-annually
Relevant institutions	Communication tool • Telephone call • Facsimile	• Contact list shall be checked and updated at least bi-annually • Contact person for external shall be appointed and communicate with relevant institutions • Formal report to be issued if required

This communication system shall be indicated as chart or sketch in order to understand easily, and shall be posted at the easily viewable place.

Conceptual notice and report chart is as follows. Contact details such as names, location, telephone number, email shall be included.

Figure VI-7 Conceptual notice and report chart



6.6.5 *Emergency Preparedness and Response Procedures*

6.6.5.1 *Overview*

Where emergencies occur, an Emergency Response Team will be organized and initiate emergency response pursuant to the Emergency Preparedness and Response Procedures with notification to relevant government institutions. As a minimum, the Emergency Preparedness and Response Procedures will include following:

- Details of Emergency Response Team and individual responsibilities;
- Preparation in the event of emergency;
- Actions during the emergency;

- Actions after the emergency;
- Contact list (names, location, telephone numbers).

The plans will be communicated to all employees and also relevant communities if required.

6.6.5.2 *Employee's initial action*

In the event of an emergency, all employees shall:

- Not panic;
- Stop work, and leave the area immediately to the designated assembly points;
- Not re-enter the building to save property;
- Shut off power or machines if safety requirement to do so;
- Return to work only if instructed by emergency controller.

Further details will be addressed in the Health, Safety, and Environmental management plan.

6.6.5.3 *Emergency Preparedness and Response Controls*

Following table is listed the measures for the Emergency Preparedness and Response, but not an exhaustive list. A detailed and comprehensive plan will be prepared at the implementation stage.

Table VI-22 Emergency Preparedness and Response Control Measures

Aspect	*Applicability*	*Control Description*	*Responsible parties*
Emergency Response Planning	Project plan	A project-wide emergency response plan will be prepared. This plan addresses: - Roles and responsibilities - Lines of communication - Contact details for Project personnel and relevant organisations - Equipment and resource needs including PPE - Specific procedures such as fire protection - Emergency procedures include: • Response actions • Recovery actions • Evacuation plans	General Manager Principle Contractors
Training	Throughout Construction and Operation	All employees, contractors will be introduced and instructed. Specific inductions will be given to relevant employee. At safety meeting, health, safety, and environmental concerns and awareness will be discussed. All employees will be made aware of the nature and location of hazardous materials and will be familiar with Material Safety Data Sheets (MSDS). And also each employee will be made aware of the locations of storage and the locations of spill containment and recovery equipment.	HSE Manager Principle Contractors
Drills	Throughout Construction and Operation	All employees will be required to undertake periodic drill of the emergency response procedures at least bi-annually basis. The outcome of each exercise will be recorded, and reviewed for areas of improvement.	HSE Manager Principle Contractors
Reporting	Throughout Construction and Operation	Reporting shall be undertaken through monthly reports that shall be prepared and submitted to SOL. Reporting shall include: - A summary of activities during the reporting period - Planned activities during next reporting period - Any material deviations or non-compliance to this ERP - Any emergencies occurrence	HSE Manager
Fire Prevention	Throughout Construction and Operation	Fire prevention measures will be implemented in line with the HSE plan.	HSE Manager Principle

Aspect	*Applicability*	*Control Description*	*Responsible parties*
			Contractors
Spill prevention (oil)	Oil handling	Measures to prevent the accidental release of oil to the environmental and requirements for spill response equipment will be implemented under the specific plan.	HSE Manager Principle Contractors
Spill prevention (hazardous material)	Hazardous material handling	Measures to prevent the accidental release of hazardous material to the environment and requirements for spill release equipment will be implemented under the specific plan.	HSE Manager Principle Contractors
Spill response (for soils)	In the event of a spill	The general response procedures for spill is as described below: - The source of spill is closed or, where immediate closure is not possible, isolated by appropriate catchment provisions - The spilled material will be contained using earthen dams, or other techniques - For oils, free product will be recovered. Sorbent material may be used to soak the free oil. - For hazardous material/chemical spills, appropriate PPE shall be used. - Contained materials will be removed to the waste management facility and stored impermeable containment. Final disposal/remediation disposal of contaminated materials will be implemented in line with the AMDAL.	HSE Manager Principle Contractors
Spill response (for surface water)	In the event of a spill	The general response procedures for spills to surface water is as described below: - The source of spill is closed or, where immediate closure is no possible, isolated be appropriate catchment provisions. - For hazardous materials/chemical spills, appropriate PPE shall be used. - For contaminants such as free oil, these will be gathered and contained appropriate containment structures. - Residual oil in the water may be recovered using sorbent material. - If sorbent material is utilised, then the spent sorbent material will subsequently be disposed appropriately. - Once free oil has been removed, the banks will be remediated.	HSE Manager Principle Contractors

Aspect	Applicability	Control Description	Responsible parties
Well blowout prevention	In the event of a well blowout	Well blowout may occur during well drilling. Drilling contractor shall use the preventive measure for well blowout such as Blowout Preventers (BOPs).	HSE Manager Principle Contractors
High H_2S Concentrations response	In the event of a high concentration	If an exceeded concentration area is found, HSE manager will implement the ERP according to the concentration level.	HSE Manager Principle Contractors
Pipeline rupture response	In the event of a pipeline rupture	If there is a pressure drop inside the pipeline fluids, steam supply valve shall be closed to stop the steam supply. In the event of failing to close the valve, a safety exclusion zone shall be established, until other measures can be implemented to prevent the release.	HSE Manager Principle Contractors

6.6.5.4 *Emergency resources*

6.6.5.4.1 *Budgeting*

In order to implement the efficient response for an emergency, SOL will prepare the budget for the sufficient level of funds for Emergency Preparedness and Response, in consideration of the availability of external resources for emergency such as fire-fighting equipment.

6.6.5.4.2 *Emergency Equipment*

Emergency equipment including PPE must be prepared to prevent further disaster. Such equipment shall be maintained by utilizing check-list such as validity, certification and shall be handled by trained person.

The first aid equipment of the power plant can be served for not only power plant employee but also communities in case of an emergency. Required medicine and its prescription must be invented and its location shall be informed.

6.6.5.4.3 *Relation with Communities*

SOL will consult with communities for the availability of emergency resources. If emergency resource is not available in Sarulla area, SOL shall initiate the communities in case of an emergency. Contact list will be maintained as described in 6.6.4.8 Communication systems.

6.6.5.5 *Contractors during construction phase*

Particularly during the construction phase, the contractors will provide medical services in the construction area and regular medical check-ups to ensure the good health of workers throughout the construction phase.

The contractors will coordinate with local institutions including police, fire fighters and medical personnel with regard to establishing the Emergency Preparedness and Response Plan.

6.6.5.6 Training and Updating

Trainings and drills including checking for communication list based on the accident and Emergency Preparedness and Response Plan must be carried out regularly with employees and local communities. As a minimum there will be:

- General training
- Specific training
- Emergency response training with/ without local communities

Training will include the provision of appropriate written materials to reinforce learning, and will record the training results. Training program shall be kept updating by incorporating the opinion/suggestion from training results.

6.6.5.6.1 General training

Basic training for emergency response shall be provided for all employees and contractors including its sub-contractors as a part of general induction training. Additional specific training shall be provided for power plant employees and key personnel identified in the detailed emergency plans.

6.6.5.6.2 Specific training

The specific training for hazardous substances and chemicals, particularly for any employee who is responsible for the use, storage or management of such material, shall be provided with general information and awareness. Specific training is to be coordinated, recorded in a training experience, and registered trained personnel.

6.6.5.6.3 Emergency response training with/without local communities

The objective is to ensure that both employees and local communities are well trained and able to respond to any emergencies that may arise. In the absence of emergency response capabilities in the Sarulla area, SOL initiates the local communities in the event of an emergency situation. Evacuation mock drills must take place in this training.

6.6.5.7 *Monitoring*

A key part of preparedness for emergencies is to ensure that all preparations and emergency equipment are in place and functioning as intended. There are two aspects to this:

- Routine site inspections
- Training updates

As a minimum, monitoring measures shall be as described in the table below.

Table VI-23 Monitoring Measures

Phase	*Measures*	*Frequency*	*Location*
Construction	Contractors shall report to the EPC/Drilling manager on the implementation of this Management Plan during the construction phase, including: • Training records • Personal Protective Equipment ("PPE") adequacy	Monthly	All construction areas
	Contractor shall inspect the site and record significant observations.	Daily	
Operation	HSE manager shall inspect the Project and shall maintain appropriate records. The inspection shall include: • Training • PPE • Site conditions • Observations of management practices • Compliance with applicable regulation	Monthly	All operation areas

6.6.6 *Facilities Decommissioning Plans*

6.6.6.1 *Overview*

This section will elaborate the project's plan for facilities decommissioning activities after the 30-year term of contract as agreed in ESC/JOC. The following circumstances will determine the need for implementing the decommissioning plan:

- The economic life of the project has been reached which is not expected to occur within or earlier than the duration of the 30-year term of the ESC and the JOC.

- The subsequent Owner of the Facility, in this case PLN in accordance with the ESC, or to whoever PLN transfers such ownership right over the Facility, either by sales, transfers or by laws and regulations, decides to decommission earlier than the economic life of the project

6.6.6.2 *Decommissioning Activities*

All decommissioning activities will refer to applicable regulation & procedure in Indonesia. The activities will be explained in the following sub sections.

6.6.6.2.1 *Closure of production and reinjection wells*

Wells will be deactivated by following well closure. A well closure procedure area is as follows:

To block the bore hole with cement with a minimum of 30 m thickness placed onto productions casing shoe and another layer of cement near and up to the top. Mud with similar or greater density than those used as drilling mud will be used as filling between the cement layers; Wellheads will be removed.

6.6.6.2.2 *Reclamation of well pads*

- All remaining liquid inside the sumps shall be injected into the wells prior to the closure of the wells. Mud and other solid materials will be excavated and will be transported to the drill disposal area.
- Separator, brine tanks, accumulator vessels, pipes, fencing and other above ground structures will be dismantled. These products can be sold as scrap materials or donate selected materials that can be useful to the host community.
- Remove high protruding concrete/steel foundation to make the reclaimed area blend with the surrounding.
- Re-plantation/re-vegetation with grass and local vegetation

6.6.6.3 *Reclamation of geothermal pipe gathering system*

- Demolition of all pipes and major structural steel supports. These materials can be sold as scrap material or donated to the host community.
- Remove high protruding concrete/steel foundation to make the reclaimed area blend with the surrounding.
- Re-plantation/re-vegetation with grass and local vegetation particularly on location of removed foundation

6.6.6.4 *Reclamation of Power Plant Facility*

The ultimate goal is to reclaim the power plant area, free of structures that were built as part of the project and restore it in a condition as close as possible to its baseline condition. This means that the area will be replanted and/or re-vegetated with grass and local vegetation. Furthermore, the project will undertake the following activities:

- High protruding concrete foundation will be demolished. Concrete foundations that can be covered will be left and buried under the ground.
- All of the electro-mechanical equipment (i.e. turbines and generators, motors, transformers, instruments, others) will be dismantled. Equipment that is still functional will be for sale, or for donation to the host community for equipment that has use for the community, or sold as scrap materials. The generators, motors and transformer are containing plenty of copper materials that are of interest to scrap buyers. Steel can be recycled.
- Cables will collected and sold mostly like to scrap buyers because of their interest on copper and aluminium components of the electric cables.
- Pipe materials and steel structures will be dismantled. These are again of prime interest to buyers of second hand materials or to scrap buyers. Those can be useful to host communities will be donated. Some of hot-dipped galvanized steel can usually sustain much longer period without excessive corrosions and can still have many usages.
- Building structures will be torn down and dismantled to pieces. Pieces can be sold as scrap or donated to the host community.

6.6.6.5 Road system including bridges

Since roads will be very useful to the community, it is not intended to reclaim the roads built for the project. These roads will continue to be very useful to people specially in accessing farm lands. Increase of community residences may also develop in the area and these roads will be of prime necessity to them.

6.6.6.6 Disposal area for drilling

The disposal area for drilling is where muds and excessing cutting during drilling of wells are contained. Disposal area pits are lined with geomembrane liner to keep contamination of soil from drill cutting that may contain toxic substances.

These pits will be covered by concrete slurries to permanently cover it. The areas where the pits covered with concrete will not be replanted.

6.6.6.7 Abandonment of existing facilities that were built prior to SOL taking over the project

6.6.6.7.1 Wells

There are no immediate plans to abandon the existing wells during the operation stage of this project. Instead, these wells will be utilised as follows:

SIL 1-2 and SIL 1-3	As part of the permanent production well for SIL plant
SIL 1-1, 2-1 and 3-1	As temporary reinjection wells during production testing of SIL 1-2 and SIL 1-3 wells; Afterwards, the well will continue to be used as monitoring points for the resource
NIL 1-1, NIL 2-1 and NIL 2-2	Will be used as monitoring points for the resource
NIL 3-1	As temporary reinjection wells during production testing of new wells drilled in NIL Afterwards, the well will continue to be used as monitoring point for the resource

The decommissioning of these well are anticipated not to be performed until the time the whole facility is decommissioned as described in the foregoing section

6.6.6.7.2 Roads/Bridges

Existing roads will be developed as permanent part of the infrastructure to support the operations of this project. These roads will serve as main access to the power plant and well pads. They will also be made available for the people living in the vicinity of the project. SOL has plans to improve, widen and maintain these roads through the operation of the facility. As further described above, these roads are not intended to be decommissioned due to the projected continuous usage for the local community.

6.6.6.7.3 Well pads

SIL 1 and SIL 2 well pads will house drilling of new wells, the separator station and well testing facility for SIL. These will therefore remain functional through the period of the operation of the facility

NIL 1, NIL 2 and NIL 3 well pads are housing the existing wells which are described above as wells that will be used as monitoring points for the project. Therefore, these wells pads will continue to exist and maintained by SOL through the operation period. Decommissioning will be in accordance to the procedure stout above for well pads.

6.6.6.8 150KV transmission line from SIL to PLN substation and from NIL to PLN substation

In accordance with the ESC, ownership of the transmission line upon completion of its construction, testing and commissioning will be transferred to PLN, and PLN will have the subsequent control, custody and care of this facility through the operation period of the Project. This is called Special Facility in the ESC.

As PLN may have its own plan for the decommissioning the transmission facilities which is standard to the numerous lengths of transmission lines owned by PLN. In this regard, the decommissioning plan for the Special Facility is excluded from this plan.

6.6.6.9 Reclaimed land

Under the JOC, PGE has the right to decide on what to do with the lands acquired for this project after the cooperation period. In case PGE decides to sell them, based upon the usage of the these land for the Project all areas duly identified in the decommissioning plans to be reclaimed, and restored by re-plantation and re-vegetation are safe to be re-used for agricultural or plantation purposes if PGE decides to sell them

7 *Monitoring and Verification*

This section outlines the processes of monitoring and performance management associated with the ESMP. These processes are required to:

- Verify and document that management and mitigation measures identified in this ESMP have been implemented;
- Validate predictions made in the ESIA and assess the actual impacts of the Project on the environment and people;
- Document and evaluate the effectiveness of management and mitigation measures; and
- Demonstrate compliance with applicable legal and other requirements.

7.1 *VERIFICATION*

Contractors will be required verify that the management and mitigation measures identified in this ESMP have been implemented both during the construction and operational phases.

Construction verification will be undertaken through daily site inspections of construction work areas. These inspections are to be conducted by the HSE manager to monitor work practices and identify non-conforming areas and activities or work practices which could lead to potential environmental harm. A Daily Environmental Inspection Checklist will be developed and used to record and report observations and any improvements required.

The purpose of the inspections will be to:

- Provide a surveillance tool to ensure that management measures are being implemented; and
- Facilitate the identification and early resolution of problems.

Operational verification will be undertaken through monitoring and audit programmes as outlined below.

7.2 *VALIDATION*

Monitoring and assessment procedures will be implemented to validate predictions made in the ESIA, assess the actual impacts of the Project, evaluate the effectiveness of management measures and demonstrate compliance with relevant limits and standards.

Issue specific monitoring programs will be established as part of each of the management plans identified in *Section* 6. The monitoring programs will range from those involving formal sample collection, analysis and measurement to those involving a more qualitative assessment including visual observations.

As a minimum, monitoring requirements include the following:

- The timing, frequency and duration of monitoring for the proposed environmental monitoring programs. In some cases monitoring may continue for the duration of the project and for a period thereafter;
- Sampling strategies and protocols undertaken for each monitoring program including locations, responsibilities and quality assurance; and
- The applicable standards, environmental objectives and performance goals;
- Reporting requirements; and
- All laboratory analyses shall be undertaken by accredited laboratories.

SOL will undertake periodic assessments of monitoring results (including contactor and subcontractor data) on a weekly basis, to evaluate the effectiveness of the environmental and social mitigation measures being implemented against performance goals.

Where monitoring methods permit, results will be obtained at the time of the assessment and analysed immediately to allow a prompt response should an exceedance of accepted goals be identified.

Where a non-compliance with nominated performance goals is detected the incident management procedure (see *Section 7.3*) will be followed.

7.2.1 Audit

Environmental and social audits of the Project will be undertaken with the objective of determining the appropriateness of the ESMP in achieving environmental objectives and performance goals throughout the Project development.

The following audits may be undertaken at the auditor's discretion:

- SOL will undertake internal audits and audits of contractor and subcontractor activities;
- An independent body may, on behalf of an international finance institution, undertake audits of overall Project activities; and
- The Ministry of Environment (MOE) may undertake audits of overall Project activities.

All such audits will be undertaken in accordance with predetermined protocols agreed with between both parties. SOL, contractors and subcontractors shall cooperate fully with the auditing party in the execution of audits. This may include but not be limited to ensuring availability of relevant project staff, provision of requested documentation in a timely manner and provision of transport and access to Project sites.

Upon completion of the audits, the auditor will provide a draft audit report to be discussed at an audit review meeting. Following the audit review meeting the auditor will provide a final audit report outlining any actions to be implemented or recommendations for improvement.

7.2.2 *Performance Indicators*

The performance of the Project will be measured against a set of Key Performance Indicators (KPIs). A summary of general Project KPI's is outlined in Table VI-24. Discipline specific KPIs for the Project will be defined in each of the management plans identified in *Section* 6.

Table VI-24 Project KPIs

Performance Objective	*KPI*	*Target*
Maintain compliance with ESMP requirements throughout the project.	Results from scheduled audits. Percentage of near misses and non-conformances observed.	100% conformance
Maintain the project overall goal of zero environmental or social impact.	Number of environmental or social incidents reported. Number of community complaints reported.	Zero incidents or complaints
Maintain compliance with workplace inspection, observation and audit schedules.	Percentage of daily inspections completed. Percentage of audits completed.	95% of weekly inspections and audits conducted to schedule.
Ensure all staff are adequately trained and competent for the work they are to undertake.	Percentage of staff trained according to the training plan. Percentage of staff performing work for which they are not trained or verified as competent.	90% of training conducted to schedule. 0% staff not trained or competent to perform operations.

7.3 INCIDENT MANAGEMENT

An incident is defined as a specific event, sequence of events, or extended condition that had an unwanted or unintended impact on safety, security, health and/or livelihood of people, property, or the environment, or on legal / regulatory compliance.

An incident management process has been developed for the Project outlining the requirements for managing safety, health, environmental, social and security related incidents, including near misses. Incident management is performed to ensure the appropriate level of post incident care is provided to people and the environment, address requirements related to good business practices and ensure regulatory compliance.

The objectives of the incident management process are to define SOL's responsibilities in managing its own as well as contractor incidents, to provide users with guidance to effectively implement incident management processes and provide tools to support effective and consistent implementation.

The incident management process is comprised of the following key steps:

- Secure the area – reduce further harm to personnel, the environment, and assets;
- Emergency response – initiate emergency response (if required, see *section 6.6.5)*;
- Perform case management (if required) – confirm prompt and proper medical care / treatment of injured or ill persons, and perform the appropriate level of follow-up surveillance to ensure injuries and illnesses do not escalate;
- Incident notification – notify incident details to internal and external stakeholders as required, including government authorities;
- Incident investigation – investigate all incidents identifying cause, extent and responsibility;
- Implement corrective actions – identify and implement the necessary corrective action to prevent incident recurrence; identify the personnel responsible for carrying out the corrective action; identify any modifications to controls necessary; and record any changes in procedures required;
- Share lessons learned – distribute the incident investigation report; and stimulate learning opportunities by sharing lessons learned internally and externally as appropriate; and
- Legal requirement – address potential legal sensitivities and involve legal counsel as required.

SOL shall maintain an appropriate and auditable record system in accordance Quality Management Plan under the Project EMS. Environmental and social reporting shall be conducted in accordance with Permit conditions and shall include requirements as outlined in this Chapter.

7.4 *REPORTING*

7.4.1 *Compliance Reporting*

SOL will prepare and submit quarterly Environmental and Social Reports (ESR) to the MOE (and any other identified groups required). The quarter four (Q4) report will be an annual summary of data to be reported and submitted to MOE. SOL will prepare in accordance with the requirement of ADB's Safeguard Policy Statement.

The ESR will detail the results of the monitoring programs under approved management plans, and compare actual performance against goals and objectives. The structure, content and format of the report will be agreed with MOE prior to commencement of work.

As a minimum the reports will contain the following information:

- Details of environmental and/or social surveys undertaken in the reporting period and additional management and mitigations arising where applicable;
- Evidence of verification of implementation of the EMP, including records of and outcomes of daily site inspections;
- Details of environmental and social monitoring undertaken during the reporting period, including an assessment of results against performance goals;
- Reporting of required KPIs applicable during the reporting period;
- Outcomes and recommendations of audits undertaken in during the reporting period;
- A summary of incidents, non-conformances and near misses that have occurred during the reporting period including copies of incident reports, non-conformance reports and statutory notifications, status of the incident, corrective actions implemented or planned, lessons learnt and any procedural changes required;
- A summary of grievance management (workers grievances and community grievances) applicable during the reporting period;
- A summary of public consultation and disclosure activities undertaken during the reporting period;
- A summary of training and induction undertaken during the reporting period;
- periodic monitoring reports on safeguard measures as agreed with ADB; and
- Progress against and changes to the work schedule.

7.4.2 *Incident Reporting*

All Project personnel shall immediately verbally report all incidents, non-conformances and near misses to their Site Manager. The event will then be reported using an Incident Investigation Report Form and investigations conducted in order that the event can be prevented or better managed in the future.

An Incident Investigation Report is to be raised by the Site Supervisor in conjunction with the person who identified the incident, within 24hrs of an incident or non-conformance occurring. The report shall contain:

- The date, time, location and description of events;
- Materials involved and volumes for spills and releases;
- Root cause analysis; and
- Remedial and corrective actions required to prevent future occurrences.

7.4.2.1 *Incident Tracking*

SOL shall develop and maintain an Environmental and Social Incident Tracking System, which will be used for the tracking and stewardship of all incidents, non-conformances and near misses. The system will include:

- The details of all environmental and social incidents that have occurred;
- Identification of the remedial and/or corrective action required;
- Assignment of timings and responsibilities for implementation of corrective actions; and
- Indication of the status of implementation of the corrective action.

The Environmental and Social Incident Tracking System shall be kept current at all times.

7.4.3 *Statutory Notification*

The HSE Manager will notify the appropriate regulatory authorities of significant environmental or social incidents on or around the site which have occurred in the course of activities in the following circumstances:

- If there has been a non-compliance with legislation or approval conditions; or
- If the actual or potential harm to the health or safety of human beings or the environment is considered significant.

The HSE Manager will be notified immediately of any pollution incidents involving notification of the MOE or any other external Government agency. Following the initial report to the relevant agency, the results of the incident investigation will be provided within one month of the incident.

7.5 *TRAINING REQUIREMENTS*

7.5.1 *Overview*

This section provides a summary of training, awareness and competency requirements associated with the ESMP.

SOL shall ensure that all personnel responsible for the implementation of this ESMP are competent on the basis of education, training and experience. All personnel shall be provided with environmental and social training appropriate to their scope of activity and level of responsibility.

Environmental and social training activity shall be appropriately documented through the development and implementation of a Workforce Environmental Training Programme including:

- Definitions of role specific training requirements;
- A training needs assessment; and
- Records of training undertaken including detailing the attendees, content, trainer and dates of the induction/training.

Contractor's environmental and social management documentation shall describe the training and awareness requirements necessary for its effective conduct of their activities within the requirements of this ESMP. Contractor's training, awareness and competency program, including delivery and verification thereof, is subject to SOL's review and approval.

7.5.1.1 Competency Levels

An initial evaluation of environmental training and awareness needs associated with this ESMP shall be undertaken by SOL. The outcomes of the needs assessment will be used to develop and maintain the Workforce Environmental Training Programme detailing the training needs for each position based on job description and level of environmental and social responsibility and involvement.

The Workforce Environmental Training Programme shall include several levels of competency and training, including:

- **Induction and General Awareness** - for visitors and personnel who do not have direct roles and responsibilities within the ESMP. The training will provide a summary of the key environmental and social aspects of the Project, and an overview of the control/mitigation measures in place for the Project.
- **Management Training** – for management (Site Supervisors and higher), covering the key aspects of the ESMP and providing an overview of each specific sub plan document within it.
- **Job Specific Training** – job specific training and awareness for all personnel who have direct roles and responsibilities within the ESMP or whose specific work activities may have an environmental or social impact. The training will provide a detailed review of the components of the ESMP specific to that employee, including a detailed description of employee

duties.

7.5.2 Training Programmes and Delivery

Training Programmes to be delivered are outlined in Table VI-25.

Table VI-25 Environmental and Social Training programmes.

Training	*Content*	*Personnel*	*Frequency*
Induction and General Awareness			
Project Induction	Overview of the Project and general in induction and conduct.	All Project personnel	Once (with a refresher course taken every 12 months)
ESMP Induction	Overview of the general commitments of the ESMP	All Project personnel	Once (with a refresher course taken every 12 months)
Site Induction	Detailed site-specific training to understand the Project expectations, requirements, and commitments at that site.	All Site Personnel	Once (with refreshers as needed)
Biodiversity Induction	Overview of: the commitments of the Project to biodiversity (outlined in the Biodiversity Action Plan); significance of biodiversity in the Project area, including IUCN listed species; and measures to minimise impacts.	All Site Personnel	Once (with refreshers as needed)
Management Training			
Environmental and Social Management Strategy training	Project environmental and social vision overview	Management/Supervision	Once (with refreshers as needed)
Environmental and Social Management Team Communication	To ensure that the Environmental and Social Management Team as a whole is effective and aware of Project-wide lessons and issues, all site-based environmental personnel will meet at least weekly.	Environmental and Social Management Team	Weekly/Monthly
Job Specific Training			
Pre-start Toolbox Meetings	Pre-start Toolbox Meetings will be undertaken to ensure Project personnel understand their required commitment and responsibilities with regards to a particular task.	All site personnel involved in the specific task.	Once prior to the commencement of each new task.
Environmental and Social Issues Training	Issue specific environmental and social training to focus on: • the framework of the relevant Plan;	Environmental and Social Manager, Site Supervisor, Environment Officer,	Training to be provided prior to start-up of identified tasks and updated if tools or procedures

Training	*Content*	*Personnel*	*Frequency*
	• mitigation measures required to be implemented including responsibilities; • objectives and performance goals; • monitoring and reporting requirements; • grievance mechanism (Field Issues Register); and • incident investigation and response.	Community Affairs Officer and any specialists or personnel identified as responsible for specific tasks.	change. Refresher frequency as required based on environmental risks associated with the task.
Daily Toolbox Talks	Daily Toolbox Talks will be undertaken to ensure Project personnel understand their day to day responsibilities, as well as to assess site conditions and identify any changes which may result in new or previously unidentified hazards and require implementation of different management procedures.	All Site Personnel	Daily
Project Environmental Alerts	Where required, Project Environmental and Social Alerts will be prepared to convey approved important information to the Construction Team. This information may be triggered by a recent incident, infringement notice, change in acceptable work practices, good practices etc. Project Environmental and Social Alerts will be approved for issue by the Environmental and Social Manger and presented by the relevant Environment Officer at Daily Toolbox Talks.	All Site Personnel	As required

8 CONCLUSIONS

This Report has been prepared as an Environmental and Social Impact Assessment (ESIA) Addendum for the development of the geothermal field and power plant combined capacity of 330 MW in Sarulla, in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province (the Project). This report presents information on the management of environmental, social and health risks as requested during consultation with the Lenders, which builds upon the information presented in the studies prepared for environmental approvals under Indonesian Regulations. As such, this document is not a stand-alone report but forms part of an overall set of documentation for the Project.

The conclusions of the ESIA Addendum are as follows:

- No insurmountable impacts have been identified;
- Project benefits outweigh the potential impacts identified;
- Environmental and social impacts can be mitigated to acceptable levels on the adoption of the ESMP;
- Substantial commitments during construction will be implemented by contractors, requiring effective management controls from SOL;
- Ongoing commitments during operations will be implemented by SOL through the Project ESMS; and
- The Project ESMS supported by Management Plans and KPIs are key for the effective management of predicted impacts.

Annex A

Applicable Standards

At the time of writing the ESIA Addendum, there is a lack of information on the levels of wastes, emissions and discharges that are predicted from the Project due to the current status and the need to finalise equipment selection.

As discussed in the main ESIA Addendum text, when host country regulations differ from the levels and measures presented in the EHS Guidelines, projects will be required to achieve whichever is more stringent. If less stringent levels or measures than those provided in the EHS Guidelines are appropriate in view of specific project circumstances, a full and detailed justification must be provided for any proposed alternatives through the environmental and social risks and impacts identification and assessment process. This justification must demonstrate that the choice for any alternate performance levels is consistent with the objectives of Performance Standard 3.

The following IFC and Indonesian regulatory standards are applicable to the Project. The most stringent standard is highlighted for ease of reference.

Table A.1 Ambient Air Quality

Parameter	*Averaging Period*	*Unit*	*PP41/1999* (4	*MoE Decree 50/1996* (5	*Ministry of Manpower Letter No. SE-01/MEN/1997* (6	*MoE Reg. No. 21/2008* (7	*IFC EHS Guidelines*	*WHO Guidelines* (8
Carbon monoxide (CO)	1 hour	μg/m³	30,000	-			-	
	24 hour	μg/m³	10,000	-			-	
Hydrocarbons (HC)	3 hour	μg/m³	160	-			-	
Nitrogen dioxide (NO_2)	1 hour	μg/m³	400	-			200	
	24 hour	μg/m³	150	-			-	
	1 year	μg/m³	100	-			40	
Sulphur Dioxide (SO_2)	10 minute	μg/m³	-	-			500	
	1 hour	μg/m³	900	-			-	
	24 hour	μg/m³	365	-			125(1	
		μg/m³		-			50(2	
		μg/m³		-			20	
	1 year	μg/m³	60	-			-	
Dust (TSP)	24 hour	μg/m³	230	-			-	
	1 year	μg/m³	90	-			-	
Lead (Pb)	24 hour	μg/m³	2	-			-	
	1 year	μg/m³	1	-			-	
Oxidant (O_3)	1 hour	μg/m³	50	-			-	
	8 hour	μg/m³	-	-			160(1	
		μg/m³	-	-			100	
	1 year	μg/m³	235	-			-	
PM_{10}	24 hour	μg/m³	150	-			150(1	
		μg/m³		-			100(2	
		μg/m³		-			75(3	

Parameter	Averaging Period	Unit	PP41/1999 (4	MoE Decree 50/1996 (5	Ministry of Manpower Letter No. SE-01/MEN/1997 (6	MoE Reg. No. 21/2008 (7	IFC EHS Guidelines	WHO Guidelines (8
		µg/m^3		-			50	
	1 year	µg/m^3	-	-			70(1	
		µg/m^3		-			50(2	
		µg/m^3		-			30(3	
		µg/m^3		-			20	
$PM_{2.5}$	24 hour	µg/m^3	15	-			75(1	
		µg/m^3		-			50(2	
		µg/m^3		-			37.5(3	
		µg/m^3		-			25	
	1 year	µg/m^3	65	-			35(1	
		µg/m^3		-			25(2	
		µg/m^3		-			15(3	
		µg/m^3		-			10(1	
H_2S	-	µg/m^3	-	28	14,000 (8 hour)	35,000	-	150 (24 hour)
NH_3	-	µg/m^3	-	1,360		500	-	-

Notes:

1 Interim target-1
2 Interim target-2
3 Interim target-3
4 Government Regulation No. 41 Year 1999 regarding Air Pollution Control
5 Ministry of Environment Decree No. 50 Year 1996 regarding Odour Level Standard
6 Ministry of Manpower Letter No. SE-01/MEN/1997 regarding Threshold Limit Value of Chemical Factors in the Work Environment
7 Ministry of Environment Regulation No. 21 Year 2008 regarding Emission Standard of Stationary Emission Source for Thermal Power Generation
8 WHO Air Quality Guidelines Global Update 2005 (IFC uses WHO Global Update as reference)

Under Indonesian standards, the Decree of Environmental Ministry No. 48/1996 on Noise level Quality Standard and IFP regulates ambient noise. Noise health and safety limits are established under the Ministry of manpower Decree No 51 of 1999.

The IFC Performance Standards applicable for industrial noise applies to fixed noise sources only. Noise impacts should not exceed the levels presented in **Table A.2**, or result in a maximum increase in background levels greater than 3 dB at the nearest receptor location off-site.

Table A.2 Noise Standards (dBA)

Receptor	*Unit*	*MoE Decree No. 48/1996*[1)]	*Kep. Menaker 51/1999*[2)]	*IFC EHS Guidelines*	
				Daytime (07:00 - 22:00)	*Nighttime (22:00 - 07:00)*
Residential; Institutional; educational	dBA	55		55	45
Trade and service	dBA	70			
Office and trade	dBA	65			
Green space	dBA	50			
Industrial; commercial	dBA	70		70	70
Officials and public facility	dBA	60			
Recreational	dBA	70			
Airport	dBA	-			
Train station	dBA	60			
Sea port	dBA	70			
Cultural heritage	dBA	-			
Hospitals	dBA	55			
Schools	dBA	55			
Worship place	dBA	55			
Receptor	*Unit*	*MoE Decree No. 48/1996*[1)]	*Kep. Menaker 51/1999*[2)]	*World Health Organisation (WHO), 1999* [3)]	
Occupational Health & Safety (exposure limits)			Exposure Limit/Day	LAeq, 8h	Max LAmax, fast
			-	40-45 (closed offices)	-
			-	45-50 (Open offices)	-
	dBA		85 (8 hours)	85 (heavy industry)	110 (heavy industry)
	dBA		88 (4 hours)		
	dBA		91 (2 hours)		
	dBA		97 (30 minutes)		

Notes:

1) Ministry of Environment Decree No. 48 Year 1996 regarding Noise Level
2) Ministry of Manpower Decree No. KEP-51/MEN/1999 regarding Threshold Limit Value of Physical Factors in the Work Environment
3) World Health Organisation (WHO), 1999.

The IFC does not establish numerical standards for surface water quality but states:

"Discharges of process wastewater, sanitary wastewater, wastewater from utility operations or stormwater to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria."

Indonesian standards are established by Government Regulation (PP) #82/2001 on Water Quality Management and Water Pollution Control, which includes different classes according to use. Class I is applicable to the Project as standards for drinking water (Class I) and Classes II-IV as water suitable for use for recreational, fresh water fish cultivation, livestock and irrigation.

Table A.3 Surface Water Quality

Parameters	*Units*	*IFC*	*PP 82/2001 Class I*	*PP 82/2001 Class II*	*PP 82/2001 Class III*	*PP 82/2001 Class IV*
Physical Tests						
Temperature	°C	-	3 deviation	3 deviation	3 deviation	3 deviation
pH	-	-	6 - 9	6 - 9	6 - 9	5 - 9
Hardness (calc)		-	-	-	-	-
Total Dissolved Solids, TDS	mg/L	-	50	50	400	400
Total Suspended Solids, TSS	mg/L	-	1,000	1,000	1,000	2,000
Anions & Nutrients						
Fluoride, F	mg/L	-	0.5	1.5	1.5	-
Chloride, Cl	mg/L	-	600	-	-	-
Sulphate, SO_4	mg/L	-	400	-	-	-
Nitrate Nitrogen, NO_3-N	mg/L	-	10	10	20	20
Nitrite Nitrogen, as N	mg/L	-	0.06	0.06	0.06	-
Total Phosphate, T-PO_4 sebagai P	mg/L	-	0.2	0.2	1	5
Sulfide, H_2S	mg/L	-	0.002	0.002	0.002	-
Free Ammonia Nitrogen, NH_3-N	mg/L	-	0.5	-	-	-
Cyanide, CN	mg/L	-	0.02	0.02	0.02	-
Dissolve Metals						
Arsenic, As	mg/L	-	0.05	1	1	1
Barium, Ba	mg/L	-	1	-	-	-
Boron, B	mg/L	-	1	1	1	1
Cadmium, Cd	mg/L	-	0.01	0.01	0.01	0.01
Chromium Hexavalent, (Cr^{6+})	mg/L	-	0.05	0.05	0.05	0.01
Cobalt, Co	mg/L	-	0.2	0.2	0.2	0.2

Parameters	*Units*	*IFC*	*PP 82/2001 Class I*	*PP 82/2001 Class II*	*PP 82/2001 Class III*	*PP 82/2001 Class IV*
Copper, Cu	mg/L	-	0.02	0.02	0.02	0.2
Iron, Fe	mg/L	-	0.3	-	-	-
Lead, Pb	mg/L	-	0.03	0.03	0.03	1
Manganese, Mn	mg/L	-	0.1	-	-	-
Mercury, Hg	mg/L	-	0.001	0.002	0.002	0.005
Selenium, Se	mg/L	-	0.01	0.05	0.05	0.05
Zinc, Zn	mg/L	-	0.05	0.05	0.05	2
Microbiology						
Fecal Coliform	MPN/100ml	-	100	1000	2000	2000
Total Coli form	MPN/100ml	-	1,000	5000	10000	10000
Others						
Biochemical Oxygen Demand, BOD	mg/L	-	2	3	6	12
Dissolve Oxygen, DO	mg/L	-	6	4	3	0
Chlorine, Cl_2	mg/L	-	0.03	0.03	0.03	-
Chemical Oxygen Demand, COD	mg/L	-	10	25	50	100
Surfactant, MBAS	µg/L	-	200	200	200	-
Oil & Grease	mg/L	-	1	1	1	1
Senyawa Phenol, as Phenol	µg/L	-	1	1	1	-
BHC	µg/L	-	210	210	210	-
Aldrin/Dieldrin	µg/L	-	17	-	-	-
Chlordane	µg/L	-	3	-	-	-
DDT	µg/L	-	2	2	2	2
Heptachlor and Heptachlor epoxide	µg/L	-	18	-	-	-
Lindane	µg/L	-	56	-	-	-
Methoxychlor	µg/L	-	35	-	-	-
Endrin	µg/L	-	1	4	4	-
Toxaphane	µg/L	-	5	-	-	-
Radioactivity						
Gross-A	Bq/L	-	0.1	0.1	0.1	0.1
Gross- B	Bq/L	-	1	1	1	1

Class I water used as raw water for drinking water, or other uses that require water quality similar as aforementioned

Class II water used for infrastructure / water recreation facilities, freshwater fish farming, livestock, water for irrigating crops or other uses that require water quality similar as aforementioned

Class III water used for freshwater fish farming, livestock, water for irrigating crops or other uses that require water quality similar as aforementioned

Class IV water used to irrigate crops and or other uses that require water quality similar as aforementioned

Table A.4 Ground Water Quality

Parameters	*Units*	*Permenkes 416/1990 Appendix II*
Physical Tests		
Colour	TCU	50
Odour	-	No odour
Temperature	°C	± 3
Taste	-	No taste
Total Hardness as CaCO3	mg/L	500
Total Dissolved Solids, TDS	mg/L	1500
pH	-	6.5 - 9
Turbidity	NTU	25
Anions & Nutrients		
Chloride, Cl	mg/L	600
Fluoride, F	mg/L	1.5
Nitrate Nitrogen, NO3-N	mg/L	10
Nitrite Nitrogen, NO2-N	mg/L	1
Sulphate, SO4	mg/L	400
Cyanide, CN-	mg/L	0.1
Sulfide, H2S	mg/L	-
Microbiology Tests		
Total Coli form	MPN/100ml	50
Fecal Coliform	MPN/100ml	10
Dissolve Metals		
Arsenic, As	mg/L	0.05
Cadmium, Cd	mg/L	0.005
Chromium Hexavalent, (Cr6+)	mg/L	0.05
Copper, Cu	mg/L	-
Iron, Fe	mg/L	1
Lead, Pb	mg/L	0.05
Manganese, Mn	mg/L	0.5
Mercury, Hg	mg/L	0.001
Selenium, Se	mg/L	0.01
Sodium, Na	mg/L	-
Zinc, Zn	mg/L	15
Organic Chemistry		
Aldrin dan Dieldrin	mg/L	0.0007
Benzena	mg/L	0.01
Benzo (a) pyrene	mg/L	0.00001
Chlordane (total isomer)	mg/L	0.007
Coloroform	mg/L	0.03
2,4 D	mg/L	0.1
DDT	mg/L	0.03
Detergen	mg/L	0.5
1,2 Discloroethane	mg/L	0.01
1,1 Discloroethene	mg/L	0.0003
Heptaclor dan heptaclor epoxide	mg/L	0.003

Parameters	*Units*	*Permenkes 416/1990 Appendix II*
Hexachlorobenzene	mg/L	0.00001
Gamma-HCH (Lindane)	mg/L	0.004
Methoxychlor	mg/L	0.03
Pentachlorophanol	mg/L	0.01
Pestisida Total	mg/L	0.1
2,4,6 urichlorophenol	mg/L	0.01
Zat organik (KMnO4	mg/L	10
Radioactivity		
Gross Alpha Activity)	Bq/L	0.1
Gross Beta Activity)	Bq/L	1
PerMenKes 416-1990 Lampiran II		

The following effluent standards are applicable.

Table A.5 Wastewater Effluent

Types	*Parameter*	*Unit*	*MoE Decree KEP-19/MENLH/2010 Att II*	*MoE Reg. No. 08/2009*	*IFC EHS Guidelines for Thermal Power Plants*	*IFC EHS Guidelines for Thermal Power Plants (New Plants)*
Produced Water	COD	mg/L				
	BOD	mg/L				
	Oil and grease	mg/L				
	Sulfide (as H_2S)	mg/L	1			
	Ammonia (as NH_3-N)	mg/L	10			
	Total Phenols	mg/L				
	Temperature	°C	45			
	pH		6 - 9			
	TSS	mg/L				
	TDS[2]	mg/L				
	Heavy metal (total)[3]	mg/L				
	Chlorides	mg/L				
	Total Hydrocarbon	mg/L				
	As		0.5			
	Hg		0.005			
Drainage Wastewater	Oil and grease	mg/L	15			
	Total Organic Carbon (TOC)	mg/L	110			

Types	Parameter	Unit	MoE Decree KEP-19/MENLH/2010 Att II	MoE Reg. No. 08/2009	IFC EHS Guidelines for Thermal Power Plants	IFC EHS Guidelines for Thermal Power Plants (New Plants)
Sourced from Main Process	pH			6 - 9	6 – 9	6 – 9
	TSS	mg/L		100	50	50
	Oil and grease	mg/L		10	10	10
	Free Cl_2	mg/L		0.5	0.2	0.2
	Chromium (Cr)	mg/L		0.5	0.5	0.5
	Copper (Cu)	mg/L		1	0.5	0.5
	Iron (Fe)	mg/L		3	1	1
	Zinc (Zn)	mg/L		1	1	1
	Phosphate (PO^{4-})	mg/L		10		
	Lead	mg/L			0.5	
	Cadmium	mg/L			0.1	
	Mercury	mg/L			0.005	
	Arsenic	mg/L			0.5	
	Temperature	mg/L				± 3[c]
Blow Down	pH			6 - 9		
	Free Cl_2	mg/L		1		
	Zinc (Zn)	mg/L		1		
	Phosphate (PO^{4-})	mg/L		10		
Containing Oil	COD	mg/L		200[1)]		
	TOC	mg/L		110[2)]		
	Oil and grease	mg/L		15[3)]		

Notes:

Ministry of Environment Decree No. KEP-19/MENLH/2010 regarding Waste Water Quality Standard for Oil and Gas also Geothermal Activity

Attachment II - Geothermal Exploration and Production

Ministry of Environment Regulation No. 08 Year 2009 regarding Wastewater Effluent for Thermal Power Plants

1. COD parameter is only valid until 31 December 2009
2. TOC parameter into force osmiley
3. n January 2010
4. If the source of wastewater containing oil is not flowing to the WWTP

Table A.6 Domestic Wastewater

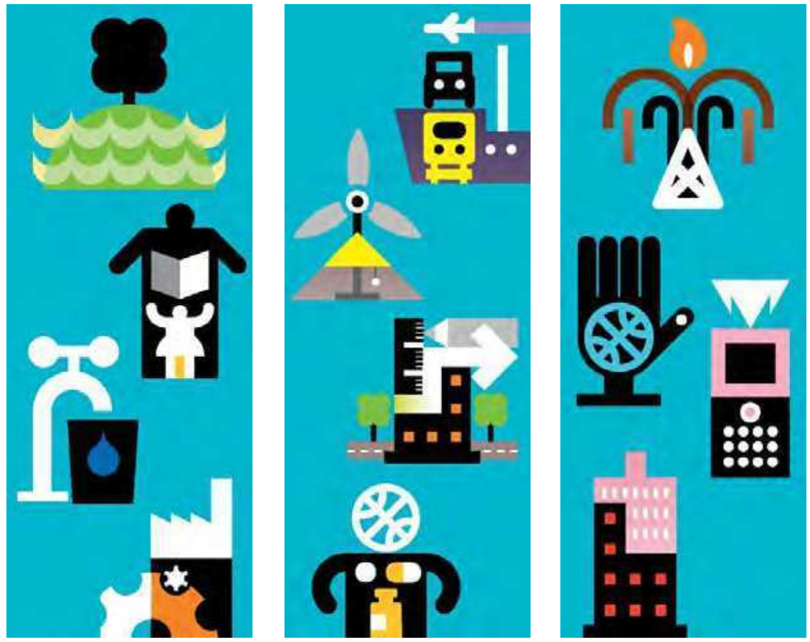
Parameter	*Unit*	*MoE Decree No. 112/2003*	*IFC EHS Guidelines Indicative Values for Treated Sanitary Sewage Discharges*
pH	-	6 – 9	6 – 9
TSS	mg/L	100	50
BOD	mg/L	100	30
COD	mg/L		125
Total nitrogen	mg/L		10
Total phosphorus	mg/L		2
Oil and grease	mg/L	10	10
Total coliform bacteria	MPN[b] / 100 ml		400[a]

Notes:

1. Not applicable to centralised, municipal, wastewater treatment systems which are included in EHS guidelines for water and sanitation
2. MPN = Most Probable Number
3. The effluent should result in a temperature increase of no more than 3° C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 m from the point of discharge when there are no sensitive aquatic ecosystems within this distance.
4. Site specific requirement to be established by the EA.
5. Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.
6. Ministry of Environment Decree No. 112 Year 2003 regarding Domestic Wastewater Standard

Annex B

Seismic Hazard Desk Study



Sarulla Geothermal Plant

Seismic Hazard Desk Study

July 2013

Sarulla Operation LTD

Mott MacDonald

Sarulla Geothermal Plant

Seismic Hazard Desk Study

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Executive Summary

Geothermal power in Indonesia is an increasingly significant source of renewable energy. Due to its volcanic geology, Indonesia has 40% of the world's potential geothermal resources and is the world's third largest geothermal electricity producer after the United States and the Philippines**.** The country is also surrounded by multiple tectonic plates causing it to be highly exposed to earthquake risk in both frequency and intensity. It ranks 11th for its economic exposure to earthquakes and 3rd out of 153 countries for the number of people present in earthquake hazard zones.

Pahae Julu and Pahae Jae Districts have been determined as areas of geothermal natural resources. Sarulla power plant construction is located in those districts in Tapanuli Utara, North Sumatra, Indonesia. The Sarulla Geothermal Power Plant will have an installed capacity of 330MW which will be constructed in three phases of 110MW each. The plant will be fuelled by two steam production and injection reservoirs, Silangkitang (SIL) and Namora I Langit (NIL).

This is a seismic hazard desk study which identifies the tectonic setting, seismicity and geology of Indonesia and Sarulla project and highlights potential seismic hazards which needs to be remediated through risk management. A seismic assessment was performed for the project area and the seismic soil class was determined according to the factual ground investigation data from Sarulla Operations LTD. The seismic design criteria were established and recommendations are made for the use of appropriate seismic code. It is concluded that some of the seismic risks are still not eliminated completely and recommendations for further work are provided, taking into account that no site visit was undertaken and all the available information were reviewed from published documents.

Table below summarises the key seismic hazards and provides recommendations for their mitigation. In conclusion the project can proceed as designed currently provided additional fault trenching activities are carried out before detailed design phase and facilities in the vicinity of the rupture zone are designed to accommodate the possible predicted movement from the rupture of the fault if the fault is deemed active.

Hazard	Effect on Ground	Effect on Facilities	Possible mitigation options
Possible Fault movement	Ground disturbances vertically and horizontally over a zone depends on depth to rock below surface. Cracks in land surface.	Upheaval, tearing apart, movement of foundations, severe damage to structures which cross the fault.	Verify by fault trenching and other methods detailed. Recommend that fault trenching is carried out in sufficient time to enable the designer to address any possible fault activity within the design. To be monitored by the Lender. Assess impact on infrastructure options: a) incorporate special strengthening and accommodate movement in design. b) provide weak links or special isolation to limit damage
Ground shaking	Violent horizontal and vertical motions for up to one minute duration.	Cracking, fracture, collapse of buildings. Breaks in underground services. Deformation of surface infrastructure.	Assess impact. Follow Seismic code recommendations. This needs to be included within the EPC Contract and EPC Contractor to incorporate in the design. To be monitored by the Lender. Options: a) comply with current codes for design and construction b) incorporate strength and resilience a) secure vulnerable parts and contents
Liquefaction	Shaking causes some soils to behave like liquid, causing loss of support to structures above. Such soils maybe up to 10m below ground surface. Lateral movement of large soil masses, especially adjacent to rivers. Variable subsidence of ground surface.	Sinking and tilting of structures supported on liquefied material. Severe damage to underground services. Flotation of empty underground tanks and chambers.	Verify through detailed analysis by the EPC contractor. Assess impact of liquefaction on well lining. These exercises can be stipulated as being a requirement within the EPC Contract document. EPC Contractor to design out solution and implement

Hazard	Effect on Ground	Effect on Facilities	Possible mitigation options
			within an early works package. To be monitored by the Lender. Options: a) compact ground at site b) install piles and gravel drains c) drain liquefiable layers
Slope failure	A significant soil masses moves bodily down the slope, from few hundred millimetres to many metres. Landslides occur at many different locations	Ranges from deformation of foundations and structural failures to total destruction of site and all buildings and infrastructure above and below ground.	Verify through detailed analysis by EPC contractor. Assess impact of movement on slopes. These exercises can be stipulated as being a requirement within the EPC Contract document. EPC Contractor to design out solution and implement within an early works package. To be monitored by the Lender. Options: a) stabilise slope retaining walls b) stabilise slope – ground anchors c) improve drainage, reduce erosion

1 Introduction

1.1 Background

Indonesia is surrounded by multiple tectonic plates causing it to be highly exposed to earthquake risk in both frequency and intensity. Indonesia ranks 11th for its economic exposure to earthquakes, estimated at US $79 billion, and ranks 3rd out of 153 countries for the number of people present in earthquake hazard zones. Overall, approximately 20 percent of the world's damaging earthquakes occur in Indonesia. Earthquake risk is pervasive across the country with more than 14,000 events of magnitude 5 or greater being catalogued between 1897-2009.

The Sarulla Contract Area is approximately 15 by 63 km dimension, elongated in a NW-SE direction, and is located between the towns of Padangsidempuan and Tarutung in the state of North Sumatra. A seismic hazard desk study is produced for the site which will be issued by Medco Energi. This will highlight any potential seismic risk.

1.2 Objectives

A seismic hazard desk study will be produced for the site which will cover the following aspects and highlight any potential seismic risk.

1.3 Scope of work

The key topics covered in the seismic desk study will be

- Identification of the tectonic setting and seismicity of the site and surrounding area.
- Seismic assessment, with specific reference to the notable earthquake in the region.
- Review of the published geology of the region and site;
- Review of available factual ground investigation data for the site and surrounding area for determining site class;
- Identify if seismic hazards associated with the site (seismic ground motion, liquefaction, earthquake induced landslides and lateral spreading, fault rupture hazards and tsunami hazards) have been appropriately addressed within the design criteria.
- Identify if the possibility of a nearby fault rupture.
- Establishing the seismic design criteria for the site
- Advice on appropriate local seismic code to be used for design and code specified spectra.
- Recommendations for further work, if required.

1.4 Sources of information

A table regarding all the used data for the Sarulla Geothermal Plant project is provided below. For further information about the documents used please refer also to the References section.

Table 1.1: Referred documents

Document reference	Description
SOL-DR-0001 R00 SIL	Feasibility report written in 1996 for SIL
SOL-DR-001 R00 NIL	Feasibility report written in 1999 for NIL
SOL-PLN-0005 R00 PLN	The report is designed for prospective bidders to develop the project, written in 2004. It contains a technical appendix
07 Environmental and Social, AMDAL, Original AMDAL Aug 2009	Chapter 3: 'environmental baseline study' that was carried out.
TOR Part1 – EPC Technical Specification	Full technical specification of most of the Sarulla Geothermal power plant project.
TOR Part 2 – 01_A. Geotechnical Reports SIL and NIL	Full geotechnical report, written in 2008, listing the fieldwork, lab testing and recommendations for both SIL and NIL.
TOR Part 2_1 Electricity Resistivity	Results of soil electrical resistivity testing and potential active faults at the SILANGKITANG (SIL) Site. The report comments on potentially active faults in and around the proposed SIL site.

1.5 Limitations and Uncertainties

It should be noted that we have performed a desk based study and have not undertaken any site visit at this time. We have consulted all the publicly available documents related to the site.

2 Site location

The Sarulla Contract Area is approximately 15 by 63 km dimension, elongated in a NW-SE direction, and is located between the towns of Padangsidempuan and Tarutung in the state of North Sumatra. Sarulla power plant construction is located in those districts in Tapanuli Utara, North Sumatra, Indonesia. The exact location coordinates are 99° 4' 12''E and 1° 51' 00''N, as indicated in Figure 2.1. The Sarulla Geothermal Power Plant will have an installed capacity of 330MW which will be constructed in three phases of 110MW each. The plant will be fuelled by two steam production and injection reservoirs, Silangkitang (SIL) and Namora I Langit (NIL). One unit will operate in SIL and two at NIL, each with a capacity of 110MW.

Figure 2.1: Map showing Sarulla location within Tapanuli Utara Regency, Sumatera Utara Province, North Sumatra.

Source: Sarulla Operations LTD, August 2009.

3 Overview of geology and tectonics

3.1 Regional Geology

Sumatra Island lies on the western edge of Sundaland, a southern extension of the Eurasian Continental Plate. Its backbone is formed by the Barisan Range which runs along the western side. This region divides the west and the east coast. The slope towards the Indian Ocean is generally steep, consequently the west belt is mostly mountainous. The eastern belt of the island is covered by broad, hilly areas of Tertiary formations and alluvium lowlands. The Sumatra Island is interpreted to be constructed by collision and suturing of discrete microcontinents in late Pre-Tertiary times.

The examined area is located between the towns of Padangsidempuan and Tarutung in the state of North Sumatra. The area can be distinguished into two regions according to its physiography, the Barisan mountains with rugged uplands and the low flat terrain within the Sarulla graben that runs along the axis of the mountains.

The Barisan mountains consist of Permian – Carboniferous metamorphic rocks intruded by Mesozoic plutons. A sequence of Tertiary sedimentary rocks lies above and is capped by Neogene and Quaternary volcanics. During the Miocene, subduction along Sunda trench led to the formation of Barisan mountains with uplift and folding of older strata and arc volcanism. The pre-tertiary stratigraphy of Sumatra as proposed by the DMR/BGS Northern Sumatra Project (Cameron et al. 1980) and used on the geological maps of northern Sumatra published by GRDC are presented in Table 3.1. The distribution of Carboniferous to Early Permian rocks in Sumatra is provided in Figure 3.1. The distribution of the Carboniferous, Permian and Triassic stratigraphic units in north central Sumatra are provided in Figure 3.2. In this map the rock types and critical fossil localities as well as the Late Permian to Triassic intrusives are provided. Blank areas are covered by Late Mesozoic to Quaternary sediments and volcanics. The Jurassic and early Cretaceous Woyla Group distribution is provided in Figure 3.3.

Table 3.1: Stratigraphic units in Sumatra.

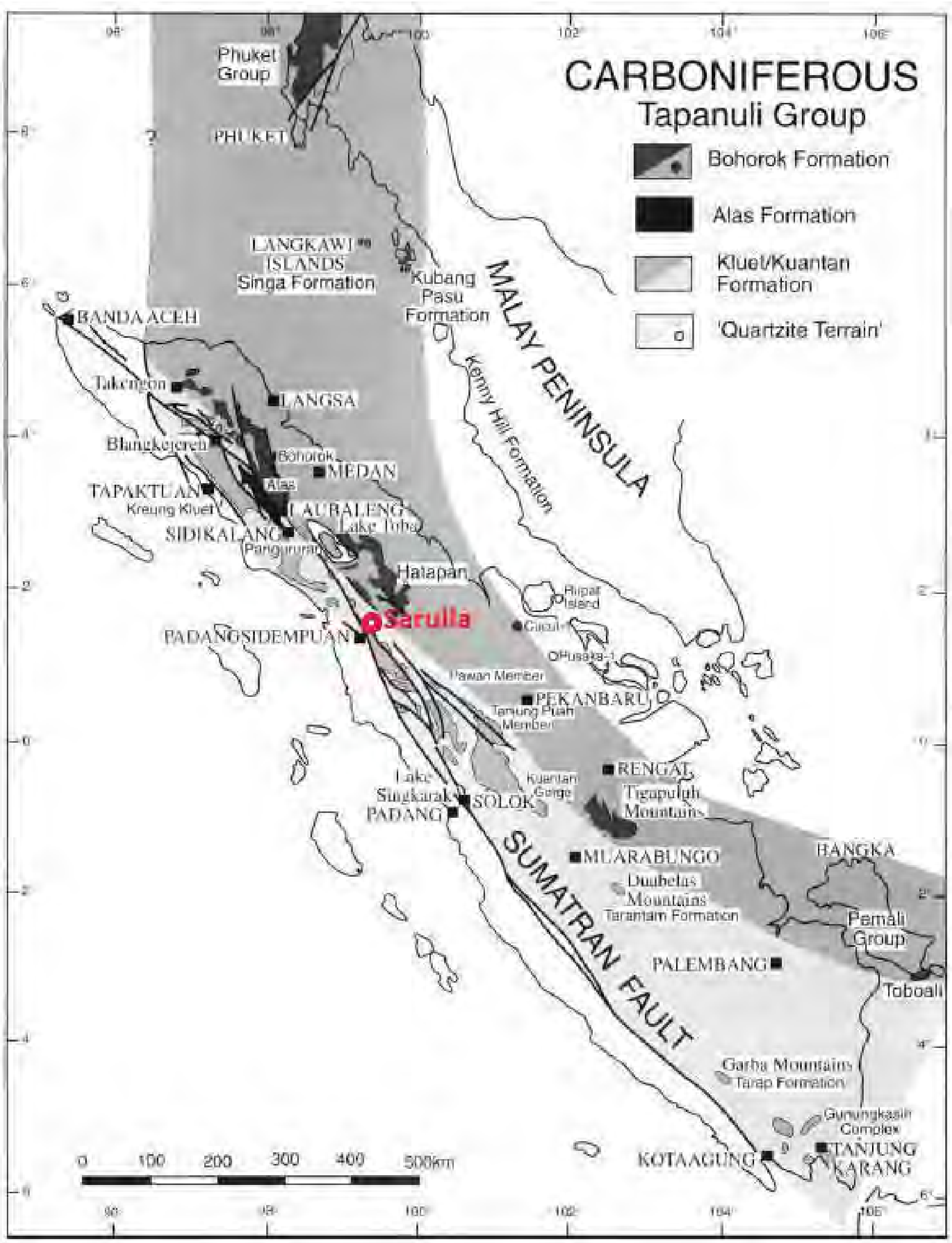
Era	Groups	Formations	Description
CENOZOIC	Sediments and volcanics	River alluvium	-Free gravel, sand, silt, clay, peat and carbonate clay. -Formed in fluviatil to lacustrine environment. In Graben of Tarutung to Sarulla it often contains cracks of Toba Tuff and Toru formation, dacitic and andesitic of gap eruption. -In the fault zone of Toru-Asik in Sipirok it contains mud with rock consisted of semi-consolidated alluvial fan and bad sand.
		Toru formation	-Consists generally of tuff sand -Does not have layers, relatively soft, sometimes silty. -Various position of rock slope caused by Toru Fault movement. Weathered soil of thickness 0.5+3m. Sandy silt, really porous and fragile.
		Toba tuff	-Volcanic sediment: sandy, crystal and pumice tuff. -Volcanic breccia insetions among the tuff. -Contains quartz and mica at some places.

Era	Groups	Formations	Description
			-Near hot spring water it is heavily caolinized. -Lower part of formation is strong, containing elements of minor minerals. -Mostly located at the west of SARULLA AND Tarutung graben, sometimes separated by existing valleys.
		Toru volcanic formation	-Tertiary volcanic sediment -Agglomerate andesitic, lava andesitic, breccias, rhyodacitic ignimbrite. -Andesite with porphyritic texture with minerals of plagioclase or pyroxenes with thickness of weathered soil around 2-4m was found on 12-13km of Tarutung-Sipirok road. It has clayey sand, high permeability and porosity and it is loose. - Rocks with rhyodacitic ignimbrite, rhyolitic vault and gap eruption were found west and east of Sarulla and Tarutung Graben.
CRETACEOUS			
JURASSIC	WOYLA GROUP	Bentaro	Volcanics
		Lamno	Reef limestones
		Geumpang Lam Minet	Serpentinites, pillow lavas, cherts, greywackes
TRIASSIC	PEUSANGAN GROUP	Kualu, Tuhur	-Thin bedded sandstones, wackes, siltstones and mudstones (often contain wood/plant fragments). -Upper part of succession has cross-beds, load and flute casts and slump structures in the sandstone units. -Mud mound deposition environment with rocks moderately to tightly folded about NW-SE trending sub-horizontal axes with easterly dipping axial planes.
PERMIAN		Situtup Batumilmil	Limestones
		Palepat Silungkang Mengkarang	Generally volcanics, sandstones, limestones, shales -Andesitic, basaltic and rhyolitic lavas and tuffs interbedded with siltstones and crystalline limestones (volcanic member of Barisan formation). -Limestone interbedded with shales, sandstones and tuffs. Conglomerate sandstone, siltstone, claystone, limestone and thin coals.
CARBONIFEROUS	TAPANULI GROUP	Bohorok, Mentulu	-Unbedded pebbly mudstone. -Poorly sorted breccia/conglomerate of angular-subangular rock fragments. -Mudstones faulted against Permo-Triassic Batumilmil limestones or Tertiary Bruksah ans Bampo formations.

Era	Groups	Formations	Description
		Alas, Kuantan	-Shales, siltstones, sandstones, quartz wackes and conglomerates (possible green tuffs) -Rocks are intensely folded locally, intruded by granites and migmatised.
		Kluet, Kuantan	-Black shales with phyllites, quartzose arenites, conglomeratic metagreywackes. -Poorly sorted volcaniclastic wackes occur along the Sibolga to Trutung road.
DEVONIAN AND LOWER PALAEOZOIC			
PRECAMBRIAN BASEMENT			-Shales interbedded with quartzites. -Extrusive ignimbites and intrusive tin granites imply an underlying continental basement (not identified in outcrop).

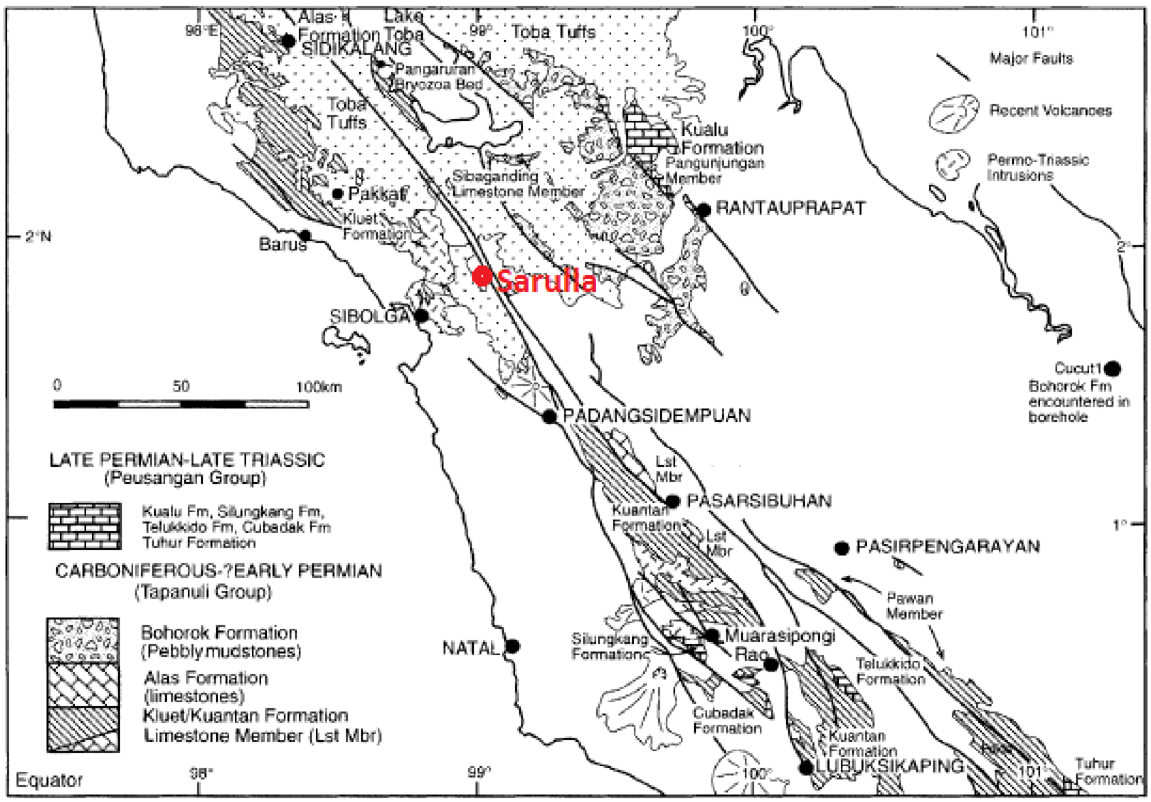
Source: A.J. Barber and M.J. Crow (2005).

Figure 3.1: Distribution of Carboniferous to Early Permian rocks in Sumatra. Dense tones indicate outcrops, the filled circles indicate Carboniferous rocks encountered in boreholes, paler tones indicate subcrop beneath Late Paleozoic, Mesozoic, Tertiary and Quaternary sediments and volcanics.



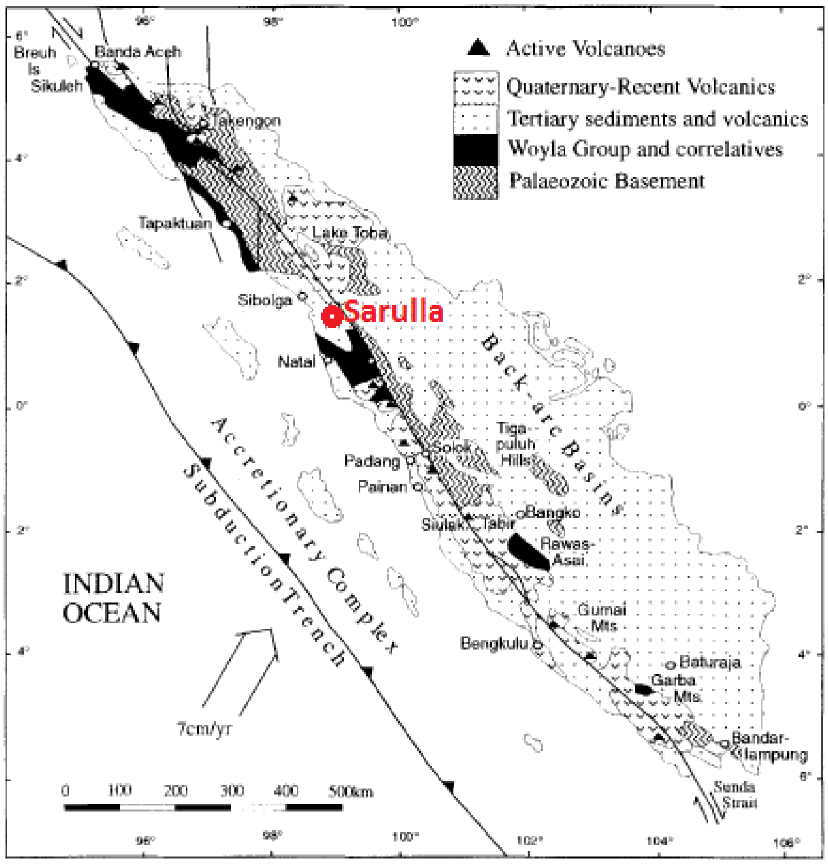
Source: A.J. Barber and M.J. Crow (2005).

Figure 3.2: Distribution of Carboniferous, Permian and Triassic stratigraphic units in north central Sumatra. Rock types, critical fossil localities as well as Late Permian to Triassic intrusives are shown. Blank areas indicate Late Mesozoic to Quaternary sediments and volcanics.



Source: A.J. Barber and M.J. Crow (2005).

Figure 3.3: Geological map of Sumatra showing the distribution of Woyla Group.



Source: A.J. Barber and M.J. Crow (2005).

3.2 Regional Tectonics

Sumatra is an active continental margin where present – day tectonic processes are controlled by three major fault systems. The most obvious is the subduction thrust which crops out in the Sunda Trench. Subduction of the Indian-Australian plate beneath the continental Eurasian plate at a rate of 80mm/year down the Sunda trench has resulted in an active volcanic arc that follows the NW trend of Sumatra. Subduction angle is of about 30^{o} (Fauzi et al., 1996). The Sumatra Fault System (SFS) consists of northwestward moving faults in line with plate edges and in accordance with model of active strike-slip fault. Oblique subduction at about 45^{o} has resulted in two significant faults that are parallel to and lie between the trench and volcanic arc. The vertical Sumatran fault marks the boundary between the Eurasian plate and the majority of the volcanic arc to the northeast with a forarc basin to the southwest. The Mentawai fault separates the forarc basin from a forarc ridge complex further southwest. The entire area between the trench and the Sumatran fault moves northwestward. Inland, the dextral Sumatran Fault runs the entire length of the island, from Banda Aceh to the Sunda Strait. Estimates of total lateral displacement vary from several hundred to twenty kilometres. The 150km value suggested by McCarthy and Elders (1997) is close to the mean of the published values with estimated annual slip rates of 2.3cm/year near lake Toba. A conspicuous feature on the Indian-Australian plate is a 2km high ridge known as the Investigator Ridge Fracture Zone (IFZ) that subducts almost directly beneath Toba. Figure 3.4 presents the tectonic setting of Sumatra. The India-SE Asia convergence vector changes significantly in direction and magnitude over the length of the island. The major volcanic centres (red triangles) that produce rhyolitic ash flow tuffs lie on the Sumatran Fault. The volcanism is associated with elevated regional heat flow centred around Lake Toba. While there were numerous Quaternary volcanic centres in the Sarulla contract area, no active volcanos exist anymore and the most recent eruption at Toba Caldera occurred 74000 years ago.

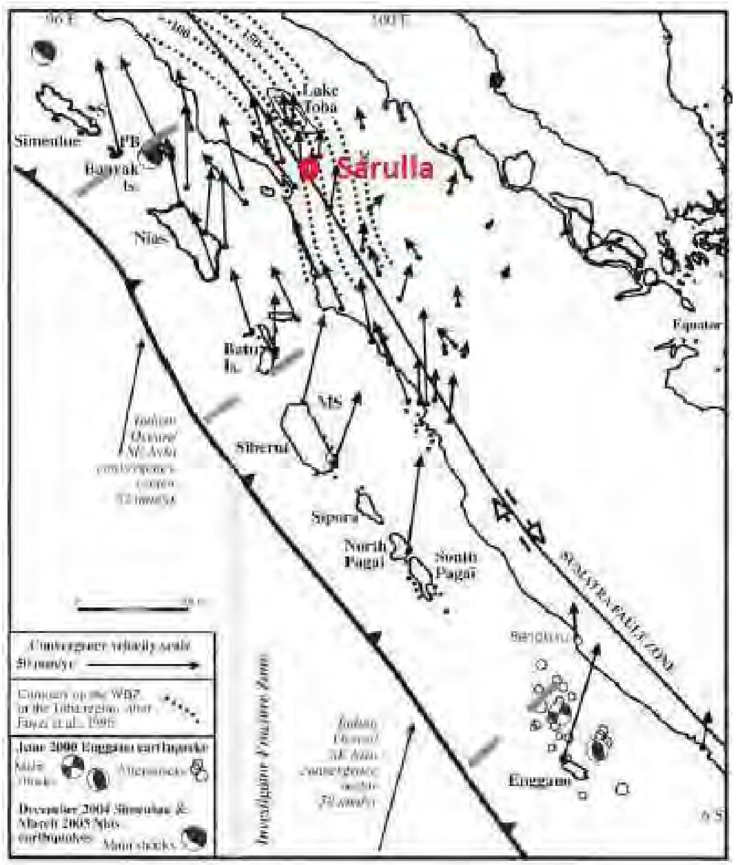
Figure 3.4: The tectonic setting of Sumatra.

Source: Geology of Indonesia.

Based on geology, landscape, water content, soil precipitation, land use and land cover the stability of the ground motion along the Tarutung-Sepirok can be divided into four zones, stable, relatively stable, unstable and largely moving zones. Slip partitioning and subduction of Indian Ocean lithosphere produce high levels of seismicity in the Barisan Mountains, in the forearc basin and along the forearc ridge. The potential for extremely destructive earthquakes was most recently demonstrated by the Magnitude 9 event near Simeule in December 2004. However, and despite the geological evidence for a long history of subduction, shocks deeper than 200km are rare.

Figure 3.5 depicts the movements of sites in Sumatra as determined by GPS observations during the period 1989-1993. Vectors show rates of movement relative to a stable SE Asian part. Vectors imply stress accumulation in parts of the forearc region, some of which would have been released by the June 2000 earthquake near Enggano, the December 2004 earthquake near Simeulue and the March 2005 earthquake near Nias. Locations of aftershocks of the Enggano earthquake are also shown. Major aftershocks to the Simeulue earthquake occurred almost entirely NW of the limits of the map. The pecked grey lines show the locations of barriers to propagation of ruptures from Great Earthquakes inferred by Newcomb and McCann (1987).

Figure 3.5: Movements of sites in Sumatra as determined by GPS observations during the period of 1989-1993.



Source: A.J. Barber and M.J. Crow (2005).

4 Geology & Tectonics of Sarulla

4.1 Geology of Sarulla

The contract area surface geology is dominated by Quaternary arc volcanism and the strike slip faulting. These young features are superimposed on the uplifted, folded and faulted crustal basement rocks, which include Paleozoic metasedimentary rocks, Mesozoic to Tertiary intrusive rocks and Tertiary sedimentary rocks as well as other older crustal structures. A geologic map of the Sarulla contract area is provided in Figure 4.1 and Figure 4.2. The Paleozoic age strata are exposed to both sides of the SFS along the margins of the Sarulla graben. Mesozoic and Early Tertiary deposits are not exposed within the contract area but occur within 15km of the western margin (Aspden et al., 1982). Miocene sandstones and limestones crop out 5-10km along the central Sumatra basin. Carbonaceous formations crop out in a small graben within the southern part of the study area, west of the active Tor Sibohi strand of the SFS. Due to the uplift and erosion of the Barisan mountains during the Neocene, most of the sediments consist of lacustrine and alluvial sandstones, mudstones and conglomerates.

One of the wells that were dug at Silangkitang encountered conglomerates with volcanic clasts, overlain by 2km of tuffs and interbedded lacustrine siltstones. The Namora-I-Langit (NIL) volcanic centre consists of a number of andesitic to rhyolitic domes and flows located west of the Sumatran Fault System at the northwest end of the contract area. South of the NIL complex, a rhyolite dome near the town of Sarulla represents the youngest volcanic feature (0.12Ma) within the northern part of the contract area. There are also abundant silicic pyroclastic deposits, the most recent of which is the regional 74ka Young Toba Tuff which caps most of the area. Many of them have been reworked, forming widespread, laminated volcaniclastic lacustrine deposits in the Sarulla graben.

Specifically, in the vicinity of Silankitang, surface mapping and well results indicate the statigraphy of Table 4.1 while in Namora-I-Langit the stratigraphy is presented in Table 4.2.

Table 4.1: SIL stratigraphy

Formation	Description
Recent alluvium	-Poorly consolidated sandstones and pebble conglomerates that represent river bed deposits -Clasts composed of local reworked tuffs and andesite lava pebbles
Rhyolite dome	-Outcrops south of the investigated zone. - 2km in diameter and located at the eastern edge of the valley. -Partially buried by the fine-grained lake sediments. It contains rhyolite lava, fresh in situ tuffaceous material. Fresh quartz-feldspar-hornblende-biotite lava.
Lake sediments	-Thickness of 400-600m with tendency to thicken towards the Sumatran Fault. -Interlayered mudstone, shale, siltstone and reworked ash beds. The beds range in thickness from tens to several hundreds of feet. -Sediments are generally well consolidated but quite soft.
Rhyolite ash flow tuff	-Thick cooling units with local thin shaly interbeds

Formation	Description
	-Thickness over 1000meters -Quartz, feldspar, biotite, Fe-Ti oxides -Soft and weakly lithified texture at the top while densely welded and hard near the base -Porosity decreases with depth
Pre-volcanic Tertiary products	-Valley filling river deposits, well cemented coarse to fine grained sediments
Paleozoic Metasediments	-Meta-argillites, quartzites, mals and marbles. -Outcrop at the east of the Sumatran Fault.

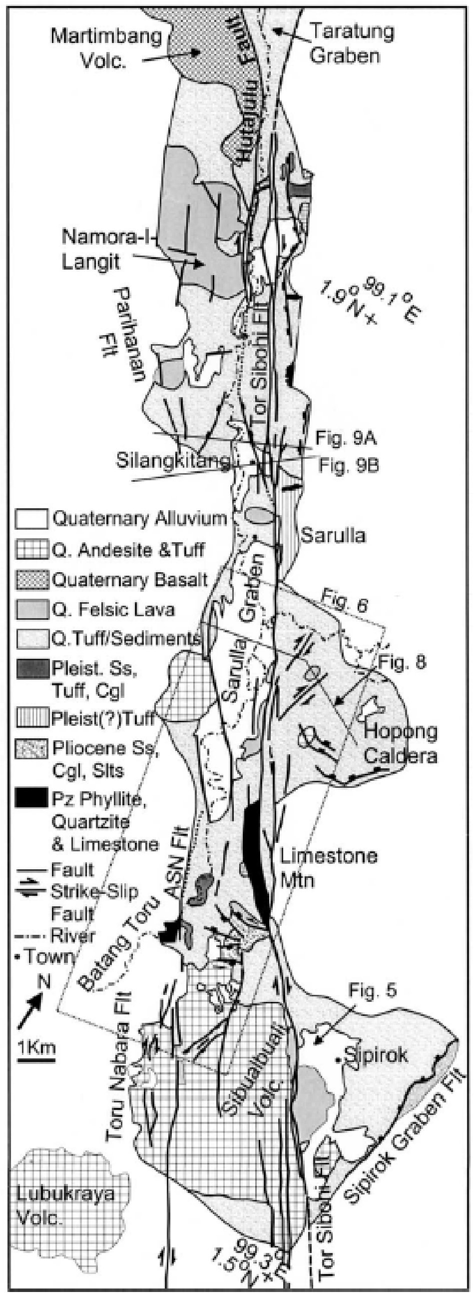
Source: SOL-DR-0001 R00 SIL

Table 4.2: NIL stratigraphy

Formation	Description
Toba rhyolitic ash flow tuffs	-Thickness of 100meters -Referable to huge emissions of the Toba Caldera
Dacitic to rhyolitic lavas and tuffs	-Thickness of 500meters -Related to recent acidic activity of volcanic centers within the graben.
Rhyolitic tuffs	-Thickness over 1000meters -Minor interbeds of andesitic to basaltic products and clayish material.
Basement –Paleozoic metasediments and Tertiary sediments	-Depth of 2200m and elevation of -1200m asl -Tendency to rise westward -Impervious top of layer, representing the lower limit of the reservoir.

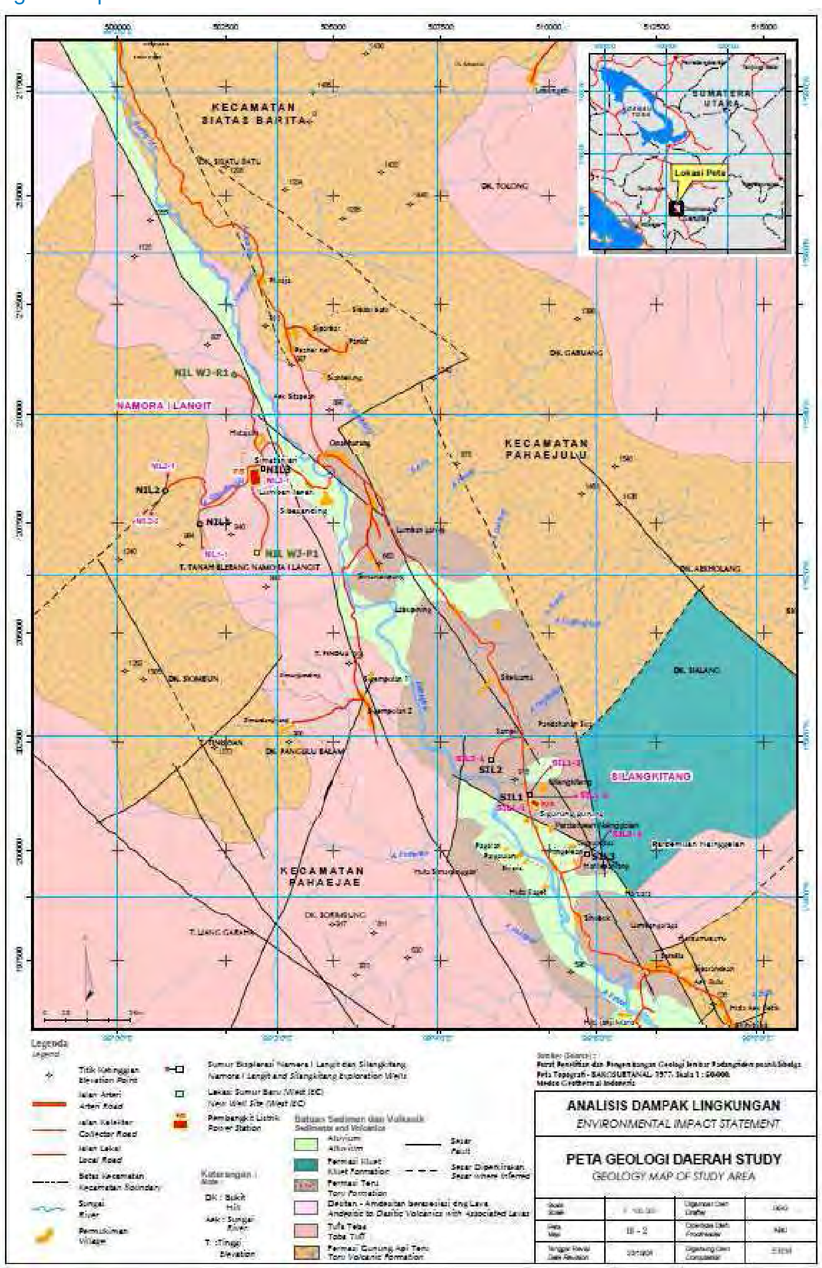
Source: SOL-DR-0001 R00 NIL

Figure 4.1: Geologic map of the contract area.



Source: Hickman et al. (2004).

Figure 4.2: Geological map of the contract area.

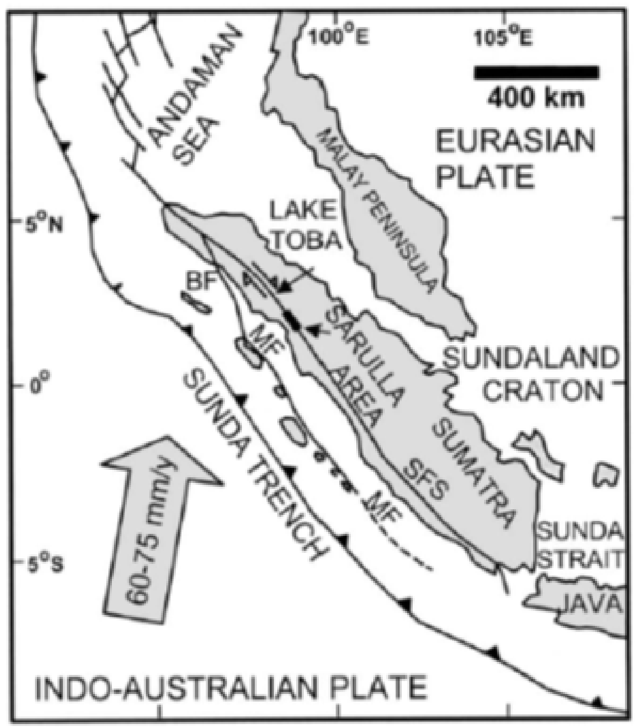


Source: Sarulla Operations LTD.

4.2 Tectonics of the contract area

The Sarulla contract area is dominated by the presence of the right lateral strike slip Sumatran Fault System (SFS) (see Figure 4.3). The principal strand extends from the eastern flank of Sibualbuali volcano and has numerous small subsidiary parallel and antithetic (tensional/extensional) faults, as evidenced by common minor fault scarps and sag ponds. A second major strand lies along the western margin of the volcano. Sarulla Graben, a large segment of 25km length, is lying west of the main trace of the SFS, near the northern end of the valley where the SIL geothermal plant is found. The multiple fault strands created a series of elongate basins along the Sumatra fault zone in the late Neogene.

Figure 4.3: The tectonic setting of Sarulla.



Source: Hickman et al. (2004)

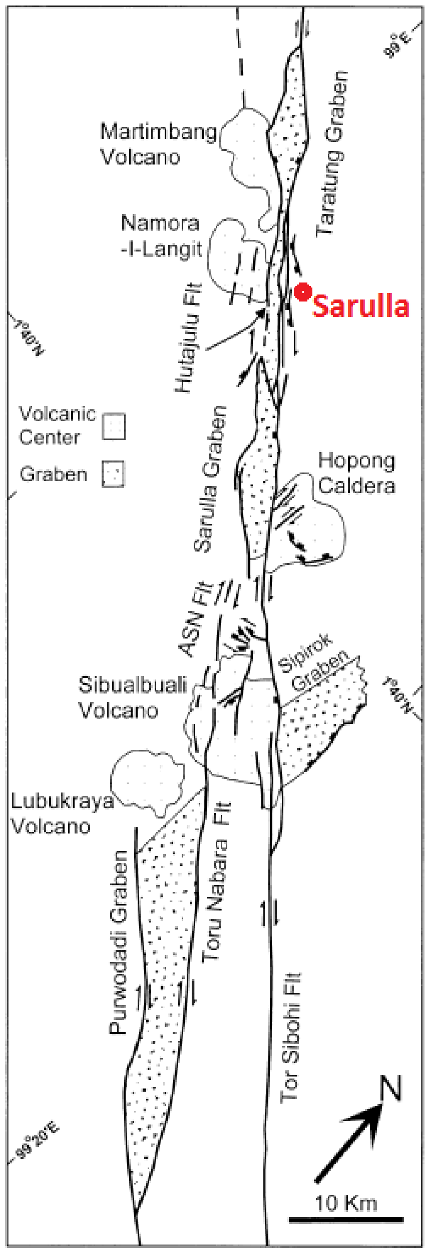
A recent model based on interpreted focal mechanisms of Sumatran earthquakes has suggested relatively high and variable slip rates along the SFS that increase northwestward. This variability is consistent with measured fault offsets of 1.4cm/yr around Maninjou (270km SE of Sarulla) and 2.7cm/yr near Tarutung. Most of the documented earthquakes in the vicinity of Sarulla are associated with subduction, but the 1892 Tapanuli earthquake and the 1987 Taratung earthquake were related to movement along the SFS.

SFS forms a wide zone (10km) along the length of the study area, where the active Tor Sibohi fault lies. The fault strikes at N35^{o}W and produces a dextral-slip motion which creates a bend near Silangkitang, a releasing bend south of Sarulla graben and a constraining bend north of Sibualbuali volcano. At the northern part of the contract area the fault strikes N45^{o}W and dips 67^o to the SW. In Silangkitang fault dips at 87^o to the SW and along the northeast flank of Sibualbuali the fault strikes N46^{o}W and dips 85^o to the SW.

In Sarulla contract area, stream offsets were estimated from aerial photos and topographic maps (Hickman et al. 2004). The range is between 130-1400m. In Toba area stream offsets were found to be of 1660±100m using SPOT Satellite images and 1700-2100m using aerial photographs and topographic maps. Offset rate was found to be 23±3mm/yr. Recent fault slip rates in Sarulla cannot be determined easily because of the older ground formations around the streams which are not useful for age dating. The Aek Sitandiang Namenek (ASN) fault shows topographic evidence of recent movement with offsets of about 300m. SW of Sipirok the ground composition and observed offsets make it easier for slip rate estimations of the Tor Sibohi fault. Slip rates are found to be about 9mm/yr with dextral direction. The range of the offset extremes gives minimum and maximum slip rate value of 7 and 14mm/yr respectively. The discrepancies between the two slip rate values result from the additional slips of other faults in the region and the different slip rates of the Holocene and the Quaternary deposits.

A map of the faults in Sarulla contract area is shown in Figure 4.4. The currently active Tor Sibohi fault and Aek Sitandiang Namenek (ASN)/Toru Nabara fault zone define a valley that parallels the Purwodadi graben. The northern end of this basin is a complex releasing step which transfers displacement from the ASN fault to the Tor Sibohi strand through a series of normal sinistral oblique-slip faults northern of Sibualbuali volcano. The area between the ASN and Toru Nabara fault zone and the Purwodadi graben are a series of pull apart basins. Sarulla graben is not a pull apart basin. Tor Sibohi fault bounds the NE side of Sarulla graben and the north part of the graben is cut by normal dextral-slip faults that parallel the linear trace of Tor Sibohi fault. Sarulla graben appears to have been formed by perpendicular extension to the TSF. The Taratung graben at the north is a pull apart basin, formed between two understepping strike slip faults.

Figure 4.4: Map of the faults in Sarulla region.



Source: Hickman et al. (2004)

4.3 Fault identification

The Sumatra fault system (SFS) forms a zone up to 10km wide along the length of the study area. One active strand of the fault, the Tor Shibohi Fault (TSF) extends along the entire distance and in exposed in the northern limit of the contract area.

Golder Associates (2008) produced three maps identifying the fault locations around the project area (Report No 088712044 015 R Rev0). The purpose of the study was to identify fault traces in the vicinity of the Sarulla Geothermal plant location. The future movement along the active Sumatran Fault traces may result in horizontal and vertical ground displacements of 1 to 10m. Active faults at that time were defined as those that show evidence for single or repeated surface movement during the last 10000years (Holocene era). The conclusion for the SIL site was that none of the identified possible faults crosses the SIL plant location. However some of them are located very close to the plant.

None of the possible faults crosses the NIL plant location.

The SIL site is located at less than 1km from the surface Sumatran Fault trace, further investigation was performed by Golder Associates in 2010, using the Electrical Resistivity test (ERI) results. The ERI survey identified five potential faults (GNZ1 to GNZ5) and a fluid filled fracture zone striking NNW-SSE (see Figure 4.5). The faults generally coincide with the topographic lineaments that were found in the area in 2008 but the fault locations were slightly refined by the interpretation of the ERI data. Golder (2010) provides a much more extensive fracture zone than it was defined in 2008. In Figure 4.5 faults GNZ1-4 cross the SIL plant plan while fault GNZ5 and the fracture zone are very close to the SIL plant location. They conclude that faults GNZ1 to GNZ4 are not active but fault GNZ5 and fracture zone are potentially active. It is recommended that further trenches need to be performed in order to test those faults activity. The right time for such studies should be before the detailed design is finalised and construction starts in the site as this will cause minimum obstructions in the fault trenching activities.

Further field investigations should be accompanied by related studies that include (Golder 2010)

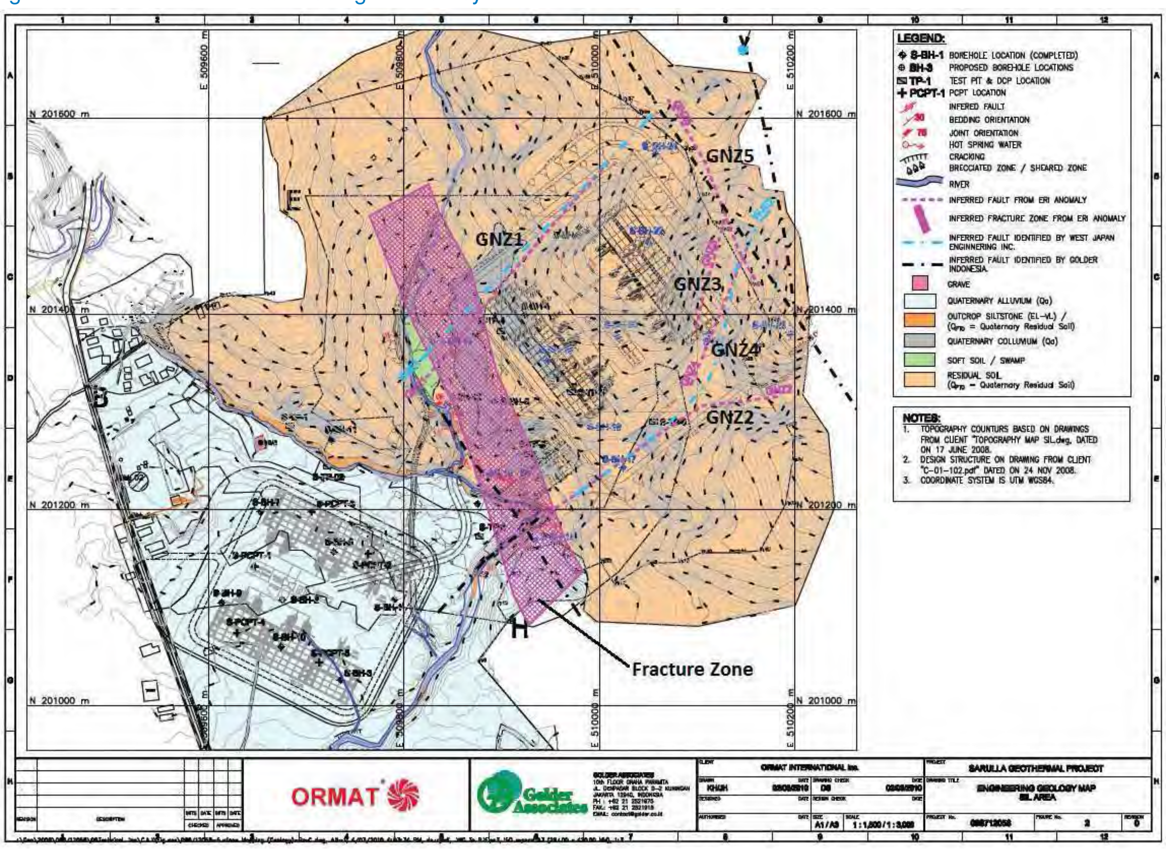
- Interpretation of large-scale stereo aerial photographs and/or LiDAR imagery of the site and surrounding areas;
- Tectonic geologic and geomorphic field mapping of the area surrounding the site (± 3 km radius);
- Radiometric dating, where possible, of soil and organic materials collected from natural or manmade exposures with clear association to the faults mapped or inferred within the SIL site; and
- Reference studies of the nearby Sumatran fault where its location and rate of Holocene activity are well constrained.

4.4 Effect of possible fault movement

Fault movement affects surface landforms and infrastructure with possible movements in vertical and horizontal directions. Significant damage is usually restricted to a narrow zone ranging up to 300 meters wide along the fault, although subsidiary ruptures may occur three to four kilometers from the main fault. The length of the surface ruptures can range up to several hundred kilometers.

In addition to buildings, linear structures such as roads, railroads, bridges, tunnels, and pipelines are susceptible to damage from surface faulting. Obviously, the most effective way to limit such damage is to avoid construction in the immediate vicinity of active faults. Where this is not possible, some mitigation measures such as installing pipelines above ground or using flexible connections can be considered.

Figure 4.5: Fault identification using ERI survey.



Source: Golder, 2010

5 Geotechnical appraisal

A comprehensive geotechnical programme was followed for the SIL and NIL areas. The geotechnical information is useful to determine a seismic site class to aid the design. Based on the site investigation data a geological model can be developed for the sites as shown in Table 5.1 and Table 5.2 respectively.

5.1 Design ground profile

Detailed results of the investigation are provided in Table 5.1, Table 5.2 and Table 5.3 for SIL and NIL respectively. Three gullies were also found at SIL site, whose site conditions are summarised in Table 5.4.

Table 5.1: Results of GI at SIL site.

Formation	Description
Alluvial soils	-Depths of 3 to 6m -Variable, including very soft clayey silt, silty caly, very loose to medium dense silty or clayey sands.
Underlying Alluvium	-Tertiary residual soils, clayey silts and silty sands grading into extremely weathered rock -Firm to stiff or loose to medium dense zones were found at the top 5-6m of the stata -Very stiff to hard and medium dense to dense soils between 10 to 18m depths.
Siltstone and sandstone bedrock	-Extremely low to low strength between depths 39 and 43m at some BH logs. -Final drilling depth of 50m

Source: Report No 088712044 015 R Rev0 (2008)

Table 5.2: Results of GI at SIL hillside.

Formation	Description
Colluvium	-Thickness up to 5m -Upper 1-3m sensitive to disturbance
Residual silts and clays	-Variable across the hillside, those found in lower elevations are less disturbed, with lower moisture content and with stiff to hard consistency increasing with depth.
Bedrock	-Tuffaceous sandstones and siltstones -Residual sandy silts and clays except the upper 20m of S-BH-04 and S-BH-23 where silty gravels and sands were found. -No slicken – sides or other evidence of disturbance of bedding was found.

Source: Report No 088712044 015 R Rev0 (2008)

Table 5.3: Results of GI at NIL site.

Formation	Description
Colluvium	-Thickness of 0.5 to 2m except around gullies with thickness up to 2-4m
Residual soils	-Up to depths of 12 to 18m

Formation	Description
	-Sensitive to remoulding at depths between 8 to 12m
Extremely weathered bedrock	-Residual very dense silty sands or very stiff to hard sandy silt -Depths between 12 to 18m -Most of the BH's terminate at this material
Siltstone, claystone and tuffaceous sandstone	-Variable depths between 20 and 40m

Source: Report No 088712044 015 R Rev0 (2008)

Table 5.4: Gullies at NIL results

Soil reference	Thickness
Southern gully	
Very soft silts and clays	4m
Medium dense or firm to stiff residual soils	8-12m
Bedrock (tuffaceous sandstone or breccia)	-
Eastern gully	
Very soft clay	1-2m
Residual soil	2.5m in the north and up to 10m in the south
Very dense residual sands grading into extremely weathered bedrock	-
Northern gully - east	
Very soft clay	2m
Residual soil	2.5m
Very dense residual sands (extremely weathered sandstone)	-
Northern gully - west	
Residual soil	1.5m
Very dense residual sands (extremely weathered sandstone)	-

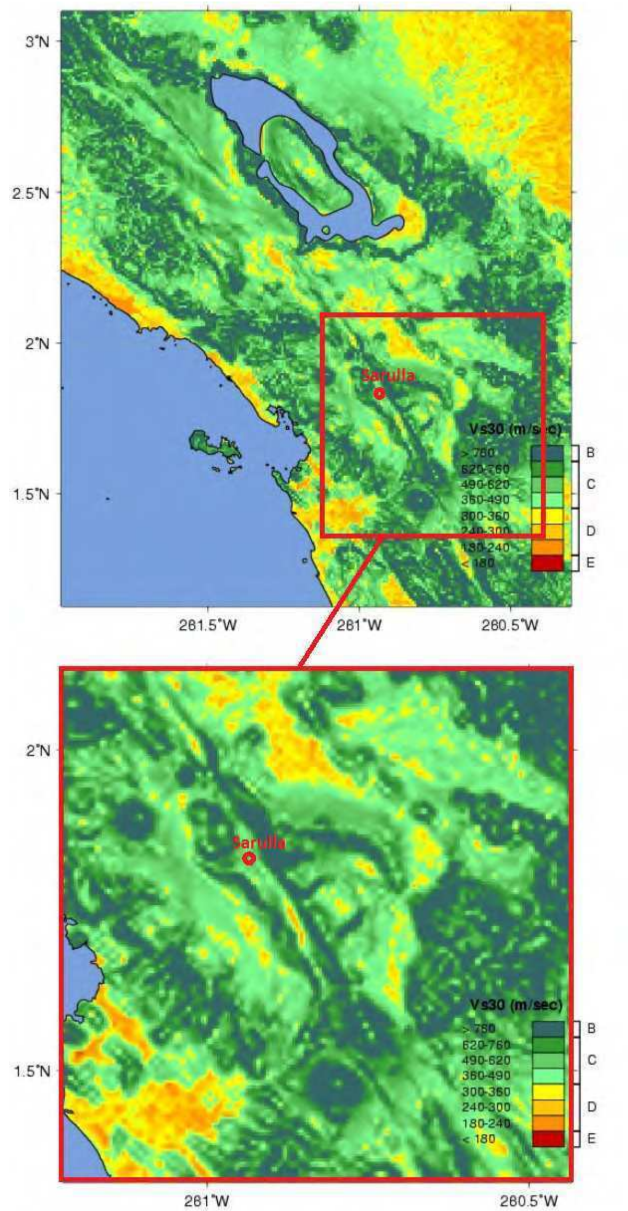
Source: Report No 088712044 015 R Rev0 (2008)

5.2 Seismic site class

The U.S. Geological Survey (USGS) global shear-wave velocity maps web application (USGS, 2010) has been used for obtaining a first-order estimate of the average shear-wave velocity values over the top 30meters of ground ($V_{s,30}$). According to the USGS web tool, within the North Sumatra region$V_{s,30}$ values range from 360-490m/sec and raise up to >760m/sec at some areas. Maps showing these values are provided in Figure 5.1. The shear wave velocity is required for determining the seismic site class. This is required for deriving the seismic spectra. A higher shear wave velocity signifies better conditions for seismic behaviour of the ground. The Indonesian Seismic Design Code follows site classification based on the following generic site classes: Hard Soil, Medium Soil and Soft Soil. The classification is based on SPT N values, shear wave velocity and undrained shear strength according to the requirements given in Table

5.5 as reproduced from SNI-03-1726-2002. Based on the Indonesian Seismic Design Code and using the $V_{s,30}$ values estimated from Figure 5.1, the soil around Sarulla region would be classified as "Hard soil".

Figure 5.1: Map of the average shear wave velocity over the top 30meters ($V_{s,30}$) for North Sumatra and the specific area of the Sarulla Geothermal plant.



Source: USGS web application

Table 5.5: Types of soil according to SNI-03-1726-2002

Soil type	Average shear wave propagation speed (m/sec)	Average standard penetration test result, N	Average non-flowing shear strength (kPa)
Hard soil	$V_s \geq 350$	$N \geq 50$	$S_u \geq 100$
Medium soil	$175 \leq V_s \leq 350$	$15 \leq N \leq 50$	$50 \leq S_u \leq 100$
Soft soil	$V_s < 175$	$N < 15$	$S_u < 50$
	Or, each profile with soft soil having total thickness of more than 3m with PI>20, $W_n \geq 40\%$ and $S_u < 25$kPa.		
Special soil	Requires special evaluation at each location.		

Source: SNI-03-1726-2002

It should be noted that the web application $V_{s,30}$ maps are not based on direct measurements. These estimates have been derived using correlations between shear wave velocity values and topographic slope using datasets from various regions and therefore the above classifications should stand as preliminary classifications which will need to be confirmed by appropriate site investigation. According to Eurocode 8 the Sarulla region is typically classified as Ground Type B or Ground Type A (See Table 3.1: Ground Types, BS EN 1998-1:2004+A1:2013).

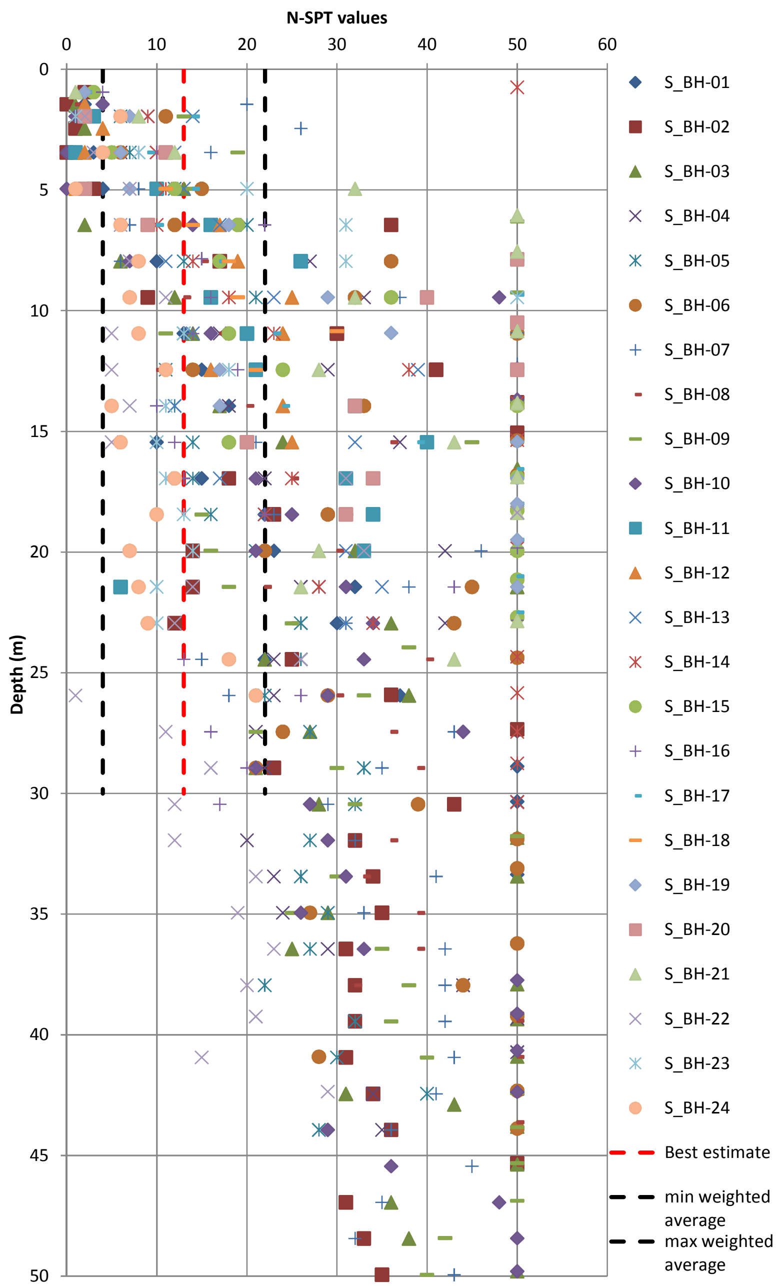
The N-SPT values with depth resulting from the borehole data in SIL and NIL are provided in Figure 5.2 and Figure 5.3. Relationships of $V_{s,30}$ with N_{SPT} for all soil types are used for calculating $V_{s,30}$ (see Table 5.6). Weighted average minimum and maximum as well as best estimate N_{SPT} values of 13 and 26 are considered for the first 30meters of soil for SIL and NIL respectively. Both from the N-SPT results and the $V_{s,30}$ it results that soil type according to the Indonesian code is “Medium soil” and according to Eurocode is type C.

Table 5.6: Resulting V_s according to V_s-N_{SPT} correlations reported in literature.

Author (s)	Correlation	Country	$V_{s,30}$ (m/sec)	
			SIL	NIL
Imai and Yoshimura (1970)	$V_s=76.0N^{0.39}$	Japan	207	271
Imai (1977)	$V_s=91.0N^{0.34}$	Japan	218	276
Ohta and Goto (1978)	$V_s=85.3N^{0.35}$	Japan	209	267
Imai and Tonouchi (1982)	$V_s=97.0N^{0.31}$	Japan	215	266
Yokota et al. (1991)	$V_s=121.0N^{0.27}$	Japan	242	292
Seed and Idriss (1981)	$V_s=61.0N^{0.50}$	USA	220	311
Kalteziotis et al. (1992)	$V_s=76.2N^{0.24}$	Greece	141	167
Athanasopoulos (1995)	$V_s=107.6N^{0.36}$	Greece	271	348
Jafari et al. (1997)	$V_s=22.0N^{0.85}$	Iran	195	351

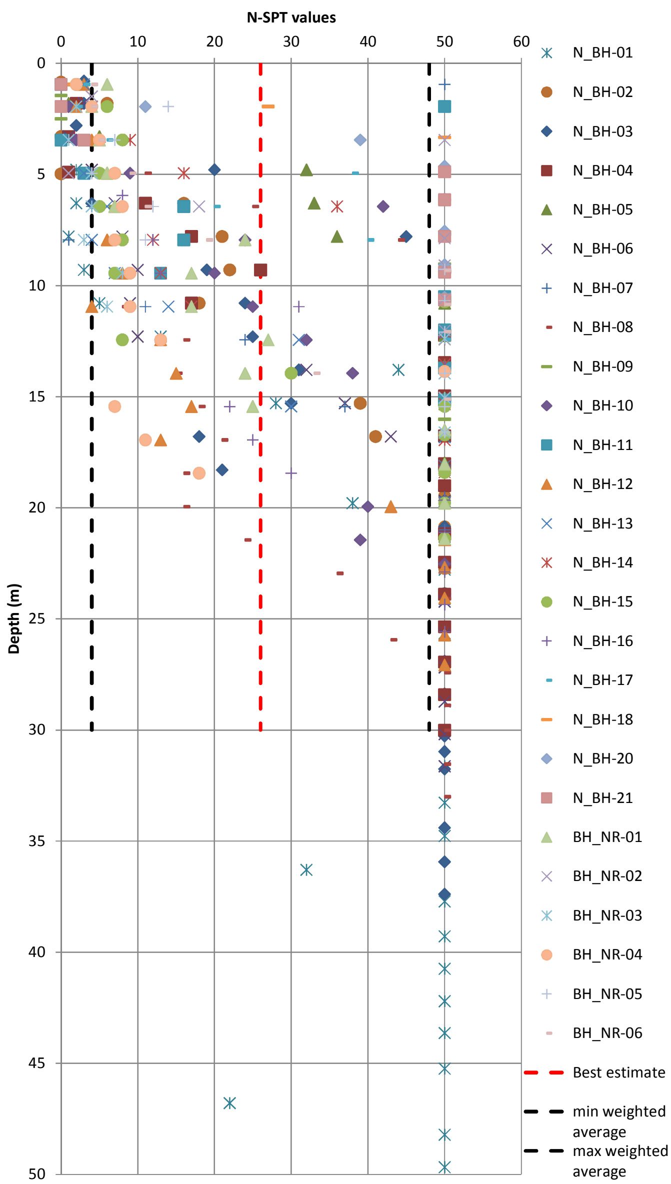
Source: Hanumantharao and Ramana (2008)

Figure 5.2: N-SPT values with depth for the SIL site. Dashed line represents the considered average N-SPT value for the first 30meters depth.



Source: Geotechnical report for SIL – Report No 088712044 R Rev0

Figure 5.3: N-SPT values with depth for the NIL site. Dashed line represents the considered average N-SPT value for the first 30meters depth.



Source: Geotechnical report for NIL – Report No 088712044 R Rev0

6 Seismic Hazard

Indonesia is surrounded by multiple tectonic plates causing it to be highly exposed to earthquake risk in both frequency and intensity. In this section some of the recent earthquakes near the site will be assesed.

6.1 Historical Earthquake catalogue

The Significant Earthquake Database of the National Geophysical Data Center (NGDC) was used to produce Table 6.1 of the historical earthquakes that happened close to the contract area (coordinates 99° 4' 12''E and 1° 51' 00''N).. Earthquakes are considered significant if they meet a specific criterion of at least: "Moderate damage (approximately $1 million or more), 10 or more deaths, Magnitude 7.5 or greater or the earthquake generated a tsunami". The database was used to provide all such significant earthquakes from 2150 B.C to 1964, within a rectangular region of approximately 1000 km side length, centred on the proposed geothermal power plant location.

Table 6.1: Historical earthquakes around the contract area.

Location	Date	Location	Magnitude	Depth (km)	Details
200km south of the proposed geothermal power plant	10/02/1797	0.001°N 99.00°E	8.0	N/A	-Associated tsunami caused approximately 300 deaths, mainly at Padang.
500km SW from proposed geothermal power plant	24/11/1833	-2.50°N 100.50°E	8.3	75	-Felt at Singapore and Java. -Barrier on Kaba Volcano burst and seven villages flooded. -Cracks of 0.5 m or more in ground at Pariaman. Less than 50 deaths overall.
350km SW from proposed geothermal power plant	16/02/1861	-1.00°N 97.50°E	8.5	70	-The induced tsunami caused approximately 1105 deaths, mainly from Pulu Tello, Fort Laundi and the Atjeh coast.
430km SSE from proposed geothermal power plant	06/02/1908	-2.00°N 100.00°E	7.5	130	-No major damage reported by NGDC.
463km SE from proposed geothermal power plant	03/06/1909	-2.00°N 101.00°E	7.6	40	-Between 100 and 1000 deaths. -Serious destruction in Kerintji and Redjanglebong districts
218km SW from proposed geothermal power plant	28/12/1935	0.00°N 98.25°E	7.9	33	-Moderate damage caused, few injuries, less than 50.
319km SW from proposed geothermal power plant	09/06/1943	-1.00°N 98.25°E	7.6	50	-No Major damage reported by NGDC.

Source: NGDC Website.

In order to produce a seismic catalogue relevant for the examined area, the seismic data were obtained from earthquake listings held by the U.S. Geological Survey (USGS) and the International Seismological Centre (ISC). Using the USGS website, earthquakes between 1973 and the present were considered in a 300km large box centred on Sarulla. A circular search was conducted through the ISC website, using a radius of 150km and providing data on earthquakes between 1964 and the present. From both searches, the magnitudes of all earthquakes were converted to the moment magnitude scale as far possible. The conversions used were obtained from Asrurifak et al. (2010) study. The results from both searches were then combined to provide a more comprehensive list of past seismic activity. The total number of the examined events is 1116 and duplicated between the catalogues were removed. This is shown in Figure 6.1.

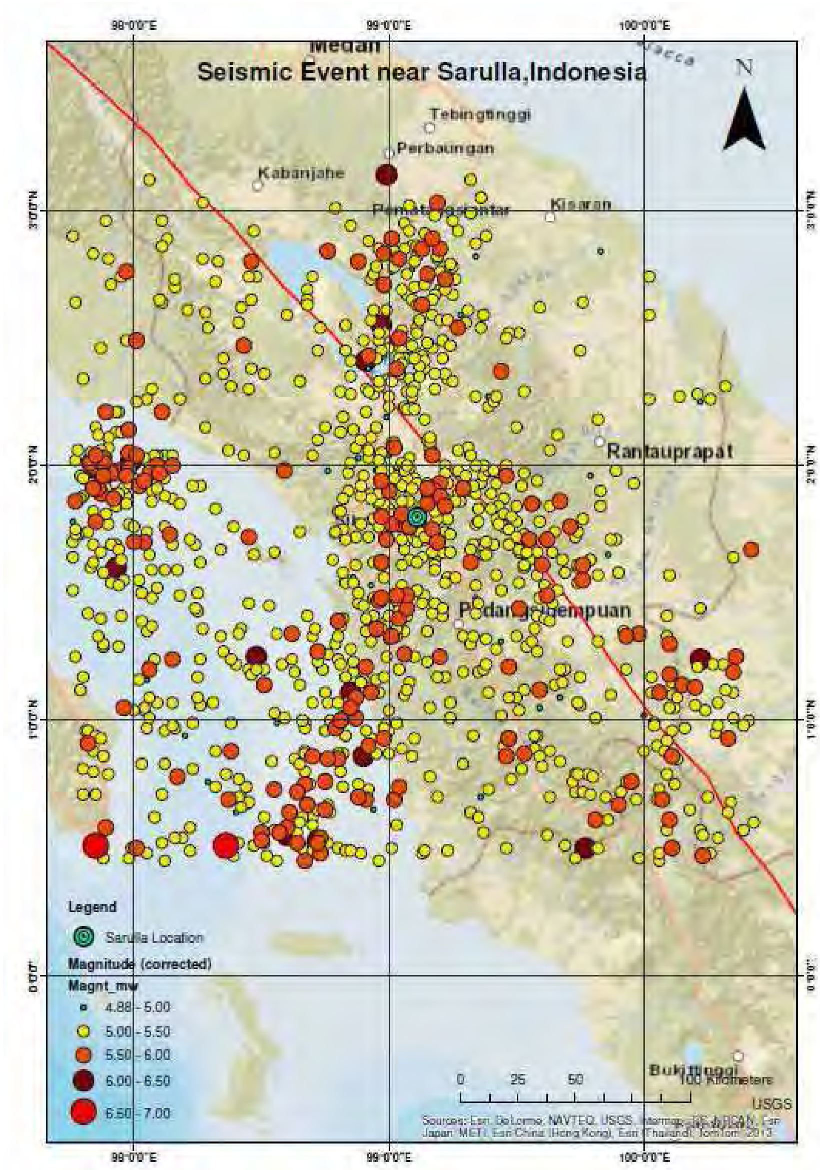
An overview of the largest earthquakes which have occurred within 150km radius of the location of the proposed Sarulla geothermal power plant (coordinates 99° 4' 12''E and 1° 51' 00''N) are summarised in Table 6.2 (See Figure 6.1). The three last rows of Table 6.2 refer to the recent very large earthquakes that happened in the region. Those earthquakes are outside the search region applied to the earthquake catalogues.

Table 6.2: Summary of damaging earthquakes in the project area.

Location	Date	Location	Magnitude	Depth (km)	Details
162km SW from the proposed geothermal power plant	14/05/2005	0.51°N 98.36°E	6.7	34.0	
200km SW of the proposed power plant	0/12/1974	0.505°N 97.852°E	6.8	44.8	
147km SSW from the proposed power plant	02/02/1971	0.528°N 98.719°E	6.5	39.6	-Recorded damage in Northern Sumatra -Earthquake was felt in Singapore
76km NNW from the proposed plant	25/04/1987	2.409°N 98.906°E	6.4	7.7	-No major damage finally reported
137km WWN of the proposed plant	03/04/2005	1.970°N 9°E	6.2	36.0	
398 km NW of the proposed location of the geothermal power plant	26/12/2004	3.316°N, 95.854°E	9.1	30.0	This earthquake, known as the Sumatra-Andaman earthquake, ranked 3rd in the USGS' list of largest earthquakes since 1900. The death toll was approximately 227,898, with another 1.7 million affected across 14 countries from the earthquake and associated tsunami
235 km W of the proposed location of the geothermal power plant	28/03/2005	2.074°N, 97.013°E	8.6	30.0	This earthquake, also known as the Nias earthquake, ranked 9th in the USGS' list of largest earthquakes since 1900. The death toll was approximately 1313
674 km W of the proposed location of the geothermal power plant	11/04/2012	2.311°N, 93.063°E	8.6	22.9	This earthquake is sometimes referred to as the 2012 Indian Ocean earthquake, ranked 11th in the USGS' list of largest earthquakes since 1900. Approximately 10 people died and a further 12 were injured

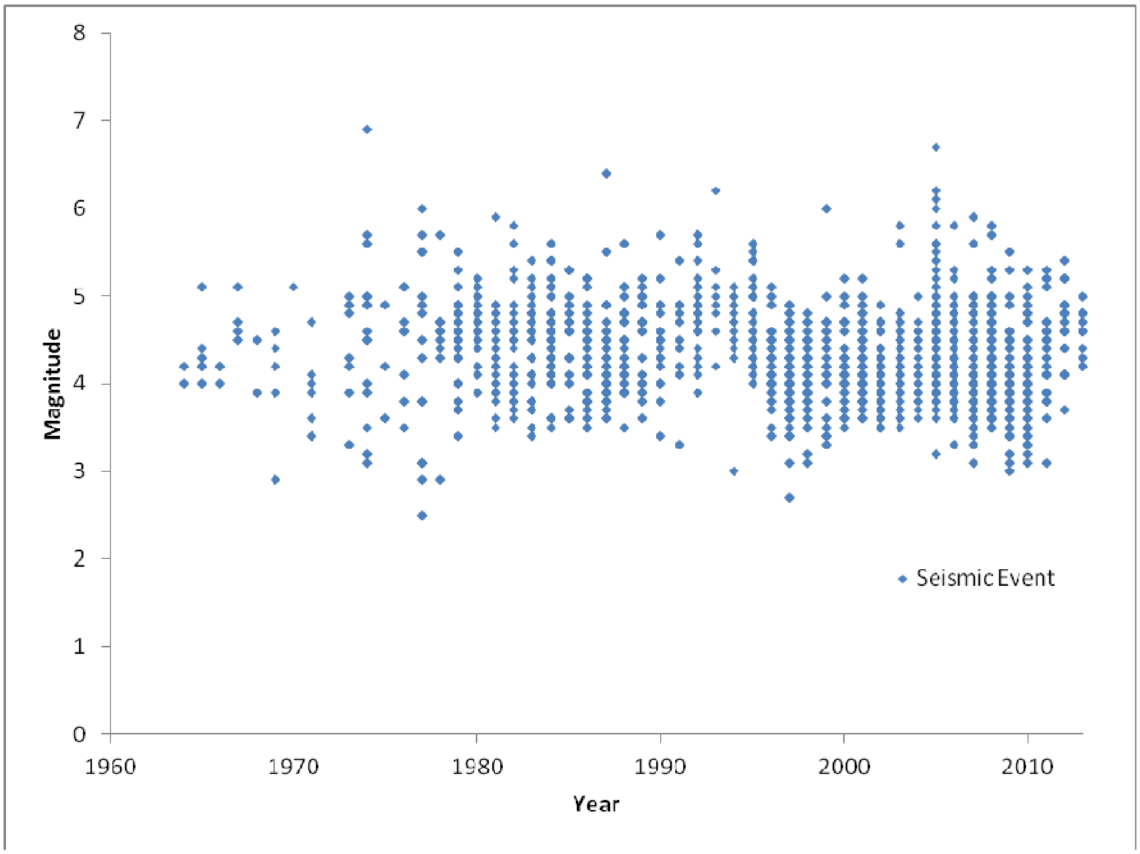
Source: USGS and ISC website.

Figure 6.1: Seismicity map of Sarulla region.



Source: USGS and ISC earthquake catalogues.

Figure 6.2: Instrumental Catalogue Completeness



Source: USGS & ISC

Figure 6.2 presents the distribution of seismic events present in the combined USGS and ISC catalogues. It can be seen that the catalogue is relatively complete for smaller events since 1964 (where modern instrumental era started). In the last ten years there has been an average of about 45 events between magnitude 4-6 and approximately very few events greater than 6 to 8 in the last ten years in the vicinity of the site area. The biggest event is a 6.8 event magnitude with its epicentre located at 200km SW from the proposed plant (coordinates 99° 4' 12''E and 1° 51' 00''N).

7 Review of Seismic Hazard Studies

This section summarises existing seismic hazard estimates for the Sarulla Region, which come from published regional studies and online resources.

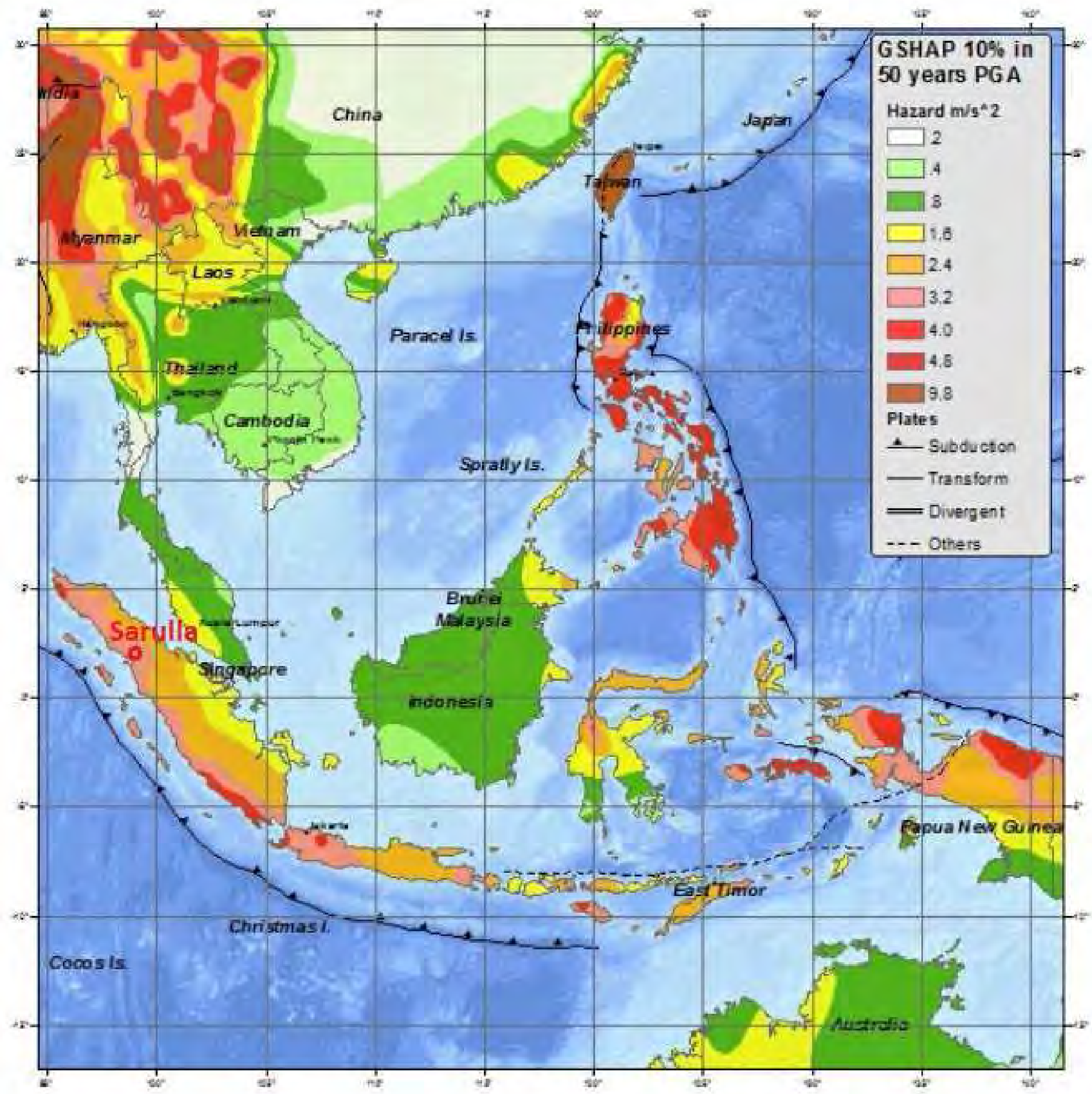
7.1 Regional Seismic Hazard Maps

7.1.1 GSHAP (1999)

As part of the decade for natural disaster reduction, the United Nations carried out the Global Seismic Hazard Assessment Programme (GSHAP) in order to produce a seismic hazard map of the world. The project consisted of local studies that were integrated into regional and global maps.

A seismic hazard map of Indonesia expressing Peak Ground Acceleration (PGA) at bedrock expected at 10% probability of exceedance in 50 years is shown in Figure 7.1. This shows the hazard rating in Sarulla to be 3.2m/sec^2, corresponding to a seismic bed rock acceleration of 0.33g. It should be noted that this is for a return period of 475 years and bed rock conditions only.

Figure 7.1: Seismic Hazard Map of Indonesia – GSHAP 10% in 50years PGA



Source: USGS website

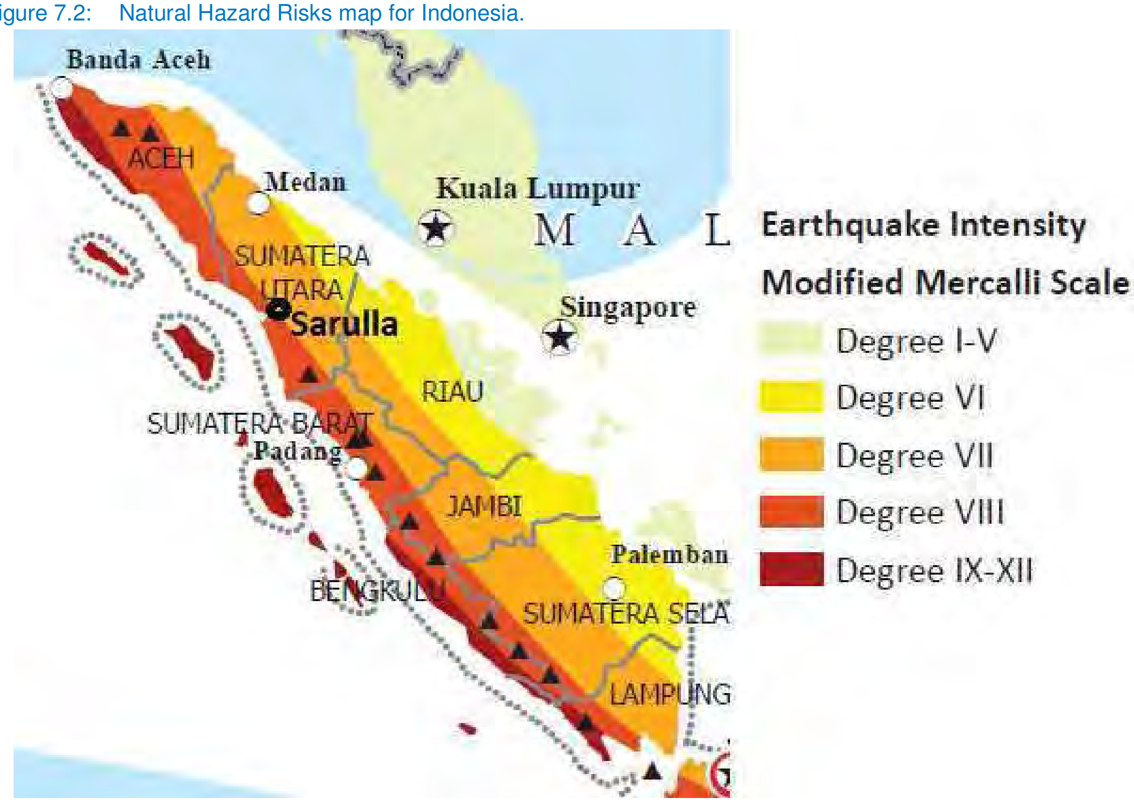
7.1.2 OCHA (2011)

The all natural hazard risk map issued by OCHA (2011) is shown in Figure 7.2. Earthquake intensity risk is shown using the 1956 version of the Modified Mercalli Scale (MM), describing the effects of an earthquake on the surface of the earth. The zones indicate where there is a probability of 20% that degrees of intensity shown on the map will be exceeded in 50 years. Pacific islands and countries too small to be easily visible are represented by boxes giving an approximate level of equivalent risk based on data from Munich Reinsurance Company's NATHAN system.

According to this map, Sarulla is associated with a MMI of VII to VIII for a 475 year return period. According to the relationship between PGA and MMI given in Figure 7.3, this is equivalent to a PGA between 0.3 and 10 m/sec² (about 0.03 to 1.0g).

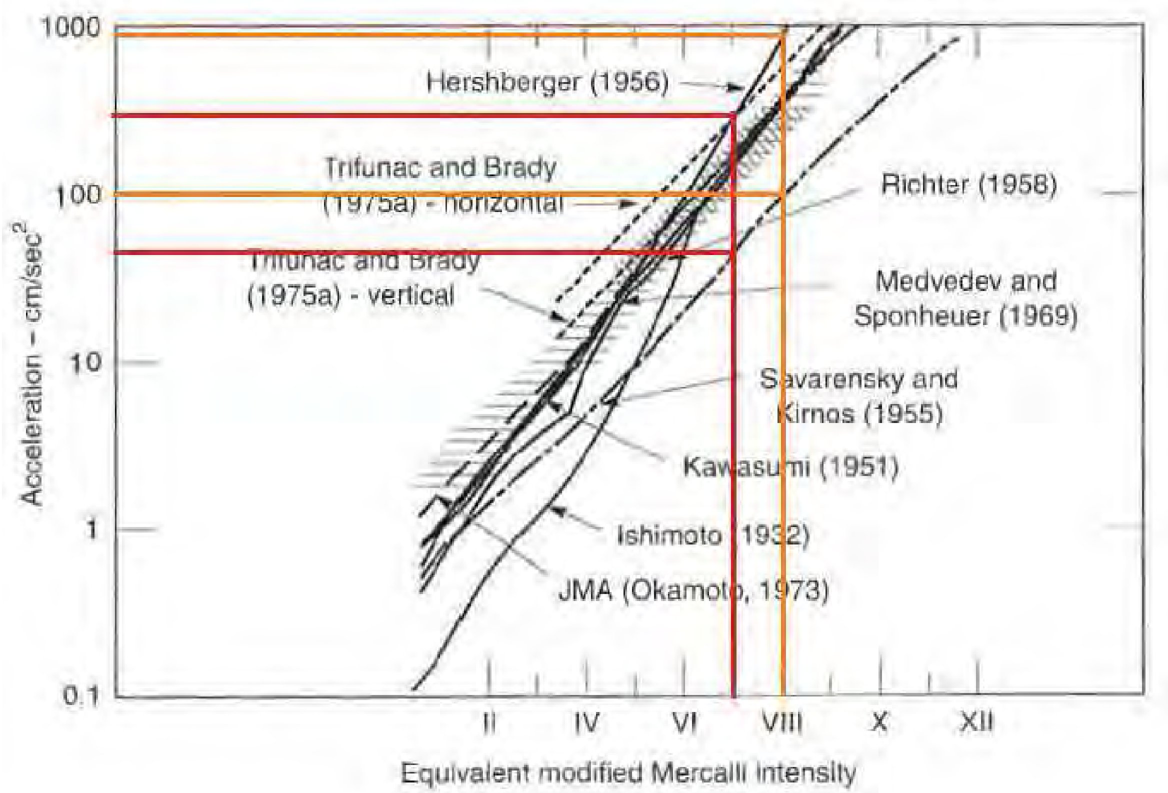
It should be noted that the above MMI and PGA values are applicable to the wider Sarulla region as the world hazard map is not of sufficient detail to define PGA of specific sites.

Figure 7.2: Natural Hazard Risks map for Indonesia.



Source: OCHA Regional Office for Asia Pacific (2011).

Figure 7.3: Proposed relationships between PGA and MMI



Source: Trifunac and Brady (1975), Kramer, (1996).

Table 7.1 and Table 7.2 presents the relationship between the earthquake intensity scale and peak ground acceleration associated with each scale. However it should be noted that these relations are approximate.

Table 7.1: Earthquake intensity scale

Earthquake intensity Modified Mercalli scale	Abbreviated Definition
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls

Earthquake intensity Modified Mercalli scale	Abbreviated Definition
	make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

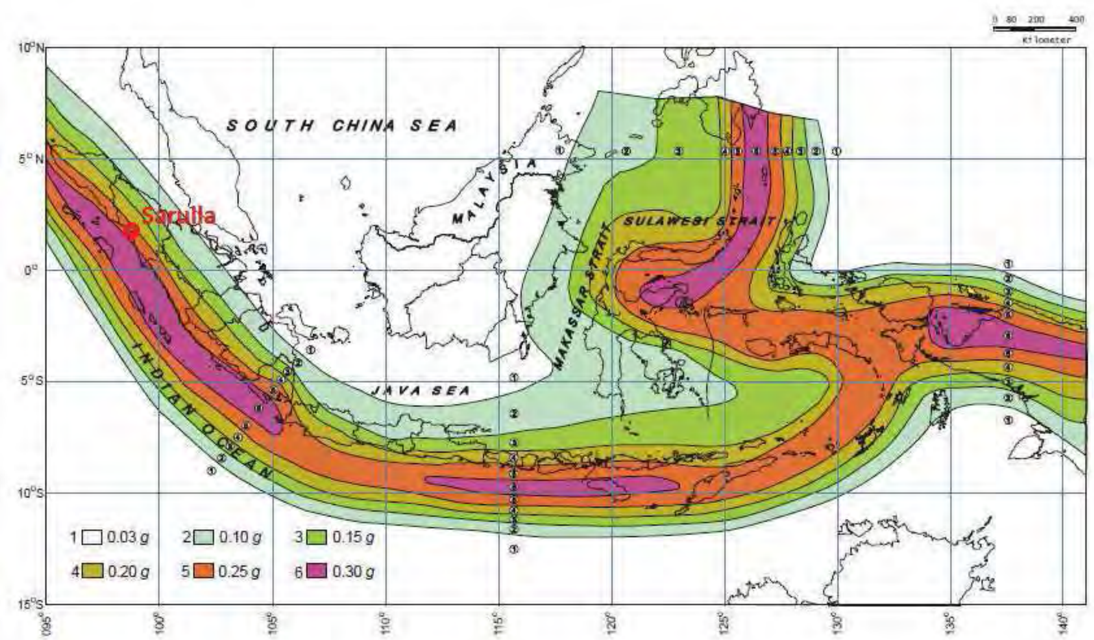
Table 7.2: Relation between PGA and MMI

MMI	PGA
IV	0.03 and below
V	0.03-0.08
VI	0.08-0.15
VII	0.15-0.25
VIII	0.25-0.45
IX	0.45-0.60

7.1.3 Indonesian Design Code (SNI 03-1726-2002)

The Indonesian Design Code defines Seismic Zones across the country as shown in Figure 7.4. The Indonesian seismic zones are defined according to base rock peak acceleration for a return period of 475 years. Sarulla lies within Seismic Zone 5 and has a PGA at bedrock of 0.25g for a 475 year return period.

Figure 7.4: Indonesian Hazard Map of PGA at bedrock for 500yr return period.



Source: Indonesian National Standard (SNI 03-1726-2002).

7.2 Site Specific Seismic Hazard Studies for Sumatra

Currently, three earthquake hazard maps have been issued for Indonesia by the Department of Public Works. The first concerns peak ground acceleration at bedrock for 475years return period in the Indonesian Earthquake Code, the second is a hazard map for designing waterworks and the third is used for designing bridges and road constructions. Some of the performed studies for producing a hazard map in locations close to the Sarulla power plant are provided in Table 7.3.

Table 7.3: Seismic hazard studies performed for Indonesia

Study	Location	PGA		0.2sec spectral acceleration		1sec spectral acceleration		Details
		Probability 2% in 50 yrs (2475yrs return period)	Probability 10% in 50 yrs (475yrs return period)	Probability 2% in 50 yrs (2475yrs return period)	Probability 10% in 50 yrs (475yrs return period)	Probability 2% in 50 yrs (2475yrs return period)	Probability 10% in 50 yrs (475yrs return period)	
Asrurufak et al. (2010)	Sarulla picked from a general map for Indonesia	1.2-1.5g	N/A	2.0-3.0g	N/A	1.0-1.2g	N/A	-Total probability method and 3D source models with recent seismotectonic parameters were used. -Results significantly higher than the Indonesian code SNI 03-1726-2002. -Increased values are attributed to the used input parameters and the use of a 3D earthquake source model.
Putra et al. (2012)	Banda Aceh city	N/A	0.3g (rock) 0.5g (medium) 0.7g (soft)	N/A	0.4g (rock) 1.2g (medium) 1.8g (soft)	N/A	0.25g (rock) 0.8g (medium) 1.8g (soft)	-Probability 10% in 50yrs (475yrs return period). -Used 48000 events with M>4
Irsyam et al. (2008)	Sarulla picked from a general map for Sumatra	0.8-0.9g	0.5-0.6g	N/A	1.0-1.2g	N/A	0.5-0.6g	-Used 3D source model (fault source model) and recent tectonic setting of Sumatra.
Petersen et al. (2004)	Sarulla picked from a	1.0-1.2g	0.25-0.3g	N/A	N/A	N/A	N/A	-Used 4 source zones and 2 major faults at the

Study	Location	PGA		0.2sec spectral acceleration		1sec spectral acceleration		Details
		Probabi-lity 2% in 50 yrs (2475yrs return period)	Probabi-lity 10% in 50 yrs (475yrs return period)	Probabi-lity 2% in 50 yrs (2475yrs return period)	Probabi-lity 10% in 50 yrs (475yrs return period)	Probability 2% in 50 yrs (2475yrs return period)	Probability 10% in 50 yrs (475yrs return period)	
	general map for Sumatra							area. Same procedures with the US National Seismic Hazard Maps.

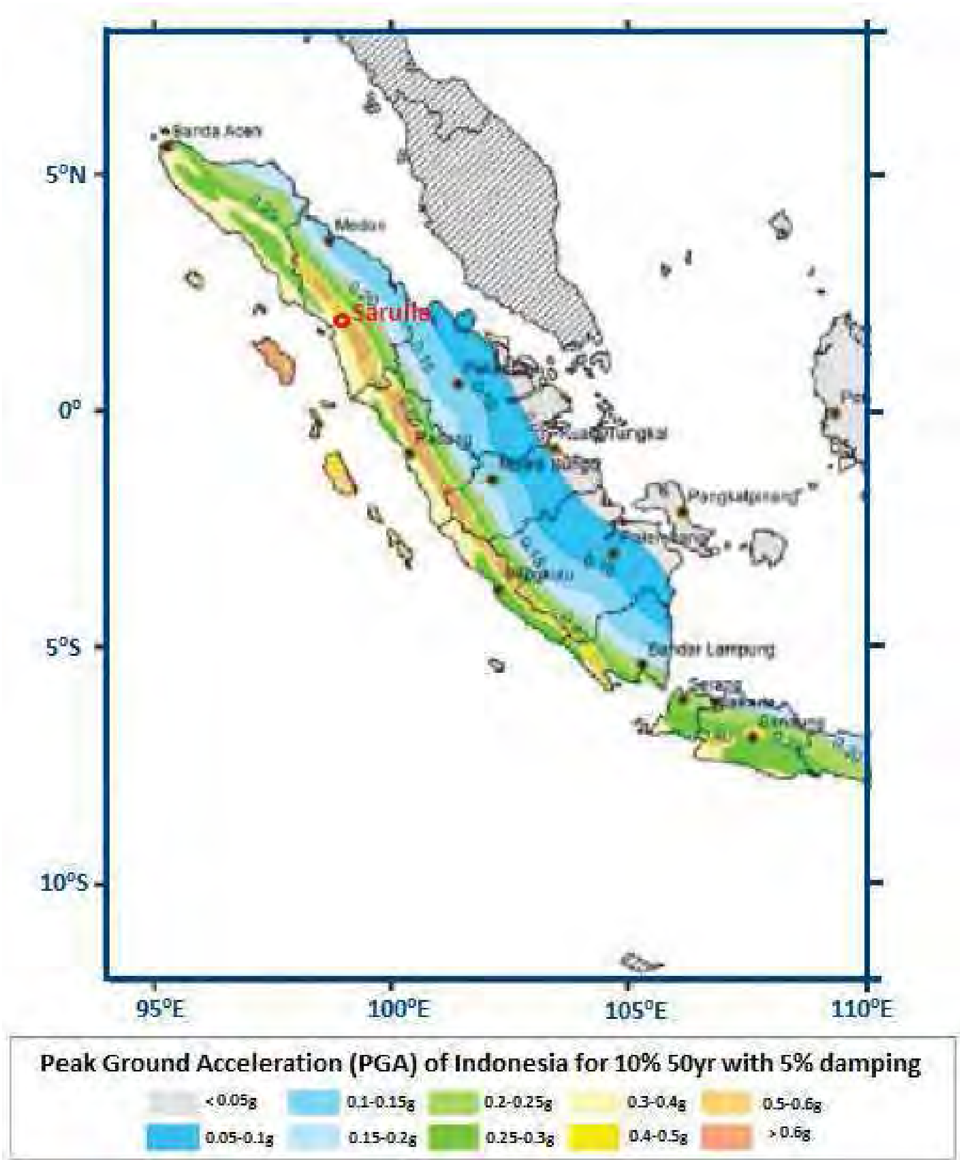
It can be seen that the Indonesian seismic code provides values for peak ground acceleration which can be considered unconservative compared to other specific studies. The map for PGA at bedrock in the SNI 03-1726-2002 (Figure 7.4) was developed by averaging values from four seismic hazard maps developed by four different research groups in Indonesia. These seismic hazard map were developed using total probability theorem and by applying area sources model. This 2-dimension (2-D) model has some limitations in modeling the fault source geometries. Thus it is recommended that the revised maps should be used for design. The PGA in the region is likely to be in the range of 0.5 to 0.6g.

7.3 Improvements to National Seismic Code

The need to revised current Indonesian Seismic Hazard Map contained in Indonesian Earthquake Resistant Building Code SNI 03-1726-2002 which partially adopting the concept of UBC 1997, was driven among others by the desire to better reflect the potential larger earthquake disasters faced by the nation predictably in the future. The much larger than maximum predicted Aceh Earthquake (Mw9.0-9.3) of 2004, followed by the fast destructions observed during 2005 Nias Earthquake (Mw 8.7) urgently underline to need to consider the new conceptual approach and technological shift shown in the transition of UBC 1997 to IBC 2006.

The 2002 hazard map has recently been revised by the Team for Revision of Seismic Hazard Maps of Indonesia as part of a collaborative effort between numerous Government of Indonesia agencies (Ministry of Public Works, Indonesian National Disaster Management Agency [BNPB], BNKG, and others) and external donors, notably the Australia-Indonesia Facility for Disaster Reduction (AIFDR). The PSHA generated three PGA contour maps at 10 and 2 percent probability of exceedance in 50 years and the 10 percent probability of exceedance in 100 years. The mapping effort has a high degree of spatial specificity, reflecting the detailed knowledge of faulting in the better-studied areas. In addition, the methods and models used in the analysis are transparent and well documented. Seismic sources were modeled by background, fault, and subduction zones by considering truncated exponential model, pure characteristic model or both models. Logic tree method was performed to account for the epistemic uncertainty and several attenuations functions were selected. Maps of PGA and spectral accelerations for short period (0.2 sec) and for 1-second period were then developed using probabilistic approach. The maps have been proposed as a revision for the current seismic hazard map in Indonesian Seismic Building Code (Irsyam et al., 2010). It is recommended that for the current project these maps (Figure 7.5) should be used for design. Sarulla lies in zone with peak ground acceleration PGA=0.5-0.6g in bedrock for 10% probability of excedance in 50yrs with 5% damping.

Figure 7.5: Sarulla contract area in the latest hazard map for Indonesia.



Source: Asrurifak, M. et al. 2010

8 Seismic Design Requirements

In this section the seismic design requirements are evaluated. A response spectrum is provided based on the Indonesian Seismic Code. However it is recommended that the project consider using the IBC (International Building Code, 2012) in line with the International Best Practice.

8.1 Indonesian Seismic Code

A peak bedrock acceleration of 0.25g has been estimated for the Sarulla region (see section 0) and the soil has been classified as Medium Soil (SNI 03-1726-2002), although at some locations the soil is classified as Medium to Hard Soil. Using the Indonesian National Standard for earthquake resistance the peak acceleration of surface soil, A_o, can be determined using Table 8.1 (re-produced from SNI 03-1726-2002). For the Sarulla region an estimated value of A_o=0.32g is obtained. For some areas close to the plant location where the soil is Hard, the value of A_o is estimated as A_o=0.28g.

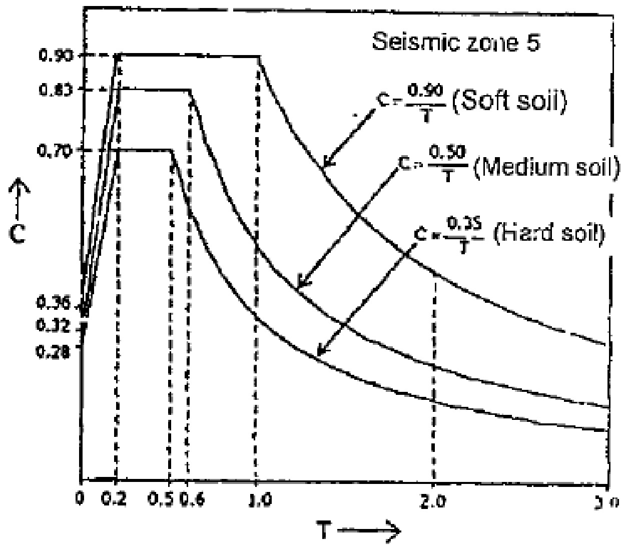
Table 8.1: Peak acceleration of base rock and peak acceleration of soil surface for each Indonesian Seismic Zone.

Seismic zone	Peak acceleration of base rock (g)	Peak acceleration of soil surface A_o (g)			
		Hard Soil	Medium Soil	Soft Soil	Special Soil
1	0.03	0.04	0.05	0.08	Requires special evaluation at each location
2	0.10	0.12	0.15	0.20	
3	0.15	0.18	0.23	0.30	
4	0.20	0.24	0.28	0.34	
5	0.25	0.28	0.32	0.36	
6	0.30	0.33	0.36	0.38	

Source: SNI 03-1726-2002

The Indonesian National Standard for earthquake resistance recommends deriving the Design Earthquake Response Spectrum for soils within Seismic Zone 5 based on the soil type as illustrated in Figure 8.1.

Figure 8.1: Design Earthquake Response Spectrum



Source: SNI 03-1726-2002

The maximum response acceleration (A_m) and corner natural frequency (T_c) are defined by Equation 1 and Equation 2, respectively.

Equation 1: $A_m = 2.5\ A_o$

Equation 2: $T_c = 0.6$ sec (Medium Soil) $T_c = 0.5$ sec (Hard Soil)

The Earthquake Response Factor (C) is defined by Equation 3 and Equation 4.

Equation 3: $C = A_m$ (For $T \leq T_c$)

Equation 4: $C = A_r / T$ (For $T > T_c$)

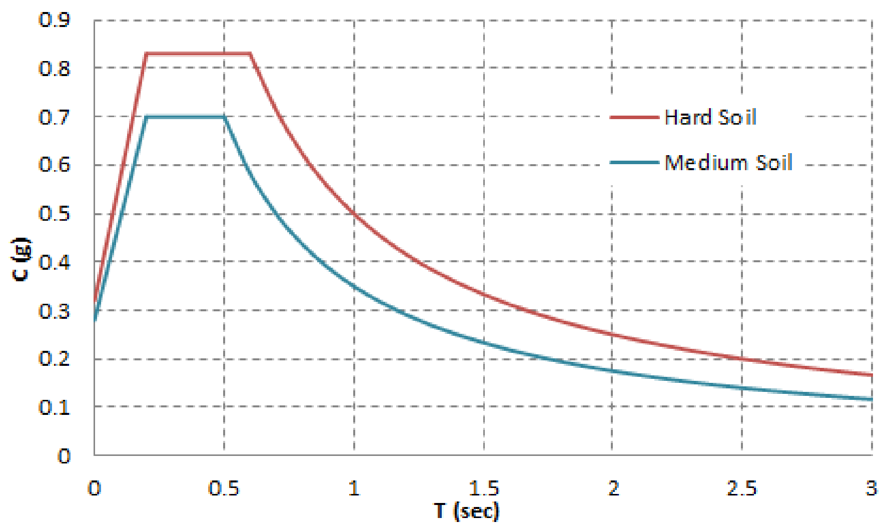
Where A_r is given by Equation 5:

Equation 5: $A_r = A_m \cdot T_c$

Where A_m = maximum response acceleration (g), A_o = peak acceleration of the soil surface (g), T_c = corner natural frequency period (sec) C = Earthquake Response Factor, T = natural frequency period (sec), A_r = response acceleration (g).

For Medium Soil in Seismic Zone 5, values of A_m=0.83g and A_r=0.50g can be determined. For Hard Soil in Seismic Zone 5, A_m=0.7g and A_r=0.35g. The design response spectra for Medium and Hard Soils derived based on the equations above are given in Figure 8.2. The Indonesian code design requirements refer to 475 years return period.

Figure 8.2: Design Earthquake response Spectra for Medium and Hard soils in Seismic Zone 5 in accordance with the Indonesian National Standard earthquake resistance.



Source: SNI 03-1726-2002

8.2 Design according to Eurocode 8

According to Eurocode 8 the Sarulla region is typically classified as Ground Type C (See section 5.2 and EC8 Table 3.1: Ground Types, BS EN 1998-1:2004+A1:2013). The earthquake motion at a given point on the surface is represented by an elastic ground acceleration response spectra. This is defined using Equation 6 to Equation 9, below.

Equation 6: $S_e(T) = a_g \cdot S \cdot [1 + (T/T_B) \cdot (2.5 \cdot \eta - 1)]$ $\quad 0 \le T \le T_B$

Equation 7: $S_e(T) = a_g \cdot S \cdot 2.5 \cdot \eta$ $\quad T_B \le T \le T_C$

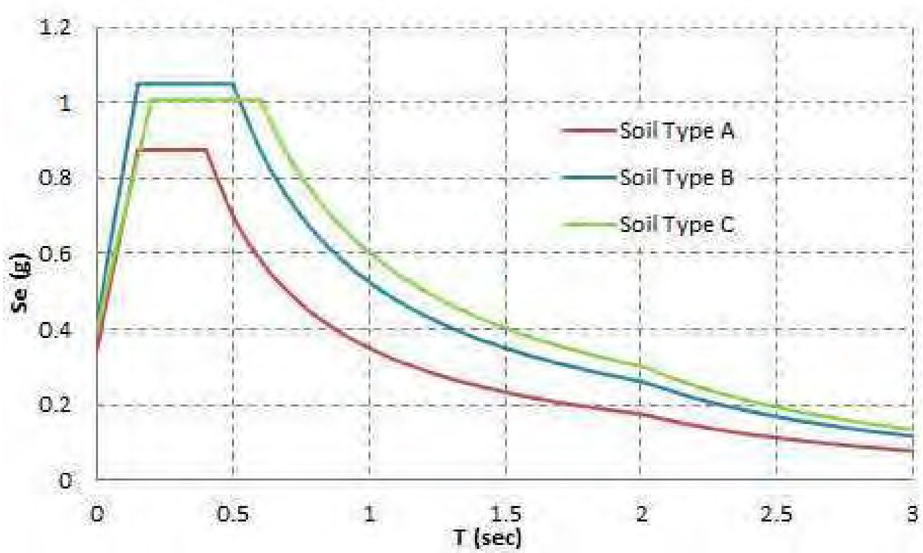
Equation 8: $S_e(T) = a_g \cdot S \cdot 2.5 \cdot \eta \cdot [T_C / T]$ $\quad T_C \le T \le T_D$

Equation 9: $S_e(T) = a_g \cdot S \cdot 2.5\eta \cdot [T_C \cdot T_D / T^2]$ $\quad T_D \le T \le 4s$

Where: $S_e(T)$ = elastic response spectrum, T = vibration period, a_g = design ground acceleration, T_B = lower limit for constant spectral acceleration branch, T_C = upper limit for constant spectral acceleration branch, T_D = value for defining the beginning of constant displacement response range of the spectrum, S = soil factor, η = damping correction factor.

The EC8 response spectra are provided in Figure 8.3. Eurocode spectra acceleration values are larger than the Indonesian code ones. For the purpose of this study the Design Earthquake Response Spectra given by the Indonesian National Standard for Earthquake Resistance will be adopted. The Eurocode 8 design requirements refer to 475 years return period.

Figure 8.3: Eurocode 8 Design Response Spectra.



Source: BS EN 1998-1:2004

9 Other Earthquake Induced Hazards

In this section other seismic related hazards are discussed.

9.1 Liquefaction

Liquefaction is defined as the temporary loss of strength of saturated soil, due to cyclic loading and builds up of pore water pressures. Typically, poorly graded loose granular deposits with low fines content are most susceptible to liquefaction.

9.1.1 Liquefaction Susceptibility

Liquefaction does not occur at random, but is restricted to certain geological and hydrological environments, primarily recently deposited sands and silts in areas with high ground water levels. Dense and more clayey soils, including well compacted fills have low susceptibility to liquefaction.

The liquefaction process itself may not necessarily be particularly damaging or hazardous. For engineering purposes, it is not the occurrence of liquefaction that is of importance, but the capability of the process and associated hazards to cause damage to structures. The adverse effects of liquefaction can be summarised as follows:

- Flow failures - completely liquefied soil or blocks of intact material ride on a layer of liquefied soil. Flows can be large and develop on moderate to steep slopes.
- Lateral spreads - involve lateral displacement of superficial blocks of soil as a result of liquefaction of a subsurface layer. Spreads generally develop on gentle slopes and move toward a free face such as an incised river channel or coastline.
- Ground oscillation - where the ground is flat or the slope too gentle to allow lateral displacement, liquefaction at depth may disconnect overlying soils from the underlying ground, allowing the upper soil to oscillate back and forth in the form of ground waves. These oscillations are usually accompanied by ground fissures and fracture of rigid structures such as pavements and pipelines.
- Loss or reduction in bearing capacity - liquefaction is induced when earthquake shaking increases pore water pressures, which in turn causes the soil to lose its strength and hence bearing capacity.

9.1.2 Geological Criteria

The depositional environment, hydrological environment and age of a soil deposit all contribute to its liquefaction susceptibility (Youd and Hoose, 1977). Liquefaction only occurs in saturated soils, so the depth to groundwater is also important.

Geological processes which sort soils into uniform grain size distributions and deposit them in a loose state are all susceptible to liquefaction. Hence alluvial and Aeolian deposits are likely to be susceptible.

The susceptibility of older soil deposits to liquefaction is generally lower than for newer deposits. Soils of Holocene age (< 10,000 years old) are more susceptible than soils of Pleistocene age (10,000 years to 2.5 million years old). Liquefaction of pre-Pleistocene deposits is rare.

According to the borehole results at SIL and NIL locations (Figure 5.2 and Figure 5.3, N – SPT values are high at depths below 12m. Soil is described as silty clay, clayey silt and clayey sandy silt which need to be investigated further according to the fines contents in order to determine liquefaction risk. Moreover, below those formations and at depths between 10-12m, soil is described as silty sand and has low N-SPT values thus it is more prone to liquefaction during an earthquake. Liquefaction assessment is proposed for the area by using the laboratory test Plasticity Index results and most up to date liquefaction assessment techniques (like Idriss and Boulanger, 2008) in order to estimate the possible liquefaction hazard.

9.2 Volcanic risk due to seismic activity

The position of the Sumatra fault zone and the volcanic arc are similar and it is possible that the location and geometry of the Sumatran fault system is controlled by the position of the volcanic arc. Within Sarulla area volcanic centres lie within a few kilometres from the SFS and the fault system may control the position of these volcanic centres. There is a strong suggestion that volcanic features are localised at steps between faults, fault intersections or fault tips. While there were numerous Quaternary volcanic centres in the Sarulla contract area, no active volcanos have been recorded after the most recent eruption at Toba Caldera occurred 74000 years ago. However, the volcanic hazard may be considered for the plant design.

9.3 Landslides & Slope Stability

Seismic slope stability is usually performed using a pseudostatic analysis, but results from a pseudostatic analysis can be somewhat misleading. Better approximations of seismic slope stability can be calculated using finite element analyses that compute the displacement due to seismic slope failure.

The current method suggested by the designers relies on using a pseudo static coefficient for the slope stability analysis. Generally pseudo statistic coefficient is taken as half of the maximum peak ground accelerations and thus this value will be in the range of 0.4g. This method is conservative as it relies on the use of a single parameter for the whole duration of the earthquake. In the absence of a dramatic loss of strength, this method yields excessively conservative results since the peak acceleration acts only momentarily in one direction.

Important clues about the performance of slopes in seismic conditions can be obtained from case histories from past earthquakes. Pacoima Dam is a 113m high concrete arch dam located north of the city of Los Angeles. A well-known ground motion record obtained above the south abutment during the 1971 San Fernando earthquake showed large accelerations of 1.25g horizontal and 0.70g vertical which have been attributed to topographical amplification. This dam was also shaken by the 17 January 1994 Northridge Earthquake of M 6.8. Despite being subjected to high accelerations, the arch dam survived the Northridge earthquake well with the main damage being an opening of the contraction joint between the arch dam and the thrust block at the left abutment of approximately 50mm (2 inches). This suggests that slopes can survive bigger magnitude events compared to the design events.

The method that we propose to use has been published in peer reviewed journal and is recommended by Rathje & Antonakos (2011). This method has been coded up in the following software SLAMMER. The program can be downloaded at http://pubs.usgs.gov/tm/12b1/. This program is designed to facilitate conducting sliding-block analysis (also called permanent-deformation analysis) of slopes in order to estimate slope behavior during earthquakes.

It is believed that this approach would reduce the reliance on the PGA and make it possible to design cheaper remedial works. Slope stability remedial work can be carried out by EPC contractor after the contract is awarded, prior to construction.

9.4 Ground Subsidence

As described in section 4.2, stream offsets are evident in Sarulla contract area and there is topographic evidence of recent fault movements. Since there are pull apart basins in the area a possible uplift hazard is expected. Also, land use around Tarutung-Sepirok can be divided into four zones referring to the ground movement. GPS monitoring at Sumatra imply stress accumulation that is released by earthquake events in the area. As a result, both vertical and horizontal movements are expected around the plant location.

9.5 Increased seismic activity

The optimal regions for geothermal energy production and areas of high seismic activity often coincide. Further, it is purported that the pumping of water through subterranean regions subjects the rocks to cyclic heating and cooling. Fatigue and eventual fracturing of the rock can lead to weakness' developing, and hence potentially induce earthquakes from nearby fault lines.

The Swiss government and Geothermal Explorers International both believe that a 3.4 magnitude earthquake in Basel, Switzerland which occurred in 2006 was due to the nearby presence of an Enhanced Geothermal System,(Majer et al. 2007). (EGS systems intentionally fracture rocks deep below the surface to allow easier access to reservoirs).

The U.S. Department of Energy published the "Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems". The protocol offers a summary of international efforts to understand the risk of induced seismicity, and offers steps on minimising the risk in terms of preliminary screening, monitoring and analysis of a prospective project. The conclusion states "although the risks associated with induced seismicity in EGS projects are relatively low, it is nevertheless prudent to consider that some type of mitigation may be needed at some point during the project".

It should be noted that research into geothermal power plants and significant increases of seismic activity has only started relatively recently. The protocol states it is a suitable ‘advisory document’ to assist both industry and regulators, but that local or state regulations must be preferentially followed. Nevertheless, the key issues outlined by the protocol provide a framework for making formal assessments, and the more technical advice summarised below.

- Preliminary screening evaluation: Sufficient detail to be technically credible, major impacts should be identified and plans moving forward made. Focus should be on ground motion, damage and/or nuisance.
- Evaluate current noise and ground vibration levels, and judge future impacts against baseline specific to the site.

- On-going collection of local seismic data allows for comparisons to baselines before geothermal operations began, managing current operations and predicting future activity.

Natural seismicity in the area should be quantified and a baseline hazard analysis should be conducted. The hazard from induced seismicity should be estimated. For example the Shapiro et al (2007) or McGarr (1976) models can be used. The development of induced seismicity models is still currently an active area of research. Accounting for the injection properties and site specific lithography is critical

It should be noted that Microearthquake monitoring was performed in 1996 during the two flow tests in SIL by using a 6 station digital array for a period of 70 days. The monitoring has shown that a significant number of microearthquakes are induced by injection at SIL. The rate of seismicity is increased at the start of the injection but decreases with time. Significant differences of the patterns and depths of seismicity were observed between the two injection wells, since seismicity of well SIL1-1 had average depths of 1000 meters below surface while at well SIL2-1 the depths were 4000 meters below surface.

10 Conclusions & Recommendations

10.1 Conclusions

A desk based seismic hazard study was performed for the site. In conclusion the project can proceed as designed currently provided additional fault trenching activities are carried out before detailed design phase and facilities in the vicinity of the rupture zone are designed to accommodate the possible predicted movement.

The key conclusions can be summarised as

- The area is located in a complex tectonic regime. It is likely to be affected by near source earthquakes. This implies that seismic design should be incorporated in all the structures built within the power plant site. This risk can be mitigated by the EPC Contractor following the latest international seismic design codes and the updated version of the local seismic code.
- The area is located within the vicinity of the Sumatra fault system (SFS) which forms a zone up to 10km wide along the length of the study area. One active strand of the fault, the Tor Shibohi Fault (TSF) extends along the entire distance and in exposed in the northern limit of the contract area. Comprehensive fault identification activities have been performed in previous investigations in the site to understand the potential of future rupture of the faults. This has mitigated the risks to a certain extent and additional fault trenching activity is recommended for the next stage.
- An extensive fracture zone has been identified in the plant locations. The effect of this fracture zone on the performance of the substructure infrastructure needs to be assessed carefully. This may involve additional analyses of facilities located in this zone.
- The U.S. Geological Survey (USGS) global shear-wave velocity maps web application (USGS, 2010) has been used for obtaining a first-order estimate of the average shear-wave velocity values over the top 30meters of ground ($V_{s,30}$). According to the USGS web tool, within the North Sumatra region$V_{s,30}$ values range from 360-490m/sec and raise up to >760m/sec at some areas. This implies that correct seismic spectra as proposed in the report should be used for design.
- The Indonesian Seismic Design Code follows site classification based on the following generic site classes: Based on the Indonesian Seismic Design Code and using the $V_{s,30}$ values estimated from the soil around Sarulla region would be classified as “Hard soil”.
- The geotechnical information in the site was critically reviewed. The weighted average of the SPT values indicates that the seismic site class should be classified as ‘Medium soil’ based on Indonesian seismic code. Site class C should be used for Eurocode site classification.
- A historical and instrumental earthquake catalogue was developed for the area around the Sarulla region. In the last ten years there has been an average of about 45 events between magnitude 4-6 and approximately very few events greater than 6 to 8 in the last ten years in the vicinity of the site

area. The biggest event is a 6.8 event magnitude with its epicentre located at 200km SW from the proposed plant.

- Review of regional seismic hazard maps show that the peak ground acceleration for the rock site in the Sarulla region vary between 0.33g to 0.25g.

- The Indonesian seismic code provides values for peak ground acceleration which can be considered unconservative compared to other specific studies. The map for PGA at bedrock in the SNI 03-1726-2002 (Figure 7.4) was developed by averaging values from four seismic hazard maps developed by four different research groups in Indonesia. Thus it is recommended that the revised maps should be used for design (Asrurifak, M. et al. 2010). The PGA in the region is likely to be in the range of 0.5 to 0.6g.

- Liquefaction risk cannot be eliminated completely. Liquefaction assessment from geological criteria cannot eliminate the risk completely as the expected peak ground acceleration is high. This should be mitigated by further analysis by the EPC contractor.

- There is pronounced fault activity in the area since imminent vertical and horizontal movements are studied and Tor Sibohi fault is described as active by Hickman et al. (2004). Slip partitioning and subduction of Indian Ocean lithosphere produce high levels of seismicity in the Barisan Mountains, in the forearc basin and along the forearc ridge. The potential for extremely destructive earthquakes was most recently demonstrated by the Magnitude 9 event near Simeule in December 2004 and a future earthquake hazard is considered as possible for the plant area.

- The current method suggested by the designers relies on using a pseudo static coefficient for the slope stability analysis. This method is extremely conservative for high values of acceleration.

- The risk due to lateral spreading is considered minimal as wide scale liquefaction is not envisaged in the current site.

10.2 Recommendations

Based on the available information while performing this seismic desk study some seismic risks have been identified. It is recommended that these risks are mitigated in the following manner

- According to previous studies faults GNZ1 to GNZ4 cross the SIL plant plan while fault GNZ5 and the fracture zones are very close to the plant location. Potentially faults GNZ1 to GNZ4 are not active but fault GNZ5 and fracture zone are potentially active. It is noted that Fault No. GNZ5 is outside the footprint of the current SIL plant area. It is recommended that further field trenches need to be performed in order to test those faults activity prior to construction. Further field investigations should be accompanied by related studies during detailed design. This may include

- Interpretation of large-scale stereo aerial photographs and/or LiDAR imagery of the site and surrounding areas;
- Tectonic geologic and geomorphic field mapping of the area surrounding the site (± 3 km radius);
- Radiometric dating, where possible, of soil and organic materials collected from natural or manmade exposures with clear association to the faults mapped or inferred within the SIL site; and
- Reference studies of the nearby Sumatran fault where its location and rate of Holocene activity are well constrained.

- The use of International Building code (IBC) is recommended in the design for those cases where the local seismic code is unconservative. However it is acknowledged that the Uniform Building Code (UBC) is still used in several countries outside the US and can be used for elements of the seismic design.
- Monitoring of micro tremoring activities should be continued in order to associate the relation with induced seismicity and injection of fluids in the wells.
- It is reminded that detailed liquefaction assessment should be carried out for the area by using the laboratory test Plasticity Index results and internationally accepted liquefaction assessment techniques (like Idriss and Boulanger, 2008) in order to estimate the possible liquefaction hazard by the EPC contractor. If liquefaction is deemed to be a problem then the EPC contractor should consider proper mitigation measures as mentioned in Table 10.1 for the plant design.
- It is reminded that the seismic slope stability assessments should be performed by the EPC contractor during detailed plant design. Slope stability remedial work can be carried out by EPC contractor after the contract is awarded, prior to construction. It is recommended that such analysis should possibly be based on displacement based methods.

Table 10.1 presents the mitigation options for various hazards identified in the studies so far. In conclusion the project can proceed as designed currently provided additional fault trenching activities are carried out before detailed design phase prior to construction and facilities in the vicinity of the rupture zone are designed to accommodate the possible predicted movement.

Table 10.1: Mitigation options for various hazards

Hazard	Effect on Ground	Effect on Facilities	Possible mitigation options
Possible Fault movement	Ground disturbances vertically and horizontally over a zone depends on	Upheaval, tearing apart, movement of foundations, severe damage to structures	Verify by fault trenching and other methods detailed Assess impact on

Hazard	Effect on Ground	Effect on Facilities	Possible mitigation options
	depth to rock below surface. Cracks in land surface.	which cross the fault.	infrastructure. Recommend that fault trenching is carried out in sufficient time to enable the designer to address any possible fault activity within the design. To be monitored by the Lender. Options: a) incorporate special strengthening and accommodate movement in design b) provide weak links or special isolation to limit damage
Ground shaking	Violent horizontal and vertical motions for up to one minute duration.	Cracking, fracture, collapse of buildings. Breaks in underground services. Deformation of surface infrastructure.	Assess impact. Follow Seismic code recommendations. This needs to be included within the EPC Contract and EPC Contractor to incorporate in the design. To be monitored by the Lender. Options: a) comply with current codes for design and construction b) incorporate strength and resilience c) secure vulnerable parts and contents
Liquefaction	Shaking causes some soils to behave like liquid, causing loss of support to structures above. Such soils maybe up to 10m below ground surface. Lateral movement of large soil masses, especially adjacent to rivers. Variable subsidence of ground surface.	Sinking and tilting of structures supported on liquefied material. Severe damage to underground services. Flotation of empty underground tanks and chambers.	Verify through detailed analysis by the EPC contractor. Assess impact of liquefaction on well lining. These exercises can be stipulated as being a requirement within the EPC Contract document. EPC Contractor to design out solution and implement within an early works package. To be monitored by the Lender.

Hazard	Effect on Ground	Effect on Facilities	Possible mitigation options
			Options: a) compact ground at site b) install piles and gravel drains c) drain liquefiable layers
Slope failure	A significant soil masses moves bodily down the slope, from few hundred millimetres to many metres. Landslides occur at many different locations	Ranges from deformation of foundations and structural failures to total destruction of site and all buildings and infrastructure above and below ground.	Verify through detailed analysis by EPC contractor. Assess impact of movement on slopes. These exercises can be stipulated as being a requirement within the EPC Contract document. EPC Contractor to design out solution and implement within an early works package. To be monitored by the Lender. Options: a) stabilise slope retaining walls b) stabilise slope – ground anchors c) improve drainage, reduce erosion

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11 References

Asrurifak, M., Irsyam, M., Budiono, B., Triyoso, W. and Hendriyawan (2010). *Development of Spectral Hazard Map for Indonesia with a Return Period of 2500 Years using Probabilistic Method*. Civil Engineering Dimension, Vol. 12, No. 1, March 2010, 52-62 ISSN 1410-9530 print / ISSN 1979-570X online

Asrurifak M., Irsyam M., Budiono B., Triyoso W. and Hendriyawan (2010). *Development of Spectral Hazard Map for Indonesia with Return Period of 2500 Years using Probabilistic Method*. Civil Engineering Dimension, Vol.12, No.1, pp.52-62.

Aspden J.A., Stephenson B., Cameron N.R. (1982a). *Tectonic Map of Northern Sumatra (1:1500000).* Directorate of Overseas Surveys, Keyworth.

Aspden J.A., Kartawa W., Aldiss D.TY., Djunuddin A., Whandoyo R., Diatma D., Clarke M.C.G. and Harahap H (1982b). *The Geology of the Padangsidempuan and Sibolga Quadrangles (0617 and 0717), Sumatra. Scale 1:250000.* Geological Survey of Indonesia, Directorate of Mineral Resources, Geological Research and Development Centre, Bandung.

Barber A.J., Crow M.J. and Milsom J.S (2005). *Sumatra: Geology, Resources and Tectonic Evolution*, Geological Society Memoir No.31.

Cameron N.R., Clarke M.C.G., Aldiss D.T., Aspden J.A. and Djunuddin A. (1980). The geological evolution of northern Sumatra. In: Indonesian Petroleum Assossiation, Proceedings of the 9th Annual Convention, Jakarta, Vol.9, pp.149-187.

Environmental Impact Statement, ANDAL (2009), *Development of Sarulla Geothermal Field and Power Plant of 330MW Capacity, North Tapanuli Regency, North Sumatera Province*. Chapters 3 and 5.

EPC Technical Specification (2008), TOR Part1 and TOR Part2-01_A.

Eurocode 8: Design of structures for earthquake resistance – Part 1: General rules seismic actions and rules for buildings.

Fauzi, McCaffrey R., Wark D., Sunaryo and Haryad Prih R.Y. (1996). *Lateral variations in slab orientation beneath Toba caldera, northern Sumatra*. Geophysical Research Letters, Vol.23, pp.443-446.

Gunderson R., Dobson P.F., Sharp W.D., Pudjianto R. and Hasibuan A. (1995). *Geology and Thermal Features of the Sarulla Contract Area, North Sumatra, Indonesia*, World Geothermal Congress.

Hanumantharao C. and Ramana G.V. (2008). *Dynamic soil properties for microzonation of Delhi, India*. Journal of Earth Syst. Sci., Vol.117, S2, PP.719-730.

Hickman R.G., Dobson P.F., Gerven M., Sagala B.D. and Gunderson R.P. (2004). *Tectonic and stratigraphic evolution of the Sarulla graben geothermal area, North Sumatra, Indonesia*. Journal of Asian Sciences, Vol.23, pp.435-448.

Idriss I.M. and Boulanger R.W. (2008). *Soil Liquefaction during earthquakes*. Earthquake Engineering Research Institute.

Indonesia: Natural Hazard Risks (2011), OCHA Regional Office for Asia Pacific.

Irsyam M., Dangkua D.T., Hendriyawan, Hoedajanto D., Hutapea B.M., Kertapati E.K., Boen T. and Petersen M.D. (2008). *Proposed seismic hazard maps of Sumatra and Java islands and microzonation study of Jakarta city, Indonesia*, Journal of Earth Syst. Sci., Vol.117, S2, pp.865-878.

Irsyam M. and Asrurifak M. (2010). *Development of Spectral Hazard Maps for Proposed Revision of Indonesia Seismic Building Code*. Geomechanic and Geoengineering International Journal, Vol.5, No.1, pp.35-47.

Kramer S. L. (1996), *Geotechnical Earthquake Engineering*, Prentice-Hall, New Jersey.

Majer EL., Baria R., Stark M., Oates S., Bommer J., Smith B. and Asanuma H. (2007), *Induced seismicity associated with enchanced geothermal systems*. Geothermics, Vol.36, pp.185-222.

Majer E.L. , Nelson J., Robertson-Tait A., Savy J. and Wong I. (2012). *Protocol for Addressing Induced Seismicity Associated eith Enchanced Geothermal Systems*, US Department of Energy, DOE/EE-0662.

McCarty A.J., Elders C.F. (1997). *Cenozoic deformation in Sumatra: oblique subduction and the development of the Sumatran Fault System*. In: Fraser A.J. and Matthews S.J. (eds) Petroleum Geology of Southeast Asia, Geological Society, London, Special Publications, Vol.126, pp.355-363.

National Geophysical Data Center/World Data Service (NGDC/WDS), Significant Earthquake Database, Boulder, CO, USA (Available at: http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=1&d=1).

Newcomb K.R. and McCann W.R. (1987). *Seismic history and seismotectonics of the Sunda arc*, Journal of Geophysical Research, Vol.92, pp.421-439.

NIL Project Resource Feasibility Report (1999) Tech. 1.2, Report No: SOL-DR-0001 R00 NIL

Petersen M.D., Hartzell S., Mueller C., Harmsen S., Frankel, A.D. and Rukstales K. (2004). *Probabilistic seismic hazard analysis for Sumatra, Indonesia and across the Southern Malaysian Peninsula*, U.S. Geological Survey, USGS-MS966, Box 25046, Denver, CO 80225, United States.

Putra R.R, Kiyono J., Ono Y., Parajuli H.R. (2012). *Seismic Hazard Analysis for Indonesia, Journal of Natural Disaster*, Vol.33, No.2, pp.59-70.

Sarulla Geothermal Project Due Dilligence Report (2004) Part 2, Report No: SOL-PLN-0005 R00 PLN-RFP

SIL Project Resource Feasibility Report (1996) Tech. 1.1, Report No: SOL-DR-0001 R00 SIL

Standar National Indonesia (Indonesian National Standard) (2002). SNI 03-1726-2002: Design method of earthquake resistance for buildings, Badan Standardisasi Nasional (BSN) (National Standardization Agency).

The U.S. Geological Survey (USGS), (2008). (USGS-NEIC, 2008) The Seismic Hazard of Western Indonesia maps information sheet.

The U.S. Geological Survey (USGS), (2010). Global shear-wave velocity maps web application, Website: http://earthquake.usgs.gov/hazards/apps/vs30/ [Last accessed July 2013]

World Map of Natural Hazards (2009), Muncheren Ruck, Munich Re Group.

Annex C

Flood Risk Assessment

Sarulla Geothermal Project

Flood Risk Assessment

September 2013

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Sarulla Geothermal Project

Flood Risk Assessment

September 2013

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Executive Summary

Objectives

Sarulla Operations Ltd has commissioned Mott MacDonald to undertake a flood risk assessment for the Sarulla Geothermal Project. The scope of this assessment includes:

- Estimating the magnitude of flow in a severe flood event for return periods of 1 in 100 and 1 in 500 years;
- Assessing the risk these flood flows could pose to the project site in relation to the site topography and levels;
- Considering the effects of climate change on extreme rainfall occurrence (from tropical storms/typhoons) and the subsequent implications on flood risk to the site.

Approach

A field visit to visually assess the potential flood risk to the sites was completed on 5 September 2013. An assessment of the site topography in relation to local watercourses was undertaken to inform this assessment. Meetings were held with local meteorological and hydrological authorities to identify and collect rainfall and flow data.

Based on annual maximum rainfall data for local rainfall stations flood flow estimates were derived for key locations using the US SCS Approach for the 1 in 100 year and 1 in 500 year return periods. Climate change projections were considered and incorporated into the assessment to derive equivalent return period flows for the 2060's. Hydraulic calculations were undertaken to derive flood levels for these key locations.

Conclusions

The main conclusions of this assessment is that there is a very low risk of flooding from the Batang Toru River to the Namora I Langitand (NIL) and Silangkitang (SIL) wellpad and power plant sites, with all calculated flood levels significantly below design levels both currently and in the future as a result of climate change.

The majority of the tributaries that pass close to the NIL and SIL sites also pose very low flood risk both currently and in the future as a result of climate change.

However, there are three small watercourses which pose some limited risk to the NIL Power Plant, SIL Power Plant and SIL 1 Wellpad. For the NIL and SIL Power Plants it will be necessary to undertake stream diversions to mitigate this risk and in the case of the SIL 1 Wellpad there is some limited risk from overland flow. In this case appropriate site drainage would mitigate this risk.

These drainage requirements should be considered as part of the site drainage design.

Various uncertainties exist in this type of assessment but the extent to which the sites are raised from these watercourses suggests that the uncertainties involved in the analysis would have little impact on the overall conclusions.

1 Introduction

Sarulla Operations Ltd has commissioned Mott MacDonald to undertake a flood risk assessment for the Sarulla Geothermal Project. This assessment includes consideration of the potential impacts of climate change over the project design lifespan.

1.1 Background

The Sarulla Geothermal plant is located south of Lake Toba in North Sumatra Province, Indonesia. The project area consists of two power plant sites, Namora I Langitand (NIL) and Silangkitang (SIL), which are approximately 15 km apart. Each site has its own power plant and a network of above-ground pipes that connect the extraction wellpads with the power plant and the reinjection wellpads.

Flooding is a regular phenomenon in low-lying areas of Indonesia and causes significant damage to property, agriculture and infrastructure. Flooding can pose a critical risk to infrastructure, in particular to the flood vulnerable equipment in the power plant and the wellheads and separator pads. Flood risks in Indonesia are likely to increase in the future due to the impacts of climate change.

1.2 Scope

The scope of this assignment is to conduct a flood risk assessment of the Sarulla project site. There are three parts to the assignment:

- Estimating the magnitude of flow in a severe flood event (return period of 100 and 500 years);
- Assessing the risk these flood flows could pose to the project site in relation to the site topography and levels;
- Consider the effects of climate change on extreme rainfall occurrence (from tropical storms/typhoons) and the subsequent implications on flood risk to the site.

It is noted that the scope specifically referred to the consideration of typhoons. Typhoons are mature tropical cyclones that develop in the northwestern part of the Pacific Ocean. The equivalent term for those that develop in the South Indian Ocean is ‘severe tropical cyclone’. It is also noted that tropical cyclones rarely form within 5° of the equator. Given the location of the site within this equatorial zone it has been assumed for the purposes of this assessment that this aspect of the scope should relate to the incidence of storm events that result in extreme rainfall, and not specifically tropical cyclones. Consideration of extreme rainfall events both currently and as a result of climate change is an integral part of the analysis adopted in this assessment.

1.3 Task Activities

As part of this flood risk assessment the following activities have been undertaken in order to address the project objectives:

- Preliminary site visit to assess the locations of watercourses and site topography in relation to the NiI and SIL sites;
- GIS assessment of catchment areas and river characteristics in the vicinity of the sites using supplied topographic information;
- Analysis of extreme rainfall data (annual maximum daily rainfall) and flow data to derive predicted flood flows;
- Estimation of flood magnitudes using the US SCS method;
- Extract basic channel and floodplain dimensions from available topographic information upstream and downstream of the site, and estimate roughness coefficients, so that basic hydraulic calculations can be made to estimate flood levels from the calculated flood flows;
- Sensitivity studies to review the potential impact of uncertainties in the data;
- Consideration of the regional effects of climate change on typhoon occurrence and rainfall in this part of Sumatra and impact on the flood flows and flood levels estimated as part of the study.

2 Data Collection

As part of the field visit meetings were arranged with the local meteorological and hydrological authorities to identify the availability of rainfall and flow data. This section summarises the data collected as part of the study.

2.1 Rainfall data

On 4 September 2013 a meeting was held with Badan Meteorologi, Klimatologi, dan Geofisika (Meteorological Department) in Medan in which available rainfall data was collected for raingauges in the vicinity of the project area. The data collected is summarised in Table 2.1 below. Locations of the rain gauges are approximations, as exact locations could not be determined. Four of the gauges are within or very close to the catchment, with the other two more distant (Simalungun to the east of Lake Toba and Sibolga close to the coast).

Table 2.1: Summary of Rainfall Gauges Record in Batang Toru Catchment

Rain Gauge	Coordinates Lat, Long (Decimal Degrees)	Elevation (m)	Period of Record Available
Simalungun	2.70, 98.93	1064	1997 - 2012
Tarutung	2.17, 98.96	300	2006 - 2012
Pahae Julu	1.93, 99.05	722	2006 - 2012
Pahae Jae	1.79, 99.12	595	2006 - 2012
Purba Tua	1.88, 98.96	881	2006 - 2012
Sibolga	1.55, 98.88	10	1974 - 2012

2.2 Hydrological data

On 3 September 2013 a meeting was held with Balai Wilayah Sungai Sumatera II (Hydrological Department) in Medan in which available river flow and level data was collected for a station on the Batung Toru. It was confirmed by this department that flooding is not considered a problem in the project area.

Table 2.2: Summary of Flow Gauging Stations Record in Batang Toru Basin

Gauging Station	River	Coordinates Lat, Long (Decimal Degrees)	Period of Record Available
Sipetang	Batang Toru River	1.76, 99.10	2007 - 2012

3 Site Visit

A field visit to visually assess the potential flood risk to the sites was completed on 5 September 2013. An assessment of the site topography in relation to local watercourses was undertaken. This section summarises the locations visited and an initial assessment of flood risk.

3.1 NIL Sites

The NIL sites lie in the Batung Toru river valley and are shown in Figure 3.1 in relation to the overall topography and local drainage network. Each location that was visited is discussed in the sections below.

3.1.1 Hamilton Bridge

The Batung Toru River was visited at the Hamilton Bridge which is the main access route to the NIL sites. Since the construction of the bridge in 1992 there have been no records of it being overtopped. Whilst there is likely to be some risk to surrounding rice field areas it is noted that the NIL sites are at a significantly higher elevation and are unlikely to be at risk from this major watercourse.

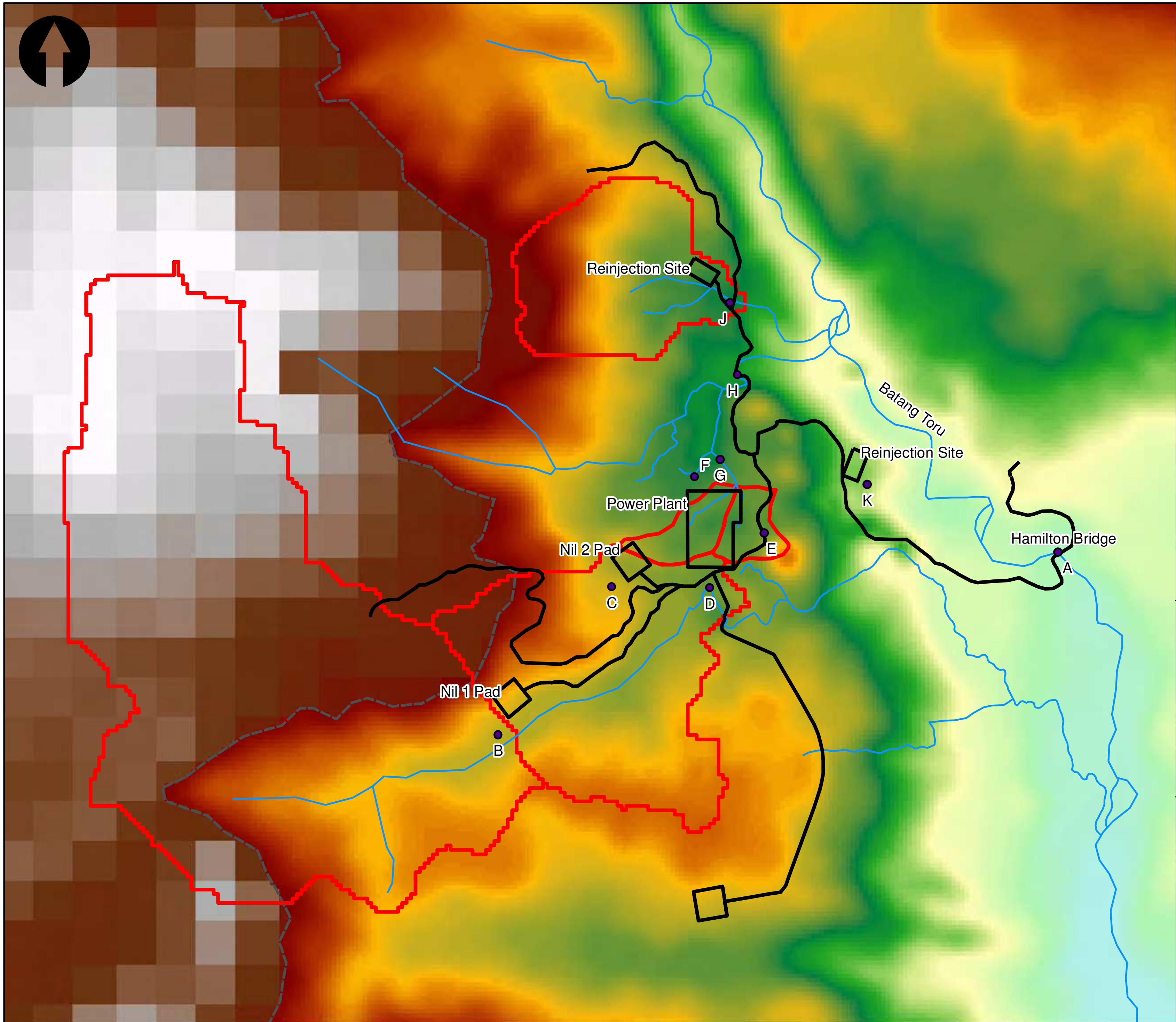
The watercourse is estimated to be approximately 22m wide with fast turbulent flow. The river has a steep slope given its size. The water depths were estimated to be between 1 and 2m. Photo 3.1 to Photo 3.4 show the river and the bridge crossing.

Photo 3.1: Batung Toru River at Hamilton Bridge, looking upstream

Source: MM 5 September 2013, Location A (11025632E 210193N)

Photo 3.2: Batung Toru River at Hamilton Bridge

Source: MM 5 September 2013, Location A (11025596E 210163N)



Legend

- Photo Locations
- NIL Site
- Watercourses
- Tributary Catchments
- Bakosurtanal Topography Boundary

Digital Terrain Model (DTM) (m)

High : 1332

Low : 556

Data Sources
Topography - Bakosurtanal 2013 and GMTED 2010 - Data available from the U.S. Geological Survey.
Watercourses - Digitised from satellite imagery, not all are shown.

0 0.25 0.5 1 Km

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Project Title
Sarulla Geothermal Project: Flood Risk Assessment

Drawing Title
Figure 3.1 NIL Site Arrangement

Scale	MM Project No.	Status
1:30,000	326959	INF

GIS File: Figure 3.1 NIL Site Arrangement.mxd

Drawing No.

Rev P1

Photo 3.3: Batung Toru River at Hamilton Bridge

Source: MM 5 September 2013, Location A (11025700E 210224N)

Photo 3.4: Batung Toru River at Hamilton Bridge, looking downstream

Source: MM 5 September 2013, Location A (11025632E 210193N)

3.1.3 NIL 1 Wellpad

The NIL 1 Wellpad is located in a valley of one of the tributaries of the Batang Toru. The site is located at a higher elevation than the nearby stream that drains this valley (see Photo 3.5 to Photo 3.8). The bridge that was constructed as part of the previous development has been washed away.

The watercourse is estimated to be approximately 5m wide and about 0.2m deep. The NIL 1 site is estimated to be over 10m above the river. As such the NIL 1 site is unlikely to be at risk of flooding.

Photo 3.5: NIL 1 Wellpad Location

Source: MM 5 September 2013, Location B (11022450E 209151N)

Photo 3.6: Stream Next to NIL 1 Wellpad

Source: MM 5 September 2013, Location B (11022450E 209151N)

Photo 3.7: Stream Next to NIL 1 Wellpad Looking Upstream

Source: MM 5 September 2013, Location B (11022469E 209098N)

Photo 3.8: Former Bridge Over Stream Next to NIL 1 Wellpad (Looking Downstream)

Source: MM 5 September 2013, Location B (11022469E 209098N)

3.1.4 NIL 2 Wellpad

The NIL 2 Wellpad is located in a sloping forested area (see Photo 3.9) and no nearby tributary watercourse could be identified that poses a risk to the site. Examination of the topography of the area in Figure 3.1 indicates that the NIL 2 Wellpad sits close to the catchment divide.

The closest watercourse in the catchment was that which drains the NIL 1 site. This watercourse was accessed down a slope from the access road. The watercourse is shown in Photo 3.10 and was estimated to be about 5m wide with a depth of approximately 0.3m. The vertical height difference from the access road to this watercourse was approximately 30m.

Given the elevations involved it is therefore unlikely that the NIL 2 Wellpad is at risk of flooding from any watercourse.

Photo 3.9: NIL 2 Wellpad Location in Forested Area

Source: MM 5 September 2013, Location C (11023095E 209991N)

Photo 3.10: Stream draining valley in which NIL 1 and NIL 2 are located.

Source: MM 5 September 2013, Location D (11023658E 209986N)

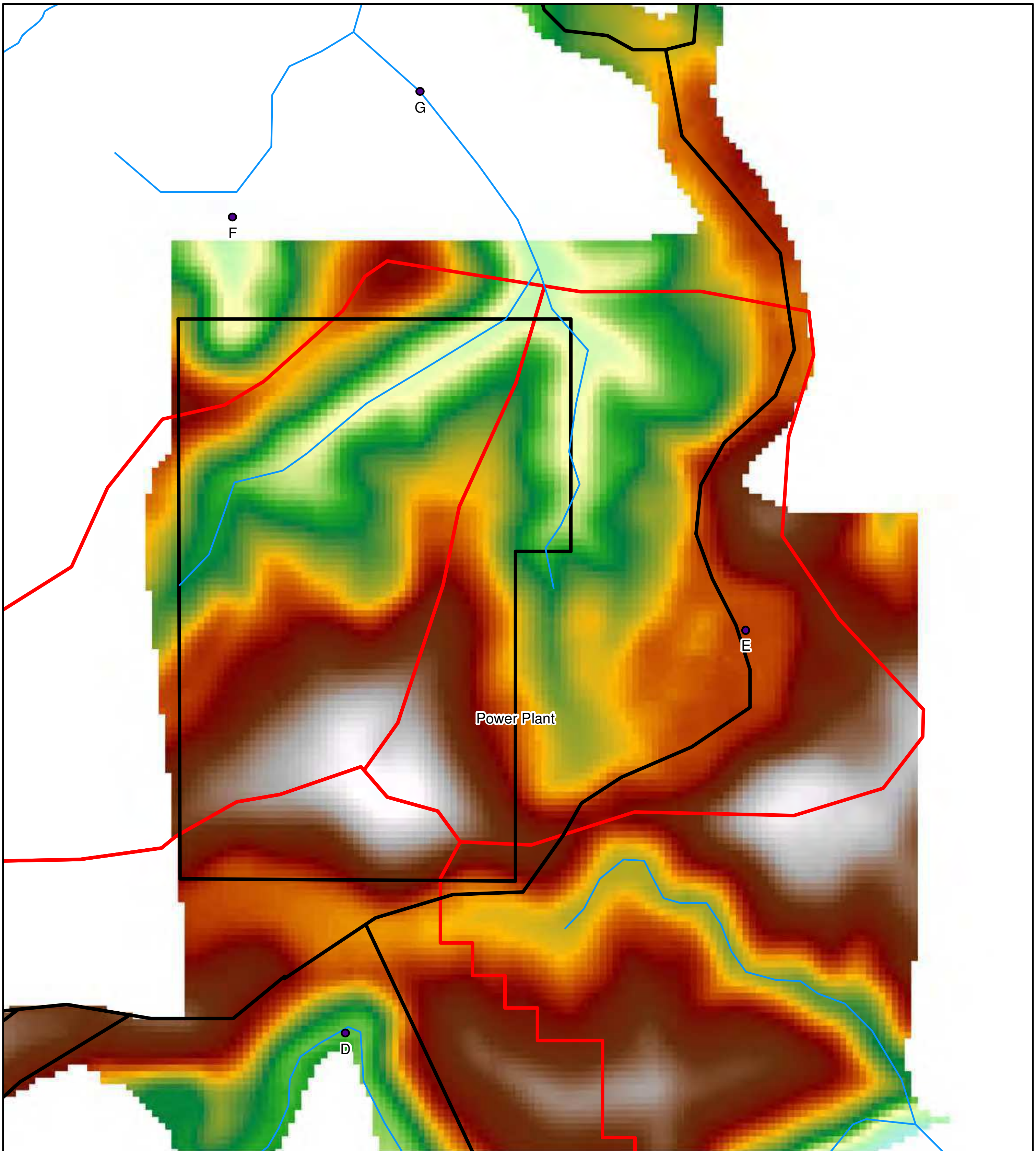
3.1.5 Power Plant

The power plant construction will involve extensive levelling and diversion of an existing tributary. The small hill identified in Photo 3.11 will be levelled. A detailed map of the topography and drainage around the power plant location is shown in Figure 3.2.

Whilst the stream identified in Photo 3.10 (in the valley that drains both the NIL 1 and NIL 2 Wellpads) is the closest watercourse to the southern end of the Power Plant site, it is not considered to pose a risk to the site as the topography suggests that there is a natural catchment divide. In addition the vertical height difference is significant and as such flooding is unlikely to pose a risk to the site.

Figure 3.2 shows that the power plant location cuts across the natural valley in the northern half. Photo 3.13 shows this valley a little further downstream. Given that these areas are currently rice fields it is likely that there is a risk of flooding to these areas. Given that ground levelling for the power plant will substantially modify the local topography, drainage of the power plant and diversion of this watercourse will be extremely important to prevent localised flooding to the site.

Photo 3.12 shows the small valley that drains the NE corner of the power plant site. As this will be levelled and form part of the site any drainage from this area will be incorporated into the site drainage. The stream that collects water from all of the north side of the power plant was visited at the road bridge further downstream (see Figure 3.2 and Photo 3.14).



0 20 40 80 120 160 m

Project Title
Sarulla Geothermal Project:
Flood Risk Assessment

Drawing Title
Figure 3.2 NIL Power Plant Site Arrangement

Scale 1:4,000	MM Project No. 326959	Status INF

GIS File Figure 3.2 NIL Power Plant Site Arrangement.mxd

Drawing No. | Rev P1

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Data Sources
Topography - Bakosurtanal 2013 and GMTED 2010 - Data available from the U.S. Geological Survey.
Watercourses - Digitised from satellite imagery, not all are shown.

Legend
- Photo Locations
- Watercourses
- NIL Site
- Tributary Catchments

Digital Terrain Model (DTM) (m)
High : 868
Low : 789

Provided that adequate provision is made for the diversion of the natural channel (which may also consist of flow through and over the rice fields) and that the power plant has adequate site drainage it is considered likely that there would be little external flood risk to the site.

Photo 3.11: NIL Power Plant Site in Distance

Source: MM 5 September 2013, Location E (11023963E 210296N)

Photo 3.12: Stream Draining NW Corner of Power Plant Site

Source: MM 5 September 2013, Location F (11023567E 210615N)

Photo 3.13: Valley Draining NE Side of NIL Power Plant Site

Source: MM 5 September 2013, Location G (11023963E 210296N)

Photo 3.14: Valley Draining North Side of NIL Power Plant Site by Road Bridge

Source: MM 5 September 2013, Location H (11023814E 211201N)

3.1.6 NIL WJR-1 Reinjection Wellpad (North)

During the site visit, the northernmost reinjection site (WJR-1) was indicated to be located in the rice fields and as such would be at risk of flooding (see Photo 3.15). The rice fields are drained by a small stream on the left-hand edge (facing downstream) of the rice fields (see Photo 3.16). The stream passes under the existing site road immediately downstream of the site location before dropping steeply down into the lower rice fields. This site road that crosses the valley immediately downstream may present a barrier to drainage in flood conditions.

However, examination of the site plans in relation to the GPS tracks (see Figure 3.1) indicates that NIL WJR-1 may be located at a slightly higher elevation, set further back from the rice fields.

Photo 3.15: NIL WJR-1 Location in Rice field Valley

Source: MM 5 September 2013 Location J (11023770E 211609N)

Photo 3.16: Stream Draining NIL WJR-1 Site

Source: MM 5 September 2013 Location J (11023786E 211663N)

3.1.7 NIL WJR-2 Reinjection Wellpad (ENE of Power Plant)

The central reinjection site is significantly raised from the Batung Toru and no nearby watercourse could be identified that poses a risk to this site. Photo 3.17 and Photo 3.18 show the site location.

Photo 3.17: NIL WJR-1 Location By Site Access Road

Source: MM 5 September 2013 Location J (11024419E 210550N)

Photo 3.18: NIL WJR-1 Location, Looking West (Uphill)

Source: MM 5 September 2013 Location J (11024551E 210574N)

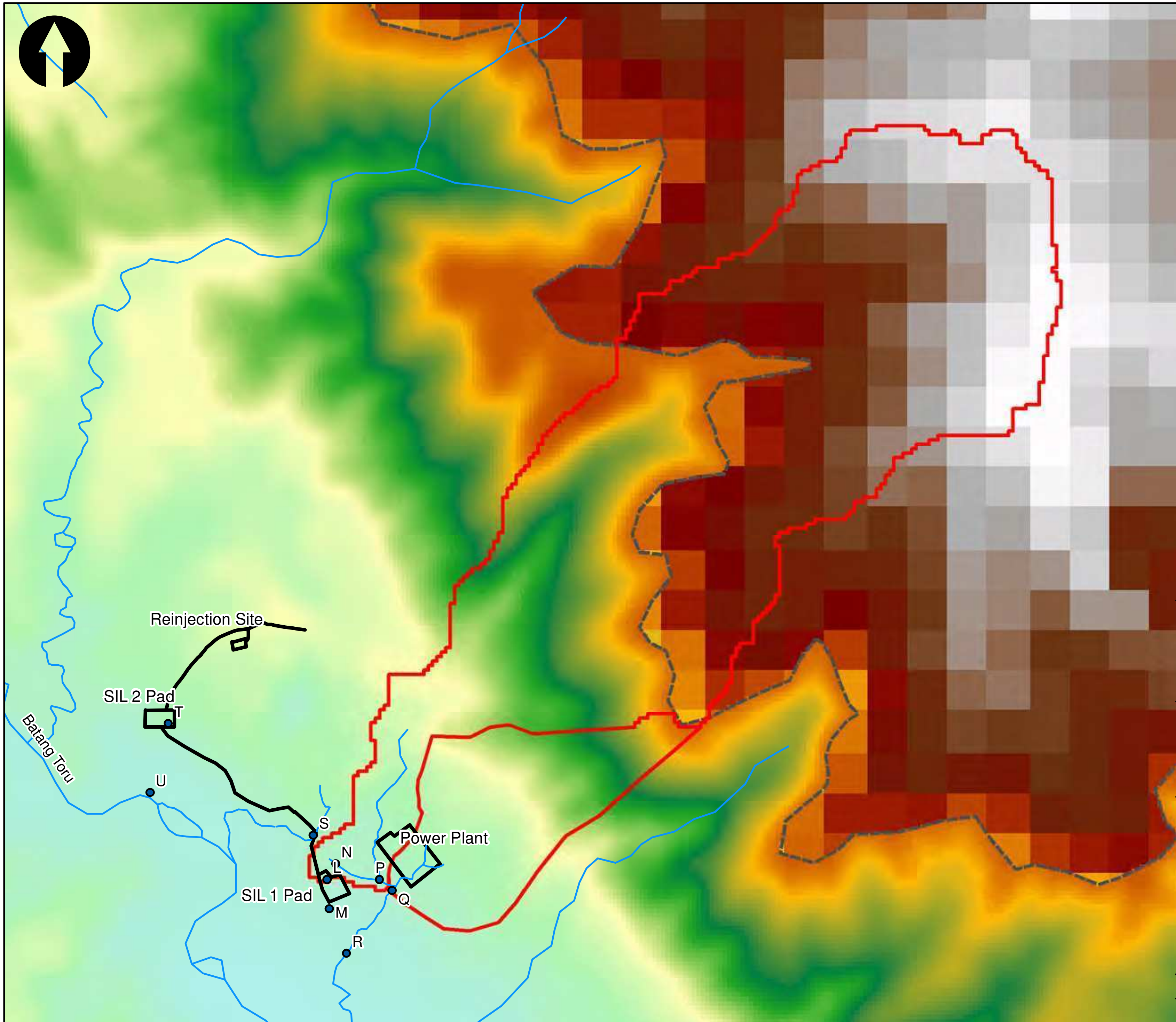
3.2 SIL Sites

The SIL sites lie further down the Batung Toru river valley and are shown in Figure 3.3 in relation to the overall topography and local drainage network. Each location that was visited is discussed in the sections below.

3.2.1 SIL 1 Wellpad

Photo 3.19 shows the location of the SIL 1 wellpad. Photo 3.20, taken further down the main road (see Figure 3.3 for the location) shows the general area of the additional wellpad. The closest watercourse is a small drain to the NE of the SIL 1 wellpad (Photo 3.21) which has the potential to overtop. However, examination of the topography suggests that the main SIL 1 wellpad is not in the flow path. Depending on the chosen level and location of the additional SIL 1 wellpad there may be some limited flood risk from overland flow.

The Hapesong River (Photo 3.22) was also visited at the road crossing to the north of SIL 1. Examination of the local topography suggests that this watercourse does not pose a flood risk to the SIL 1 wellpad.



Legend

- Photo Locations
- Watercourses
- SIL Site
- Tributary Catchments
- Bakosurtanal Topography Boundary

Digital Terrain Model (DTM) (m)

High : 1608

Low : 464

Data Sources
Topography - Bakosurtanal 2013 and GMTED 2010 - Data available from the U.S. Geological Survey.
Watercourses - Digitised from satellite imagery, not all are shown.

0 0.25 0.5 1 Km

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Project Title
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Drawing Title
Figure 3.3 SIL Site Arrangement

Scale	1:30,000	MM Project No.	326959	Status	INF
GIS File	Figure 3.3 SIL Site Arrangement.mxd				
Drawing No.				Rev	P1

Photo 3.19: SIL 1 Wellpad Site

Source: MM 5 September 2013 Location L (11030191E 202713N)

Photo 3.20: View Towards SIL 1 Additional Wellpad Site

Source: MM 5 September 2013 Location M (11030201E 202547N)

Photo 3.21: Drainage Ditch NE of SIL 2 Wellpad

Source: MM 5 September 2013 Location N (11030191E 202713N)

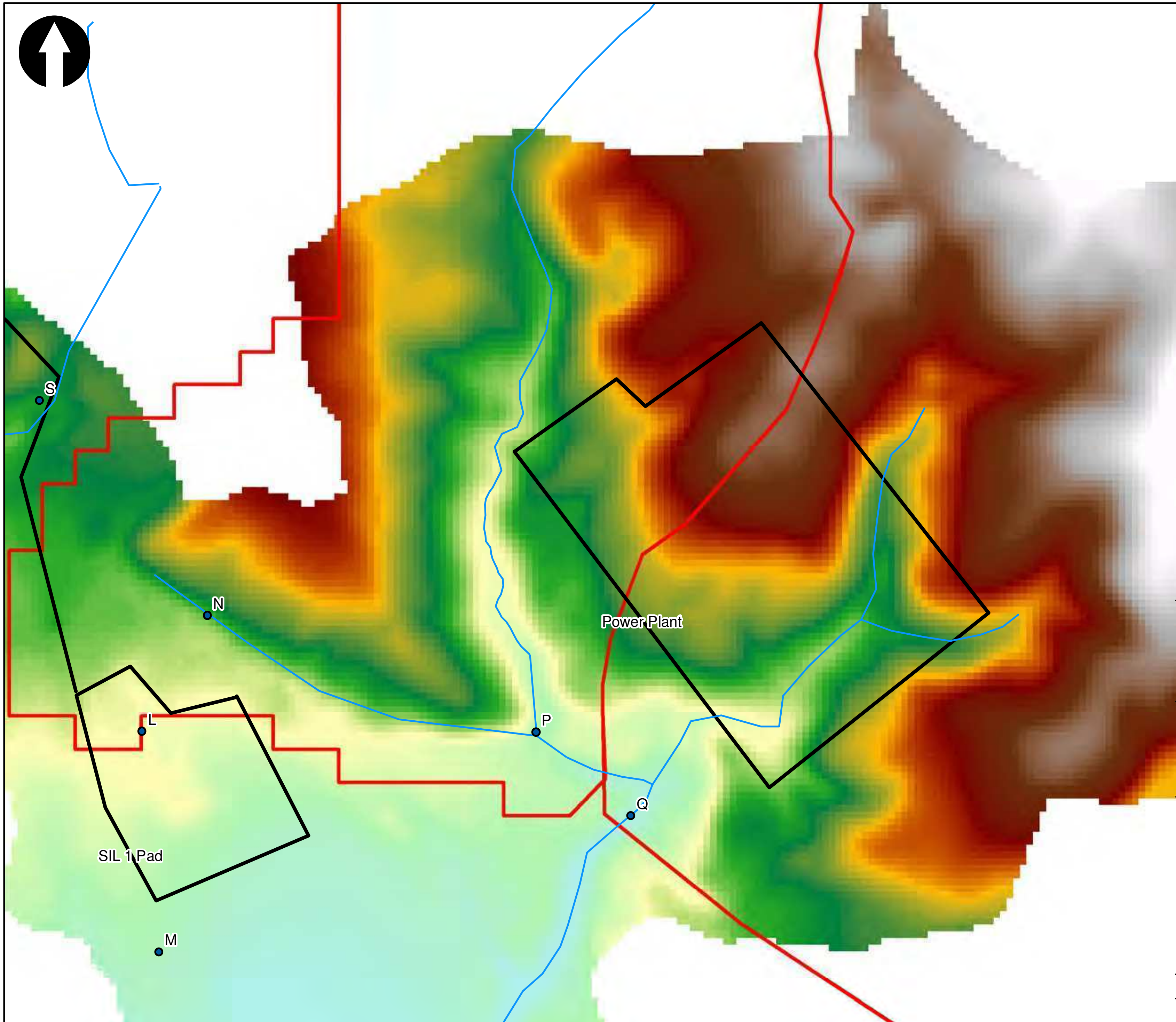
Photo 3.22: Hapesong River Looking Downstream

Source: MM 5 September 2013 Location S (11030087E 202967N)

3.2.2 SIL Power Plant

The power plant construction will involve extensive levelling and diversion of an existing tributary. A detailed map of the topography and drainage around the power plant location is shown in Figure 3.4.

Photo 3.23 shows the stream that drains the west side of the Power Plant site at its confluence with the smaller drain identified in Photo 3.21. The streams are small and drain steeply vegetated slopes.



Legend

- Photo Locations
- Watercourses
- SIL Site
- Tributary Catchments

Digital Terrain Model (DTM) (m)

High : 586

Low : 497

Data Sources
Topography - Bakosurtanal 2013 and GMTED 2010 - Data available from the U.S. Geological Survey.
Watercourses - Digitised from satellite imagery, not all are shown.

0 40 80 160 m

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Project Title
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Flood Risk Assessment

Drawing Title
Figure 3.4 SIL Power Plant Site Arrangement

Scale	1:4,000	MM Project No.	326959	Status	INF
GIS File	Figure 3.4 SIL Power Plant Site Arrangement.mxd				
Drawing No.		Rev	P1		

Figure 3.4 shows that the power plant location cuts across the natural valley in the southern half which is drained by the stream shown in Photo 3.24. The lowest parts of these valleys will be at risk of flooding. Given that ground levelling for the power plant will substantially modify the local topography, drainage of the power plant taking into account runoff from the steep vegetated slopes above it will be important to prevent localised flooding of the site.

Photo 3.23: Stream Draining West Side of Power Plant

Source: MM 5 September 2013 Location P (11030484E 202714N)

Photo 3.24: Stream Confluence near South Corner of Power Plant

Source: MM 5 September 2013 Location Q (11030557E 202649N)

Photo 3.25 shows the stream that drains the power plant at the road crossing further downstream.

Photo 3.25: Stream Draining Power Plant at Road Crossing Looking Upstream

Source: MM 5 September 2013 Location R (11030296E 202290N)

3.2.3 SIL 2 Reinjection Wellpad

SIL 2 is in a sloping area of secondary forest and no nearby tributary watercourse could be identified that poses a risk to the site. Photo 3.26 and Photo 3.27 show the SIL 2 reinjection wellpad location.

The Batung Toru River (Photo 3.28 and Photo 3.29) was visited via the site road starting at the SIL 2 reinjection site. The road drops approximately 40m to the river. Whilst there is flood risk to the surrounding rice fields, and to the temporary water abstraction point, it is noted that all the SIL 2 sites are at an elevation high enough from this watercourse as to minimise the potential flood risk.

Photo 3.26: SIL 2 Reinjection Wellpad Location

Source: MM 5 September 2013 Location T (11029288E 203616N)

Photo 3.27: SIL 2 Reinjection Wellpad Location

Source: MM 5 September 2013 Location T (11029288E 203616N)

Photo 3.28: Batang Toru River near SIL 2 Looking U/s

Source: MM 5 September 2013 Location U (11029684E 202806N)

Photo 3.29: Batang Toru River near SIL 2 Looking D/s

Source: MM 5 September 2013 Location U (11029684E 202806N)

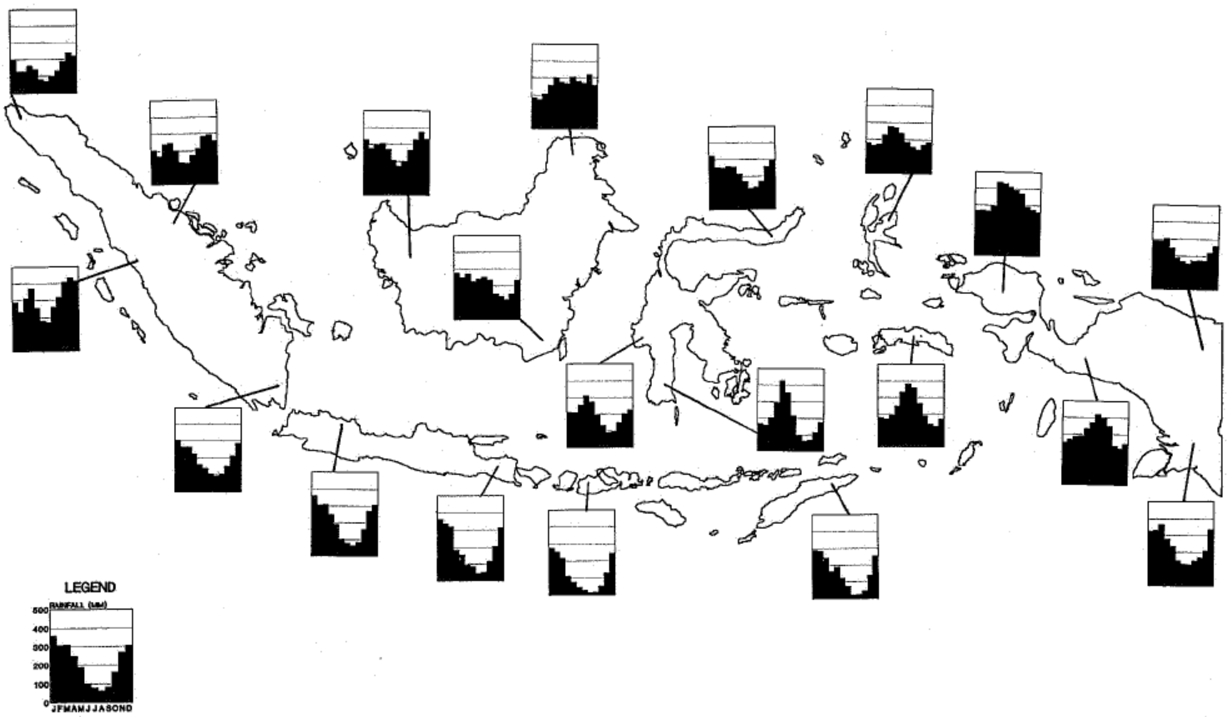
4 Flood Flow Estimation

Estimation of flood flows is fundamental to understanding the flood risk to sites. Whilst information on river flows has been collected it is not of a suitable quality for use in this assessment. As such the widely adopted US SCS approach has been used for estimation of flood flows. This section summarises the catchments of interest and the flood flow estimation for each.

4.1 Hydrological Background

The climate of North Sumatra is monsoonal and although the seasonal rainfall variation in Sumatra is not as pronounced as it is in Java, there is still a difference from one season to another. This is supported by Van der Weert (1994), as shown in Figure 4.1 below. This shows that North Sumatra is subject to two wet seasons, primarily September to December, but also a less pronounced wet season from March to May.

Figure 4.1: Seasonal Rainfall Variation in Indonesia



Source: Van der Weert (1994)

Sumatra, along with the rest of Indonesia experiences year-to-year variability in climate linked with both the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). El Niño influences the monsoons in the region; generally bringing warmer and drier conditions. La Niña brings wetter and colder conditions (Case et al., 2007; McSweeney et al., 2010).

Flooding is therefore most likely to occur during the principal wet season between September and December, but also from enhanced periods of rainfall during La Niña episodes.

The sites are located in the valley of the Batung Toru River, which is shown in Figure 4.2. Elevations range from approximately 500m to 1750m and the Batung Toru River drains a long NW-SE oriented catchment with one major tributary which drains areas to the NE. Various smaller tributaries drain the slopes of the valley and contribute to the Batung Toru River.

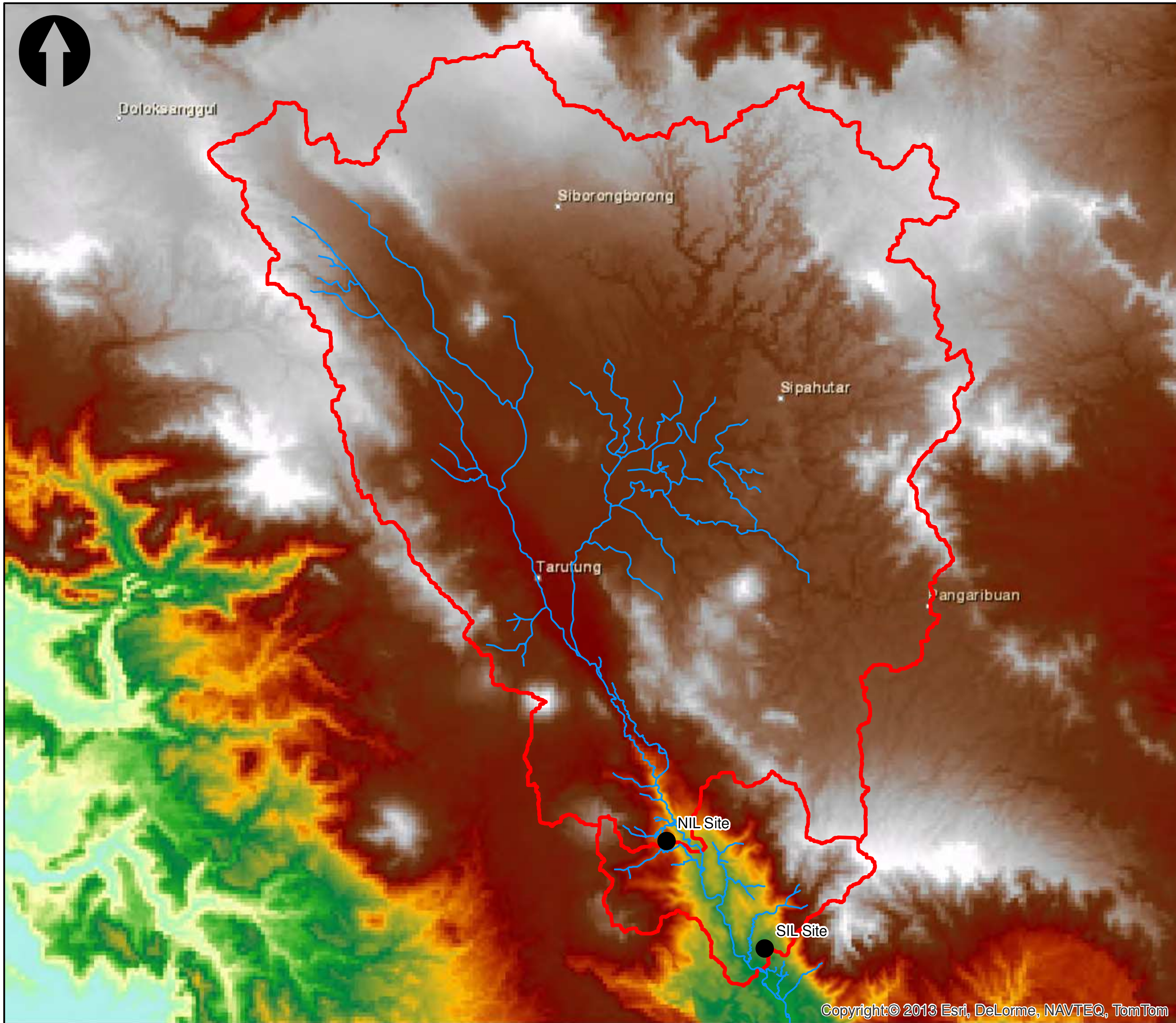
Land use information from the Ministry of Forestry of Republic of Indonesia is shown in Figure 4.3. The valley areas are mainly agricultural and rice fields. In the vicinity of the NIL and SIL sites there are forested areas which although marked as secondary forest according to the land classification may also include areas of primary forest.

Flow data and water level data for the gauging station at Sipetung was considered as part of this study. However, the record available was limited and it was not possible to verify the rating curve to validate the associated flows. The stated maximum recorded flow between 2007 and 2012 is 202m^3/s, though it is noted that the rating curve has a low exponent of 1.145 which might lead to underestimation of flow for high water levels. After review the data was not used further in the assessment due to a lack of confidence in the data.

4.2 Rainfall Data

Annual maximum rainfall data was obtained for six local rain gauges, as shown in Figure 4.4 and summarised in Table 2.1. The annual maximum rainfall data is summarised in Appendix A. The annual maximum rainfall was found to be higher in Sibolga (close to the coast) than at the other rain stations. The general trend for higher intensities at Sibolga seems to be similar to information from the Agency of Meteorology, Climatology, and Geophysics, which shows a precipitation forecast map for July 2013, indicating higher monthly rainfalls at Sibolga (Figure 4.5). This may suggest that average rainfall, and rainfall intensities are lower in the Batang Toru river valley.

A Generalised Extreme Value Analysis (Type 1) was undertaken on the maximum annual daily rainfall data to derive the 100 year and 500 year return period rainfalls. Due to the short available records at each station the analysis was undertaken on a combined record of rainfall for all the stations. As part of this analysis the results have been produced twice, once with Sibolga included and once excluded. This is summarised in Table 4.2 and shown in Figure 4.6.



Legend

- Site Locations
- Watercourses
- Batang Toru Basin

Digital Terrain Model (DTM) (m)

High : 1886

Low : 1

Data Sources
Topography - Bakosurtanal 2013 and GMTED 2010 - Data available from the U.S. Geological Survey.
Watercourses - Digitised from satellite imagery, not all are shown.

0 2.5 5 10 15 Km

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Project Title
Sarulla Geothermal Project: Flood Risk Assessment

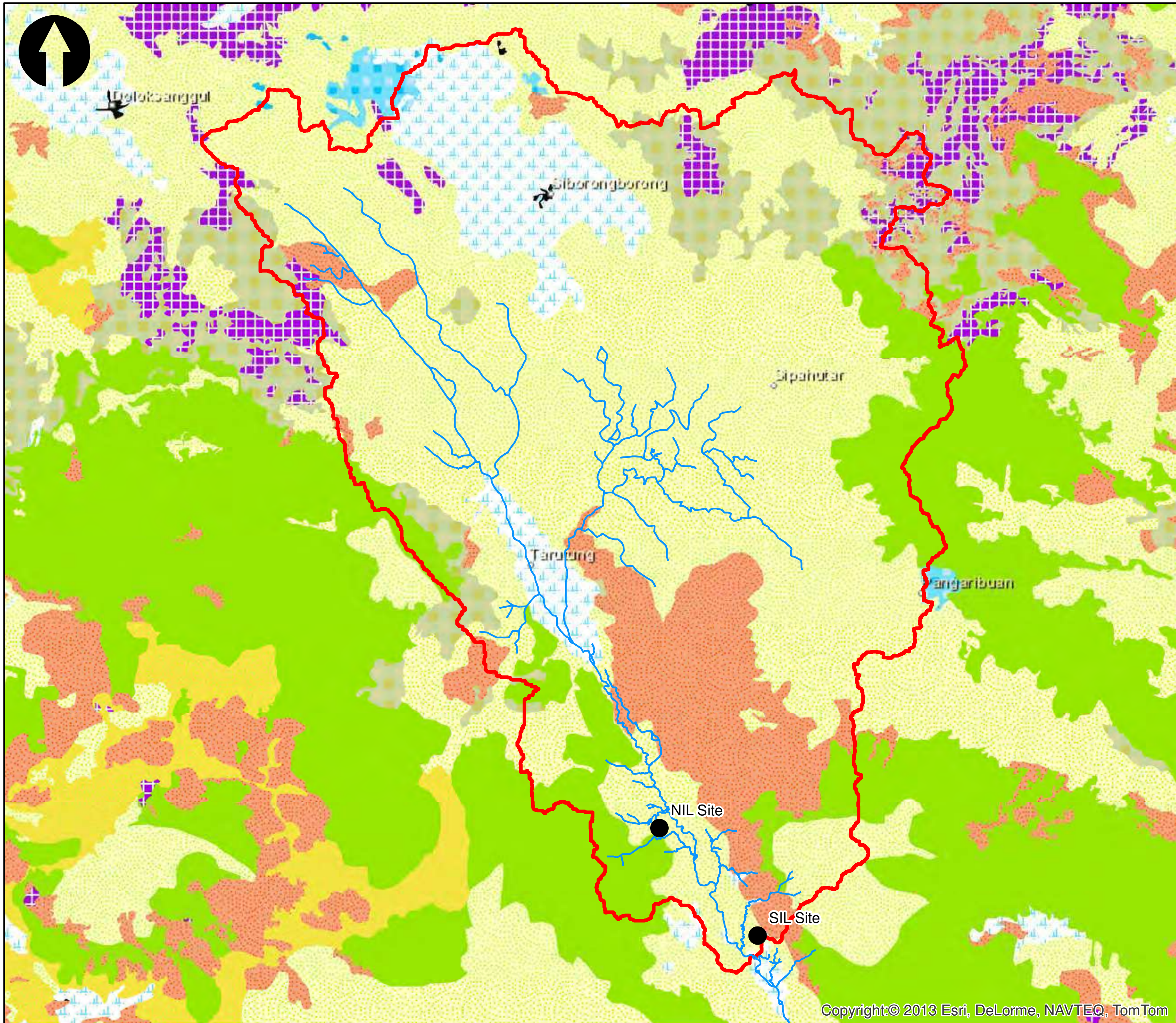
Drawing Title
Figure 4.2 Batang Toru River Basin Topography

Scale	MM Project No.	Status
1:300,000	326959	INF

GIS File: Figure 4.2 Batang Toru River Basin Topography.mxd

Drawing No.

Rev P1



Legend

- Site Locations
- Watercourses
- Batang Toru Basin

Land Use

- Primary Forest
- Secondary Forest
- Primary Mangroves
- Secondary Swamp Forest
- Industrial Forest
- Plantations
- Settlements
- Dryland Agriculture
- Dryland Agriculture with Bush
- Swamps
- Rice Fields
- Bush
- Bush and Swamps
- Open Land
- Waterways

Data Sources
Land use - Ministry of Forestry of Republic of Indonesia
Watercourses - Digitised from satellite imagery, not all are shown.

0 2 4 8 12 16 Km

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Project Title
Sarulla Geothermal Project: Flood Risk Assessment

Drawing Title
Figure 4.3 Batang Toru Basin Land Use

Scale	MM Project No.	Status
1:300,000	326959	INF

GIS File: Figure 4.3 Batang Toru Basin Land Use.mxd

Drawing No. | Rev P1

0 5 10 20 Km

Project Title
Sarulla Geothermal Project: Flood Risk Assessment

Drawing Title
Figure 4.4 Location of Rainfall Stations

Scale 1:630,000	MM Project No. 326959	Status INF

GIS File Figure 4.4 Location of Rainfall Stations.mxd

Drawing No. | Rev P1

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Data Sources
Rainfall Stations - Digitised from map provided by Badan Meterologi, Climatologi, dan Geofisika

Legend
- Rainfall Stations
- Site Locations
- Batang Toru Basin

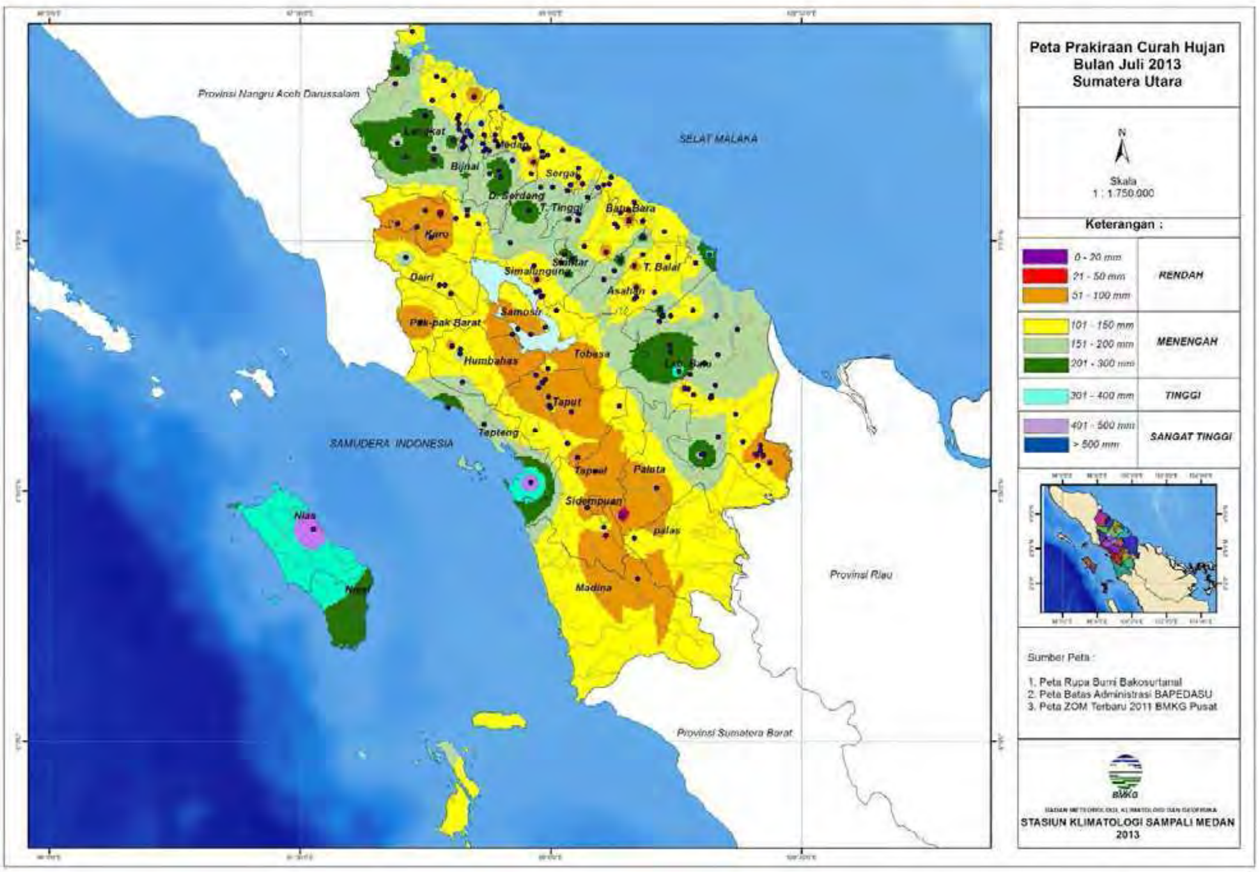
Table 4.1: Generalised Statistical Extreme Value Analysis (Type 1) – Daily Rainfall Data

	Maximum daily point rainfall (mm)	
Return Period	**All Stations**	**All Stations except Sibolga**
1 in 100 years	342	177
1 in 500 years	429	215

Source: GEV Analysis (Type 1) of annual maximum daily rainfall data

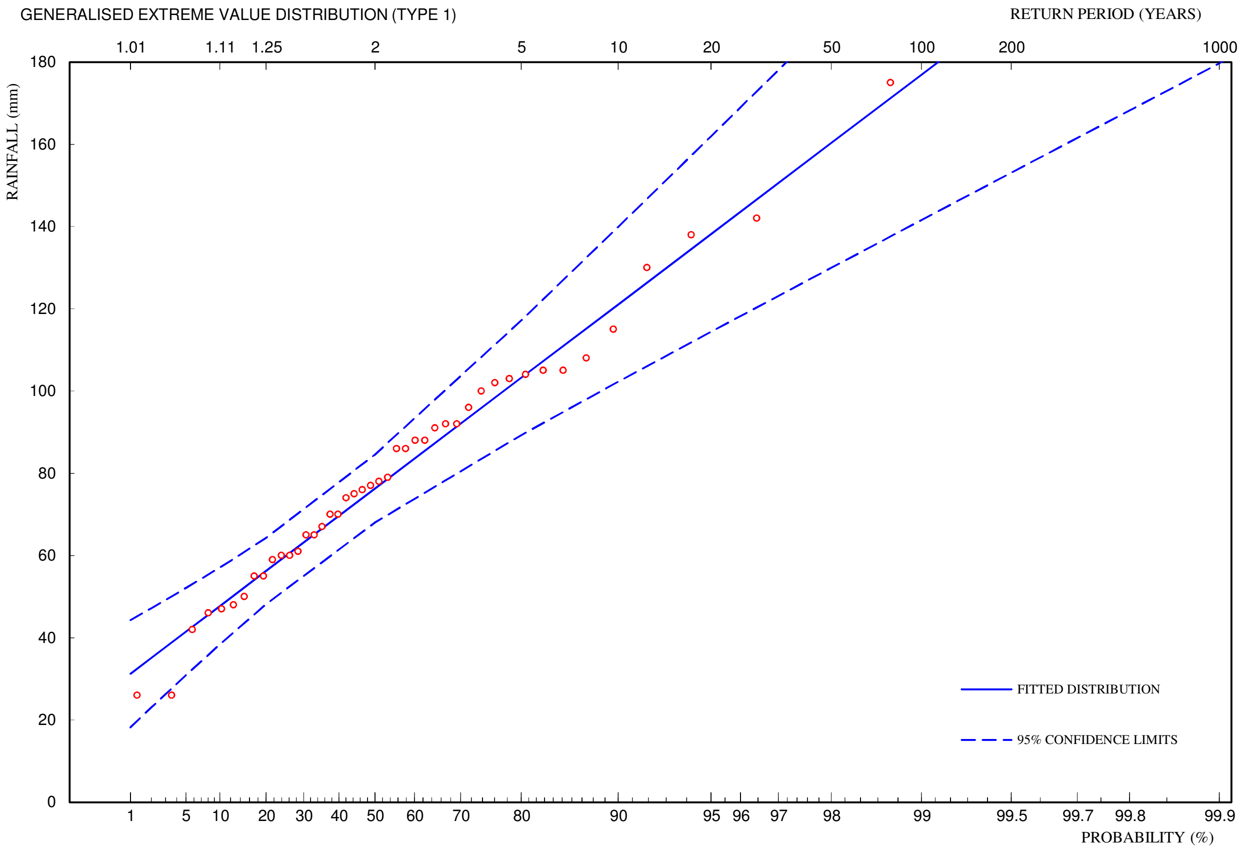
Given the extreme difference in the assessment of the maximum rainfall, caution should be exercised when using the Sibolga rainfall station as it is giving extreme rainfall projections. Given the differing climatic regime of Sibolga the station has not been included in the flood risk analysis, though it should be emphasised that the point rainfalls at Sibolga are plausible, particularly since the maximum daily rainfall recorded in Indonesia is 802mm in West Java in 1964 (Van der Weert, 1994). As such inclusion of Sibolga has been considered as part of the sensitivity analysis.

Figure 4.5: Precipitation Forecast Map in Sumatera Utara



Source: Agency of Meteorology, Climatology, and Geophysics (2013)

Figure 4.6: Generalised Statistical Extreme Value Analysis (Type 1) – Daily Rainfall Data



Source: GEV Analysis (Type 1) of annual maximum daily rainfall data

4.3 Catchments

In order to estimate the flood flows in the vicinity of the sites it is necessary to derive the catchment boundaries and characteristics for the nearby watercourses. Using a combination of topographic data from site survey drawings, Bakosurtanal mapping, and GMTED2010 satellite imagery it has been possible to derive a digital terrain model to gain a better understand of the topography of the project area. It should be emphasised that whilst the site survey topography is reliable for deriving levels, the other sources, whilst acceptable for comparing relative changes in topography, are not suitable for estimating precise ground levels.

From the river and topographic data of the project area, eight catchments were identified. The Batang Toru River itself poses a risk to both the NIL and SIL sites. In addition various tributaries also pose a risk to the various sites. HEC-GeoHMS, an extension used in ArcGIS, was used to delineate the catchments of interest. A summary of each catchment is provided in Table 4.2 below. The boundaries of these catchments are shown in Figure 3.1 to Figure 3.4 and Figure 4.2.

Table 4.2: Summary of Catchment Characteristics

Site Location	River	Catchment Area (km^2)	Main River Length (m)	Main River Slope (m/m)
NIL 1 Wellpad	Tributary	5.5	3.7	0.100
NIL WJR-1 Reinjection Wellpad	Tributary	1.0	0.5	0.069
NIL Power plant South	Tributary	7.2	5.4	0.078
NIL Power plant North West	Tributary	0.14	0.4	0.041
NIL Power plant North East	Tributary	0.12	0.3	0.054
NIL Sites - Hamilton Bridge	Batang Toru	1228	64.8	0.014
SIL Power plant West	Tributary	6.8	5.4	0.146
SIL Power plant East	Tributary	1.1	0.4	0.086
SIL Sites - Batang Toru	Batang Toru	1326	75.0	0.013

4.4 Flood Estimation

The most widely-used method for flood estimation in the absence of flow data is the US Soil Conservation Service (SCS) method. This requires the following information:

- Catchment area;
- Main river length;
- Main river slope;
- 24-hour rainfall; and
- Curve number (based on soils and land use).

The first three items can be found in Table 4.2 above.

To obtain 24-hour rainfall, it is usual to apply a factor to a daily rainfall estimate to obtain a 24-hour value, reflecting the fact that the daily rainfall is for fixed time periods (typically 0900 to 0900) and a 24-hour period overlapping two such fixed periods may have higher rainfall than a single fixed period. The standard adjustment factor is 1.13 for climates prone to monsoonal rainfall (Institute of Hydrology, 1995).

The above adjustment relates to point rainfall. As the average rainfall over an area will be lower than at a point, an areal reduction factor is also applied. For a 24-hour storm, areal reduction factors are derived based on the size of the catchment as outlined in the Flood Design Manual for Java and Sumatra (Institute of Hydrology, 1983). The 1 in 100 year and 1 in 500 year return period design rainfalls after applying the standard adjustment factor and areal reduction factor for each catchment are shown in Table 4.3.

Table 4.3: Derivation of Catchment Rainfall

Site Location	Standard Adjustment Factor	Areal Reduction Factor	1 in 100 year 24-hour Rainfall (mm)	1 in 500 year 24-hour Rainfall (mm)
NIL 1 Wellpad	1.13	0.99	198	241
NIL WJR-1 Reinjection Wellpad	1.13	0.99	198	241
NIL Power plant South	1.13	0.97	194	236

Site Location	Standard Adjustment Factor	Areal Reduction Factor	1 in 100 year 24-hour Rainfall (mm)	1 in 500 year 24-hour Rainfall (mm)
NIL Power plant North West	1.13	0.99	198	241
NIL Power plant North East	1.13	0.99	198	241
NIL Sites - Hamilton Bridge	1.13	0.77	154	188
SIL Power plant West	1.13	0.97	194	236
SIL Power plant East	1.13	0.99	198	241
SIL Sites - Batang Toru	1.13	0.77	153	187

The curve number is difficult to assess, partly because of a lack of observations of conditions across the catchments but also because the US SCS approach was originally developed in 1954 and calibrated for agricultural fields in the USA. However, using the land use information shown in Figure 4.3, the proportion of land use in each catchment has been derived and a curve number assigned to each class.

However, little is known about the hydrological condition or the soil type. As such a sensitivity analysis was undertaken on the Curve Numbers. In this situation the most defensible choice of curve number is from an assumption of average soil type and hydrological condition. The SCS tables cover four soil types from A (high infiltration even when wet) to D (very slow infiltration when thoroughly wet); for this assessment types A and B soils were tested. The weighted curve number has been derived and is shown in Table 4.4.

Table 4.4: SCS Curve Number for Catchments

Catchment	Type A Soils Curve Number	Type B Soils Curve Number	Predominant land use
NIL 1 Wellpad	36	60	Secondary Forest
NIL WJR-1 Reinjection Wellpad	58	72	Dryland Agriculture
NIL Power plant South	38	61	Secondary Forest
NIL Power plant North West	58	72	Dryland Agriculture
NIL Power plant North East	58	72	Dryland Agriculture
NIL Sites - Hamilton Bridge	56	70	Dryland Agriculture/Bush/Rice Fields
SIL Power plant West	37	61	Primary Forest/Bush
SIL Power plant East	56	71	Dryland Agriculture/Bush
SIL Sites - Batang Toru	55	70	Dryland Agriculture/Bush/Rice Fields

Testing of the critical storm duration was undertaken to ensure that the most appropriate storm duration was adopted. The 24-hour rainfall was converted to the appropriate critical storm duration rainfall as per curves presented in Van der Weert (1994). The critical storm durations and the corresponding storm rainfall for each catchment are shown in Table 4.5.

Table 4.5: Catchment Critical Storm Durations

Catchment	Storm Duration (hr)	1 in 100 year Storm Rainfall (mm)	1 in 500 year Storm Rainfall (mm)
NIL 1 Wellpad	4	157	182

Catchment	Storm Duration (hr)	1 in 100 year Storm Rainfall (mm)	1 in 500 year Storm Rainfall (mm)
NIL WJR-1 Reinjection Wellpad	2	134	152
NIL Power plant South	4	155	179
NIL Power plant North West	2	134	152
NIL Power plant North East	2	134	152
NIL Sites - Hamilton Bridge	8	143	168
SIL Power plant West	4	155	179
SIL Power plant East	2	134	152
SIL Sites - Batang Toru	8	142	167

Previous work in Indonesia undertaken by Mott MacDonald has identified limitations associated with adopting the SCS approach. In particular the flood growth curve derived from SCS results can be more extreme than other approaches. Comparison of the SCS approach has been made with the Java and Sumatra Flood Design Manual, as shown in Table 4.6. Whilst there is significant uncertainty with either assessment it suggests that adoption of the SCS approach with Type B soils is too extreme. A suitably conservative approach is to adopt the SCS approach assuming Type A soils.

Table 4.6: Comparison of SCS Approach with Flood Design Manual for the Batang Toru at Hamilton Bridge

Approach	100-year Return Period Peak Discharge (m^3/s)	500-year Return Period Peak Discharge (m^3/s)
US SCS Analysis Type B Soils	2479	3260
US SCS Analysis Type A Soils	**1365**	**1945**
Java and Sumatra Flood Design Manual (IoH, 1983)	659	948
Java and Sumatra Flood Design Manual (IoH, 1983) Standard Deviation	436	693

Source: Flood Discharges calculated from the Java and Sumatra Flood Design Manual by calculation of the mean annual flood from catchment characteristics and use of growth factors.

The peak flow discharges for Type A soils for each catchment is shown in Table 4.7. As part of the sensitivity analysis, analysis was also done for Type B soils, and the results are summarised in Table 6.4 .

Table 4.7: Peak Flow Discharges for Catchments

Catchment	100-year Return Period Peak Discharge (m^3/s)	500-year Return Period Peak Discharge (m^3/s)
NIL 1 Wellpad	7.0	12.6
NIL WJR-1 Reinjection Wellpad	14.2	18.7
NIL Power plant South	10.7	18.4
NIL Power plant North West	2.1	2.8
NIL Power plant North East	1.7	2.2
NIL Sites - Hamilton Bridge	1365.5	1945.4
SIL Power plant West	9.0	16.0

Catchment	100-year Return Period Peak Discharge (m^3/s)	500-year Return Period Peak Discharge (m^3/s)
SIL Power plant East	14.6	19.5
SIL Sites - Batang Toru	1257.1	1809.7

5 Climate Change

Climate change is an important factor to consider when determining flood risk to sites, as rainfall intensities and flood events are likely to become more frequent and more extreme in the future. This section summarises the projected impact of climate change on future precipitation patterns according to the UNDP Climate Change Country Profile for Indonesia.

5.1 Impact of Climate Change in Indonesia

Observational mean precipitation in Indonesia has decreased at an average rate of 7.8mm per month (3.6%) per decade since 1960, with similar trends across all seasons. In spite of this decline, Indonesia is predicted, with some uncertainty, to become wetter due to climate change, with an overall increase in precipitation (McSweeney et al., 2010). Projected changes in annual precipitation ranges between -28mm and +53mm per month (-12% to +20%) by the 2090's. There are, however, large spatial and seasonal variations when trying to predict changes in rainfall patterns. The easternmost islands will most likely have the greatest increases in rainfall (-6 to +38%) by the 2090's (McSweeney et al., 2010).

When considering flood risk and the increased occurrence of extreme rainfall events (tropical storms), it is the changes in maximum precipitation that are important rather than changes to mean precipitation. Observational maximum precipitation in Indonesia has also shown a substantial decrease in magnitude since 1960; however the proportion of total annual precipitation that falls in heavy events is projected to increase by up to 15% by the 2090's (McSweeney et al., 2010) (Figure 5.1). Maximum 1-day (0 to +86mm) and 5-day (0 to +123mm) precipitation is projected to increase by the 2090's (McSweeney et al., 2010).

It is worth noting that there is disagreement in projected changes in the amplitude of future El Niño events, contributing to uncertainty in future climate variability in projections for this region.

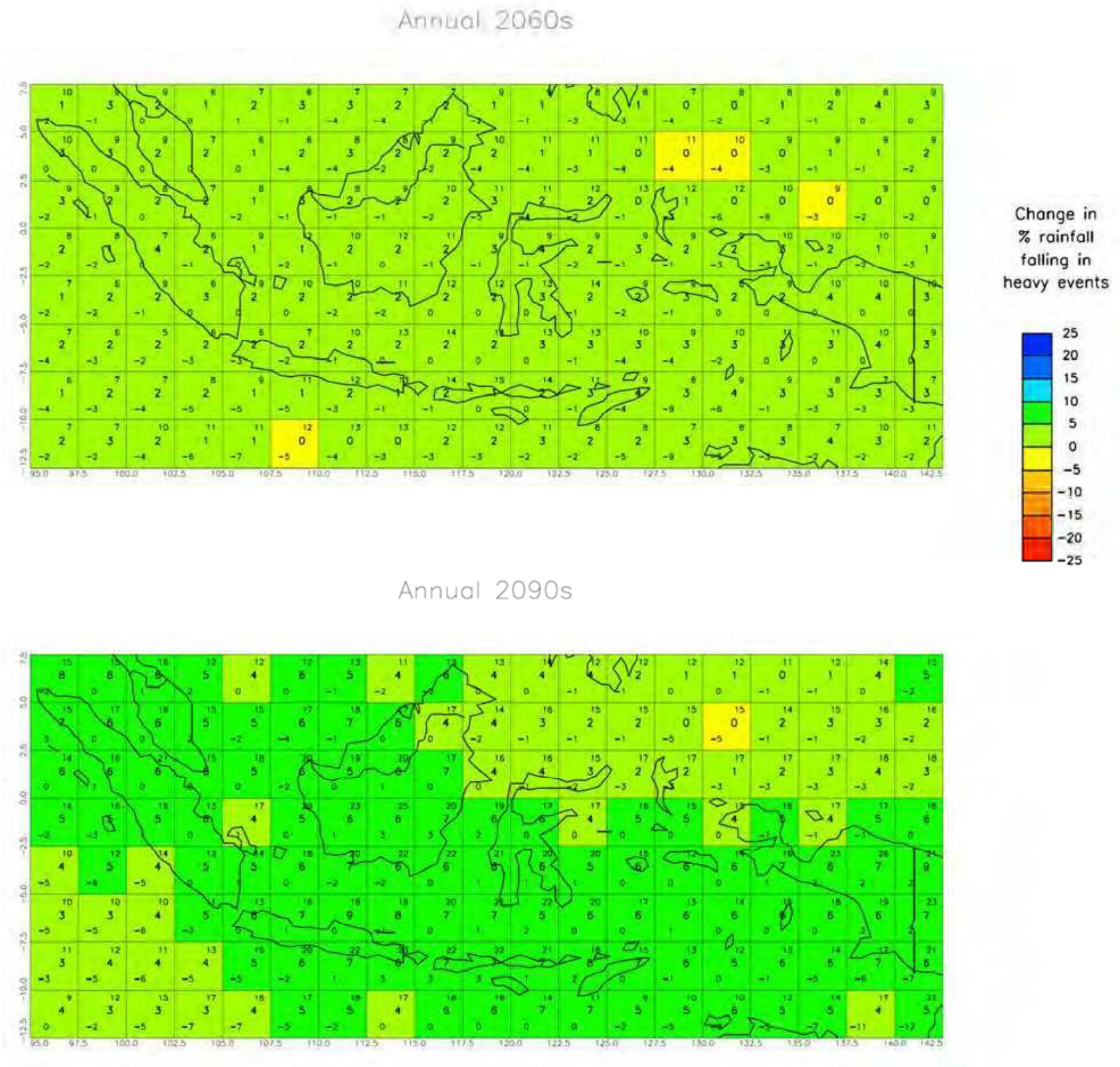
5.2 Flood Estimation

In order to assess the range of projected changes in maximum precipitation as a result of climate change it is necessary to consider the design lifespan of the facility. The project RFP states that the plant should have an operational life of no less than 30 years. In light of this it is considered that the 2060's horizon is appropriate for consideration, rather than the 2090's.

The various projections for changes to maximum 1-day rainfall summarised in the UNDP Climate Change Profile for Indonesia are summarised in Table 5.1.

Projected changes in maximum daily precipitation range between -5mm and +39mm by the 2060's. Given that this assessment is associated with determining the potential impacts to critical infrastructure, a risk averse approach should be adopted. As such an increase in maximum 1 day rainfall of 39mm has been adopted. It is worth noting that given that current emission pathways are exceeding the high emissions scenario (A2) this is not considered unreasonable for this assessment.

Figure 5.1: Change in Percentage Rainfall Falling in Heavy Events in Indonesia



Source: McSweeney et al., 2010

Table 5.1: Projected Change in Maximum 1-day Rainfall by 2060's

Model	Scenario	Minimum	Median	Maximum
			Change in mm	
Annual	A2 (High)	-3	4	35
	A1B (Medium)	-2	6	39
	B1 (Low)	-1	2	23
JFM	A2 (High)	0	2	17
	A1B (Medium)	0	5	12
	B1 (Low)	0	1	17
AMJ	A2 (High)	-1	2	19
	A1B (Medium)	-1	4	19
	B1 (Low)	0	2	12
JAS	A2 (High)	-3	0	10
	A1B (Medium)	-2	2	12
	B1 (Low)	-5	0	8
OND	A2 (High)	-2	1	12
	A1B (Medium)	0	3	14
	B1 (Low)	-1	1	9

Source: McSweeney et al., 2010

The annual maximum rainfall series for each individual station was therefore adjusted to reflect a 39mm increase in annual maximum daily rainfall and the critical duration storm rainfall was rederived using the same approach as outlined in Section 4.4, and results are summarised in Table 5.2.

Table 5.2: Catchment Critical Storm Durations with Climate Change

Catchment	Storm Duration (hr)	1 in 100 year with Climate Change Storm Rainfall (mm)	1 in 500 year with Climate Change Storm Rainfall (mm)
NIL 1 Wellpad	4	182	203
NIL WJR-1 Reinjection Wellpad	2	152	166
NIL Power plant South	4	179	201
NIL Power plant North West	2	197	222
NIL Power plant North East	4	182	203
NIL Sites - Hamilton Bridge	8	168	193
SIL Power plant West	4	179	200
SIL Power plant East	2	152	166
SIL Sites - Batang Toru	8	168	192

Using the same catchment characteristics and curve numbers as shown in Table 4.2 and Table 4.4 respectively, the SCS method was used to compute the peak flow discharges for each catchment with the increased rainfall. A summary of the peak flow discharges for each catchment is shown in Table 5.3.

Table 5.3: Peak Flow Discharges for Catchments with Climate Change for the 2060’s

Catchment	100-year Return Period Peak Discharge with Climate Change (m3/s)	% Increase from Baseline (100-year Return Peak Discharge without Climate Change)	500-year Return Period Peak Discharge with Climate Change (m3/s)	% Increase from Baseline (500-year Return Peak Discharge without Climate Change)
NIL 1 Wellpad	12.8	83	19.4	54
NIL WJR-1 Reinjection Wellpad	18.8	32	22.5	20
NIL Power plant South	18.5	73	27.5	50
NIL Power plant North West	2.8	33	3.3	18
NIL Power plant North East	2.2	29	2.8	27
NIL Sites - Hamilton Bridge	1955	43	2570	32
SIL Power plant West	16.2	80	24.6	54
SIL Power plant East	19.6	34	23.7	22
SIL Sites - Batang Toru	1819	45	2405	33

It should be noted that the above analysis is based on a summary of observed data and the results of climate model experiments, rather than a summary of the existing literature on projected climate change. Any decision-making based on this analysis should be used with reference to other studies which make use of alternative techniques and information.

Modelled data for the future are not predictions of climate, but model simulations of future climate under a range of hypothetical emissions scenarios. Further research or analysis should take account of the accuracies and uncertainties associated with these projections.

6 Inundation Probability

Based on the site survey topography, hydraulic calculations have been undertaken to establish estimated flood levels based on the flood hydrology. A comparison of flood levels with design levels has been made to understand the flood risk to each of the sites. This section also includes consideration of the flood levels with climate change projections taken into consideration.

6.1 Hydraulic Calculations

Hydraulic calculations were done using steady state HEC-RAS models. A channel cross section was extracted from the detailed topographic data using ArcGIS, and input into HEC-RAS to determine the water levels. Average river slope was also calculated and the extracted cross section replicated and shifted accordingly. Using the flood hydrology results presented in Table 4.7, extreme water levels were derived for the 1 in 100 year and 1 in 500 year flood events.

Appropriate Manning's n values were selected as these have a significant impact on the accuracy of the computed water surface profiles. Manning's n values are highly variable and depend on a number of factors. These values should be calibrated using observed water surface profile information, but since this is not available, values of n for the catchments were selected based on observations from the site visit. A summary of Manning's n values adopted for each watercourse is shown in Table 6.1 below.

Table 6.1: Manning's n Values for Catchments

Catchment	Watercourse	Left Overbank	Channel	Right Overbank
NIL 1 Wellpad	Tributary	0.05	0.035	0.05
NIL WJR-1 Reinjection Wellpad	Tributary	0.05	0.04	0.05
NIL Power plant South	Tributary	0.07	0.04	0.07
NIL Power plant North West	Tributary	0.07	0.04	0.07
NIL Power plant North East	Tributary	0.07	0.04	0.07
NIL Sites - Hamilton Bridge	Batang Toru	0.06	0.035	0.05
SIL Power plant West	Tributary	0.05	0.035	0.05
SIL Power plant East	Tributary	0.07	0.048	0.07
SIL Sites - Batang Toru	Batang Toru	0.07	0.048	0.07

The cross-section profile of each river location is included in Appendix B. It should be emphasised that these hydraulic calculations are basic steady state assessments and no detailed modelling has been undertaken. Upstream and downstream changes in channel shape have not been reflected in the calculations due to a lack of detailed topographic information.

6.2 Flood Risk to Sites

Table 6.2 summarise the calculated flood levels for the catchments of interest. Table 6.3 interprets these flood levels for each of the site locations to evaluate the overall flood risk to each location. It is important to note that flood risk has been considered separately in relation to each watercourse. Flood risk from the Batang Toru has been considered in relation to all sites at NIL and all sites at SIL.

Table 6.2: Summary of Derived Flood Levels

Catchment	Watercourse	1 in 100 year Flood Level (m)	1 in 500 year Flood Level (m)	1 in 100 year Flood Level with Climate Change(m)	1 in 500 year Flood Level with Climate Change (m)
NIL 1 Wellpad	Tributary	853.45	853.60	853.61	853.76
NIL WJR-1 Reinjection Wellpad	Tributary	787.86	787.94	787.94	788.00
NIL Power plant South	Tributary	795.80	796.07	796.07	796.37
NIL Power plant North West	Tributary	810.18	810.20	810.20	810.22
NIL Power plant North East	Tributary	803.71	803.74	803.74	803.78
NIL Sites - Hamilton Bridge	Batang Toru	611.48	612.66	612.67	613.66
SIL Power plant West	Tributary	505.55	505.71	505.71	505.89
SIL Power plant East	Tributary	529.71	529.83	529.84	529.93
SIL Sites - Batang Toru	Batang Toru	491.90	492.28	492.29	492.78

The difference in flood levels between the 1 in 100 year and 1 in 500 year flood levels are small, with less than 0.3m change in flood levels for all the tributary catchments. Changes on the Batang Toru are more significant with a difference of over 1m at the Hamilton Bridge.

The difference in flood levels with the inclusion of climate change is mostly small, with only minimal increases in flood levels for some locations, particularly for the small catchments draining the power plants. The largest increase in flood levels occurs on the Batang Toru at Hamilton Bridge. It is noticeable that the 1 in 100 year with climate change levels are comparable to the current 1 in 500 year levels.

Table 6.3: Summary of Potential Inundation to Sites

Site	Design Level (m)	Source of Flooding	Range of Flood Levels (m)	Flood Risk Potential
All NIL Sites	**752.28 – 886.92**	**Batang Toru River**	**611.48 – 613.66**	**VERY LOW** **All sites are raised by at least 140m from all calculated flood levels.**
NIL 1 Wellpad	886.92	Tributary - NIL 1 Wellpad	853.45 – 853.76	VERY LOW Site is raised by more than 30m from all calculated flood levels.
NIL 2 Wellpad	855.87	Tributary - NIL Power plant South	No assessment near site but likely to be between the NIL 1 Wellpad (max 853.76) and NIL Power plant South (max 796.37) levels	VERY LOW Although precise flood levels are not known at this location comparison with upstream and downstream locations indicates that this site is similarly raised from the tributary and is therefore to have a similar low level of flood risk.
NIL WJP1n	878.00	Access constraints prevented visit to site so local watercourses unknown,	No assessment near site possible	NOT DETERMINED Risks to site from tributaries unknown but site is at higher elevation in a steeper sloping area which suggests risks might be low.
NIL Power Plant	813.00 and 823.00 (split level)	Tributary - NIL Power plant South	795.80 – 796.37	VERY LOW Lowest plant level at site is raised by more than 18m from the calculated flood levels.
		Tributary - NIL Power plant North West	810.18 – 810.22	LOW Site is raised by at least 2.8m from the calculated flood levels. However, it will be important to ensure there is adequate stream diversion as the site will block the NIL North West catchment valley and this has the potential to cause flooding.
		Tributary - NIL Power plant North East	803.71 – 803.78	VERY LOW Site is raised by at least 9.2m from the calculated flood levels. However, it will be important to ensure there is adequate site drainage as the site will partially constrict the NIL Power plant North East catchment valley.
NIL WJR-1 Reinjection Wellpad	800.00	Tributary - NIL WJR-1 Reinjection Wellpad	787.86 – 788.00	VERY LOW Site is raised by more than 12m from all calculated flood levels.
NIL WJR-2 Reinjection Wellpad	752.28	Tributary - NIL Power plant South	N/A	VERY LOW No nearby tributary watercourse could be identified that poses a risk to the site.
All SIL Sites	**511.00 – 530.00**	**Batang Toru River**	**491.90 – 492.78**	**VERY LOW** **All sites are raised by at least 18m from all calculated flood**

Site	Design Level (m)	Source of Flooding	Range of Flood Levels (m)	Flood Risk Potential
				levels.
SIL 1 Wellpad	511.00	Drainage Ditch NE of SIL 2 Wellpad	Not possible to calculate with available information	LOW SIL 1 Wellpad might be at risk from overland flow from the overtopping of a small drainage ditch to the NE but this risk is low and volumes of water would be limited. Depending on the chosen level and location of the additional SIL 1 wellpad there may be some limited flood risk from overland flow. Appropriate site drainage would mitigate this risk as the site is located in a sloping area.
SIL Power plant	525.00	Tributary - SIL Power plant West	505.55 – 505.89	VERY LOW Site is raised by more than 19m from all calculated flood levels. However, it will be important to ensure there is adequate site drainage as the site will partially constrict the SIL Power plant West catchment valley.
		Tributary - SIL Power plant East	529.71 – 529.93 (Levels taken for upstream cross section and drop as the stream passes through the area of interest).	LOW Site is at risk of flooding from the small tributary which drains the SIL Power plant East catchment. Adequate stream diversion will be required as the SIL Power plant site will block this small valley.
SIL 2 Reinjection Wellpad	530.00	N/A	N/A	VERY LOW No nearby tributary watercourse could be identified that poses a risk to the site.

6.3 Sensitivity Analysis

Whilst there are a variety of uncertainties associated with the analysis it is considered that the most significant uncertainty is associated with the use of the SCS approach and uncertainty with the flood hydrology, in particular, exclusion of the Sibolga rainfall station.

In order to understand this level of uncertainty the SCS approach has been tested by adopting Type B soils. As can be seen in Table 4.6 this significantly increases the flow rates. It is worth noting that this is a useful parameter to test as it is possible that potential changes in land use practices could have a significant impact on runoff potential.

The results of this sensitivity analysis are shown in Table 6.4.

Table 6.4: Summary of Sensitivity Analysis Results: Type B Soils

Catchment	Watercourse	1 in 100 year Flood Flow (m^3/s)	1 in 500 year Flood Flow (m^3/s)	1 in 100 year Flood Level (m)	1 in 500 year Flood Level (m)
NIL 1 Wellpad	Tributary	56.5	77.7	854.33	854.55
NIL WJR-1 Reinjection Wellpad	Tributary	25.5	31.1	788.04	788.12
NIL Power plant South	Tributary	64.3	87.0	797.09	797.37
NIL Power plant North West	Tributary	3.8	4.6	810.24	810.27
NIL Power plant North East	Tributary	3.0	3.7	803.79	803.82
NIL Sites - Hamilton Bridge	Batang Toru	2478.8	3259.9	613.51	614.53
SIL Power plant West	Tributary	65.9	89.6	506.30	506.52
SIL Power plant East	Tributary	28.1	34.3	530.02	530.14
SIL Sites - Batang Toru	Batang Toru	2413.9	3177.7	492.78	493.20

Comparison with Table 6.2 indicates that flood levels for the tributary catchments are up to approximately 1.3m higher when considering Type B soils. The Batang Toru at Hamilton Bridge is approximately 2m higher. Despite some higher water levels, it is noted that four of the sites show only small increases of no more than 0.3m. These levels have been checked against the design levels stated in Table 6.3 and it is confirmed that these increases would have minimal impact on the flood risk potential at each site.

Another important contributor to uncertainty is the exclusion of the Sibolga rainfall station. To understand the effects of including this rainfall station, the analysis was recomputed with the Sibolga rainfall data included. This is a useful parameter to test as rainfall patterns have a significant impact on flood levels and the availability of long term records in the area is a serious limitation.

The results of this sensitivity analysis are shown in Table 6.5.

Table 6.5: Summary of Sensitivity Analysis Results: Includes Sibolga Rainfall Station

Catchment	Watercourse	1 in 100 year Flood Flow (m^3/s)	1 in 500 year Flood Flow (m^3/s)	1 in 100 year Flood Level (m)	1 in 500 year Flood Level (m)
NIL 1 Wellpad	Tributary	42.2	78.0	854.15	854.55
NIL WJR-1 Reinjection Wellpad	Tributary	31.0	37.5	788.12	788.20
NIL Power plant South	Tributary	47.6	72.1	796.87	797.19
NIL Power plant North West	Tributary	4.6	5.6	810.27	810.30
NIL Power plant North East	Tributary	4.0	5.2	803.83	803.86
NIL Sites - Hamilton Bridge	Batang Toru	4058.6	5660.3	615.37	616.47
SIL Power plant West	Tributary	73.6	68.0	506.19	506.31
SIL Power plant East	Tributary	34.0	45.0	530.14	530.33
SIL Sites - Batang Toru	Batang Toru	3902.7	5465.8	493.38	494.32

The inclusion of the Sibolga rainfall station significantly increases the flow rates and the flood levels. Comparison with Table 6.2 indicates that flood levels for the tributary catchments are up to approximately 1.1m higher when including the Sibolga rainfall station. The Batang Toru at Hamilton Bridge is approximately 4m higher. Despite some higher water levels, it is noted that four of the sites show only small increases of no more than 0.5m. These levels have been checked against the design levels stated in Table 6.3 and it is confirmed that these increases would have minimal impact on the flood risk potential at each site.

These sensitivity tests have shown that there is potentially significant impact on flows and water levels when adopting a different soil type in SCS or including the Sibolga rainfall station. However, the extent to which the sites are raised from these watercourses suggests that the uncertainties involved in the analysis would have little impact on the overall conclusions.

7 Conclusions

7.1 Conclusions

The main conclusion of this assessment is that there is a very low risk of flooding from the Batang Toru River to the NIL and SIL wellpad and power plant sites, with all calculated flood levels significantly below design levels.

The majority of the tributaries that pass close to the NIL and SIL sites also pose very low flood risk. However, there are three tributaries which pose some risk to three sites:

- NIL Power Plant - Tributary draining North West catchment: Whilst the site is raised by at least 2.8m from the calculated flood levels it will be important to ensure there is adequate stream diversion as the site will block the NIL North West catchment valley and this has the potential to cause flooding.
- SIL 1 Wellpad might be at risk from overland flow from the overtopping of small drainage ditch to the NE but this risk is low and volumes of water would be limited. Depending on the chosen level and location of the additional SIL 1 Wellpad there may be some limited flood risk from overland flow. Appropriate site drainage would mitigate this risk as the site is located in a sloping area.
- SIL Power Plant site is at risk of flooding from the small tributary which drains the catchment covering the east side of the site. Adequate stream diversion will be required as the SIL Power plant site will block this small catchment valley.

Overall it is considered that with appropriate stream diversion and on site drainage this low level of flood risk can be mitigated. It should be emphasised that these risks are from small catchments that would contribute runoff to the site locations. This should be considered as part of the site drainage design.

7.2 Uncertainties and Assessment Limitations

It should be noted that this flood risk assessment is preliminary in nature and the level of detail of the assessment has been limited to the project timeframe of one month and the availability of climatological and topographic information.

In light of this the following uncertainties need to be emphasised:

- Flood risk has not been considered in relation to the road network, bridges or other infrastructure associated with the sites;
- Land use change, in particular deforestation in the catchments, may increase flood flows;
- Annual maximum rainfall data that has been supplied by Badan Meteorologi, Klimatologi, dan Geofisika (Meteorological Department) in Medan is a partial record for all of the identified stations and cannot be verified;
- Available rainfall records for stations within or close to the catchment are very limited (about 7 years); this means that estimates of 100-year and 500-year rainfalls are subject to substantial uncertainty.
- There is not enough reliable flow gauged data to be able to undertake any statistical analysis of recorded flood flows on the Batang Toru. The assessment is therefore based on the SCS approach

with adjustment of the Curve Number to provide the closest match to the Flood Design Manual estimates for Java and Sumatra;

- The topographic survey is limited in its extent and has not considered the river channels in detail. Hydraulic calculations have been undertaken where adequate topography of the channel and floodplain exists;
- The hydraulic calculations are basic steady state assessments and no detailed modelling has been undertaken;
- The climate change analysis is based on a summary of observed data and the results of climate model experiments, rather than a summary of the existing literature on projected climate change. Any decision-making based on this analysis should be used with reference to other studies which make use of alternative techniques and information; and
- Modelled data for the future are not predictions of climate, but model simulations of future climate under a range of hypothetical emissions scenarios. Further research or analysis should take account of the accuracies and uncertainties associated with these projections.

Whilst these uncertainties need to be recognised in this case, the extent to which the sites are raised from these watercourses suggests that the uncertainties involved in the analysis would have little impact on the overall conclusions.

8 References

Case, M., Ardiansyah, F., Spector, E., 2007, Climate Change in Indonesia, World Wide Fund for Nature (WWF), http://assets.panda.org/downloads/inodesian_climate_change_impacts_report_14nov07.pdf [Accessed 10 August 2013].

Institute of Hydrology, 1983, Flood Design Manual for Java and Sumatra, Wallingford, UK

Institute of Hydrology, 1995, Allowance for discretization in hydrological and environmental risk estimation, Wallingford, UK

McSweeney, C., New, M. & Lizcano, G. 2010. UNDP Climate Change Country Profiles: Indonesia. Available: http://country-profiles.geog.ox.ac.uk/ [Accessed 20 September 2013].

Met Office, 2011, Climate: Observations, Projections, and Impacts, United Kingdom, http://www.metoffice.gov.uk/media/pdf/8/f/Indonesia.pdf [Accessed 17 September 2013.

Thomas, V., Albert J., Perez, R., 2013, Climate-Related Disasters in Asia and the Pacific, Asian Development Bank (ADB), http://www.adb.org/sites/default/files/pub/2013/ewp-358.pdf [Accessed 17 September 2013].

Van der Weert, R., 1994, Hydrological Conditions in Indonesia, Delft Hydraulics, Jakarta

Appendices

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Appendix A. Annual Maximum Rainfall Data

This appendix includes a summary of the annual maximum rainfall data collected from rainfall stations located within the vicinity of the Batung Toru basin. The data was obtained from the Badan Meteorologi, Klimatologi, dan Geofisika (Meteorological Department) in Medan.

Table A.1: Annual Maximum Rainfall Data

	Annual Maximum Rainfall (mm)					
Year	Sibolga	Purba Tua	Pahae Jae	Pahae Julu	Tarutung	Simalungun
1974	112					
1975	103					
1976	136					
1977	167					
1978	154					
1979	136					
1980	196					
1981	100					
1982	215					
1983	121					
1984	167					
1985	149					
1986	180					
1987	110					
1988	113					
1989	106					
1990	166					
1991	298					
1992	120					
1993	98					
1994	141					
1995	154					
1996	197					
1997	205					91
1998	265					92
1999	226					86
2000	330					88
2001	175					103

	Annual Maximum Rainfall (mm)					
Year	Sibolga	Purba Tua	Pahae Jae	Pahae Julu	Tarutung	Simalungun
2002	185					70
2003	199					76
2004	126					105
2005	161					88
2006	153	104	48	47	46	65
2007	424	115	79	70	60	105
2008	162	55	138	42	26	74
2009	175	50	108	60	77	100
2010	171	92	142	55	67	86
2011	269	75	175	26	65	96
2012	108	102	130	78	59	61
Average	**174**	**85**	**117**	**54**	**57**	**87**
Average (2006 – 2012)	**204**	**85**	**117**	**54**	**57**	**84**

Source: Department of Meteorology, Climatology, and Geophysics, Medan, 2013

Appendix B. Hydraulic Calculations

This appendix includes cross sections from the hydraulic calculations generated from HEC-RAS. The elevation data for the cross sections were derived from the detailed topographic data using ArcGIS.

Figure B.1: Cross-section of NIL 1 Pad

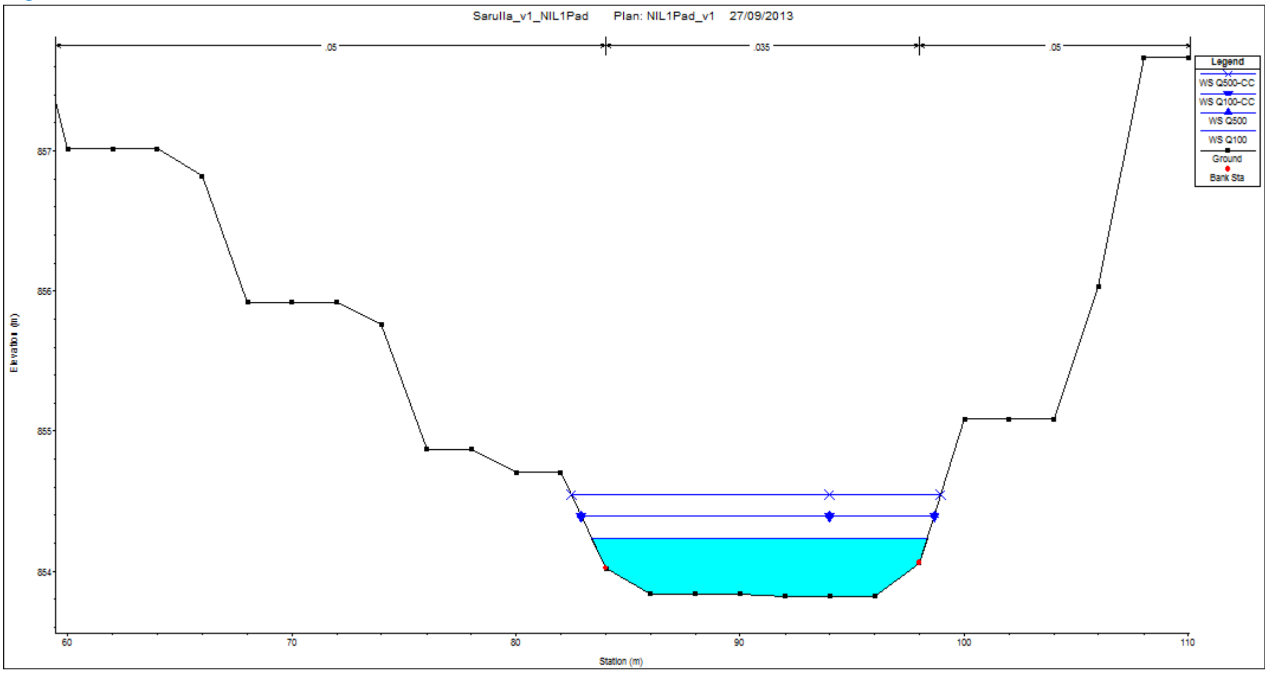


Figure B.2: Cross-section of NIL WJR-1 Reinjection Wellpad

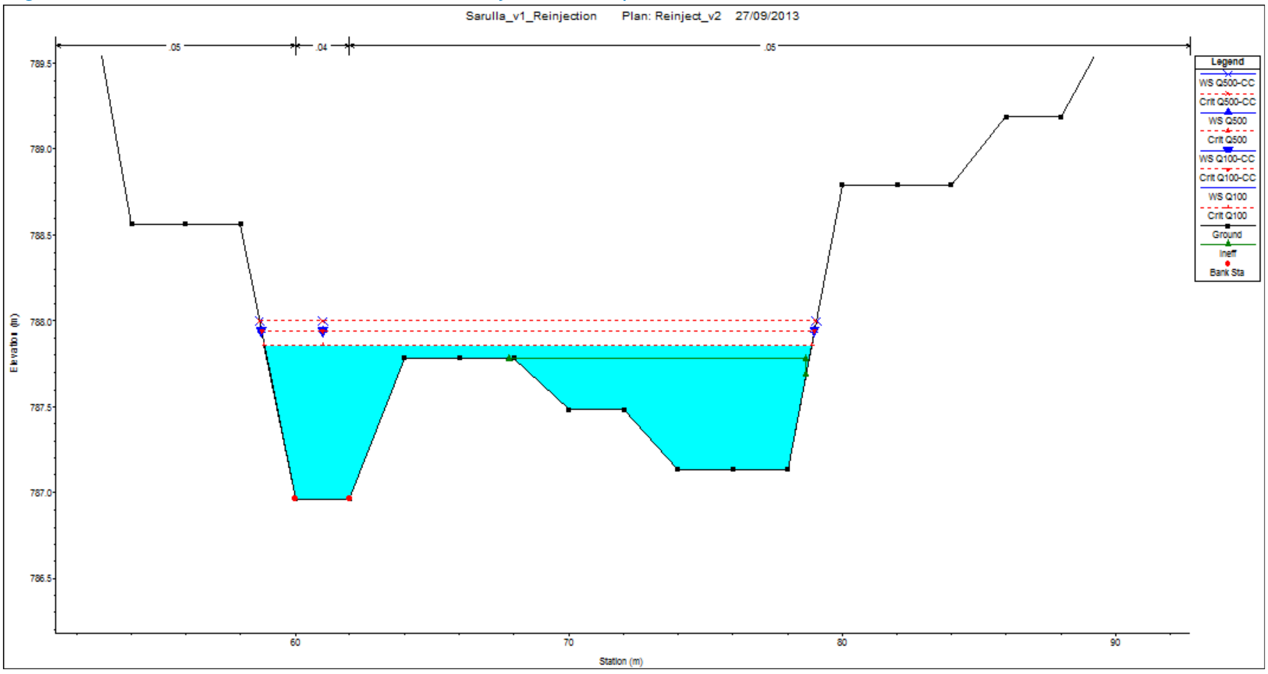


Figure B.3: Cross-section of NIL Power plant South

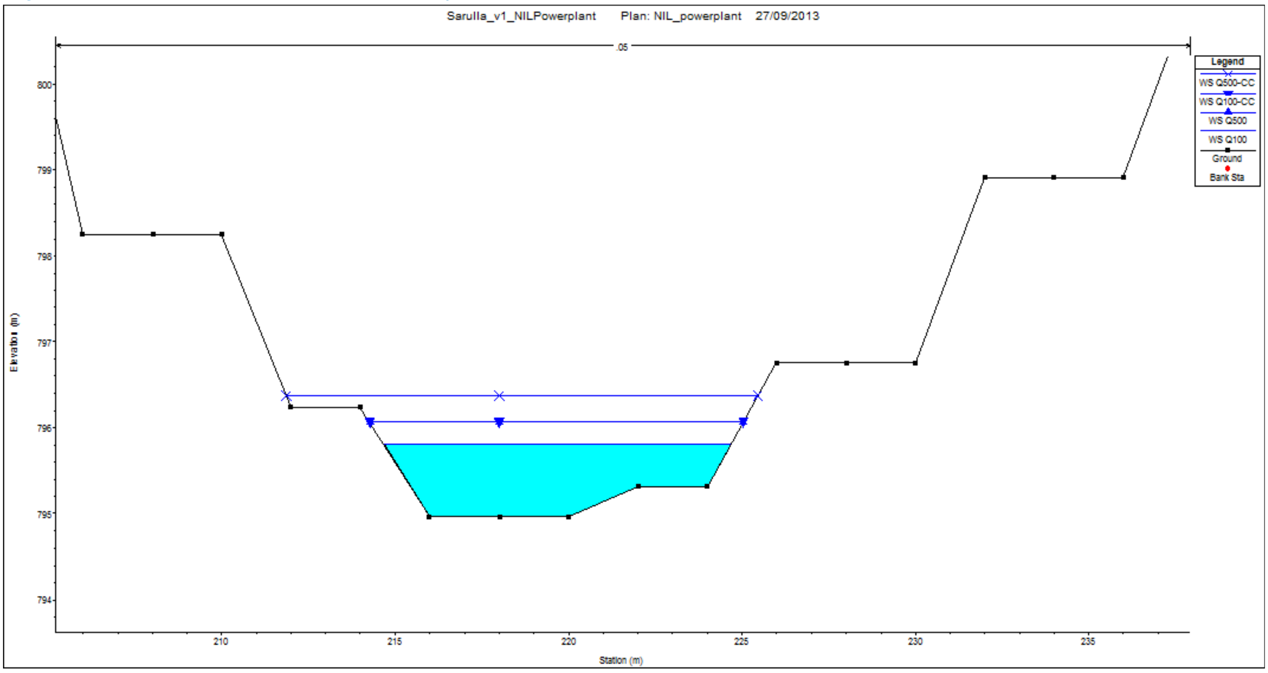


Figure B.4: Cross-section of NIL Power plant North West

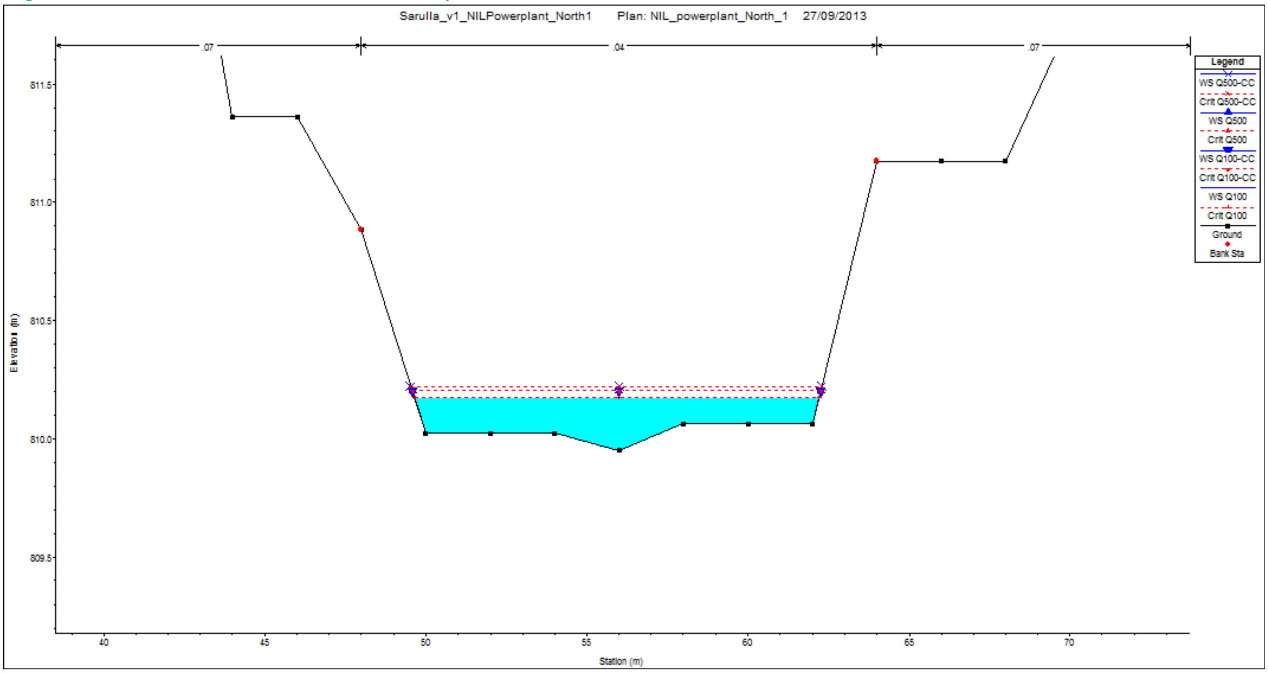


Figure B.5: Cross-section of NIL Power plant North East

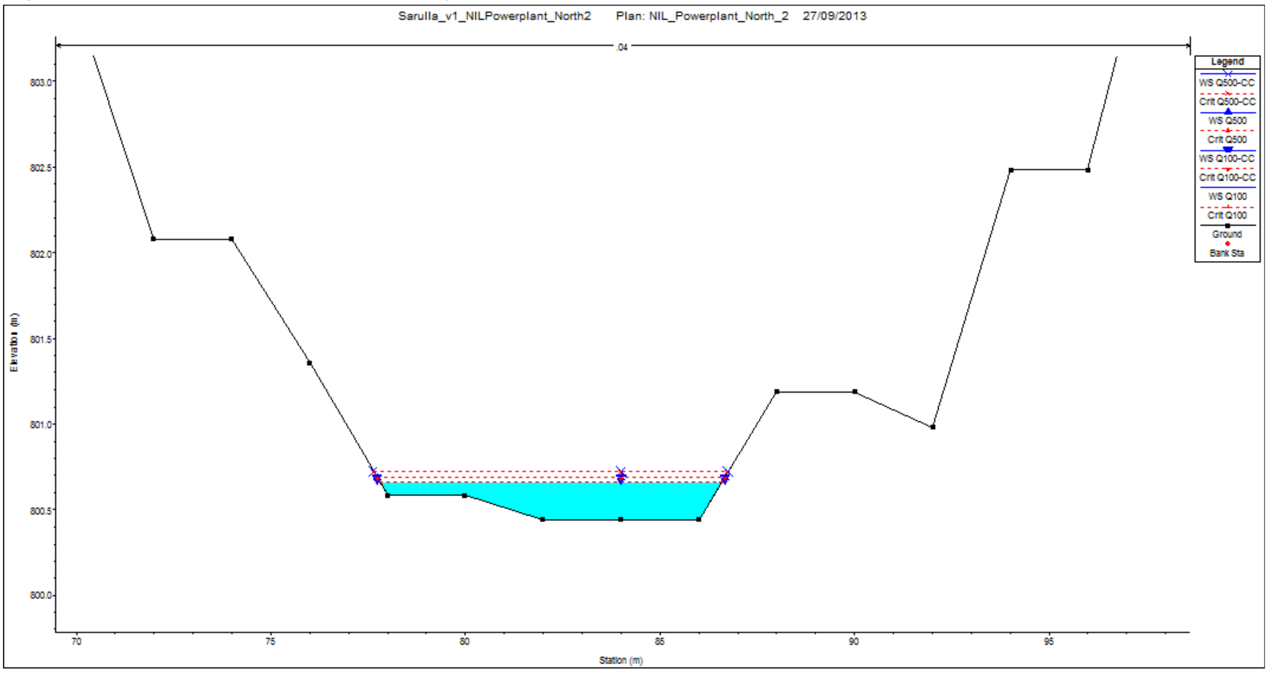


Figure B.6: Cross-section of NIL Sites – Hamilton Bridge

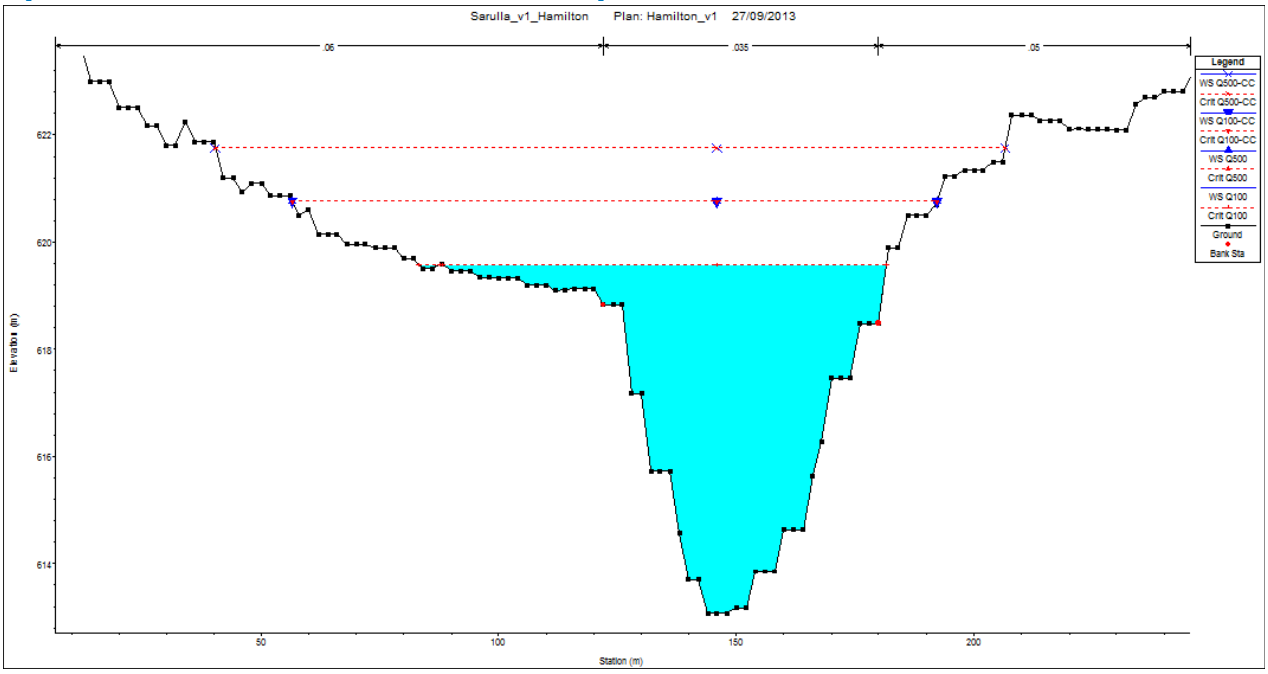


Figure B.7: Cross-section of SIL Power plant West

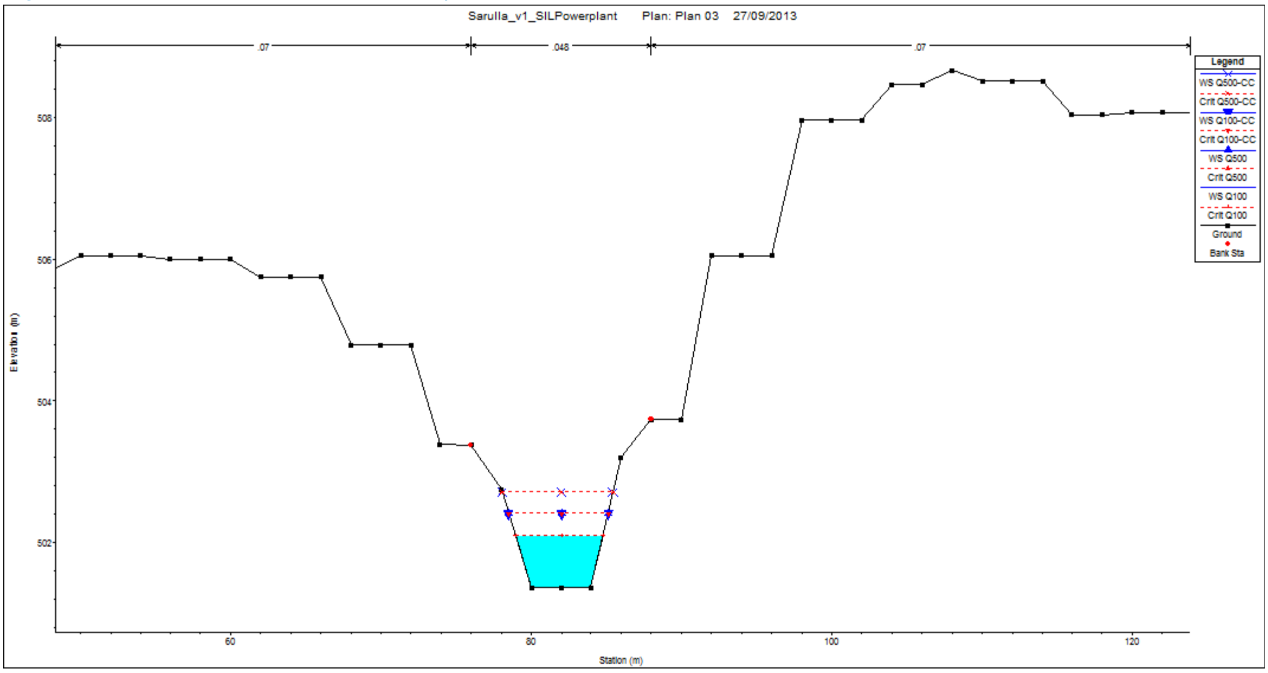


Figure B.8: Cross-section of SIL Power plant East

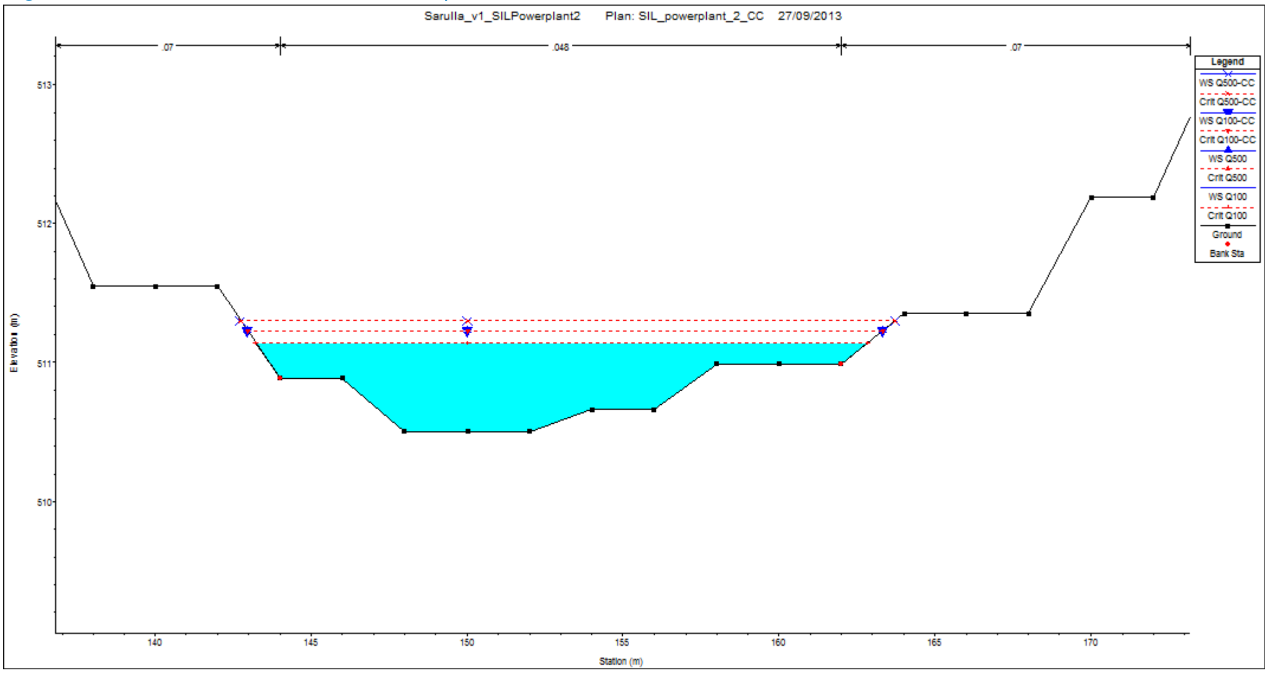
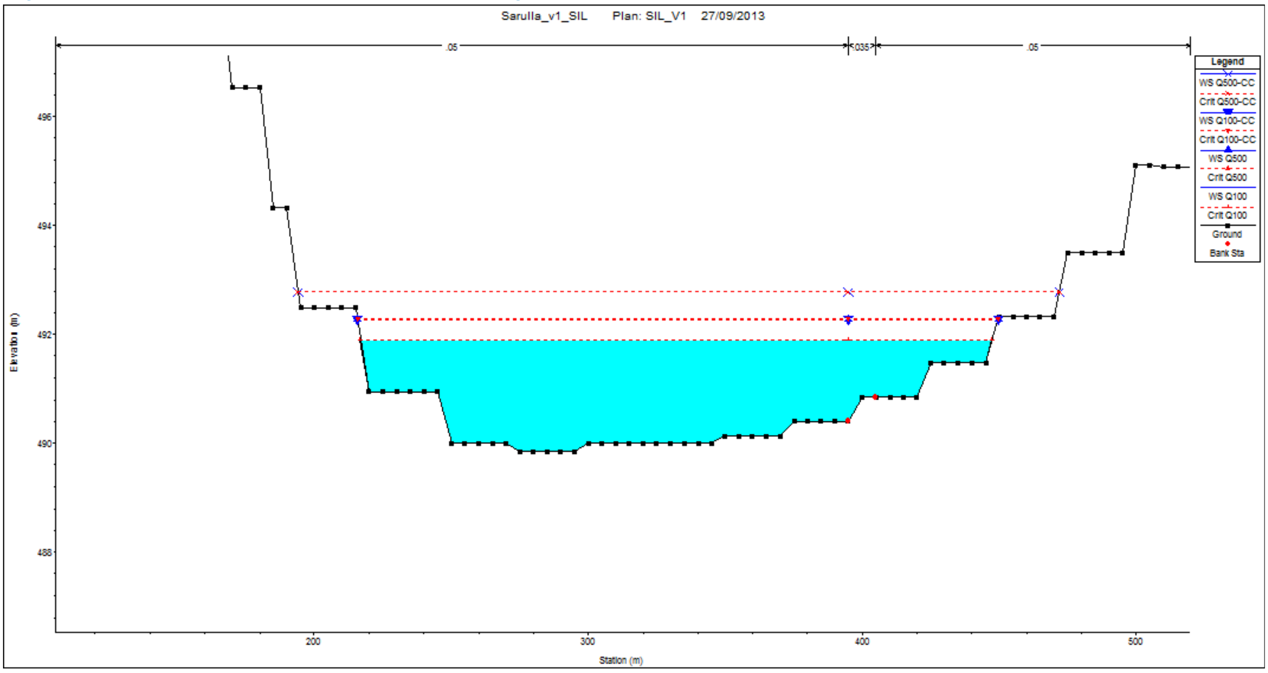


Figure B.9: Cross-section of SIL Sites – Batang Toru



Annex D

Steam Field Piping Network Review

Mott MacDonald

Sarulla geothermal project

Introduction

Mott MacDonald has been asked to provide an independent high level review of the steam field piping network for the Sarulla geothermal development. This review focuses on the steam field only, from the separation plants to the power plant itself.

Project description.

The Sarulla geothermal project consists of two power plant site locations. There is the Silangkitang development (SIL), preliminary assessed to be a 110 MW development. The second steam field and power plant is roughly 15 km (by road) to the north, called Namora-I-Langit (NIL). This field is assessed to be capable of producing 220 MW. It is the intention to develop the Project in three (3) phases. The first phase is for a 110 MW capacity from SIL, followed by NIL-1 phase at 110MW and NIL-2 phase at 110MW. Planned commercial operation dates of each phases are 30, 40 and 46 months reckoned from the Project's successful achievement of financial closing. Conceptual studies, field modeling and initial engineering/design, including those for the steam field separation and pipe gathering systems have been prepared. This includes heat mass balance, process flow diagram, conceptual layout of pipe gathering and in NIL, a relatively detailed pipe routing have been prepared.

Brief overview of the process.

The production wells produce hot, pressurized fluid called a two-phase fluid because it contains both liquid and steam. The two-phase fluid pipelines from well head to separation plant have been kept short, and the separation stations are located close to the wellheads. This is good practice, as two-phase fluids can form slugs of liquid (as opposed to the flow regime where the liquid flows along the pipe walls and steam on the inside) which results in undesirable water hammer.

Within the separation stations, the two-phase fluid is separated into steam and brine. One separation station generally handles the fluid of several production wells (see process flow diagram (PFD) attached in Appendix 1).
The brine and steam are piped (within the same corridor) to the power plant, where the thermal energy is converted to electrical energy. The resulting condensate and (colder) brine waste streams are combined piped to the reinjection wells. Reinjection has two principal advantages.

- It avoids disposing of the geothermal liquid to surface water (geothermal liquid may contain bromide, mercury, boron, silicate etc., which at high concentrations are not permitted to dispose to surface waters as it would affect flora and fauna detrimentally).
- Re-injecting the fluid into the field helps in maintaining the field production levels for longer, i.e., helps to maintain field pressure and liquid levels.

Within the power plant the geothermal energy is converted into electrical energy. The steam expands in the (back pressure) steam turbine and exits the back pressure turbine at just above atmospheric pressure. It than enters the bottoming Ormat Energy Converters (OEC) where more electricity is generated. Steam leaves the bottoming OEC's as condensate. The brine converts part of its thermal energy into electricity in a different set of OECs. A simplified process flow diagram is included in Appendix 1.
The plant is equipped with a turbine bypass system that allows the steam (after pressure reduction) to divert directly to the bottoming OECs.
The plant is also equipped with a vent system for the steam (both high pressure and low pressure) in case for some reason the steam can not be used within the power plant, but the production wells have not been shut down yet. The steam is vented to the atmosphere, and mufflers are used to reduce noise levels during venting (but venting is still a very noise event, only done during emergencies)..

The colder brine exits the OEC units at a temperature of around 120 ^{o}C (down from around 185 ^{o}C). At those temperatures scaling is not expected to be a major issue, as minerals remain in solution.

Condensate and used brined are combined together and piped to the designated re-injection wells.

Steam field piping review.

NIL

The NIL power plant geothermal fluid supply is shown to come from 3 production wellpads namely NIL-1n, NIL-2n and WJP-1n. Used geothermal fluid from the NIL power plant is to be re-injected via two (2) reinjection wellpads namely WJR-1n and WJR-2. The planned number of wells to be drilled in each wellpad are:

Wellpad	Number of wells intended for service	Number of wells allocated for failed (dry) wells	Total number of wells drilled in the wellpad
NIL-1n	6	1	7
NIL-2n	7	1	8
WJP-1n	5	0	5
WJR-1n	3	0	3
WJR-2	3	0	3

The geothermal fluid from each of the wellpad will be transported to the power plant via pipelines. The estimated quantities of geothermal fluid that will be flowing in each section of the pipeline connecting the wellpads to the power plant are shown in the table below. The values indicated in the table below reflect the changes in the wellpad configurations adapted by the Project. The heat mass balance diagram and the process flow diagram still need to be updated to reflect those changes. It is noted however that the design pressure and temperature are still the same, the only variation relates to the flowrates. This may have an impact on the pipe sizes, but the pipeline corridors and position of pipe supports and expansion loops is not expected to change significantly.

The estimated quantities of the geothermal fluid flowing through such pipelines are:

From	To	Steam		Brine		Mixed Brine and Condensate		Pipe Length (m)
		Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	
NIL-1n	PLTP	551	11.5 - 10.3	2,250	14-22			~2,000
NIL-2n	PLTP	550	11.5 - 10.3	2,445	14-22			~1,000
WJP-1n	PLTP	410	11.5 - 10.3	1773	14-22			~3,200
PLTP	WJR-1n					3,940	20	~2,000
PLTP	WJR-2					3,940	20	~2,000

PLTP = Power Plant

SIL

The SIL power plant geothermal fluid supply is shown in the table below. Used geothermal fluid from the SIL power plant is re-injected into two (2) reinjection wellpads namely SIL-1 and SIL-2. The planned number of wells to be drilled in each wellpads are:

Wellpad	Number of wells intended for service	Number of wells allocated for failed (dry) wells	Total number of wells drilled in the wellpad
SIL-1 (production)	2 new + 2 existing	1	3
SIL-1 (re-injection)	2	0	2
SIL-2 (reinjection)	3	0	3

The SIL power plant has the same concept as the NIL power plant. Similarly, the SIL steamfield piping will adhere to the same principles as NIL, ie pipe corridors to follow the natural contours of the land as much as possible to reduce the number of vertical changes of direction and keep visual impact minimal.

The estimated quantities of the geothermal fluid flowing through the pipelines are as follows:

From	To	Steam		Brine		Mixed Brine and Condensate		Pipe Length (m)
		Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	Flow (t/h)	P (bar)	
SIL-1	PLTP	579	19.9-19.5	2,315	19			
PLTP	SIL-1					1,146	~16	600
PLTP	SIL-2					1,720	~16	1,800

PLTP = Power Plant

Although a preliminary design and layout for all field pipelines sizes and routes are already completed, only the steam and brine pipelines from the wellpads NIL-1 and NIL-2 to the power plant are designed in more detail (support types, location of expansion loops). Those have been made available for review. We have been informed that all other pipelines will be designed on the same basis.

The information provided in respect to the detailed design of the steam and brine gathering systems for review is still limited. No isometrics or detailed pipe design drawings were available for review. We received a schedule of the pipe material and dimensions used, and a basic layout of the field piping. For example, condensate traps are located along the length of the steam pipes as needed, but no details regarding the position of the traps, or of the piping arrangement for the collected condensate, has been provided. Similar, this information is not yet available for vents and drains that are located along the pipelines.

Furthermore, no information was received regarding the proposed commissioning and testing of the steam field piping systems.

A review of the available information regarding the steam and brine pipes from separation plants NIL-1 and NIL-2 to the power plant showed that the pipelines follow the contour of the field. The steam and brine pipes follow the same corridor. The pipes are arranged at grade, which makes them easily accessible for inspection and maintenance purposes. There are fixed anchors on average between 70 and 100 m apart, with an expansion loop in between. Where there is no expansion loop as such, the pipes have a change in direction which serves as an expansion loops. Sliding supports are provided to accommodate the pipe movement. This design is acceptable.

When shutting down the pipelines, the temperature will drop over time, and especially for the brine pipes, dissolved solids will come out of solution and tend to deposit within the pipe as scale. This reduces the pipeline capacity and increases the pressure drop along the pipeline, both undesirable effects. The pipe gradient is generally above 1%, which means that draining of the pipes should not be a problem. There are also few changes of grade, which makes the operational procedures for draining the pipelines much easier.

The material used for the piping is in accordance with ASTM A53 or ASTM A106, with a corrosion allowance of 3mm. Given the temperature and pressure range of the steam and brine in question, the proposed materials are acceptable.

Although the steam field piping design is in accordance with typical steam field piping standards and practices, things can go wrong. Geothermal fields, by their very nature, are often located within seismically active areas. Even though the design standards take this seismic activity into account, there is always a risk that the actual seismic activity is more severe than anticipated (point in case the earthquake in Christchurch, NZ, where a previously inactive fault moved).

Catastrophic pipe ruptures of field lines will result in a very visible steam cloud, which is likely to be noticed by the steam field operators. This is self-explanatory for steam lines. If a two-phase flow or brine line ruptures, the pressure loss results in the brine flashing into steam and boiling water. The steam cloud will alert field staff that something is wrong. At the same time, the resulting loss of pressure of the incoming fluid into the power plant alerts the plant operators that something is wrong in the field, and they will contact the steam field staff to check it out. The steam field operators will isolate the affected pipeline, close the separation plant and/or the associated wells, if needed.

Small leakages will occur during the operational phase of the project, such as leaks on pipe fittings, flanges, gaskets, condensate traps etc. Those leakages are generally small, and will be picked up by the steam field operators during their regular inspections of the field installations.

A third possible area of leaks could be the result of the corrosive action of the liquids on the pipe material. The composition of fluids from each well differs, and is likely to change over time as well. Some well samples have a pH as low as 2.3, but the average pH is (based on available fluid characteristics for the wells) is expected to be only slightly acidic for NIL and neutral to slightly alkaline for SIL. The pipe material has been selected taking into account the geothermal nature of the fluids, and a 3mm corrosion allowance has been included in the pipe specifications. But it is possible that the geothermal fluid composition changes over time.
Steamfield piping will be subject to regular O&M inspections, during which the pipes will be assessed for corrosion damage (expected to occur say every three to five years, depending on actual experience during operations). If this corrosion damage is not picked up during O&M inspections, and severe pipeline corrosion actually results in pipe leakage, this initial leakage is likely to be small. However, the evidence of pipeline leakage is expected to be picked up by field operators.

Geothermal fluids are also prone to scaling, where dissolved solids deposit within pipes, specially on cooling. Scaling is generally easier to detect, as the pressure drop along the pipeline increases and the mass flow decreases. Those parameters are monitored over time, and trend analysis will indicate if scaling is affecting the field pipes or not. Appropriate steps will have to be taken to remedy this, either cleaning of the pipes

(mechanically and/or chemically), or replacement. These activities are not expected to result in any major fluid spills.
Both issues (scaling and corrosion) require that pipelines will need to be inspected on a regular basis to assess their condition. This is recognized and part of normal steamfield operating practice.

Any steam that escapes will be dispersed into the atmosphere. The steam contains a small amount of non-condensable gases such as CO_2, H_2S, N_2, NH_3 and CH_4. Concentrations of those gases is sufficiently low (total about 2.7% for SIL and 6.5% for NIL, of which CO_2 is the main constituent at 95% and 97% respectively) as not considered to be harmful to health in case of a steam pipe rupture.
In case of a brine pipeline rupture, the brine will follow the contours and eventually drains itself into the surface water within the area or seeps into the groundwater. The fields are within a narrow valley, drained by the Batung Toru river. This river is a substantial river, with an estimated flowrate of around 100 m3/s. The total brine flow from NIL is around the 1.5 m3/s, and hence from a thermal dispersion point of view the impact on the main river is likely to be acceptable. However, the effect on much smaller contributory rivers is likely to be more extensive, depending on where the actual rupture occurred. This aspect needs to be reviewed within the environmental assessment of the project.

We have not received the project's detailed approach to automation and associated instrumentation. The Process Flow Diagram (PFD) provided indicates the use of motorized control valves from each well going into the separation system, which can be controlled remotely in case of a need to shut down the wells. It may not automatically recognize a situation where pipes have ruptured as the level of automation has not been finalized. However, even if the control system does not automatically pick up a ruptured pipe, the power plant operators will, as the incoming energy into the plant will not be sufficient to produce the required power output. Field operators will be sent out into the field to investigate, and they will close down the required separation plant or well heads, if that has not already been initiated remotely by the station operators. With good steamfield and O&M practices it is expected that any pipeline rupture will be contained within a 24-hr period.

Conclusions

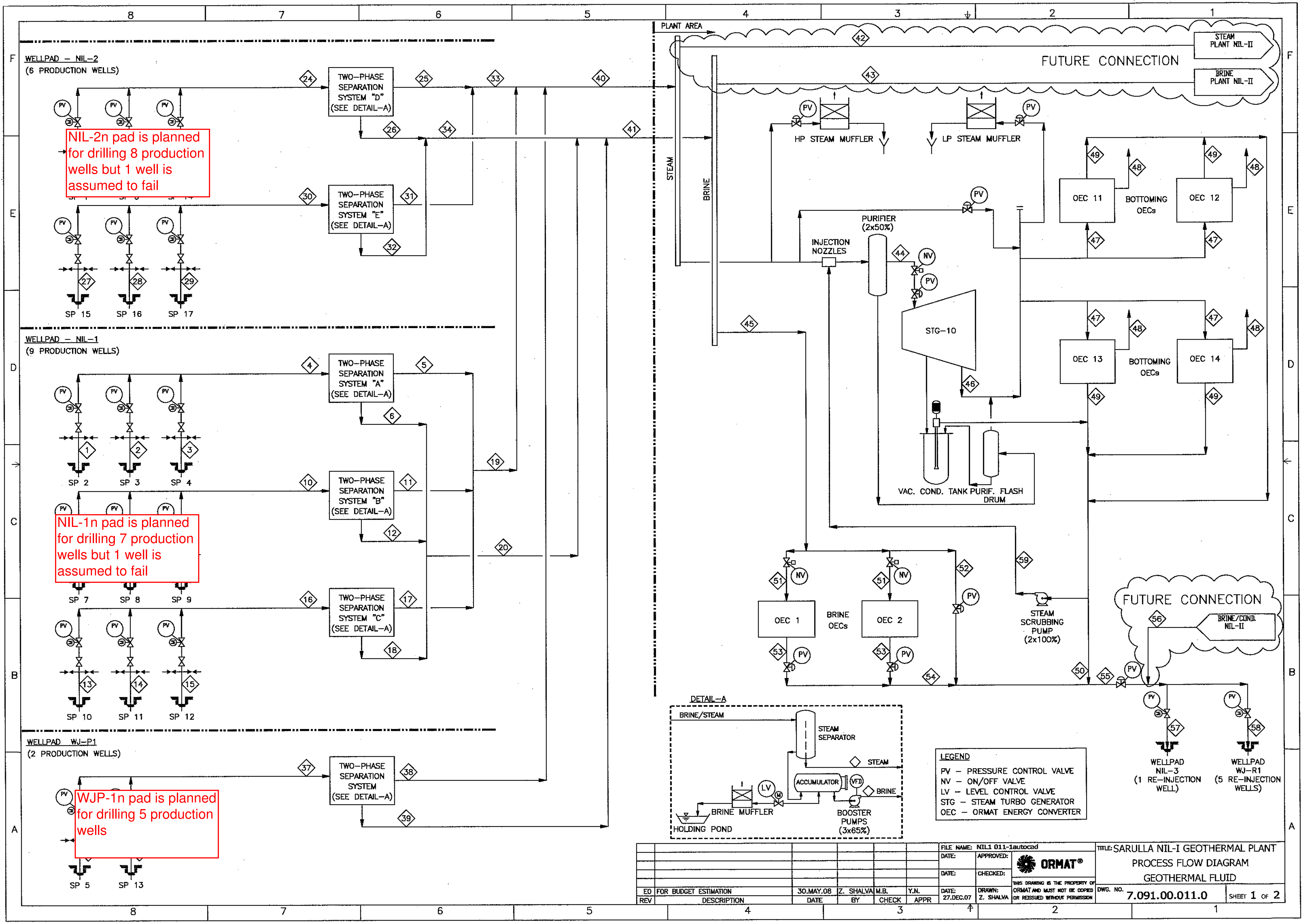
Although the final pipe size dimensions have not been finalized, the approach to the design and standards used are acceptable. The pipeline corridors identified for both the NIL and SIL fields for the brine and steam pipe lines from the separation plants to the power plants follow the local contours, has relatively few changes in the vertical direction, which results in simplifying the venting and drainage equipment needed. It also reduces the visual impact of the field piping.
The well heads have motor controlled main valves, so can be closed remotely if something unexpected does go wrong.
Unexpected failure of either steam or brine pipe lines will result in clearly visable steam plumes, which will be picked up by field staff, and appropriate measures will be taken to

limit the impact of those failures. At the same time, control room staff will notice the reduction in plant output due to pipe failure, and will also contact steam field staff to check what is happening. It is our expectation that any unexpected failure of steam field piping will be discovered and any discharges to the surface be controlled well within 24 hrs.

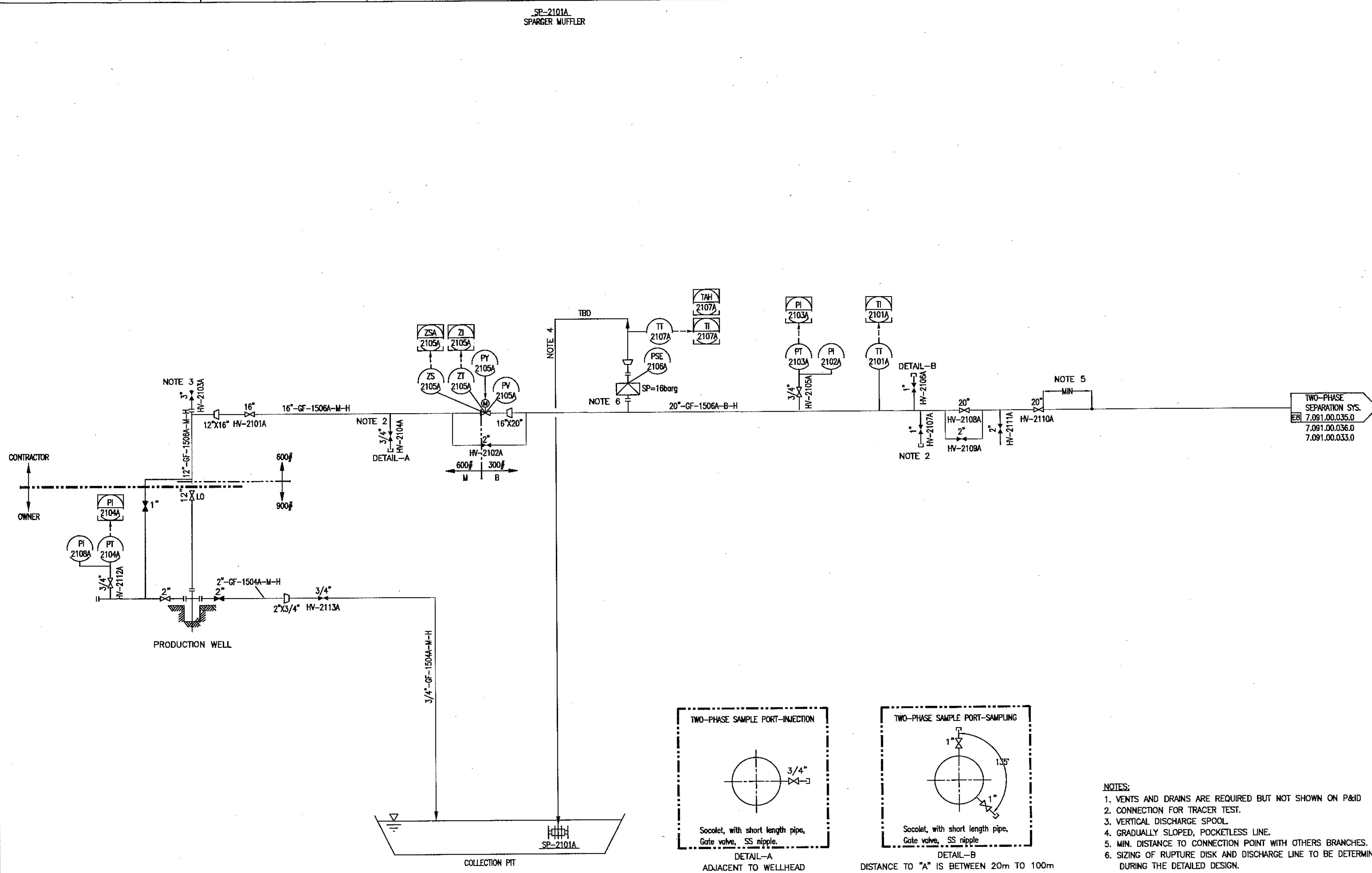
Appendix 1

Overall field process flow diagram

Simplified power plant process flow diagram.



PLANT AREA
FUTURE CONNECTION
STEAM PLANT NIL-II
BRINE PLANT NIL-II
WELLPAD – NIL-2
(6 PRODUCTION WELLS)
NIL-2n pad is planned for drilling 8 production wells but 1 well is assumed to fail
TWO-PHASE SEPARATION SYSTEM "D" (SEE DETAIL-A)
TWO-PHASE SEPARATION SYSTEM "E" (SEE DETAIL-A)
SP 15
SP 16
SP 17
WELLPAD – NIL-1
(9 PRODUCTION WELLS)
TWO-PHASE SEPARATION SYSTEM "A" (SEE DETAIL-A)
TWO-PHASE SEPARATION SYSTEM "B" (SEE DETAIL-A)
TWO-PHASE SEPARATION SYSTEM "C" (SEE DETAIL-A)
SP 2
SP 3
SP 4
NIL-1n pad is planned for drilling 7 production wells but 1 well is assumed to fail
SP 7
SP 8
SP 9
SP 10
SP 11
SP 12
WELLPAD WJ-P1
(2 PRODUCTION WELLS)
TWO-PHASE SEPARATION SYSTEM (SEE DETAIL-A)
WJP-1n pad is planned for drilling 5 production wells
SP 5
SP 13
STEAM
BRINE
HP STEAM MUFFLER
LP STEAM MUFFLER
PURIFIER (2x50%)
INJECTION NOZZLES
STG-10
OEC 11
OEC 12
BOTTOMING OECs
OEC 13
OEC 14
BOTTOMING OECs
VAC. COND. TANK
PURIF. FLASH DRUM
OEC 1
OEC 2
BRINE OECs
STEAM SCRUBBING PUMP (2x100%)
FUTURE CONNECTION
BRINE/COND. NIL-II
WELLPAD NIL-3 (1 RE-INJECTION WELL)
WELLPAD WJ-R1 (5 RE-INJECTION WELLS)
DETAIL-A
BRINE/STEAM
STEAM SEPARATOR
STEAM
ACCUMULATOR
BRINE
BRINE MUFFLER
HOLDING POND
BOOSTER PUMPS (3x65%)
LEGEND
PV – PRESSURE CONTROL VALVE
NV – ON/OFF VALVE
LV – LEVEL CONTROL VALVE
STG – STEAM TURBO GENERATOR
OEC – ORMAT ENERGY CONVERTER
FILE NAME: NIL1 011-1autocad
ORMAT®
THIS DRAWING IS THE PROPERTY OF ORMAT AND MUST NOT BE COPIED OR REISSUED WITHOUT PERMISSION
TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PROCESS FLOW DIAGRAM
GEOTHERMAL FLUID
DWG. NO. 7.091.00.011.0
SHEET 1 OF 2
E0 FOR BUDGET ESTIMATION 30.MAY.08 Z. SHALVA M.B. Y.N.
REV DESCRIPTION DATE BY CHECK APPR
DATE: 27.DEC.07 DRAWN: Z. SHALVA



DETAIL-A
ADJACENT TO WELLHEAD

DETAIL-B
DISTANCE TO "A" IS BETWEEN 20m TO 100m

NOTES:

1. VENTS AND DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID
2. CONNECTION FOR TRACER TEST.
3. VERTICAL DISCHARGE SPOOL.
4. GRADUALLY SLOPED, POCKETLESS LINE.
5. MIN. DISTANCE TO CONNECTION POINT WITH OTHERS BRANCHES.
6. SIZING OF RUPTURE DISK AND DISCHARGE LINE TO BE DETERMINED DURING THE DETAILED DESIGN.

REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

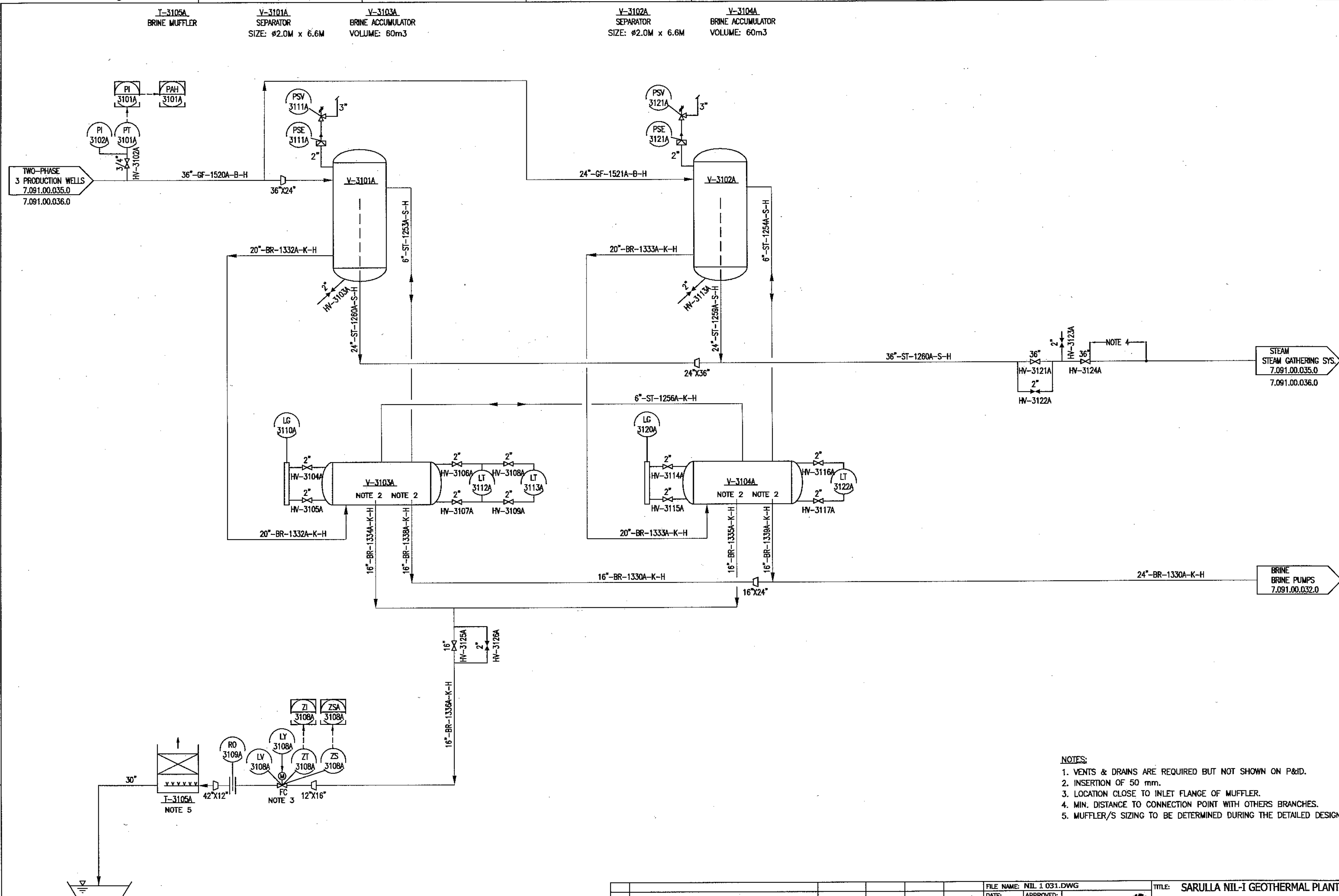
FILE NAME: NIL 1 021.DWG

DATE: | APPROVED:
DATE: | CHECKED:
DATE: 09.MAR.08 | DRAWN: Z. SHALVA

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
PRODUCTION WELL - TYPICAL

DWG. NO. 7.091.00.021.0 SHEET 1 OF 1



NOTES:

1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. INSERTION OF 50 mm.
3. LOCATION CLOSE TO INLET FLANGE OF MUFFLER.
4. MIN. DISTANCE TO CONNECTION POINT WITH OTHERS BRANCHES.
5. MUFFLER/S SIZING TO BE DETERMINED DURING THE DETAILED DESIGN.

REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 031.DWG

DATE: | APPROVED:

DATE: | CHECKED:

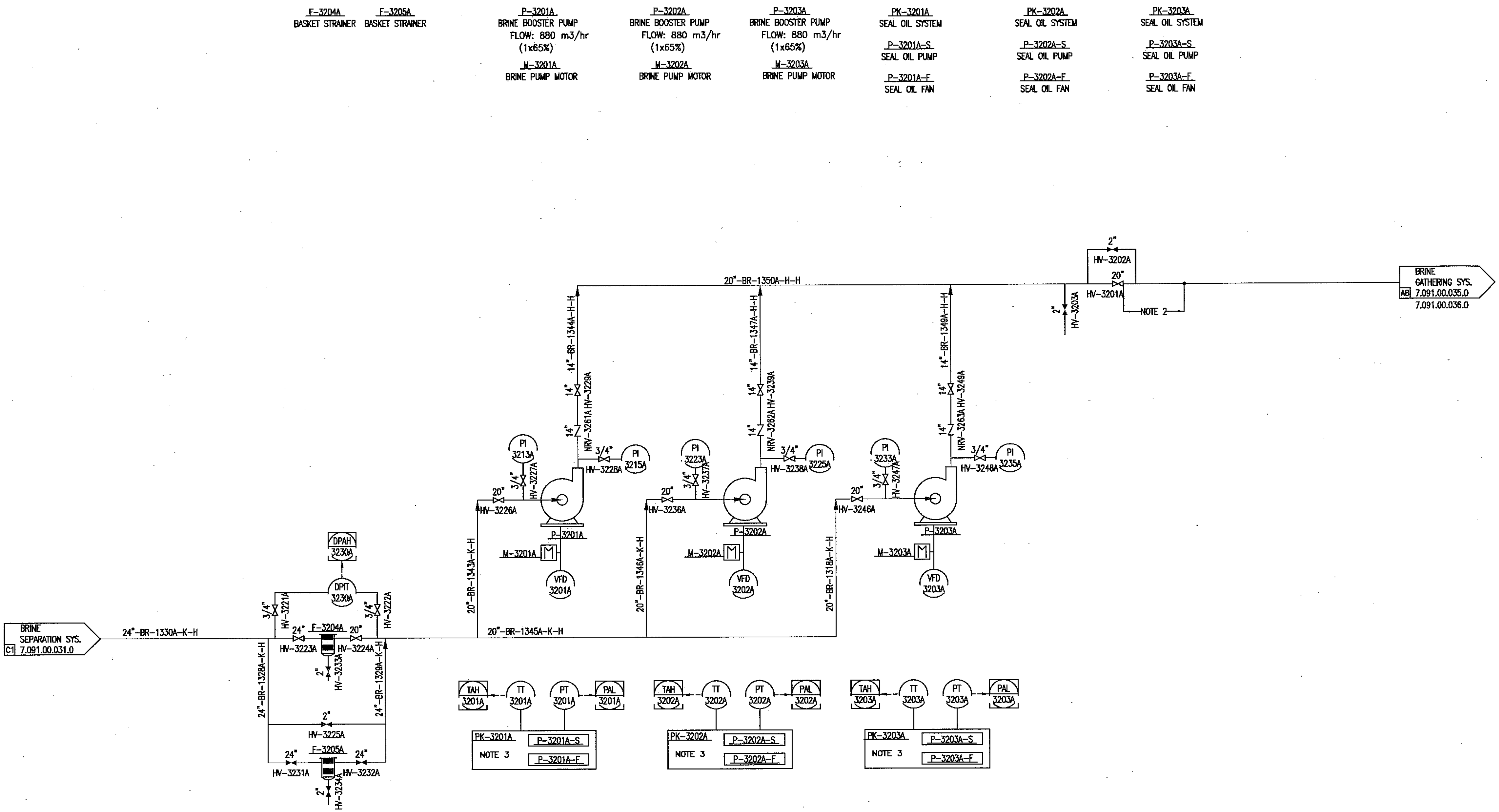
DATE: 23.APR.08 | DRAWN: Z. SHALVA

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
SEPARATION SYS. -TYPICAL FOR NIL-1/2

DWG. NO. 7.091.00.031.0

SHEET 1 OF 1



NOTES:
1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. MIN. DISTANCE TO CONNECTION POINT WITH OTHERS BRANCHES.
3. TYPICAL SEAL OIL SYS. SEE DWG: 7.091.00.073.0.

REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 032.DWG
DATE: | APPROVED:
DATE: | CHECKED:
DATE: 20.MAR.08 | DRAWN: Z. SHALVA

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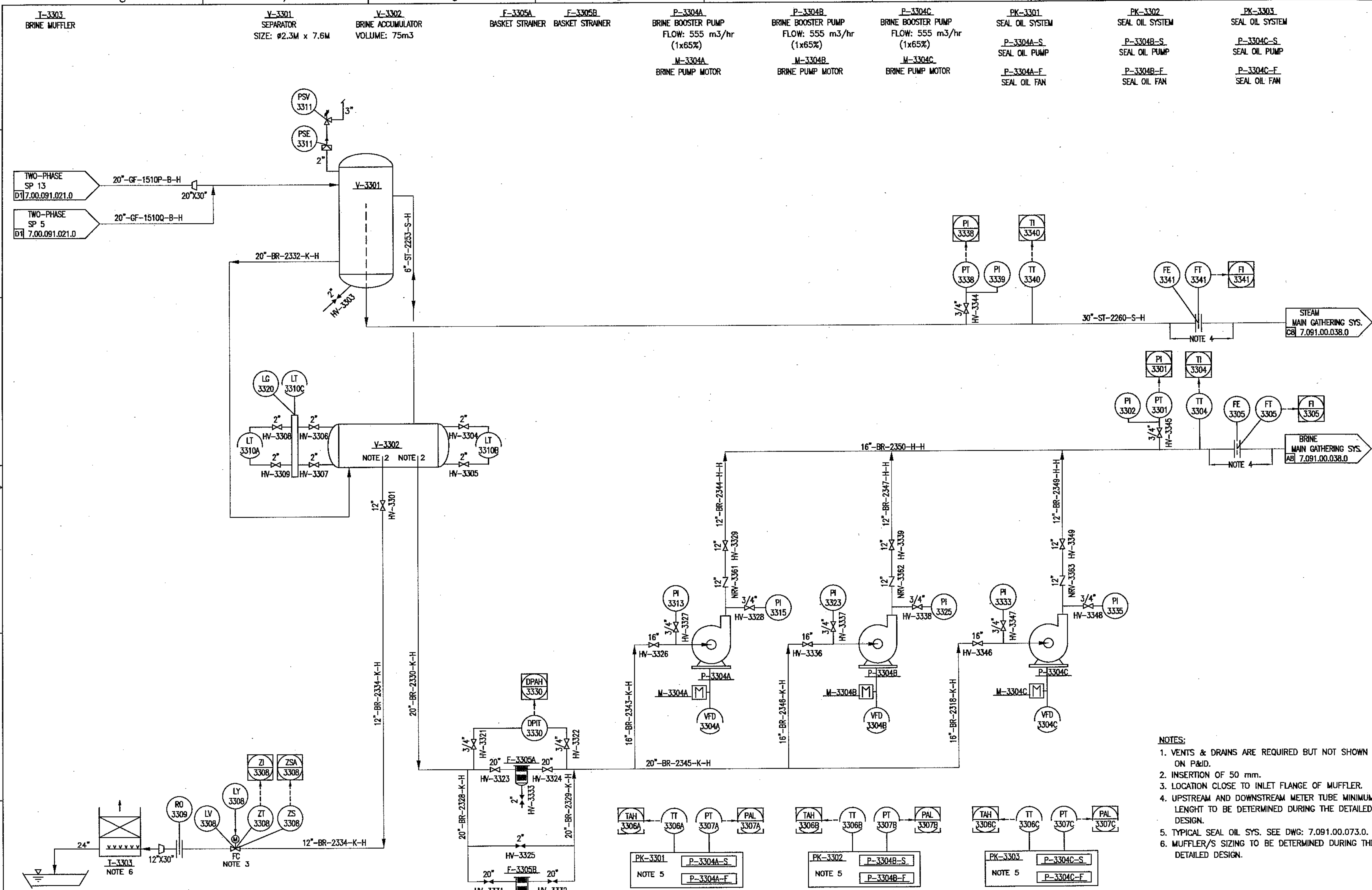
TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
BRINE PUMPS-TYPICAL FOR NIL 1 & NIL 2

DWG. NO. 7.091.00.032.0 SHEET 1 OF 1



NOTES:
1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. INSERTION OF 50 mm.
3. LOCATION CLOSE TO INLET FLANGE OF MUFFLER.
4. UPSTREAM AND DOWNSTREAM METER TUBE MINIMUM LENGHT TO BE DETERMINED DURING THE DETAILED DESIGN.
5. TYPICAL SEAL OIL SYS. SEE DWG: 7.091.00.073.0.
6. MUFFLER/S SIZING TO BE DETERMINED DURING THE DETAILED DESIGN.

REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 033.dwg

DATE: | APPROVED:
DATE: | CHECKED:
DATE: 23.MAR.08 | DRAWN: Z. SHALVA

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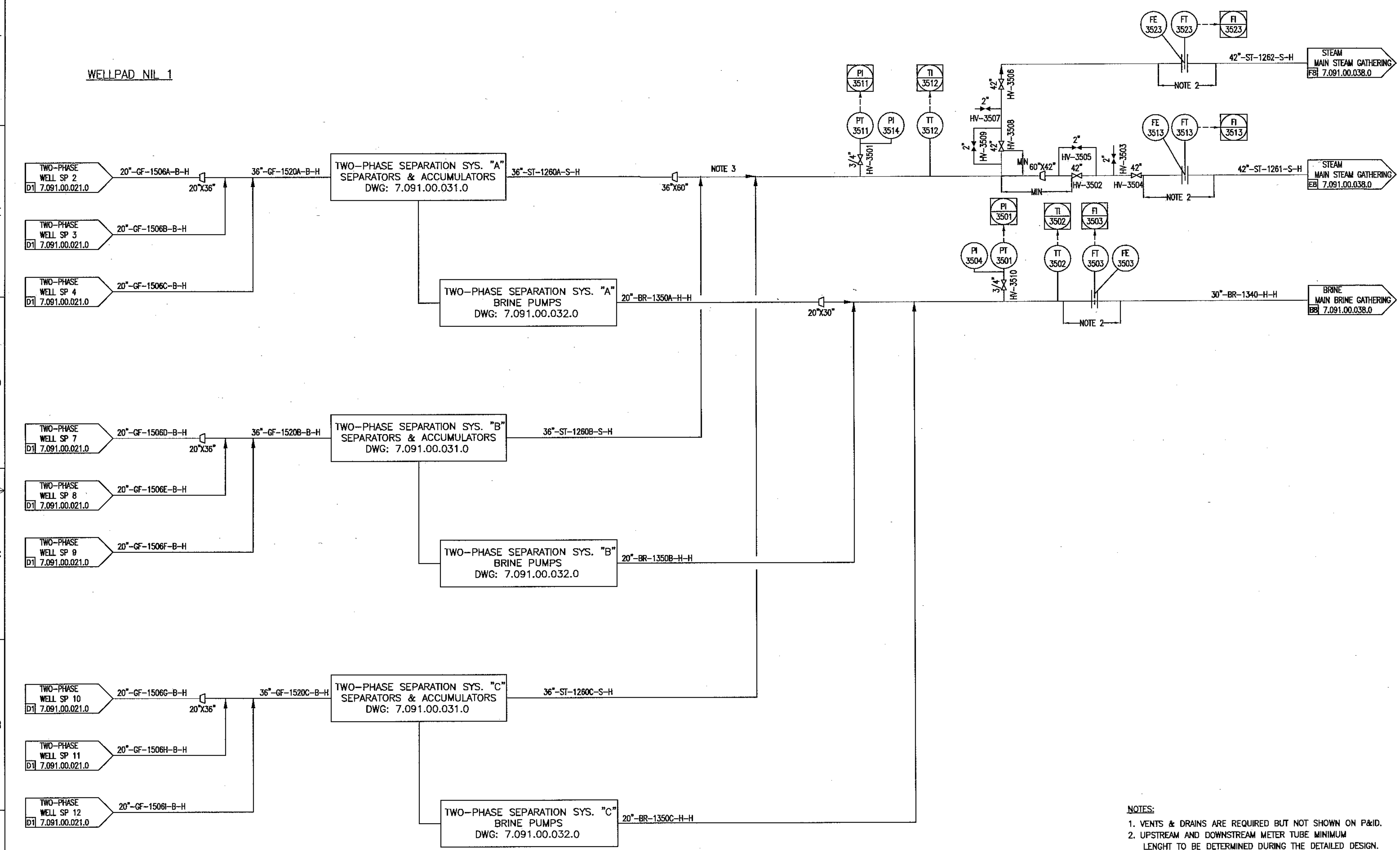
TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
SEPARATION SYSTEM -WJ-P1 PAD

DWG. NO. 7.091.00.033.0 | SHEET 1 OF 1



NOTES:

1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. UPSTREAM AND DOWNSTREAM METER TUBE MINIMUM LENGHT TO BE DETERMINED DURING THE DETAILED DESIGN.
3. THE CONFIGURATION OF THE COLLECTOR TO BE DETERMINED DURING THE DETAILED DESIGN.

REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 035.DWG

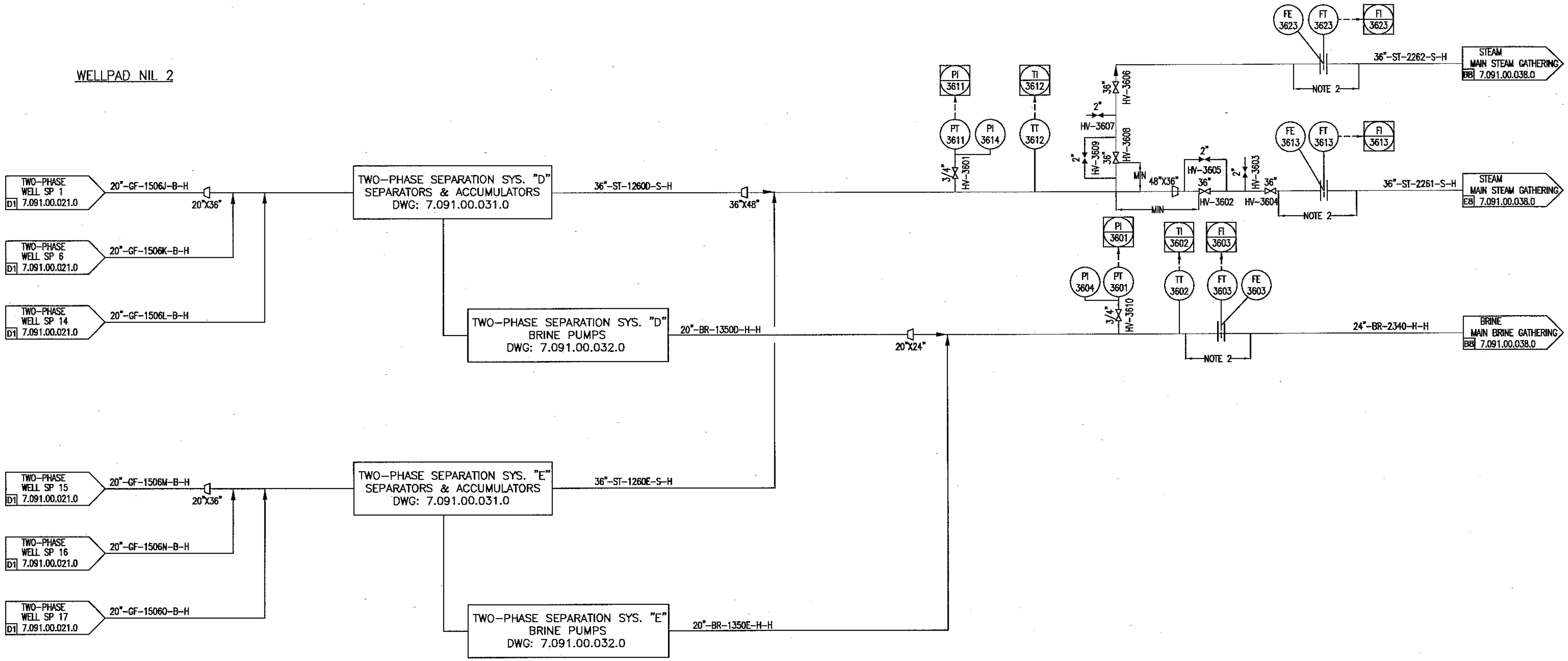
DATE: | APPROVED:
DATE: | CHECKED:
DATE: 23.APR.08 | DRAWN: Z. SHALVA

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
GATHERING SYSTEM WELLPAD NIL 1

DWG. NO. 7.091.00.035.0

SHEET 1 OF 1



NOTES:

1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. UPSTREAM AND DOWNSTREAM METER TUBE MINIMUM LENGHT TO BE DETERMINED DURING THE DETAILED DESIGN.

REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

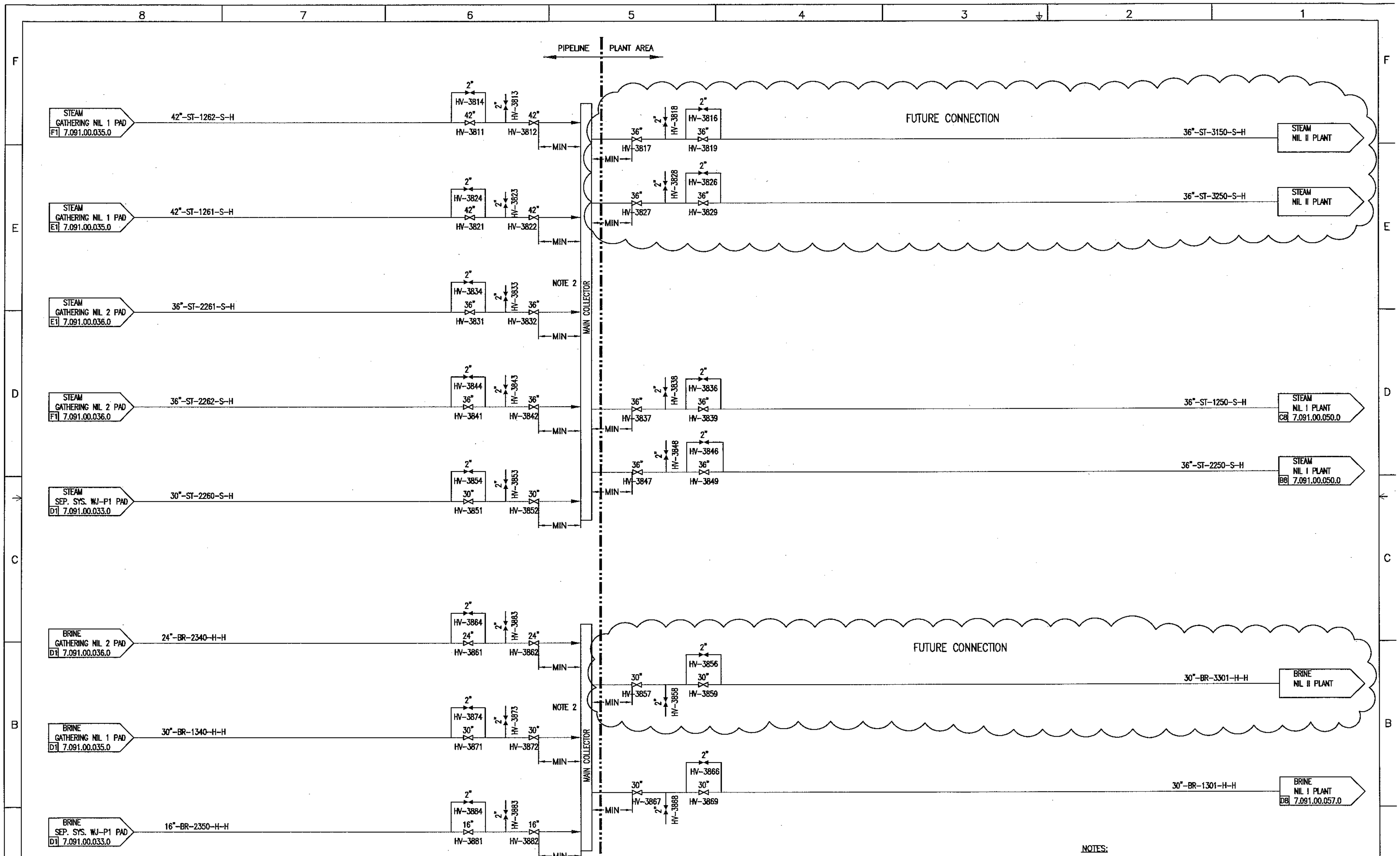
FILE NAME: NIL 1 036.DWG

DATE: | APPROVED:
DATE: | CHECKED:
DATE: .FEB.08 | DRAWN: Z. SHALVA

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
GATHERING SYSTEM WELLPAD NIL-2

DWG. NO. 7.091.00.036.0 SHEET 1 OF 1



NOTES:

1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. THE CONFIGURATION OF THE MAIN COLLECTOR TO BE DETERMINED DURING THE DETAILED DESIGN.

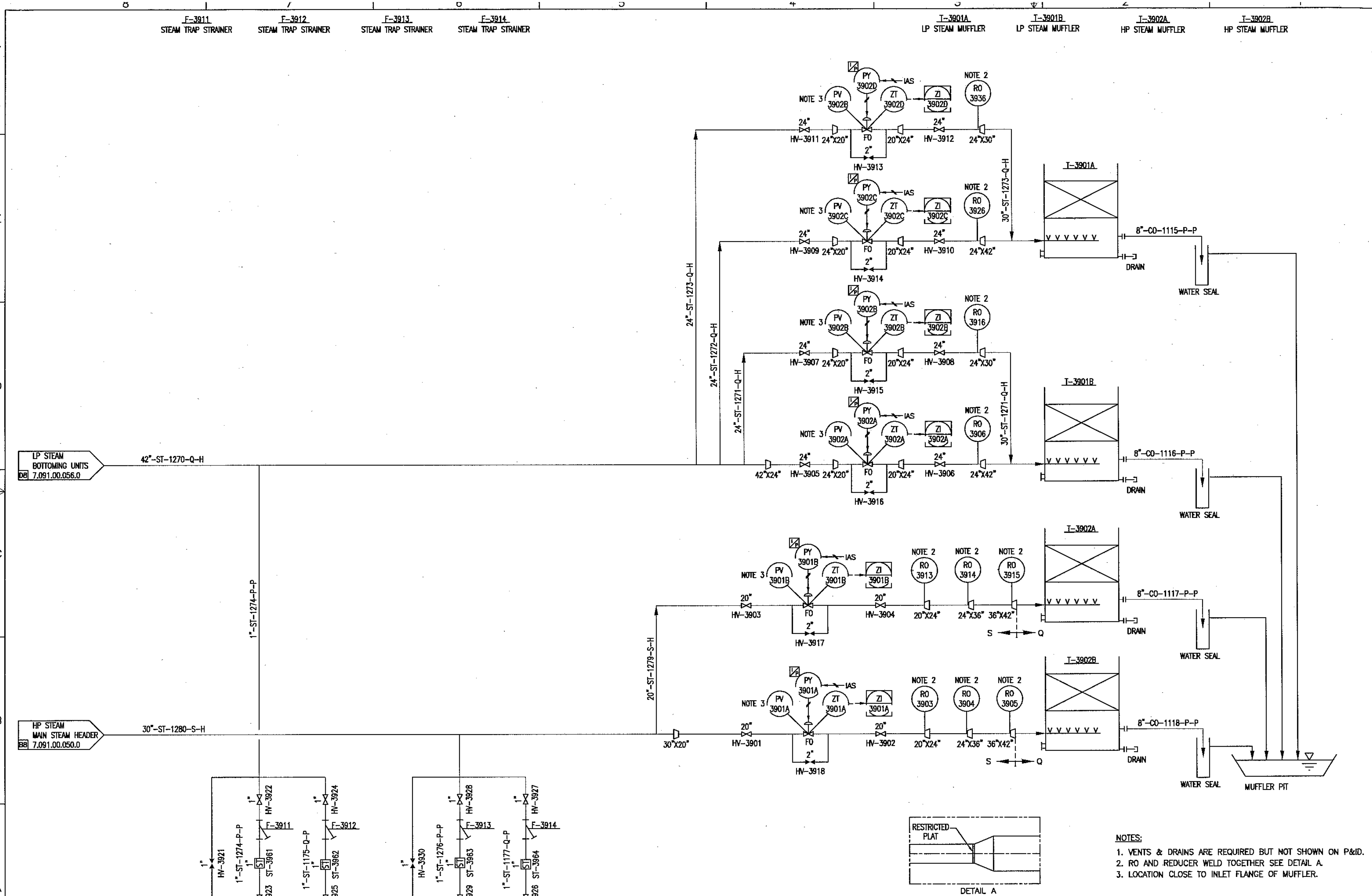
REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 038.DWG
DATE: 20.MAR.08 DRAWN: Z. SHALVA
APPROVED:
CHECKED:

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
MAIN STEAM & BRINE GATHERING SYS.

DWG. NO. 7.091.00.038.0 SHEET 1 OF 1



NOTES:

1. VENTS & DRAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. RO AND REDUCER WELD TOGETHER SEE DETAIL A.
3. LOCATION CLOSE TO INLET FLANGE OF MUFFLER.

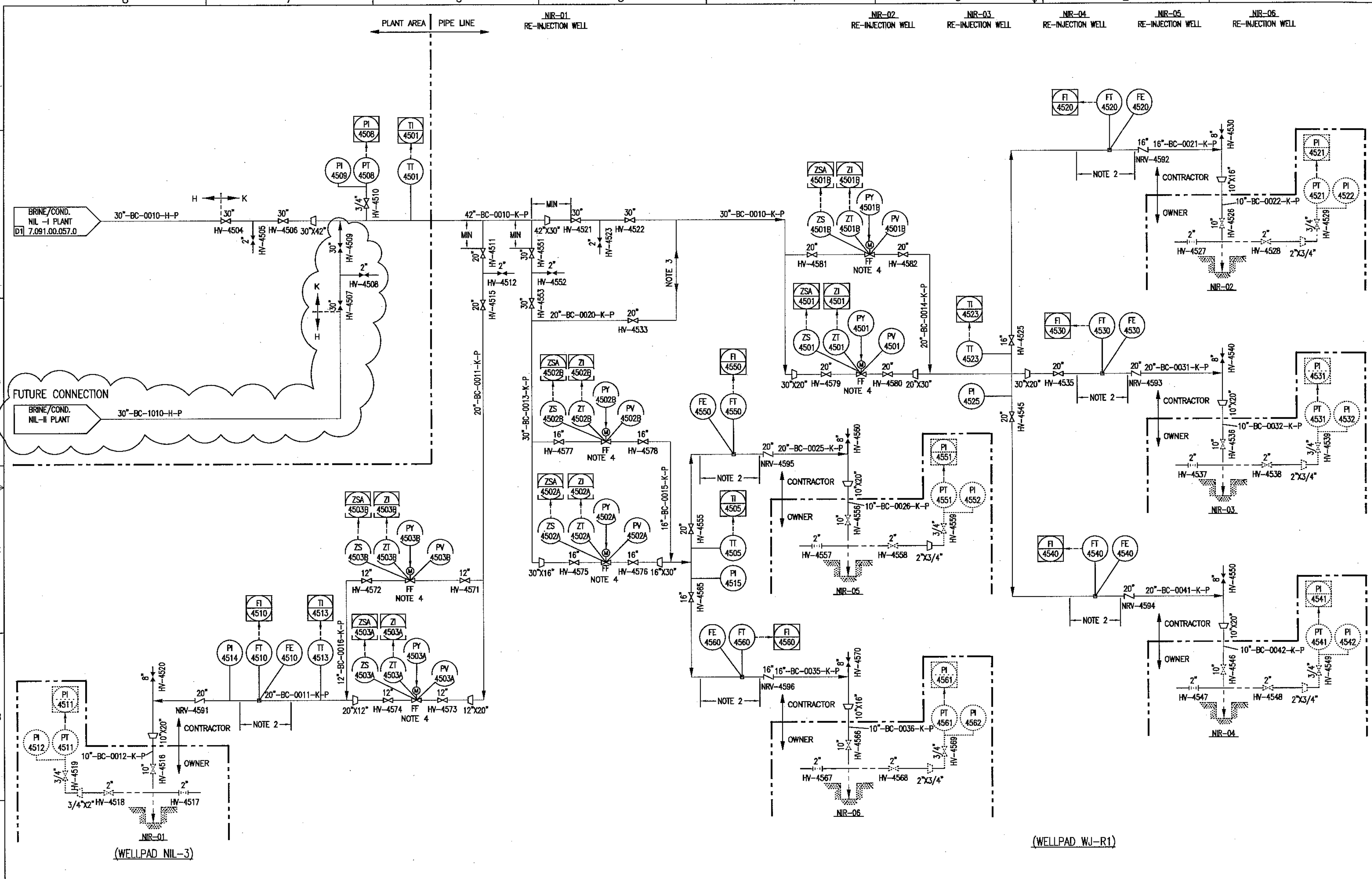
REV	DESCRIPTION	DATE	BY	CHECK	APPR
E0	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 039.DWG
DATE: | APPROVED:
DATE: | CHECKED:
DATE: 23.MAR.08 | DRAWN: Z. SHALVA

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
MUFFLERS SYSTEM

DWG. NO. 7.091.00.039.0 | SHEET 1 OF 1



NOTES:

1. VENTS & ORAINS ARE REQUIRED BUT NOT SHOWN ON P&ID.
2. UPSTREAM AND DOWNSTREAM METER TUBE MINIMUM LENGHT TO BE DETERMINED DURING THE DETAILED DESIGN.
3. CROSS LINE CONNECTION AT WJ-R1 AREA.
4. CONTROL VALVE SHOULD BE LOCATED AT WELLPAD AREA.

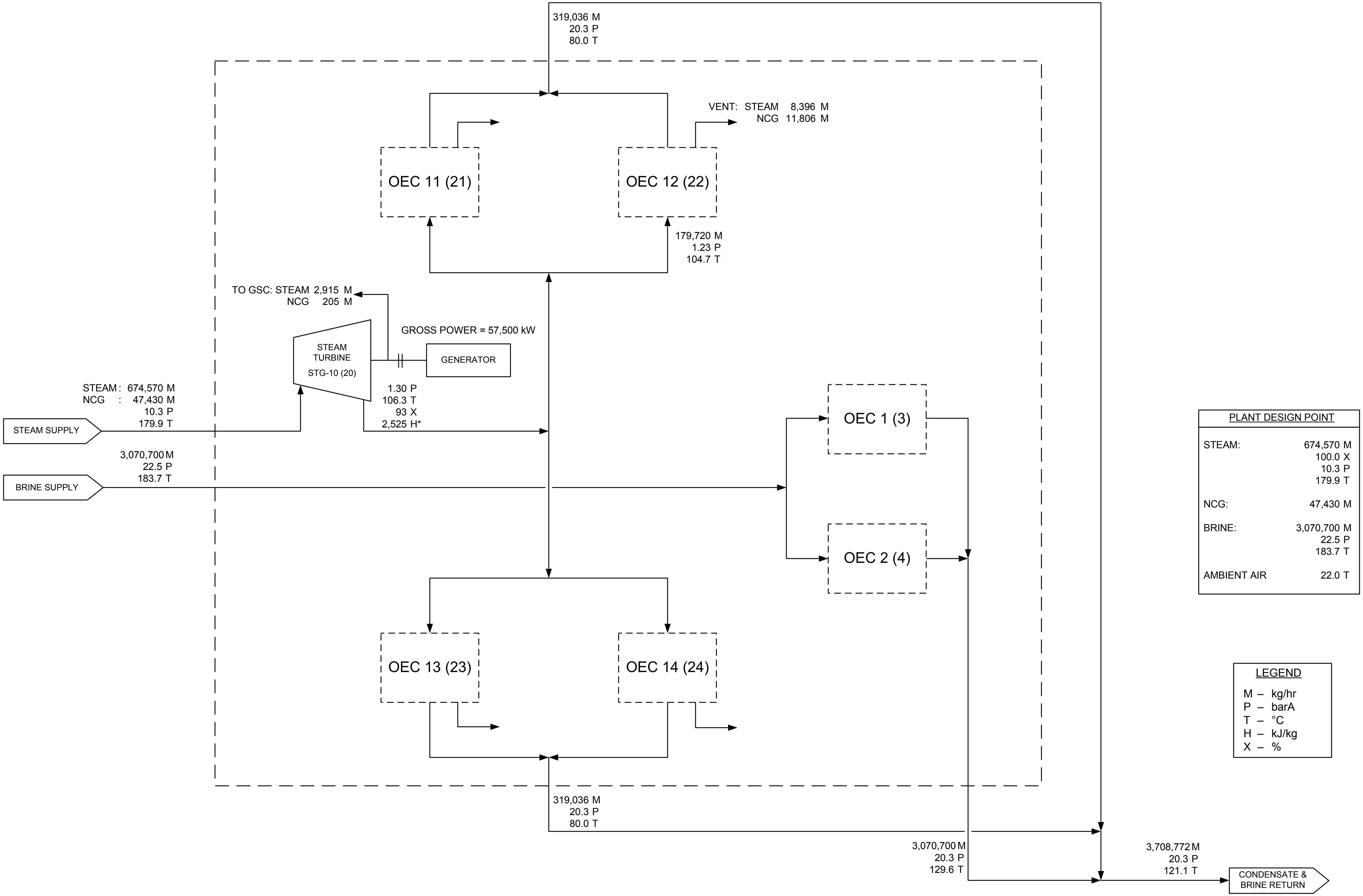
REV	DESCRIPTION	DATE	BY	CHECK	APPR
ED	FOR BUDGET ESTIMATION	30.MAY.08	Z. SHALVA	M.B.	Y.N.

FILE NAME: NIL 1 045.DWG
DATE: / APPROVED:
DATE: / CHECKED:
DATE: 27.APR.08 / DRAWN: Z. SHALVA

ORMAT®

TITLE: SARULLA NIL-I GEOTHERMAL PLANT
PIPING & INSTRUMENTATION DIAGRAM
RE-INJECTION SYSTEM

DWG. NO. 7.091.00.045.0 SHEET 1 OF 1



*Note: Enthalpy is of steam portion only.

REV.	DESCRIPTION	DATE	BY	CHECK	APPR
P6D	GSC OUTLET ADDED	21 Feb 12	AN	AN	DB
P6	INCREASED BRINE FLOW TO OECS	20 Feb 12	AN	AN	DB
P5	UPDATE TO STEAM TURBINE	29 Dec 11	AN	AN	DB
P4	PROCESS TEMPERATURES ADDED	16 Jun 08	MK	MK	DB

REVISIONS

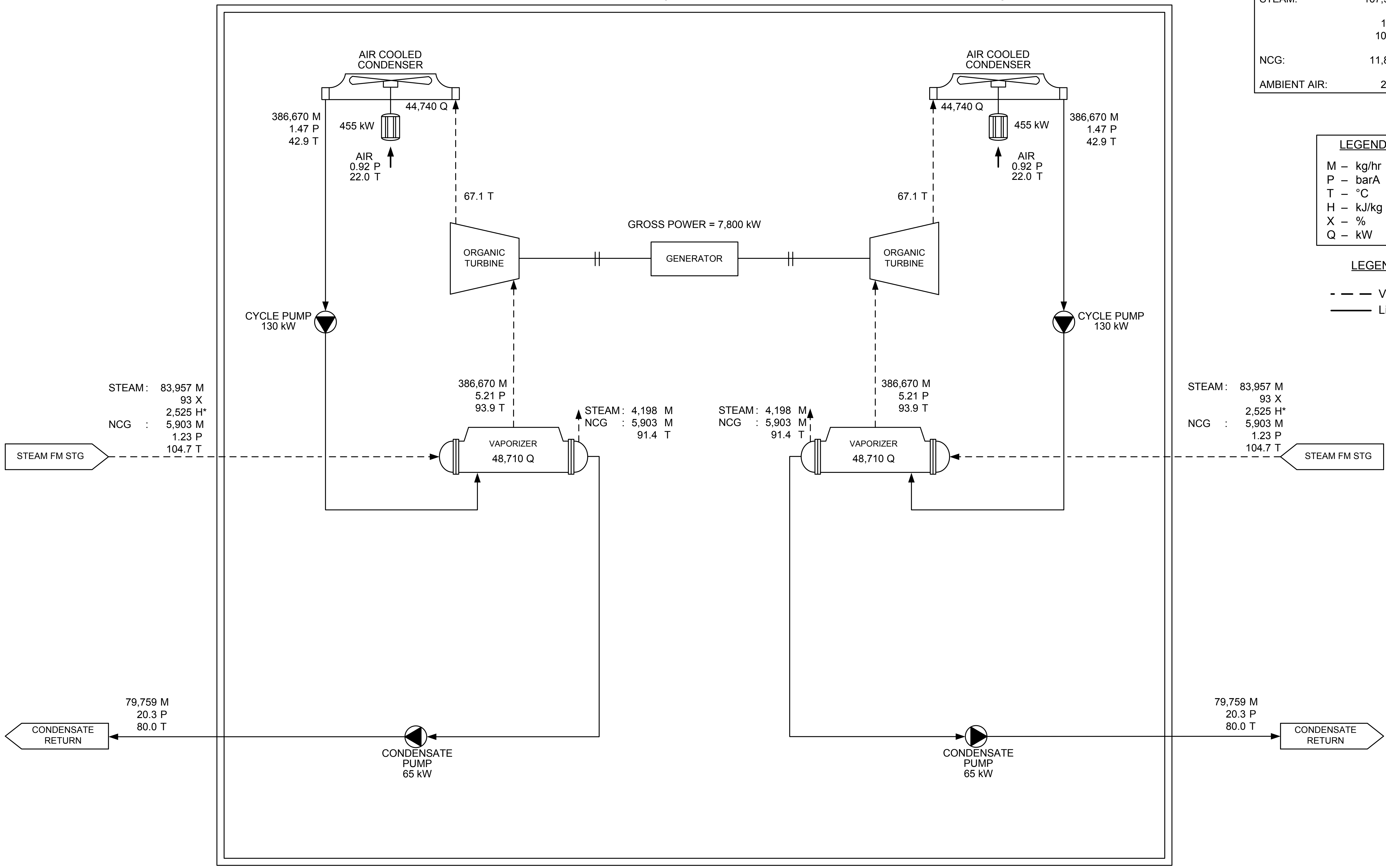
DATE: 2/21/2012
DRAWN: AN
CHECKED:
APPROVED:

ORMAT

SARULLA – NIL
HEAT AND MASS BALANCE DIAGRAM
POWER PLANT 1 (2)

0.002.95.795.0 | SHEET 1/3 | REV. – P6D

ORMAT ® ENERGY CONVERTER (OEC 11 THROUGH 14, 21 THROUGH 24)



OPERATING DATA	
STEAM:	167,914 M 93 X 1.23 P 104.7 T
NCG:	11,806 M
AMBIENT AIR:	22.0 T

LEGEND

M – kg/hr
P – barA
T – °C
H – kJ/kg
X – %
Q – kW

LEGEND

- - - Vapor
—— Liquid

*Note: Enthalpy is of steam portion only.

REV.	DESCRIPTION	DATE	BY	CHECK	APPR
P6D	GSC OUTLET ADDED	21 Feb 12	AN	AN	DB
P6	INCREASED BRINE FLOW TO OECS	20 Feb 12	AN	AN	DB
P5	UPDATE TO STEAM TURBINE	29 Dec 11	AN	AN	DB
P4	PROCESS TEMPERATURES ADDED	16 Jun 08	MK	MK	DB

REVISIONS

DATE: 2/21/2012 | DRAWN: AN | CHECKED: | APPROVED:

ORMAT

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SARULLA – NIL
HEAT AND MASS BALANCE DIAGRAM
BOTTOMING OEC UNIT

0.002.95.795.0 | SHEET 2/3 | REV. – P6D

ORMAT® ENERGY CONVERTER (OEC 1 THROUGH 4)

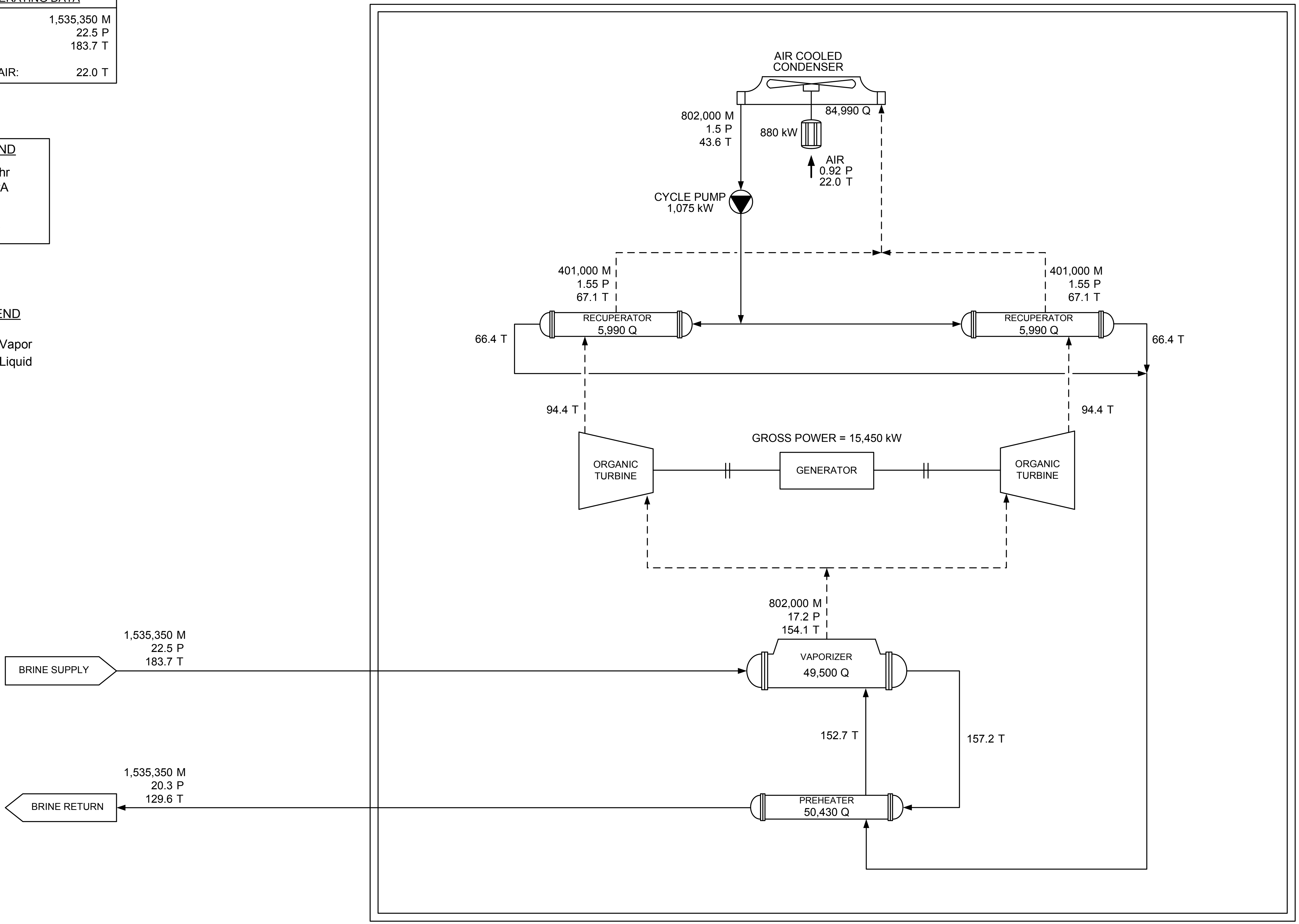
OPERATING DATA	
BRINE:	1,535,350 M 22.5 P 183.7 T
AMBIENT AIR:	22.0 T

LEGEND

M – kg/hr
P – barA
T – °C
X – %
Q – kW

LEGEND

- - - Vapor
—— Liquid



REV.	DESCRIPTION	DATE	BY	CHECK	APPR
P6D	GSC OUTLET ADDED	21 Feb 12	AN	AN	DB
P6	INCREASED BRINE FLOW TO OECS	20 Feb 12	AN	AN	DB
P5	UPDATE TO STEAM TURBINE	29 Dec 11	AN	AN	DB
P4	PROCESS TEMPERATURES ADDED	16 Jun 08	MK	MK	DB

REVISIONS

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	APPROVED:	

SARULLA – NIL
HEAT AND MASS BALANCE DIAGRAM
BRINE OEC UNIT

0.002.95.795.0	SHEET 3/3	REV. – P6D

Annex E

Biodiversity Assessment

FINAL REPORT

Sarulla Operations Ltd.

Sarulla Geothermal Field and Power Plant of 330 MW Capacity

Biodiversity Impact Assessment

October 2013

Reference: International Report

Environmental Resources Management Australia
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Spring Hill, QLD 4000
Telephone +61 7 3839 8393
Facsimile +61 7 3839 8381
www.erm.com

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EXECUTIVE SUMMARY

Development of geothermal energy is a priority of the Government of Indonesia, in efforts to seek alternative sources of energy. The development of Sarulla geothermal field and the construction of the Sarulla power plant in Pahae Julu and Pahae Jae districts, North Tapanuli Regency, commenced in 1993 and investigations and negotiations have progressed to the current status whereby Sarulla Operation Limited completed an ANDAL (2009) and are currently preparing an Addendum to the ANDAL.

The Project comprises two geothermal fields (Namora I Langit (NIL) field and Silangkitang (SIL) field), each consisting of a power station (two at NIL), production and reinjection wells, and connecting pipeline as well as a transmission line to the Perusahaan Listrik Negara (PLN) power substation. The transmission line will be suspended by a series of transmission towers. In addition, the Project will involve upgrade to existing transport corridors and development of new routes as well as development of accommodation and waste disposal facilities. The Project is located between the East and West Batang Toru Forest, located in the valley of Sarulla in North Tapanuli District. The Batang Toru River meanders north/south through the forest blocks with modified forest, agricultural and settlement areas lining the watercourse.

As part of an Asian Development Bank (ADB) review of the Project ANDAL, information gaps relating to impacts to biodiversity was identified, in particular impacts to IUCN listed species in the context of International Finance Corporation (IFC) Performance Standard 6 (PS6). This report uses available information (from desktop and preliminary field surveys) to describe the biodiversity values in accordance with the requirements of IFC Performance Standard 6 and ADB Environmental Safeguard Policy. Primarily this involves the identification and assessment of habitats that may be directly and/or indirectly impacted by the Project infrastructure. As such, for the purposes of this assessment the *Project footprint* is defined as the area of land to be disturbed for the infrastructure installation. The *Project area* is defined as the area within a 500 metre buffer of the Project footprint.

The majority (approximately 97%) of the Project footprint is located within modified habitat (mixed plantation landuse and paddy field) with direct and indirect impacts to natural habitat mainly associated with footprints of the NIL1 and WJP1 production well sites and connector pipeline. The Project footprint is relatively small for a project of this nature, at approximately 86 hectares (ha), with only 2.7 ha within natural habitats.

A preliminary field survey was undertaken at NIL and SIL in April 2013 to identify dominant habitat types within the Project area. Opportunistic records of fauna species present were recorded during the survey and a number of vegetation plots measured. In addition, geospatial mapping was undertaken to map modified and natural habitats that may be impacted by the project and a literature review provided additional species and community information to understand the local biodiversity values. An additional survey was undertaken in September 2013 to identify habitat suitability for threatened species in the area identified as natural habitat in the preliminary field survey and geospatial mapping. Results from these field surveys, in combination with information obtained from desktop sources, were used to inform a biodiversity impact assessment.

Although the majority of the Project area contains modified habitats, some small areas of natural habitat were identified to provide potential habitat to a variety of flora and fauna species listed under the IUCN Red List of Threatened Species. In many cases, species information is limited and the confirmation of presence of microhabitat features that contribute to the survival of the species (for example nest locations or breeding areas) and/or locations of populations within the Project area is not available. Therefore, the precautionary principle has been applied and it has been assumed that 'potential critical habitat' may occur in the Project area for the purposes of undertaking an impact assessment. The likelihood of 'actual critical habitat' occurring in the Project footprint is low. However, due to the lack of information at this stage of assessment and in the absence of more detailed field survey data and information from consultation with recognised candidate species experts, there remains uncertainty in making a final determination.

An impact assessment was undertaken for seven species. The species included the Sumatran tiger (*Panthera tigris sumatrae*), Sumatran orangutan (*Pongo abelii*), agile gibbon (*Hylobates agilis*), Malayan pangolin (*Manis javanica*), mitred leaf monkey (*Presbytis melalophos*), siamang (*Symphalangus syndactylus*) and Asian tapir (*Tapirus indicus*). Following an assessment against Tier 1 and Tier 2 sub-criteria (according to the IFC PS6 Guidance Note 6) 'potential critical habitat' was considered for only six of these species - Sumatran tiger, Sumatran orangutan, agile gibbon, siamang, Malayan pangolin and Asian tapir.

The significance of the potential impacts to the seven IUCN Red List endangered and critically endangered species was considered very low. According to the Biodiversity Decision Framework (IFC, ADB Sourcebook 2012), the Project will not lead to a reduction in population size, will not impact on ecosystem function and will not compromise the persistence of a representative host community for each of the threatened species.

A Biodiversity Action Plan will be developed to document a strategy for refining the mitigation and management approach to conservation of biodiversity values (including IUCN listed threatened species), including specific measures for the IUCN listed threatened species with potential to occur in the Project area. The Biodiversity Action Plan will include the requirement for additional site inspections at the proposed well and pipeline locations (to inform final design) and will provide an opportunity to undertake detailed and targeted searches to record the locations of microhabitat features of importance to the candidate species as well as targeted surveys to identify the likely occurrence of populations of the candidate species. This report details the objectives, timing, techniques and outputs associated with the targeted surveys. Using this information, there is an opportunity to implement additional avoidance measures (for example, realignment of the pipeline to avoid a breeding feature), refine mitigation measures and define offsetting and compensatory measures. Primarily, the more detailed investigations will allow for 'potential' critical habitat areas (as presented in this report) to be confirmed (or not) as 'actual' critical habitat.

A Biodiversity Offset Management Plan (BOMP) will be developed upon final determination of the residual impact to biodiversity and will outline the strategy for investigation, identification, acquisition or development, implementation and ongoing management (if applicable) of the biodiversity offset package for the Project. Options for consideration for the development of the BOMP are provided in this report.

These actions (targeted field surveys for species and habitats, development of the BAP and BOMP) are interrelated, with the outcomes of each required to be considered in the development of the other. Further detail on the objectives, timing, responsibilities, key outputs and interrelatedness of these actions is provided in this report.

1 INTRODUCTION

1.1 BACKGROUND

The Sarulla Geothermal Field and Power Plant of 330W Capacity Project (the Project) incorporates geothermal fields at Namora I Langit (NIL) and Silangkitang (SIL). Each location will include a power station (two at NIL), production and reinjection wells, connecting pipeline and aerial transmission line to the Perusahaan Kistrik Negara (PLN) power substation. The Project will require upgrades to existing transport corridors, new access roads and development of accommodation and waste disposal facilities.

In 2009 Sarulla Operation Ltd (SOL) prepared an Environmental Impact Statement (ANDAL) for the Project. A detailed Project description and background to the Project is found in the ANDAL.

In 2012 the ANDAL was reviewed by the Asia Development Bank (ADB) in the context of corporate safeguard policy. Specific to biodiversity, the ADB review identified two issues for clarification:

- Identification of measures to avoid, minimise or mitigate potentially adverse impacts and risks to biodiversity; and
- Consideration of protected species under IUCN including hairy nosed otter or berang berang (*Lutra sumatrana*), black-handed/agile gibbon or ungko (*Hylobates agilis*), and Malayan pangolin or trenggiling (*Manis javanica*). Underground bees should also be considered in the vicinity of WJP-1n and NIL-1.

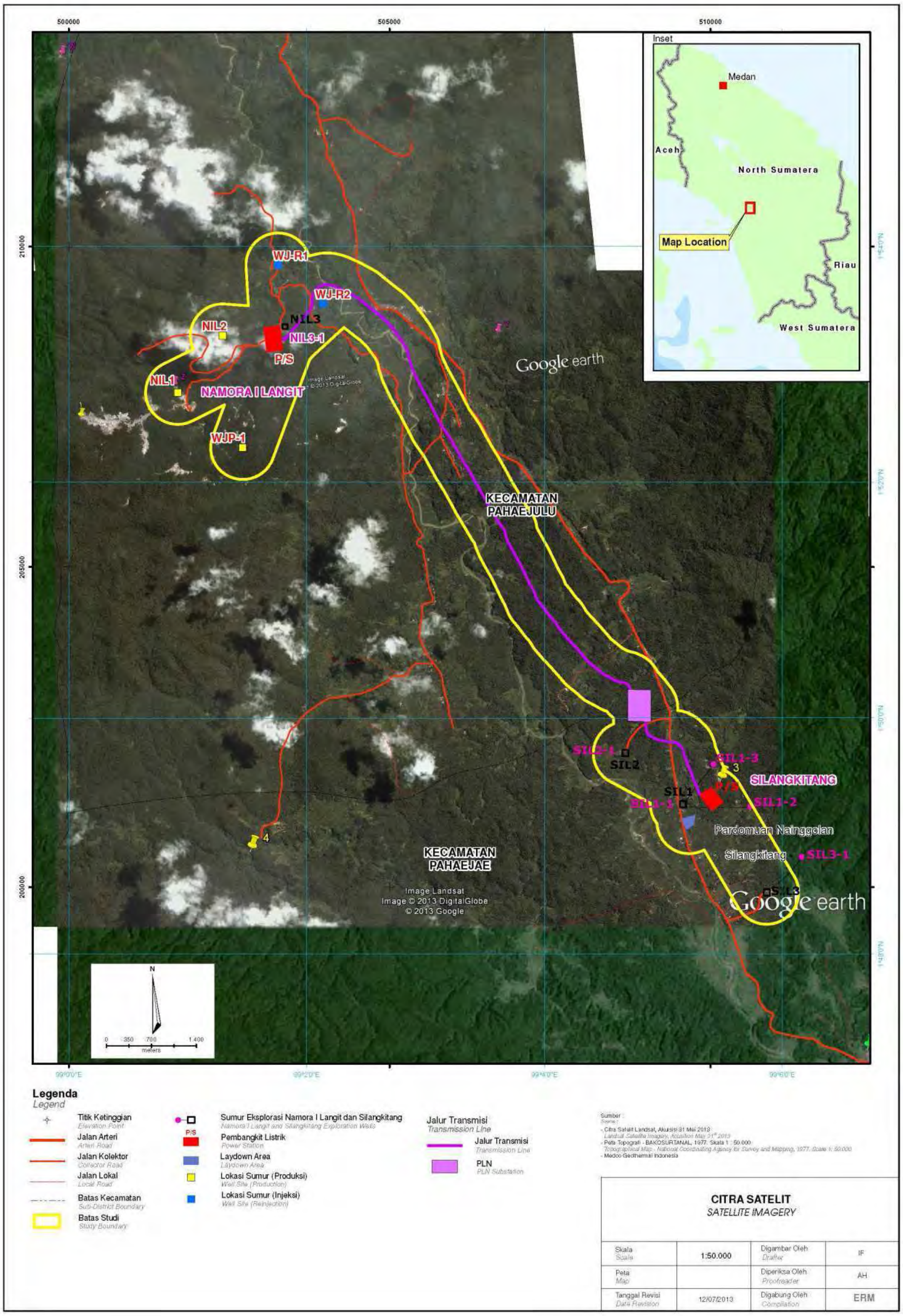
Following reviews from the ADB, SOL proceeded with further investigation of the potential impacts to biodiversity values associated with the Project. An Addendum ESIA is currently being prepared for the Project. This biodiversity impact assessment report will provide supporting information specific to the ADB and International Finance Corporation (IFC) biodiversity related standards. A biodiversity survey was undertaken in April 2013 to obtain some detail of on-ground biodiversity conditions at NIL and SIL fields, and the information gathered has been summarised to inform this impact assessment specific to IFC and ADB requirements.

1.2 PURPOSE OF THE REPORT

The purpose of this report is to identify the potential impacts to biodiversity in relation to the requirements of the IFC Performance Standard 6 and relevant ADB environmental safeguard policies.

The biodiversity impact assessment considers the potential direct and indirect impacts of the Project infrastructure. As such, for the purposes of this assessment the *Project footprint* is defined as the area of land to be disturbed for the infrastructure installation. The *Project area* is defined as the area within a 500 metre buffer of the Project footprint (*Figure 1.1*).

Figure 1.1 Project Area Overview



2 RELEVANT STANDARDS AND POLICY

To undertake this assessment, ERM has considered the following standards and policies.

2.1 INTERNATIONAL FINANCE CORPORATION

The IFC Performance Standards establish a range of social and environmental obligations to be met by recipients of IFC financing. Governance of the Performance Standards is the responsibility of the IFC. Performance Standard (PS) 6 relates to Biodiversity Conservation and Sustainable Natural Resource Management.

IFC PS6 defines the parameters of biodiversity and ecosystem services which will be considered when assessing the Project against the IFC Performance Standards. This includes the identification and consideration of habitat values, threatened species, ecosystem services, protected areas and invasive species. PS6 outlines the objective of no net loss of biodiversity in natural and modified habitats and a net gain of biodiversity in Critical Habitats, where feasible. The PS6 also identifies the need to consider use of offsets to compensate for residual impacts to biodiversity as a result of the Project, but only after the mitigation hierarchy has been applied to the fullest extent practicable.

2.1.1 *Threatened Species*

Threatened species are identified in PS6 as those listed on the IUCN Red List of Threatened Species. The IUCN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants and animals that have been evaluated using the IUCN Red List categories and criteria. The criteria identify three categories of threatened species: Critically Endangered (CE), Endangered (EN) and Vulnerable (VU). Five additional categories of plants and animals are included in the IUCN Red List including Extinct, Extinct in the Wild, Near Threatened (NT), Least Concern (LC), those for which data is insufficient (Data Deficient (DD)) and those which have not been evaluated (NE). Species categorised as CR, EN and VU are considered to be at a heightened risk of extinction and are awarded an elevated level of consideration under the IFC Performance Standards.

2.1.2 *Critical Habitat*

One of the key provisions of IFC PS 6 is the determination of 'Critical Habitat'. IFC PS6 defines Critical Habitats as areas with high biodiversity value, including:

- Habitat of significant importance to Critically Endangered and/or Endangered species;
- Habitat of significant importance to endemic and/or restricted-range species;

- Habitat supporting globally significant concentrations of migratory species and/or congregatory species;
- Highly threatened and/or unique ecosystems; and/or
- Areas associated with key evolutionary processes.

Critical Habitat is not limited to pristine or highly biodiverse areas but rather includes the broader landscape that supports the biodiversity values that trigger the Critical Habitat designation, which typically include a mosaic of modified, natural, and Critical Habitats. IFC Guidance Note 6 provides additional information on process and definitions to support the assessment of critical habitat determination.

2.2 *ASIAN DEVELOPMENT BANK*

The ADB references a Policy Paper specific to environmental safeguards: Safeguard Policy Statement (SPS) (June 2009). The document outlines the requirements that the borrower/clients are required to meet when delivering environmental safeguards for project supported by the ADB. Further technical guidance and clarity specific to the SPS is drafted in the ADB Environmental Safeguards: A Good Practice Sourcebook – Draft Working Document (November 2012).

Environmental assessment requirements are identified, including the basis for the assessment process. Specific to biodiversity conservation and sustainable natural resource management the borrower/client:

'will assess the significance of Project impacts and risks on biodiversity and natural resources as an integral part of the environmental assessment process…. The assessment will focus on the major threats to biodiversity, which include destruction of habitat and introduction of invasive alien species, and on the use of natural resources in an unsustainable manner. The borrower/client will need to identify measures to avoid, minimise, or mitigate potentially adverse impacts and risks and, as a last resort, propose compensatory measures, such as biodiversity offsets, to achieve no net loss or a net gain of the affected biodiversity.'

The policy paper describes habitat area categories to be considered including:

- **Modified Habitats** - Modified habitat is altered natural habitat, often formed by the removal of native species for harvesting, land conversion and/or introduction of alien flora and fauna species. The Project should minimise further conversion or degradation of this habitat type and where appropriate identify opportunities to enhance habitat.

- **Natural Habitats** – Natural habitat is an environment where the biological communities are largely formed by native plant and animal species and where human activity has not modified the areas primary ecological functions. The Project should not significantly convert or degrade natural habitat unless: no alternatives are available, overall benefits of the Project outweigh environmental costs, or conversion or degradation is appropriately mitigated. Mitigation should be designed to achieve at least no net loss of biodiversity.

- **Critical Habitats** – no Project activity will be implemented in critical habitat (as defined in IFC SP6) unless:

  - There is no measureable (or likelihood of) adverse impact which could impair its high biodiversity value or the ability to function;

  - The project is not anticipated to reduce the population of an endangered or critically endangered species or a loss of habitat such that the persistence of a representative host ecosystem by compromised; or

  - Any lesser impacts are mitigated to achieve at least no net loss.

3 *METHODOLOGY*

A biodiversity assessment is required when habitat is likely to be affected by a Project. In accordance with the ADB sourcebook (Section V) the objectives of the biodiversity assessment are to identify and quantify the potential project impacts; design measures to avoid, minimise or mitigate potential adverse impacts; and identify likely residual impacts. To achieve this; a five step process was undertaken. This included:

- **Screening** to determine the biodiversity features that require studying (*Section 4*);
- **Scoping** to determine which direct and indirect biological impacts are likely to be significant in order to determine the focus issues of the impact assessment (*Section 4*);
- **Baseline Studies** to define the values of the habitats that will be affected on the Project area and in the area of influence (*Section 5*);
- **Impact Analysis** to assess impacts identified during scoping and baseline studies to determine the significance of the impacts (*Section 6*);
- **Mitigation Measures** are developed to avoid or reduce adverse impacts to biodiversity with a priority given to impacts on features with significant biodiversity values (*Section 7.1*); and
- **Biodiversity Offsets** are determined to compensate for unavoidable residual harm caused to biodiversity (Section *8.2*).

Section V of the ADB sourcebook provides guidance specific to Biodiversity Conservation and Sustainable Natural Resource Management. The Biodiversity decision framework (*Figure 3.1*) cited in the ADB sourcebook and IFC has been used to guide the biodiversity assessment, in particular following the Scoping and Baseline Studies phases when the biodiversity values of the site are understood.

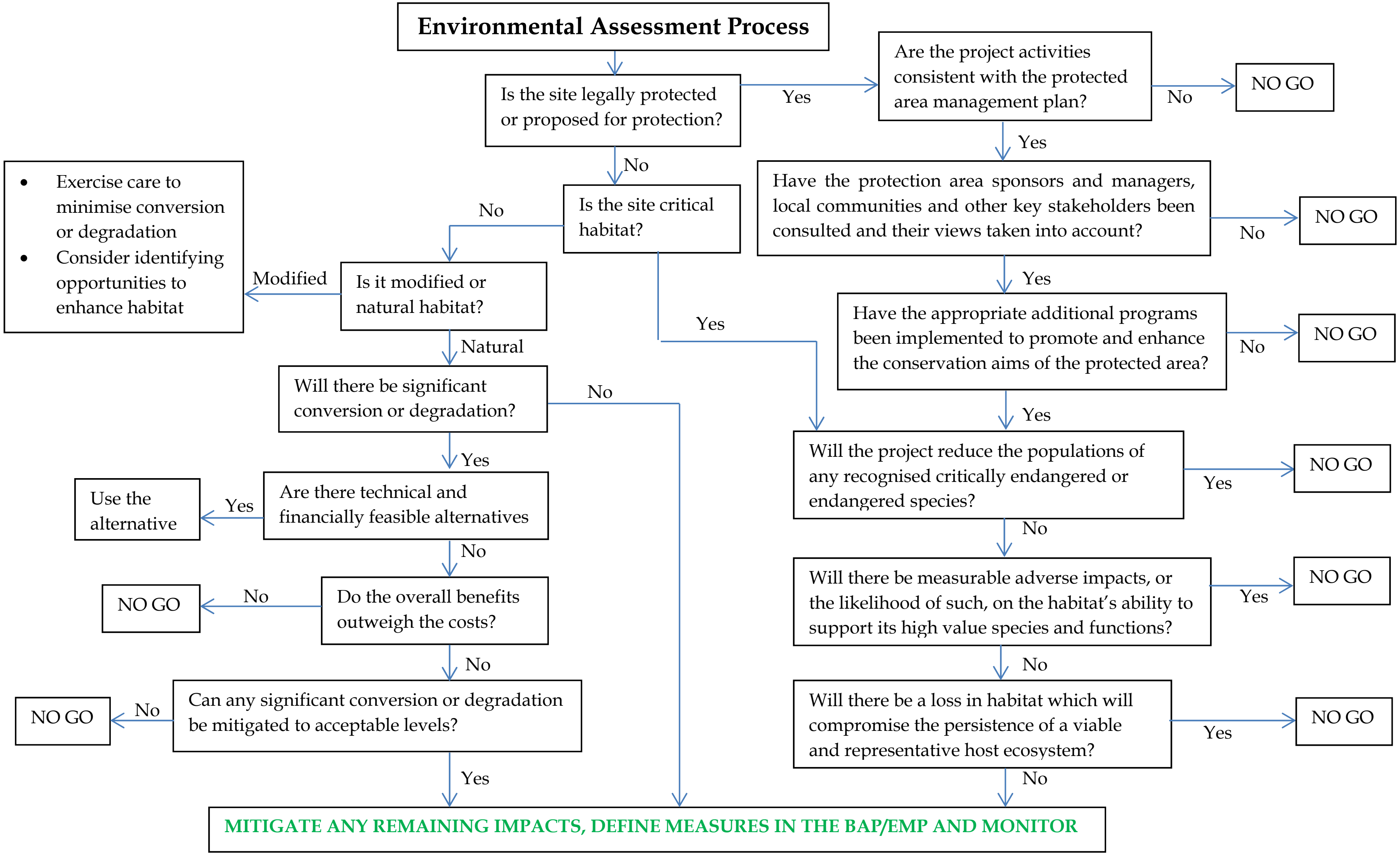


Figure 3.1 Biodiversity decision framework (IFC, World Bank Group)

4 SCREENING AND SCOPING

The Project is located between the East and West Batang Toru Forest, located in the valley of Sarulla in North Tapanuli District. The Batang Toru Forest and adjacent areas are known to support a diversity of flora and fauna species including a number of mammals, avifauna and flora that are listed on the IUCN Red List of threatened species. The Batang Toru River meanders north/south through the Project area, dividing the east and west regions of the forest and the NIL and SIL geothermal fields. Paddy fields and mixed plantation forest line the Batang Toru River and surround the settlements.

The majority of the Project area is located within the paddy field and mixed plantation area of the Batang Toru River with two well sites located within the West Batang Toru Forest.

4.1 KEY PROJECT COMPONENTS

The Project comprises two geothermal fields (NIL and SIL), each consisting of a power station (two at NIL), production and reinjection wells, and connecting pipeline as well as transmission line to the PLN power substation. The transmission line will be supported by a series of transmission towers. In addition the Project will involve upgrade to existing transport corridors and development of new routes as well as development of accommodation and waste disposal facilities.

The location of the well sites and connecting pipelines at NIL has not been finalised. Final details will be defined upon detailed engineering design and outcomes of discussion with the North Sumatera Province and the Ministry of the Environment. Using the precautionary approach locations of production well pads NIL1 and WJP1may be within the natural habitat area (Batang Toru Forest). Connecting pipeline will join the well sites to the power station. For this assessment a 25 m wide disturbance corridor has been assumed to conservatively estimate the footprint of the connecting pipeline. With final design, the estimate may be reduced by following existing access roads where possible to reduce disturbance. At SIL there are two existing well pad sites and connecting pipeline footprints have been estimated as for NIL.

The majority of the Project footprint (>97%) is located within mixed plantation landuse and paddy field with direct and indirect impacts to the forest area mainly associated with footprints of the NIL production well sites and connecting pipeline. The Project footprint is approximately 86 hectares (ha) and comprises the elements summarised in *Table 4.1*. The only element that will require disturbance to natural habitat is the WJP-1 well pad and associated access track. Based on an access track width of 15 m, and well pad dimensions of 120 x 50 m, the project footprint within natural habitat is only 3% of the total footprint (2.7 ha).

Table 4.1 Project Infrastructure Footprints

Infrastructure	Required Area (ha)
Brine injection pipeline	4.2
SIL (no change from ANDAL 2009)	
Power plant	8
Employee residential area	4
Landfill	6.125
Construction worker accommodation area	0.9
Access road	0.5
Connecting pipelines to power plant (~3.3km)	*8.2*
NIL	
Power plants	21
3 production well pads	*1.8*
3 reinjection well pads	*1.5*
Transmission tower (25mx25m) x 50 towers	4
Base camp	3
Landfill	5
Other supporting roads	4.2
Connecting pipeline to power plant (~5.6km)	*14.1*

1. Reinjection well site = 100m x 50m; Production well site = 120m x 50m

2. Italics items updated from ANDAL and estimates. Pipelines at 25m wide corridor and pads as point 1

3. Pipeline estimates may be reduce by following existing access roads

4.2 DIRECT AND INDIRECT BIODIVERSITY IMPACTS

The direct and indirect impacts to biodiversity associated with the Project are largely related to:

- Vegetation and land clearing for infrastructure footprints during the construction phase;
- Noise and dust generated during earthworks and operation of machinery during construction activities;
- Waste and debris generated during construction activities;
- Land disturbance at watercourse crossings during establishment of infrastructure;
- Noise generated during operation of the power plants and drilling operations; and

- Solid and liquid wastes (domestic and industrial) generated during the operation of the Project infrastructure.

The potential impacts to biodiversity that arise from these activities include removal of habitat (terrestrial and aquatic), fauna mortality as a result of habitat removal, habitat fragmentation, degradation of habitat (edge effects and downstream impacts), disturbance to breeding roosting and foraging behaviours, and introduction or exacerbation of invasive alien species. These are described in more detail below.

4.2.1 *Removal of Habitat*

To facilitate establishment of the infrastructure components, vegetation and land clearing will be undertaken and as such, habitat for flora and fauna species may be removed. Vegetation will be cleared and topsoil stripped and placed in disposal areas where vegetation will be re-planted.

4.2.2 *Fauna Mortality*

Fauna mortality can occur during vegetation clearing activities in the event individuals are struck by vehicles and machinery. Animals that are unable to disperse during clearing activities are vulnerable to being injured or destroyed through interaction with machinery or falling debris.

It is likely that most individuals will disperse from clearing locations into adjacent habitats however some less mobile species may experience a localised reduction in abundance during this period, such as amphibians, reptiles and small mammals.

4.2.3 *Habitat Fragmentation*

The existing road infrastructure has potential to create a barrier to fauna movement currently. The installation of additional linear and non-linear infrastructure has the potential to introduce physical barriers to fauna movement whereby habitat areas become fragmented. Fragmentation can lead to genetic isolation of flora and fauna populations and isolate individuals from dispersal habitat, reliable forage and breeding resources.

Linear infrastructure generally has potential to result in fragmentation of habitats. The relevant Project components include pipelines, roadways and the transmission line. Overall the transmission line will be suspended with minimal ground infrastructure that would create a barrier effect. The pipeline and roadways for access may create a barrier to movement, especially for smaller, ground dwelling species, but due to the narrow nature, will be less likely to impact larger more mobile species.

4.2.4 *Degradation of Habitat*

A range of Project activities have the potential to lead to indirect impacts to native flora, fauna and habitats. In general this includes dust and runoff impacts during construction as well as longer term edge effects and noise impacts of the operation of the facilities.

During construction, land preparation has the potential to generate dust which may settle on vegetation adjacent to the construction area. Excessive dust deposition on flora may act to suppress growth through limiting photosynthesis and the dusted foliage may also become unpalatable to foraging fauna. The construction activities will be temporary and short lived, and dust generation is likely to be localised to active work areas. Rainfall will generally remove dust from foliage.

Land preparation will create exposed bare earth areas that are vulnerable to erosion (wind and/or runoff) until infrastructure construction or replanting is completed to stabilise the surface. Erosive processes transport and deposit sediment to downstream habitats (both aquatic and terrestrial). The indirect impact has potential to degrade downstream habitat areas or change habitat characteristics, and as such influencing suitability for native flora and fauna communities.

Edge effects are an indirect impact of land clearing. Where vegetation clearing occurs, adjacent vegetation and habitats are exposed to increased noise, light, dust and wind environment as well as increased competition from predators and invasive species. In extreme cases some of these effects have potential to alter the habitat characteristics of the ecotone and influence suitability for native flora and fauna.

4.2.5 *Invasive Alien Species*

Invasive or alien species have the potential to be introduced or spread throughout the Project area through increased movement of people, vehicles, machinery, vegetation and soil. An increase in the prevalence of weeds or other pests has the potential to reduce the quality of habitat for some native flora and fauna. Invasive flora species can rapidly germinate in disturbed areas whereby affecting the ability of native vegetation communities to re-establish. Alien animals also have the potential to be introduced or increased in abundance. These animals may adversely impact native fauna as a result of increased competition for resources, predation or habitat degradation.

4.2.6 *Behaviour Disturbance*

Noise and light disturbances have the potential to influence fauna breeding, roosting or foraging behaviour. The consequences of these influences are dependent on the extent of disturbance but in extreme cases these factors can influence local populations. The Project area contains a number of settlement areas where human habitation is likely to induce a base level of disturbance in directly adjacent areas.

Excessive noise can impede fauna communication and deter the use of habitats nearby. Similarly, introducing light sources has the potential to deter foraging and dispersal activities of nocturnal species.

4.3 SUMMARY

The Batang Toru Forest and adjacent areas contain biodiversity and conservation values as the forest is known to support a diversity of flora and fauna species, and ecosystems, including some species listed on the IUCN Red List. There are a number of Project activities that have potential to impact the biodiversity and conservation values in the vicinity of the Project. As such, the focus of the biodiversity assessment will be the potential impacts to threatened species and their habitats.

Determining the presence of potential critical habitat for threatened species, to enable assessment of impacts, will be the focus of baseline studies.

5 *BASELINE STUDY*

Biodiversity conservation values in the Project area were determined using a combination of desktop and field-based sources. A preliminary field survey was undertaken at NIL and SIL (April 2013) to identify the habitats within the Project area. Habitat descriptions at a number of sites were undertaken, and sampling at 2x2 m plots to determine flora species lists, species density and frequency. In addition, geospatial mapping was undertaken to map the types of habitat that may be impacted by the project (*Annex A)*.

An additional survey was undertaken over two days in September 2013 to further investigate areas identified as natural habitat at NIL1 and WJP1 from the preliminary field survey and through geospatial mapping. This survey involved assessing habitat types, condition and suitability to support IUCN Red Listed species. The field report from this survey is provided in *Annex B.*

During each survey, opportunistic records of fauna species present were recorded based on direct and indirect encounters. While specific fauna sampling techniques were not implemented, direct encounters where individual species could be identified with certainty where recorded, while indirect encounters from scratches, dung, trails and vocalisations where also noted during the field survey.

In addition, community based information as well as that obtained from a review of relevant literature provided additional species information to contribute to the understanding of the biodiversity values in the Project area. The results of the field survey were used to inform the habitat mapping and impact assessment in this report.

This section provides an overview of the biodiversity values associated with the Project area to enable determination of impact assessment associated with the project activities. Specifically, a description of habitats within the Project area in accordance with the terminology defined by IFC PS6 and the ADB Safeguard Policy Statement is provided.

5.1 *VEGETATION AND HABITATS*

Using landcover analysis processing, natural and modified habitats were delineated across the region and are shown in *Figure 5.3. Table 5.1* summarises the landuse types shown in *Figure 5.3* as they correspond to the habitat categories. Further detail for each habitat type is provided below.

Table 5.1 Landuse mapping types of each habitat category

Natural Habitat	Modified Habitat
Forest	Bareland
Shrub	Mixed plantation
Sulfur crater	Dryland farming
	Settlement

5.1.1 Natural Habitat

Natural habitat is an environment where the biological communities are largely formed by native plant and animal species and where human activity has not modified the area's primary ecological functions (ADB, 2012).

The Batang Toru Forest area and adjacent forest (shown as landuse type 'Forest' in *Figure 5.3*) is considered to be natural habitat as it is reported to be natural vegetation (Sumatra Rainforest Institute, 2012; *Annex A*) with only slight evidence of human activities such as footpaths and wood shavings during the survey.

The forest around NIL has a high floral diversity. Assessment of the species in the forest vegetation at NIL identified that the vegetation at this location is dominated by cantagi species from the Ericaceae family and woody plant species from the Fagaceae family. Forest with taller, larger boled trees with structured canopy layers and epiphytic plant communities exists further from the sulphur crater. This includes dipterocarp forest within the Project area north of NIL1 and across the wider landscape to the west of NIL1 (*Annex B*).

'Shrub' landuse type is found around the NIL sulphur crater and is another natural habitat. The Shrub landuse is of interest in that the flora species (particularly cantagi) found are generally associated with mountain top regions. This is due to the similar environmental conditions associated with sulphur craters and mountain tops.

The natural habitat represents the highest quality habitat in the Project area. These habitats are expected to provide foraging, breeding and dispersal habitat for a range of native flora and fauna. An assessment of suitability of these areas as 'critical habitat' for IUCN red list species is discussed in *Section 6*.

The natural habitat area (shown as 'Forest' and 'Shrub' in *Figure 5.3*) adjoins or is part of the Batang Toru Forest (east and west lots) which spans approximately 148,000 ha in total. Only 347 ha of natural habitat, which is equal to approximately 0.2% of the total Batang Toru Forest area, is located within 500 m of the Project infrastructure (Project area).

Figure 5.1 Natural Habitat: Example of Natural Habitat at Location NIL1

5.1.2 Modified Habitats

Modified habitat is altered natural habitat, often formed by the removal of native species for harvesting, land conversion and/or introduction of alien flora and fauna species (ADB, 2012).

The plantation area that lines the Batang Toru River (shown as landuse type 'Mix Plantation', 'Dryland Farming' and 'Paddy Field' in *Figure 5.3*) is considered to be modified habitat as field surveys identified these areas display cultivated vegetation characteristics with plants generally planted to meet basic needs or economic value.

Modified habitat comprises the large majority of the area within 500m of Project infrastructure (approximately 80%). Modified habitats are represented by four vegetation communities: yard vegetation, field vegetation, rubber plantation, and mixed plantation vegetation.

Yard vegetation is found around residential areas and the borders of rubber plantations and fields. It is commonly made up of fruit, agricultural, ornamental and medicinal plant species. Field vegetation is generally paddy field, occasionally peanuts, coconut or areca nut.

Figure 5.1 Modified Habitat: Yard vegetation at SIL1 well; Field vegetation SIL1 well

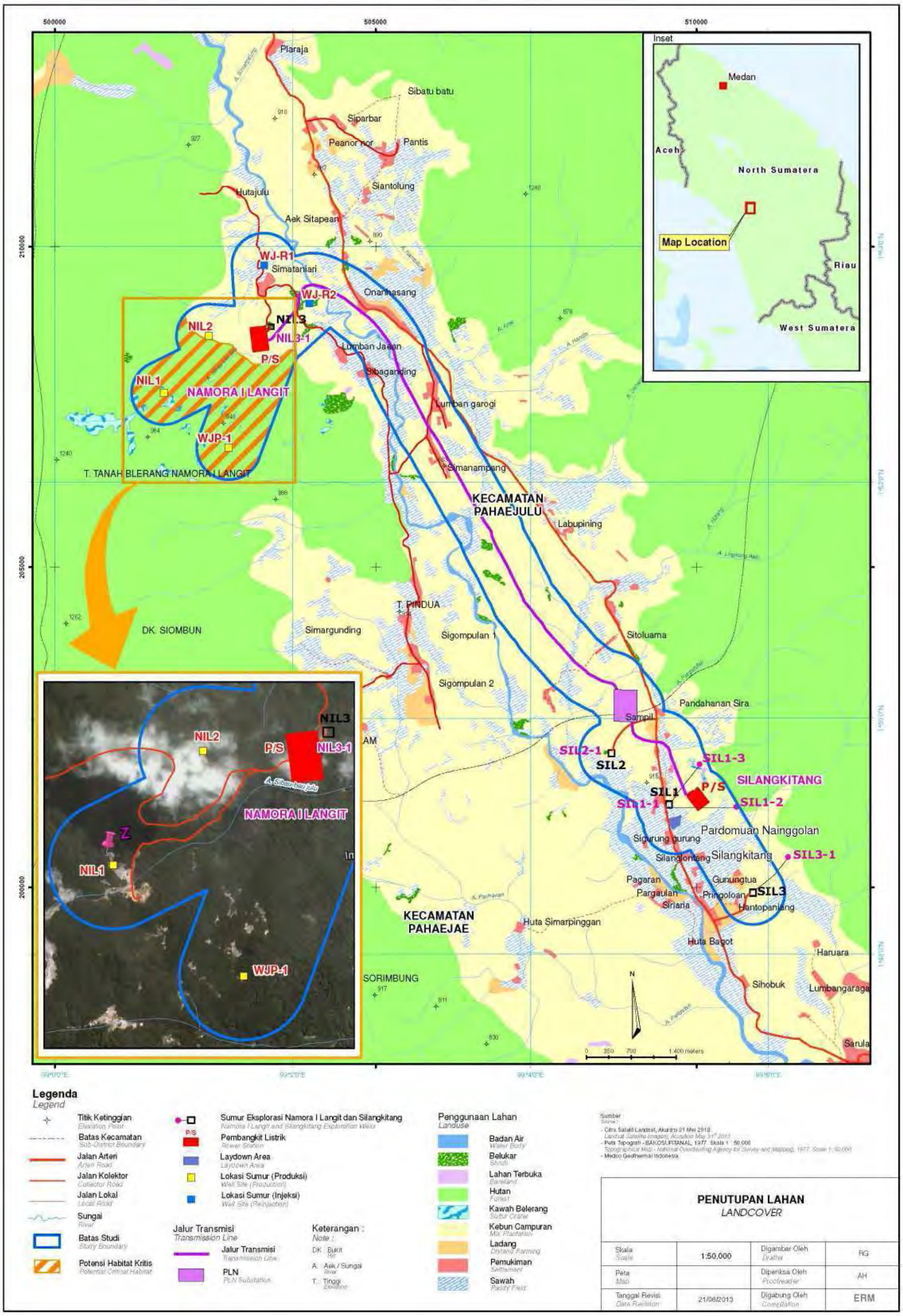
Rubber plantation is an agricultural landuse which is extremely intensive. The vegetation is not monoculture as traditional management includes several other crops species planted in between rubber plants. The plantations surveyed displayed a variety of vegetation strata including lower plants, seedlings, saplings, poles and trees. The number of lower plants species (bushes and grasses) recorded indicated that the plantations are managed traditionally and tend to be left standing low. The sapling strata is dominated by rubber.

Mixed plantation is intensive agricultural vegetation that is planted with various annual plant species. The community was recorded to be dominated by rubber plants and bushes mixed with forest plants at sampling locations. The formation and structure resembled a secondary forest with lower plant complexity that is quite high and dense.

Modified habitats provide values for native and non-native fauna species. Monoculture communities or communities with limited structural diversity represent the lowest biodiversity values with open areas lacking forage resources and cover and as such exposing individuals that may be moving through the area to predation. Communities with greater structural diversity, such as mixed plantation, although modified may provide foraging and breeding habitat for some native fauna species. These areas play a role in the landscape mosaic of fauna habitat, connecting the large tracts of the Batang Toru Forest. The modified nature of these habitats can present a higher incidence of weed and pest species that will compete with native species for resources.

Figure 5.2 Modified Habitat: Rubber plantation at SIL2; Mixed plantation at SIL2

Figure 5.3 Habitat Types in the Project Region (Landcover Analysis)



5.2 *FLORA AND FAUNA SPECIES*

5.2.1 *General*

Flora and fauna species were recorded during the field surveys undertaken. There was a diversity of species recorded and a comprehensive list and description of the field survey results is provided in *Annex A* and *Annex B.*

IFC PS6 identifies threatened species as those listed on the IUCN Red List of Threatened Species (the Red List) and species categorised as critically endangered (CR), endangered (EN) and vulnerable (VU) are considered to be at a heightened risk of extinction.

5.2.2 *Flora*

Three flora species listed under the Red List were recorded during the field survey, with only one listed as vulnerable, endangered or critically endangered. Sumatran pine (*Pinus merkusii*) is listed as vulnerable and was observed on the road side between NIL1 and NIL3. The species is known from three relatively large populations in Sumatra, however the extent within the Project area is not known.

In addition, kantong semar (*Nepenthes melamphora*), listed as endangered on Indonesian Legislation PP No. 7 of 1999, was recorded on a roadside near SIL. The species lives in marginalized land with poor nutrients. Little is known about the extent of the species in the Project area.

5.2.3 *Fauna*

Twenty fauna species listed as vulnerable, endangered or critically endangered under the Red List have been previously recorded or have potential to occur in the Project area (based on other evidence such as interviews with the community) (*Annex A)*. All of these species are mammals and the list includes carnivore, primate, rodentia and ungulate mammal Orders. In addition, the ADB review highlighted the potential for two additional mammals and underground bees for consideration. To determine the presence of critical habitat in accordance with IFC PS 6, critically endangered and endangered species have been considered candidate species. *Table 5.2* summarises the candidate species for assessment. Despite being highlighted by ADB for consideration, no information specific to underground bees was identified during the desktop review and the field survey and as such this group has not been considered further.

Table 5.2 ***IUCN listed Critically Endangered, Endangered and Vulnerable species with potential to occur within the Project area***

Scientific Name	English Name	Indonesian Name	IUCN Status	Method of Detection
Panthera tigris sumatrae	Sumatran Tiger	Harimau sumatera	CR	Vocalisation & interview
Pongo abelii	Sumatran Orangutan	Orangutan Sumatera	CR	Interview
Hylobates agilis	Agile Gibbon	Ungko	EN	Vocalisation
Lutra sumatrana	Hairy Nosed Otter	Berang berang	EN	
Manis javanica	Malayan Pangolin	Trenggiling	EN	Signs
Presbytis melalophos	Mitred Leaf Monkey	Simpai	EN	
Symphalangus syndactylus	Siamang	Siamang	EN	Vocalisation
Tapirus indicus	Asian Tapir	Tapir	EN	Interview
Helarctos malayanus	Malayan Sun Bear	Beruang madu	VU	Signs
Arctictis binturong	Binturong	Binturung muntu	VU	Interview
Capricornis sumatrensis	Sumatran Serow	Kambing hutan	VU	
Cervus unicolor	Sambar Deer	Rusa	VU	Signs & interview
Macaca nemestrina	Pig-tailed Macaque	Beruk	VU	Observed
Maxomys whiteheadi	Whitehead's Spiny Rat	Lesoq lati whiteheadi	VU	
Nycticebus coucang	Slow Loris	Kukang	VU	Interview
Pardofelis marmorata	Marbled Cat	Kucing batu	VU	Signs & interview

6 IMPACT ANALYSIS

6.1 APPROACH

The screening and scoping described in *Section 4* identified the range of impacts that have potential to occur as a result of the Project construction and operation. The impact analysis aims to determine the significance of the impacts using a combination of details associated with the Project and baseline biodiversity information.

The impact assessment is guided by the biodiversity decision framework (ADB, 2012) (*Figure 3.1*). Primarily the assessment focusses on two clear pathways as shown in the schematic below, potential impacts to modified habitat and critical habitat.

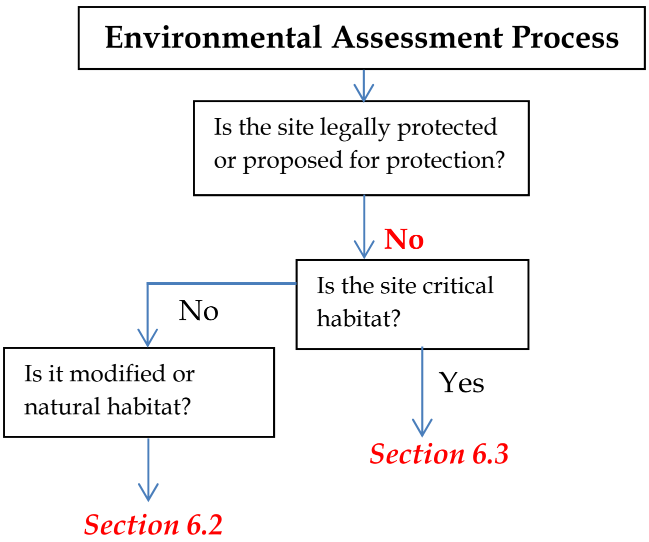


Figure 6.1 Decision framework impact assessment pathways

6.2 IMPACT TO MODIFIED HABITAT

In accordance with the SPS, the Project should minimise further conversion or degradation of modified habitats and where appropriate identify opportunities to enhance habitat.

The majority (97%) of the landscape within the Project footprint is classified as modified habitat (mixed plantation habitat or paddy field). Approximately 83.3 ha of modified habitat will be directly disturbed to facilitate construction and operation of the Project. These habitats are not considered to play a critical role in the persistence of the candidate threatened species, however may play a role in landscape connectivity and habitat for other native species that have the ability to persist in modified and natural habitats.

The area of disturbance is considered to be small such that the viability and function of surrounding habitats will not be compromised. Similarly, the habitat values are not recognised as significant locally, regionally or globally and the habitats are common and widespread. As such the significance of the direct disturbance of 83.3 ha of modified habitat is considered to be negligible.

Mitigation measures are described in *Section 7* to minimise conversion or degradation and identify enhancement opportunities for the modified habitat area.

6.3 *IMPACT TO NATURAL HABITAT AND CRITICAL HABITAT*

6.3.1 *Critical Habitats*

One of the key provisions of IFC PS 6 is the determination of 'Critical Habitat'. IFC PS6 defines critical habitats as areas with high biodiversity value, including (but not limited to) habitat of significant importance to critically endangered and/or endangered species. There are three steps to identify and characterise critical habitat:

1. Step 1 – *Stakeholder Consultation/Initial Literature Review* to understand biodiversity within the landscape from the perspective of all relevant stakeholders. This consists of in-field consultation and desktop research.
2. Step 2 – *In-field Data Collection and Verification of Available Information* to collect field data and verify available detailed information necessary for the assessment. This includes consultation with qualified specialists.
3. Step 3 – *Critical Habitat Determination* (using the guidance criterion (IFC6 GN71-78) to determine whether the project is situated in critical habitat. Critical habitat can be categorised as Tier 1 or Tier 2 habitat in accordance with IFC SP6 Guidance Note 6. This involves the interpretation of the desktop and field data collected, and in some circumstances consultation with recognised species specialists.

For this Project, Step 1 included in-field consultation and a five-day field visit to describe biodiversity values of the Project area. The threatened species identified with potential to occur (the candidate species) within the Project area have been described in *Section 5.2.2* (flora) and *Section 5.2.3* (fauna). The candidate species identified includes eight mammal species listed as endangered or critically endangered. No candidate species from other fauna groups or flora were identified with potential to occur.

Step 2 has commenced, with an additional one-day field visit to confirm the habitat condition of areas initially mapped as natural habitat undertaken in September 2013. Details of additional targeted field surveys recommended to be undertaken are provided in *Section 8.1*.

In the absence of detailed field information and noting refinement of the final location of the Project footprint to occur, there is uncertainty regarding determination of Tier 1 and Tier 2 criteria for Step 3. Additional investigation (as required by Step 2) or consultation with recognised species specialists would be required to verify the characteristics of the natural habitat within the Project area and determine critical habitat presence or absence. Despite this, the field visit undertaken in September 2013 (*Annex B*) has indicated that a large part of the proposed development footprint within the identified natural habitat areas is already disturbed. This includes tracks and roads that already occur for access to NIL1 and NIL2 and that the NIL1 site has been cleared in the past, and vegetation associated with the site is recent regrowth.

To undertake Step 3 and identify if potential critical habitat occurs within the Project area, species habitat requirements have been considered in the context of the definition of critical habitat. Specifically, critical habitat includes (ADB, 2012):

- *Habitat required for the survival of critically endangered or endangered species;*
- *Areas with special significance for endemic or restricted-range species;*
- *Sites that are critical for the survival of migratory species;*
- *Areas supporting globally significance concentrations or numbers of individuals of congregatory species;*
- *Areas with unique assemblages of species that are associated with key evolutionary processes or provide key ecosystem services; and*
- *Areas having high biodiversity that has significance social, cultural or economic importance to local communities.*

For the candidate species identified in this assessment, the first definition criterion listed is the only relevant factor to determining critical habitat. No migratory or congregatory species were identified with potential to occur and key evolutionary processes or local community significance was not identified to occur in the habitat of the Project area.

For the purposes of undertaking this impact assessment, the precautionary principle has been applied and it has been assumed that 'potential critical habitat' may occur within natural habitats within the Project area where vegetation community characteristics are consistent with species habitat preferences and are located within a species distribution (survey information and species profiles as shown in *Table 6.1*). These potential critical habitats for the candidate species have been matched where appropriate to mapped landuse types such that the extent of disturbance can be estimated. The potential critical habitat areas correspond with the 'Forest' landuse type within the Project area shown in *Figure 5.3* for six of the eight candidate species, based on assessments against Criterion 1 and Tier 1, Tier 2 sub-criterion (*Table 6.1)*. The likelihood of 'actual critical habitat' occurring in the Project footprint is low. However, due to the lack of information at this stage of assessment and in the absence of more detailed field survey data and information from consultation with recognised candidate species experts, there remains uncertainty in making a final determination.

The area of 'Forest' landuse within 500 m of the Project infrastructure (the 'Project area') is approximately 347 ha (highlighted in *Figure 5.3* as potential critical habitat). Based on the footprint size assumptions detailed in *Section 4.1*, the estimated area of direct disturbance to the 'Forest' landuse is only 2.7 ha, and is largely associated with impacts from development of WJP1, as NIL1 and road access to NIL1 is regarded as modified habitat.

Table 6.1 summarises the species habitat requirements for the critically endangered and endangered species that may occur within the Project area and identifies the landcover types that may represent potential critical habitat.

An assessment was undertaken in accordance with the assessment pathways in the decision framework. The assessment focusses on a response to three key questions to determine if impacts can be mitigated or if the Project should not proceed.

6.3.2 *Assessment Outcomes Summary*

The natural habitat area associated with the Project (shown as 'Forest' landuse in *Figure 5.3)* has potential to provide critical habitat values for the candidate species. Detailed information within the Project footprint is limited and as such, there is uncertainty regarding the determination of critical habitat within the Project area. For the purposes of this impact assessment, the precautionary principle has been applied and it is assumed that 'potential critical habitat' may occur within the Project area.

Within the forested area, the Project footprint will disturb 2.7 ha or approximately 2% of the area of 'potential critical habitat' in the Project area (i.e. within 500 m of the Project infrastructure). The risk generated by the Project to the survival of any endangered or critically endangered species or ecosystem functions required by these species is considered to be very low. According to the Biodiversity Decision Framework (IFC, ADB Sourcebook 2012) described in *Figure 3.1* , the Project will not lead to a reduction in population size, will not impact on ecosystem function and will not compromise the persistence of a representative host community for each of the threatened species.

Additional investigation would be required to verify the characteristics of the 2.7 ha area to be disturbed to assist with the determination of critical habitat process. Step 2 of the determination of critical habitat process (IFC PS6 Guidance Note 6) recommends a combination of baseline survey, ecological research, expert consultation and literature review (see *Section 8*).

Table 6.1 Critical habitat assessment

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Panthera tigris sumatrae Sumatran Tiger Harimau Sumatera	The Sumatran tiger's global population, estimated to be approximately 600, is known from less than 60,000 km^2 on the island of Sumatra (Sanderson *et al*. 2006). The Batang Toru Forest is known to host key populations of the Sumatran Tiger (Perbatakusuma *et al*., 2010) and is mapped as 'Probably extant (resident)' area on IUCN species distribution mapping (Wildlife Conservation Society 2011). Population size in the Batang Toru Forest is unknown. Tigers are tolerant of a wide variety of habitats, mainly requiring vegetation cover, access to water and sufficient prey (Mazak, 1981). Size of territory varies dependant on habitat type, access to prey and maturity of the individual (Mazak, 1981). Major threats to the species are listed as habitat loss due to expansion of oil palm and acacia plantations, illegal trade and prey-base depletion (Linkie *et al*., 2008). In the Project area Sumatran tiger vocalisations were heard during field survey and local community information indicates the species is present. Wild boars were detected around NIL, a prey source for the species. **The <u>natural habitats</u> of the Project area may provide occasional foraging resources and movement habitat for the Sumatran tiger. These features may play a role in the suitability of the area as habitat. Potential Critical Habitat (Tier 2(c)) = landuse 'Forest' on *Figure 5.3.***	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is highly mobile and is likely to avoid areas of high activity which will be localised and generally restricted to the construction period. The species prefers habitats closer to forest centres, rather than the forest edge. Due to the roaming nature of the species, and that the impact due to vegetation clearing is only <0.01% of the Batang Toru Forest, and that the great majority of the Project footprint has avoided natural habitats, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. This may include lighting and noise disturbance which may impede natural foraging behaviours. The Sumatran tiger is a highly mobile species and is likely to avoid areas of high activity during construction, including the margins of disturbance. The construction period will be temporary and disturbance will be localised and as such a significant impact of noise to foraging behaviours of the tiger is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed (approx 2.7 ha) is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. The area to be disturbed is <0.01% of the available natural habitat in the Batang Toru Forest. It is expected that foraging resources within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such this ecosystem function for the Sumatran tiger is unlikely to be compromised. **Outcome: No**

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Pongo abelii Sumatran Orangutan Orangutan Sumatera	*Pongo abelli* is endemic to the island of Sumatra and generally restricted to the northern area. IUCN mapping depicts areas of the Batang Toru Forest as 'Extant (resident)' area on the species distribution mapping (UNEP-WCMC and IUCN, 2008). The global population is estimated at 7,300 (Singleton *et al*., 2004), with the Batang Toru River regarded as the southernmost extent of the existing population. Current population size in the Batang Toru Forest area is unknown. In the West Batang Toru area, the forest types where the species is found is described as mid-high altitude dipterocarp forests. The species mainly forages on fruits but also on leaves and termites. The home range for females is 800 to 1,500 ha with the male range thought to be much larger. Major threats to the species are listed as habitat loss due to conversion of forest to agricultural or oil palm plantations and fragmentation by roads (Singleton *et al*., 2008). In the Project area interviews with local communities identified that orangutans are encountered occasionally entering fields or plantation from the forest during durian fruiting season. **The natural habitats of the Project area may provide occasional foraging resources and nesting habitat for the Sumatran orangutan. Details of nesting locations are not available. These features may play a role in the suitability of the area as habitat. Potential Critical Habitat (Tier 1, GN 20) = landuse 'Forest' on *Figure 5.3.***	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is highly mobile and is likely to avoid areas of high activity. The construction period will involve clearing of forest trees in a small area (approx. 2.7 ha of potential habitat in the Batang Toru Forest) and as such care will be required during felling to check for presence of this arboreal species. If present during clearing action can be taken to allow the individuals to move to adjacent forest and avoid harm during high construction activity. Prior to clearing a survey can be undertaken to identify any evidence of nests such that these trees can be avoided where possible. Due to the very small impact to potential habitat for the species, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. This may include lighting, noise and alien species (including predators) disturbance which may impede natural foraging or nesting behaviours. The Sumatran orangutan is a highly mobile species and is likely to avoid areas of high activity during construction, including the margins of disturbance. The construction period (and associated noise) will be temporary and disturbance will be localised and as such a significant impact of noise to behaviours is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed (approx 2.7 ha) is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. The area to be disturbed is <0.01% of the available natural habitat in the Batang Toru Forest. It is expected that foraging resources and nesting habitats within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such the ecosystem function for the Sumatran orangutan is unlikely to be compromised. **Outcome: No**

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Hylobates agilis Agile Gibbon Ungko	*Hylobates agilis* is found in Sumatra, Peninsular Malaysia and south Thailand. IUCN mapping depicts areas of the Batang Toru Forest as 'Extant (resident)' area on the species distribution mapping (IUCN, 2008a). The global population size is unknown. The species occurs in highest densities in dipterocarp–dominated forests in southern Sumatra but also known from swamp and lowland forests, submontane forest and montane forest. Populations in Bukit Barisan Selatan National Park in Sumatra do not seem to avoid forest edges near human habitations (and has been estimated at 4,500 individuals (Obrien *et al*., 2004). The species occurrence in Batang Toru Forest is likely to be at low densities. Species mainly forages on fruit but will also eat insects and leaves. The home range is expected to be 29 ha (Geissman and Nijman, 2008). Major threats to the species are listed as conversion of forest habitats and pet trade (Geissman and Nijman, 2008). This species was heard in the morning and evening during field surveys. **The <u>natural habitats</u> of the Project area may provide foraging resources for the agile gibbon. These features may play a role in the suitability of the area as habitat.** **Potential Critical Habitat (Tier 2(c)) = landuse 'Forest' on *Figure 5.3.***	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is highly mobile. The construction period will involve clearing of forest trees in a small area (approx. 2.7 ha of potential habitat in the Batang Toru Forest) and as such care will be required during felling to check for presence of this species given it foraging habitats on the ground and in trees. If present during clearing action can be taken to allow the individuals to move to adjacent forest and avoid harm during high activity. Due to the very small impact to potential habitat for the species, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. Noise and light (if construction and operation requires night lighting) may disrupt the species if foraging nearby. The agile gibbon is a mobile species capable of moving away from temporary disturbances during construction, including the margins of disturbance. The construction period (and associated noise) will be temporary and disturbance will be localised and as such a significant impact of noise to behaviours is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed (approx 2.7 ha) is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. The area to be disturbed is <0.01% of the available natural habitat in the Batang Toru Forest. It is expected that foraging resources within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such this ecosystem function for the agile gibbon is unlikely to be compromised. **Outcome: No**

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Lutra sumatrana Hairy Nosed Otter Berang berang	*Lutra sumatrana* is endemic to south Asia and although once believed to be extinct, has been rediscovered in Thailand, Viet Nam and Cambodia. It has been historically and recently (2005) recorded in Sumatra (2005). Information suggests the species utilises freshwater and coastal areas, especially mangroves and on larger inland rivers. The species mainly eats fish, but also reptiles, amphibians and crustaceans. Major threats include habitat reduction and poaching (Hussain *et al*., 2013). This species was not noted as recorded during 2006 survey by Conservation International at Batang Toru Forest (Perbatakusuma *et al.,* 2010). However, the Project area is not within the IUCN mapped distribution of the species (IUCN, 2008b). **The habitats of the Project area are considered unlikely to provide habitat for the hairy-nosed otter as the freshwater habitats lie in a modified landscape.**			

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Manis javanica Malayan Pangolin Trenggiling	*Manis javanica* is native to Brunei. Cambodia, Indonesia, Lao, Malaysia, Myanmar, Singapore, Thailand and Viet Nam. IUCN mapping depicts the Project region and beyond as 'Extant (resident)' area on the species distribution mapping (IUCN, 2008c). Global population size is unknown, as the species is rarely observed due to its secretive, solitary and nocturnal behaviour. It is reported to be extremely rare in the northern part of the range, less so in the south and very common in parts of Singapore. The species can be found in primary and secondary forest areas as well as cultivated areas (plantations and gardens). It is a specialist feeder, foraging only on ants and termites. The Malayan Pangolin is nocturnal and solitary. Major threats include loss and degradation of available habitat and also due to hunting for trade (Duckworth *et al*., 2008). This species was not noted as recorded during 2006 survey by Conservation International at Batang Toru Forest (Perbatakusuma *et al*., 2010), however a vacant burrow was identified in scrub forest near WJP1 in the September 2013 field visit. **The <u>natural habitats</u> of the Project area may provide foraging resources for the Malayan pangolin. These features may play a role in the suitability of the area as habitat.** **Potential Critical Habitat (Tier 2(c)) = landuse 'Forest' on *Figure 5.3***	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is mobile and is likely to avoid areas of high activity. The construction period will involve clearing of forest trees in a small area (approx. 2.7 ha, of potential habitat in the Batang Toru Forest) and as such care will be required during felling to check for presence of this species given it foraging habitats on the ground. If present during clearing action can be taken to allow the individuals to move to adjacent forest and avoid harm during high activity. Due to the very small impact to potential habitat for the species, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. Noise and light (if construction and operation requires night lighting) may disrupt the species if foraging nearby as this is a nocturnal species. The Malayan pangolin is a mobile species and is likely to avoid areas of high activity during construction, including the margins of disturbance. The construction period (and associated noise) will be temporary and disturbance will be localised and as such a significant impact of noise to behaviours is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed (approx 2.7 ha) is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. The area to be disturbed is 2.7 ha of the available natural habitat in the Batang Toru Forest. It is expected that foraging resources within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such this ecosystem function for the Malayan pangolin is unlikely to be compromised. **Outcome: No**

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Presbytis melalophos Mitred Leaf Monkey Simpai	*Presbytis melalophos* is endemic to Sumatra. IUCN mapping depicts the Project region and beyond as 'Extant (resident)' on the species distribution mapping (IUCN, 2008d). While global population size is unknown, where appropriate habitat occurs, the species is relatively common.. The species can be found in modified and secondary forest areas as well as being found in hill rainforest, shrub forest and plantations. The species mainly eats foliage but will also eat fruits, flowers and seed. The home range is recorded to be 14-29.5 ha. Extensive habitat loss due to forest conversion to oil palm plantation has been identified as a major threat to the species (Nijman and Manullang, 2008). The species was not recorded during baseline assessments and interviews with villagers **The <u>natural habitats</u> of the Project area may provide foraging resources for the mitred leaf monkey. These features may play a role in the suitability of the area as habitat.** **Not considered likely to satisfy Tier 1 or Tier 2 Critical Habitat criteria with regard to the Project area.**	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is highly mobile. The construction period will involve clearing of forest trees in a small area (approx. 2.7 ha of potential habitat in the Batang Toru Forest) and as such care will be required during felling to check for presence of this species given it foraging habitats on the ground and in trees. If present during clearing action can be taken to allow the individuals to move to adjacent forest and avoid harm during high activity. Due to the very small impact to potential habitat for the species, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. Noise and light (if construction and operation requires night lighting) may disrupt the species if foraging nearby. The leaf monkey is a mobile species capable of moving away from temporary disturbances during construction, including the margins of disturbance. The construction period (and associated noise) will be temporary and disturbance will be localised and as such a significant impact of noise to behaviours is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed (approx 2.7 ha) is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. The area to be disturbed is <0.01% of the available natural habitat in the Batang Toru Forest. It is expected that foraging resources within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such this ecosystem function for the mitred leaf monkey is unlikely to be compromised. **Outcome: No**

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Symphalangus syndactylus Siamang	*Symphalangus syndactylus* is found in Indonesia, Malaysia and a small area of southern peninsular Thailand. IUCN mapping depicts the Project area and beyond as 'Extant (resident)' on the species distribution mapping (IUCN, 2008e). Population size in Sumatra is regarded as more than 20,000 (Obrien *et al*., 2004) with highest densities recorded in southern Sumatra. Population size within Batang Toru Forest is unknown. The species is known from primary and secondary semi-deciduous and tropical evergreen forest with emergent trees required for sleeping and resting. During a short survey in southern Sumatra the species appeared less sensitive to habitat degradation than the agile gibbon. The species is strictly arboreal and highly territorial. May be flexible foragers, preferring fruits when available. Home range has been recorded at 15-47 ha (Nijman and Geissman, 2008). Major threats to the species are listed as conversion of forest habitats and pet trade (Nijman and Geissman, 2008). This species was heard in morning and evening during preliminary field surveys at the Project area. **The <u>natural habitats</u> of the Project area may provide foraging resources for the mitred leaf monkey. These features may play a role in the suitability of the area as habitat.** **Potential Critical Habitat (Tier 2(c)) = landuse 'Forest' on *Figure 5.3*.**	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is highly mobile and is likely to avoid areas of high activity. The construction period will involve clearing of forest trees in a small area (approx. 2.7 ha of potential habitat in the Batang Toru Forest) and as such care will be required during felling to check for presence of this strictly arboreal species. If present during clearing action can be taken to allow the individuals to move to adjacent forest and avoid harm during high activity. Due to the very small impact to potential habitat for the species, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. This may include lighting, noise and alien species (including predators) disturbance which may impede natural foraging behaviours. The siamang is a highly mobile species and thought to be less sensitive to habitat degradation. The construction period (and associated noise) will be temporary and disturbance will be localised and as such a significant impact of noise to behaviours is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. The area to be disturbed is approx. 2.7 ha of the available natural habitat in the Batang Toru Forest. It is expected that foraging resources within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such this ecosystem function for the siamang is unlikely to be compromised. **Outcome: No**

Species	Critical Habitat associated with the Project area	Importance of the Project area to the species		
		Will the project reduce populations of any recognised critically endangered or endangered species?	**Will there be measureable adverse impacts, or likelihood of such, on the habitat's ability to support its high value species and functions?**	**Will there be a loss in habitat which will compromise the persistence of viable and representative host ecosystem?**
Tapirus indicus Asian Tapir Tapir	*Tapirus indicus* is native to Indonesia (Sumatra), Malaysia, Myanmar and Thailand. The population size in Sumatra is unknown, with the stronghold of the species on mainland southeast Asia and an estimated population size in Malaysia of approximately 2000. IUCN mapping depicts the Project region to the west of the Batang Toru River as 'Extant (resident)' on the species distribution mapping (IUCN, 2008f). This may not intersect with the Project area, although local village interviews indicate likely presence. The species is restricted to tropical moist forests. Major threats to the species are listed as large scale deforestation and increasingly, hunting. Habitat conversion to oil palm plantations is the main reason for decline. This is a shy species that appears to be sensitive to forest fragmentation, not venturing far from edges in some areas (Lynam *et al.*, 2008). **The <u>natural habitats</u> of the Project area may provide foraging resources for the mitred leaf monkey. These features may play a role in the suitability of the area as habitat.** **Potential Critical Habitat (Tier 2(c)) = landuse 'Forest' on *Figure 5.3.***	It is considered unlikely that individuals will be harmed during the construction or operation of the Project as the species is highly mobile and is likely to avoid areas of high activity. The construction period will involve clearing of forest trees in a small area (approx. 2.7 ha of potential habitat in the Batang Toru Forest) and as such care will be required during felling to check for presence of this species given it foraging habitats on the ground. If present during clearing action can be taken to allow the individuals to move to adjacent forest and avoid harm during high activity. Due to the very small impact to potential habitat for the species, there is not likely to be any reduction in population abundance. **Outcome: No**	Project activities may lead to indirect impacts (edge effects) to natural habitats adjacent to the Project area. Noise and light (if construction and operation requires night lighting) may disrupt the species if foraging nearby. The Asian tapir is a mobile species and is likely to avoid areas of high activity during construction, including the margins of disturbance. The construction period (and associated noise) will be temporary and disturbance will be localised and as such a significant impact of noise to behaviours is considered unlikely. Well site design will minimise light spill if permanent lighting is required and directional lighting installed in areas adjacent to critical habitat. **Outcome: No**	The natural habitat area to be directly disturbed (approx 2.7 ha) is unlikely to play a key role in the sustainability of the surrounding natural habitat area as it is relatively small in the context of habitat available in the neighbouring Batang Toru Forest. It is expected that foraging resources within the disturbance area will be equivalent to those represented within the remaining natural habitat area in the region and as such this ecosystem function for the Asian tapir is unlikely to be compromised. **Outcome: No**

7 MITIGATION MEASURES

Although disturbance to habitat in modified and natural habitat areas has potential to have impacts on the local biodiversity, mitigation measures can be implemented to manage the disturbance so that biodiversity values are not significantly impacted. Management and mitigation measures specific to minimising the clearing footprint, managing the introduction or spread of invasive species and managing light and noise disturbance should be included in the RKP.

Mitigation measures are developed to avoid or reduce adverse impacts to biodiversity. For this Project, the impact assessment discussed in this report identified potential impact to approximately 2.7 ha of potential critical habitat for IUCN Red List endangered and critically endangered species. The location of the potential critical habitat disturbance is restricted to the 'Forest' area at NIL at which the location of the well sites and connecting pipelines has not been finalised. Final siting of the well pads and connecting pipelines will be defined upon detailed engineering design and outcomes of discussion with the North Sumatera Province and the Ministry of the Environment. This may bring about opportunities for further avoiding impacts to potential critical habitat, as detailed below.

7.1 MITIGATION/MANAGEMENT

The impact assessment pathways identified negligible impact to the biodiversity values of modified habitats. Throughout the assessments a number of impacts were identified that although not likely to result in a significant impact should be managed to avoid the potential for localised or cumulative impacts to biodiversity values.

An Environmental Management Plan (RKL) will be submitted for the Project to identify effective management of natural resources associated with the Project area, including managing any negative impacts. SOL is committed to implementation of international standard best practice on environmental management, and health and safety. An environmental management system will be integrated at each stage of the development.

Management measures specific to managing the natural environment will be included in the RKL and these will include (but not be limited to):

- Maintain construction vehicles appropriately to minimise unnecessary noise generation;

- Implement speed limits to maximum of 40 km/hr for construction vehicles to limit noise and dust generation and minimise potential for fauna strike;

- Utilise or upgrade existing roads to minimise additional clearing requirements;
- Clearly demarcate areas to be cleared to limit unnecessary or accidental clearing of habitat;
- Raise awareness of values of natural habitat areas to construction work force and make arrangements for restriction of poaching and forest product collection;
- Manage construction and domestic waste to avoid attracting native and alien species to the construction areas;
- For adjacent areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and maintained until vegetation replanting can occur to stabilise disturbed surfaces;
- All chemicals to be stored and treated according to the requirements of each material safety data sheet (MSDS);
- Directional drilling technology will be employed to allow efficient use of drilling well pads and avoid the requirement for additional pad area;
- Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors;
- Condensate and brine generated during the power plant production testing and operation will be injected into reinjection wells;
- For construction and operation areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible; and
- Any replanting of disturbed areas will be done using native plant species, and where possible those common to the area.

These general environmental management measures will assist in reducing the potential for degradation of habitat, behaviour disturbance, fauna mortality and habitat fragmentation for native species.

Specific to potential critical habitat species, likely management measures are summarised in *Table 7.1*. The Biodiversity Action Plan will define additional investigations specific to each species to confirm the presence of critical habitat features and the strategy to finalising species specific management.

Table 7.1 Summary of species specific management measures

Species	Species specific management measures
Sumatran Tiger	• Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Sumatran Orangutan	• Pre-clearing survey for presence of individuals prior to tree felling • Pre-clearing survey for presence of nests prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Agile Gibbon	• Pre-clearing survey for presence of individuals prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Malayan Pangolin	• Pre-clearing survey for presence of individuals prior to clearing • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Mitred Leaf Monkey	• Pre-clearing survey for presence of individuals prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Siamang	• Pre-clearing survey for presence of individuals prior to tree felling • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss
Asian Tapir	• Pre-clearing survey for presence of individuals prior to clearing • Lighting design near forest areas to incorporate directional lighting to limit light spill into habitats • Rehabilitation of any disturbed areas as soon as practical after clearing • Compensatory measure for unavoidable habitat loss

8 KEY ACTIONS

The majority (approximately 97%) of the Project footprint is located within modified habitat (mixed plantation landuse, paddy field and existing access roads and tracks) with the limited direct and indirect impacts to natural habitat mainly associated with footprints of the WJP1 production well site and connecting pipeline. The estimated direct disturbance area of natural habitat is limited to 2.7 ha. For the purposes of this impact assessment, it has been assumed that the 2.7 ha is 'potential critical habitat' for six of the eight candidate CR and EN IUCN listed species – Sumatran tiger, Sumatran orangutan, agile gibbon, siamang, Malayan pangolin and Asian Tapir.

Despite a key finding of this assessment that there is no significant impact to any of the CR or EN IUCN listed species that may occur in the Project area, and due to the uncertainty associated with the determination of critical habitat, there are three key actions that will be implemented so that the Project avoids, minimises and offsets impacts associated with Project development and determines the extent of critical habitats in the Project area. These actions are:

- The implementation of a targeted field survey for IUCN listed species within the Project area (*Section 8.1*);
- The development of a Biodiversity Action Plan (BAP) based on the species specific habitat and population information for IUCN listed species obtained from the targeted field survey that outlines specific mitigation and compensatory measures (*Section 8.2*); and
- The development of a Biodiversity Offset Management Plan (BOMP) (*Section 8.3*).

SOL commit to conducting the targeted survey and development of the BAP prior to disturbance activities associated with the potential critical habitat. These actions are interrelated, with the outcomes of each required to be considered in the development of the other. Further detail on the objectives, timing, responsibilities and key outputs of these actions is provided in the following sections. A survey plan has been proposed (*Section 8.1*) which considers habitat preferences of the candidate species, and outlines appropriate survey techniques and timing for the surveys. Additional input from specialists is required prior to finalising the survey techniques and confirming survey effort.

The targeted survey program has been developed to support the BAP (*Section 8.2*), and the final survey plan will be required to be documented in the BAP. Using the information obtained from the additional surveys, a final determination may be reached according to the Tier 1 and Tier 2 critical habitat criteria for each species. In addition, outcomes from field investigations provide an opportunity to implement additional avoidance measures (such as realignment of the pipeline to avoid breeding features) and refine mitigation measures such that any residual impact can be quantified. This is also an important component that will be required to assist with final offset determination.

Unavoidable disturbance to natural habitats (or actual critical habitat if confirmed to be associated with the Project area) would be minimised where possible and managed through suitably designed offsetting and compensatory measures as identified within a Biodiversity Offsets Management Plan (BOMP) in *Section 8.3*. The outcomes of the current impact assessment (*Section 6*), where the precautionary principle has been applied, combined with an opportunity to provide input to final well siting suggest that the residual impact can be further minimised.

8.1 FIELD SURVEY PLAN

8.1.1 Objectives

The objectives of the field survey are to:

- Determine the suitability of habitat throughout the Project area for vulnerable, endangered and critically endangered species identified as potentially occurring in the Project area;
- Confirm the presence or absence of endangered and critically endangered species identified as potentially occurring in the Project area; and
- For species known to occur in the Project area, assess the value of the habitat for the existing population.

8.1.2 General Approach

The field survey will be undertaken by suitably qualified specialists. Ideally, the targeted surveys will be undertaken prior to final well and associated infrastructure alignment siting so that the identification of any important habitat areas can be avoided during final design phases. Final design of the survey, and selection of targeted survey techniques, will be further refined following specialist input prior to the field survey. The survey design will utilise a two stage approach:

1. Habitat assessments throughout the Project area to identify potential habitat for vulnerable, endangered and critically endangered IUCN species; and
2. Targeted field surveys for endangered and critically endangered species identified as potentially having critical habitat in the Biodiversity Impact Assessment (*Section 6*).

8.1.3 Survey Techniques

Habitat Assessment

Habitat assessments will be undertaken at approximately 15 locations throughout the Project area (including areas mapped as modified and natural habitats) to determine the habitat suitability for vulnerable, endangered and critically endangered species identified as having potential to occur in the Project area (*Table 5.2*). As the field assessment in September (*Annex B*) has provided supporting information from site based investigations for the natural habitat areas, the focus of this component of work will be other parts of the Project area.

A site specific habitat data sheet will be designed and used in the assessment, which will collate the suitable and preferred habitat types and features for the target species. Findings of the habitat assessment will be used to determine habitat suitability throughout the Project area for vulnerable, endangered and critically endangered species. Preliminary findings of the habitat assessment will be used in the field to refine the locations of surveys for targeted endangered and critically endangered species. A final output from this component of work would be a habitat map for the Project area.

Targeted Species Surveys

Targeted surveys will be undertaken in areas identified as suitable habitat through the habitat assessment. Proposed survey techniques for target species are outlined in *Table 8.1*. Survey techniques have been selected to provide the information required to determine if habitat meets the numerical thresholds for Tier 1 or Tier 2 critical habitat designation. The required information includes:

- Presence or absence of critically endangered species; and
- The presence of regionally important concentrations of endangered species, based on relative density and availability of breeding and foraging habitat.

Table 8.1 Proposed survey techniques targeting IUCN endangered and critically endangered species with potential to occur in the Project area.

Scientific Name	English Name	Indonesian Name	IUCN Status	Survey Technique	Survey Effort²	Habitat Features to target during surveys
Panthera tigris sumatrae	Sumatran Tiger	Harimau sumatera	CR	*Camera Traps* Camera Traps will be placed systematically in areas of suitable habitat to maximise the likelihood of detection. Camera traps will be baited, and placed at knee height to allow tiger cubs and potential prey animals to trigger the camera. Cameras will be installed in pairs facing each other to allow for identification of individual tigers, if more than one detection occurs. Cameras will be located and installed to avoid human disturbance and vandalism. *Indirect Detection* Areas where traps are installed will be searched for signs of target species, such as scats and tracks.	• Approximately six pairs of cameras will be installed • Cameras will remain installed for a minimum of four nights	• Primary forest; and • plantation areas with dense understorey can be used, but less likely (Sunarto, 2011).
Pongo abelii	Sumatran Orangutan	Orangutan Sumatera	CR	*Nest Searches* Presence of orangutans will be detected through nest searches. Sumatran Orangutans are a cryptic species difficult to detect through direct observation. Nest identification is a standard survey method, and nests are long lasting, allowing robustness against short term population fluctuations (Spehar *et al*., 2010). Nest searches will be undertaken within areas identified as potential habitat.	• Up to six one kilometre transects	• Undisturbed forest; • can utilise agro-forest landscape if no natural forest available, however has strictly wild food diet when undisturbed forest is available, even when bordering farmland (Campbell-Smith *et al.*, 2011).

Scientific Name	English Name	Indonesian Name	IUCN Status	Survey Technique	Survey Effort[2]	Habitat Features to target during surveys
Hylobates agilis	Agile Gibbon	Ungko	EN	*Auditory detection along transects* Compared to other primates, Gibbons express regular vocal displays (Hoing *et al.,* 2013). Detection of the Agile Gibbon will be undertaken through transects of potential habitat, in which teams of two record auditory or visual observations of Agile Gibbons, and other primate species. Details including species, cluster size and location (measured using a laser range finder and GPS) will be recorded. Recent research based on a *Hylobates klossii* population in Sumatra has shown this method can produce similar accuracy in population estimates compared to the alternative method, triangulation, while allowing detection of a greater range of species (Hoing *et al* .,2013).	• Up to six one kilometre transects, walked twice daily for three days	• Highest densities in dipterocarp-dominated forests; • other habitat includes swamp and lowland forests, hill, submontane, and montane forests; and • some populations in Sumatra do not seem to avoid forest edges near human habitations (Geissmann and Nijman, 2008).
Manis javanica	Malayan Pangolin		EN	Population density of Pangolins will be estimated through identification of active dens along defined transects. Active dens are those with pangolin scratches or tracks around the entrance. Inactive dens are those which are overgrown with vegetation, or with spider webs at the entrance. Inactive burrows will also be recorded.	• Six one kilometre transects	• Primary and mature secondary forest; • Hollows in or at the base of trees for sleeping and den sites; • Rotting logs colonised by ants; and • Dense understorey (Duckworth *et al.,* 2008; Sopyan, 2008).

Scientific Name	English Name	Indonesian Name	IUCN Status	Survey Technique	Survey Effort[2]	Habitat Features to target during surveys
Symphalangus syndactylus	Siamang	Siamang	EN	*Auditory detection along transects* Compared to other primates, Gibbons express regular vocal displays (Hoing *et al*., 2013). Detection of Siamang will be undertaken through transects of potential habitat, in which teams of two record auditory or visual observations of Siamang, and other primate species. Details including species, cluster size and location (measured using a laser range finder and GPS) will be recorded. Recent research based on a *Hylobates klossii* population in Sumatra has shown this method can produce similar accuracy in population estimates compared to the alternative method, triangulation, while allowing detection of a greater range of species (Hoing *et al*., 2013).	• Up to six one kilometre transects, walked twice daily for three days	• Primary and secondary semi-deciduous; • tropical evergreen forest; • emergent trees required for resting and sleeping; • elevation up to 1,500 m; • less sensitive to habitat degradation than Agile Gibbons; and • feeds primarily on figs (Nijman and Geissman, 2008).

Scientific Name	English Name	Indonesian Name	IUCN Status	Survey Technique	Survey Effort[2]	Habitat Features to target during surveys
Tapirus indicus	Asian Tapir	Tapir	EN	*Camera traps* Camera traps will be located to maximise capture rate, by locating in areas of preferred habitat, on existing animal tracks, and by baiting or located traps near natural food sources such as fruiting durian and jackfruit trees. Camera traps will be installed in pairs facing each other to enable individuals to be distinguished. Distinguishing individual tapirs will draw on the following features: marks and deep scarring on the body, wrinkles on the neck and belly, damage to ears and irregularities along the border of the white saddle. *Indirect Detection* Areas where traps are installed will be searched for signs of target species, such as scats and tracks.	• Approximately six pairs of cameras will be installed • Cameras will remain installed for a minimum of four nights	• Primary or secondary tropical moist forest; and • lowlands and lower montane zone.

8.1.4 *Survey Outputs*

The targeted surveys will produce a number of direct outputs, as well as support the refinement and finalisation of other plans to be prepared. These outputs are listed in *Table 8.2*.

The timing of these outputs will coincide with Project development and the BAP will be developed prior to disturbance activities associated with the potential critical habitat.

Table 8.2 Direct and indirect outputs of the targeted survey

Direct Outputs	Documents to be updated based on survey outputs
• Habitat mapping for the vulnerable, endangered and critically endangered species listed in *Table 5.2;* • Indicative map of discrete management units for relevant species; • Updated record of species known or with potential to occur in the Project area; • Estimate of density of targeted endangered species; • Determination of frequency of habitat use, based on previous and current survey; and • Recommended additional infrastructure realignments to avoid areas of important habitat.	• Biodiversity Action Plan • Biodiversity Offset Plan • Species-specific measures in Environmental Management Plan

8.2 *BIODIVERSITY ACTION PLAN*

The Project impact assessment identified the removal of a small area of natural habitat used by IUCN listed threatened species which is restricted to 'Forest' landuse type at NIL1 and WJP1. The loss of this habitat, albeit small in the context of the region, will be for the life of the Project and is unavoidable. The mitigation hierarchy necessitates consideration of avoidance, minimisation and restoration, followed by consideration of biodiversity offsets.

A Biodiversity Action Plan (BAP) will be developed prior to disturbance activities associated with the potential critical habitat that outlines specific mitigation and compensatory measures. The BAP will document the strategy for refining the mitigation and management approach to conservation of biodiversity values and for each IUCN listed species in the Project area. This will require additional detail of the final infrastructure footprint as well as information specific to the IUCN listed threatened species and their habitats that will be obtained from a targeted survey program, as described in *Section 8.1*.

As noted previously, the BAP targeted survey program will consider:

- IUCN listed flora and fauna species with potential to occur in the Project area as identified in this report;
- Survey design input from recognised species specialists;
- Habitat preferences of the candidate species;
- Timing of the surveys prior to final well and associated infrastructure alignment siting; and
- Use of appropriate survey techniques for habitat assessments and species census.

A primary phase of the BAP will be to undertake consultation with species specialists to refine the survey plan for implementation. As described above additional site inspections at the proposed well and pipeline locations of NIL1 and WJP1 will provide opportunity to confirm the area of actual (or not) critical habitat for the candidate species and implement further avoidance measures where possible. The footprint of potential critical habitat to be disturbed is approximately 2.7 ha. The Project design has considered minimum footprint requirements and proposes restoration of well pads post-operation and removal of pipelines, pumps and supporting facilities at decommissioning of the Project. This component of work will need to be drafted and finalised prior to the completion of the BAP.

In addition to the survey plan, the BAP will also include:

- Incorporation of targeted survey results and refinement of species specific mitigation measures;
- Requirements for monitoring the effectiveness of mitigation measures;
- Adaptive management protocols to be activated in the event mitigation measures require alteration;
- Residual impact quantification and compensatory measure identification (as a key input into the BOMP);
- Reporting and data recording requirements; and
- Roles and responsibilities.

8.3 BIODIVERSITY OFFSETS

8.3.1 Residual Impact to Biodiversity Values

The unavoidable residual harm caused to biodiversity by Project activities (after impact avoidance, minimisation and mitigation measures described in *Section 7.1* and implementation of the BAP) includes approximately 2.7 ha of natural habitat.

This habitat area consists of scrub, secondary forest and mixed forest and provides potential habitat for Sumatran tiger, Sumatran orangutan, agile gibbon, siamang, Malayan pangolinand Asian tapir (CR and EN IUCN listed species). The loss of this habitat area is not considered to lead to a reduction in population size, will not impact on ecosystem function and will not compromise the persistence of a representative host community for each of the threatened species (according to the Biodiversity Decision Framework (IFC, ADB Sourcebook 2012). Despite this, the impact should be considered with regard to compensatory measures.

The Business and Biodiversity Offsets Programme (BBOP) Standard on Biodiversity Offsets (2012) describes the relationship between IFC PS6 habitat types and the standard. Amongst other provisions it includes reference that in areas of natural habitat, mitigation measures will be designed to achieve 'no net loss' of biodiversity where feasible.

As described in the ADB sourcebook (Section V), the principle of 'no net loss' or a 'net gain' requires that the area and quality of the site be maintained, or preferably enhanced in terms of key biodiversity components, habitat extent and/or structure, and ecosystem function. As such, a biodiversity offset is considered a requirement for a residual impact of what is likely to be in the order of 2.7 ha of natural habitat for the Project.

In accordance with IFC requirements and BBOP standards a Biodiversity Offset Management Plan (BOMP) will be developed to document the design and implementation of biodiversity offsets.

8.3.2 Biodiversity Offset Management Plan

The BOMP will seek to offset residual impacts from the development of the Project. Initial investigations into offset options have been based on the residual impact estimated in this report: approximately 2.7 ha of natural habitat with potential to support six endangered and critically endangered IUCN listed species. The final magnitude of residual impacts to be offset in the BOMP will be quantified in the BAP based on the findings of the targeted threatened species survey outlined in *Section 8.1.*

Given the anticipated small area to be offset, a land-based offset (i.e. creation of an equivalent or greater area of new habitat) is not considered the most appropriate mechanism for achieving a conservation benefit for the greater Batang Toru Forest region. Indirect offsets, such as research, education and enhancement of existing habitat, and investment in improved management of adjacent areas are considered to provide greater conservation benefits to the target species than habitat small land based direct offset.

Provision of an offset package requires consideration and understanding of the values to be offset, local availability of suitable indirect offsets, potential partnership opportunities with key stakeholders and government and international expectations. The BOMP will be developed to provide information specific to implementation of the compensatory measures identified to overcome the residual impacts that have been quantified in the BAP. The BOMP therefore cannot be designed until the targeted survey program has been completed and the BAP has quantified the offset requirement.

Overall the BOMP will document the offset design, intended conservation outcomes, and identify the implementation process. Due to the reliance on completion of the BAP, engagement with relevant stakeholders and the determination of appropriate offsetting mechanisms, the BOMP is not likely to be completed until mid-2014. The offset design process will include:

- Identification and consultation with relevant stakeholders;
- Selection and justification of appropriate offset metrics;
- Establishment of agreements (requires additional round of consultation);
- Review potential offset locations and activities to assess the biodiversity gains that can be achieved; and
- Calculation of offset gains and selection of the most appropriate sites or activities (required for completion of the BOMP).

The offset design process will provide opportunity to investigate the most suitable offset options which may consist of a combination of measures that will lead to a net benefit for the species of interest, and biodiversity in general. For this Project, the residual impact is limited to approximately 2.7 ha of natural habitat and as such there are a variety of opportunities available in terms of offset design to achieve 'no net loss' to biodiversity and greater conservation outcomes across the broader region.

Alternatives may include:

- Rehabilitation of an area of modified habitat directly adjacent to the natural habitat area of the Batang Toru Forest to achieve natural habitat characteristics;
- Actions to improve the biodiversity values of the adjacent Batang Toru Forest, including investment by the proponent into the development of management programs, facilitating stakeholder workshops or establishng long-term conservation mechanisms for selected high value areas within the forest;
- Activities relating to threat abatement for the species for which habitat will be impacted. For example:
    - Community education activities regarding threatened species poaching and illegal pet trade;

- Pest species management or population reduction activities including provision of funds and/or employment for local residents to assist in management.

- Support for existing protected area network for the species for which habitat will be impacted;

- Support for species research in the Batang Toru Forest to contribute to enhancing the knowledge of the species and addressing species data deficiencies and contributing to conservation information; and

- Contribution to existing conservation programs.

Stakeholder consultation will provide valuable input to determining the preferred offset design. Stakeholders will include SOL, national and local government representative, research institutions, local communities and conservation groups.

Following identification of the preferred offset design, implementation mechanisms will be developed and documented. This will include roles of stakeholders, legal mechanisms, financial mechanisms, risk areas and measures to manage risk, delivery milestones and monitoring indicators, monitoring requirements and grievance procedures. Further development of the concepts above will be the focus of the development of the BOMP. It is envisaged, based on the timeline above, that the BOMP is not likely to be completed before mid-2014.

9 *REFERENCES*

Campbell-Smith, G, Campbell Smith, M, Singleton, I and Linkie, M (2011) 'Raiders of the Lost Bark: Orangutan Foraging Strategies in a Degraded Landscape', *PLoS One*, v.6, no. 6, e20962.

Duckworth, J.W., Pattanavibool, A., Newton, P. and Nguyen Can Nhuan (2008). *Manis javanica*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 22 July 2013.

Fredriksson, G., Steinmetz, R. Wong, S. and Garshelis, D.L. (IUCN SSC Bear Specialist Group) (2008). *Helarctos malayanus*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013. www.iucnredlist.org. Downloaded on 18 July 2013.

Geissmann, T. and Nijman, V. (2008). *Hylobates agilis*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on July 18 2013.

Hoing, A, Quinten, M, Indrawati, Y, Cheyne, S and Waltert, M (2013) 'Line transect and triangulation surveys provide reliable estimates of the density of Kloss' Gibbons (*Hylobates klossii*) on Siberut Island, Indonesia', *International Journal of Primatology,* v. 34, pp. 148-156.

Hussain, S.A., Kanchanasakha, B., de Silva, P.K. and Olson, A. (2008). Lutra sumatrana. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 22 July 2013.

IUCN. (2008a). *Hylobates agilis*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

IUCN. (2008b). *Lutra sumatrana*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

IUCN. (2008c). *Manis javanica*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

IUCN. (2008d). *Presbytis melalophos*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

IUCN. (2008e). *Symphalangus syndactylus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

IUCN. (2008f). *Tapirus indicus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

Linkie, M., Wibisono, H.T., Martyr, D.J. and Sunarto, S. (2008). *Panthera tigris ssp. Sumatrae*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 18 July 2013.

Lynam, A. Traeholt, C., Martyr, D., Holden, J., Kawanishi, K., van Strien, N.J., and Novarino, W. (2008). *Tapirus indicus*. In IUCN 2013. IUCN Red List Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 18 July 2013.

Mazak, V. (1981). *Panthera tigris*: Mammalian Species no. 152, pp 1-8. Published 8 May 1981 by the American Society of Mammalogists.

Nijman, V. & Geissman, T. 2008. *Symphalangus syndactylus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 02 October 2013.

Nijman, V. and Manullang, B. (2008). *Presbytis melalophos*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Downloaded on 18 July 2013.

Perbatakusuma, E.A., Supriatna, J., Wijayanto, I., Soedjito, H., Damanik, A.H.,. Azmi, K., Arif, M.C. and Lubis, A.H. (2010) Strengthening Biodiversity Conservation at Key Landscape Areas in the Northern Sumatra Corridor. Technical Project Report Conservation International, Jakarta, Indonesia.

Singleton, I., Wich, S.A. and Griffiths, M. (2008). *Pongo abelii*. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1 www.iucnredlist.org. Downloaded on 18 July 2013

Sopyan, E (2008) 'Malayan Pangolin *Manis javanica* Trade in Sumatra, Indonesia' in *Proceedings of the Workshop on Trade and Conservation of Pangolins Native to South and Southeast Asia*, Singapore.

Spehar, S, Mathewson, P, Nuzuar, Wich, S, Marshall, A, Kuhl, H, Nardiyono and Meijaard, E (2010), 'Estimating Orangutan Densities Using the Standing Crop and Marked Nest Count Methods: Lessons Learned for Conservation' *Biotropica*, v.42, no.6, pp.748-757.

Sumatra Rainforest Institute. (2012). Batang Toru Forest Range. http://www.sumatra-rainforests.org/index.php?option=com_content&view=article&id=130&Itemid=54

Sunarto (2011) *Ecology and restoration of Sumatran Tigers in forest and plantation landscapes*, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

UNEP-WCMC and IUCN. (2008). *Pongo abelii*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

Wildlife Conservation Society. (2008). *Helarctos malayanus*, In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

Wildlife Conservation Society. (2011). *Panthera tigris*, In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

Annex A

ERM Preliminary Site Survey Study Results

Source: Environmental Water and Productivity Laboratory (IPB). Survey of the Sarulla Location (2013)

A.1 BIOLOGY COMPONENTS

A.1.1 Land Biology

A.1.1.1 Flora

The flora making up the vegetation in the study area is classified into two primary groups, which are natural vegetation and cultivated vegetation. Natural vegetation found in the study area covers forests. Cultivated vegetation can be categorized into 4 groups. These four groups are yard vegetation, field vegetation, rubber plantation vegetation, and mixed plantation vegetation. Cultivated vegetation is usually planted with plants to meet basic needs and economic value plants. Whereas, natural vegetation in the form of forest vegetation is dominated by the cantigi species from the *Ericaceae* family and woody plant species from the *Fagaceae* family.

Yard Vegetation

Yard vegetation is vegetation that is generally found around SIL-1 Well. This vegetation is vegetation with plant species that have economic value and can be found around residential areas to the borders with rubber plantations and fields. Common plant species found are fruit plants, agricultural plants, ornamental plants and medicinal plants. Plant species that make up yard vegetation that can be found in the study area cover chocolate (*Theobroma cacao*), hazelnut (*Aleurites moluccana*), lamtoro (*Leucaena leucocephala*), durian (*Durio zibethinus*), jackfruit (*Artocarpus heterophyllus*), guava (*Psidium guajava*), coconut (*Cocos nucifera*), areca nut (*Areca pinanga*), banana (*Musa paradisiaca*), mango (*Mangifera indica*), olive (*Lansium domesticum*), mangosteen (*Garcinia mangostana*), and petai (*Parkia speciosa*). An illustration of the yard vegetation around SIL-1 well can be seen in Figure A-1.

Figure A-1 An Overview of Yard Vegetation Around SIL-1 Well.

Field

Field vegetation is only found around SIL-1 Well. Fields can be found outside SIL-1 well in the east and west. The fields here are generally planted with 2 planting periods per year. Occasionally, the people will plant other species such as peanuts (*Arachis hypogaea*) as variation before planting paddy again. Apart from paddy, several embankment areas are also planted with plant species including coconut (*Cocos nucifera*) and areca nut (*Areca pinanga*). Figure A-2 gives an overview of field vegetation in SIL-1 well.

Figure A-2 Overview of Field Vegetation Around SIL-1 Well.

Mixed Plantation

Mixed plantation is intensive agricultural vegetation planted with various annual plant species. Some species often found cover chocolate (*Theobroma cacao*), coffee (*Coffea robusta*), benzoin (*Styrax benzoin*), durian (*Durio zibethinus*), coconut (*Cocos nucifera*), areca nut (*Areca pinanga*), stinkybeans (*Parkia speciosa*), olives (*Lansium domesticum*) and areca palm (*Areca catechu*). Mixed plantation vegetation can be found around SIL-1 and SIL-2 Well. An overview of a mixed plantation around SIL-2 well presented in Figure A-3.

Figure A-3 Overview of Mixed Plantation Vegetation Around SIL-2 Well.

Rubber Plantation

Rubber plantations are agricultural activities that are carried out extremely intensively and use vast agricultural land. The rubber plantations in the study area are community plantations managed privately or in groups by the surrounding communities. Rubber plantations are managed traditionally, which is why they are not monoculture because there are several other crops planted between the rubber plants. To obtain an overview of the rubber plantation in the study area, a vegetation analysis was conducted. A vegetation analysis was conducted in two locations, which was the rubber plantation vegetation around SIL-1, later named "V SIL-1" and the rubber plantation vegetation around SIL-2, later named "V-SIL-2".

Rubber Plantation Vegetation around SIL-1 Well (V-SIL-1)"

The rubber plantation vegetation in "V SIL-1" is classified into 5 strata of plants, which are lower plants and seedlings, saplings, poles and trees. Lower plants are plant species in the form of grass, bushes and shrubs, whereas seedlings are in the form of cambium plants (trees) with height less than 1.5m. Seedlings and lower plants are in one group because its vegetation analysis calculation was conducted on the same plot, which was a 2x2m plot. The results of the vegetation analysis on seedling and lower plant strata are presented in Table A-1.

According to the results of the vegetation analysis on seedlings and lower plants, it was identified that there are 14 seedling and lower plant species. From the 14 species, only 2 species are classified as seedlings, which were rubber and medang while 12 species were lower plants. Harendong bulu (*Melastoma malabatricum*) is a dominant lower plant species with an INP of 28.71%, in second place is rubber with an INP of 31.70%, and in third place is harendong (*Clidemia hirta*), which is a lower plant species with 24,16%.

The number of lower plant species (grass and bushes) found in the survey location indicates that community rubber plantations are managed traditionally and tend to be left standing low. Cultivated plants found are possibly species that have grown naturally and not intentionally planted by the owner or tenant of the land.

In the sapling strata, only one species was found, which was rubber. Rubber is a dominant species in the sapling strata because it was the only one found. The INP of rubber is 200%. The recapitulation of the sapling strata vegetation analysis is presented in Table A-2.

In the pole strata, two species were found, which were rubber and benzoin. Rubber is a dominant species with an INP of 215.22%, whereas benzoin only has an INP of 84.78%. The recapitulation of the pole strata vegetation analysis calculation is presented in Table A-3.

Table A-1 Lower Plant and Seedling Strata Vegetation Analysis Results in Location "V SIL-1".

No.	Local Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)
1	Paku Resam	*Dicranopteris linearis*	Gleicheniaceae	5	4167	0.33	11.36	5.26	16.63
2	Paku Kawat	*Lygodium scandens*	Lygodiaceae	3	2500	0.33	6.82	5.26	12.08
3	Paku	*Pteris* sp.	Pteridaceae	2	1667	0.33	2.27	5.26	9.81
4	Liana	*Gymnema latifolium*	Apocynaceae	1	833	0.33	2.27	5.26	7.54
5	Harendong bulu	*Melastoma malabatricum*	Melastomataceae	8	6667	0.67	18.18	10.53	28.71
6	Harendong	*Clidemia hirta*	Melastomataceae	6	5000	0.67	13.64	10.53	24.16
7	Rotan	*Calamus* sp.	Arecaceae	4	2500	0.33	6.82	5.26	12.08
8	Aren	*Areca* sp.	Arecaceae	1	833	0.33	2.27	5.26	7.54
9	Nanas	*Ananas comosus*	Bromeliaceae	2	1667	0.33	4.55	5.26	9.81
10	Paku	*Polypodium cyathoiodes*	Polypodiaceae	1	833	0.33	2.27	5.26	7.54
11	Karet	*Hevea brasiliensis*	Euphorbiaceae	7	5833	1.00	15.91	15.79	31.70
12	Spesias 1			1	833	0.33	2.27	5.26	7.54
13	Medang	*Litsea* sp.	Lauraceae	1	833	0.33	2.27	5.26	7.54
14	Cakar ayam	*Selaginella doederleinii*		3	2500	0.33	6.82	5.26	12.08
Total					**36667**	**6.33**	**100**	**100**	**200**

Table A-2 Sapling Strata Vegetation Analysis in Location "V SIL-1".

No.	Local Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)
1	Karet	*Hevea brasiliensis*	Euphorbiaceae	5	667	0.33	100	100	200
Total				**5**	**667**	**0.33**	**100**	**100**	**200**

Table A-3 Pole Strata Vegetation Analysis Results in Location "V SIL-1".

No.	Local Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m^2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Karet	*Hevea brasiliensis*	Euphorbiaceae	3	0.019	300	1	1.88	75	50	90.22	215.22
2	Kemenyan	*Styrax benzoin*	Styracaceae	1	0.002	100	1	0.20	25	50	9.78	84.78
Total				**4**	**0.021**	**400**	**2**	**2.08**	**100**	**100**	**100**	**300**

Table A-4 Tree Strata Vegetation Analysis Results in Location "V SIL-1".

No.	Local Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Karet	*Hevea brasiliensis*	Euphorbiaceae	29	2.92	290	1	29.12	90.63	33.33	94.57	218.53
2	Kemenyan	*Styrax benzoin*	Styaracaceae	2	0.10	20	1	1.00	6.25	33.33	3.24	42.82
3	Petai	*Parkia speciosa*	Fabaceae	1	0.07	10	1	0.67	3.13	33.33	2.19	38.65
Total				**32**	**3.08**	**320**	**3**	**30.79**	**100**	**100**	**100**	**300**

In the tree strata, 3 species were found which were rubber, benzoin and petai. Rubber is the dominant species with a density of 290 individuals/ha and an INP of 218.53%. Benzoin and petai were only found in small amounts, with a density of 20 and 10 individuals/ha and an INP of 42.82% and 38.65% respectively. The recapitulation of the tree strata vegetation analysis calculation is presented in Table A-4.

Based on the vegetation analysis, it was identified that community rubber plantations were not only planted as rubber as the main commodity, but also planted with other crops as additional commodities and they are forms of the intercropping system. The plant species as intercrops and those that are important commodities for the people are incense and stinkybeans at any given time.

In general, the condition of vegetation in community rubber plantations in this area is good. Apart from rubber and other crop commodities in this area, there are still plenty of lower plants such as rattan, aren, and other types. The number of lower plant species indicates that the plantations in this area are not managed intensively and tend to be left alone. An overview of the rubber plantation vegetation in location "V-SIL-1" is presented in Figure A-4.

Figure A-4 Rubber Plantation Vegetation in Plot 1

A.1.1.2 Rubber Plantation Vegetation in "V SIL-2"

The rubber plantation vegetation in location "V SIL-2" is classified into 5 strata of plants, which are lower plants and seedlings, saplings, poles and trees. Lower plants are plant species in the form of grass, bushes and shrubs, whereas seedlings are cambium plants (trees) with height less than 1.5m. Seedlings and lower plants are in one group because its vegetation analysis calculation was conducted on the same plot, which was a 2x2m plot. The results of the lower plant and seedling strata vegetation analysis are presented in Table A-5. According to Table A-5, it was identified that the lower plant and seedling strata in location "V SIL-2" is dominated by grass and bushes. Overall, there were 3 seedling species and 12 lower plant species. Lower plant species found cover ferns, harendong bulu, besi –besi, handolok and nut-grass. Nut-grass and harendong bulu are the most dominant types of lower plants with an INP of 29.67% and 22.83% respectively. For seedling strata, rubber was found with an INP of 13.62%, jengkol with an INP of 5.50% and incense with an INP of 5.50%.

In the sapling strata, two species were found, which were rubber and petai. Rubber is a dominant species with an INP of 167% whereas the INP of petai was 133%. The recapitulation of the vegetation analysis calculation is presented in Table A-6.

Table A-5 Seedling and Lower Plant Strata Vegetation Analysis Results in Location "V SIL-2"

No.	Local Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)
1	Besi-besi	*Wrightia religiosa*	Apocynaceae	5	4167	1.00	6.67	12.50	19.17
2	Handolok	*Syzigium* sp.	Myrtaceae	5	4167	1.00	6.67	12.50	19.17
3	Harendong	*Clidemia hirta*	Melastomaceae	6	5000	0.33	8.00	4.17	12.17
4	Paku	*Pteris* sp4.	Pteridae	5	4167	0.33	6.67	4.17	10.83
5	Rumput Teki	*Cyperus rotundus*	Cyperaceae	16	13333	0.67	21.33	8.33	29.67
6	Siak-siak	*Cinnamomum* sp.	Lauraceae	1	833	0.67	1.33	8.33	9.67
7	Karet	*Hevea brasiliensis*	Euphorbiaceae	4	3333	0.67	5.33	8.33	13.67
8	Harendong bulu	*Melastoma malabatricum*	Melastomaceae	14	11667	0.33	18.67	4.17	22.83
9	Paku (label plot 2)	*Pteris* sp5.	Pteridaceae	6	5000	0.33	8.00	4.17	12.17
10	Jengkol	*Pithecelobium jiringa*	Fabaceae	1	833	0.33	1.33	4.17	5.50
11	Kemenyan	*Styrax benzoin*	Styracaceae	1	833	0.33	1.33	4.17	5.50
12	Paku	*Pteris* sp1.	Pteridaceae	8	6667	0.33	10.67	4.17	14.83
13	Paku	*Pteris* sp2.	Pteridaceae	1	833	0.33	1.33	4.17	5.50
14	Paku	*Pteris* sp3.	Pteridaceae	1	833	0.33	1.33	4.17	5.50
15	Paku andam	*Dicranopteris linearis*	Gleicheniaceae	1	833	0.33	1.33	4.17	5.50
Total					**62500**	**8**	**100**	**100**	**200**

Table A-6 Sapling Strata Vegetation Analysis Results in Location "V SIL-"

No.	Local Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)
1	Karet	*Hevea brasiliensis*	Euphorbiaceae	8	3200	1	67	100	167
2	Petai	*Parkia speciosa*	Fabaceae	4	1600	1	33	100	133
Total					**4800**	**1**	**67**	**100**	**167**

In the pole strata, only one species was found, which was rubber. Rubber is a dominant species in the pole strata because it was the only one found. The INP of rubber is 300%. The recapitulation of the pole strata vegetation analysis is presented in Table A-7.

In the tree strata, 6 species were found, which were rubber, durian, jengkol, benzoin, torop and rambutan. Rubber is a dominant species with a density of 380 individuals/ha and an INP of 177.76%. Other species apart from durian were only found individually in the sample plot with a density of 10 individuals/ha and the INP was 26,41%, 2,13%, 22,68% and 21,98% each. For durian, 2 individuals in the plot were found with a density of 20 individuals/ha and an INP of 27.12. The recapitulation of the tree strata vegetation analysis calculation is presented in Table A-8.

Table A-7 Pole Strata Vegetation Analysis Results in Location "V SIL-2"

No.	Local Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Karet	*Hevea brasiliensis*	Euphorbiaceae	3	0.1	300	1	12.43	100	100	100	300
Total				**3**	**0.1**	**300**	**1**	**12.43**	**100**	**100**	**100**	**300**

Table A-8 Tree Strata Vegetation Analysis Results in Location "V SIL-2"

No.	Local Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m^2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Karet	*Hevea brasiliensis*	Euphorbiaceae	29	1.0	380	1	10.17	86.36	16.67	74.73	177.76
2	Duren	*Durio zibethinus*	Malvaceae	2	0.1	20	1	0.80	4.55	16.67	5.91	27.12
3	Jengkol	*Archidendron jeringa*	Fabaceae	1	0.1	10	1	1.02	2.27	16.67	7.47	26.41
4	Kemenyan	*Stirax benzoin*	Styracaceae	1	0.1	10	1	0.71	2.27	16.67	5.19	24.13
5	Torop	*Ficus elastica*	Moraceara	1	0.1	10	1	0.51	2.27	16.67	3.74	22.68
6	Rambutan	*Nephelium lappaceum*	Sapindaceae	1	0.0	10	1	0.40	2.27	16.67	2.95	21.89
Total				**35**	**1.4**	**44**	**6**	**13.61**	**100**	**100**	**100**	**300**

In general, the rubber plantation vegetation in location "V SIL-2" is rubber vegetation associated with other species, particularly lower plant species such as ferns, nut-grass and harendong. When cultivating, the people do not only plant rubber, but they also plant other species in the form of intercropped plantations. Several crops chosen as intercrops are benzoin, durian, jengkol and rambutan.

Apart from the flora species found in the table above, there were other flora species found outside of the sample plot. One of the species that was interesting was kantong semar (*Nepenthes melamphora*). Plenty kantong semar was found along the road towards Well SIL-2. In Sumatera, this plant usually has a local name such as *ketupat beruk, periuk monyet, kendi kera, akar ketakong,* and *tahul-tahul*. Kantong semar is included in the liana plant classification (vine) on the branches of trees or on the ground, has two reproductive parts (separate male and female flowers in different individuals). Kantong semar has changes in shape from the tip of the leaf, which functions to trap insects or other small animals. Because of this, this plant is classified as a carnivorous plant, apart from *Venus Flytrap* (Dionaea muscipula), *sundews* (Droseraceae) and several other species. Kantung semar lives in marginalized land with poor nutrients. According to CITES, almost part of this plant population is included in the Appendix II category. According to the Indonesian legislation, kantong semar is listed in the protected species list based on PP No. 7 of 1999, because it is endangered due to habitat damage and direct individual picking from nature. Figure A-5 illustrates kantong semar species found around location "V SIL-2".

Figure A-5 Kantung Semar (*Nepenthes melamphora*) found around Transect "V SIL-2".

Mixed Forests

There are many mixed forests found in Namora I Langit (NIL). Mixed forests are vegetation dominated by rubber plants and bushes mixed with forest plants. They are not managed intensively. In general, the mixed forests in NIL are rubber and incense plants. In the sample plot, it can be seen that sap is no longer taken from rubber plants while for benzoin, it is still apparent that there are damages to produce benzoin sap. In the formation of this mixed forest, a vegetation analysis was conducted in the sample plot later named location "V NIL 2". The formation and structure of this mixed forest resembles a secondary forest with lower plant and bush complexity that is quite high and dense. In addition, there is also rattan that is a typical wet forest plant. Overall, 12 species were found in the lower plant and seedling strata.

According to the results of the vegetation analysis calculation, it was identified that the dominant lower plant species was fern with an INP of 39.74% and rattan (*Calamus* sp.1) with an INP of 30,77%. Whereas, for the seedling strata, there were only kayu salib and besi-besi, each with an INP of 8,97% and 10,26%.

In the sapling strata, it was identified that there were 11 species that make up the mixed forest vegetation composition in location "V NIL-2". There were no dominant species in the sapling strata. Andis had the highest INP at 35%. Another species that had quite a high INP was kayu salib with 21,67%. The lowest INP was by three species, which was DSC 8387, simartolu and himorate-ate with an INP of 11.67%. Other sapling strata species found in location "V-NIL-2" include benzoin, cempedak, gumo-gumo, petai, and sitarak. The recapitulation of the sapling strata vegetation analysis calculation in location "V NIL-2" is presented in Table A-9.

In the pole strata, only 2 species were found, which were rubber and benzoin. Rubber and benzoin are the main species that make up the mixed forest vegetation composition in location "V NIL-2". According to the results of the vegetation analysis calculation, it was identified that benzoin is more dominant compared to rubber. The INP of benzoin was 165,08% while rubber was 134.92%. The recapitulation of the pole strata vegetation analysis calculation in location "V NIL-2" is presented in Table A-10.

In the tree strata, it was identified that there were 7 species found in location "V NIL-2", which were jamuju, handolok, benzoin, rubber, atarodan, medang and simartolu. Rubber is the species with the highest INP at 98.53%. Apart from rubber, there were also benzoin and simartolo that also had quite a high INP, each with 60,18% and 68.18%. The recapitulation of the tree strata vegetation analysis calculation in location "V-NIL-2" is presented in Table A-11

Table A-9 Sapling Strata Vegetation Analysis Results in Location "V-NIL-2"

No.	Local Name	English Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)
1	Kemenyan	Sumatra Benzoin Tree	*Stirax benzoin*	Styracaceae	3	400.00	0.33	10.00	8.33	18.33
2		White Hazelwood	*Symplocos cochinchinensis*	Symplocaceae	3	400.00	0.33	10.00	8.33	18.33
3	DSC8367-68	-	-		1	133.33	0.33	3.33	8.33	11.67
4	Salib	-	*Canarium* sp.	Burseraceae	4	533.33	0.33	13.33	8.33	21.67
5	Taki	Cempedak	*Artocarpus integer*	Moraceae	2	266.67	0.33	6.67	8.33	15.00
6	Gumo-gumo	-	*Dillenia* sp.	Dilleniaceae	2	266.67	0.33	6.67	8.33	15.00
7	Petai	Petai	*Parkia speciosa*	Fabaceae	2	266.67	0.33	6.67	8.33	15.00
8	Simartolu	Needlewood	*Schima wallichii*	Theaceae	1	133.33	0.33	3.33	8.33	11.67
9	Himorate-ate	-	*Glochidion* sp.	Phyllanthaceae	1	133.33	0.33	3.33	8.33	11.67
10	Sitarak	-	*Macaranga* sp.	Euphorbiaceae	3	400.00	0.33	10.00	8.33	18.33
11	Andis	Merpauh	*Swintonia floribunda*	Anacardiaceae	8	1066.67	0.33	26.67	8.33	35.00
Total						**4000**	**4**	**100**	**100**	**200**

Table A-10 Pole Strata Vegetation Analysis Results in Location "V NIL-2"

No.	Local Name	English Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m^2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Karet	Rubber Plant	*Hevea brasiliensis*	Euphorbiaceae	1	0.07	100	0.5	7.47	16.67	33.33	84.92	134.92
2	Kemenyan	Sumatra Benzoin Tree	*Stirax benzoin*	Styracaceae	5	0.01	500	1	1.33	83.33	66.67	15.08	165.08
Total					6	0.09	600	1.5	8.80	100.00	100	100	300

Table A-11 Tree Strata Vegetation Analysis Results in Location "V NIL-2"

No.	Local Name	English Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m^2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Jamuju	-	*Dacrycarpus imbricatus*	Podocarpaceae	1	0.04	10	0.33	0.42	4.76	10	2.22	16.98
2	Handolok	-	*Syzigium* sp.	Myrtaceae	1	0.03	10	0.33	0.35	4.76	10	1.85	16.61
3	Kemenyan	Sumatra Benzoin Tree	*Stirax benzoin*	Styracaceae	6	0.22	60	0.67	2.17	28.57	20	11.61	60.18
4	Karet	Rubber Tree	*Hevea brasiliensis*	Euphorbiaceae	8	0.57	80	1.00	5.70	38.10	30	30.44	98.53
5	Atarodan	-	-		3	0.82	30	0.33	8.22	14.29	10	43.89	68.18
6	Medang	-	-	Lauraceae	1	0.09	10	0.33	0.85	4.76	10	4.56	19.33
7	Simartolu	Needlewood	*Schima wallichii*	Theaceae	1	0.10	10	0.33	1.02	4.76	10	5.43	20.19
Total					**21**	**1.87**	**210**	**3.33**	**18.73**	**100**	**100**	**100**	**300**

According to the vegetation analysis calculation in location "V-NIL-2", it generally shows a diverse composition starting from lower plant to tree strata. Mixed forest vegetation at the time of the survey appears to be left alone to grow naturally without any handling such as fertilizing, thinning and treatment for other cultivation activities. The only handling of cultivated plants is harvesting and the presence of young plants believed to be planted by farmers. A picture of Location "V NIL-2" can be seen in Figure A-6.

Figure A-6 Picture of the Mixed Forest Vegetation in Location "V NIL-2"

<u>Forests</u>

Forests are natural vegetation that grow around the crater of Namora I Langit and are behind the formation of mentigi bush formations from the sulfur crater. The forests around NIL that are the sampling locations are called "V NIL 1". In this location, a vegetation analysis was conducted by dividing the plant strata into 5 groups, which are lower plants, seedlings, saplings, poles and trees.

In the seedling and lower plant strata, *Rhodeleia championii* was very dominant with an INP of 86%. Other species found include *Lomariopsis sorbifolia, Vaccinium bancanum* and *Piper* sp. The results of the vegetation analysis in location "V NIL-1" are presented in Table A-12

Table A-12 Lower Plant and Seedling Strata Vegetation Analysis Results in Location "V NIL-1"

No.	Local Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)	Description
1		*Rhodoleia championii*	Hamamelidaceae	31	25833	0.33	75.61	11.11	86.72	
2		*Vaccinium bancanum*	Ericaceae	1	833	0.33	2.44	11.11	13.55	
3	Paku	*Lomariopsis sorbifolia*	Pteridaceae	2	1666	0.33	4.88	11.11	15.99	
4	DSC8318			1	833	0.33	2.44	11.11	13.55	Unidentified
5	DSC8333			1	833	0.33	2.44	11.11	13.55	Unidentified
6		*Piper* sp.	Piperaceae	1	833	0.67	2.44	22.22	24.66	
7	DSC8315			4	3333	0.67	9.76	22.22	31.98	Unidentified
Total					**34167**	**3**	**100**	**100**	**200**	

Table A-13 Sapling Strata Vegetation Analysis Results in Location "V NIL-1"

No.	Local Name	Scientific Name	Family	∑	Density (Total/Ha)	Frequency	KR (%)	FR (%)	INP (%)	Description
1	Jirak	*Symplocos cochinchinensis*	Symplocaceae	7	5833	1.00	14.89	14.29	29.18	
2	DSC8320			1	833	1.00	2.13	14.29	16.41	Unidentified
3	Kedudampit	*Rhododendron kemulense*	Ericaceae	32	26666	1.00	68.09	14.29	82.37	
4	Kemenyan	*Stirax benzoin*	Styracaceae	3	2500	1.00	6.38	14.29	20.67	
5	DCS8366			2	1666	1.00	4.26	14.29	18.54	Unidentified
6	DSC8367-68			1	833	1.00	2.13	14.29	16.41	Unidentified
7	DSC8369-70			1	833	1.00	2.13	14.29	16.41	Unidentified
Total					**39167**	**7**	**100**	**100**	**200**	

In the sapling strata, 7 species were found. Kududampit was the species found in the largest amount and is the most dominant with an INP of INP 82,37%. Several other species were found with more than 1 individual, which were jirak and benzoin. Benzoin that was found was grown naturally. Benzoin seeds are naturally distributed by the wildlife through digestion and the movement of the wildlife alone. The recapitulation of the sapling strata vegetation analysis calculation in location "V NIL-1" is presented in Table A-13.

In the pole strata, only 2 species were found, which were salagundi and kayu arang. Salagundi is a dominant pole species with an INP of 172,36%, while the INP for kayu arang was 127,64%. The recapitulation of the vegetation analysis calculation in location "V NIL-1" is presented in Table A-14.

In the tree strata, 5 species were found, which were salagundi, hoting, ipis kulit, haumisar and simartolu. Hoting and simartolu are dominant species with almost the same INP, each with an INP of 85,03% and 83,44%. Only 1 individual Ipis kulit and haumisar were found with an INP of 31,69% and 28,82%. The recapitulation of the vegetation analysis calculation is presented in Table A-15.

In general, it can be drawn that the forest in location "V NIL-1" is natural slightly affected by human activities. This can be seen from the presence of footpaths that are often passed and several used wood shavings. The vegetation of this location is dense with a not very large average tree diameter. An overview of the natural forest vegetation in location "V NIL-1" can be seen in Figure A-7.

Table A-14 Pole Strata Vegetation Analysis Results in Location "V NIL-1"

No.	Local Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m^2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Salagundi	*Rhodiola teysmannii*	Crassulaceae	5	0.003	5000	0.50	0.26	83.33	50.00	39.02	172.36
2	Kayu arang	*Dyospiros* sp.	Ebenaceae	1	0.004	1000	0.50	0.40	16.67	50.00	60.98	127.64
Total				**6**	**0.007**	**6000**	**1.00**	**0.66**	**100**	**100**	**100**	**300**

Table A-15 Tree Strata Vegetation Analysis Results in Location "V NIL-1"

No.	Local Name	English Name	Scientific Name	Family	∑	LBDS (m^2)	Density (Total/Ha)	Frequency	Dominance (m^2/Ha)	KR (%)	FR (%)	DR (%)	INP (%)
1	Salagundi	-	*Rhodiola teysmannii*	Crassulaceae	2	0.12	20	1.00	1.22	20.00	22.22	28.80	71.02
2	Hoting	-	Lithocarpus*	Fagaceae	3	0.04	30	2.00	0.45	30.00	44.44	10.58	85.03
3	Ipis kulit	-	*Kibessia azurea*	Melastomataceae	1	0.04	10	0.50	0.45	10.00	11.11	10.58	31.69
4	Haumisar	-			1	0.03	10	0.50	0.33	10.00	11.11	7.71	28.82
5	Simartolu	Needlewood	*Schima wallichii*	Theaceae	3	0.18	30	0.50	1.79	30.00	11.11	42.33	83.44
Total					**10**	**0.42**	**100**	**4.50**	**4.23**	**100**	**100**	**100**	**300**

Figure A-7 Overview of the Natural Forest Vegetation in Location "V NIL-1".

The forest around Namora I Langit has a high diversity of types and species that make up the forest. The vegetation analysis conducted did not indicate the overall composition of species, because of the diverse vegetation type, particularly in an area quite far away from the sulfur crater. In terms of ecology, the forests around Namora I Langit are included in Batang Toru Forest, which is a mountain chain tropical rainforest. According to *Baseline Terrestrial Ecology Survey of Martabe Project Area, North Sumatra, Indonesia, 2003,* at least 121 plant species were found in Batang Toru Forest. The list of plant species found in Batang Toru Forest based on this data is presented in Table Table A-16.

Table A-16 List of Plant Species Spread in Batang Toru Forest

No.	Family	Scientific Name	Indonesian Name
1	Aceraceae	*Acer laurinum*	
2	Rutaceae	*Acronychia laurifolia*	
3	Rutaceae	*Tetractomia obovata*	
4	Rutaceae	*Evodia glabra*	
5	Lauraceae	*Actinodaphne glabra*	Medang
6	Lauraceae	*Litsea elliptica*	Medang
7	Lauraceae	*Litsea umbellata*	Medang
8	Lauraceae	*Cinnamomum iners*	Akar tiga
9	Lauraceae	*Persea declinata*	
10	Theaceae	*Adinandra dumosa*	
11	Theaceae	*Eurya acuminata*	
12	Theaceae	*Adinandra sarosanthera*	
13	Theaceae	*Ternstroemia aneura*	
14	Theaceae	*Ternstroemia bancana*	
15	Fabaceae	*Antidesma puncticulatum*	
16	Fabaceae	*Archidendron borneense*	
17	Fabaceae	*Archidendron ellipticum*	
18	Fabaceae	*Archidendron jeringa*	Jengkol
19	Fabaceae	*Parkia speciosa*	Petai

No.	Family	Scientific Name	Indonesian Name
20	Fabaceae	*Phanera kockiana*	
21	Fabaceae	*Sindora sumatrana*	Sindur
22	Moraceae	*Artocarpus dadah*	Nangka
23	Moraceae	*Artocarpus elasticus*	Nangka
24	Moraceae	*Artocarpus gomeriana*	Nangka
25	Moraceae	*Artocarpus heterophyllus*	Nangka
26	Moraceae	*Artocarpus integer*	Cempedak
27	Moraceae	*Artocarpus nitidus*	Nangka
28	Moraceae	*Ficus ribes*	Hamerang
29	Moraceae	*Ficus* sp.	Ara
30	Euphorbiaceae	*Aporosa benthamiana*	
31	Euphorbiaceae	*Baccaurea kunstleri*	
32	Euphorbiaceae	*Baccaurea sumatrana*	
33	Euphorbiaceae	*Bridelia glauca*	
34	Euphorbiaceae	*Endospermum moluccanum*	Medang gembung
35	Euphorbiaceae	*Glochidion borneense*	
36	Euphorbiaceae	*Macaranga triloba*	Mahang
37	Euphorbiaceae	*Mallotus peltatus*	
38	Euphorbiaceae	*Antidesma punticulatum*	
39	Celastraceae	*Bhesa paniculata*	
40	Celastraceae	*Kokoona littoralis*	
41	Celastraceae	*Lophopetalum javanicum*	
42	Clusiaceae	*Calophyllum inophyllum*	Nyamplung
43	Clusiaceae	*Callophylum soulatri*	Bintangur
44	Clusiaceae	*Callophylum teijsmannii*	
45	Clusiaceae	*Garcinia rostrata*	Kandis
46	Clusiaceae	*Garcinia rigida*	Kandis
47	Clusiaceae	*Garcinia rostrata*	Kandis
48	Clusiaceae	*Mesua lepidota*	
49	Anacardiaceae	*Campnosperma auriculata*	Terentang
50	Anacardiaceae	*Dracontomelon dao*	Dahu
51	Anacardiaceae	*Gluta renghas*	Rengas
52	Anacardiaceae	*Mangifera foetida*	Kweni
53	Anacardiaceae	*Parishia paucijuga*	
54	Burseraceae	*Canarium* sp.	Kenari
55	Burseraceae	*Dacryodes ineurvata*	
56	Burseraceae	*Santiria apiculata*	Medang sengit
57	Burseraceae	*Santiria griffithii*	Medang
58	Dipterocarpaceae	*Cotylelobium melanoxylon*	
59	Dipterocarpaceae	*Hopea mengarawan*	Merawan
60	Dipterocarpaceae	*Shorea curtisii*	Meranti
61	Dipterocarpaceae	*Shorea ovata*	Meranti

No.	Family	Scientific Name	Indonesian Name
62	Dipterocarpaceae	*Shorea* sp.	Meranti
63	Dipterocarpaceae	*Vatica ridleyana*	
64	Hypericaceae	*Cratoxylum arborescens*	
65	Crypteroniaceae	*Crypteronia griffithii*	Medang
66	Ctenolophoniaceae	*Ctenolophon parvifolius*	
67	Ebenaceae	*Diospyros evena*	
68	Ebenaceae	*Diospyros sumatrana*	
69	Bombacaceae	*Durio oxleyanus*	Durian hutan
70	Meliacaceae	*Dysoxylum arborescens*	
71	Elaeocarpaceae	*Elaeocarpus griffithii*	Medang knit
72	Elaeocarpaceae	*Elaeocarpus peduncttulatus*	Medang knit
73	Elaeocarpaceae	*Elaeocarpus paniculatus*	Medang kunyit
74	Elaeocarpaceae	*Elaeocarpus petiolatus*	Medang kunyit
75	Elaeocarpaceae	*Sloetia elongata*	
76	Elaeocarpaceae	*Sloanea javanica*	
77	Flacourtiaceae	*Flacourtia rukam*	Rukam
78	Ulmaceae	*Gironniera nervosa*	Medang kunyit
79	Icacinaceae	*Gomphandra capitulata*	
80	Icacinaceae	*Stemonurus secundiflorus*	
81	Myristicaceae	*Gymnacranthera forbesii*	
82	Myristicaceae	*Horsfieldia irya*	Darah-darah
83	Myristicaceae	*Knema laurina*	Darah-darah
84	Ixonanthaceae	*Ixonanthes crassifolia*	
85	Ixonanthaceae	*Ixonanthes petiolaris*	
86	Sabiaceae	*Meliosma nitida*	
87	Tiliaceae	*Microcos florida*	
88	Tiliaceae	*Microcos loezingiii*	
89	Sapindaceae	*Nephelium mangayi*	Rambutan hutan
90	Sapindaceae	*Nephelium rubescens*	Rambutan hutan
91	Sapindaceae	*Nephelium lappaceum*	Rambutan
92	Sapindaceae	*Xerospermum noronhianum*	
93	Sapotaceae	*Palaquium microphylum*	Mayang
94	Sapotaceae	*Palaquium quercifolium*	Mayang
95	Sapotaceae	*Palaquium ridleyi*	Mayang
96	Sapotaceae	*Palaquium rostratum*	Mayang susu
97	Sapotaceae	*Palaquium semaram*	Mayang
98	Sapotaceae	*Chrysophyllum lanceolatum*	Sawo
99	Rubiaceae	*Plectronia didyma*	
100	Rubiaceae	*Timonius splendens*	
101	Annonaceae	*Polyalthia rumphii*	
102	Melastomataceae	*Pternandra caerulescens*	
103	Fagaceae	*Quercus subserica*	Hoting

No.	Family	Scientific Name	Indonesian Name
104	Myrtaceae	*Rhodamnia cinerea*	Baja-baja
105	Myrtaceae	*Syzigium acuminatissima*	Jambu-jambu
106	Myrtaceae	*Syzigium cymosa*	Jambu-jambu
107	Myrtaceae	*Syzigium laxiflorum*	Jambu-jambu
108	Myrtaceae	*Sizygium longiflora*	Jambu-jambu
109	Myrtaceae	*Syzigium magnoliaefolia*	Jambu-jambu
110	Myrtaceae	*Syzigium monticola*	Jambu-jambu
111	Myrtaceae	*Tristania whiteana*	Malu tua
112	Oxalidaceae	*Sarcotheca griffithii*	
113	Oxalidaceae	*Sarcotheca laxa*	
114	Sterculiaceae	*Scaphium macropodum*	
115	Sterculiaceae	*Sterculia coccinea*	
116	Styraceae	*Styrax benzoin*	Kemenyan
117	Apocynaceae	*Tabernaemontana pandacaqui*	
118	Combretaceae	*Terminalia citrina*	Ketapang
119	Verbenaceae	*Vitex laban*	Laban
120	Polygalaceae	*Xanthophyllum flavescens*	Medang batu
121	Polygalaceae	*Xanthophyllum rufum*	Medang batu

Bushes

Bush vegetation is usually found in used opened areas, particularly around geothermal wells in NIL. Species in the bush vegetation composition around these wells cover putri malu (*Mimosa pudica*), harendong (*Clidermia hirta*) harendong bulu (*Melastoma malabatricum*), tembelekan (*Lantana camara*), teki (*Cyperus rotundus*), resam (*Dicranopteris linearis*), and alang-alang (*Imperata cylindrica*). Bush vegetation composition species are those that act as pioneer plants.

Bush vegetation is also found around the NIL crater. Bush vegetation around the NIL crate is quite unique, where flora species are found that generally grow in mountain top regions. The flora species covers cantigi (*Vaccinium* sp.) from the Ericaeae family. Even though this species is usually found in mountain tops, the conditions around NIL Well is a sulfur crater that has similar environmental conditions to mountain tops, particularly mountains with sulfur craters or active craters. In addition, bush vegetation in NIL also covered kantong semar (*Nepenthes melamphora)*, which is protected according to PP No. 7 of 1999. The following is a photo of *Nepenthes melamphora* found in NIL.

Figure A-8 Kantung Semar (*Nepenthes melamphora*) found in NIL.

A.1.1.3 Fauna

The forest area and cultivated vegetation in the study area is part of Batang Toru Forest, which is unique and rich in potential, representing the forest conditions of the Sumatera mountain chain. Batang Toru Forest is divided into 2 main blocks, which are the east block and west block with Batang Toru river and residences and cultivation areas in the center separating these two blocks. The east block is inhabited by several key wildlife species of which their existence supports the unique and rich potential of Batang Toru Forest. The observation location is situated in the East Block of Batang Toru Forest (Sarulla), exactly in SIL Block (Silangkitang) and NIL Block (Namora I Langit). In detail, the results of the observation on insects, amphibians, reptiles, birds and mammals will be explained. The observation path is illustrated in the pictures below here. (Figure A-9).

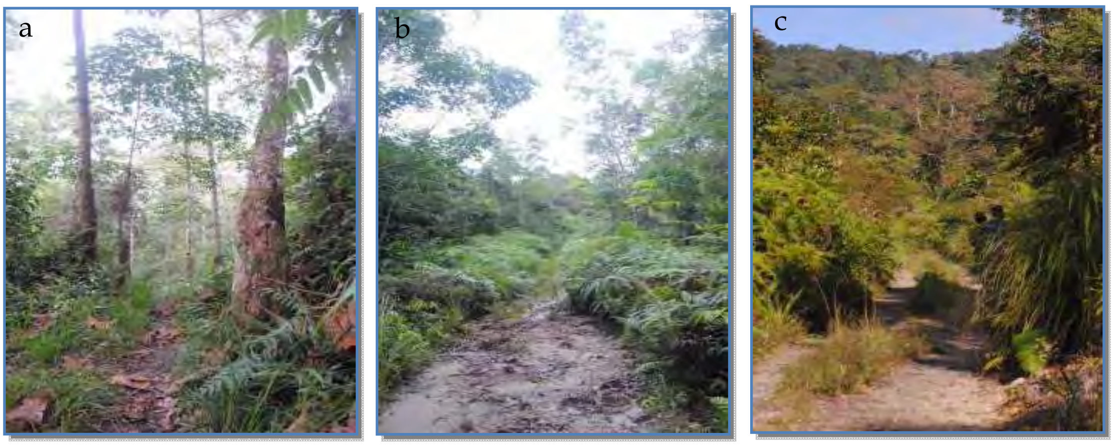


Figure A9 From Left to Right, Rubber Plantation in SIL-1 (a), SIL-2 Observation Path (b), and NIL Observation Path (c).

Mammals

The area around SIL-1 well, SIL-2 well, and NIL is the observation path included in the East Block of Batang Toru or Sarulla Block. The observation path is in the form of agricultural habitat and rubber plantations. In general, this habitat is inhabited by small mammal species to ungulate species. The recording of mammal species was conducted based on direct and indirect encounters. Direct encounters are those with mammal species where their physique can be seen clearly. Indirect encounters are those with mammal species through the marks left such as scratches, dung, trail, sound and smell. The mammal species directly encountered cover the Sumatra Tiger, honey bear, wild boar, ape and agile gibbon.

As part of the Batang Toru Mountain Chain Forest, the presence of mammals in the study area cannot be separated from the presence of mammals in batang toru forest outside of the study area. The finding of 9 mammal species in the study area cannot indicate that there are only 9 species in the study area. By matching the encounters during the survey, interview with citizens and secondary data, there are at least 55 mammal species found in the batang toru forest. The list of mammal species, description of encounters and protection status are presented in Table A-17.

Table A-17 List of Mammal Species Found in Batang Toru Forest

No.	Latin Name	English Name	Indonesian Name	Order	Family	Description	PP No.7/1999	IUCN	CITES
1	*Hystrix brachyura*	Asian Porcupine	Landak raya	Rodentia	Brachyuridae	Interview			
2	*Arctictis binturong*	Binturong	Binturung muntu	Carnivore	Viverridae	Interview	Protected	VU	--
3	*Helarctos malayanus*	Malayan Sun Bear	Beruang madu	Carnivore	Ursidae	Old scratches on the tree	Protected	EN	1
4	*Panthera tigris sumatrae*	Sumatran Tiger	Harimau sumatera	Carnivore	Felidae	Interview/sound	Protected	CR	1
5	*Pardofelis marmorata*	Marbled Cat	Kucing batu	Carnivore	Felidae	Interview	Protected	VU	1
6	*Prionailurus bengalensis*	Leopard Cat	Kucing kuwuk	Carnivore	Felidae	Secondary Data	Protected	LC	2
7	*Paguma larvata*	Masked Palm Civet	Musang	Carnivore	Viverridae	Dung, crossing the road		LC	
8	*Paradoxurus hermaphroditus*	Common Palm Civet	Musang luwak	Carnivore	Viverridae	Interview	--	LC	--
9	*Hipposideros cervinus*	Gould's Roundleaf Bat	Barung gauld	Chiroptera	Hipposideridae	Secondary Data	--	LC	--
10	*Hipposideros larvatus*	Large Roundleaf Bat	Barong besar	Chiroptera	Hipposideridae	Secondary Data	--	LC	--
11	*Cynopterus sphinx*	Short Nosed Fruit Bat	Codot barong	Chiroptera	Pteropidae	Secondary Data	--	LC	--
12	*Macroglossus sobrinus*	Greater Long-tongued Fruit Bat	Cecadu pisang besar	Chiroptera	Pteropidae	Secondary Data	--	LC	--
13	*Penthetor lucasi*	Luca's Short-nosed Fruit Bat	Pentae'n coboe	Chiroptera	Pteropidae	Secondary Data	--	LC	--
14	*Rousettus amplixicaudatus*	Geoffroy's Rousette	Nyap biasa	Chiroptera	Pteropidae	Secondary Data	--	LC	--
15	*Cynocephalus variegatus*	Malayan Flying Lemur	Kubung Malaya	Dermoptera	Cynocephalidae	Secondary Data	Protected	LC	--
16	*Aethalops alecto*	Gray Fruit Bat	Codot bukit	Mega Chiroptera	Pteropodidae	Secondary Data	--	NT	--
17	*Balionycteris maculata*	Spotted-winged Fruit Bat	Langai isiq totol	Mega Chiroptera	Pteropodidae	Secondary Data	--	--	--
18	*Chironax melanocephalus*	Black-capped Fruit Bat	Codot kepala hitam	Mega Chiroptera	Pteropodidae	Secondary Data	--	LC	
19	*Cynopterus brachyotis*	Lesser Dog Faced Fruit Bat	Codot krawar	Mega Chiroptera	Pteropodidae	Secondary Data	--	LC	--
20	*Cynopterus titthaecheilus*	Greater Dog Faced Fruit Bat	Codot besar	Mega Chiroptera	Pteropodidae	Secondary Data	--	LC	--

No.	Latin Name	English Name	Indonesian Name	Order	Family	Description	PP No.7/1999	IUCN	CITES
21	*Eonycteris spelaea*	Cave Nectar Bat	Lalai kembang	Mega 22Chiroptera	Pteropodidae	Secondary Data	--	--	--
22	*Cheiromeles torquatus*	Common Hairless Bat	Tayo gundul umum	Micro Chiroptera	Molossidae	Secondary Data	--	NT	--
23	*Hipposideros bicolor*	Bicolored Roundleaf Bat	Barong dwi warna	Micro Chiroptera	Hipposideridae	Secondary Data	--	LC	--
24	*Rhinolophus affinis*	Intermediate Horseshoe Bat	Prok bruk hutan	Micro Chiroptera	Rhinolophidae	Secondary Data	--	LC	--
25	*Tylonycteris robustula*	Greater Club Footed Bat	Kekeki besar	Micro Chiroptera	Vespertilionidae	Secondary Data	--	LC	--
26	*Macaca nemestrina*	Pig-tailed Macaque	Beruk	Primata	Cercopithecidae	On the main road	Protected	VU	II
27	*Hylobates agilis*	Agile Gibbon	Ungko	Primata	Hylobatidae	Suara (± 800 m dari jalur pengamatan)	Protected	EN	I
28	*Symphalangus syndactylus*	Siamang	Siamang	Primata	Hylobatidae	Sound (± 700 m from the observation path)	Protected	EN	I
29	*Pongo abeli*	Sumatran Orangutan	Orangutan Sumatera	Primata	Hominidae	Interview	Protected	CR	I
30	*Presbytis melalophos*	Mitred Leaf Monkey	Simpai	Primata	Cercopithecidae	Secondary Data	Protected	EN	II
31	*Nycticebus coucang*	Slow Loris	Kukang	Primata	Lorisidae	Interview	Protected	VU	II
32	*Leopoldamys sabanus*	Long-tailed Giant Rat	Mondok sabanus	Rodentia	Muridae	Secondary Data	--	LC	--
33	*Maxomys surifer*	Red Spiny Rat	Lesoq lati merah	Rodentia	Muridae	Secondary Data	--	LC	--
34	*Maxomys whiteheadi*	Whitehead's Spiny Rat	Lesoq lati whiteheadi	Rodentia	Muridae	Secondary Data	--	VU	--
35	*Niviventer cremoriventer*	Dark-tailed Tree Rat	Timpaus gayat	Rodentia	Muridae	Secondary Data	--	LC	--
36	*Niviventer fulvescens*	Chestnut Rat	Timpaus punggung coklat	Rodentia	Muridae	Secondary Data	--	LC	--
37	*Rattus exulans*	Polynesian Rat	Tikus polinesia	Rodentia	Muridae	Secondary Data	--	LC	--
38	*Rattus tanezumi*	Japan's House Rat	Tikus rumah	Rodentia	Muridae	Secondary Data	--	LC	--
39	*Rattus tiomanicus*	Malaysian Field Rat	Tikus belukar	Rodentia	Muridae	Secondary Data	--	LC	--
40	*Sundamys muelleri*	Muller's Rat	Sundamis muelleri	Rodentia	Muridae	Secondary Data	--	LC	--
41	*Callosciurus nigrovittatus*	Black Banded Squirrel	Bajing hitam	Rodentia	Sciuridae	Secondary Data	--	NT	--
42	*Callosciurus notatus*	Plantain Squirrel	Bajing kelapa	Rodentia	Sciuridae	SIL 1 and SIL 2			

No.	Latin Name	English Name	Indonesian Name	Order	Family	Description	PP No.7/1999	IUCN	CITES
43	*Lariscus insignis*	Three-striped Ground Squirrel	Bokol buut	Rodentia	Sciuridae	Secondary Data	Protected	NT	--
44	*Nannosciurus melanotis*	Black-eared Pygmy Squirrel	Kekek pilis	Rodentia	Sciuridae	Secondary Data	--	LC	--
45	*Ratufa affinis*	Black Giant Squirrel	Jelarang bilalang	Rodentia	Sciuridae	Secondary Data	Protected	NT	II
46	*Sundasciurus hippurus*	Slender Squirrel		Rodent	Sciuridae	Secondary Data		NT	
47	*Sundasciurus tenuis*	Slender Squirrel	Tigae bancirot	Rodent	Sciuridae	Secondary Data	--	LC	--
48	*Tupaia glis*	Common Tree Shrew	Tupai akar	Scandentia	Tupaiidae	SIL-1 and SIL-2	--	LC	II
49	*Tupaia tana*	Large Tree Shrew	Tupai tanah	Scandentia	Tupaiidae	SIL-2		LC	II
50	*Tragulus javanicus*	Lesser Mouse Deer	Pelanduk kancil	Tragulidae	Tragulidae	Secondary Data	Protected	DD	I
51	*Cervus unicolor*	Sambar Deer	Rusa	Ungulate	Cervidae	Interview	Protected	VU	
52	*Muntiacus muntjak*	Common Barking Deer	Kijang	Ungulate	Cervidae	Secondary Data	Protected	LC	
53	*Capricornis sumatrensis*	Sumatran Serow	Kambing hutan	Ungulate	Bovidae	Secondary Data	Protected	VU	I
54	*Sus scrofa*	Wild Boar	Babi hutan	Ungulate	Suidae	Young		LC	
55	*Tapirus indicus*	Asian Tapir	Tapir	Ungulate	Tapiridae	Interview	Protected	EN	I

*Source : Baseline Terrestrial Ecology Survey of Martabe Project Area, North Sumatra, Indonesia, 2003 and Batang Toru Research Station Data, Yayasan Ekosistem Lestari

According to Table A-17 above, Batang Toru Forest is rich in mammal species that are highly diverse. From the observation results in the three observation paths, two in SIL-1 and SIL-2 and one path in NIL, the total wildlife observed directly was eight species, covering the honey bear (*Helarctos malayanus*), wild boar (*Sus scrofa*), ape (*Macaca nemestrina*), agile gibbon (*Hylobates agilis*), gibbon (*Symphalangus syndactylus*), plantain squirrel (*Callociurus notatus*), common tree shrew (*Tupaia glis*), chipmunk (*Tupaia tana*) and the Sumatran Tiger (*Phantera tigris sumatrae*). Species from *Hylobatidae* family, such as the gibbon and agile gibbon were observed according to their great call throughout observation. Figure A-10 illustrates several mammal findings in Silangkitang and Namora I Langit.

Figure A-10 **From Right to Left and Down, Old Honey Bear Scratches (*Helarctos malayanus*) on a Dead Tree (a), Wild Boar Trail (*Sus scrofa*) in NIL (b) and Plantain Squirrel (*Callosciurus notatus*) (c).**

The common tree shrew and plantain squirrel are small mammal species often found in fields, plantations and yards. Squirrels and shrews use plantations and yards for roaming and feeding. Squirrels and shrews feed off fruits, seeds, and small insects. Whereas wild boars usually live in plantations bordering the forest, both secondary and primary forests. The wild boar is an omnivore, making it easy to adapt to plantation habitats. From the observation, wild boar trails were found in the form of young in SIL-1 bordering plantations, whereas in NIL, findings were in the form of foot prints.

The area around the NIL crater is an area easily identified with primates from *Hylobatidae* family. There are 2 hylobates species found in the location around the NIL crater, which are the gibbon and agile gibbon. The habits of these two species are making sounds in the morning and evening at relatively the same time every day and this marks the existence of these two primates. According to the volume of the sound heard, the location of the animal is estimated to be around 700-800 m from the observation location. These two animals roam around quite a vast area. The agile gibbon roams to about 29 ha or more narrow compared to the gibbon at 31 ha (Chiever 2001). With a roaming area that vast, it is highly possible that these two primates live quite close to the NIL sulfur crate. The roaming area may change from time to time, depending on food, supply, water, climate changes, competition within the group and several habitat change issues (Rowe 1996), both natural and human intervention changes. The gibbon and agile gibbon are primate species protected by the Indonesian government according to PP No. 7 of 1999. Based on the IUCN red book, these two primates are endangered (*Endangered*/EN).

Apart from these two primates, according to community information, there is also another type of primate, which is the orangutan. Batang Toru Forest is the last orangutan habitat in Sumatera south of Lake Toba. Based on the population study by Wich *et al.* 2008, the population of the Sumatera orangutan in Sarulla Block forest ranges at about 150. However, based on direct observations, none were found, both direct and based on nest trails left in observation areas. Whereas according to interviews with local citizens, orangutans are sometimes encountered coming down to the field or plantation during the fruiting durian season. The Sumatra orangutan is included in the “Critical” category according to IUCN and is protected by the Indonesian government based on PP No. 7 of 1999.

Apart from primates, 2 carnivores were also found around the NIL Crater, which was the honey bear and Sumatera Tiger. The honey bear was found in quite a unique area, where the forest conditions are mountainous forests 900 m above sea level. The existence of the honey bear was detected based on old scratches on trees. The old scratches were found on bark that was peeled off and ripped, which indicates former foraging. The honey bear has an important ecological function as a seed distributor. When the bear eats food containing seeds, the bear is unable to digest the seeds, which is why when the seeds are discharged from the body, the seeds are still intact and can grow into new individual plants. The honey bear is a species protected by the Indonesian government through PP No. 7 of 1999 and internationally, it is an endangered animal according to the IUCN Red Book.

During the observation, Sumatera Tiger roars were heard. Seeing that the forest conditions are still good, there is an extremely high possibility of tigers in this region. This analysis is strengthened with information from the people who are active around the forest often encountering Sumatra tiger trails and hearing them. The existence of wild boars detected based on their foot prints in the area around the NIL crater supports indications of Sumatera Tigers in this area, because the wild boar is one of the tiger's preys. Ecologically, the Sumatera Tiger is in the highest position in the food pyramid or is the top predator. The Sumatera Tiger is a carnivore included in the IUCN list with a Critically Endangered (CR) status or is a critical animal. Based on PP No. 7 of 1999, the Sumatra tiger is also an animal protected by the Indonesian government.

Birds

Birds are hot blooded (endothermic) vertebrate animals included in the Aves class. In terms of morphology, the characteristics of birds cover their feathers, wings, beaks without teeth and the bipedalism abilities. Based on the survey results in the three observation locations in the PT. SOL ecology study area, 56 bird species from 27 families were identified. The list of bird species found and their protection status are presented in Table A-18.

Table A-18 List of Bird Species and Protection Status in the Study Area

No.	Indonesian Name	English Name	Latin Name	Protection Status		
				IUCN 3.1	CITES	PP No. 7 of 1999
Accipitridae						
1	Elang brontok	Changeable Hawk-eagle	*Nisaetus cirrhatus*	LC	II	v
2	Elang tikus	Black-winged Kite	*Elanus caeruleus*	LC	II	v
3	Elang ular bido	Crested Serpent-eagle	*Spilornis cheela*		II	v
4	Sikep madu asia	Oriental Honey-buzzard	*Pernis ptilorhyncus*		II	v
Aegithinidae						
5	Cipoh jantung	Green Iora	*Aegithina viridissima*	LC		v
6	Cipoh kacat	Common Iora	*Aegithina tiphia*	LC		
Alcedinidae						
7	Cekakak sungai	Collared Kingfisher	*Todiramphus chloris*			
Apodidae						
8	Kapinis jarum kecil	Silver-rumped Spinetail	*Rhaphidura leucopygialis*			
9	Walet sapi	Glossy Swiftlet	*Collocalia esculenta*	LC		
Artamidae						
10	Kekep babi	White-breasted Woodswallow	*Artamus leucorynchus*	LC		

No.	Indonesian Name	English Name	Latin Name	Protection Status		
				IUCN 3.1	CITES	PP No. 7 of 1999
Campephagidae						
11	Kapasan kemiri	Pied Triller	*Lalage nigra*	LC		
Caprimulgidae						
12	Cabak maling	Large-tailed Nightjar	*Caprimulgus macrurus*			
Cisticolidae						
13	Cici padi	Zitting Cisticola	*Cisticola juncidis*			
14	Perenjak gunung	Hill Prinia	*Prinia atrogularis*	LC		
15	Perenjak rawa	Bar-winged Prinia	*Prinia familiaris*			
Columbidae						
16	Perkutut jawa	Zebra Dove	*Geopelia striata*	LC		
17	Tekukur biasa	Spotted Dove	*Stigmatopelia chinensis*	LC		
18	Uncal kouran	Little Cuckoo-dove	*Macropygia ruficeps*	LC		
Cuculidae						
19	Bubut alang-alang	Lesser Coucal	*Centropus bengalensis*	LC		
20	Wiwik kelabu	Plaintive Cuckoo	*Cacomantis merulinus*	LC		
21	Wiwik lurik	Banded Bay Cuckoo	*Cacomantis sonneratii*	LC		
Dicaeidae						
22	Cabai bunga api	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	NT		
23	Cabai gunung	Blood-breasted Flowerpecker	*Dicaeum sanguinolentum*	LC		
24	Cabai merah	Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	LC		
25	Cabai perut kuning	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	LC		
26	Cabai rimba	Yellow-vented Flowerpecker	*Dicaeum chrysorrheum*	LC		
27	Pentis kumbang	Scarlet-breasted Flowerpecker	*Prionochilus thoracicus*	LC		
28	Pentis pelangi	Crimson-breasted Flowerpecker	*Prionochilus percussus*	LC		
29	Pentis raja	Yellow-breasted Flowerpecker	*Prionochilus maculatus*	LC		
Dicruridae						
30	Srigunting keladi	Bronzed Drongo	*Dicrurus aeneus*	LC		
Estrildidae						
31	Bondol haji	White-headed Munia	*Lonchura maja*	LC		v
32	Bondol peking	Scaly-breasted Munia	*Lonchura punctulata*			
33	Bondol tunggir putih	White-rumped Munia	*Lonchura striata*	NT		
Hirundinidae						
34	Layang-layang	Asian House-martin	*Delichon dasypus*	LC		v

No.	Indonesian Name	English Name	Latin Name	Protection Status		
				IUCN 3.1	CITES	PP No. 7 of 1999
	rumah					
Laniidae						
35	Bentet kelabu	Long-tailed Shrike	*Lanius schach*	LC		v
Nectariniidae						
36	Burung madu belukar	Ruby-cheeked Sunbird	*Anthreptes singalensis*	LC		v
37	Burung madu kelapa	Plain-throated Sunbird	*Anthreptes malacensis*	LC		v
38	Burung madu rimba	Purple-naped Sunbird	*Hypogramma hypogrammicum*	LC		
39	Burung madu sepah raja	Crimson Sunbird	*Aethopyga siparaja*	LC		
40	Burung madu sriganti	Olive-backed Sunbird	*Nectarinia jugularis*			
Oriolidae						
41	Kepudang kerudung hitam	Black-hooded Oriole	*Oriolus xanthornus*			
Passeridae						
42	Burung gereja Eurasia	Eurasian Tree Sparrow	*Passer montanus*			
Picidae						
43	Pelatuk kijang	Rufous Woodpecker	*Celeus brachyurus*	LC		
Podargidae						
44	Paruh kodok kepala-pucat	Short-tailed Frogmouth	*Batrachostomus poliolophus*	LC		
Pycnonotidae						
45	Brinji Kelabu	Ashy Bulbul	*Hemixos flavala*	LC		
46	Cucak kuning	Black-crested Bulbul	*Pycnonotus melanicterus*			
47	Cucak kuricang	Black-headed Bulbul	*Pycnonotus atriceps*	LC		
48	Merbah cerukcuk	Yellow-vented Bulbul	*Pycnonotus goiavier*	LC		
Rallidae						
49	Kareo padi	White-breasted Waterhen	*Amaurornis phoenicurus*	LC		
Ramphastidae						
50	Takur ungkut-ungkut	Coppersmith Barbet	*Megalaima haemacephala*	LC		
Sylviidae						
51	Cikrak bambu	Yellow-bellied Warbler	*Abroscopus superciliaris*			
52	Cinenen kelabu	Ashy Tailorbird	*Orthotomus ruficeps*			
53	Kerakbasi besar	Oriental Reed Warbler	*Acrocephalus orientalis*			
Timaliidae						
54	Asi kumis	Moustached Babbler	*Malacopteron magnirostre*			

No.	Indonesian Name	English Name	Latin Name	Protection Status		
				IUCN 3.1	CITES	PP No. 7 of 1999
Turnicidae						
55	Gemak loreng	Barred Buttonquail	*Turnix suscitator*	LC		
Zosteropidae						
56	Kacamata biasa	Oriental White-eye	*Zosterops palpebrosus*	LC		

According to Table A-18, it was identified that several families had quite a number of species and other families only had 1 species. The *Dicaeidae* family (flowerpeckers) was the family with the most species, which was 8. Other families with quite a number of species include *Cisticocidae* with 6 species, *Nectariniidae* with 6 species, *Pygnonotidae* with 5 species and *Ploceidae* with 6 species. Other families with only one species member cover *Zosterpidae, Rallidae, Picidae, Oriolodae, Hirundidnidae, Dicruridae, Capitonidae, Artamidae and Alcedinidae*. Family diversity according to the number of species members found is presented in Figure A-11.

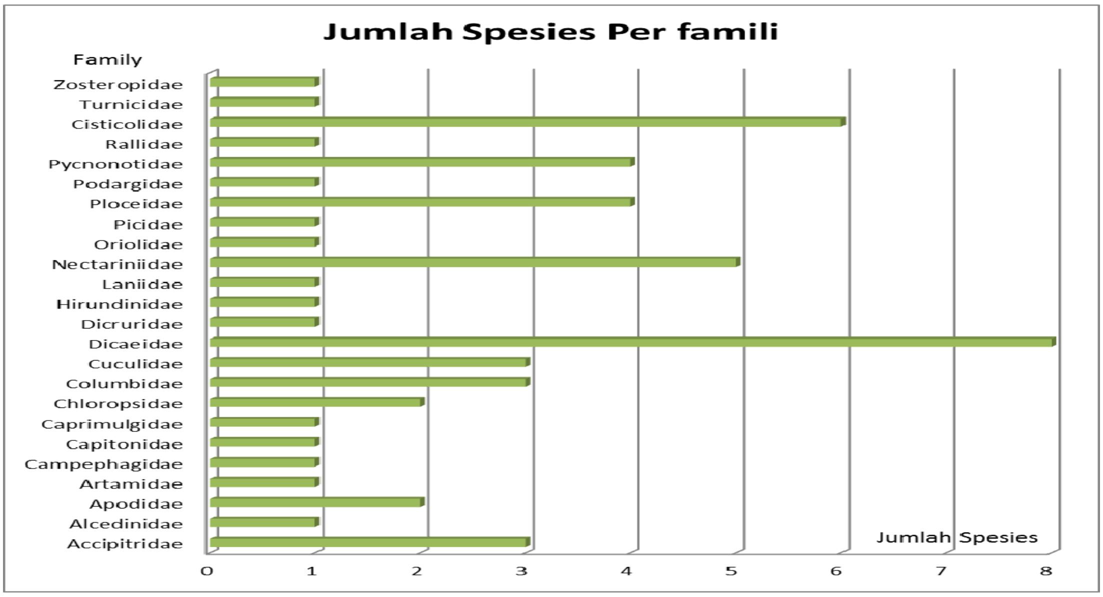


Figure A-11 Number of Species Per Family from the List of Birds Found

The birds in the study area can be broadly classified based on the dominance of materials that are their primary feed. This classification covers seed eating birds (granivore), fruit eaters (frugivore), nectar eaters (nectarivore), insect eaters (insectivore) and meat eaters (carnivore/predator). The classification based on feed will directly correlate with the habitat of the birds in the study area. The most bird species identified came from the Dicaeidae family. The birds in this family are a group of fruit eating birds (frugivore), such as burung cabai (*Dicaeum* spp.) and pentis (*Prionochilus* spp.). One of these species, cabai bunga api (*Dicaeum trigonostigma*), is the most common species found.

Frugivore birds are those that are usually found in yards, bushes and mixed plantations with a lot of fruit producing trees, such as cherries (*Muntingia calabura*), harendong bulu (*Melastoma malabatricum*) and chocolate (*Theobroma cacao)*. Apart from the birds from the *Dicaeidae family, other frugivore birds* include those from the *Pycnonotidae* (cucak and merbah), *Chloropsida*e (cipoh) and *Zosteropidae* (kacamata) family. They are also birds that are usually found around yard, mixed plantation and bush vegetation.

Figure A-12 **Several Frugivore Bird Species in Sarulla, (a) Asi kumis (*Malacopteron magnirostre*) Photo : Bagus Chandra, 17 April 2013 and (b) Pentis pelangi (*Prionochilus percussus*) Photo : Iqrarul Fata, 18 April 2013.**

The next largest group of birds are from the seed eaters. This group of birds is mostly represented by the *Ploceida*e family (bondol and pipit). Most of these bird species inhabit fields around the SIL1 and SIL2 wells. An example of the birds from this group found in the study location is Bondol (*Lonchura* spp.) and Perenjak (*Prinia* spp.).

In addition, the *Columbidae* family covers pigeons and the imperial pigeon is also part of this group as well as the common cuckoo (*Stigmatopelia chinensis*) and uncal kouran (*Macropygia ruficeps)*. Another bird group is the insect eaters, which are mostly represented by the *Cisticolidae* family (cuckoos and coucals). Swallows and starlings of the *Apodidae family* are also include in the insect eating group (insectivore). The uniqueness of this family is the nature of their life that is very aerial. They fly very quickly and rarely perch. One of the species in this bird group, the house sparrow (*Delichon dasypus)*, is a migrant species.

The existence of these birds is generally closely related to the habitat they live in. The availability of feed sources is the main reason that the birds choose their habitat. The distribution of bird species based on the type of habitat they live in is presented in Table A-19.

Table A-19 Distribution of Bird Species Based on the Type of Habitat They Live In

No	Local Name	Type of Habitat					
		Yard	Field	Rubber Plantation	Mixed Plantation	Forest	Bushes
1	Elang ular bido				√	√	
2	Elang tikus		√		√		
3	Sikep madu Asia					√	
4	Elang brontok					√	
5	Cekakak sungai	√	√				
6	Walet sapi	√	√	√			
7	Kapinis jarum kecil			√	√		
8	Kekep babi	√		√	√		
9	Kapasan kemiri			√	√		
10	Takur ungkut-ungkut		√	√	√		
11	Cabak maling				√		√
12	Cipoh kacat	√			√		
13	Cipoh jantung				√	√	
14	Uncal kouran	√		√	√		√
15	Tekukur biasa	√	√		√		√
16	Perkutut jawa					√	
17	Wiwik kelabu			√	√		√
18	Wiwik lurik			√	√		√
19	Bubut alang-alang		√				√
20	Cabai bunga api	√		√	√		√
21	Cabai gunung			√	√	√	√
22	Pentis kumbang				√	√	
23	Cabai rimba				√	√	√
24	Pentis raja			√	√		√
25	Cabai perut kuning				√		√
26	Cabai merah				√		√
27	Pentis pelangi				√	√	
28	Srigunting keladi					√	
29	Layang-layang rumah		√	√			
30	Bentet kelabu	√		√	√		√
31	Burung madu kelapa	√	√				√
32	Burung madu rimba				√		√
33	Burung madu belukar			√		√	
34	Burung madu sriganti	√			√		√
35	Burung madu sepah raja			√	√	√	
36	Kepudang kerudung hitam			√	√		

No	Local Name	Type of Habitat					
		Yard	Field	Rubber Plantation	Mixed Plantation	Forest	Bushes
37	Pelatuk kijang			√	√	√	
38	Bondol haji		√	√			√
39	Burung gereja Eurasia	√	√				√
40	Bondol peking	√	√				√
41	Bondol tunggir putih	√	√				√
42	Paruh kodok kepala-pucat			√	√		
43	Merbah cerukcuk	√	√	√	√		
44	Cucak kuning			√	√		
45	Cucak kuricang			√	√		
46	Brinji Kelabu				√	√	
47	Kareo padi		√				
48	Cici padi		√				√
49	Perenjak rawa		√				√
50	Perenjak gunung		√				√
51	Kerakbasi besar		√		√		√
52	Cinenen kelabu	√		√	√		√
53	Cikrak bambu			√	√		√
54	Asi kumis				√	√	
55	Gemak loreng		√				√
56	Kacamata biasa				√	√	

The existence of birds of prey, both diurnal (active in the day) such as eagles and nocturnal (active at night) such as owls and frogmouths, are extremely significant indicators for the environmental health of an ecosystem. Birds of prey are top predators in the food chain. Their existence is only supported by a healthy ecosystem that is able to meet the needs of the prey. In the study area, 4 diurnal bird of prey species were successfully identified. All of them were from the *Accipitridae* family (eagle), which were the changeable hawk-eagle (*Spizaetus cirrhatus*), crested serpent eagle (*Spilornis cheela*), black-winged kite (*Elanus caeruleus*) and crested honey buzzard (*Pernis ptilorhyncus*); and 1 nocturnal bird of prey species, which was the short-tailed frogmouth (*Batrachostomus poliolophus*). The crested honey buzzard is a predator bird that is migratory, breeds in the Northern Hemisphere and migrates to Indonesia during the cold season. All bird of prey species (raptors) are birds protected by the wildlife protection laws in Indonesia.

Figure A-13 **Several Bird of Prey Species (Raptors) in Sarulla (a) Frogmouth (*Batrachostomus poliolophus*) Photo : Bagus Chandra, 19 April 2013 and (b) Crested Honey Buzzard (*Pernis ptilorhyncus*) Photo : M. Faesal R.H., 20 April 2013.**

Based on PP No. 7 of 1999, 9 bird species were found in the study area that are protected by the law, which covered 3 species from the *Accipitridae* family (eagle), 5 bird species from the *Nectariniidae* family (honey bird) and 1 bird species from the *Alcedinidae* family, which was the collared kingfisher (*Todirhampus chloris*). According to the *International Union for Conservation of Nature and Natural Resources (IUCN*), there are 2 bird species included in the "Near Threatened/NT" category, which are the scarlet-breasted flowerpecker (*Prionochilus thoracicus*) and short-tailed frogmouth (*Batrachostomus poliolophus*). Most of the other species are included in the "Least Concern/LC" category or not included in any category. Meanwhile, according to the *Convention on International Trade in* Endangered *Species of Wild Fauna and Flora (CITES*), the four birds of prey found in Sarulla are included in Appendix II. The species included in CITES Appendix II are species that may be endangered, except if trading is tightly controlled. International trading in Appendix II can only be authorized by the granting of export licenses or re-export certificates.

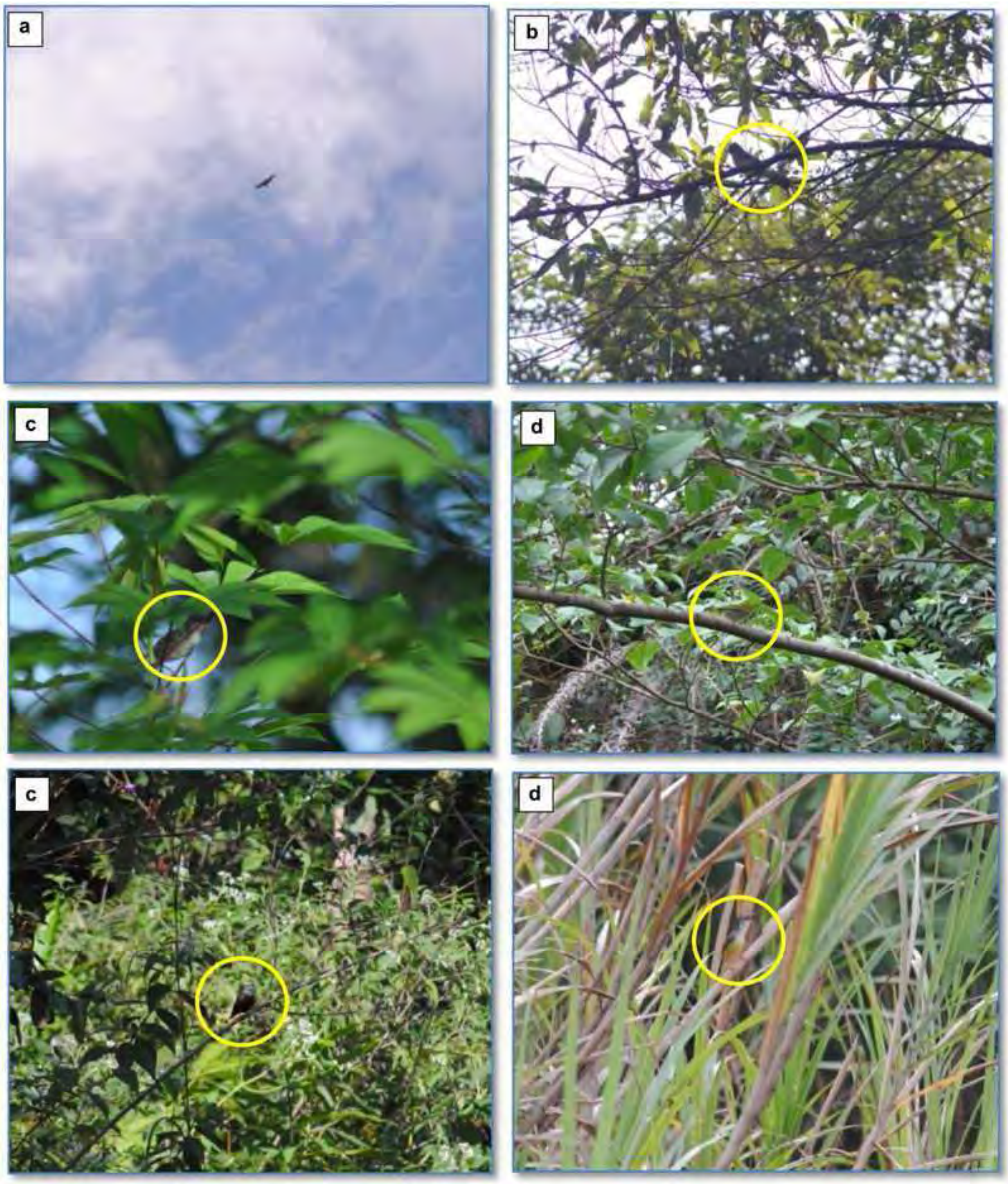


Figure A-14 **Photo of Several Bird Species in Sarulla;** Changeable Hawk-eagle *(Spizaetus cirrhatus)* Photo : Iqrarul Fata ; (b) Yellow-vented bulbul (*Pycnonotus goiavier)* Photo : M. Faesal R.H. ; (c) Hill Prinia (*Prinia atrogularis)* Photo: Iqrarul Fata ; (d) Oriental white-eye (*Zosterops palpebrossus)* Photo: Iqrarul Fata ; (e) White-headed Munia (*Lonchura maja)* Photo : M. Faesal R.H. ; and (f) Yellow-bellied Prinia (*Prinia flaviventris)* Photo : M. Faesal R.H.

Herpetofauna

The results of the observation conducted over five days in 4 different locations found 60 herpetofauna individuals. In detail, there were 17 reptile individuals and 43 amphibian individuals. These animals were made up of 11 species, 4 of which were reptiles and 7 were amphibians. Overall, these species were not only found during the observation, but also outside of the observation period. These species covered

Hylarana nicobariensis, and several East Indian Brown Mabuyas (*Eutropis multifasciata*).

The amphibian species identified were divided into 6 families, which were *Ranidae* 4 species), *Bonidae* (3 species), and *Microhylidae* (1 species). Most of the amphibian species were only limited to a certain location. The discovery of species from the *Microhylidae* family was only in specific habitat conditions, such as stands with litter. However, encounters with several species from the Bufonidae and Ranidae families in all observation locations indicate that a quite high tolerance of the habitat makes it possible for the species to be encountered in different forms of habitats. Figure A-15 illustrates several herpetofauna species found in the study area.

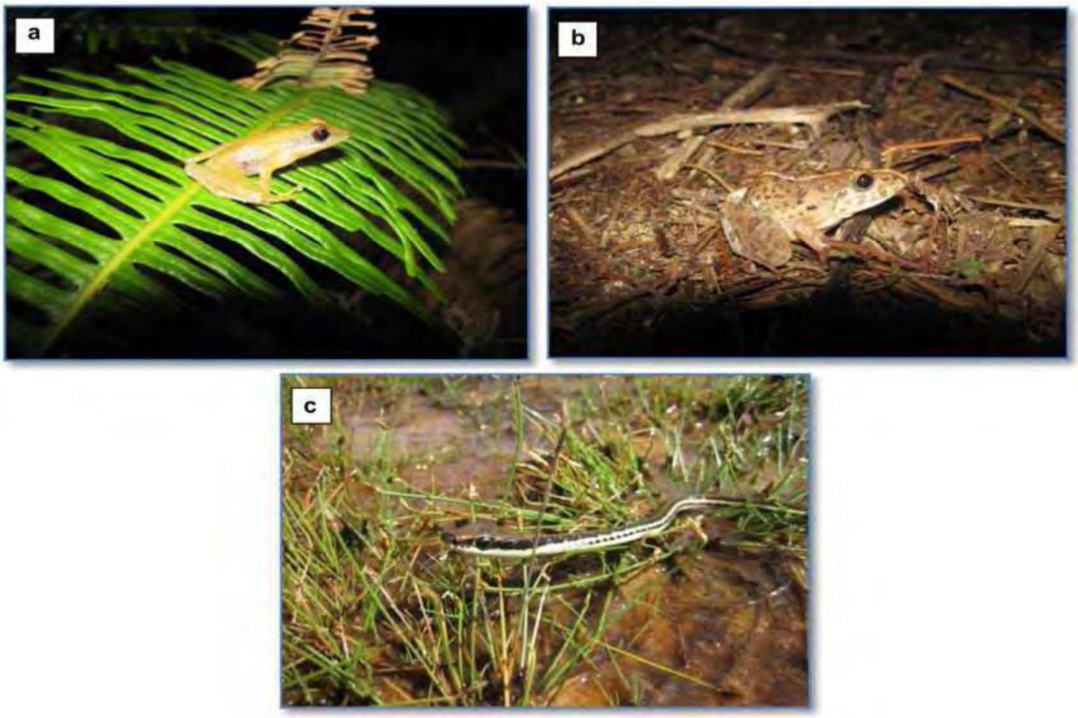


Figure A-16 **(a)** ***Hylarana Chalconota;*** **(b)** ***Fejervarya limnocharis;*** **and (c)** ***Dendrelaphis Formosus*.**

Most of the reptile species were found in the telestrial path in all observation locations. Only 1 reptile species was recorded to being found in the terrestrial path and 3 other species were found in trees and bushes. A common species found in all observation locations was the East Indian Brown Mabuya (*Eutropis multifasciata*).

Table A-20 List of Herpetofauna Species in Sarulla

Class	Order	Family	Latin Name	Indonesian Name	English Name	Description	IUCN Status	SIL 1	SIL 2	NIL 1
Amphibian	Anura		*Fejervarya limnocharis*	Katak tegalan	Grass Frog	Field frog	LC	7	9	1
			Hylarana chalconota	Kongkang kolam	White-lipped Frog	Indicator of a disturbed environment	LC	1	5	0
			Hylarana nicobariensis	Kongkang jangkrik	Cricket Frog	Indicator of a disturbed environment	LC	1	1	0
			Limnonectes macrodon	Kongkang baru	Stone Creek Frog	Moor frog	LC	6	4	0
		Megophryidae	*Ingerophrynus melanostictus*	Kodok puru	Asian Toad	Indicator of a disturbed environment	LC	0	1	0
			Ingerophrynus parvus	Kodok puru kecil	Dwarf/Lesser Stream Toad	Indicator of an undisturbed environment	LC	2	2	0
			Ingerophrynus asper	Kodok buduk sungai	River Toad	Indicator of a good-poor river	LC	1	1	0
		Microhylidae	*Microhyla spp.*	Katak mulut sempit	Narrow-mouthed Frog	Secondary forest frog	DD	0	1	0
Reptile	Squamata	Agamidae	*Bronchocela cristatella*	Bunglon mini	Slender Agama	Secondary forest animal	NE	1	0	0
		Scincidae	*Eutropis multifasciata*	Kadal bengkarung	East Indian Brown Mabuya	Common lizard	NE	6	4	2
		Colubridae	*Dendrelaphis formosus*	Ular lidah api	Elegant Brozeback	Non venomous snake	NE	0	1	1
		Colubridae	*Rhabdophis subminiatus*	Ular picung	Red-necked Keelback	Venomous snake (haemotoxin)	NE	0	2	0
Total								**25**	**31**	**4**

LC = Least Concerned; NE = Not Evaluated

In terms of ecology, herpetofauna play an important role in food networks. In general, frogs and toads are primary predators as insect controllers including disease source insects. While reptiles play a diverse role in the ecosystem. Several lizards and geckos are insect consumers. However, others are top predators such as snakes and monitor lizards.

Frogs and toads are always associated with water and most of them live in vegetated areas and close to water sources (Iskandar 1998). This behavior can be explained by the needs of frogs and toads to always maintain skin moisture and body temperature. While reptiles are "poikilothermic" animals that live in a range of habitats and have relatively high tolerance compared to amphibians.

The observation results informs of several species from the Ranidae family with a relatively large amount in several locations. These locations are habitats with high human interaction. Even species such as *Hylarana chalconota* and *Hylarana nicobariesis* are able to live in disturbed habitats. Other species were only found in primary and secondary forests (*Ingerophrynus parvus*, *Ingerophrynus asper*, and *Microhyla* spp.).

Other species usually found in disturbed habitats include: *Fejervarya limnocharis, Limnonectes macrodon*, and *Ingerophrynus melanostictus*). Information on the existence of frogs and toads according to their preferred habitat can be used to explain the function of amphibians as bioindicators of habitat changes.

Referring to the IUCN red list published by IUCN 2013, most of the species found, both reptiles and amphibians, are classified as "Least Concern". The existence of most of the species are relatively abundant. Meanwhile, there is still supportive capacity for shelter to grow and develop for most of these species. However, only a few have different status. However, habitat disturbances that have occurred and are still ongoing definitely increase the status of these animals.

Insects

Insects (Insect class) are a group of segmented animals (Arthropod phylum) with exoskeleton, have six legs, and a set of antenna. Insects are the most diverse group of animals on the face of the earth, representing more than on million animal species or 60% of the total species found. In line with this, insects are also the most common animals found in the Sarulla ecology study area. 50 species from 21 families were recorded to be found, of which 24 were successfully identified up to the level of species. Table A-21 displays the list of insect species found in the survey location.

Table A-21 List of Insect Species in the Sarulla Ecology Study Area

No.	Species Name	English Name	Family
LEPIDOPTERA (Butterflies, Moths and Skippers)			
1.	*Papilio demolion*	Banded Swallowtail	Papilionidae
2.	*Tanaecea pelea*	Malay viscount	Nymphalidae
3.	*Moduza procris*	Commander Butterfly	Nymphalidae
4.	*Euploea sp.*	Dark Crow Butterfly	Nymphalidae
5.	*Danaus affinis*	Malay tiger Butterfly	Nymphalidae
6.	*Neptis hylas*	Common Sailer	Nymphalidae
7.	*Neptis nisaea*	Sailer	Nymphalidae
8.	*Euploea mulciber*	Striped Blue Crow Butterfly	Nymphalidae
9.	*Euploea caramelman*	Crow Butterfly	Nymphalidae
10.	*Hypolimnas bolina*	Great Eggfly	Nymphalidae
11.	*Cupha erymanthis*	Rustic Butterfly	Nymphalidae
12.	*Doleschallia bisaltidae*	Autumn Leaf Butterfly	Nymphalidae
13.	*Eurema brigitta*	Small Grass Yellow	Pieridae
14.	*Jamides alecto*	Metallic Cerulean	Pieridae
15.	*Eurema blanda*	Three-spot Grass Yellow	Pieridae
16.	*Junonia orithya*	Blue Pansy	Pieridae
17.	*Junonia atlites*	Grey Pansy	Pieridae
17.	*Mycalesis mineus*	Dark-branded Bushbrown	Pieridae

No.	Species Name	English Name	Family
18.	*Ypthima sp.*	Ringlet Butterfly	Pieridae
19.	*Eurema hecabe*	Common Grass Yellow	Pieridae
20.	*UnPi1*	Brush-footed Butterfly	Pieridae
21.	*UnLy1*	Gossamer-winged Butterfly	Lycaenidae
22.	*Lyssa zampa*	Tropical Swallowtail Moth	Uraniidae
23.	*UnHe1*	Skipper	Hesperiidae
24.	*UnHe2*	Skipper	Hesperiidae
25.	*UnHe3*	Skipper	Hesperiidae
26.	*UnSp1*	Hawk Moth	Sphingidae
27.	*UnGe1*	Geometer Moth	Geometridae
	Cethosia cyane	Leopard Lacewing	Cyrestidae
ODONATA (Capung dan Capung jarum)			
28.	*Orthetrum sabina*	Slender skimmer	Libellulidae
29.	*Neurothemis sp.*	Forest Skimmer	Libellulidae
30.	*Trithemis sp.*	Dropwing Skimmer	Libellulidae
31.	*UnLi1*	Skimmer	Libellulidae
32.	*UnLi2*	Skimmer	Libellulidae
33.	*UnLi3*	Skimmer	Libellulidae
34.	*UnAe1*	Hawker	Aeshnidae
35.	*UnCo1*	Damselfly	Coenagrionidae
ORTHOPTERA (Belalang dan Jangkrik)			
36.	*UnAc1*	Grasshopper	Acrididae
37.	*UnAc2*	Grasshopper	Acrididae
38.	*UnTe1*	Bush Cricket	Tettigonidae
39.	*UnTe2*	Bush Cricket	Tettigonidae
40.	*UnTe3*	Bush Cricket	Tettigonidae
COLEOPTERA (Kumbang)			
41.	*UnLa1*	Firefly	Lampyridae
HEMIPTERA (Kepik Sejati)			
44.	*UnIc1*	Ichneumon Wasp	Ichneumonidae
45.	*UnRe1*	Assassin Bug	Reduviidae
PHASMIDA (Belalang ranting)			
46.	*Bactrododema sp.*	Stick insect	Phasmatodea
47.	*UnPh1*	Stick insect	Phasmatodea
MANTIDAE (Belalang sembah)			
49.	*UnMa1*	Praying mantis	Mantodea
50.	*UnMa2*	Praying mantis	Mantodea

The very high diversity of insects, plus the abundance of individuals in nature are significant factors for the ecological cycle of a region. Insects play a large role as the foundation of the food chain, both as first-level consumers (insect herbivores) and higher level consumers (insect carnivores and predators). Several insects also play an important role in processing organic materials left by other living creatures through their role as detritivores. A large number of insects are dominant agents in the plant pollination process, particularly nectar-eating insect species such as butterflies, bees and beetles.

Based on the data in the survey conducted over three days in three different locations, the most group of insects found was from the Lepidoptera order, covering butterflies, moths and skippers. Insects from the Lepidoptera order are part of a very important group as plant pollination agents. Butterflies are diurnal (active in the day) Lepidoptera, whereas moths are nocturnal (active at night). The most families found were Nymphalidae and Pieridae. According to its term, members of the Nymphalidae family have a pair of reduced front legs, which is why it looks like they only have 2 pairs of legs. Members of this group often tend to be found in open land habitats, such as terrains, bushes and yard, including plantations.

Other groups generally found were the Odonata Order (dragonflies and damselflies) and Orthoptera Order (grasshoppers and crickets). Odonata is a group of predator insects that prey on other insects. This group plays an important role as agricultural pest controllers. In the Sarulla study area, a species usually found from this order is the Slender Skimmer dragonfly (*Orthetrum sebina*) and red dragonfly (*Neurothemis* sp.). Several insect species found in the survey location are illustrated in Figure A-17.

Figure A-18 **Several Insect Species Found in the Sarulla Ecological Study Area (Clockwise from Left): Katydid (*Cicada spp.*) from the Cicadidae Family (a); Slender Skimmer (*Orthetrum sebina*) from the Lubellidae Family (b) ; Malay Viscount (*Tanaecea pelea*) from the Nymphalidae Family (c); and; Blue Pansy (*Junonia orythia*) from the Pieridae Family (d).**

Annex B

Habitat Condition Assessment

Sarulla Geothermal Project

Habitat Condition Assessment

October 2013

Sarulla Operations Ltd

Mott MacDonald

Sarulla Geothermal Project

Habitat Condition Assessment

October 2013

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Executive Summary

Further assessment including field surveys are recommended to determine whether the loss of habitat and other indirect impacts following construction of NIL1 and WJP1 will result in the reduction of species described in Section 6 above and by ERM (2013).

The impact on arboreal species including orang-utan is considered not likely to be significant given the relatively low amount of proposed loss of secondary forest habitat.

There may be an impact on terrestrial mammals, in particular prey species for Sumatran tiger due to the loss of habitat from the widening and introduction of roads. This particular issue could potentially be mitigated by compensating through providing an equivalent area of the same environment. Also it may be necessary to demonstrate that introducing a road or track won't affect the routes used by the tiger to access their hunting grounds.

1 Introduction

Mott MacDonald was commissioned by Sarulla Operations Ltd to undertake a habitat condition assessment at the Sarulla geothermal field in the Pahae Jula and Pahae Jay districts, North Tapanuli Regency, Sumatra in September 2013.

The aim of the survey was to provide further detailed ecological information of the status of the habitats present within the proposed infrastructure footprint in order to assess their suitability to support IUCN Red List species.

This report is intended to provide supplementary information required by the Asian Development Bank (ADB) under the International Finance Corporation Performance Standard 6 (IFC PS6) assessment process. It is intended as an addendum to the report produced by Environmental Resources Management (ERM) in September 2013 to which it should be read in conjunction. The ERM report also provides details of the project background, infrastructure layout and site mapping as well as previous ecological survey data.

2 Scope of works

The scope of the survey focused on the location of the project infrastructure (‘project footprint’) within the area identified by ERM (2013) as ‘potential critical habitat’. This area is located within the north-east of the project site and comprises the locations of the proposed NIL1 and WJP1 production wells as well as their associated access roads (‘targeted survey area’) (see Figure 5.4 in ERM, 2013). Areas outside of those identified by ERM as potential critical habitat (e.g. SIL) did not form part of this scope of work.

A survey was carried out from existing roads and forest trails. This included the locations of the proposed NIL1 and WJP1 production wells, the entire access road to NIL1 from the junction of the existing site road with NIL2, as well as approximately 1.5km of the proposed access road to WJP1 through the forest from the existing access road. Due to access limitations WJP1 was accessed via NIL1 on the second day of the survey.

All representative habitat types were surveyed. Where direct access was not permissible along the proposed access route to WJP1 consultation was undertaken with the local site team as to the habitat composition in those areas. This was later verified using satellite imagery for the site.

3 Methodology

The survey was undertaken over two days between 28th and 29th September 2013. All habitats within the targeted survey area were assessed with regards to their type and suitability to support IUCN Red Listed species. In addition all faunal species and their field signs encountered during the survey were also recorded. Field notes, photographs and GPS coordinates were taken at each habitat location and where field signs were found. These are summarised in Appendix A.

The habitats found were categorised broadly in conjunction with those described within the ERM (2013) report and the same terminology is used where appropriate. In order to provide further detail on their condition and suitability to support IUCN Red List species they were assessed as follows:

Core habitat: This habitat provides the optimal conditions for the survival of any given species. Within the context of the Sarulla site where different habitats are contiguous these areas are key to supporting the long term populations in the area.

Secondary habitat: This habitat is considered to be sub-optimal for a given species although conditions are suitable to support them. This habitat has its own ecological value but also provides corridors and supports adjacent areas of core habitat within the wider landscape.

Marginal habitat: This habitat is not considered suitable to support a given species. However, where core and secondary habitats are contiguous they may provide connectivity between them.

3.1 Survey Team

The survey was undertaken by Iain Bray, Senior Ecologist, Mott MacDonald and Pak (Mr.) Ibrahim, Field Ecologist, World Wildlife Fund. On-site support was provided by Pak Rum, Sarulla Operations, as well as assistance from site workers from the local community.

4 Results

4.1 Habitats

Five main habitat types were identified within the target study area. These included:

- non-natural scrub;
- natural scrub (or bush vegetation);
- secondary forest;
- mixed forest; and,
- scrub forest.

In addition to these habitats, unmodified forest exists away from the effects of the sulphurous springs. For example, within 500m north of NIL1 and across the wider landscape of the hills to the west ‘classic’ dipterocarp forest is present. This habitat supports taller, larger boled trees with structured canopy layers and epiphytic plant communities. As this habitat will not be directly impacted by the works it is not included within the report. However, this habitat is likely to provide core habitat for most forest dwelling species, in particular primates.

Further details of the habitats found and their location are given below:

Non-natural scrub: This habitat comprises the fast growing plant and tree species that have colonised the access route to NIL1 which was created in 1998 (see TN3 in Appendix A). These are considered to be opportunistic pioneer species and are considered to be of low ecological value.

Natural scrub: This habitat comprises the low growing *Vaccinium* species which dominate the areas immediately around the areas of the sulphurous vents (see TN 4 in Appendix A). The toxic conditions at these locations are beyond the tolerance of most plant species and areas of bare ground are also common. This habitat is present at NIL1 and to the north of WJP1.

Scrub forest: As soil conditions improve away from the sulphurous vents, areas of scrub forest occur that comprise low growing (to 20m) and narrow boled (to 30cm diameter at breast-height (dbh)) trees (see TN6 in Appendix A). The understorey comprises dense scrub vegetation (including *Vaccinium* species). This habitat is present within the location of WJP1 and within approximately 20m of the start of the adjoining access road. It is also present extensively in the area between NIL1 and WJP1.

Mixed forest: This habitat comprises scrub forest as above but which has been modified mainly through the planting of rubber (*Hevea brasiliensis*) and styrax benzoin (*Styrax benzoin*) trees. The management of this habitat is not intense and a dense understorey persists throughout. As styrax benzoin is also a native naturally occurring tree, this habitat is considered to be natural. Mixed forest occurs throughout the location of the access route to within approximately 20m of WJP1.

Secondary forest: This habitat comprises naturally occurring forest which has been selectively logged by local people (see TN4 in Appendix A). Consequently the trees within this area are generally of lower density than primary forest and are lower in height (up to approximately 25m) with narrower boles (up to 40cm dbh). The structure overall consist of an open canopy with a dense scrub understorey. Secondary forest is present along the entire up-slope side of the access road to NIL1. Occasional Sumatran pine trees (*Pinus merkusii*) were also noted within this forest. However, none were located within 6m of the road (the proposed extension area).

4.2 Fauna

Direct evidence of six mammal species were recorded within the targeted survey area. This included two Endangered and three Vulnerable IUCN Red List species. Further details are given in Table 4.1 below.

In addition agile gibbon (*Hylobates agilis*) were heard calling in the forest approximately 500m north of NIL1 (29th September) and over 1km away to the west siamang (*Symphalangus syndactylus*) were heard calling in the forest (28th September).

No evidence of Sumatran tiger (*Panthera tigris sumatrae*) or Sumatran organ-utan (*Pongo albelii*) was found. However, consultation with a local member of the site team described how a Sumatran tiger was observed during the construction of the road to NIL1 in 1998 and that pug marks were occasionally observed near the river close to proposed production well. No further background information on Sumatran orang-utan was obtained.

The fauna can be grouped into two broad categories:
- terrestrial mammals including Sumatran tiger, Marbled cat, Malayan sun bear and Malayan pangolin; and,
- arboreal mammals including all primates.

Table 5.1: Mammal species observed during the field survey.

Table 4.1: Mammal species observed during the field survey

English Name	Scientific name	Observation	IUCN status	TN in Appendix A
Agile gibbon	*Hylobates agilis*	Heard in dipterocarp forest (outside target survey area) on both days of survey.	Endangered	n/a
Siamang	*Symphalangus syndactylus*	Heard in dipterocarp forest (outside target survey area) on first day of survey.	Endangered	n/a
Malayan pangolin	*Manis javanica*	Vacant burrow found in scrub forest near location of WJP1.	Endangered	TN9
Malayan sun bear	*Helarctos malayanus*	Scratches found on tree beside forest trail in scrub forest near WJP1.	Endangered	TN8
Marbled cat	*Pardofelis marmorata*	Paw prints found in mud in scrub forest near WJP1.	Vulnerable	TN7
Sambar	*Cervus unicolor*	Slot marks found in sand south of river near NIL1	Vulnerable	TN1
Wild boar	*Sus scrofa*	Slot marks found in mud in scrub forest near WJP1	Least Concern	TN10

5 Assessment

5.1 Habitats

Overall the targeted survey area can be divided into two distinct areas. These are NIL1 (and associated access road) and WJP1 (and associated access road).

NIL1

The majority of the locations for the infrastructure in this area are already in situ following the previous construction works in 1998. Additional site clearance is believed to be required at the new NIL1 site itself and a maximum 6m road widening on the up-slope side along its entire length to the junction with NIL2. The habitats within the NIL1 site comprise scrub graduating into scrub forest due to their proximity to the sulphurous vents. These are considered to be of marginal value to primates due to the lack of suitable food plants including fruit trees. However, this habitat is considered to be core and marginal habitats for terrestrial species. Evidence of sambar deer (*Cervus unicolor*) was found during the survey (new tracks both days) across a sandy clearing south of the river indicating this species regularly passes through the area. This species is one of the main prey items for Sumatran tiger.

The secondary forest adjacent to the access road has been degraded by human interference (selective logging) but is still a naturally functioning part of the local ecosystem. This habitat is considered to be secondary for primates who may come to feed on the young leaves of trees and understorey scrub where gaps in the canopy occur. This area is contiguous with their core habitat of larger less disturbed forest found to the north where calling agile gibbon were heard on the second day of the survey. The secondary forest will also provide core habitat for terrestrial mammals due to the dense scrub understorey.

Overall NIL1 provides suitable habitat conditions for both terrestrial and arboreal mammals. However, given the relatively small and mostly narrow linear nature of the habitats within the proposed project footprint it is likely that they could be removed without causing a reduction in the local population of the species which they support.

WJP1

WJP1 will require the construction of infrastructure within land that has not been previously developed. The proposed production well site lies within an area of scrub forest and the access road will pass through an extensive area of mixed forest. These habitats are considered to be marginal for arboreal mammals due to the lack of suitable foraging plants in particular fruit trees. However, the structure and density of the scrub understorey provides core and secondary habitat for terrestrial mammals.

Given the relatively limited scope of the survey, evidence from field signs of the species found indicates an abundant and diverse assemblage of mammals.

5.2 IUCN Red List Species

5.2.1 Critically Endangered Species

Sumatran tiger

The location of NIL1 and secondary forest adjacent to the access road as well as the mixed and scrub forest within the project footprint of WJP1 represent core habitat for Sumatran tiger. The direct impacts of the proposed project are unlikely to reduce the overall hunting range of the species. However, the loss of habitat for prey species and potential indirect impacts resulting from increased human activity and access to the forest (for example hunting) may reduce the value of the habitat without mitigation.

Orang-utan

The secondary forest adjacent to the access road to NIL1 represents secondary habitat for orang-utan. The loss of this area will result in the reduction of foraging opportunities for this species. However, given the narrow (up to 6m) width of forest which will be removed along the length of the existing road it is considered unlikely to have a significant impact at the population level. The location of NIL1 and the forest present within WJP1 and associated access road are considered to be marginal and are unlikely to represent a loss of habitat.

5.2.2 Endangered and Vulnerable Species

Terrestrial mammals

As for Sumatran tiger the location of NIL1 and the secondary forest adjacent to the access road as well as the mixed and scrub forest within the project footprint of WJP1 represent core and secondary habitat for terrestrial mammals. The loss of this area without mitigation will result in the reduction of breeding, resting and foraging opportunities for the species identified during the survey and by ERM (2013).

Arboreal mammals

As for orang-utan the secondary forest adjacent to the access road to NIL1 represents secondary habitat for primates. The loss of this area without mitigation will result in the reduction of foraging opportunities for species identified during the survey and by ERM (2013).

6 References

Environmental Resources Management (2013) Sarulla Geothermal Field and Power Plant of 330 MW Capacity. Biodiversity Impact Assessment. Spring Hill, Australia.

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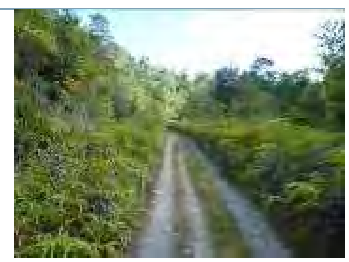
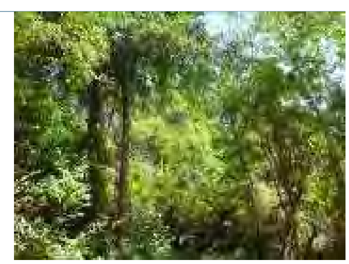
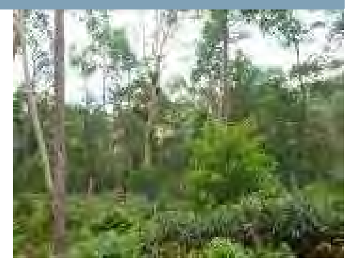
Appendix A. Photographs

Table A.1: Site Visit Photographs

TN	GPS Coordinates	Habitat/Species	Comment	Photo
1	N01º 52'38.9" E099º00'59.2"	Sambar deer	Print in soft sand south of river near NIL1.	
2	N01º 52'46.6" E099º00'58.0"	Natural scrub	View of typical natural scrub at NIL1.	
3	N01º 52'44.7" E099º00'59.4"	Non-natural scrub	View of typical non-natural scrub along rout of existing site road to NIL1 created in 1998.	
4	N01º 52'53.8" E099º01'16.5"	Secondary forest	View of typical habitat adjacent to existing access road to NIL1.	

TN	GPS Coordinates	Habitat/Species	Comment	Photo
5	N01º 52' 58.0" E99º 01' 38.5"	Mixed forest	View of typical mixed forest with dense scrub understorey on proposed access road to WJP1.	
6	N01º 52'22.2" E099º01'35.6"	Scrub forest	View of typical scrub forest with dense understorey at location of WJP1.	
7	N01º 52'28.9" E099º01'22.2"	Marbled cat	Paw print found in scrub forest.	
8	N01º 52'28.3" E099º01'27.0"	Malayan sun bear	Scratch marks found on tree in scrub forest.	

TN	GPS Coordinates	Habitat/Species	Comment	Photo
9	N01º 52'32.6" E099º01'10.8"	Malayan pangolin	Vacant burrow found in scrub forest.	
10	N01º 52'28.9" E099º01'22.2"	Wild boar	Slot marks found in mud in scrub forest.	

Annex F

Ecosystems Services Review

FINAL REPORT

Sarulla Operations Ltd

Sarulla Geothermal Field and Power Plant of 330 MW Capacity

Ecosystem Services Review

October 2013

Reference: International Report

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EXECUTIVE SUMMARY

The proposed Sarulla geothermal field and power plant at 330 MW capacity (the Project) involves the development and operation of geothermal power plants at Silangkitang (SIL) and Namora I Langit (NIL) geothermal fields, North Sumatera. The purpose of the Project is to: overcome electricity shortage in Indonesia, especially North Sumatera; support the Government of Indonesia policy in energy diversification and oil fuel consumption reduction; and optimise the use of geothermal energy that has high economic potential.

A review of Project documentation by the Asia Development Bank (ADB) identified a need for further investigations relating to International Finance Corporation (IFC) Performance Standards (PS). This Ecosystem Services Review (ESR) has been prepared to support conformance with IFC PS6 (Ecosystem Services) by identifying: Priority Ecosystem Services relevant to the Project; potential and existing impacts to Priority Ecosystem Services; and measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

The ESR included desktop review of the Project ANDAL (ERM 2009), the Addendum ANDAL (ERM 2013a) and biodiversity impact assessment report (ERM 2013b). The ESR also drew upon preliminary findings of community consultation, undertaken as part of a separate social impact assessment. Based on information from these sources, three priority Ecosystem Services were identified: Cultivated Crops; Non-wood Fibres and Resins; and Freshwater.

An impact assessment based on findings from the desktop review, and preliminary findings from community consultation, assessed impacts to Cultivate Crops and Non-wood Fibres and Resins as Minor. These services will be impacted by land acquisition and clearing within the Project footprint (approximately 86 hectares). In the context of the Pahae Julu and Pahae Jae sub-districts, the area of impact is small. However, in some cases individual farmers within the footprint may have substantial portions of their land acquired, which could affect incomes and livelihoods. A Land Acquisition Process is currently underway, which aims to manage impacts to land owners.

1 INTRODUCTION

The proposed Sarulla geothermal field and power plant at 330 MW capacity (the Project) is located approximately 40 kilometres (km) south of Tarutung at the side of the Trans Sumatera Highway (Tarutung-Sipirok).

The purpose of the Project is to:

- Overcome electricity shortage in Indonesia, especially North Sumatera;
- Support the Government of Indonesia policy in energy diversification and oil fuel consumption reduction; and
- Optimise the use of geothermal energy that has high economic potential.

The Project involves the development and operation of geothermal power plants at Silangkitang (SIL) and Namora I Langit (NIL) geothermal fields and the transmission line between. The fields have three existing well pads developed by the former project proponent (SIL1, SIL2 and SIL3).

The Project AMDAL document consisting of the ANDAL, RKL and the RPL, and the Activity Plan have been approved by the Governor of North Sumatra in accordance with the Decree of the Governor of North Sumatera No. 671.26/30672/k/Year 2009. Since this time there have been a number of changes to the Project Activity Plan and as such an Addendum to the ANDAL has been prepared. The 2009 AMDAL was also reviewed by the Asia Development Bank (ADB) in the context of, among other things, corporate safeguard policy and International Finance Corporation Performance Standard 6 (IFC PS6). Following reviews from the ADB, SOL proceeded with further investigation of the potential impacts to biodiversity values and investigation specific to Ecosystem Services in accordance with IFC PS6.

This ESR has been prepared to support conformance with IFC PS6 by identifying: Priority Ecosystem Services relevant to the Project; potential and existing impacts to Priority Ecosystem Services; and measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

To achieve these objectives, a five step process was undertaken. This included:

1. Review of baseline data, including the Project ANDAL (ERM 2009); Addendum ANDAL (ERM 2013a) and biodiversity impact assessment (ERM 2013b);
2. Screening of Ecosystem Services potentially occurring within the Project area;
3. Scoping to refine the list of Ecosystem Services;
4. Prioritisation to identify the services of importance to beneficiaries; and

5. Impact assessment.

1.1 SCOPE OF THIS REPORT

This document considers Ecosystem Services that occur within the Project footprint, or in the Project area (defined as a 500 m buffer from the infrastructure/footprint). These components are shown in *Figure 1.1*. The impact assessment addresses potential impacts which may occur as a result of construction activities, and throughout the operational phase of the Project.

1.2 STRUCTURE OF THIS REPORT

This ESR report is structured in the following chapters:

- *Chapter 1* provides an introduction to Ecosystem Services; relevant IFC Performance Standards; the purpose of this report; and the Project description;

- *Chapter 2* provides social and environmental information relevant to the Project area to provide an understanding of beneficiaries utilising the Project area and the environmental values present;

- *Chapter 3* details the methodology employed to undertake the ESR;

- *Chapters 4* to *7* outline the results of the process to identify Priority Ecosystem Services;

- *Chapter 8* presents the impact assessment for Priority Ecosystem Services; and

- *Chapter 9* provides management recommendations for the identified impacts.

1.3 DEFINING ECOSYSTEM SERVICES

Ecosystem Services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economic activities, the fulfillment of people's potential, and enjoyment of life. In order to provide a uniform basis to assess the status of all major global habitats across all of the world's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combined these diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of Ecosystem Services defined in the Millennium Ecosystem Assessment as adopted in IFC PS6:

- **Provisioning services** - those services that can be extracted from ecosystems to support human needs. This term is more or less synonymous with the term "ecosystem goods" that was used in some prior classification schemes, including such tangible assets as freshwater, food, fiber, timber and medicinal plants;

- **Regulating services –** the benefits obtained from an ecosystem's control of the natural environment, including the regulation of surface water purification, carbon storage and sequestration, climate regulation, protection from natural hazards, air quality, erosion and pests;

- **Cultural services** - nonmaterial benefits including diverse aspects of aesthetic, spiritual, recreational, and other cultural values; and

- **Supporting services** – the natural processes essential to the maintenance of the integrity, resilience, and functioning of ecosystems, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling and primary production.

The concept of Ecosystem Services highlights the fact that humans are reliant upon the benefits provided by ecosystems, and that impacts to ecosystems can subsequently impact human health and quality of life. Project Affected Communities therefore perform an important role in the identification and prioritisation of Ecosystem Services within this review.

1.4 IFC PERFORMANCE STANDARD 6 REQUIREMENTS

IFC PS6 has the following requirements regarding Ecosystem Services:

- Where a project is likely to adversely impact Ecosystem Services, as determined by the risks and impacts identification process, the client will conduct a systematic review to identify Priority Ecosystem Services. Priority Ecosystem Services are two-fold: *Type 1* those services on which project operations are most likely to have an impact and, therefore, which result in adverse impacts to Affected Communities; and/or *Type 2* those services on which the project is directly dependent for its operations (e.g., water).

- When Affected Communities are likely to be impacted, they should participate in the determination of Priority Ecosystem Services in accordance with the stakeholder engagement process as defined in Performance Standard 1.

- With respect to impacts on Priority Ecosystem Services of relevance to Affected Communities and where the client has direct management control or significant influence over such Ecosystem Services, adverse impacts should be avoided. If these impacts are unavoidable, the client will minimize them and implement mitigation measures that aim to maintain the value and functionality of priority services.

- With respect to impacts on Priority Ecosystem Services on which the project depends, clients should minimize impacts on Ecosystem Services and implement measures that increase resource efficiency of their operations, as described in Performance Standard 3.

Additional provisions for Ecosystem Services are included in Performance Standards 4, 5, 7, and 8.19.

1.5 PURPOSE OF THE ECOSYSTEM SERVICES REVIEW

The purpose of the Ecosystem Services Review (ESR) is to identify:

- Priority Ecosystem Services in the Project area;
- Potential and existing impacts to Priority Ecosystem Services; and
- Measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

The ESR has been undertaken to support compliance with the IFC Performance Standards (2012).

1.6 PROJECT DESCRIPTION

The development of Sarulla geothermal field and 330 MW power plant includes the following activities:

- Development of Sarulla geothermal field, i.e. Silangkitang (SIL) and Namora I Langit (NIL) fields;
- The construction and operation of 330 MW geothermal power plant, one unit at SIL and two units at NIL each with a capacity of 110 MW; and
- The construction of 150 kV (high voltage) transmission line from SIL to NIL, with an approximate distance of 15 km.

Drilling activity for new production and injection wells will mostly take place at the existing well pads previously developed by the former project proponent. Some will be in new areas, such as NIL. A majority of the development areas at SIL are farmland whilst at NIL are a combination of farmland and mixed forest.

The power plant locations for both SIL and NIL will be at plantation areas whereby the power plant at SIL will be located at community plantation areas whilst the power plants at NIL will be at mixed plantation areas. SIL is situated approximately 500 meters from the nearest residential area whilst NIL is located far from a residential area.

Construction activities will involve the mobilisation of equipment and materials including earth-moving equipment, drilling equipment and other construction equipment. Wherever possible, materials used in the Project will be supplied locally. If not, the materials will be supplied from the nearest area.

1.6.1 Project Components

Project components include: drilling and production wells; a power plant; and transmission network. Together, these components have a footprint of approximately 86 ha (ERM 2013b).

Drilling and Production Wells

Drilling is conducted to prepare production and reinjection wells. The drilling will use a conventional drilling rig, equipped with outpouring prevention equipment and H_2S detection tool to drill up to 3500 meters (m).

The drilling process will require approximately 400m^3 of water for each well and is proposed to be obtained from the Batang Toru River.

Water based mud will be used to prevent the borehole walls from caving during drilling, with well casing installed at certain depths to prevent leakage from or to soil and rock formations. Following completion the well head will be equipped with tools to control the fluid flow rate from the well.

Geothermal fluids from production wells will be separated into steam and brine in a separator. During production test, steam will be discharged through a steam muffler, while separated brine will be injected into reinjection wells. During operation geothermal fluid will be channelled to separators in order to separate steam and brine, both of which are used for electricity generation.

The workforce required for the drilling and production tests of the geothermal field is approximately 200 to 300 employees.

Power Plant

SOL will construct, operate and maintain a power plant with a total installed capacity of 330 MW. To fulfil the capacity, three unit power plants will be constructed where each will generate approximately 110 MW. The construction will be designed and built according with guidelines for earthquake resistance buildings. Construction will include land preparation, improvements to existing road infrastructure and construction of the plant and supporting facilities. Gravel and sand required will be taken from a quarry with license from the authority.

Each power plant will consist of one Ormat Geothermal Combined Cycle Unit (GCCU) and two Ormat Energy Converter (Brine OEC) units. Sarulla power plant will use an air cooled condenser from OEC and as such the plant will not require make up water. All brine and steam condensate will be injected into the ground through reinjection wells and pH will be controlled by the addition of H_2SO_4 to avoid scaling formation.

The power plant turbine is designed to have zero steam leak, no vibration and low noise level (i.e. ≤ 55dB from the fence boundary ± 250m). From the turbine outlet, geothermal steam is channelled to OEC heat exchangers where the thermal energy is extracted to produce pentane steam. The steam will become condensate and will be pumped to reinjection wells with the geothermal brine.

A total of 1400 employees will be required during the peak of the construction of the power plant. During operation the requirement is smaller at approximately 200 employees.

Transmission Network

Electricity generated by SIL and NIL power plants will be transmitted through transmission lines T/L 150KV which is part of the North Sumatera subsystem grid constructed by Perusahaan Listrik Negara (PLN) close to NIL.

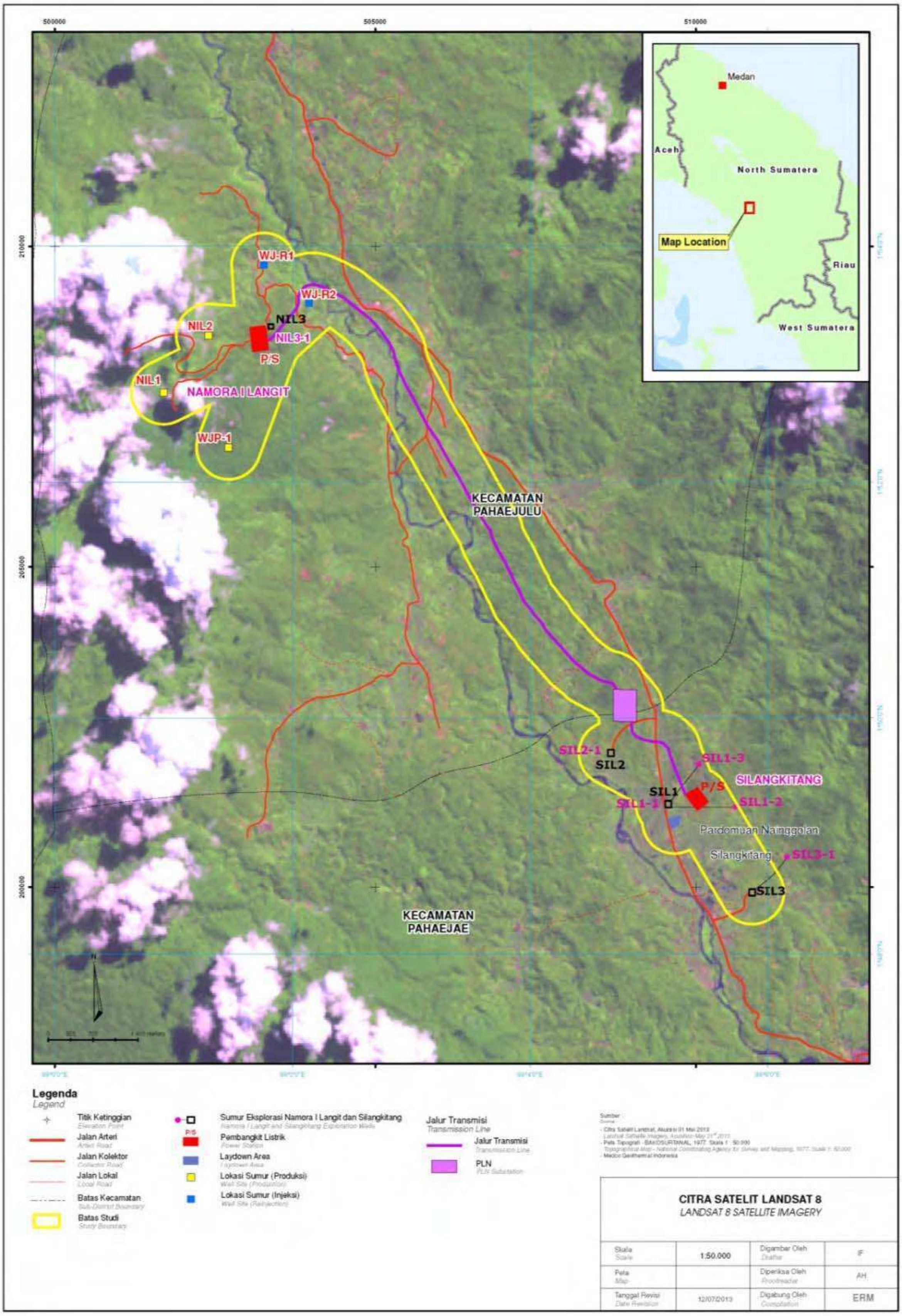
The transmission line between the PLN substation and NIL power plant will have a voltage of 150 KV, two circuits, each with a capacity to transmit electricity from Sarulla power plant units.

To obtain a more reliable transmission line, the interconnected line between NIL and SIL power plants will have two circuits, each with a capacity to transmit electricity from Silangkitang power plant.

The workforce needed to mobilise the equipment, materials, land preparation, and installation of the transmission line is between 200 and 300 people at peak of activity. Mobilisation will use the existing road network and whenever possible, materials will be supplied locally.

The number of workforce required to operation the transmission line is very few and will be integrated with the workforce required for operation of the power plants.

Figure 1.1 Proje ct Area



2 ENVIRONMENTAL AND SOCIAL CONTEXT

This Chapter summarises the existing environmental and social context of the Project area which has formed the basis of this ESR. The main activities in the surroundings of the Project in SIL and NIL include:

- Agriculture and plantations – predominantly rice fields and farm areas of the community; and
- Forest area – namely Production Forest.

2.1 SOCIAL CONTEXT

The Project is located in the Pahae Julu and Pahae Jae sub-districts of the North Tapanuli District. Currently, North Tapanuli District is divided into 15 sub-districts with 243 villages and in 2011 a recorded population of 283,059 (ERM 2013a). Primary commodities in North Tapanuli District are from plantation, fishery and mining sectors (ERM 2013a).

2.1.1 *Pahae Julu Sub-district*

In 2011 the population of Pahae Julu was 11,801 with 2950 households and is dominated by the productive age group (15-64 years old) (ERM 2013a).

In 2008, 84.4 per cent of people in Pahae Julu Sub-district earned a living as farmers (ERM 2009). Crops often planted include rice, corn, peanuts, cassava and sweet potato. Vegetables planted include chili, chives, chicory, long beans and spinach. Fruits cultivated include avocado, durian and bananas (ERM 2013a).

Apart from agriculture the people also have plantations such as rubber, Sumatra benzoin tree, coffee, cloves, coconut, cinnamon, hazelnut, palm oil, chocolate, aren and areca nuts (ERM 2013a).

Economic facilities available include markets, minimarkets, restaurants, stores and shops. In the study villages, Sibaganding, Lunbang Jaean and Simataniari only have stores that supply basic necessities (groceries) for the study village communities (ERM 2013a).

2.1.2 *Pahae Jae Sub-district*

In 2011 the population of Pahae Julu was 10,714 with 2659 households and is dominated by the productive age group (15-64 years old) (ERM 2013a).

In 2008, 80 per cent of people in Pahae Jae earned a living as farmers (ERM 2009). Crops often planted include rice, corn, peanuts, cassava and sweet potato. While vegetables planted include chili, chicory, long beans and spinach. For fruits avocado, mango, duku/langsat, snakeskin fruit, durian, water apple, papaya, bananas and pineapples are planted (ERM 2013a).

Apart from agriculture, the people also have plantations such as rubber, benzoin trees, coffee, cloves, coconut, cinnamon, hazelnut, chocolate, aren and areca nuts (ERM 2013a).

Economic facilities available include markets, minimarkets, restaurants, stores, shops and inns. In the study villages, Pardomuan Nainggolan, Pardamaean Nainggolan and Sigurung-gurung only had stores and shops selling basic necessities (groceries) for the people in the study village. In Silangkitang village, apart from stores and shops, it also has a restaurant named Sahabat baru Restaurant located on the provincial roadside (ERM 2013a).

2.2 *SOCIO-CULTURAL AND EDUCATION*

2.2.1 *Pahae Julu Sub-district*

In Pahae Julu sub-district there are worship facilities for those who are Islam (five mosques and one mushalla) and Christian (52 protestant churches and one catholic church) (ERM 2013a).

For primary school education, there are 23 public schools with 2075 students and 201 teachers. For junior high school/equivalent, there are 5 buildings with 1055 students and 86 teachers. For senior high school/equivalent, there are two schools with 545 students and 39 teachers as well as one vocational school with 180 students and 24 teachers (ERM 2013a).

Pahae Julu sub-district has sufficient health facilities serving the community with one community health centre, five supporting community health centres, 19 village maternity posts and almost every village has an integrated service post (ERM 2013a).

2.2.2 *Pahae Jae Sub-district*

In Pahae Jae sub-district there are worship facilities for those who are Islam (seven mosques and one mushalla) and Christian (23 protestant churches and one catholic church) (ERM 2013a).

For primary school education, there are 14 units with 1793 students and 146 teachers. For junior high school/equivalent, there are four buildings with 949 students and 67 teachers. For senior high school/equivalent, there are two schools with 435 students and 25 teachers as well as three vocational schools with 702 students and 35 teachers (ERM 2013a).

Pahae Jae sub-district has sufficient health facilities serving the community with one community health centre, one supporting community health centres, 13 village maternity posts and almost every village has an integrated service post (ERM 2013a).

2.3 LANDSCAPE

Information on the landscape within the Project area has been obtained from the Biodiversity Impact Assessment report (ERM 2013b).

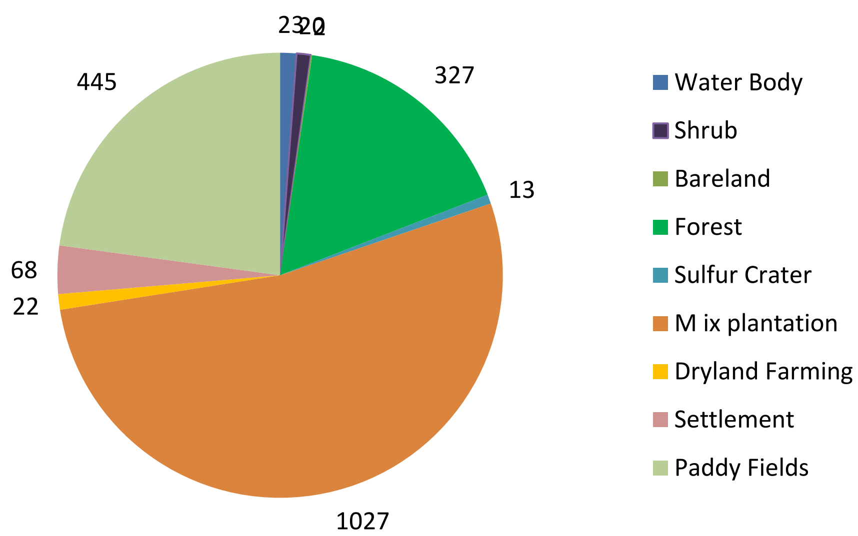
The Project is located between the East and West Batang Toru Forest, located in the valley of Sarulla in North Tapanuli District. The Batang Toru Forest and adjacent areas are known to support a diversity of flora and fauna species including a number of mammals, avifauna and flora that are listed on the IUCN Red List of threatened species. The Batang Toru River meanders north/south through the Project area, dividing the east and west regions of the forest and the NIL and SIL geothermal fields. Paddy fields and mixed plantation forest line the Batang Toru River and surround the settlements.

The majority of the Project area is located within the paddy field and mixed plantation area of the Batang Toru River with two well sites located within the West Batang Toru Forest.

2.3.1 *Land cover in the Project area*

The Project area used for this ESR covers an area of 1948 ha. The majority of the Project area is used for mixed plantations, paddy fields and dryland farming. The area (ha) of each type of land cover is shown in *Figure 2.1*.

Figure 2.1 Land Cover in the Project Area (Hectares)



The Project footprint is estimated to cover an area of approximately 86 ha (ERM 2013b). Of this, 83.3 ha (97%) consists of rice paddy fields and plantations; and 2.7 ha (3%) consists of natural forest.

2.3.2 *Modified Habitats*

Modified habitat is altered natural habitat, often formed by the removal of native species for harvesting, land conversion and/or introduction of alien flora and fauna species (ADB, 2012).

Modified habitat comprises the large majority of the area within 500m of Project infrastructure (approximately 80%). Modified habitats are represented by four vegetation communities: yard vegetation, field vegetation, rubber plantation, and mixed plantation vegetation. These communities are usually cultivated to meet basic community needs and represent sources of economic value.

Yard vegetation is found around residential areas and the borders of rubber plantations and fields. It is commonly made up of fruit, agricultural, ornamental and medicinal plant species. Field vegetation is generally paddy field, occasionally peanuts, coconut or areca nut.

Rubber plantation is an agricultural land use which is extremely intensive. The vegetation is not monoculture as traditional management includes several other crops species planted in between rubber plants. Mixed plantation is intensive agricultural vegetation that is planted with various annual plant species.

Modified habitats provide values for native and non-native fauna species. Monoculture communities or communities with limited structural diversity represent the lowest biodiversity values with open areas lacking forage resources and cover and as such exposing individuals that may be moving through the area to predation. Communities with greater structural diversity, such as mixed plantation, although modified may provide foraging and breeding habitat for some native fauna species. These areas play a role in the landscape mosaic of fauna habitat, connecting the large tracts of the Batang Toru Forest. The modified nature of these habitats can present a higher incidence of weed and pest species that will compete with native species for resources.

2.3.3 *Natural Habitats*

Natural habitat is an environment where the biological communities are largely formed by native plant and animal species and where human activity has not modified the areas primary ecological functions (ADB, 2012).

The Batang Toru Forest area and adjacent forest (shown as landuse type 'Forest' in *Figure 2.1*) is considered to be natural habitat as it is reported to be natural vegetation (Sumatra Rainforest Institute, 2012) with only slight evidence of human activities such as footpaths and wood shavings during survey. The forest around NIL has a high floral diversity. The natural habitat of the Project area is the forest vegetation which is dominated by cantagi species from the Ericaceae family and woody plant species from the Fagaceae family. 'Shrub' landuse type is also considered to be a natural habitat type. Shrub vegetation is found around the NIL crater and is unique in that the flora species found are generally associated with mountain top regions.

The natural habitat area (shown as 'Forest' and 'Shrub' in ***Error! Reference source not found.***) adjoins or is part of the Batang Toru Forest (east and west lots) which spans approximately 148,000 ha in total. Only 347 ha of natural habitat, which is equal to approximately 0.2% the total Batang Toru Forest area, is located within 500 m of the Project infrastructure. The natural habitats represent the highest quality habitat in the Project area. These habitats are expected to provide foraging, breeding and dispersal habitat for a range of native flora and fauna..

2.3.4 Flora and Fauna Species

Three flora species listed under the IUCN Red List were recorded during the field survey visit, with only one listed as vulnerable, endangered or critically endangered. Sumatran pine (*Pinus merkusii*) is listed as vulnerable and was observed on the road side between NIL1 and NIL3.

In addition, kantong semar (*Nepenthes melamphora*), listed as endangered on Indonesian Legislation PP No. 7 of 1999, was recorded on a roadside near SIL. The species lives in marginalized land with poor nutrients.

Twenty fauna species listed as vulnerable, endangered or critically endangered under the IUCN Red List have been previously recorded or have potential to occur in the Project area (based on other evidence such as interviews with the community). All of these species are mammals and the list includes carnivore, primate, rodentia and ungulate mammal Orders. In addition, the ADB review highlighted the potential for two additional mammals and underground bees for consideration. *Table 2.1* summarises the candidate species for assessment. Despite being highlighted by ADB for consideration, no information specific to underground bees was identified during desktop review or the biodiversity survey, and as such this group has not been considered further.

Table 2.1 ***IUCN listed Critically Endangered, Endangered and Vulnerable species with potential to occur within the Project area***

Scientific Name	English Name	Indonesian Name	IUCN Status	Method of Detection
Panthera tigris sumatrae	Sumatran Tiger	Harimau sumatera	CR	Vocalisation & interview
Pongo abelii	Sumatran Orangutan	Orangutan Sumatera	CR	Interview
Helarctos malayanus	Malayan Sun Bear	Beruang madu	EN	Signs
Hylobates agilis	Agile Gibbon	Ungko	EN	Vocalisation
Lutra sumatrana	Hairy Nosed Otter	Berang berang	EN	
Manis javanica	Malayan Pangolin	Trenggiling	EN	
Presbytis melalophos	Mitred Leaf Monkey	Simpai	EN	

Scientific Name	English Name	Indonesian Name	IUCN Status	Method of Detection
Symphalangus syndactylus	Siamang	Siamang	EN	Vocalisation
Tapirus indicus	Asian Tapir	Tapir	EN	Interview
Arctictis binturong	Binturong	Binturung muntu	VU	Interview
Capricornis sumatrensis	Sumatran Serow	Kambing hutan	VU	
Cervus unicolor	Sambar Deer	Rusa	VU	Interview
Macaca nemestrina	Pig-tailed Macaque	Beruk	VU	Observed
Maxomys whiteheadi	Whitehead's Spiny Rat	Lesoq lati whiteheadi	VU	
Nycticebus coucang	Slow Loris	Kukang	VU	Interview
Pardofelis marmorata	Marbled Cat	Kucing batu	VU	Interview

Source: ERM (2013b)

3 METHODOLOGY

The Ecosystem Services Review was undertaken following a four-staged approach:

- *Screening* to identify Ecosystem Services that may occur within the Project area;
- *Scoping* to refine the list of Ecosystem Services based on those potentially impacted by the Project;
- *Prioritisation* to identify Ecosystem Services of importance to beneficiaries;
- *Impact assessment* to identify the impacts to Ecosystem Services and their human beneficiaries as a result of the Project.

Each of these stages is described in greater detail in the following sections.

3.1 ECOSYSTEM SERVICE SCREENING

The objective of the screening process was to arrive at a comprehensive list of the Ecosystem Services likely to be present in the Project area. This step did not attempt to consider the importance of the services to beneficiaries or the likelihood of the Project impacting these services; it aimed to determine whether a service was likely to be present or not.

Screening was undertaken as a desk-based exercise drawing upon existing information, including:

- The Project ANDAL (ERM 2009);
- The draft addendum to the ANDAL currently being prepared (ERM 2013a); and
- The biodiversity impact assessment report (ERM 2013b).

The screening process used a template list of Ecosystem Services developed by the World Resources Institute, which is based upon the Millennium Ecosystem Assessment Reports (2005). Each of the services in this table was assessed for its likelihood to occur in the Project area based on two criteria:

- The habitats present in the Project area were known to provide this service or were similar to habitats elsewhere that provide this service; and
- People were believed to benefit from the service, either at the local, national or global level **and /or** the Project was expected to benefit from this service.

The review also considered whether the Project would be likely to be dependent on any services (such as water, flood protection, etc.) in the Project area.

3.2 *COMMUNITY CONSULTATION*

Community consultation is being undertaken as a separate study to support the development of a Social Impact Assessment and Integrated Social Program (ERM 2013c). Consultation topics included:

- Income from farming and forests;
- Income from livestock;
- Non-timber forest products, such as orchid, ornamental plants, bamboo, incense bark, traditional medicines;
- Wild pigs or other wild animals for consumption or sale;
- Clean water sources for cleaning, bathing and washing clothes;
- Drinking water sources;
- Housing construction materials, such as concrete, wood and bamboo;
- Disease vectors, such as rats, flies, mosquitos; and
- Impairment or loss of access to public facilities, including: cultural heritage, hunting, grazing, the use of traditional natural resources.

General information about the use of Ecosystem Services gained from consultation has been used to inform this ESR.

3.3 *ECOSYSTEM SERVICE SCOPING*

The scoping exercise was undertaken in order to refine the list of Ecosystem Services to include only those services that:

- Were identified as occurring in the Project area;
- Had human beneficiaries; and
- Were potentially impacted by the Project.

The goal of the scoping exercise was to identify a list of Ecosystem Services to be assessed during through the prioritisation stage.

The scoping exercise considered the following parameters:

- **Potential Beneficiaries:** Known and potential beneficiaries for a service were identified and where possible identifying people at the local, national, and/or global level.

- **Sources of Impact:** Potential sources of impact were considered based on the Project description (*Chapter 1.6*); and

- **Project Dependence:** IFC PS6 requires that the Ecosystem Services assessment take into consideration any services that the Project may rely upon during construction, operation and/or decommissioning. Therefore all services for which there is a potential project dependency were scoped into the prioritisation stage.

Based on these parameters, the services that may be impacted or depended on by the Project were scoped into the prioritisation process.

3.4 ECOSYSTEM SERVICE PRIORITISATION

IFC PS6 requires that Priority Ecosystem Services are identified, and impacts to those services are assessed (IFC 2012). The prioritisation process was aimed at identifying those services for which Project impacts would be most likely to result in adverse impacts on Project Affected Communities and other beneficiaries. Using the information collected through the baseline data collection and stakeholder engagement processes, Ecosystem Services were prioritised according to a Priority matrix ranking two criteria:

- Importance of the Ecosystem Service to the beneficiary which considers the intensity of use, degree of dependence and the importance expressed by the Project Affected Communities; and

- Irreplaceability of the Ecosystem Service, which refers to the availability of alternatives, the accessibility, cost and appetite for those alternatives as discussed with the beneficiary.

After compiling baseline information on the importance and irreplaceability of each service, these ratings were combined to assign a priority rating to the service grading from Low to Major, as shown in the Ecosystem Service Prioritisation Matrix in *Table 3.1*. Ecosystem Services identified as High Priority or Major Priority were considered Priority Ecosystem Services. The weight given to each of these components varied slightly depending upon the service, but stakeholder values were given precedence over other criteria where the rating was not clear.

In addition to the above, according to the IFC definition of Priority Ecosystem Services, all services for which project dependencies are identified are considered priority services. The importance and irreplaceability of services relied upon by the Project was assessed through the same prioritisation process outlined above, with the Project filling the role of the beneficiary.

Table 3.1 Ecosystem Service Prioritisation Matrix

Importance to Beneficiaries		Irreplaceability		
		High	Moderate	Low
Low	The service is used and valued by parts of the community, but it is not important in maintaining quality of life or livelihoods of Project Affected Communities.	Low Priority	Low Priority	Moderate Priority
Moderate	The service is readily used by some members of the Project Affected Communities for income or subsistence, but they are not dependent upon the service for their livelihoods, and not everyone utilises the service.	Low Priority	Moderate Priority	High Priority
High	The service is highly important in maintaining the livelihoods of the Project Affected Communities, and is used by most of the community regularly.	Moderate Priority	High Priority	Major Priority
Essential	The service is essential to maintain the health of the Project Affected Communities, and the service is used by all members of the community.	High Priority	Major Priority	Major Priority
Irreplaceability definition				
High	Many spatial alternatives exist that are readily available to the Project Affected Communities, and there are no major impediments to their usage.			
Moderate	Spatial alternatives exist but are either less accessible than the affected service, or there are other barriers to their use such as distance, cost and skills required to access the service.			
Low	There are few to no spatial alternatives available to the Project Affected Communities.			

3.4.1 *Status, Trends and Sustainability of Resource Use*

In addition to the prioritisation exercise, the baseline data collection process provided the opportunity to collect information on the status, trends and sustainability of resource use as they pertain to the habitats and species that support Ecosystem Services. This information was gathered through secondary sources and field studies by the environment team and where appropriate through engagement with local stakeholders. This information is important for the assessment of impacts on Ecosystem Services and therefore on local people as the final receptors of these changes.

3.5 *IMPACT ASSESSMENT*

Impacts were assessed based on the vulnerability of beneficiaries and the magnitude of potential or realised impacts, as described below.

3.5.1 *Assessing Level of Vulnerability*

Determination of the vulnerability of beneficiaries included consideration of the following questions:

- Are beneficiaries heavily dependent on a particular resource, with few alternatives available?
- Are resource shortages frequent and serious?
- Are key species or areas depended upon for goods or services legally protected and use is illegal?
- Are key resources controlled by an influential receptor and access is not guaranteed?
- Is there a low availability of alternatives for a number of important of Ecosystem Services?

Beneficiaries were considered vulnerable in the context of their immediate surroundings and were considered against existing pre-project baseline levels. Because of this there are always some vulnerable receptors within the receiving environment.

3.5.2 *Rating Magnitude of Impacts*

Magnitude of social and health impacts is understood as a reflection of the 'size' of change caused by social impacts. Magnitude is a function of the extent, duration, scale, and frequency. Impacts on human receptors as a result of changes in Ecosystem Services were assessed according to the four magnitude criteria listed above and ranked from *negligible* to *large*.

3.5.3 *Evaluating Significance*

The significance of the impact was determined by combining the magnitude of predicted impact with the value of the receptor, to produce a significance rating from Negligible to Significant. The definitions of the criteria for vulnerability and magnitude, as well as the matrix for evaluating significance are provided in *Table 3.2* (Negative Impacts) and *Table* 3.3 (Positive Impacts) below.

Table 3.2 Impact Assessment Matrix for Negative Impacts to Ecosystem Services

Negative impacts					
			Vulnerability of Receptors		
			Low: Minimal areas of vulnerabilities; consequently with a high ability to adapt to changes brought by the project.	**Medium:** Few areas of vulnerability; but still retaining an ability to at least in part adapt to change brought by the project	**High:** Profound or multiple levels of vulnerability that undermine the ability to adapt to changes brought by the project.
Magnitude of Impact	**Negligible**	Change remains within the range commonly experienced within the household or community	Negligible	Negligible	Negligible
	Low	Perceptible difference from baseline conditions. The impact results in a reduction in the availability or functionality of the Ecosystem Service across a small area and has implications for a small number of receptors. The change in the service is for a short duration or occurs with low frequency.	Negligible	Minor	Moderate
	Medium	Clearly evident difference from baseline conditions. The impact results in a reduction in the availability or functionality of the Ecosystem Service across a substantial area or number of people and is of medium duration or occasional frequency. Does not threaten the long-term viability of the service.	Minor	Moderate	Significant
	Large	Change dominates over baseline conditions. The impact results in the loss of all or a significant proportion of the availability or functionality of an Ecosystem Service and/or has implications for a large proportion or absolute number of receptors. The long-term viability of the service is threatened.	Moderate	Significant	Significant

Table 3.3 Impact Assessment Matrix for Positive Impacts to Ecosystem Services

Positive impacts					
			Vulnerability of Receptors		
			Low Low ability to take up on potential opportunities and realise positive sustained benefits	**Medium** Ability to partially capture potential opportunities and realise positive sustained benefits	**High** Able to capture potential benefits and utilise them for positive sustained benefits
Magnitude of Impact	**Negligible**	Change remains within the range commonly experienced within the household or community	Negligible	Negligible	Negligible
	Low	Perceptible difference from baseline conditions. The impact results in an improvement in the availability or functionality of the Ecosystem Service across a small area and has implications for a small number of receptors. The change in the service is for a short duration or occurs with low frequency.	Negligible	Minor	Moderate
	Medium	Clearly evident difference from baseline conditions. The impact results in an improvement in the availability or functionality of the Ecosystem Service across a substantial area or number of people and is of medium duration or occasional frequency. Does not improve the long-term viability of the service.	Minor	Moderate	Significant
	Large	Change dominates over baseline conditions. The impact results in the improvement of all or a significant proportion of the availability or functionality of an Ecosystem Service and/or has implications for a large proportion or absolute number of receptors. The long-term viability of the service may potentially be improved.	Moderate	Significant	Significant

4 SCREENING

This chapter presents the results of the Ecosystem Services screening process that was described in *Section 3.1*. The screening process is presented below in *Table 4.1*. The Screening Sheet provides a preliminary list of Ecosystem Services with the potential to occur within the Project area, with all of the known and potential Ecosystem Services carried into the scoping process in *Chapter 5*.

Table 4.1 Ecosystem Services Screening Sheet

Ecosystem Service	Description, Examples	Presence
Provisioning Services		
Food: wild-caught fish and shellfish	Fish caught for subsistence or commercial sale	Possible
Food: aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting.	No
Food: wild plants, nuts, mushrooms, fruit, honey	Fruit, nuts, wild plants, etc collected in natural areas for consumption or sale	Possible
Food: wild meat	Animals hunted for primarily for food (recreational hunting covered under cultural services)	Possible
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	Yes
Livestock farming	Sedentary and nomadic livestock farming	No
Biomass fuel	Wood dung and plant matter collected for charcoal, fuel	Possible
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp, paper	Yes
Non- wood fibres and resins	For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber	Yes
Freshwater	Freshwater for bathing, drinking, irrigation, laundry, household and industrial use	Yes
Biochemicals, natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use.	Possible
Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade	Possible
Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology	No
Regulating Services		
Regulation of air quality	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a "sink") or emitting chemicals to the atmosphere (i.e., serving as a "source")	Yes
Climate regulation: global	Carbon sequestration (impacts on global climate change)	Yes
Climate regulation: local	regulation of temperature, shade air quality by vegetated areas	Yes
Regulation of water timing and flows	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge,	Yes
Water purification and waste treatment	Role played by vegetation in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds.	Yes

Ecosystem Service	Description, Examples	Presence
Shoreline protection	Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms.	No
Fire regulation	Regulation of fire frequency and intensity (e.g. dense forest can provide firebreaks)	No
Pest regulation	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock	Yes
Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens	Yes
Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas	Yes
Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	Yes
Cultural Services		
Spiritual or religious value	Natural spaces or species with spiritual or religious importance	No
Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources.	Yes
Recreation and tourism	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting)	No
Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	No
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	No
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value	Yes
Supporting Services		
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation.	Yes
Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.	Yes
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms.	Yes
Soil formation	Natural soil-forming processes throughout vegetated areas.	Yes
Habitat Provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	Yes

5 SCOPING

This chapter presents the results of the Ecosystem Services scoping process that was described in *Section 3.3*. Scoping was undertaken based on desktop review and preliminary results of community consultation, to identify the services with human beneficiaries that will potentially be impacted by the Project. The scoping process considered impacts from the Project activities, as outlined in *Table 5.1*.

Table 5.1 Sources of Impact Considered during Scoping Stage

Code	Source of Impact
Construction	
1	Land acquisition
2	Workforce recruitment
3	Mobilisation of equipment and materials
4	Land preparation (clearing and removal)
5	Drilling and production testing
6	Installation of transmission tower
7	Construction of power plant
8	Upgrade to existing access roads and new access roads
Operation	
9	Operation of transmission line
10	Operation of power plant

Table 5.2 outlines the beneficiaries, potential sources of impact and project dependence for each service, and whether the service was scoped into or out of the ESR.

Table 5.2 Ecosystem Service Prioritisation

Service	Beneficiaries	Impact Source Code	Project depend-ence	Scoped in or out	Reasoning
Provisioning Services					
Food: wild-caught fish and shellfish	Villagers	8	N	Out	The Batang Toru River may be used by local villages for fishing and other food resources. Project activities are not expected to influence local fisheries resources for the village community. Installation of access roads and pipelines may lead to some temporary disturbance to waterway bed and/or banks during construction however these impacts are expected to be localised and negligible to this service.
Food: wild plants, nuts, mushrooms, fruit, honey	Villagers	1, 4	N	In	The mixed plantation and natural forest areas within the Project area and surround may provide this service to local villagers. Up to 86 ha of vegetation where this resource may be collected will be removed as a result of the Project.
Food: wild meat	Villagers	1, 4	N	In	The mixed plantation and natural forest areas within the Project area and surround may provide an area for hunting for local villagers. Up to 86 ha of vegetation where this resource may be collected will be removed as a result of the Project.
Food: cultivated crops	Villagers, consumers	1, 4	N	In	The Project area is dominated by modified habitats cultivated to meet basic community needs. The area to be removed is estimated at 83.3 ha.
Biomass fuel	Villagers	4	N	Out	Villagers may use local vegetation communities for fuel biomass. In the context of the surrounding forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha, which includes paddy field which would provide no biomass fuel services (refer to *Figure 2.1*).
Timber and wood products	Villagers, consumers	1, 4	N	In	The Project area is dominated by modified habitats cultivated to meet basic community needs. Some of this vegetation may be managed for timber and wood products. The area to be removed is estimated at 83.3 ha.
Non- wood fibres and resins	Villagers, consumers	4	N	In	The Project area is dominated by modified habitats cultivated to meet basic community needs. This includes rubber plantation. The area to be removed is estimated at 83.3 ha.
Freshwater	Villagers	5, 8	N	Out	Installation of access roads and pipelines may require some temporary impacts to waterway bed and/or banks however impacts to surface water are expected to be localised and negligible to this service. Assessment has indicated that groundwater used by the community is unlikely to be affected by Project operations.
Biochemicals, natural medicines,	Villagers	Limited Impacts	N	Out	Some people grow medicinal plants in their yards. The impacts of the Project on medicinal plants are expected to be negligible.

Service	Beneficiaries	Impact Source Code	Project depend-ence	Scoped in or out	Reasoning
pharmaceuticals					
Ornamental resources	Unknown	Limited Impacts	N	Out	No evidence of ornamental resources has been identified. Although some materials may be used as ornamental resources, these are unlikely to be substantially affected by the Project.
Regulating Services					
Regulation of air quality	Villagers	4	N	Out	In the context of the surrounding forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha. The contribution of this area to air quality is expected to be negligible.
Climate regulation: global	Global community	4	N	Out	In the context of the surrounding forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha, of which a substantial area is paddy field. The contribution of this area to climate regulation is expected to be negligible.
Climate regulation: local	Villagers	4	N	Out	In the context of the surrounding forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha, of which a substantial area is paddy field. The contribution of this area to climate regulation is expected to be negligible.
Regulation of water timing and flows	Villagers	8	N	Out	Project activities are not expected to alter surface water flow. Installation of access roads and pipelines may require some temporary impacts to waterway bed and/or banks to establish the crossings however impacts to flows are expected to be temporary and negligible to this service.
Water purification and waste treatment	Villagers	4, 8	N	Out	Project activities may lead to localised disturbance to riparian vegetation however this area is expected to be small at crossing locations and replanting will occur where possible. Impacts are expected to be temporary and negligible to this service.
Pest regulation	Villagers	4	N	Out	In the context of the surrounding forested area (>148,000ha), the area of vegetation to be removed is less than 86 ha, of which a substantial area is modified habitat. The natural habitat that supports pest regulating services that will be removed is 2.7 ha. The contribution of this area to pest regulation is expected to be negligible.
Disease regulation	Villagers	4	N	Out	In the context of the surround forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha. The contribution of this area to disease regulation is expected to be negligible. The impact to freshwater waters is also considered to be negligible.
Erosion regulation	Villagers	4	N	Out	Project activities may lead to localised disturbance to riparian vegetation that assist in stabilising river banks from erosion however the area is expected to be small and limited to pipeline or access road crossing locations. Replanting will occur where possible. In the context of the surrounding forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha. The contribution of this area to erosion regulation is expected to be negligible.
Pollination	Unknown	4	N	Out	In the context of the surround forested area (>148,000 ha), the area of vegetation to be removed is less than 86 ha, of which a substantial area is paddy field or modified habitat. The contribution of this area to pollination is expected to be negligible.

Service	Beneficiaries	Impact Source Code	Project depend-ence	Scoped in or out	Reasoning
Cultural Services					
Traditional practices	Villagers	Limited Impacts	N	Out	Rubber crops are grown traditionally, with several types of crops grown between the rubber plants (ERM 2013a). The impact of the Project on traditional practices is expected to be negligible.
Non-use value of biodiversity (e.g. existence, bequest value)	People who value biodiversity	Limited Impacts	N	Out	The Project area provides potential habitat for threatened species listed on the IUCN Red List. These species may provide non-use values to people with an interest in the conservation of biodiversity. The impact of the Project on people who value the conservation of biodiversity are expected to be negligible.
Supporting Services					
Primary production	Other Ecosystem Services	Limited Impacts	N	Out	Impacts of the Project on primary production are expected to be negligible.
Nutrient cycling	Other Ecosystem Services	Limited Impacts	N	Out	Impacts of the Project on nutrient cycling are expected to be negligible.
Water cycling	Other Ecosystem Services	Limited Impacts	N	Out	Impacts of the Project on water cycling are expected to be negligible.
Soil formation	Other Ecosystem Services	Limited Impacts	N	Out	Impacts of the Project on soil formation are expected to be negligible.
Habitat Provision	Global community	4	N	In	Impact to habitat expected through land preparation, including clearing.

6 ECOSYSTEM SERVICE DESCRIPTIONS

6.1 PROVISIONING SERVICES

6.1.1 *Food: Wild Plants, Nuts, Mushrooms, Fruit, Honey*

No evidence of the use of wild plants, nuts, mushrooms, fruit and honey has been identified; however natural forest areas within the Project area may provide this service to local villagers. Up to 86 ha of vegetation where this resource may be collected will be removed as a result of the Project. This includes 2.7 ha of natural vegetation and 83.3 ha of modified vegetation.

6.1.2 *Food: Wild Meat*

Participants involved in social impact assessment consultations reported that wild boars (*Sus scrofa*) are hunted.

6.1.3 *Food: Cultivated Crops*

Rice is the main crop grown in both Pahae Julu and Pahae Jae Sub Districts. Rice production in these districts in 2011 was a total of 29,667 tons (ERM 2013a). The crops with the next largest weight of production were cassava, sweet potato and durian, with production ranging from 560 to 900 tons (ERM 2013a). Other crops included: areca nut, hazelnut, aren, coconut, chives, chicory, long beans, cinnamon, banana, spinach, eggplant, peanuts, chili, duku/langsat, chocolate, corn and coffee (ERM 2013a). It is expected that production within the Project area is consistent with production for the wider sub-district.

Figure 6.1 Rice field near SIL1 (Source: ERM 2013a)

6.1.4 *Timber and Wood Products*

Participants involved in social impact assessment consultations reported that timber is collected for firewood and housing construction.

6.1.5 *Non-Wood Fibres and Resins*

Rubber palms and benzoin trees are produced in both Pahae Julu Subdistrict and Pahae Jae Subdistrict (ERM 2013a). In 2012, production of rubber was 1476 tons in Pahae Jae Sub-district and 556 tons in Pahae Julu Sub-district. Production of Benzoin was 138 tons in Pahae Jae Sub-District, and 562 tons in Pahae Julu Sub-district (ERM 2013a). Rubber plantations are managed privately or in groups by surrounding communities (ERM 2013a). Rubber plantations are managed traditionally, with several types of crops grown between rubber plants (ERM 2013a).

Figure 6.2 Rubber Plantation (Source: ERM 2013a)

6.1.6 *Freshwater*

Ground water is the clean water source for the majority of people in the Pahae Julu and Pahae Jae Sub-districts (ERM 2009). Seventy-eight per cent of people use mountain water, 18.7 per cent use water from wells, and 3.3 per cent use river water (ERM 2009). Approximately 68 per cent of people use rivers and ditches for toileting, and the remainder use septic tanks (ERM 2009).

6.2 *SUPPORTING SERVICES*

6.2.1 *Habitat Provision*

Although the majority of the Project area contains modified habitats, some small areas of natural habitats were identified to provide potential habitat to flora and fauna species listed under the IUCN Red List of Threatened Species (ERM 2013b). Seven of these were identified as endangered or critically endangered and have potential habitat within the Project area, including: the Sumatran tiger (*Panthera tigris sumatrae*), Sumatran orang-utan (*Pongo abelii*), agile gibbon (*Hylobates agilis*), Malayan pangolin (*Manis javanica*), mitred leaf monkey (*Presbytis melalophos*), siamang (*Symphalangus syndactylus*) and Asian tapir (*Tapirus indicus*) (ERM 2013b).

7 PRIORITY ECOSYSTEM SERVICES

Each of the Ecosystem Services considered in this study was evaluated to determine whether it should be considered for elevation to a Priority Ecosystem Service based on the following four criteria:

- Potential Project impact;
- Dependence of the Project on the Ecosystem Service;
- The importance of the service to the affected community; and
- The irreplaceability of the Ecosystem Service if it was to be completely removed from the region.

The criteria were combined using the matrix in *Table 3.1*, and Ecosystem Services with a priority ranking of High or Critical were assigned as Priority Ecosystem Services. *Table 7.1* displays the prioritisation of Ecosystem Services. In summary, the Priority Ecosystem Services identified for the Project are:

- Food: cultivated crops;
- Non-wood fibres and resins; and
- Freshwater.

Impacts to these services are assessed in *Chapter 8*.

Table 7.1 Ecosystem service prioritisation

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries[1]	Irreplaceability	Potential Alternatives	Priority
Provisioning Services						
Food: wild plants, nuts, mushrooms, fruit, honey	No trends identified	Villagers	Low	High	Extensive forest exists outside the Project area which could provide wild plants, nuts, mushrooms, fruit and honey.	Low
Food: wild meat	No trends identified	Villagers	Moderate	High	Extensive areas outside the Project area are available to hunt wild boars and other species.	Low
Food: cultivated crops	No trends identified	Farmers within the footprint, consumers	High	Moderate	Alternative locations for cultivation exist for the communities as a whole; however alternatives may not exist for individual land owners.	High
Timber and wood products	No trends identified	Villagers , consumers	Moderate	Moderate	Extensive forest exists outside the Project area which could provide timber and wood products; however, where timber is grown on private land, alternatives may not be available to individuals where land has been acquired.	Moderate
Non- wood fibres and resins	No trends identified	Farmers within the footprint, consumers	High	Moderate	Alternative locations for cultivation of rubber palm exist for the communities as a whole; however alternatives may not exist for individual land owners.	High
Freshwater	No trends identified	Villagers	High	Moderate	Springs and wells outside the Project area may exist, however these may be connected to aquifers within the Project area.	High
Supporting Services						
Habitat Provision	No trends identified	Villagers Global community	Moderate	High	Habitat provision for wild animals (Wild Boars) harvested is important to villagers. Wild Boars persist in a range of habitats and extensive alternatives exist outside the Project Area. Specific to species considered globally important (IUCN listed), extensive forest exists outside the Project area that would also be considered potential habitat for the species. The Biodiversity Impact Assessment (ERM 2013b) identified that the Project would have a negligible or minor impact to IUCN listed species.	Low

8 *IMPACT ASSESSMENT*

This chapter provides an assessment of the potential Project impact to Ecosystem Services using the criteria provided for the impact assessment in *Chapter 3.5**Error! Reference source not found.**,* the Project description provided in *Chapter 1.6;* and the impact sources identified in *Table 5.1.* In summary, impacts to two Ecosystem Services were assessed as being Minor: Cultivated Crops, and Non-wood Fibers and Resins.

Table 8.1 Assessment of Impacts to Priority Ecosystem Services

Ecosystem Service	Magnitude	Vulnerability	Impact	Discussion
Provisioning Services				
Cultivated Crops (Farmers within the footprint)	Low	Medium	Minor	The Project footprint covers an area of 86 ha. Up to 83.3 ha of this is mapped as being used for mixed plantation and paddy fields. In the context of the Pahae Julu and Pahae Jae sub-districts, the impact area is small. However, in some cases individual farmers within the footprint may have substantial portions of their land acquired, and this could affect the incomes and livelihoods of a small number of households or individuals. The impact is considered to be of short duration, as it is likely that land uses could be reinstated around the well pads and transmission line easement following construction. The magnitude of this impact and the vulnerability of individual landowners will be assessed in more detail through the land acquisition process.
Cultivated Crops (Consumers)	Negligible	Low	Negligible	The reduction in crop production due to the removal of 83.3 ha of mixed plantation and paddy fields is not expected to substantially affect the supply of crops to consumers. Sufficient spatial alternatives exist, both within and outside the Project area.
Non-wood Fibres and Resins (Farmers within the footprint)	Low	Medium	Minor	The Project will involve the clearing of approximately 83.3 ha of productive land including mixed plantations supporting rubber production and paddy fields. In the context of the Pahae Julu and Pahae Jae sub-districts as a whole the impact area is small. However, in some cases individual farmers within the footprint may have substantial portions of their land acquired, and this could affect incomes and livelihoods. The impact is considered to be of short duration, as it is likely that land uses could be reinstated around the well pads and transmission line easement following construction. The magnitude of this impact and the vulnerability of individual landowners will be assessed in more detail through the land acquisition process.
Non-wood Fibres and Resins (Consumers)	Negligible	Low	Negligible	The reduction in rubber and benzoin production due to the removal of 83.3 ha of mixed plantation and paddy fields is not expected to substantially affect rubber and benzoin supply to consumers. Sufficient spatial alternatives exist, both within and outside the Project area.
Freshwater (surface water)	Negligible	Low	Negligible	Project activities are not expected to influence the freshwater environment. Installation of access roads and pipelines may require some temporary impacts to waterway bed and/or banks however impacts are expected to be localised and negligible to this service.

9 RECOMMENDATIONS

This ESR identified three the Priority Ecosystem Services occurring within the Project area: Food: cultivated crops; Non-wood fibres and resins; and Freshwater. Significant impacts are not anticipated for these Ecosystem Services, based on the impact assessment. However, the impact assessment identified minor impacts to farmers within the Project footprint relating to Cultivated Crops and Non-wood Fibres and Resins.

9.1 CULTIVATED CROPS AND NON-WOOD FIBRES AND RESINS

Acquisition of productive land will affect farmers within the Project footprint that are dependent on agriculture for livelihoods. A Land Acquisition Process is currently underway, which aims to manage impacts to land owners, including those directly impacted. Land has been acquired in Pahae Jae Sub-district, and land owners have been compensated. Land Acquisition in Pahae Julu Sub-district is currently being negotiated. The Land Acquisition Process should:

- Involve baseline data collection on the uses and incomes derived from land to be acquired;
- Identify households that are vulnerable to Project impacts, whether due to the proportion of land to be acquired, or the current level of household income;
- Provide appropriate compensation, whether financial or land-based; and
- Include a grievance mechanism.

REFERENCES

ERM – See PT ERM Indonesia

PT ERM Indonesia (2009) *Environmental Impact Statement: Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity*. Report prepared for Sarulla Operation Limited.

PT ERM Indonesia (2013a) *Addendum to ANDAL, RKL-RPL Relocation Activities of Well pad Sites in Namora I Langit (Nil), Electricity Generator in Silangkitang (Sil), Transmission Line, Development of Geothermal Field and Construction of the 330 Mw Capacity PLTP Sarulla*. In Draft. Report prepared for Sarulla Operation Limited.

PT ERM Indonesia (2013b) *Sarulla Geothermal Field and Power Plant of 330 MW Capacity: Biodiversity Impact Assessment.* In Draft. Report prepared for Sarulla Operation Limited.

PT ERM Indonesia (2013c) *Social Impact Assessment and Integrated Social Program.* In Draft. Report prepared for Sarulla Operation Limited.

WRI – See World Resources Institute

World Resources Institute (2011) *Ecosystem Services Review for Impact Assessment: Introduction and Guide to Scoping.*

Annex G

Noise Assessment

FINAL REPORT

Sarulla Operations Ltd.

Sarulla Geothermal Field and Power Plant of 330 MW Capacity

Noise Impact Assessment

October 2013

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EXECUTIVE SUMMARY

Environmental Resources Management Pty Ltd (ERM) on behalf of Sarulla Operations Ltd. (SOL) has completed a noise impact assessment for the SOL Project Sarulla Geothermal Plant (the Project), a 330 MW power plant at Silangkitang (SIL) and Namora I Langit (NIL) in Indonesia.

Construction and operational noise levels have been predicted utilising internationally recognised methods and compared to applicable noise criteria.

The findings of the assessment indicate compliant (Project criteria) noise levels for operational activities and aspects of the project, with negligible impact anticipated. Construction noise levels are also compliant at the majority of noise receptors, but exceed the Project criteria at a limited number of noise receptors during certain high noise level generating activities. These exceedances warrant noise control mitigation and management measures to be considered and ERM has provided a set of project specific recommendations.

ERM makes no further recommendations for noise control mitigation, management measures or monitoring options to those presented in this report (specific to construction), or those already incorporated into the project design.

1 INTRODUCTION

This report has been prepared by Environmental Resources Management Pty Ltd (ERM on behalf of Sarulla Operations Ltd. (SOL), a Consortium of Itochu Corporation, Kyushu Electric Power Co., Inc., Ormat International, Inc. and PT. Medco Energi International Tbk. It presents the results, findings and recommendations arising from the noise impact assessment completed for the Sarulla geothermal field and power plant at a combined 330 MW capacity (the project), at Silangkitang (SIL) and Namora I Langit (NIL), Pahae Julu and Pahae Jae districts, North Tapanuli Regency in Sumatera, Indonesia.

1.1 PROJECT OVERVIEW

The project was initiated by Unocal North Sumatera Geothermal, after an Energy Sales Contract and Joint Operation Contract were signed in 1993. An extensive exploration activity was conducted in geology, geochemistry, geophysics investigations, and certain infrastructure development including well pad and its access road and followed by drilling activity starting from 1994 to 1998.

There are nine exploratory wells: five in SIL, four in NIL, that were drilled in the contract area followed by well completion and production testing to prove the quality and quantity of the resource. After receiving the right to develop the Sarulla project in 2006, SOL has re-evaluated all of the Sarulla exploration data (geology and exploration investigations) to undertake the next stage in the development of the Sarulla Contract Area. A new development plan including future drilling plan by utilising reservoir forecast simulation was established in 2011 and reflected to the well pad design and field development.

1.1.1 SOL Project Location

The proposed activity is located ± 40 km south of Tarutung adjacent to the Trans Sumatera Highway (Tarutung – Sipirok). Administratively, the project is located in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province. In relation to the Regency Spatial Plan, the Government of North Tapanuli Regency issued North Tapanuli Regency Regulation No. 19 of 1994 regarding North Tapanuli Regency spatial planning, which designated the sub districts of Pahae Jae (Silangkitang area or SIL) and Pahae Julu (Namora I Langit) as areas of geothermal natural resources.

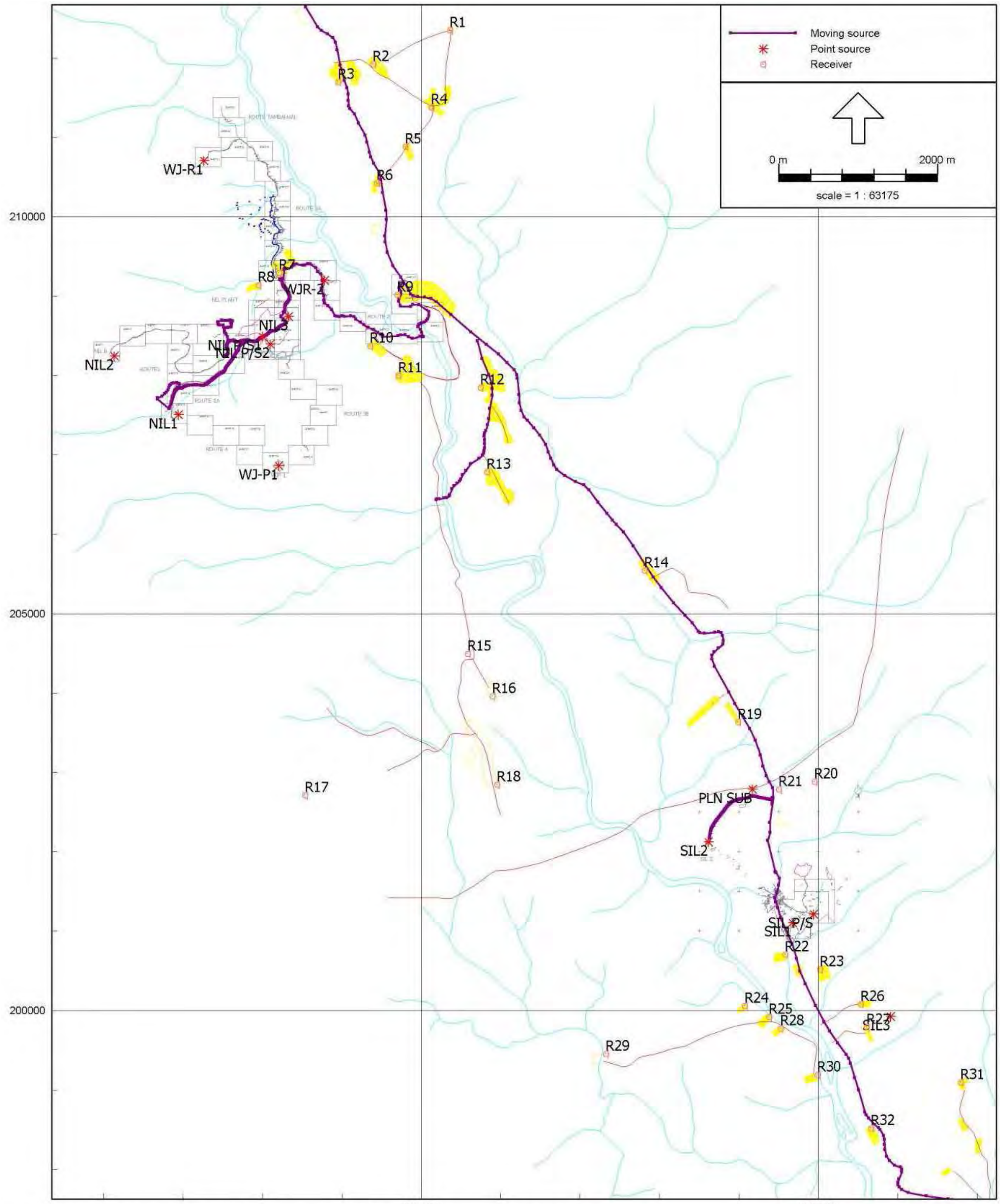
1.1.2 *Assessment Locality Map*

The project noise areas, noise receptors and other items of interest to this noise impact assessment are illustrated in *Figure 1.1* to *Figure 1.3* below, which is a direct reproduction of the project noise model layout. These locations are discussed and described in more detail in *Section 2.5* of this noise impact assessment report.

Other Reference Drawings

Other project design plans relevant to this noise impact assessment are provided in *Annex B*.

Figure 1.1 Assessment Locality (All Locations)



Industrial noise - ISO 9613.1/2, [0200780 - SOL Sarulla Geothermal - 0200780 - SOL Sarulla Geothermal] , Predictor V8.13

Figure 1.2 Assessment Locality NIL (Northern Locations)

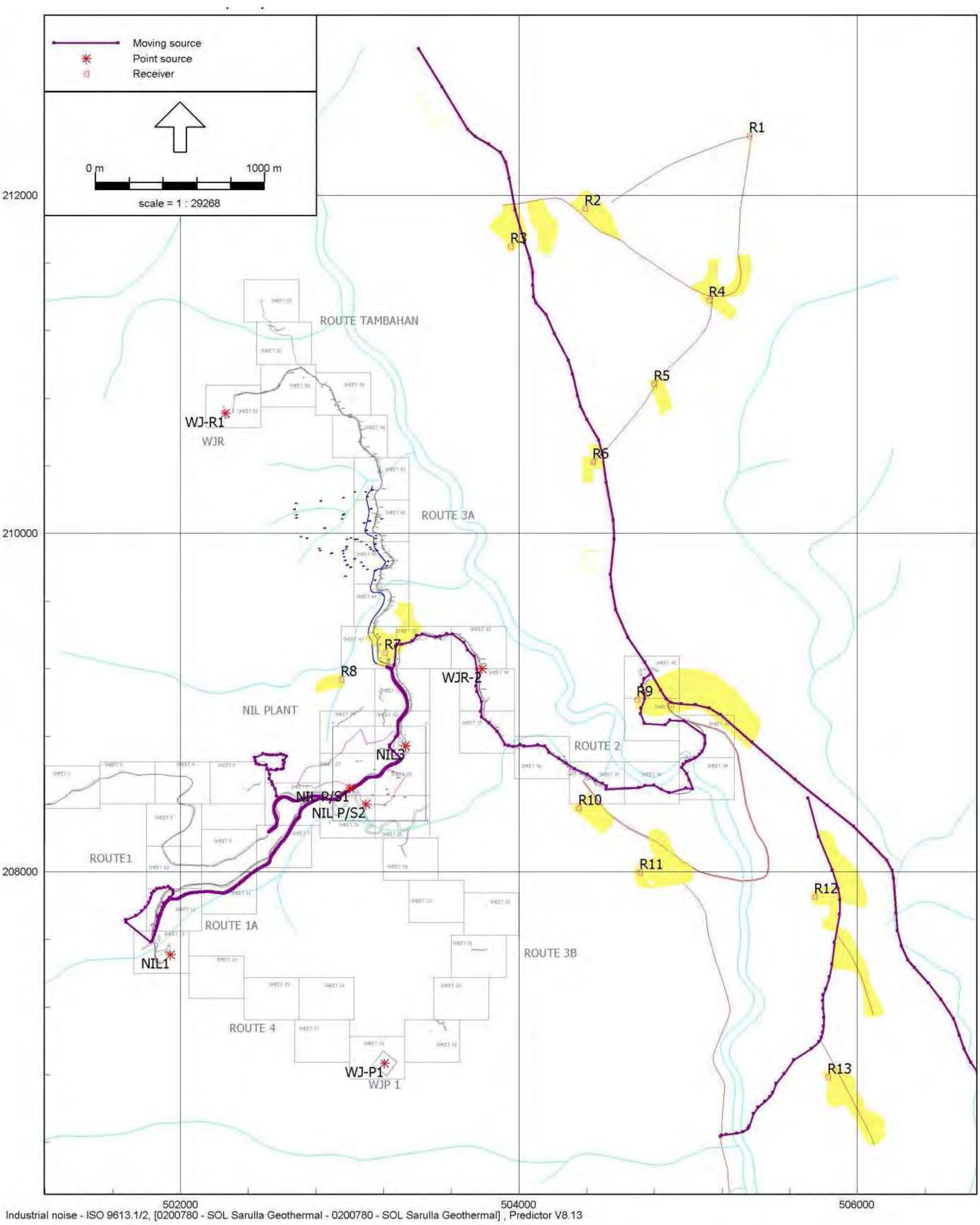
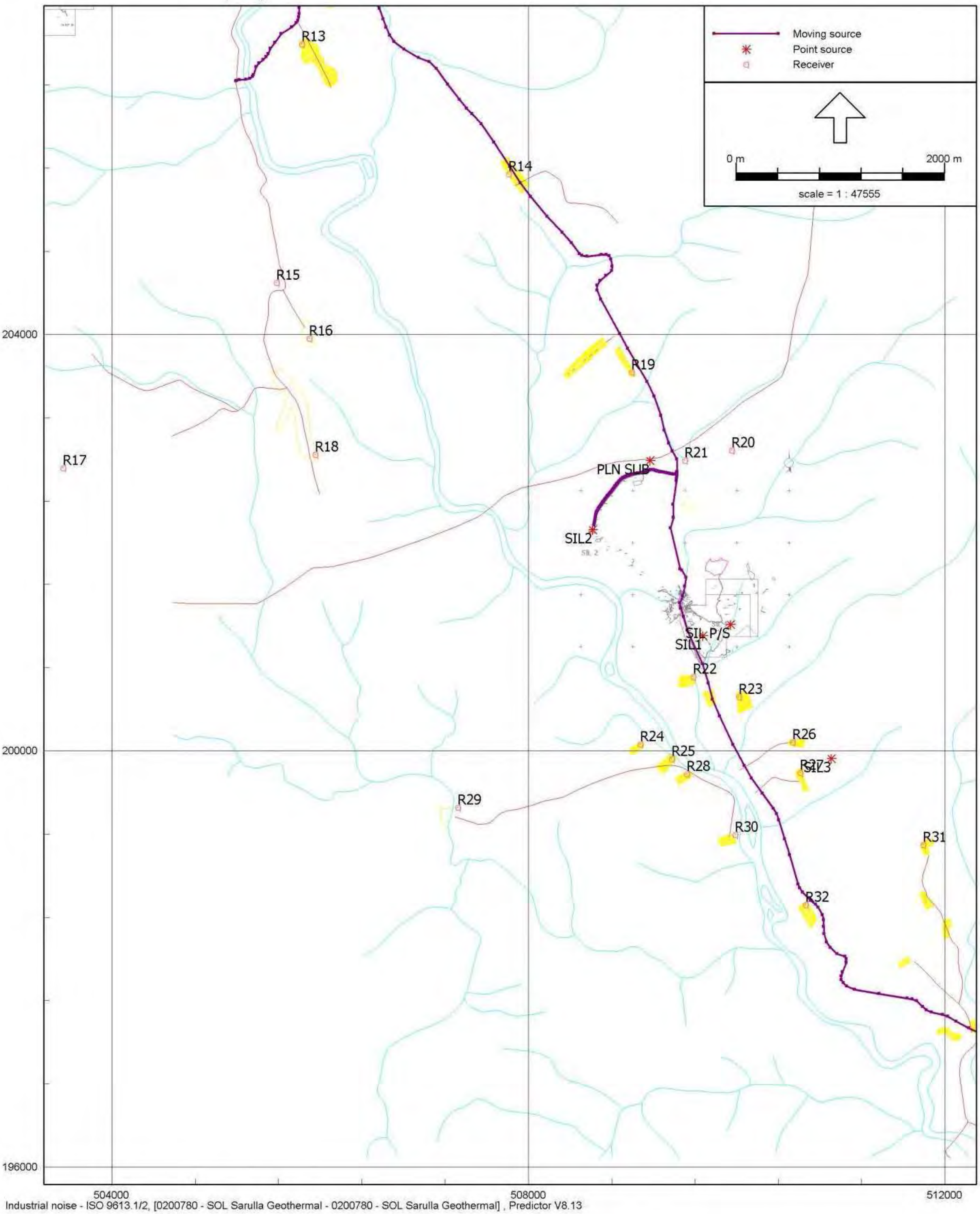


Figure 1.3 Assessment Locality SIL (Southern Locations)



2 *ASSESSMENT METHODOLOGY*

This section presents an overview of the assessment methodology adopted by ERM to complete the project noise impact assessment.

2.1 *OBJECTIVES*

The objectives of this noise impact assessment are to:

- Review project data and/or information as relevant to the assessment;
- Identify noise generating activities associated with construction and operational stages of the project;
- Identify the closest and/or potentially most affected noise receptors located in the vicinity of noise generating activities;
- Predict project noise levels (via 3d modelling) at all identified noise receptors, for construction and operational aspects of the project;
- Compare the predicted project noise levels to local and international policy, standards and guidelines and identify any exceedances of criteria; and
- Provide preliminary noise control mitigation, management measures and/or monitoring options design to minimise noise levels, and potential impacts, at applicable noise receptors.

2.2 *RELEVANT POLICY, STANDARDS & GUIDELINES*

This noise impact assessment has been completed with due regard to and in accordance with the following national legislation and international policy, standards and guidelines:

- Indonesian National – *The Minister of Environment Decree No. 48 Year 1996* (Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard);
- International Finance Corporation - World Bank Group (IFC) - *Environmental, Health and Safety (EHS) Guidelines - General EHS Guidelines: Environmental Noise Management, Section 1.7 Noise* (IFC 1.7 Noise); and
- International Organisation for Standardisation (ISO) 9613-2:1996 (ISO9613:2) - *Acoustics - Attenuation of Sound during Propagation Outdoors - Part 2: General Method of Calculation.*

2.3 NOISE CRITERIA

2.3.1 *Disturbance Values*

Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard and *IFC 1.7 Noise* were referred to develop the project-specific noise criteria. Standards or guidance provided in *Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard* are minimal and as such the criteria presented in *IFC 1.7 Noise* have been adopted for use in this project.

The project-specific noise criteria are outlined below in *Table 2.1.*

Table 2.1 Project-Specific Noise Criteria

Receptor	Maximum Allowable (free field) Noise Levels LAeq, 1hr dB(A)	
	Daytime 07:00 – 22:00	**Night-time 22:00 – 07:00**
Residential, institutional, educational	55	45
Industrial, commercial	70	70

2.3.2 *Amenity Values*

In addition the fixed values described above, IFC 1.7 Noise states that "*impacts should not exceed the levels presented in Table, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site*". In this case, ambient noise level measurements were taken for the project, over a period of 24 hours, during the daytime and night time assessment periods. Noise levels ranged between 41 dB(A) and 51 dB(A). 41 dB(A) is adopted here to represent an approximate Assessment Background Level (ABL) for all receptors during both daytime and night time periods. Thus a permissible level of 44 dB(A) specified for this project.

2.3.3 *Evaluating Impact Significance*

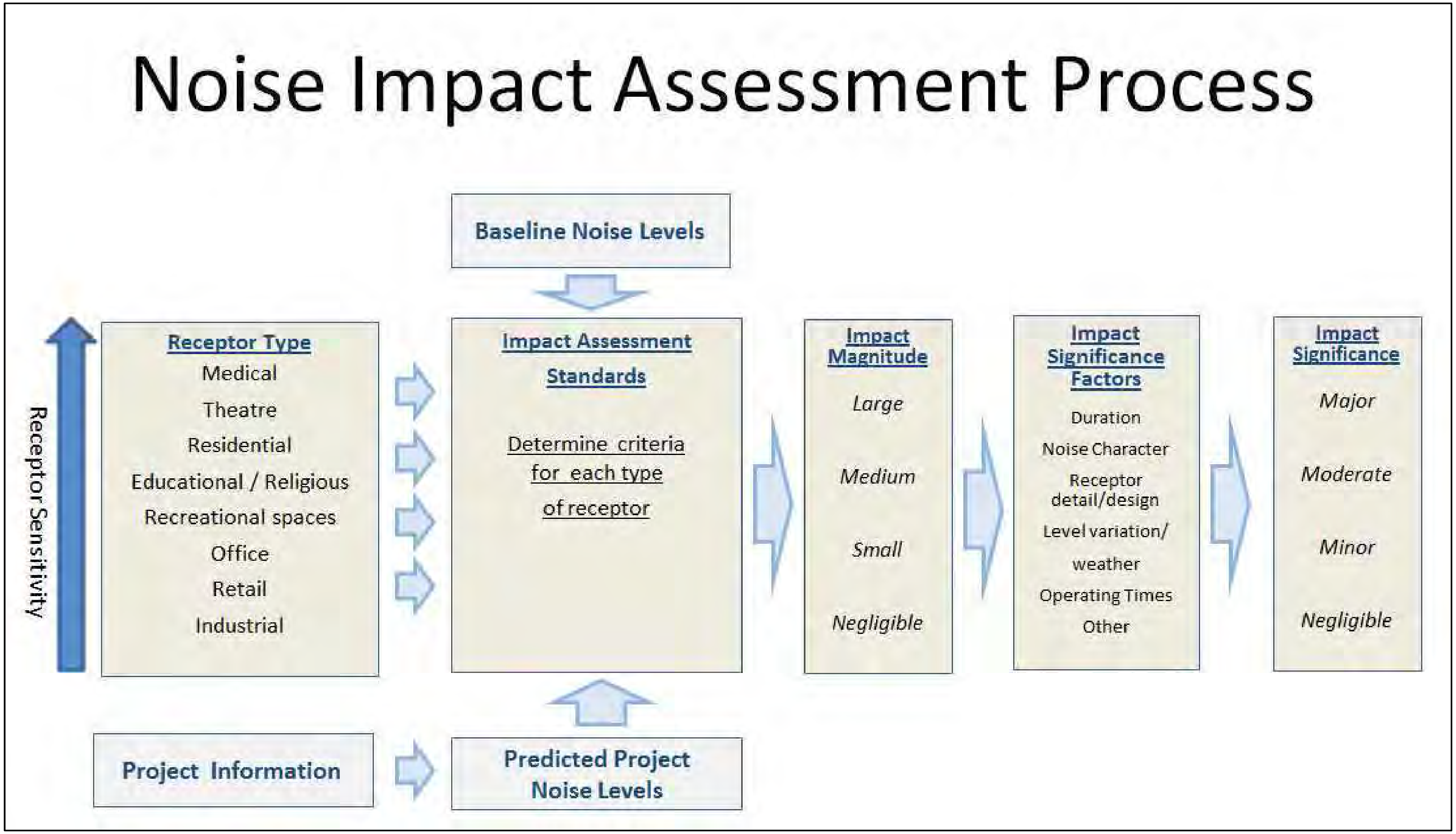
Predicted noise levels are compared to criteria to determine and exceedances and to evaluate the magnitude and extend of any impacts. Typical impact assessment methodologies require an approach that combines impact magnitude with receptor sensitivity to determine impact significance, thus:

Receptor Sensitivity X Impact Magnitude >> Impact Significance

For most environmental impact aspects this allows a significance matrix to be used that combines receptor sensitivity with impact magnitude. For noise, however, we can predict noise levels quantitatively and compare them against impact assessment standards that are receptor specific taking into account receptor sensitivity.

This is standard practice for ERM, who are experienced globally at the assessment of potential noise impacts. Furthermore, many numerical noise standards are source specific (e.g. industrial noise is different to aircraft noise), some refer to baseline levels, and there can be a number of other factors that determine impact significance. Thus, the ERM impact significance process for noise is shown in *Figure 2.1* below.

Figure 2.1 Noise Impact Assessment Process



For noise impact significance, the assessment considers the type of receptor, draw on relevant standards or guidance to determine impact magnitude, and then consider any other factors to determine significance.

Magnitude of Noise Impacts

Noise impact assessment standards and guidelines generally give threshold levels that have the potential to create nuisance or disturbance regardless of the existing noise levels, or they define changes in the noise levels above which significant noise impacts are expected. In using such guidance it is necessary to scale impact magnitude into ranges required in impact assessment. *IFC 1.7 Noise* involves two requirements – to meet the allowable threshold noise levels (as reproduced in *Table 2.1*) or to not increase background noise levels by more than 3 dB.

Determining Significance

As indicated in *Figure 2.1* above, the step from impact magnitude to significance may involve considering factors that influence significance, but in cases where these factors are not required to be considered the Magnitude descriptors Negligible, Small, Medium and Large would be replaced by the Significance descriptors Negligible, Minor Moderate and Major respectively as presented in *Table 2.2*.

Table 2.2 Noise Impact Significance Terminology

Impact Parameter		Impact Significance - Daytime or Night-time			
		Negligible	**Minor**	**Moderate**	**Major**
Disturbance Impact: Project Noise Level (PNL), **LAeq,1hr dB**	Daytime[1]	<50	50-55	>55-60	>60
	Night time[2]	<40	40-45	>45-50	>50
Amenity Impact Daytime or Night-time LAeq, PNL – LA90,ABL dB		<5	5-10	>10-15	>15

1. Daytime: 07:00 to 22:00; and
2. Night time: 22:00 to 07:00.

The threshold noise levels summarised in *Table 2.2* are the values where noise impacts are expected to occur. The meaning of the four impact significance ratings used, in context of noise impact assessment, is as follows:

- *Negligible* – no noticeable effects, no need to consider in decision making, no mitigation required;

- *Minor* – the effect may be noticeable, but is *within* applicable standards and small enough that noise management practices would ensure noise levels are below significance criteria;

- *Moderate* – an impact that is significant and mitigation should be considered. Mitigation is likely to affect design and cost;

- *Major* – an impact that is significant and mitigation must be considered. Mitigation will alter project design and cost. Impacts are undesirable if not addressed.

Hence, impacts rated as moderate or above should be mitigated where practicable with proportionately more emphasis as the rating increases. These criteria will provide the basis for developing performance standards and acoustic specifications for the Project.

2.4 *NOISE MODELLING*

3D noise modelling is used to predict representative worst-case noise levels for construction and operational aspects of a project. In this case the predicted noise levels are then to local and international noise criteria; to identify any exceedances and to inform any noise control mitigation, management and/or monitoring options.

Construction and operational noise is modelled separately, except for in this case, one scenario where a potential overlap of construction and operational noise is considered (refer *Section 2.2.2* below).

Brüel & Kjær's Predictor (Version 8.13) noise modelling software package was used to predict all noise levels at each potential noise receptor (refer *Section 2.6*). The ISO9613:2 industrial noise (1/1 octave) algorithms were used.

Brüel & Kjær's Predictor (Version 8.13) allows 3D topographic details (site terrain) to be combined with ground regions, water, grass, significant building structures etc. and project-specific assessment locations, (noise receptors), to create a detailed and accurate representation of the site and surrounding area. Noise emission sources deemed representative of construction and operational conditions under each scenario were placed at relevant locations within the site areas. All sources for each model have been included to be in use concurrently.

Noise levels were predicted adopting default modelling values, including: a temperature of 20 degrees Celsius, a relative humidity of 60% and 80% soft ground coverage. All noise levels were predicted at a height of 1.5m which represents a single storey building.

Based on review of available project data, Sound Power Level (LW) data (spectral values and overall LW, dB(A)) for known equipment, where specified in the project description, were determined by ERM. A default noise source emission level equivalent to 85 dB(A) at 1m has been adopted for non-typical site sources associated with the development as per the SOL plant and equipment noise specification. A default noise emission height of 1.8m was adopted for all sources.

2.5 Noise Generating Activities

This section presents the noise generating activities associated with construction and operational stages of the project.

2.5.1 Project Noise Areas

The following areas of potential project noise emission have been identified by ERM, as detailed in *Table 2.3* below.

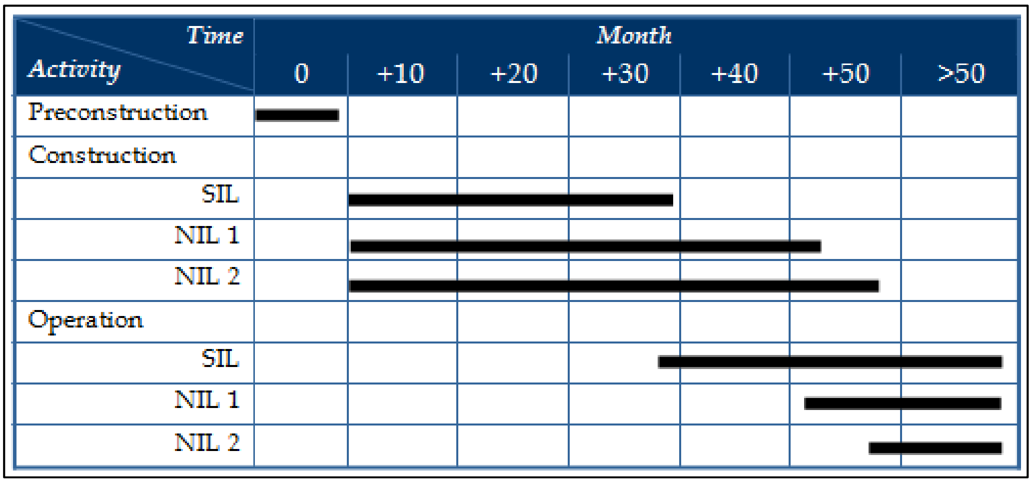
Table 2.3 Areas of Potential Project Noise Emission

Area of Potential Project Noise Emission		GPS Co-ordinates		Estimated Elevation, m
ID	**Description**	**Easting**	**Northing**	
WJ-R1	WJ-R1 Well Site	502264	210710	939
TL1	TL1 Transmission Line Construction	503479	209285	826
WJR-2	WJR-2 Well Site	503783	209201	724
NIL3	NIL3 Well Site	503328	208745	818
NIL P/S1	NIL P/S1 Power Station	503001	208495	820
NIL P/S2	NIL P/S2 Power Station	503097	208399	831
NIL2	NIL2 Well Site	501131	208245	995
NIL1	NIL1 Well Site	501941	207509	874
TL2	TL2 Transmission Line Construction	505792	207166	645
WJ-P1	WJ-P1 Well Site	503206	206868	902
PLN SUB	PLN Substation	509169	202789	597
SIL2	SIL2 Well Site	508614	202126	530
TL3	TL3 Transmission Line Construction	509847	201422	521
SIL P/S	SIL P/S Power Station	509943	201216	511
SIL1	SIL1 Well Site	509674	201107	492
SIL3	SIL3 Well Site	510910	199925	520

2.5.2 *Project Schedule*

The project schedule (for the development of the Sarulla 330 MW power plant at SIL and NIL) is shown in *Figure 2.2* below. This schedule (and other relevant project data) has been utilised to develop the assessment scenarios described in *Section 2.2.2*.

Figure 2.2 *SOL Project Schedule*



Discussion

As is identified in the project schedule, activities will begin with preconstruction preparation works, which are unlikely to generate significant noise levels. Then construction works are scheduled to commence at month 10, continuing to month 29 at SIL and month 57 at NIL. Operations at SIL are scheduled to commence at month 28 and at NIL in month 52. The schedule identifies an extended (~14 month) overlap of construction and operational activities where operations at SIL commence with construction works at NIL continuing.

2.6 NOISE RECEPTORS

The noise receptors (assessment locations) presented in *Table 2.4* are nominated by ERM to be representative of the closest and/or potentially most affected noise receivers located in the vicinity of project noise generating areas.

These locations are not intended to represent all receptors in the project area but are a representative sample set of locations at which project noise levels may be predicted in the noise model, and assessed.

Table 2.4 Noise Receptors (Assessment Locations)

Noise Receptor / Village		GPS Co-ordinates (54m)		Estimated Elevation, m
ID	**Description**	**Easting**	**Northing**	
R1	Sibatu-batu	505361	212354	995
R2	Siparpar	504390	211923	909
R3	Peanor-nor	503951	211698	875
R4	Pantis	505124	211380	922
R5	Siantolung	504799	210886	840
R6	Aek Sitapean	504438	210425	790
R7	Hutajulu	503207	209296	805
R8	Simataniari	502949	209139	784
R9	Onanhasang	504698	209019	673
R10	Lumbanjaean	504353	208376	645
R11	Sibaganding	504714	207998	634
R12	Lumbang garoga	505747	207853	647
R13	Simanam pang	505826	206787	645
R14	Lobupining	507809	205542	641
R15	T. Pindua	505584	204496	658
R16	Sigompulan 1	505898	203963	645
R17	Simardangilang	503534	202716	839
R18	Sigompulan 2	505953	202846	655
R19	Sitotuama	508990	203633	575
R20	Pandahanan Sira	509952	202887	633
R21	Sampil	509502	202790	574
R22	Sigurung-gurung	509582	200709	480
R23	Silangkitang	510022	200518	481
R24	Pagaran	509075	200061	474
R25	Pargaulan	509377	199920	470
R26	Gunungtua	510537	200081	485
R27	Rantopanjang	510608	199790	485
R28	Siriaria	509523	199774	470
R29	Huta Simarpinggan	507322	199454	490
R30	Huta Bagot	509987	199191	470
R31	Hariara	511792	199094	540
R32	Sihobuk	510663	198520	468

2.6.1 *Noise Assessment Scenarios*

Construction Assessment Scenarios

Based on ERM's detailed review of project data and/or information as relevant to the assessment and in consultation with SOL the following noise assessment scenarios were developed for construction aspects.

- *Table 2.5 - Construction Assessment Scenario (CASc01)* presents the type of plant and equipment, their location and likely quantity during general construction works;

- *Table 2.6 - Construction Assessment Scenario (CASc02)* presents the same scenario as *CASc01* with the inclusion of drill rigs in use;

- *Table 2.7 - Construction Assessment Scenario (CASc03)* presents the same scenario as *CASc01* with the inclusion of steam blowing tests in progress; and

- *Table 2.8 - Construction Assessment Scenario (CASc04)* presents the type of plant and equipment, their location and likely quantity during transmission line construction works.

Table 2.5 Construction Assessment Scenario (CASc01)

Stage	Plant and/or Equipment		Project Area												
	ID	Description	NIL1	NIL2	NIL3	WJ-R1	WJ-R2	WJP-1	NIL P/S 1	NIL P/S 2	SIL1	SIL2	SIL3	PLN Sub	SIL P/S
Construction	D01	DOZER (CAT D10 OR SIMILAR)	0	0	0	0	0	0	1	0	0	0	0	1	0
	G01	MOTOR GRADER (CAT 12G)	0	0	0	0	0	0	0	1	0	0	0	0	1
	DT01	DUMP TRUCK (E.G. 30-40 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	PL01	PAY-LOADER (CAT 966)	0	0	0	0	0	0	0	1	0	0	0	0	1
	BH01	BACKHOE (CAT 416)	0	0	0	0	0	0	1	0	0	0	0	1	0
	C01	CRANE (E.G. 250 TON)	0	0	0	0	0	0	0	1	0	0	0	0	1
	C02	MOBILE CRANE (125 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	C03	MOBILE CRANE (E.G. 60 TON)	0	0	0	0	0	0	0	1	0	0	0	0	1
	FL01	FORKLIFT (E.G. 5T)	0	0	0	0	0	0	1	0	0	0	0	1	0
	HBTT01	HIGH BED TRAILER TRUCK (E.G. 40-FOOT)	0	0	0	0	0	0	0	1	0	0	0	0	1
	FBT01	FLAT-BED TRUCK (E.G. 24 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	GC01	CONSTRUCTION NOISE (GENERAL)	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 2.6 Construction Assessment Scenario (CASc02)

Stage	Plant and/or Equipment ID	Plant and/or Equipment Description	Project Area NIL1	NIL2	NIL3	WJ-R1	WJ-R2	WJP-1	NIL P/S 1	NIL P/S 2	SIL1	SIL2	SIL3	PLN Sub	SIL P/S
Construction	D01	DOZER (CAT D10 OR SIMILAR)	0	0	0	0	0	0	1	0	0	0	0	1	0
	G01	MOTOR GRADER (CAT 12G)	0	0	0	0	0	0	0	1	0	0	0	0	1
	DT01	DUMP TRUCK (E.G. 30-40 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	PL01	PAY-LOADER (CAT 966)	0	0	0	0	0	0	0	1	0	0	0	0	1
	BH01	BACKHOE (CAT 416)	0	0	0	0	0	0	1	0	0	0	0	1	0
	C01	CRANE (E.G. 250 TON)	0	0	0	0	0	0	0	1	0	0	0	0	1
	C02	MOBILE CRANE (125 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	C03	MOBILE CRANE (E.G. 60 TON)	0	0	0	0	0	0	0	1	0	0	0	0	1
	FL01	FORKLIFT (E.G. 5T)	0	0	0	0	0	0	1	0	0	0	0	1	0
	HBTT01	HIGH BED TRAILER TRUCK (E.G. 40-FOOT)	0	0	0	0	0	0	0	1	0	0	0	0	1
	FBT01	FLAT-BED TRUCK (E.G. 24 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	GC01	CONSTRUCTION NOISE (GENERAL)	1	1	1	1	1	1	1	1	1	1	1	1	1
Well drilling	DR01	DRILL RIG	0	0	1	1	0	1	0	0	1	1	1	0	0

Table 2.7 ***Construction Assessment Scenario (CASc03)***

Stage	Plant and/or Equipment		Project Area												
	ID	**Description**	**NIL1**	**NIL2**	**NIL3**	**WJ-R1**	**WJ-R2**	**WJP-1**	**NIL P/S 1**	**NIL P/S 2**	**SIL1**	**SIL2**	**SIL3**	**PLN Sub**	**SIL P/S**
Construction	D01	DOZER (CAT D10 OR SIMILAR)	0	0	0	0	0	0	1	0	0	0	0	1	0
	G01	MOTOR GRADER (CAT 12G)	0	0	0	0	0	0	0	1	0	0	0	0	1
	DT01	DUMP TRUCK (E.G. 30-40 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	PL01	PAY-LOADER (CAT 966)	0	0	0	0	0	0	0	1	0	0	0	0	1
	BH01	BACKHOE (CAT 416)	0	0	0	0	0	0	1	0	0	0	0	1	0
	C01	CRANE (E.G. 250 TON)	0	0	0	0	0	0	0	1	0	0	0	0	1
	C02	MOBILE CRANE (125 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	C03	MOBILE CRANE (E.G. 60 TON)	0	0	0	0	0	0	0	1	0	0	0	0	1
	FL01	FORKLIFT (E.G. 5T)	0	0	0	0	0	0	1	0	0	0	0	1	0
	HBTT01	HIGH BED TRAILER TRUCK (E.G. 40-FOOT)	0	0	0	0	0	0	0	1	0	0	0	0	1
	FBT01	FLAT-BED TRUCK (E.G. 24 TON)	0	0	0	0	0	0	1	0	0	0	0	1	0
	GC01	CONSTRUCTION NOISE (GENERAL)	1	1	1	1	1	1	1	1	1	1	1	1	1
Well testing	SB01	STEAM BLOWING TEST	0	0	1	1	0	1	0	0	1	1	1	0	0

Table 2.8 Construction Assessment Scenario (CASc04)

Stage	Plant and/or Equipment		Project Area															
	ID	Description	NIL1	NIL2	NIL3	WJ-R1	WJ-R2	WJP-1	NIL P/S 1	NIL P/S 2	SIL1	SIL2	SIL3	PLN Sub	SIL P/S	TL1	TL2	TL3
Construction	GC01	CONSTRUCTION NOISE (GENERAL)	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Transmission Line Construction	D01	DOZER (CAT D10 OR SIMILAR)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	G01	MOTOR GRADER (CAT 12G)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	DT01	DUMP TRUCK (E.G. 30-40 TON)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	PL01	PAY-LOADER (CAT 966)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	BH01	BACKHOE (CAT 416)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	C01	CRANE (E.G. 250 TON)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	C02	MOBILE CRANE (125 TON)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	C03	MOBILE CRANE (E.G. 60 TON)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	FL01	FORKLIFT (E.G. 5T)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	HBTT01	HIGH BED TRAILER TRUCK (E.G. 40-FOOT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	FBT01	FLAT-BED TRUCK (E.G. 24 TON)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Operational Assessment Scenario

Based on ERM's detailed review of project data and/or information as relevant to the assessment and in consultation with SOL, the following noise assessment scenarios were developed for operational aspects of the project.

Table 2.9 presents the type of plant and equipment, their location and likely quantity during operations.

Combined Construction and Operational Assessment Scenario

As noted in *Section 2.5.2* the schedule identifies an extended (~14 month) overlap of construction and operational activities where operations at SIL commence with construction works at NIL continuing. Based on ERM's detailed review of project data and/or information as relevant to the assessment and in consultation with SOL, the following noise assessment scenarios were developed for combined construction and operational aspects of the project.

Table 2.10 presents the type of plant and equipment, their location and likely quantity during this scenario.

Table 2.9 Operational Assessment Scenario (OASc01)

Stage	Plant and/or Equipment		Project Area												
	ID	Description	NIL1	NIL2	NIL3	WJ-R1	WJ-R2	WJP-1	NIL P/S 1	NIL P/S 2	SIL1	SIL2	SIL3	PLN Sub	SIL P/S
Operations	ST01	BACK PRESSURE STEAM TURBINE	0	0	0	0	0	0	1	1	0	0	0	0	1
	BOOEC01	BOTTOMING OEC UNITS	0	0	0	0	0	0	4	4	0	0	0	0	4
	BROEC01	BRINE OEC UNITS	0	0	0	0	0	0	2	2	0	0	0	0	2
	WWP01	WASTE WATER PUMP	0	0	0	0	0	0	1	0	0	0	0	0	2
	MR01	MACHINERY ROOM	0	0	0	0	0	0	1	0	0	0	0	0	1
	SG01	SWITCHGEAR	0	0	0	0	0	0	0	6	0	0	0	0	3
	WN01	WELL NOISE (GENERAL)	1	1	1	1	1	1	0	0	1	1	1	0	0
	SN01	SUBSTATION NOISE (GENERAL)	0	0	0	0	0	0	0	0	0	0	0	1	0
	CTC01	COOLING TOWERS / CONDENSERS	0	0	0	0	0	0	84	84	0	0	0	0	16

Table 2.10 Construction and Operational Assessment Scenario (COASc01)

	Plant and/or Equipment		**Project Area**													
Stage	**ID**	**Description**	**NIL1**	**NIL2**	**NIL3**	**WJ-R1**	**WJ-R2**	**WJP-1**	**NIL P/S 1**	**NIL P/S 2**	**SIL1**	**SIL2**	**SIL3**	**PLN Sub**	**SIL P/S**
Construction	D01	DOZER (CAT D10 OR SIMILAR)	0	0	0	0	0	0	1	0	0	0	0	0	0
	G01	MOTOR GRADER (CAT 120G)	0	0	0	0	0	0	0	1	0	0	0	0	0
	DT01	DUMP TRUCK (E.G. 30-40 TON)	0	0	0	0	0	0	1	0	0	0	0	0	0
	PL01	PAY-LOADER (CAT 966)	0	0	0	0	0	0	0	1	0	0	0	0	0
	BH01	BACKHOE (CAT 416)	0	0	0	0	0	0	1	0	0	0	0	0	0
	C01	CRANE (E.G. 250 TON)	0	0	0	0	0	0	0	1	0	0	0	0	0
	C02	MOBILE CRANE (125 TON)	0	0	0	0	0	0	1	0	0	0	0	0	0
	C03	MOBILE CRANE (E.G. 60 TON)	0	0	0	0	0	0	0	1	0	0	0	0	0
	FL01	FORKLIFT (E.G. 5T)	0	0	0	0	0	0	1	0	0	0	0	0	0
	HBTT01	HIGH BED TRAILER TRUCK (E.G. 40-FOOT)	0	0	0	0	0	0	0	1	0	0	0	0	0
	FBT01	FLAT-BED TRUCK (E.G. 24 TON)	0	0	0	0	0	0	1	0	0	0	0	0	0
	WC01	WELL CONSTRUCTION (GENERAL)	1	1	1	1	1	1	0	0	0	0	0	0	0
	GC01	CONSTRUCTION NOISE (GENERAL)	1	1	1	1	1	1	1	1	0	0	0	0	0
Operations	ST01	BACK PRESSURE STEAM TURBINE	0	0	0	0	0	0	0	0	0	0	0	0	1
	BOOEC01	BOTTOMING OEC UNITS	0	0	0	0	0	0	0	0	0	0	0	0	4
	BROEC01	BRINE OEC UNITS	0	0	0	0	0	0	0	0	0	0	0	0	2
	WWP01	WASTE WATER PUMP	0	0	0	0	0	0	0	0	0	0	0	0	2
	MR01	MACHINERY ROOM	0	0	0	0	0	0	0	0	0	0	0	0	1
	SG01	SWITCHGEAR	0	0	0	0	0	0	0	0	0	0	0	0	3
	WN01	WELL NOISE (GENERAL)	0	0		0	0	0	0	0	1	1	1	0	0
	SN01	SUBSTATION NOISE (GENERAL)	0	0	0	0	0	0	0	0	0	0	0	1	0
	CTC01	COOLING TOWERS / CONDENSERS	0	0	0	0	0	0	0	0	0	0	0	0	16

2.6.2 Sound Power Level Data

Sound Power Level (LW) is used for the purposes of noise modelling. It is a measure of the total power radiated by a source. The LW value of a source is a fundamental property of the source and is independent of the surrounding environment. LW data differs from a **Sound Pressure Level (LP)**. LP is the level of sound pressure; as measured at a distance by a standard sound level meter with a microphone. This differs from LW in that this is the received sound as opposed to the sound 'intensity' at the source.

The LW data (point and moving point sources in 1/1 octaves) for each noise emission sources described in *Table 2.5* to *Table 2.8* are presented below in *Table 2.11*.

It should be noted that ERM has used a "moving point source" to represent project vehicle movements on the local area road network, all other noise emission sources are represented by point sources.

Table 2.11 Noise Emission LW Data for Noise Modelling

Stage	Plant and/or Equipment		Frequency, Hz & Sound Power Level, dB(A)									
Stage	**ID**	**Description**	**31.0**	**63.0**	**125.0**	**250.0**	**500.0**	**1000.0**	**2000.0**	**4000.0**	**8000.0**	**Lw, total**
Construction, Drilling, Steam Blowing and Transmission Line Construction+	D01	DOZER (CAT D10 OR SIMILAR)	66.0	90.0	99.0	93.0	103.1	105.0	104.0	94.0	88.0	**110**
	G01	MOTOR GRADER (CAT 120G)	77.7	85.7	87.4	88.7	94.3	103.4	100.9	93.4	81.3	**106**
	DT01	DUMP TRUCK (E.G. 30-40 TON)	60.9	76.9	94.1	94.5	102.8	102.4	99.1	89.4	79.7	**107**
	PL01	PAY-LOADER (CAT 966)	68.4	92.4	99.9	93.4	98.0	99.4	98.2	90.3	80.2	**106**
	BH01	BACKHOE (CAT 416)	60.0	84.0	98.0	96.0	101.1	101.0	100.0	89.0	81.0	**107**
	C01	CRANE (E.G. 250 TON)	70.9	81.0	107.6	98.7	100.0	104.4	103.8	98.8	90.6	**111**
	C02	MOBILE CRANE (125 TON)	67.4	83.4	97.3	96.7	103.7	103.1	101.5	95.0	90.0	**109**
	C03	MOBILE CRANE (E.G. 60 TON)	64.4	80.4	94.3	93.7	100.7	100.1	98.5	92.0	87.0	**106**
	FL01	FORKLIFT (E.G. 5T)	64.0	88.0	94.0	101.0	103.0	105.0	104.0	98.0	94.0	**110**
	HBTT01	HIGH BED TRAILER TRUCK (E.G. 40-FOOT)	64.0	88.0	94.0	97.0	103.1	106.0	104.0	96.0	83.0	**110**
	FBT01	FLAT-BED TRUCK (E.G. 24 TON)	57.0	81.0	95.0	94.0	98.1	101.0	100.0	91.0	76.0	**106**
	GC01	CONSTRUCTION NOISE (GENERAL)	65.9	86.0	90.5	100.8	100.7	104.3	102.1	95.6	87.2	**109**
	DR01	DRILL RIG	62.0	86.0	101.0	112.0	112.1	112.0	112.0	103.0	95.0	**118**
	SB01	STEAM BLOWING TEST	77.0	101.0	101.0	101.0	101.0	102.0	102.0	101.0	100.0	**110**
Operations	ST01[1]	BACK PRESSURE STEAM TURBINE	49.0	73.0	79.0	85.0	88.0	86.0	85.0	83.0	80.0	**93**
	BOOEC01[1]	BOTTOMING OEC UNITS	49.0	73.0	78.0	83.0	88.0	89.0	85.0	79.0	71.0	**93**
	BROEC01[1]	BRINE OEC UNITS	54.0	78.0	84.0	81.0	87.0	88.0	86.0	78.0	58.0	**93**
	WWP01[1]	WASTE WATER PUMP	50.6	70.8	75.9	85.4	85.8	89.0	87.2	81.0	71.9	**93**
	MR01	MACHINERY ROOM	55.2	79.8	77.8	81.3	82.4	75.9	79.2	71.7	61.1	**88**
	SG01[1]	SWITCHGEAR	61.6	75.3	82.5	89.7	86.2	84.4	82.6	75.6	65.4	**93**
	WN01[1]	WELL NOISE (GENERAL)	58.5	80.8	85.1	81.1	86.3	84.8	85.9	81.4	72.3	**93**
	SN01	SUBSTATION NOISE (GENERAL)	55.6	69.3	76.5	83.7	80.2	78.4	76.6	69.6	59.4	**87**
	CTC01	COOLING TOWERS / CONDENSERS	35.0	59.0	76.0	67.0	74.0	75.0	69.0	71.0	63.0	**81**
General	GVN01+	GENERAL PROJECT VEHICLE NOISE (MOVING POINT SOURCE)	45.9	61.9	79.1	79.5	87.8	87.4	84.1	74.4	64.7	**92**

1. LW estimated as per SOL Noise Specification, all other LW values are sourced from ERM database.

3 PREDICTED NOISE LEVELS

This section presents the resultant noise levels predicted via 3D modelling and comparison to the project-specific noise criteria, any exceedances are highlighted in **bold** typeset. All data inputs presented in *Section 2*of this noise impact assessment report were relied upon for the purposes of this modelling.

3.1 CONSTRUCTION NOISE

Predicted construction noise levels are presented in *Table 3.1* to *Table 3.4* below.

Table 3.1 Construction Assessment Scenario (CASc01)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
ID	**Description**	**LAeq, 1hr dB(A)**	**Daytime 07:00 – 22:00**	**Night-time 22:00 – 07:00**
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	31	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	33	55	45
R7	Hutajulu	42	55	45
R8	Simataniari	41	55	45
R9	Onanhasang	36	55	45
R10	Lumbanjaean	30	55	45
R11	Sibaganding	30	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	39	55	45
R20	Pandahanan Sira	42	55	45
R21	Sampil	32	55	45
R22	Sigurung-gurung	**47**	55	45
R23	Silangkitang	44	55	45
R24	Pagaran	36	55	45
R25	Pargaulan	36	55	45
R26	Gunungtua	39	55	45
R27	Rantopanjang	38	55	45
R28	Siriaria	35	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	33	55	45

Table 3.2 Construction Assessment Scenario (CASc02)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
ID	**Description**	**LAeq, 1hr dB(A)**	**Daytime 07:00 – 22:00**	**Night-time 22:00 – 07:00**
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	33	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	33	55	45
R7	Hutajulu	**46**	55	45
R8	Simataniari	44	55	45
R9	Onanhasang	37	55	45
R10	Lumbanjaean	31	55	45
R11	Sibaganding	32	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	39	55	45
R20	Pandahanan Sira	43	55	45
R21	Sampil	32	55	45
R22	Sigurung-gurung	**52**	55	45
R23	Silangkitang	**47**	55	45
R24	Pagaran	40	55	45
R25	Pargaulan	41	55	45
R26	Gunungtua	**48**	55	45
R27	Rantopanjang	**47**	55	45
R28	Siriaria	39	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	37	55	45
R31	Hariara	35	55	45
R32	Sihobuk	36	55	45

Table 3.3 Construction Assessment Scenario (CASc03)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
ID	**Description**	**LAeq, 1hr dB(A)**	**Daytime 07:00 – 22:00**	**Night-time 22:00 – 07:00**
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	33	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	33	55	45
R7	Hutajulu	43	55	45
R8	Simataniari	42	55	45
R9	Onanhasang	37	55	45
R10	Lumbanjaean	30	55	45
R11	Sibaganding	31	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	39	55	45
R20	Pandahanan Sira	42	55	45
R21	Sampil	32	55	45
R22	Sigurung-gurung	**49**	55	45
R23	Silangkitang	45	55	45
R24	Pagaran	39	55	45
R25	Pargaulan	39	55	45
R26	Gunungtua	43	55	45
R27	Rantopanjang	42	55	45
R28	Siriaria	38	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	34	55	45
R31	Hariara	30	55	45
R32	Sihobuk	34	55	45

Table 3.4 Construction Assessment Scenario (CASc04)

Noise Receptor		**Predicted Project Noise Level**	**Project Specific Noise Criteria**	
ID	**Description**	**LAeq, 1hr dB(A)**	**Daytime 07:00 – 22:00**	**Night-time 22:00 – 07:00**
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	31	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	36	55	45
R7	Hutajulu	**54**	55	45
R8	Simataniari	44	55	45
R9	Onanhasang	39	55	45
R10	Lumbanjaean	34	55	45
R11	Sibaganding	36	55	45
R12	Lumbang garoga	41	55	45
R13	Simanam pang	**51**	55	45
R14	Lobupining	33	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	33	55	45
R20	Pandahanan Sira	37	55	45
R21	Sampil	30	55	45
R22	Sigurung-gurung	47	55	45
R23	Silangkitang	42	55	45
R24	Pagaran	37	55	45
R25	Pargaulan	37	55	45
R26	Gunungtua	39	55	45
R27	Rantopanjang	39	55	45
R28	Siriaria	36	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	33	55	45

3.2 *OPERATIONAL NOISE*

Predicted operational noise levels are presented in *Table 3.5*.

Table 3.5 Operational Assessment Scenario (OASc01)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
			Daytime 07:00 – 22:00	**Night-time 22:00 – 07:00**
ID	**Description**	**LAeq, 1hr dB(A)**		
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	<30	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	<30	55	45
R7	Hutajulu	30	55	45
R8	Simataniari	30	55	45
R9	Onanhasang	<30	55	45
R10	Lumbanjaean	<30	55	45
R11	Sibaganding	<30	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	<30	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	<30	55	45
R20	Pandahanan Sira	<30	55	45
R21	Sampil	<30	55	45
R22	Sigurung-gurung	34	55	45
R23	Silangkitang	32	55	45
R24	Pagaran	<30	55	45
R25	Pargaulan	<30	55	45
R26	Gunungtua	<30	55	45
R27	Rantopanjang	<30	55	45
R28	Siriaria	<30	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	<30	55	45

3.3 COMBINED CONSTRUCTION AND OPERATIONAL NOISE

Predicted construction and operational noise levels are presented in *Table 3.6*.

Table 3.6 Construction and Operational Assessment Scenario (COASc01)

Noise Receptor		Predicted Project Noise Level	Project Specific Noise Criteria	
			Daytime 07:00 – 22:00	**Night-time 22:00 – 07:00**
ID	**Description**	**LAeq, 1hr dB(A)**		
R1	Sibatu-batu	<30	55	45
R2	Siparpar	<30	55	45
R3	Peanor-nor	<30	55	45
R4	Pantis	<30	55	45
R5	Siantolung	<30	55	45
R6	Aek Sitapean	<30	55	45
R7	Hutajulu	41	55	45
R8	Simataniari	41	55	45
R9	Onanhasang	32	55	45
R10	Lumbanjaean	<30	55	45
R11	Sibaganding	30	55	45
R12	Lumbang garoga	<30	55	45
R13	Simanam pang	<30	55	45
R14	Lobupining	<30	55	45
R15	T. Pindua	<30	55	45
R16	Sigompulan 1	<30	55	45
R17	Simardangilang	<30	55	45
R18	Sigompulan 2	<30	55	45
R19	Sitotuama	<30	55	45
R20	Pandahanan Sira	<30	55	45
R21	Sampil	<30	55	45
R22	Sigurung-gurung	34	55	45
R23	Silangkitang	32	55	45
R24	Pagaran	<30	55	45
R25	Pargaulan	<30	55	45
R26	Gunungtua	<30	55	45
R27	Rantopanjang	<30	55	45
R28	Siriaria	<30	55	45
R29	Huta Simarpinggan	<30	55	45
R30	Huta Bagot	<30	55	45
R31	Hariara	<30	55	45
R32	Sihobuk	<30	55	45

3.4 DISCUSSION

The resultant noise levels presented above are summarised below, with due regard to the processed outlined for evaluating impact significance presented in previously *Section 2.3* of this noise impact assessment report, and reproduced below in *Table 3.7*.

Table 3.7 Noise Impact Significance Terminology

Impact Parameter		Impact Significance - Daytime or Night-time			
		Negligible	Minor	Moderate	Major
Disturbance Impact: Project Noise Level (PNL), **LAeq,1hr dB**	Daytime[1]	<50	50-55	>55-60	>60
	Night time[2]	<40	40-45	>45-50	>50
Amenity Impact **Daytime or Night-time** LAeq, PNL – LA90,ABL dB		<5	5-10	>10-15	>15

1. Daytime: 07:00 to 22:00; and
2. Night time: 22:00 to 07:00.

3.4.1 *Disturbance Impacts*

- General construction noise levels (*Construction Assessment Scenario (CASc01))* are below the project specific noise criteria at the majority of noise receptors. *Negligible* impacts are predicted for the daytime period. *Moderate* impacts are predicted during the night time period for a very limited number of noise receptors (one location) located in near proximity to areas of potential project noise emission;

- General construction noise levels including well drilling activities (*Construction Assessment Scenario (CASc02))* are typically below the project specific noise criteria at the majority of noise receptors. *Negligible* or *Minor* impacts are predicted for the daytime period. *Moderate* and *Major* impacts are predicted for a limited number of noise receptors (five locations: one *Major*; four *Moderate*) located in near proximity to area of potential project noise emission;

- General construction noise levels including steam blowing activities (*Construction Assessment Scenario (CASc03))* are below the project specific noise criteria at the majority of noise receptors. *Negligible* or *Minor* impacts are predicted for the daytime period. *Moderate* impacts are predicted during the night time period for a very limited number of noise receptors (one location) located in near proximity to area of potential project noise emission;

- General construction noise levels including transmission line activities (*Construction Assessment Scenario (CASc04))* are below the project specific noise criteria at the majority of noise receptors. *Negligible* or minor impacts are predicted for the daytime period. *Major* impacts are predicted during the night time period for a limited number of noise receptors (two locations) located in near proximity to area of potential project noise emission;

- Operational noise levels (*Operational Assessment Scenario (OASc01))* are predicted to be below the project specific noise criteria at all noise receptors. *Negligible* impacts are predicted for both the daytime and night time periods; and

- Combined construction and operational noise levels (*Construction and Operational Assessment Scenario (COASc01)*) are predicted to be below the project specific noise criteria at all noise receptors. *Negligible* impacts are predicted for both the daytime and night time periods.

3.4.2 *Amenity Impacts*

As stated in *Section 2.3.2*, 41 dB(A) is adopted here to represent an approximate Assessment Background Level (ABL) for all receptors during both daytime and night time periods. Thus a permissible level of 44 dB(A) was specified for this project in accordance with *IFC 1.7 Noise*.

To provide comparison to this supplementary criterion the previously predicted noise levels ($L_{Aeq, 1hr}$) must first be converted from the L_{Aeq} parameter (which represents ambient or average noise levels) to the L_{A90} parameter (which represents background or constant noise levels). To do this ERM has applied a 5 dB(A) reduction to predicted construction noise levels, which are typically dynamic in nature and a 3 dB(A) reduction to operational noise levels, which are typically constant in nature.

Doing this results in maximum construction noise levels of between 44 dB(A) (general construction) and 51 dB(A) (transmission line works) indicating a temporary increase in background noise levels. Maximum operational noise levels of 31 dB(A) indicating no increase in background noise level and maximum combined construction and operational noise level 38 dB(A) also indicating no increase in background noise levels.

These temporary noise level increases during representative worst-case construction works noted here are consistent with the findings of the disturbance impacts assessment, which associated exceedances during the works to the closest and/or potentially most affected noise receptors in near proximity to works.

4 *RECOMMENDATIONS*

This section presents any recommendations based on the findings of the noise impact assessment.

4.1 *OPERATIONAL NOISE*

ERM makes no further recommendations for noise control mitigation, management measures or monitoring options to those already scheduled for the project or incorporated into the design plans.

4.2 *CONSTRUCTION NOISE*

Based on the limited number of exceedances and temporary increase in background noise levels, assessed in accordance with *IFC 1.7 Noise*, it is recommended that:

- High noise level generating construction works (including drilling and steam blowing activities) be limited to the daytime (07:00 to 22:00) period, if they are to be undertaken in near proximity to noise receptors;
- Prior to construction and during design of the construction methodology, equipment with lower sound power levels than those specified in this report are selected. This may extend to include the installation of silencers for fans, suitable mufflers on engine exhausts and compressor components if considred a more achievable approach to reducing nosie emissions;
- Installing acoustic barriers/screens or utiising site objects or topography to block direct line of site between high noise level generating activities and potentially impacted noise receptors. Where acoustic barriers or screens are preferred, they should be constructed without gaps or cracks and with a continuous minimum surface density of 10 kg/m^2 in order to minimise the transmission of sound through the barrier. Barriers should be located as close as possible to the source or to the receptor location to be effective;
- Noise sources are re-located to less sensitive areas to take advantage of distance and shielding. This may extent to siting permanent construction facilities as far away from community areas as is possible;
- Project traffic routing through community areas is reduced wherever possible; and
- The Project grievance mechanism is used to record and respond to complaints.

4.2.1 *Construction Noise Management Plan*

Detailed procedures for the management of construction noise across the project should be developed as part of the project Environmental Management System (EMS) with documented procedures included in the Construction Noise Management Plan (CNMP). These procedures should include those presented above in *Section 4.2* and may extend to inlcude general good practice requirements, such as:

- Establish permanent signage around the site e.g. At site offices, that is visible to all personnel, which identifies the need to limit noise e.g. 'please respect our neighbours and keep noise to a minimum';
- Provide relevant personnel with training in noise control procedures and equipment operation; and
- Establish a project complaints register and manage community complaints, as required.

The CNMP should include the following broad objectives:

- Manage construction in a way that minimises noise impacts to environment and neighbours, and limits interference to production; and
- To keep the local community and regulators informed of activities where required and to respond quickly and effectively to issues and complaints.

To ensure that the CNMP remains a reliable and robust noise control, mitigation and management tool, it should be regularly reviewed and updated during construction. The review of the CNMP should also coincide with any major infrastructure or procedural changes within the project site. Remedial measures should be noted in the CNMP, where required to be implemented to reduce noise impacts to levels below that of the project-specific noise criteria.

4.2.2 *Residual Construction Noise Impacts*

Following adequate implementation of the recommended noise control mitigation measures as described in this report, it is anticipated that noise levels would be reduced significantly (approximately 5 dB(A) to 10 dB(A)), and impacts, if any, should be reduced to be at a *Negligible* or *Minor* level. Development of a suitable CNMP will assist to maintain lower noise levels and where elevated levels are noted, to determine appropriate actions to mitigate the source of the emission.

5 *CONCLUSIONS*

Environmental Resources Management Pty Ltd (ERM) on behalf of SOL has completed a noise impact assessment for the SOL Project Sarulla Geothermal Plant (the Project), a 330 MW power plant at Silangkitang (SIL) and Namora I Langit (NIL) in Indonesia.

Construction and operational noise levels have been predicted utilising internationally recognised methods and compared to applicable noise criteria.

The findings of the assessment indicate compliant (below project criteria) noise levels for operational activities and aspects of the project, *Negligible* impact are anticipated. Construction noise levels are also compliant at the majority of noise receptors, but exceed the project criteria at a limited number of noise receptors during certain high noise level generating activities. These exceedances warrant noise control mitigation and management measures to be considered and ERM has provided a set of project specific recommendations.

ERM makes no further recommendations for noise control mitigation, management measures or monitoring options to those presented in this report (specific to construction), or those already incorporated into the project design.

REFERENCES

Indonesian National – **The Minister of Environment Decree No. 48 Year 1996** (Decree NO. KEP-48/MENLH/11/1996 – Regarding Noise Level Standard)

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

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

Client CAD file: **Secondary Data & Topo (Major Contour).dwg**

Client PDF: **369_Attachment 20a_7-091-C1-102-0_DEVELOPMENT PLATFORM PLAN.pdf** (refer *Annex B*)

Client PDF: **373_Attachment 20b_7-087-C1-102-0_DEVELOPMENT PLATFORM PLAN.pdf** (refer *Annex B*)

The **SOL Project Description** document, and other relevant project data, documentation and information provided by the client have been referred to for this noise impact assessment

Annex A

Acoustics Glossary

A.1 ACOUSTICS - GLOSSARY OF TERMS, DEFINITIONS AND METHODOLOGY

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[1] 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.

[1] Copyright © 2011 Oxford University Press

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 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 dB(A) are generally imperceptible in practice, an increase of 2 dB is hardly perceivable;
- differences in noise levels of around 5 dB(A) are considered to be significant;
- differences in noise levels of around 10 dB(A) 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; and

- 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; and

- **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-by's; and

- **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 each noise model of this assessment has been obtained 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 dB(A). 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;

- **dB(A)** - 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;

- **dB(C)** – unit used to measure 'A-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;

- **dB(Z) or dB(L)** – 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 90 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. The L_{90} level is often referred to as the "background" noise level and is commonly used as a basis for determining noise criteria for assessment purposes;

- **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. This is described using the L_{A90} descriptor;

- **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; and

- **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 and loss of amenity;

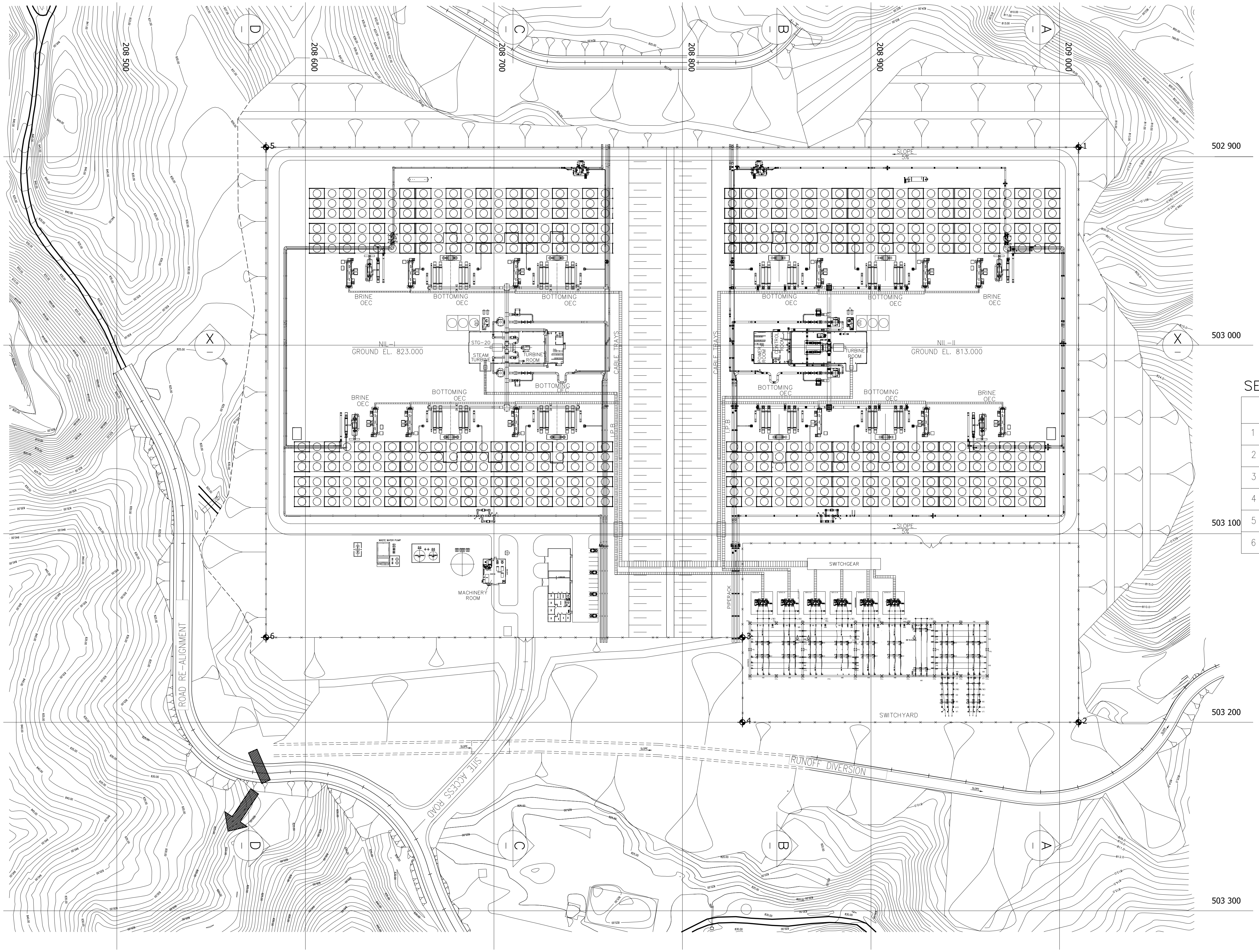
- **Noise limits** – enforceable noise levels that appear in conditions on consents and licences. The noise limits are based on achievable noise levels which the proponent has predicted can be met during the environmental assessment. Exceedance of the noise limits can result in the requirement for either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

- **Non-compliance** – development is typically deemed to be in non-compliance with its noise consent/licence conditions if the monitored noise levels exceed its statutory noise limit by more than 2 dB.

Annex B

Project Design Plans



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4	503200.00	208832.08	813.00
5	502895.00	208579.08	823.00
6	503155.00	208579.08	823.00

FOR PROPOSAL

REV	DATE	DESCRIPTION	DSGN	CHKD	APPD

EMPLOYER :
Sarulla Operations Ltd
Sarulla Operations Ltd.

PROJECT TITLE :
SARULLA NIL-I&II GEOTHERMAL POWER PLANT

CONTRACT REFERENCE NUMBER :

CONTRACTOR :
HYUNDAI ENGINEERING & CONSTRUCTION

SUPPLIER :

DESIGNED BY | DATE
CHECKED BY | DATE
APPROVED BY | DATE

TITLE :
DEVELOPMENT PLATFORM PLAN

SCALE	IDENTIFICATION	DRAWING NUMBER	REV.
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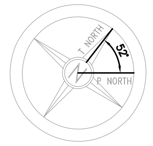
A1(841x594mm)

DWG NO. 7-087-C1-102-0



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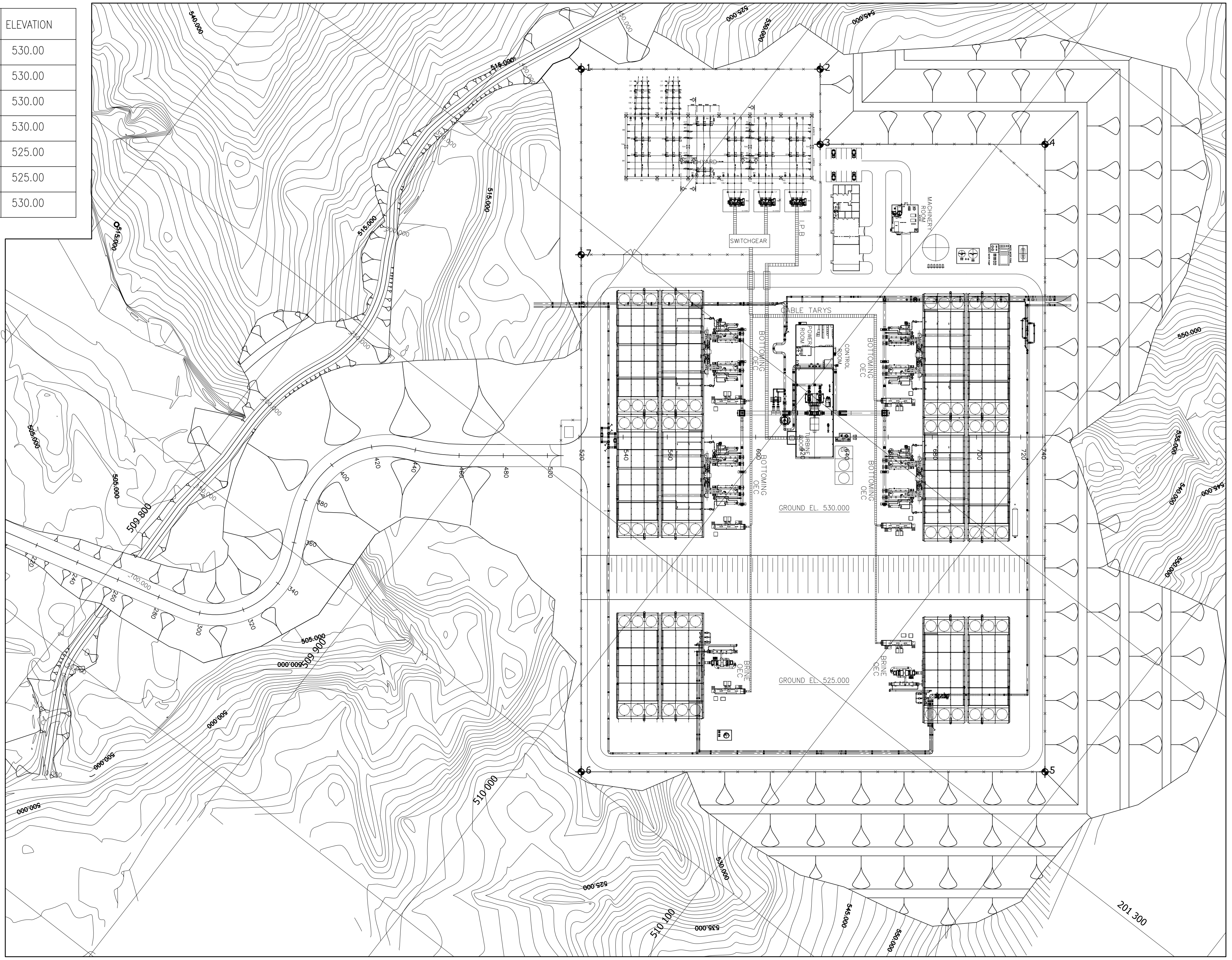


FOR PROPOSAL

REV	DATE	DESCRIPTION	DSGN	CHKD	APPD

EMPLOYER :

Sarulla Operations Ltd

Sarulla Operations Ltd.

PROJECT TITLE :

SARULLA SIL GEOTHERMAL POWER PLANT

CONTRACT REFERENCE NUMBER :

CONTRACTOR :

HYUNDAI ENGINEERING & CONSTRUCTION

SUPPLIER :

DESIGNED BY	DATE	TITLE :
CHECKED BY	DATE	DEVELOPMENT PLATFORM PLAN
APPROVED BY	DATE	

SCALE	IDENTIFICATION	DRAWING NUMBER	REV.
1/1000		7-087-C1-102-0	

A1(841x594mm)

Annex C

Model Outputs

Construction Assessment Scenario's:

01 CASc01N

02 CASc01S

03 CASc02N

04 CASc02S

05 CASc03N

06 CASc03S

07 CASc04N

08 CASc04S

Operation Assessment Scenario's:

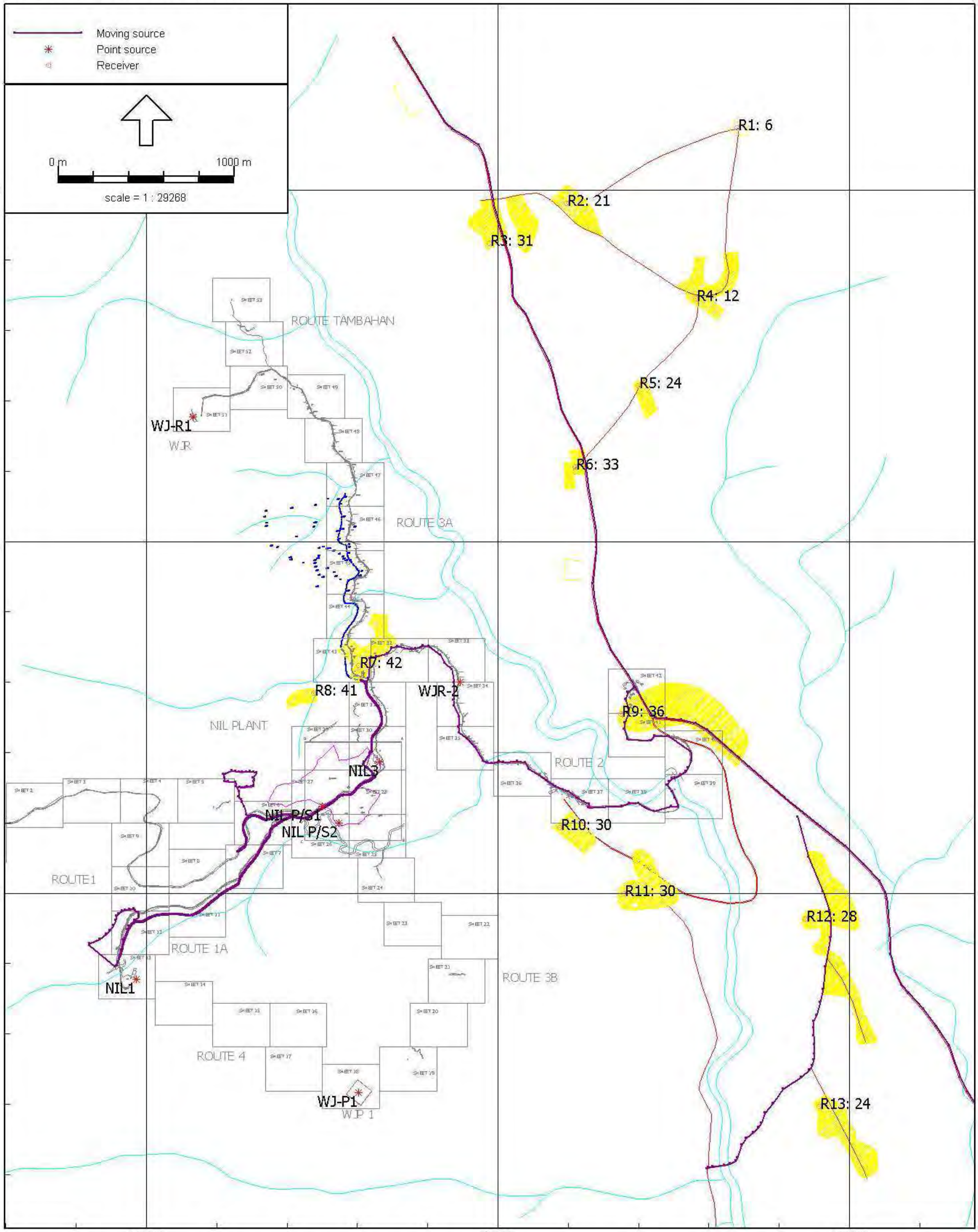
09 OASc01N

10 OASc01S

Construction & Operation Assessment Scenario's:

11 COASc01N

12 COASc01S



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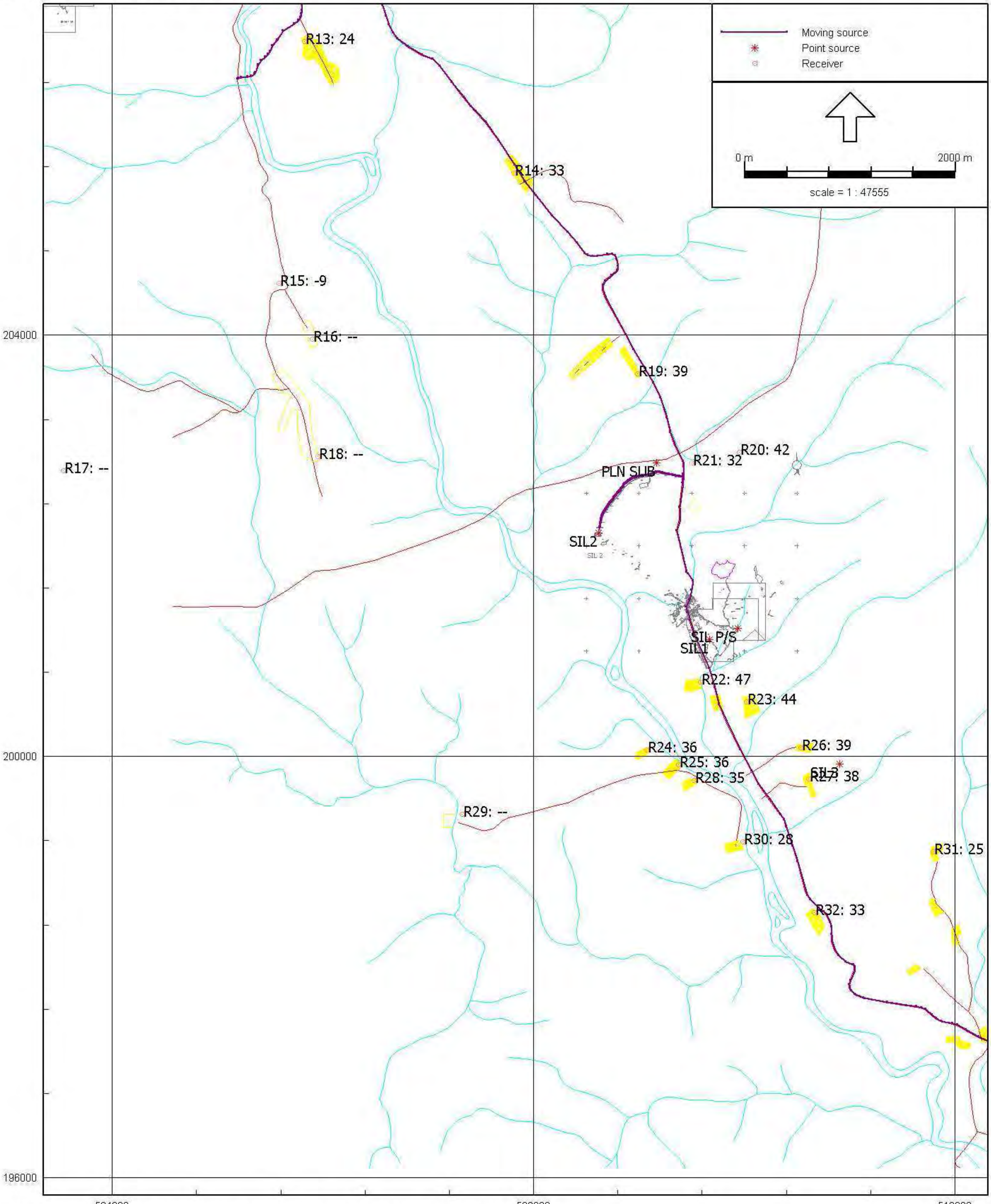

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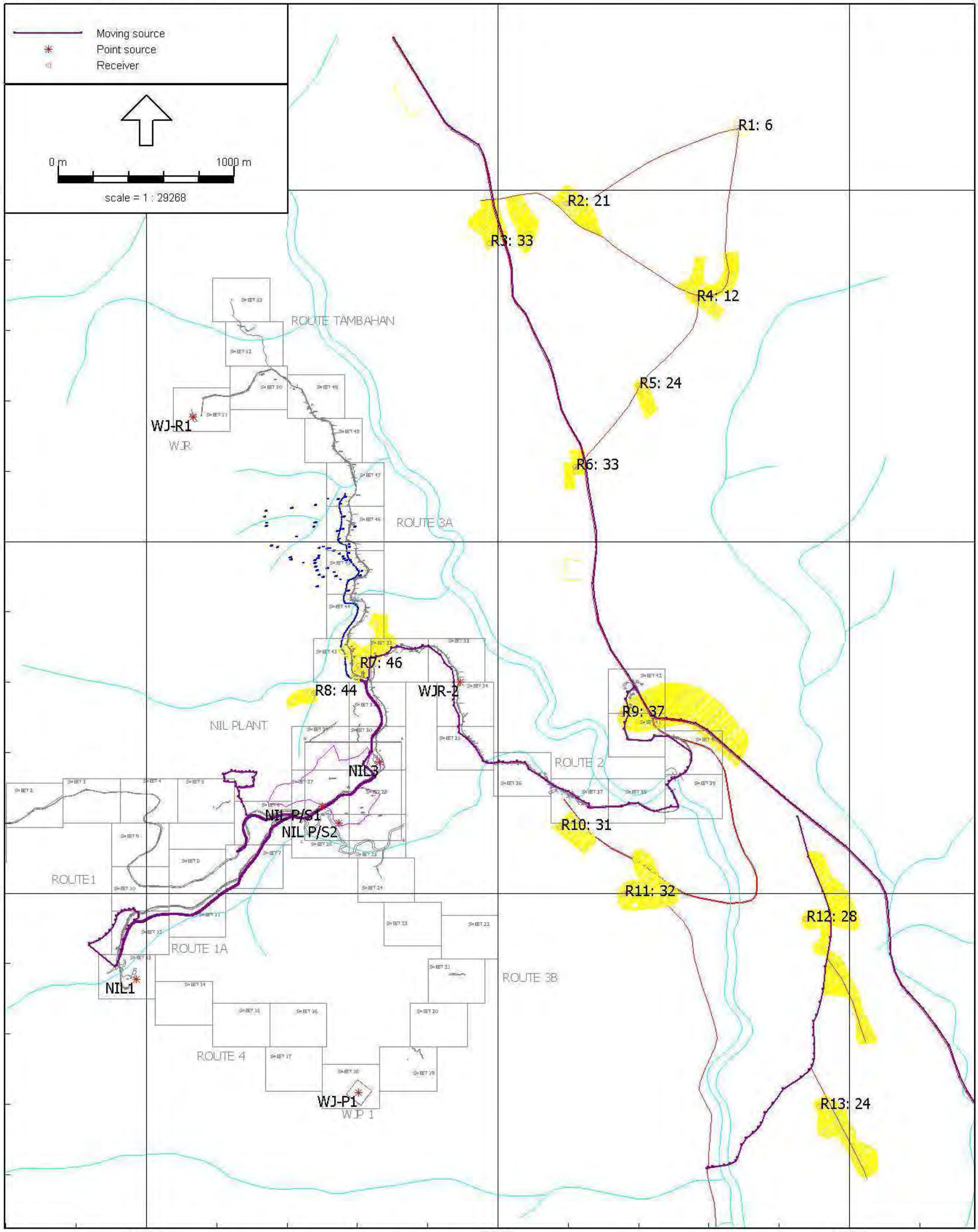

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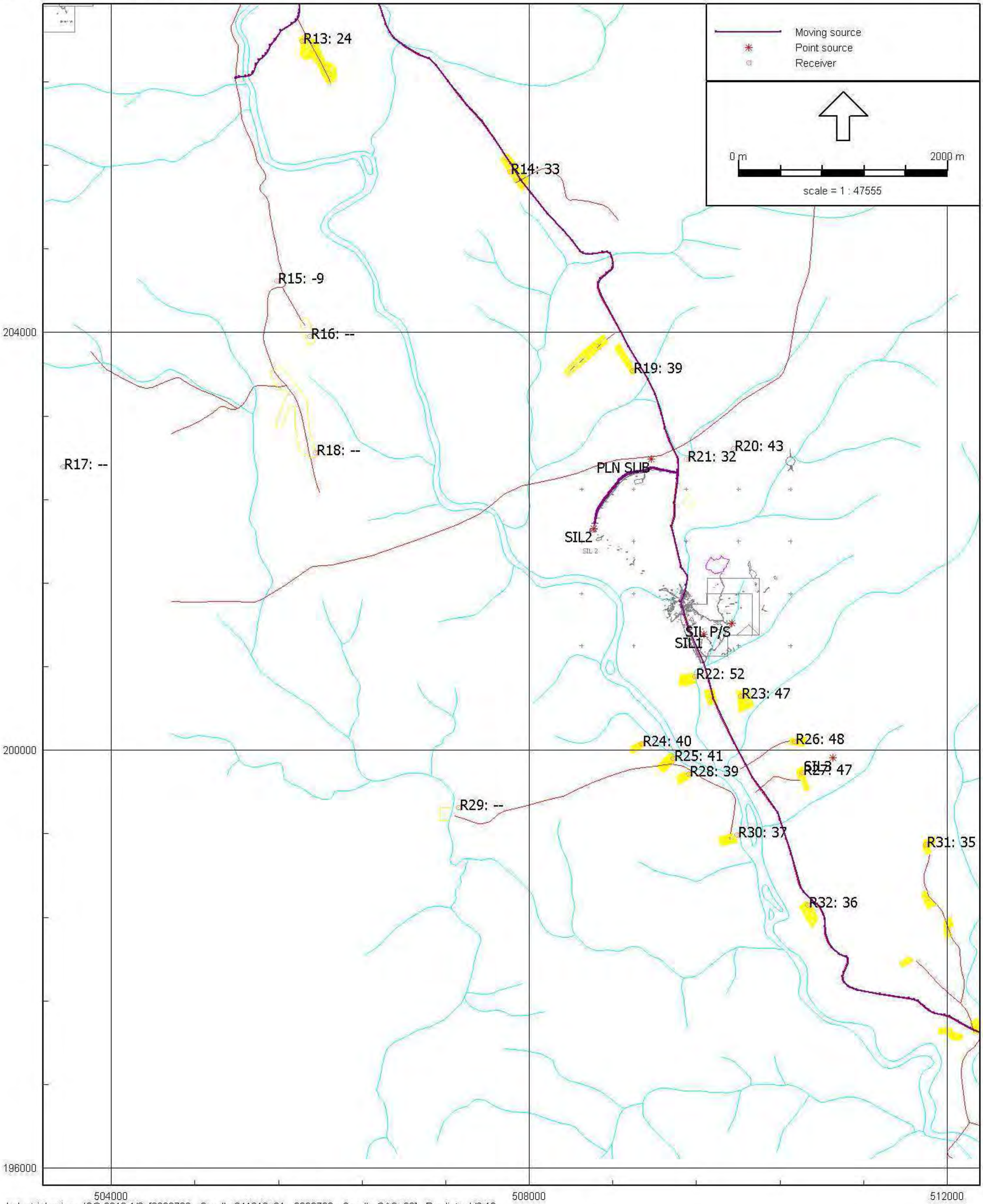

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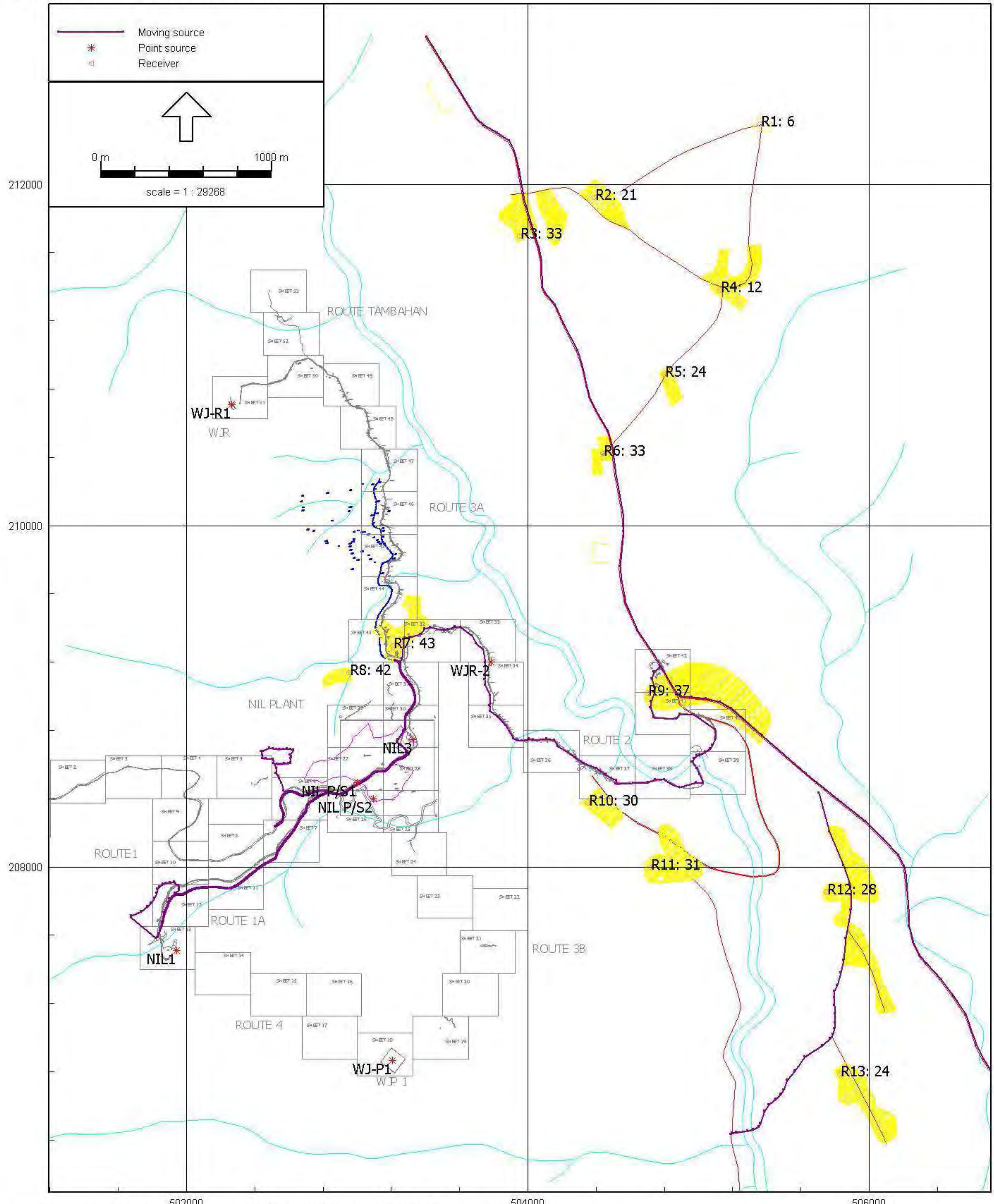

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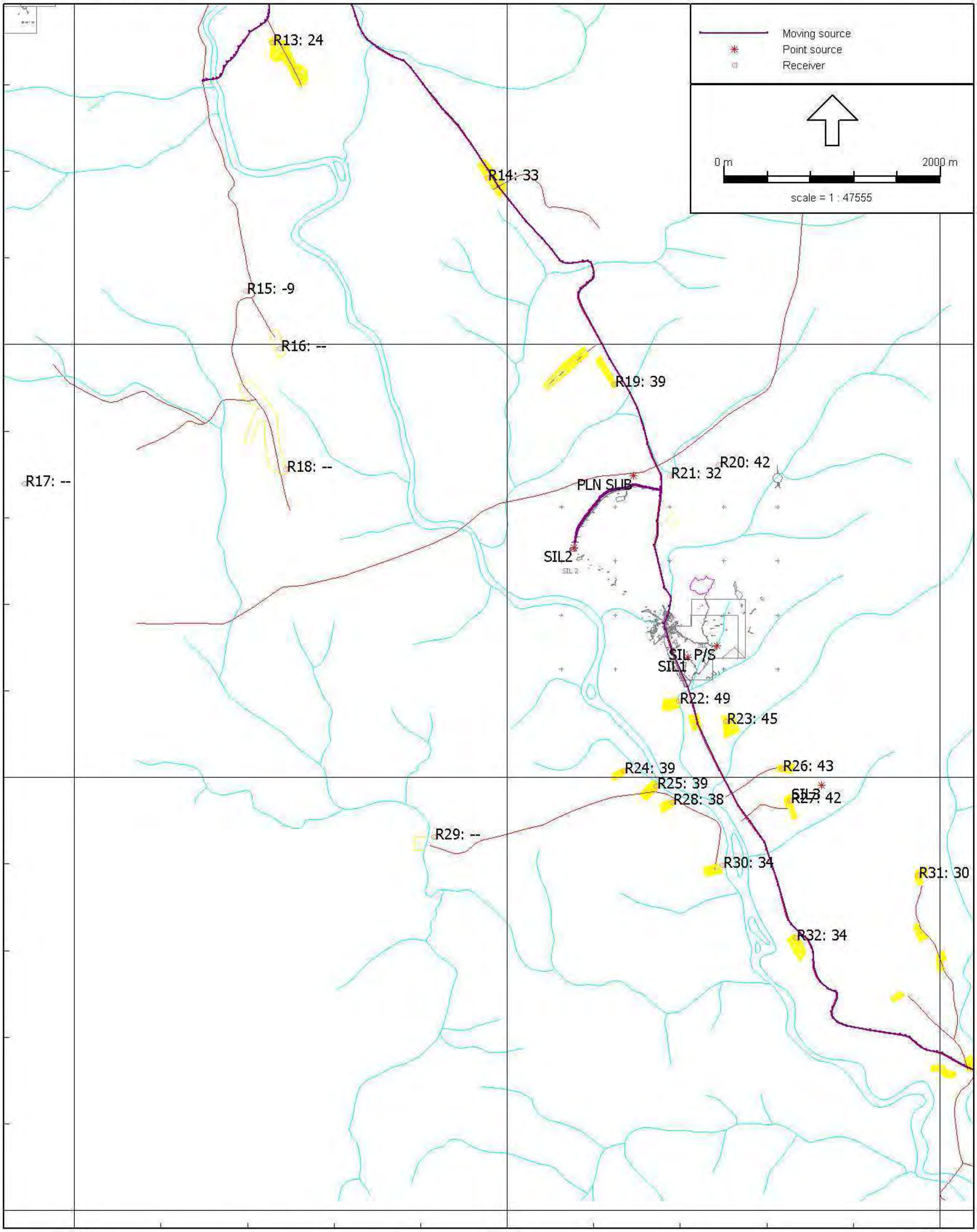

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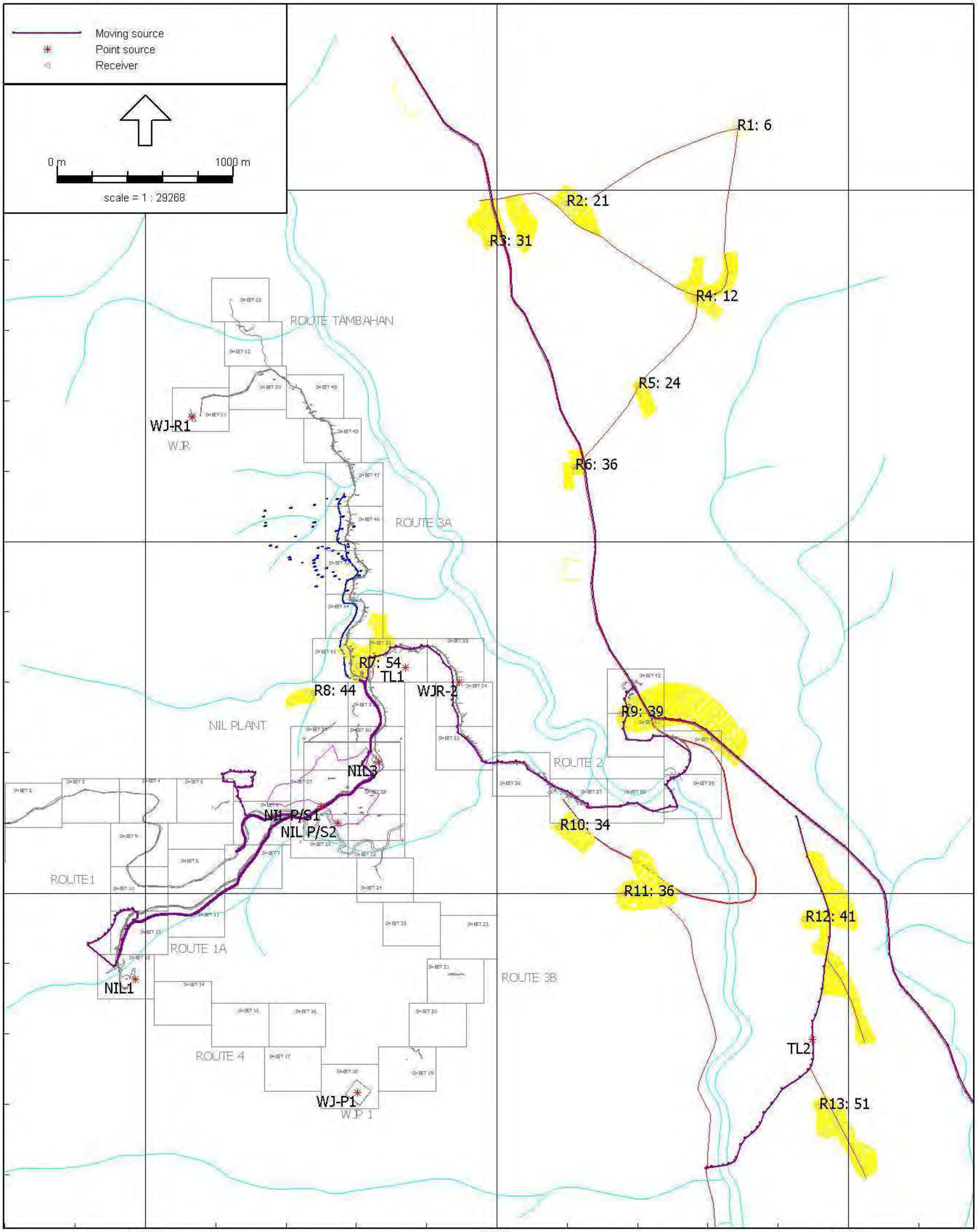

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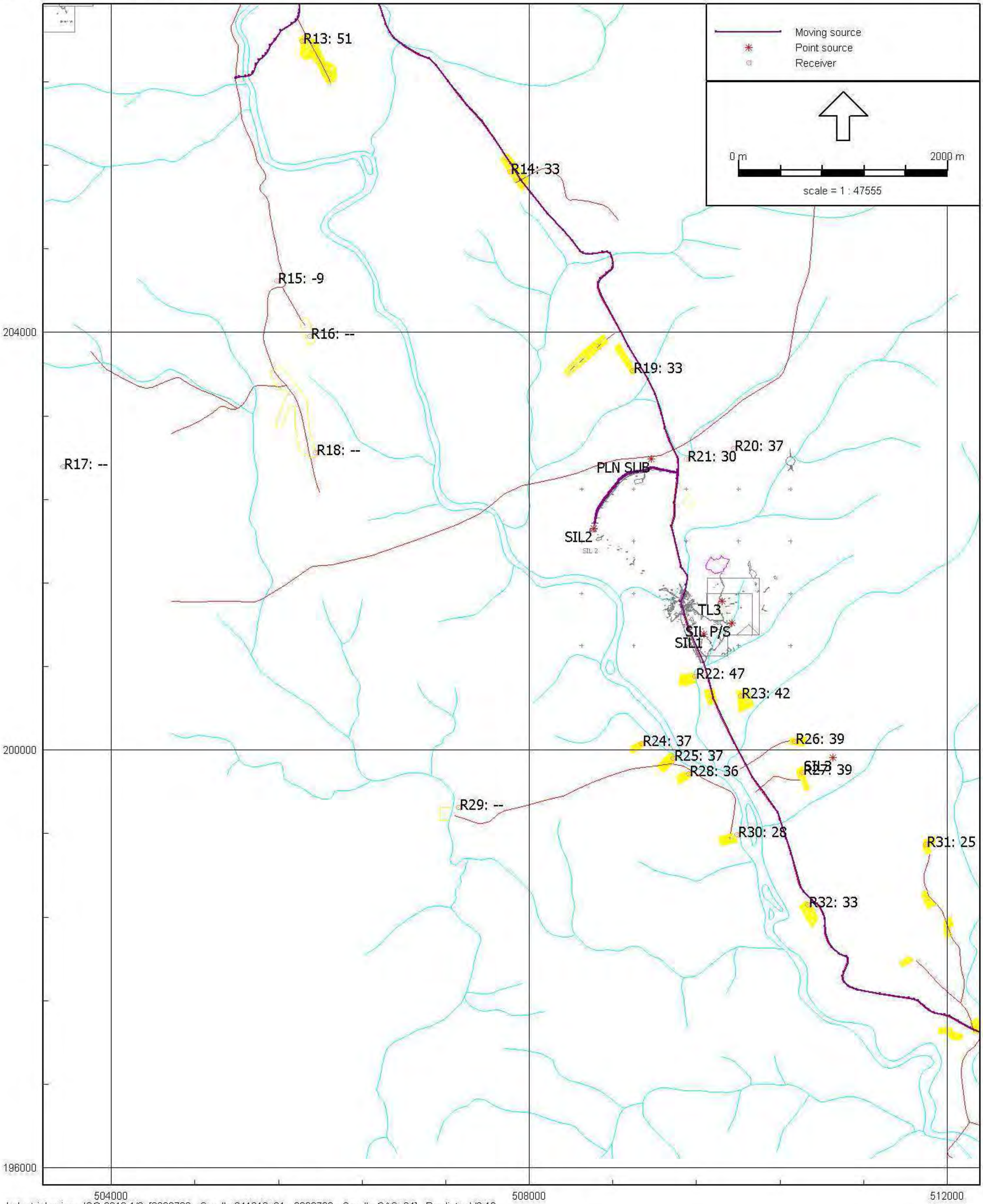

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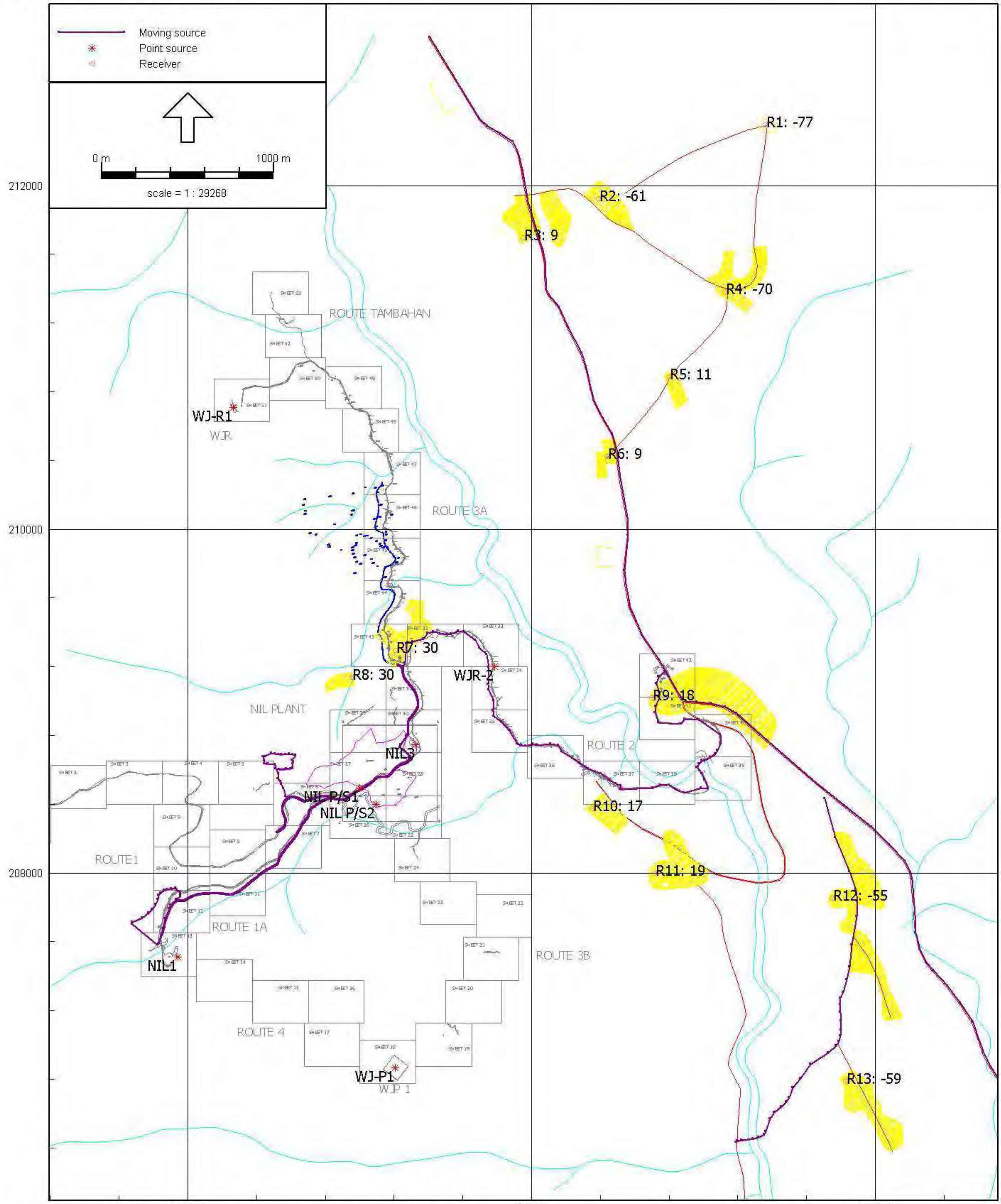
Assessment Locality SIL (Southern Locations)



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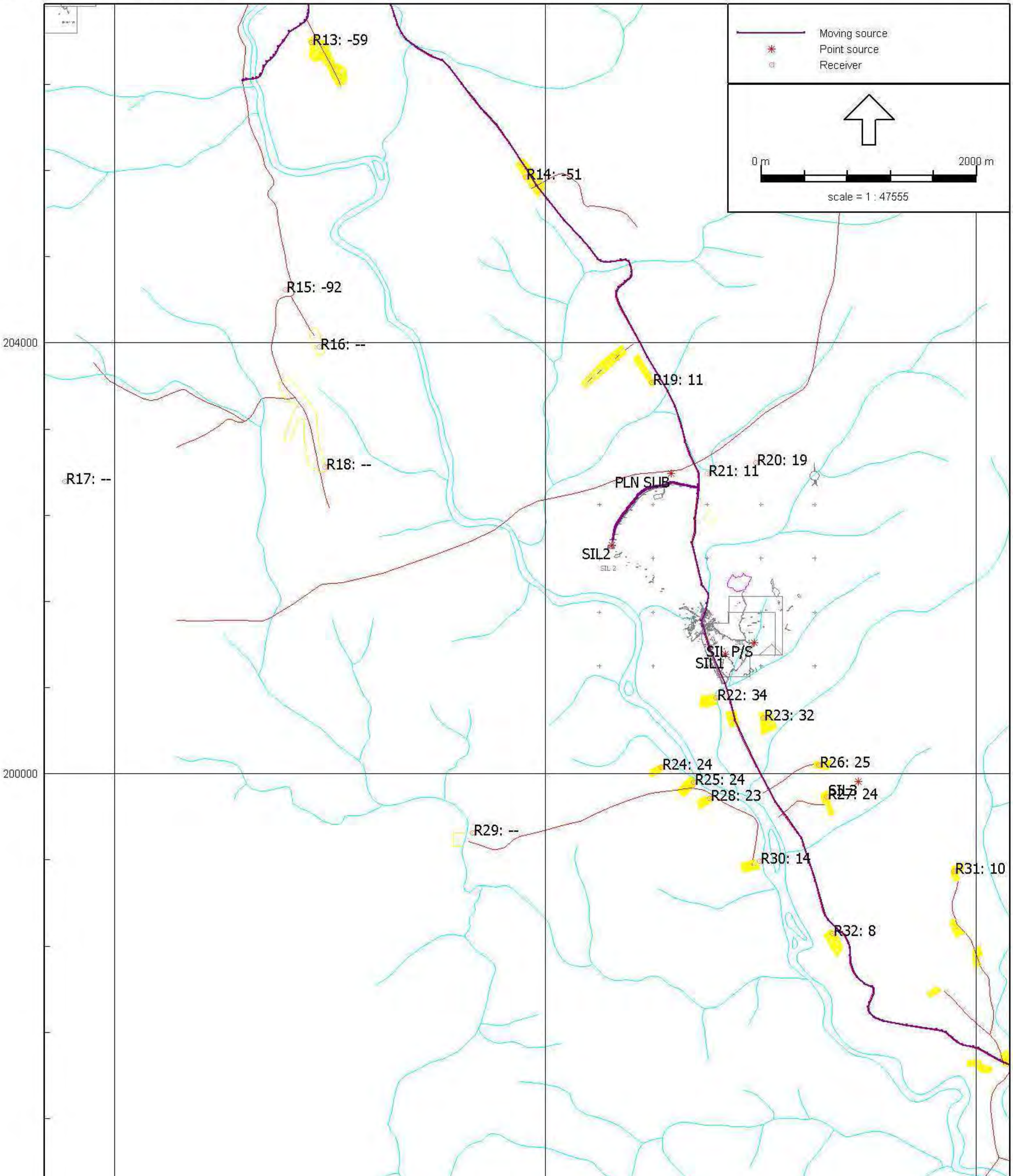
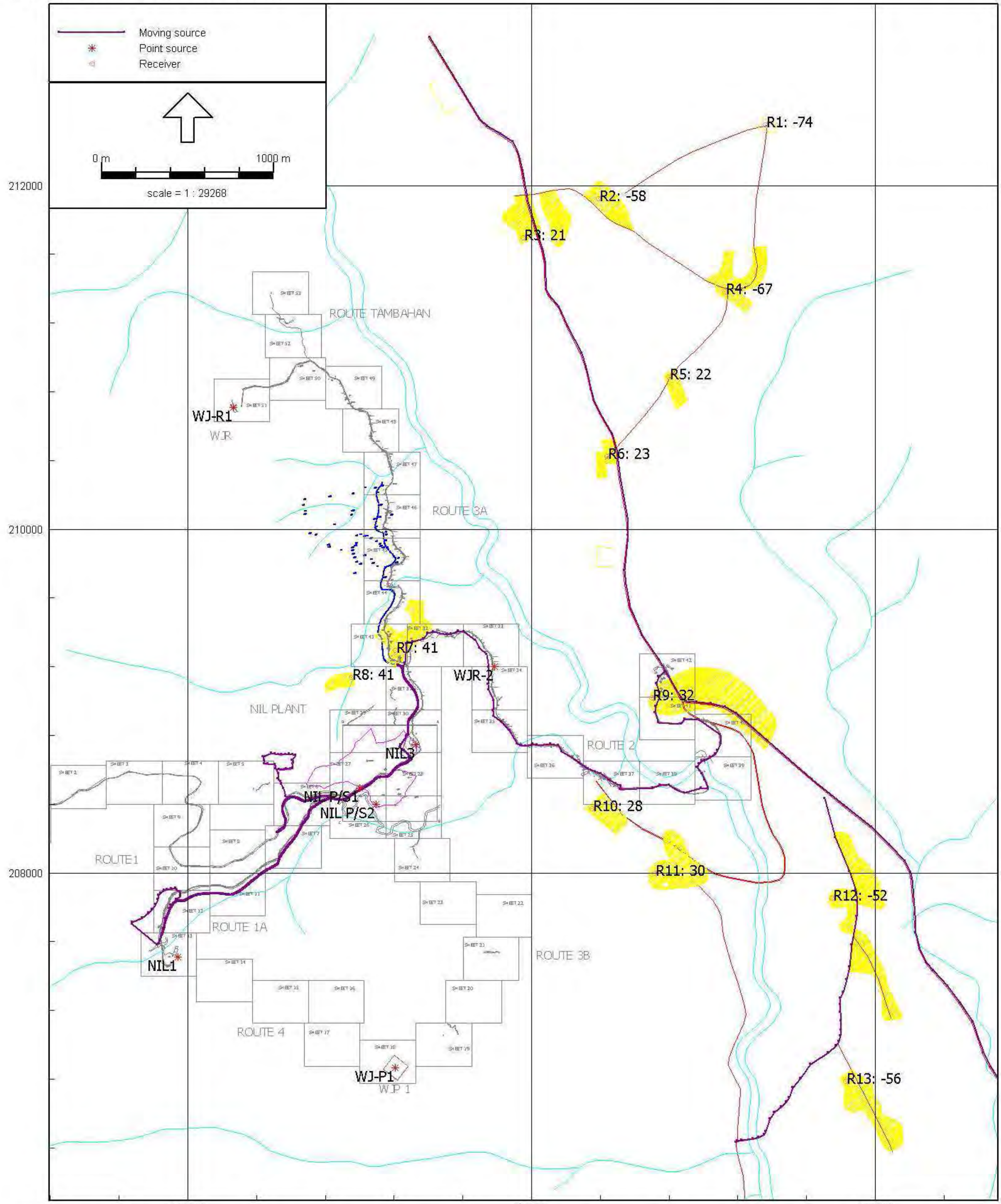


Industrial noise - ISO 9613.1/2, [0200780 - Sarulla 041013_01 - 0200780 - Sarulla OASc01] , Predictor V8.13

Assessment Locality SIL (Southern Locations)

0200780 - Sarulla Geothermal Field
and Power Plant of 330 MW Capacity

Environmental Resources Management Pty Ltd (ERM)



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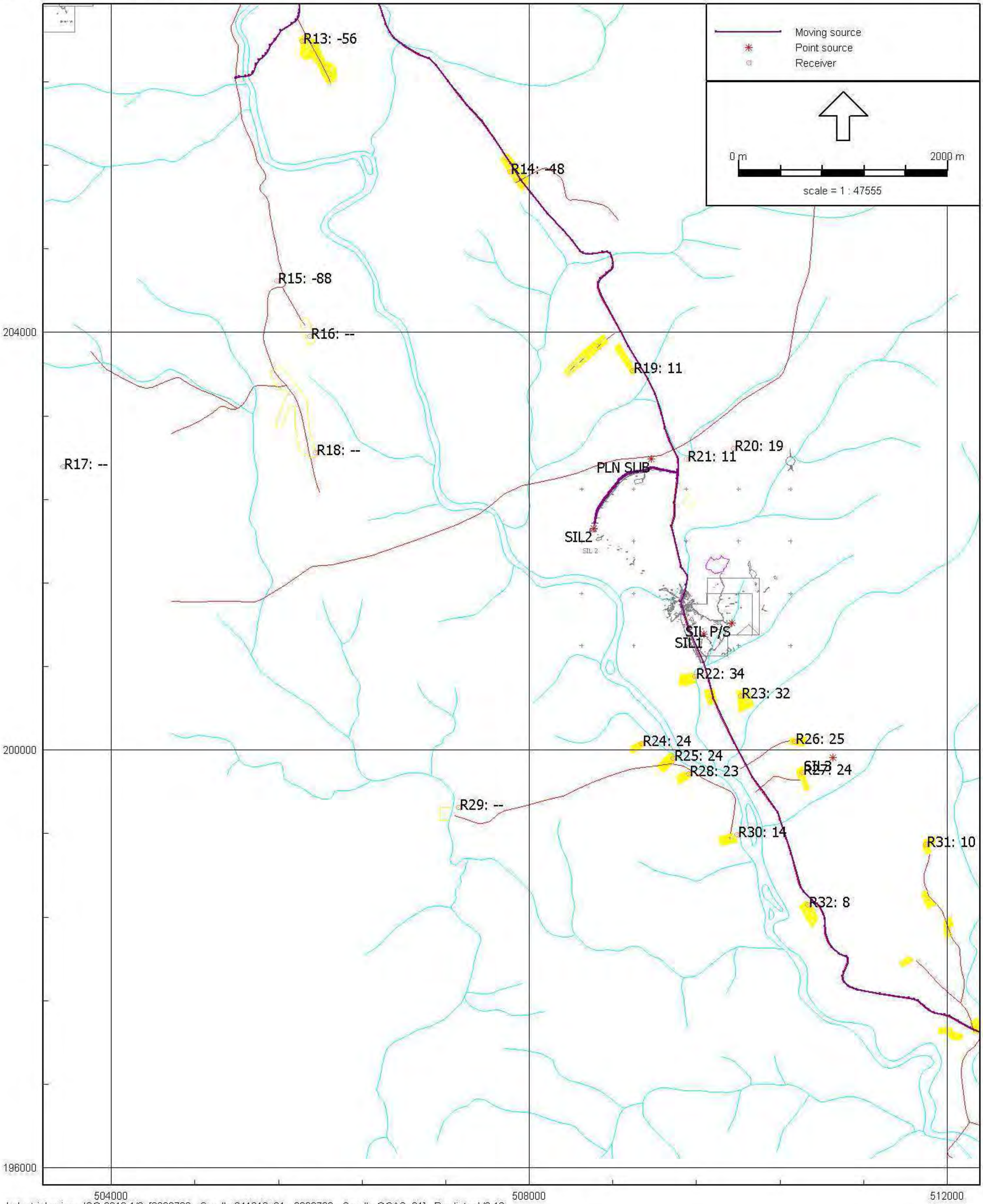

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