THE REPUBLIC OF INDONESIA
PT. PERTAMINA (PERSERO)
PT. PLN (PERSERO)

JICA PREPARATORY SURVEY FOR LUMUT BALAI GEOTHERMAL POWER PLANT DEVELOPMENT PROJECT (2)

Final Report
(Summary Report)

March 2011

JAPAN INTERNATIONAL COOPERATION AGENCY
WEST JAPAN ENGINEERING CONSULTANTS, INC.

Location of Lumut Balai Geothermal Field

(Ogan Komering Ulu District and Muaraenim District, South Sumatra Province

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1. INTRODUCTION

The Preparatory Survey is conducted to create feasibility study documents for Lumut Balai Units 3 and 4 as a condition for an ODA loan. The Executing Agency of the project will be PT. Pertamina (Persero) for steam-field development and power plant construction, and PT PLN (Persero) for transmission line and substation construction. PT. Pertamina Geothermal Energy (PT. PGE) is expected to implement the project on behalf of PT. Pertamina. The Preparatory Survey is composed of a review and assessment of the geothermal resource by reservoir simulation, programming of steam field development, conceptual design of power plants and transmission lines, an environmental study and a financial/economic assessment of the project. In addition to these studies, the current condition of production well LHD-23 in the Lahendong geothermal field is investigated as confirmation of the current status of a similar Japanese ODA loan project.

Based on this assessment of the Lumut Balai project, the Survey team formulated an implementation program for construction of the geothermal power station and associated transmission lines and substation. This Survey is to review and update the results of the previous feasibility study for realization of the Project. The survey results are summarized as follows.

2. FIELD DEVELOPMENT PLAN

Conceptual Model

(1) Major Permeable Structure Controlling Geothermal Activity

From geological information, 4 faults (F1, F2, F3 and F4) are deduced to control geothermal activity near the surface. From gravity information, it is deduced that 3 faults (G1, G2 and G3) are distributed under the ground. An additional 3 faults (R1, R2 and R3) are also estimated. Geothermal manifestations and altered ground in the Gemurah Besar-Gemurah Pamalibar sector are distributed along faults F1, F2, F3 and F4, and in the Kelumpang-Sindawan-Bunbun sector are distributed along faults F5 and F6.

(2) Cap Rock of Geothermal Resources

A low resistivity layer is detected by MT survey in this field. The elevation of the bottom of this layer around LMB 1 and LMB 3 is about 500 m to 800 m above sea level. Considering the well geology, this low resistivity layer can be correlated with an argillized layer. Temperature profiles of all drilled wells at the horizons of the argillized layer give a rather linear gradient. Moreover, lost circulation can scarcely be recognized at these horizons. This means that the detected low resistivity layer corresponding with the argillized layer can be regarded as a cap rock (impermeable layer).

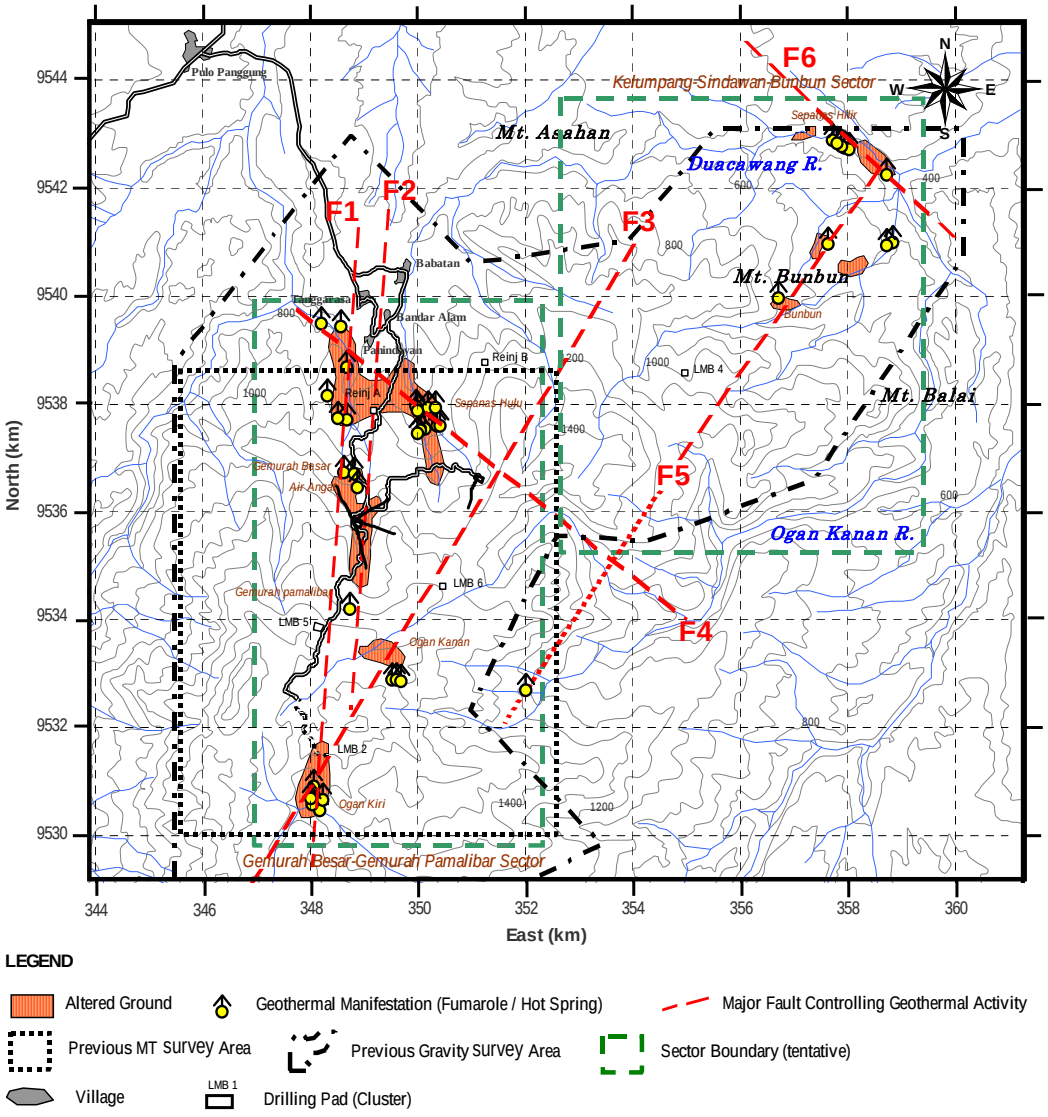
(3) Fluid Flow Pattern

In the Gemurah Besar-Gemurah Pamalibar sector (the western part of the Lumut Balai geothermal field), meteoric water is heated at depth and turns into geothermal brine. This brine flows up on the eastern side of the Mt. Lumut summit and flows north along faults F1, F2, F3 and F4. This flowing brine must be neutral in pH. Steam, gas and conductive heat derived from this brine, flowing through an argillized impermeable layer, come into a shallower aquifer and heat it up. Hot water from this heated aquifer is discharged as hot springs. The bottom of well LMB 1-2 is situated around fault F1. The bottoms of wells LMB 1-3, LMB 1-4 and LMB 1-5 are situated around fault F2, and that of well LMB 3-1 is situated around fault F3.

In the Kelumpang-Sindawan-Bunbun sector (the northeastern part of the Lumut Balai geothermal field),

geothermal brine flows northeast along fault F5, and this flow branches off where fault F5 crosses fault F6, flowing northwest along fault F6. Geothermal brine also flows up to the ground surface around that crossing point. The source of this geothermal brine flow must also be situated on the eastern side of the Mt. Lumut summit. The parental fluid has a temperature of 240°C to 300°C and Cl concentration of 5500 to 6500 ppm. However, it is still uncertain whether the source is the same as for the fluid flow system in the Gemurah Besar-Gemurah Pamalibar sector or not. They may be the same.

Considering the chemistry of fumarolic gases, the content of NCG in the geothermal steam produced in this field seems to be relatively low, which is good for future geothermal power generation.



LEGEND

Altered Ground
Geothermal Manifestation (Fumarole / Hot Spring)
Major Fault Controlling Geothermal Activity
Previous MT survey Area
Previous Gravity survey Area
Sector Boundary (tentative)
Village
LMB 1 Drilling Pad (Cluster)

(Based on PGE's data)

Fig.1 Major Structures Controlling Geothermal Activity

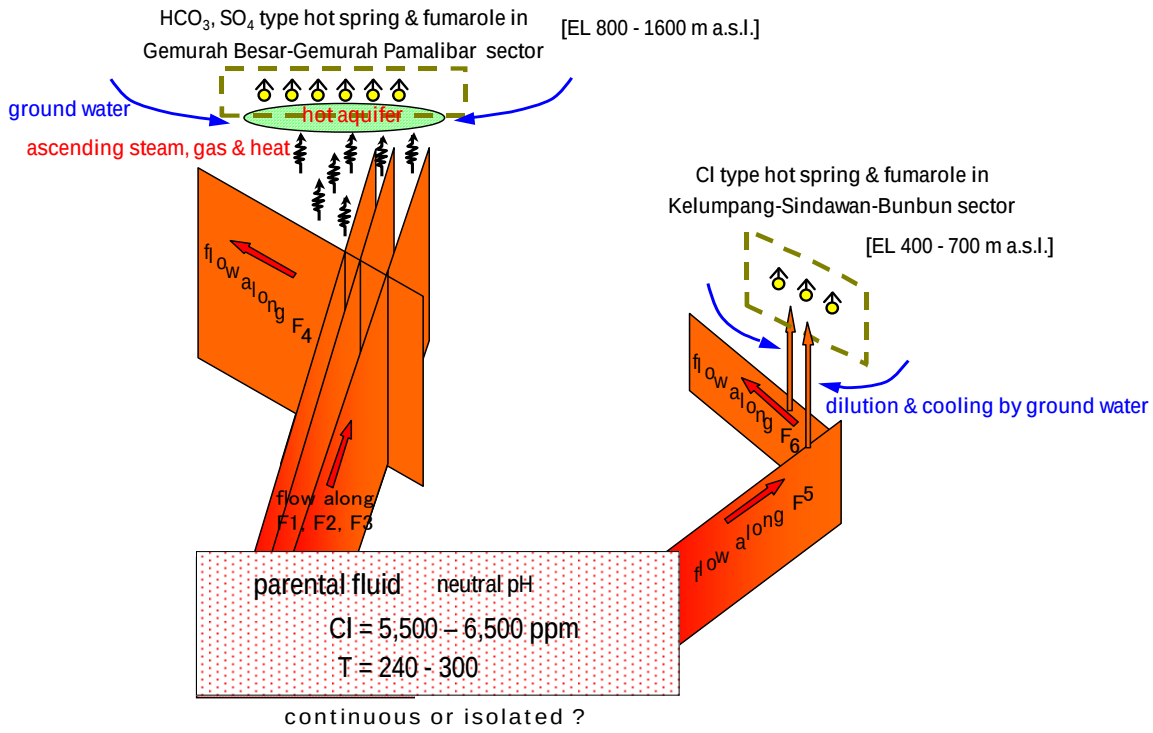
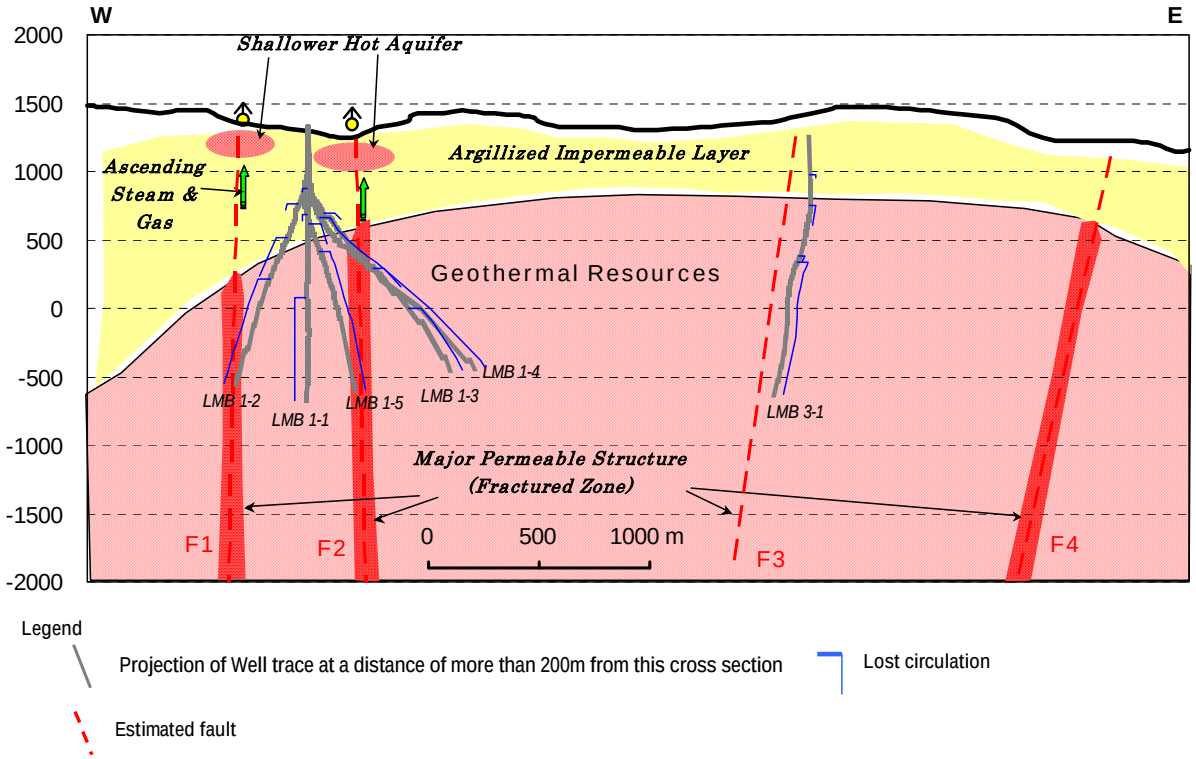


Fig.2 Fluid Flow Pattern Model



(Based on PGE's data)

Fig.3 Proposed Conceptual Model

Preliminary Reservoir Simulation Study

Based on the reservoir conceptual model, a reservoir numerical model was constructed for dedicated reservoir simulation study. As a result of the forecasting simulation it is concluded that the reservoirs in Lumut Balai will have enough capacity to sustain the power plant operation of 220 MW (Units 1 to 4) during the plant operation life of 30 years.

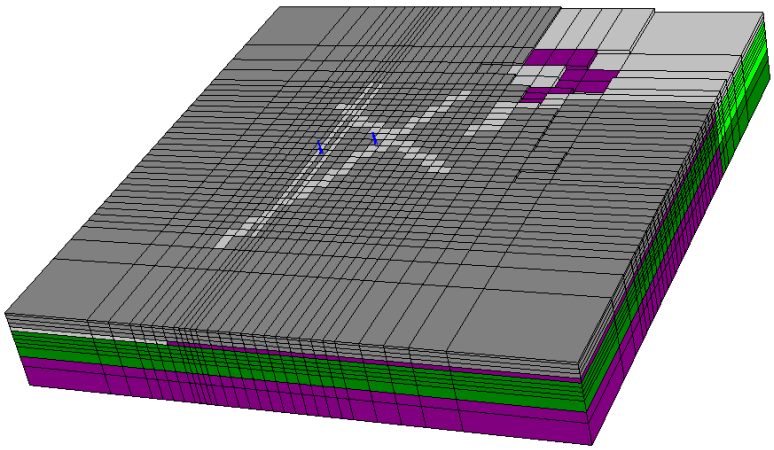


Fig.4 General View of 3-dimensional Reservoir Simulation Model

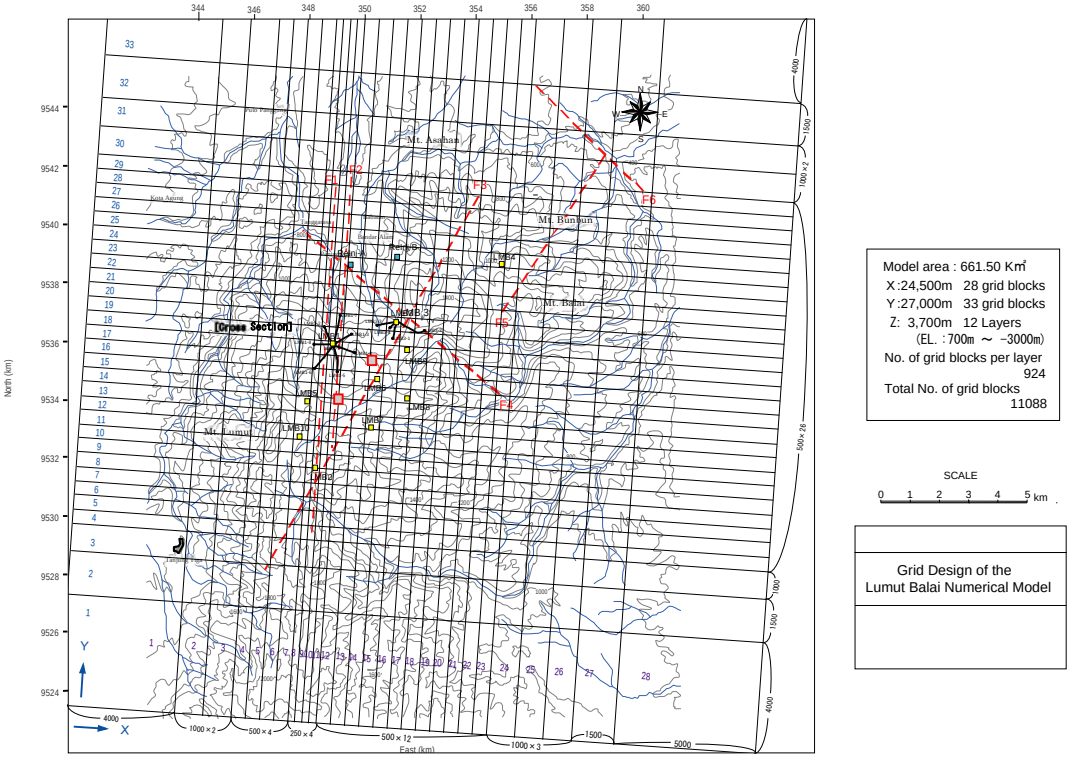


Fig.5 Grid Design of the Lumut Balai Numerical Model

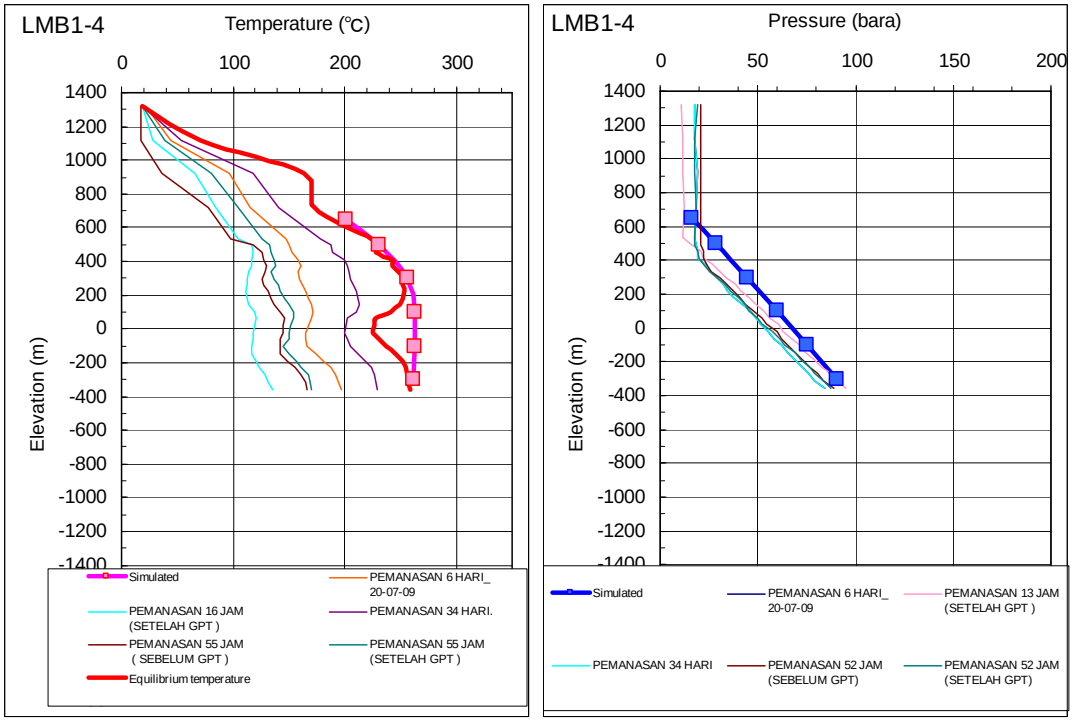


Fig.6 Matching of Temperature/Pressure Profiles of LMB1-4

(1) Number of start-up wells

The numbers of start-up wells that are required to commence the power plant operation of Units 3 and 4 (110 MW) are 17 for production and 8 for reinjection, the latter consisting of 7 for brine reinjection and one for steam condensate reinjection. Three well pads, LMB 2, 7, and 10, will be used as production well pads to commence the power plant operation of Units 3 and 4. On the assumption that the maximum number of production wells at each well pad is six, the simulated numbers of wells at the well pads LMB 10, 2 and 7 are six, six, and five, respectively. The simulated steam flow rate at each well pad is around 280 to 340 t/h and brine flow rate is around 900 to 1100 t/h.

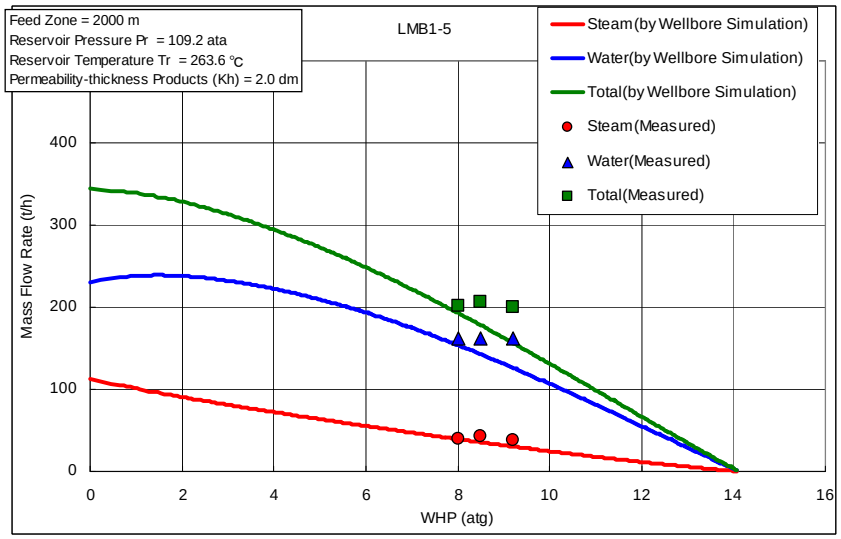


Fig. 7 Comparison of Measured and Simulated Deliverability of LMB1-5

Table 1 Number of Wells Required to Operate Units 1&2 and 3&4

Simulated No. of well	Unit 1&2 (110 MW)		Unit 3&4 (110 MW)		Total (220 MW)	
	Start-up	Make-up	Start-up	Make-up	Start-up	Make-up
Production well	21	2	17	1	38	3
Reinjection well	8	2	8 (1)	2 (1)	16 (1)	4 (1)
Total	29	4	25	3	54	7

* Make-up wells would be required for the 30-year plant operation. () indicates the number of steam condensate injection well

Table 2 The Forecasted Number of Wells

UNIT	Pad	WHP (bara)	Well Name	30 days			1 year		
				STEAM	WATER	TOTAL	STEAM	WATER	TOTAL
UNIT1,2 (21wells)	LMB1 (8wells)	8.0	LMB1-1	49.8	178.8	228.6	49.9	178.9	228.7
			LMB1-2	36.5	131.5	168.0	36.5	131.6	168.1
			LMB1-3	36.9	134.1	171.0	37.0	134.4	171.4
			LMB1-4	38.1	135.1	173.2	37.9	134.2	172.0
			LMB1-5	47.8	167.3	215.1	47.4	166.1	213.5
			LMB1-6	33.2	115.8	149.0	33.0	115.1	148.1
			LMB1-7	42.8	154.4	197.2	43.2	155.8	199.0
			LMB1-8	41.1	147.2	188.3	41.0	147.0	188.0
			TOTAL	**326.1**	**1164.3**	**1490.4**	**325.8**	**1163.1**	**1488.8**
	LMB3 (4wells)	8.0	LMB3-1	48.7	178.7	227.3	49.2	180.5	229.7
			LMB3-2	21.1	80.3	101.3	21.8	83.3	105.1
			LMB3-3	35.7	131.0	166.7	36.7	134.5	171.2
			LMB3-4	47.9	176.3	224.2	48.8	179.8	228.6
			TOTAL	**153.4**	**566.2**	**719.5**	**156.5**	**578.1**	**734.6**
	LMB5 (5wells)	8.0	LMB5-1	58.5	188.8	247.3	58.0	187.0	245.0
			LMB5-2	53.4	172.4	225.8	52.4	169.1	221.5
			LMB5-3	58.8	189.9	248.7	58.4	188.7	247.1
			LMB5-4	58.8	189.6	248.4	58.3	187.9	246.2
			LMB5-5	59.0	191.2	250.2	57.1	185.2	242.2
			TOTAL	**288.6**	**931.8**	**1220.4**	**284.2**	**917.9**	**1202.0**
	LMB6 (4wells)	8.0	LMB6-1	47.4	163.2	210.6	46.9	161.5	208.4
			LMB6-2	40.0	143.7	183.7	39.8	143.2	183.0
			LMB6-3	53.3	173.6	226.9	52.4	170.4	222.7
			LMB6-4	47.7	164.0	211.7	47.4	162.7	210.0
			TOTAL	**188.5**	**644.4**	**832.9**	**186.5**	**637.6**	**824.1**
UNIT1,2 TOTAL				**956.5**	**3306.7**	**4263.2**	**952.9**	**3296.6**	**4249.5**
UNIT3,4 (17wells)	LMB10 (6wells)	8.0	LMB5-1	53.3	171.9	225.2	52.7	169.8	222.5
			LMB5-2	58.7	189.4	248.1	58.4	188.1	246.5
			LMB5-3	57.0	186.0	243.0	56.8	185.2	242.0
			LMB5-4	54.6	180.5	235.1	54.4	179.7	234.1
			LMB5-5	58.7	189.4	248.0	58.3	188.3	246.6
			LMB5-6	57.7	187.3	245.0	57.4	186.4	243.8
			TOTAL	**340.0**	**1104.4**	**1444.4**	**337.9**	**1097.6**	**1435.5**
	LMB2 (6wells)	8.5	LMB2-1	56.6	182.6	239.2	56.5	182.0	238.5
			LMB2-2	52.7	169.8	222.5	52.2	168.2	220.3
			LMB2-3	52.6	169.5	222.1	52.1	167.8	219.9
			LMB2-4	56.4	182.3	238.7	56.3	181.7	238.0
			LMB2-5	55.7	179.9	235.6	55.6	179.5	235.1
			LMB2-6	55.9	180.6	236.5	55.6	179.8	235.4
			TOTAL	**329.9**	**1064.7**	**1394.6**	**328.1**	**1059.1**	**1387.2**
	LMB7 (5wells)	8.0	LMB7-1	54.4	175.3	229.6	53.8	173.4	227.2
			LMB7-2	54.5	176.3	230.8	53.9	174.4	228.3
			LMB7-3	58.5	188.6	247.1	58.1	187.4	245.5
			LMB7-4	52.9	170.4	223.3	52.1	168.0	220.1
			LMB7-5	55.8	180.5	236.3	52.7	170.4	223.1
			TOTAL	**276.1**	**891.1**	**1167.1**	**270.6**	**873.6**	**1144.2**
UNIT3,4 TOTAL				**946.0**	**3060.1**	**4006.1**	**936.6**	**3030.3**	**3966.9**

Start-up	Production	Reinjection	
		Brine	Steam Condensate
Unit 1,2	21	8	1
Unit 3,4	17	7	
Total	38	16	

(3) Optimum turbine inlet pressure

It is recommended that the turbine inlet pressure be 5.5 bara, talking into account appropriate turbine size in terms of manufacturing. In the future, detailed turbine design should be discussed after additional data from production wells at well pads LMB 2, 5, and 10 is obtained. If the production wells at these well pads show dominant productivity beyond the current estimation, it will be possible to increase the design turbine inlet pressure. In such a case, the cost of the gathering system and the power plant will decrease compared to the current cost estimation, because the size of piping and equipment will be reduced.

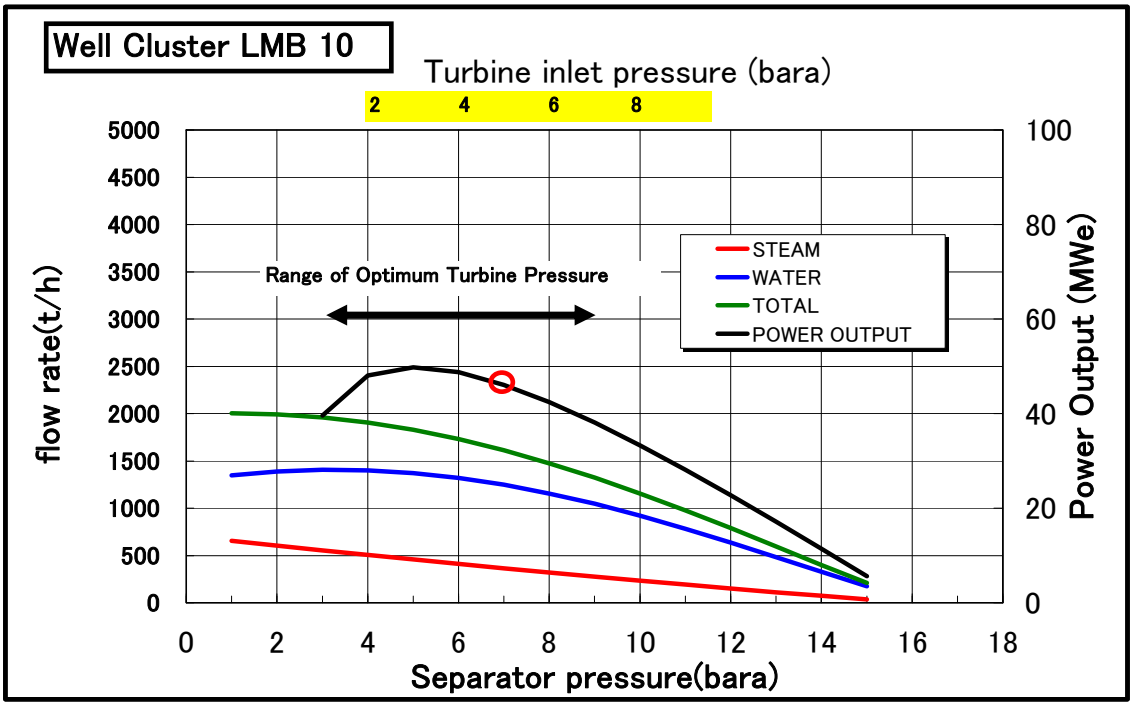


Fig. 8 Study of Range of Optimum Turbine Inlet Pressure at Well Pad LMB10

(4) Number of make-up wells

The forecasted results suggest that only one production well and two reinjection wells will be required over the plant life of 30 years. This means that the reservoir will be very stable after producing and reinjecting the geothermal fluids for power generation. However, an annual decline rate of 3% should be assumed in determining the number of necessary make-up wells for the calculation of O&M costs to avoid overly optimistic predictions, considering that the precision of this reservoir numerical model is still low. As a future task, the model should be revised to validate its reliability based on additional data from the wells.

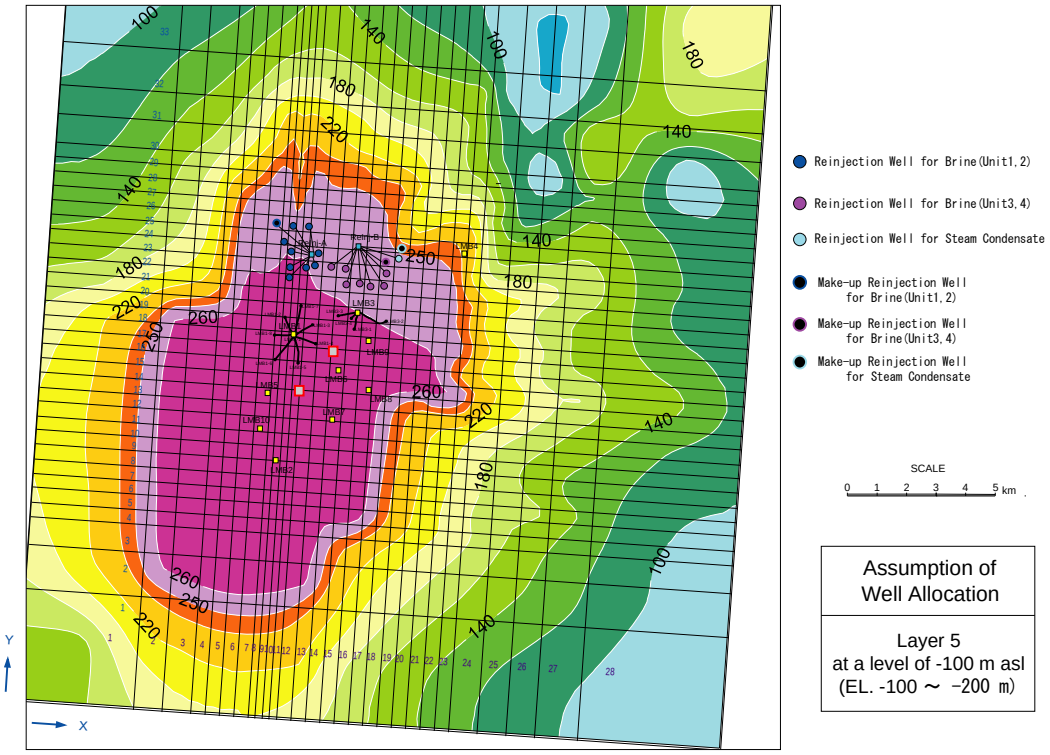


Fig. 9 Reinjection Well Allocation in Layer 5 (-100 m asl)

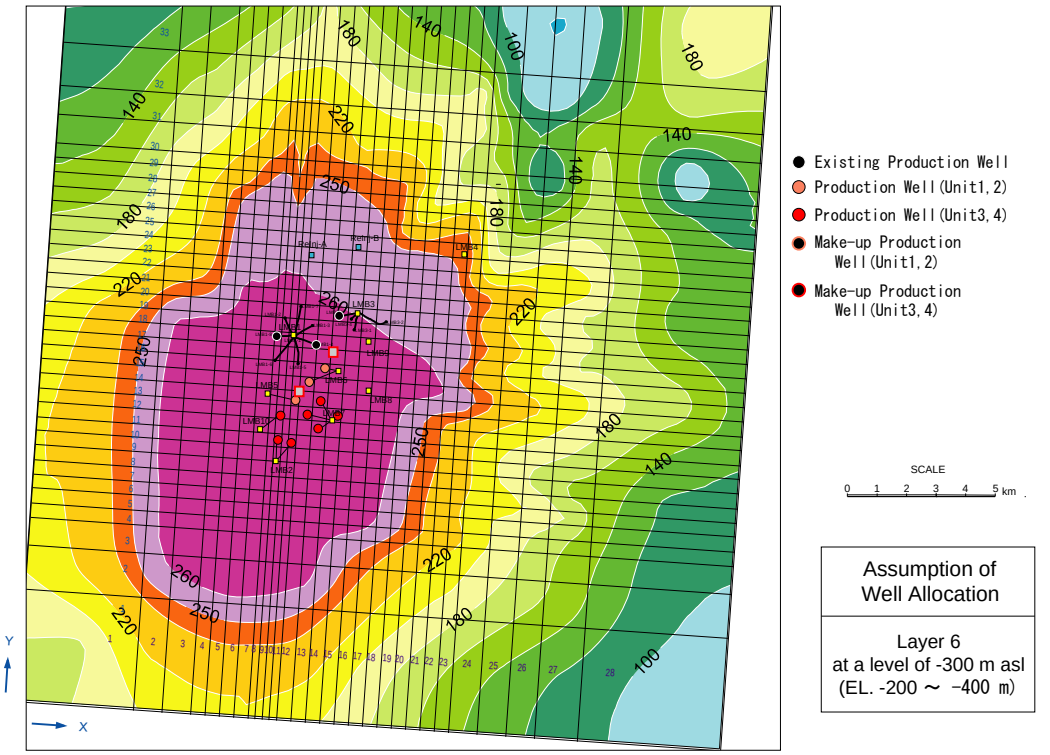


Fig. 10 Production Well Allocation in Layer 6 (-300 m asl)

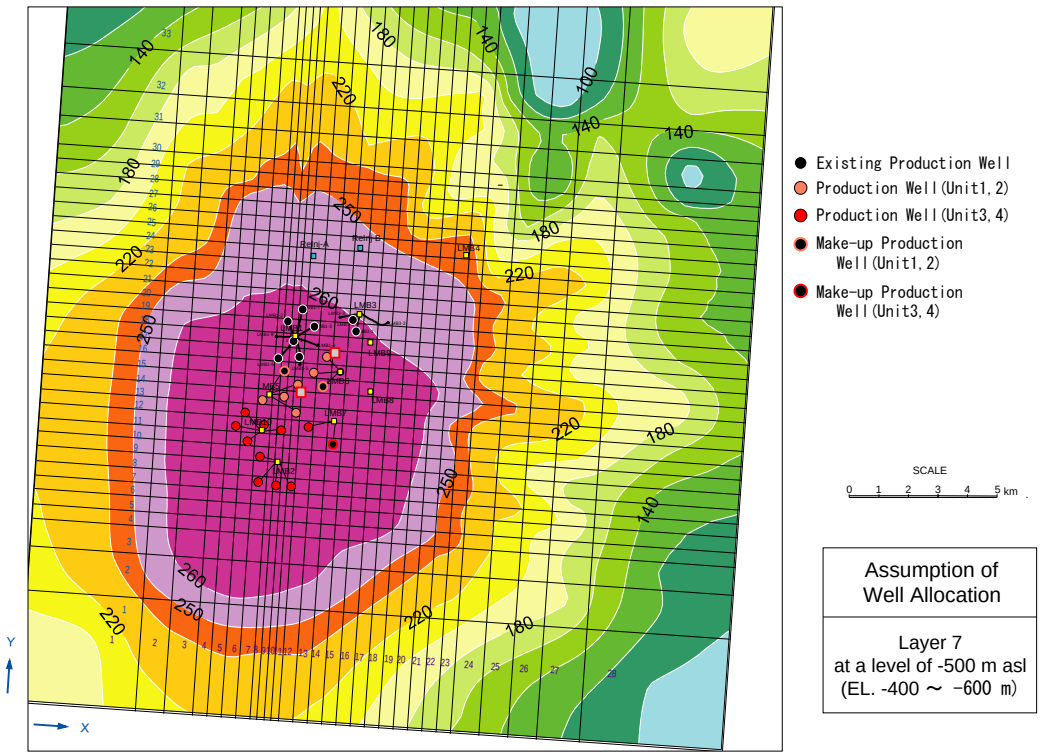


Fig. 11 Production Well Allocation at Layer 7 (-500 m asl)

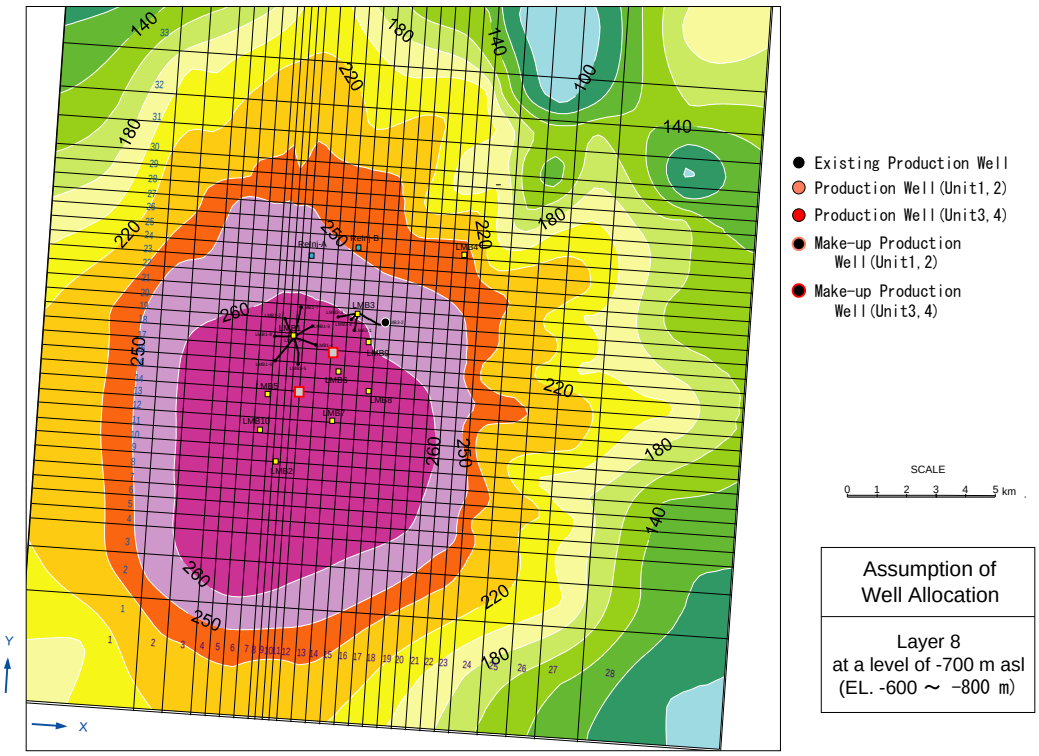


Fig. 12 Production Well Allocation at Layer 8 (-700 m asl)

Steam-field Development Plan

The production wells for Units 3 and 4 will be drilled from well pads LMB 10, 2 and LMB 7, targeting the prospective productive faults F1, F2 and F3, where reservoir temperature and permeability are expected to be higher. Seventeen (17) production wells should be prepared to commence the 110 MW power plant operation (55 MW x 2 units). The reinjection wells should be drilled from well pads InjA and InjB, targeting the faults F1, F2 and F4 in the northern area of the field. The simulation results suggest that eight (8) reinjection wells will be required for the disposal of 3060 t/h of brine and 380 t/h of steam condensate (about 20% of the total steam flow rate for all units 1 to 4), assuming the permeability-thickness product (kh) of the reinjection zones to be 10 darcy-m. Seven reinjection wells should be used for brine disposal and one reinjection well for steam condensate. When the reinjection wells are actually drilled in the prospective area in the future, reinjection zones to be developed will be distinguished more clearly.

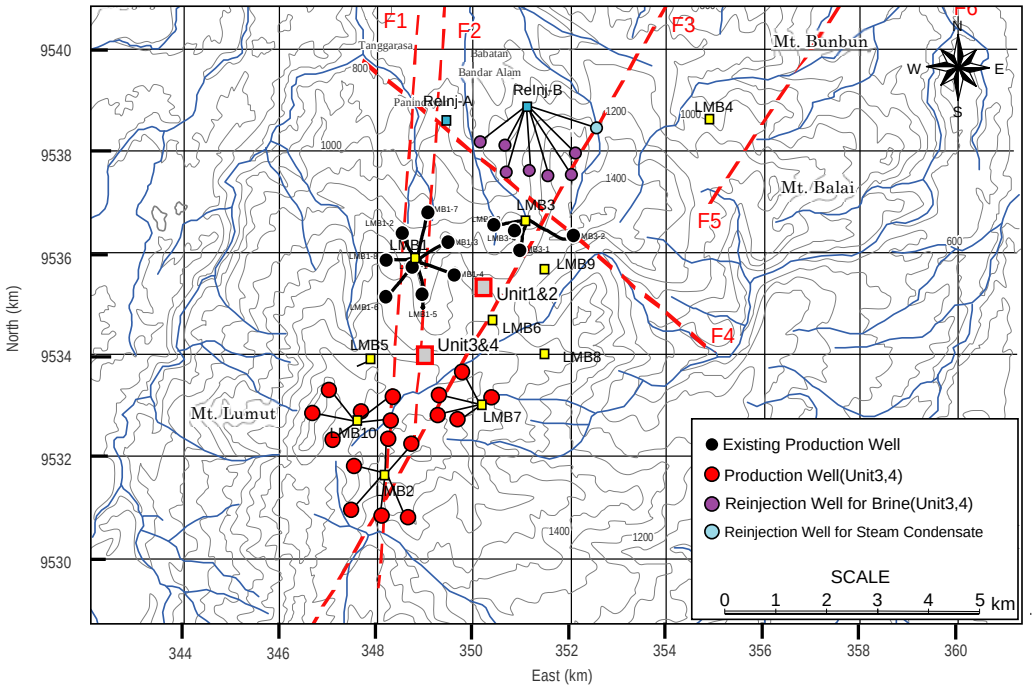


Fig. 13 Prospective Production and Reinjection Zones

The decline in capacity of production and reinjection wells will require make-up production and reinjection wells to be drilled at appropriate times to maintain the rated power output. The results of reservoir simulation forecasted that only 1 make-up production well and 2 make-up reinjection wells would be required over the plant operating life of 30 years. However, it should be noted that the current reservoir numerical model is only a preliminary model because this model was established based on the very limited existing well data from well pads LMB 1 and LMB 3. Therefore, the model should be updated to increase its precision after additional well data is obtained in the future. Therefore, in order to avoid underestimation of the required number of make-up wells in this preliminary study, the ordinary annual decline rates given below should be assumed in determining the number of make-up wells and estimating the attendant costs.

- Power output of production wells: 3% per year
- Injection capacity of reinjection wells for brine disposal: 3% per year
- Injection capacity of reinjection wells for steam condensate disposal: 1% per year

As a result, 12 make-up production wells and 4 make-up reinjection wells for brine disposal will be required over 30 years of plant operation. A new well pad for production wells LMB 8 and LMBX should be prepared within 6 years and 19 years after commencement of plant operation, respectively. To arrive at a conservative estimate, the number of make-up wells was finalized by combining the above number of wells with that forecasted as necessary by the reservoir simulation, as follows.

Table 3 Timing of Adding Make-up Wells over 30 Years after Commissioning

Year	3	6	8	10	12	15	17	19	21	24	26	28	Total
Production wells	1	1	1	1	1	1	1	1	1	1	1	1	12
Reinjection wells	1	0	0	0	1	0	1	0	1	0	1	0	5
Total	2	1	1	1	2	1	2	1	2	1	2	1	17

Strategy of Well Drilling and Production Tests

The Lumut Balai project area is located in the mountainous district of Bukit Lumut and Bukit Balai and is characterized by a relatively steep topography. In this area two drilling pads (LMB 1 and LMB 3) for Units 1 and 2 have already been constructed. Another well pad, LMB 4, is prepared for investigation in the Kelumpang-Sindawan-Bunbun Sector in the northeastern area of the field, which is more than 4 km from well pad LMB 3. This well pad cannot be used for this project, because it is too distant to utilize as a reinjection well pad. Access roads from the existing road to these drilling pads in the field have been constructed and extended in a southerly direction for the new well pads, LMB 5, LMB 10 and LMB 2, which are under construction. Three new production pads (LMB 7, LMB 8, and LMBX) should be newly constructed for the development wells and make-up wells.

Production tests and interference tests using not only existing wells but also new wells are strongly recommended to confirm well deliverability and reservoir properties, including gas and chemical conditions. This information is of extreme importance for the detailed design of the power facilities and also for reservoir management over the course of power plant operation. If testing is to be done and investment in the required facilities is to be made, then it is desirable to provide permanent production testing equipment and installations at all production well pads so that the steam and water flow rates of production wells can be measured whenever it is necessary.

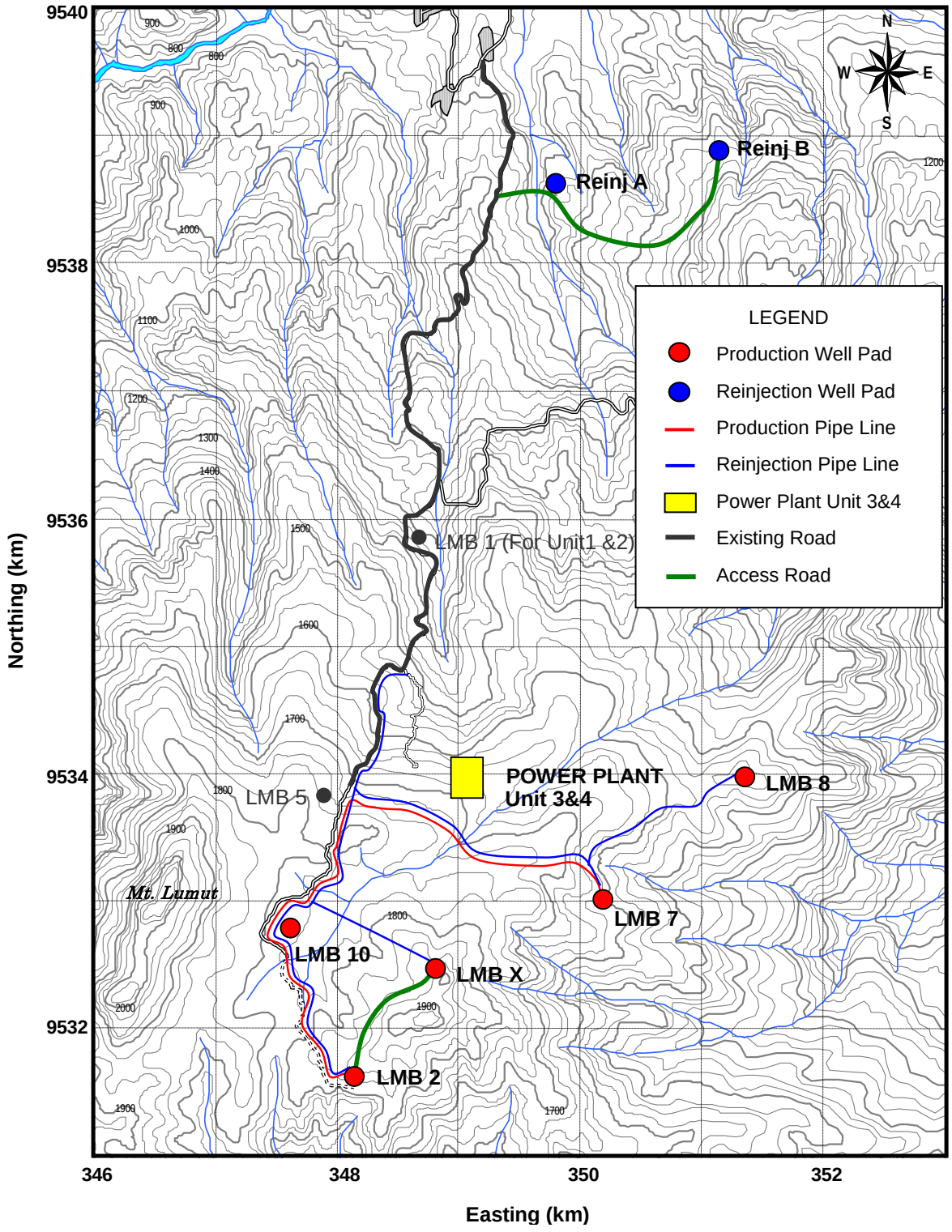


Fig. 14 Layout of Well Pads, Power Plant and Access Roads

3. POWER PLANT AND TRANSMISSION LINE

Power Plant

1) Fluid Collection and Reinjection System(FCRS)

Taking into account the medium pressure and high brine content of the resource, a two-phase transportation system from the production wells to the power plant would not be appropriate for Lumut Balai Units 3 and 4 because a significant pressure loss is anticipated. Accordingly, a wellpad separation system (constructing separator stations near production well pads) will be adopted. Separated steam will be sent to the power plant, while separated brine will be sent to the reinjection well pads and injected into the ground.

2) Power Plant

Lumut Balai Units 3 and 4 (single flash 2 x 55 MW(net) turbine-generator units) will be constructed in the southern area of Lumut Balai geothermal field. A steam ejector system would be suitable for design NCG content of 1.0% wt. However, three (3) different ejector sizes will be installed to cope with unforeseeable future NCG variation from 0.4% wt up to 1.8% wt.

3) Transportation

Two (2) unloading ports are conceivable for the project, i.e. Panjang seaport and Palembang river port. Panjang seaport is suitable for unloading heavy and bulky plant equipment and materials such as turbines, generators, condensers, etc., but the distance to the project site is a whole 370 km, so Palembang river port may be used for miscellaneous equipment and materials because of the shorter (approximately 260 km) land transportation route to the project site. Another alternative for small and miscellaneous logistic equipment and materials from Jakarta will be transportation by truck using a commuter ferry between Java and Sumatra islands.

4) O&M

PGE will be responsible for operation and maintenance of the Lumut Balai geothermal power plant both upstream and downstream.

PGE will perform routine preventive maintenance, periodical maintenance and predictive maintenance. Improvement work, such as plant rehabilitation/revamping/reconditioning/retrofitting/renovation and relocation, if necessary, will be arranged and implemented by PGE.

The O&M personnel for Units 1 and 2 will be able to operate Units 3 and 4, providing that these units are controlled remotely from the Unit 1 and 2 power plant. Common use of maintenance equipment and spare parts for Units 1 and 2 would reduce total O&M cost.

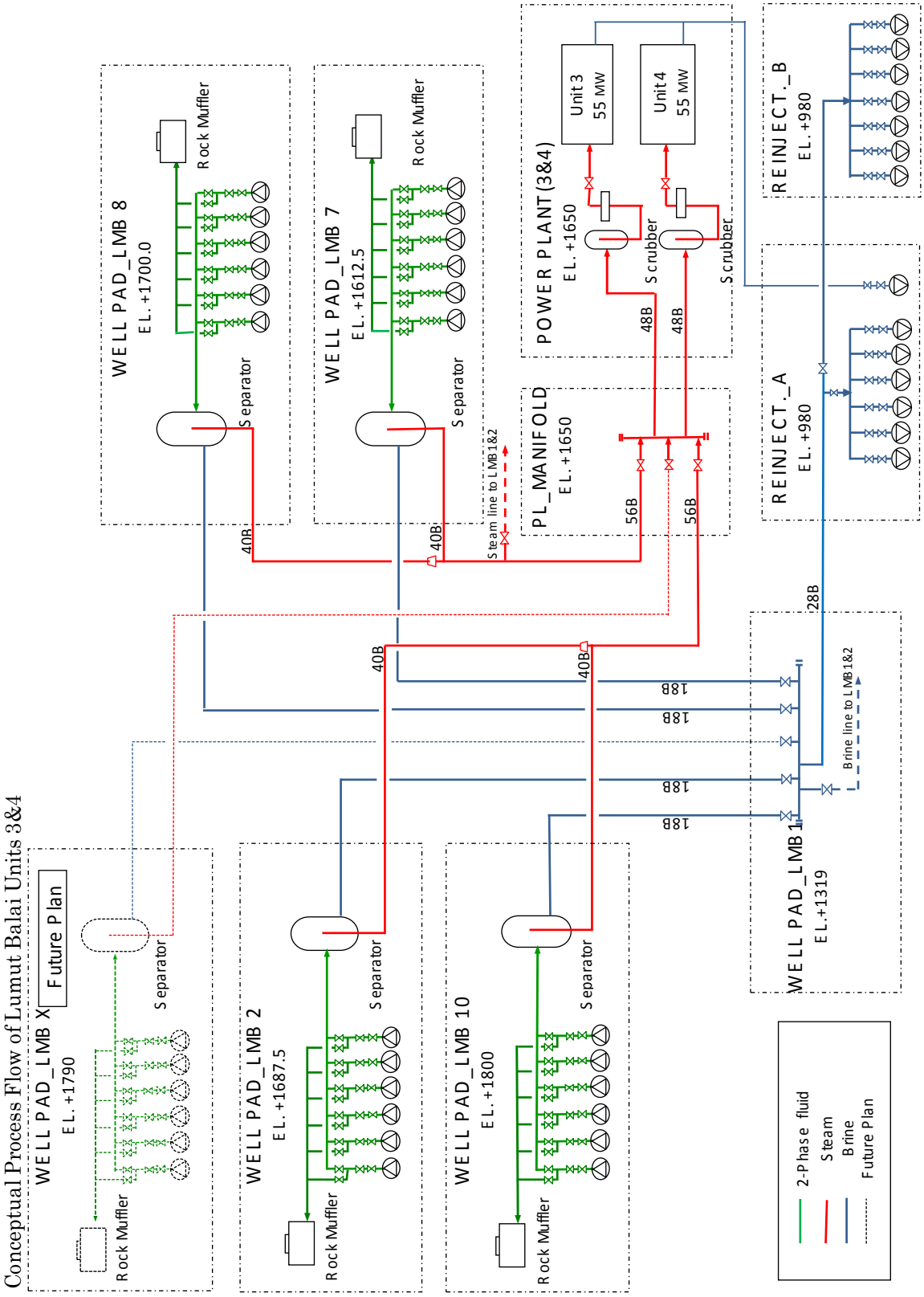


Fig.15 Steam Field Process Flow (Preliminary)

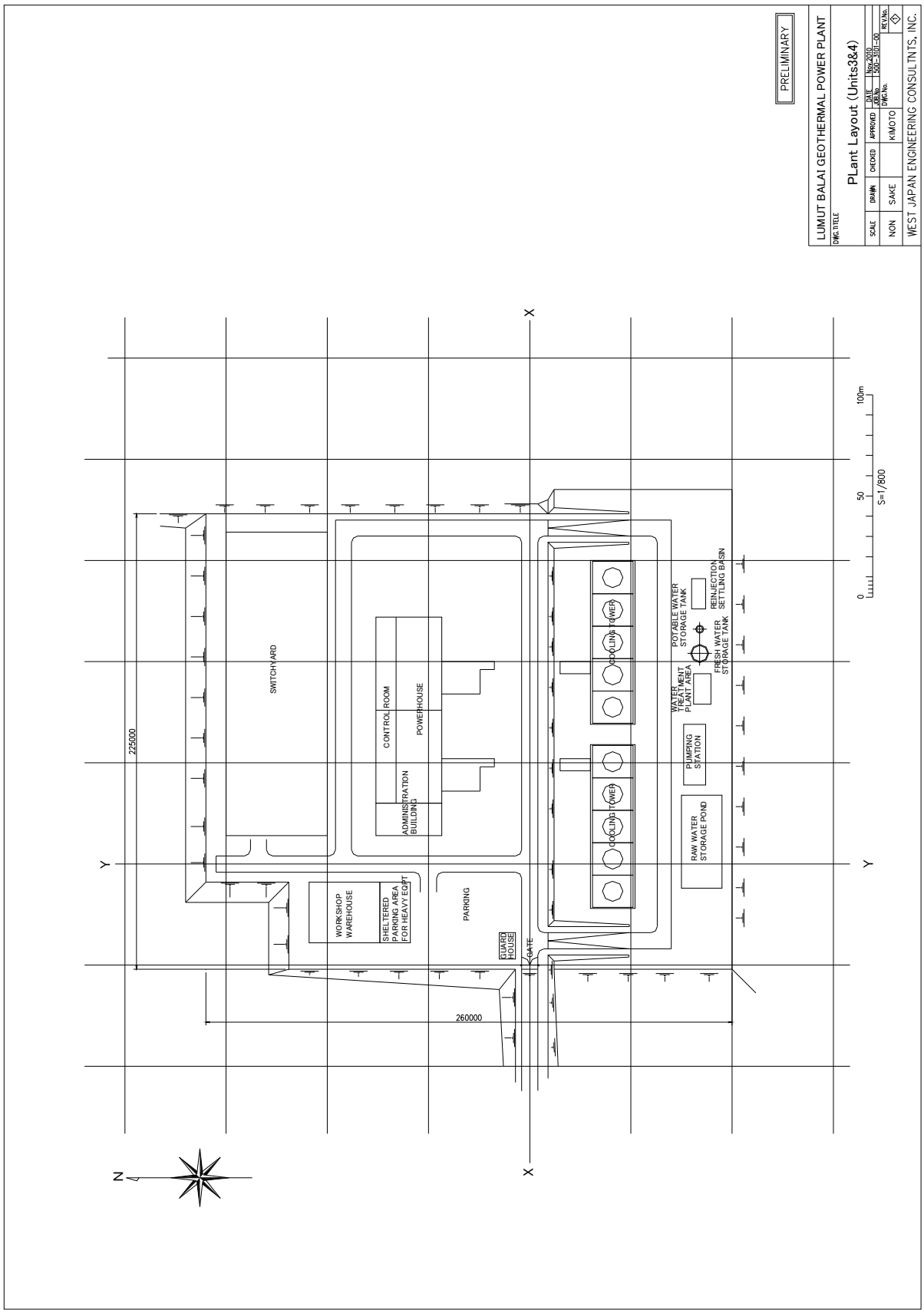


Fig. 16 Plant Layout for Units 3 and 4 (Preliminary)

Transmission Line and Substation

1) Transmission Line

It is recommended that 2 x DOVE (2 x 556.5 MCM, equivalent to 282 mm^2) be employed for the 275 kV transmission line between Lumut Balai geothermal power plant and Lahat substation in order to deliver the eventual full 4 x approx. 55 MW capacity.

The main specifications of 2 x DOVE are as follows.

- ✓ Operating Voltage : 275 kV
- ✓ Material / Cord Name : ACSR / DOVE
- ✓ Cross Section : 556.6 MCM (282 mm^2)
- ✓ Number of Conductors : 2
- ✓ Number of Circuits : 2
- ✓ Transmission Capacity : Approx 480 MVA (per circuit)
- ✓ Length : Approx. 63 km (to Lahat substation)

2) 275 kV Substation

- ✓ Existing Lahat 150/20kV Substation must be completely upgraded to 275/150/20kV before work to connect the transmission line from Lumut Balai geothermal power plant is commenced.
- ✓ Two sets of 275 kV complete line bay should be expanded to connect the transmission line from Lumut Balai.

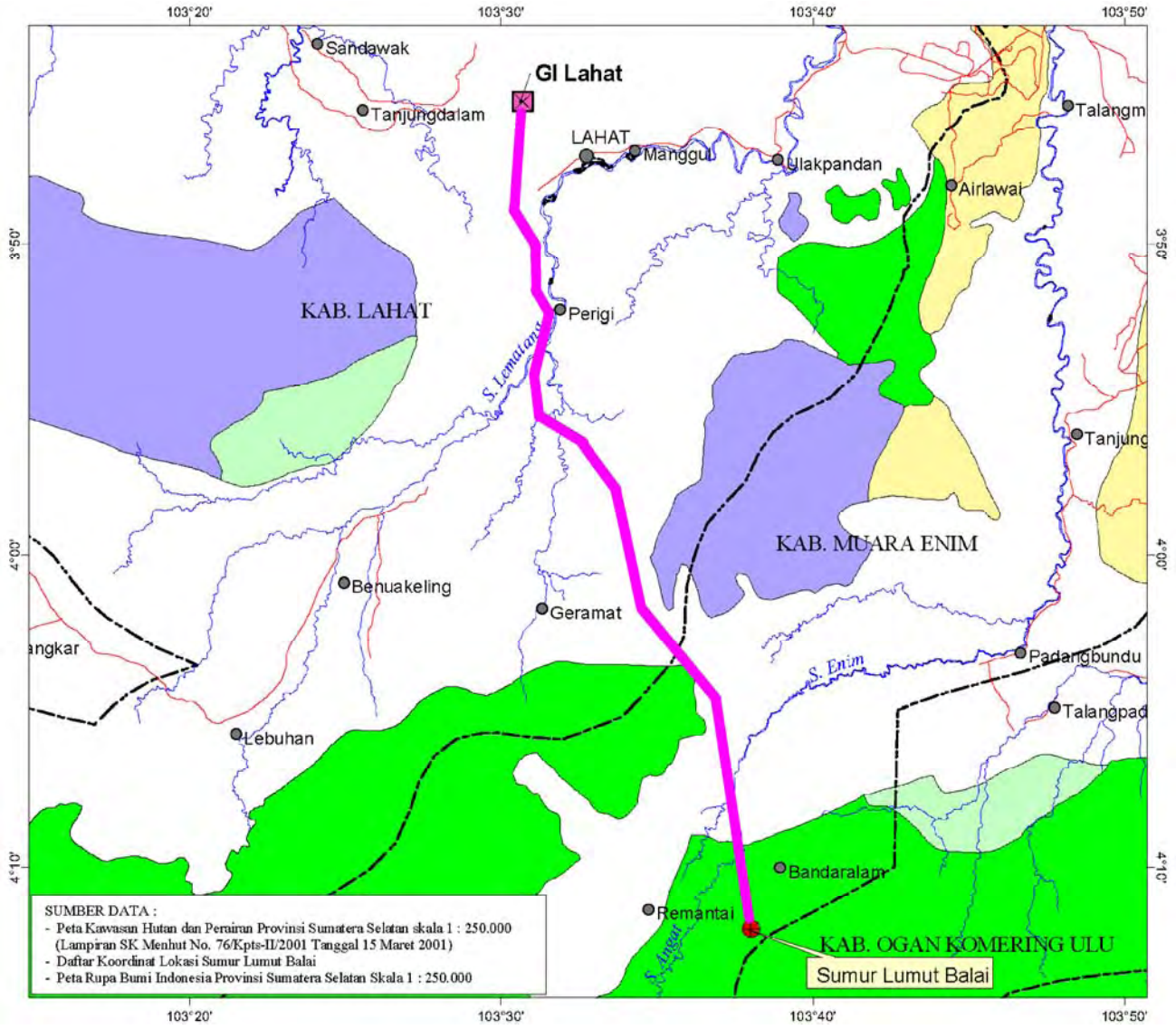


Fig. 17 Transmission line route from Units 1&2 to Lahat 275kV substation
(in planning by PLN Pikitring SBS)

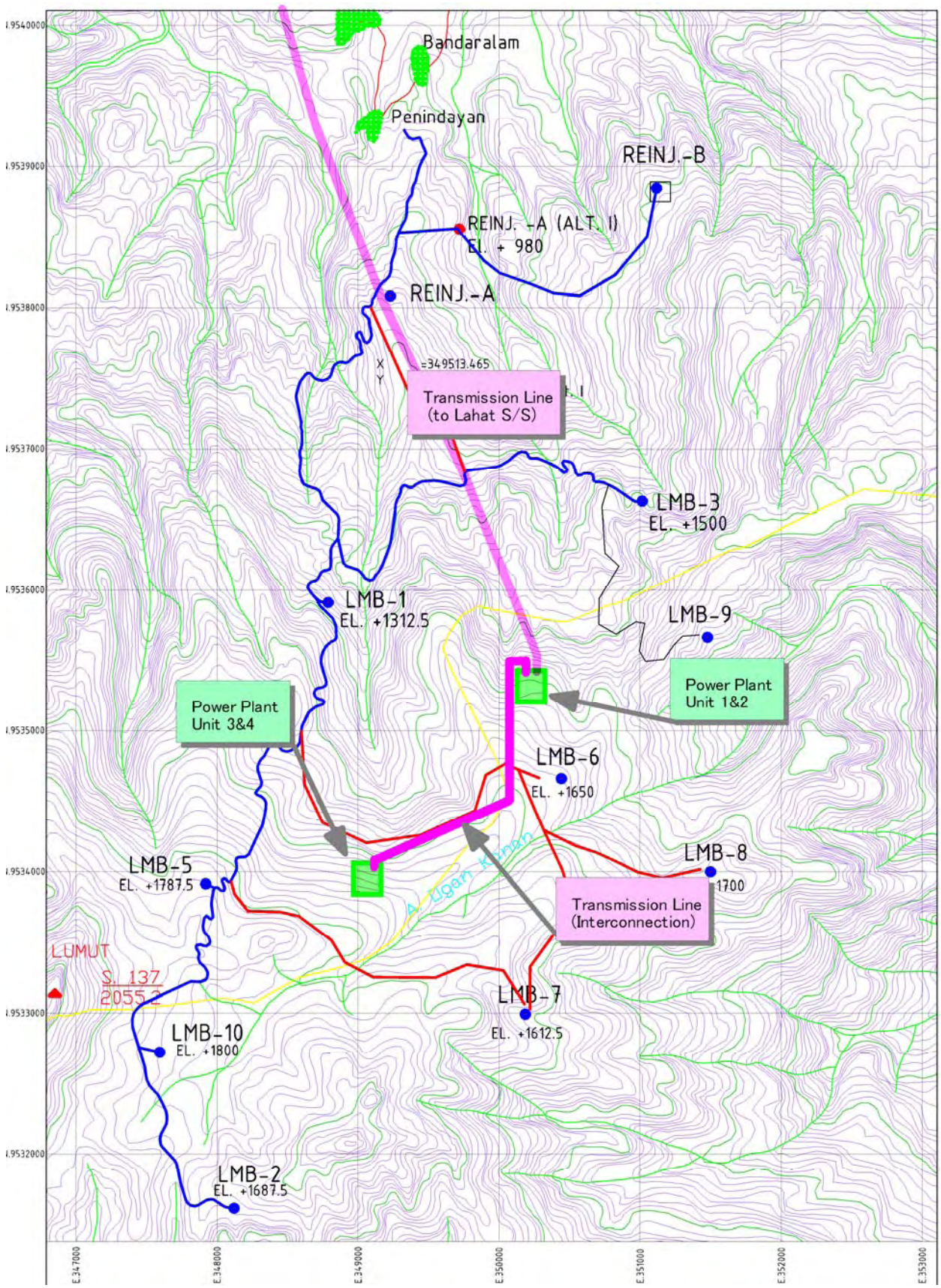


Fig. 18 Conceptual design of interconnection line route between Units 1&2 and Units 3&4.

Implementation Schedule and Costs

1) Implementation Schedule

Assuming that the L/A will be concluded at the end of February 2011 and that a certain period of time for JICA concurrence requirements for several procurement procedures is incorporated, the tentative implementation schedule is formulated as shown in the following Figure. JICA's standard schedule is shown in the following table.

Table 7 JICA Standard Schedule

1. Consultant selection *(Note)*	9 months
2. Project procurement	
a. Bidding document preparation	4 months
b. Bidding period	3 months
c. Bid evaluation	5 months
d. JICA concurrence	1 month
e. Contract negotiation	1.5 months
f. JICA concurrence of the contract	0.5 months
g. L/C opening and issue of L/Com	1 month
Subtotal	16 months

(Note): Consultant selection could be 6 months in the case of direct appointment. (Needs justification for direct negotiation)

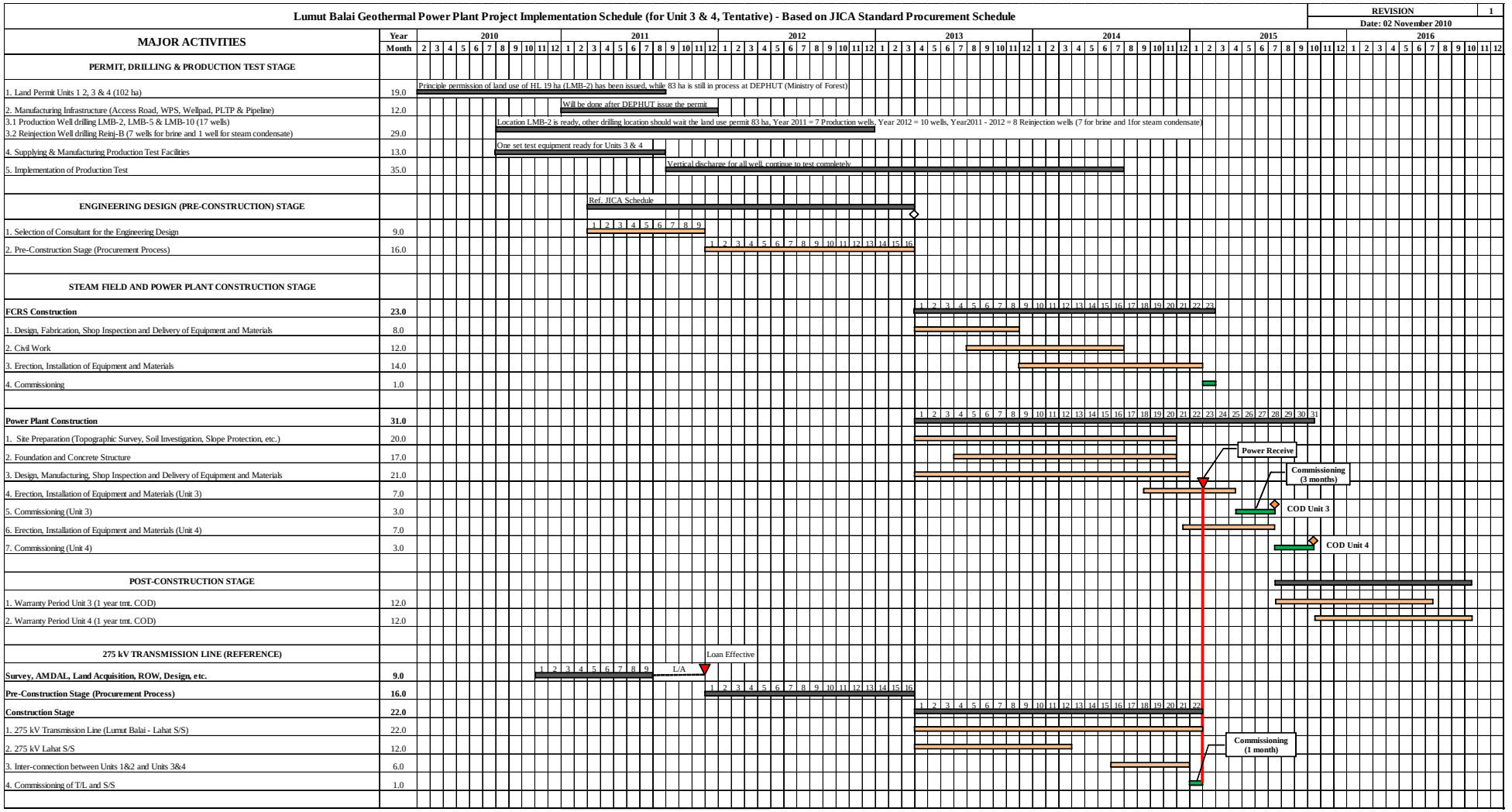


Table 8 Project Schedule

4. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

Basically, Lumut Balai units 3 and 4 is located in the same area as units 1 and 2. Legal permission for the power plant was checked and cleared last year in the preparatory survey for unit 1 and 2. So this year, we confirmed whether units 3 and 4 are also covered or not. As a result, they are confirmed to be covered.

Geothermal WKP

PERTAMINA obtained Confirmation of the Geothermal Working Area (WKP) in Lumut Balai and permission under the Minister of Mining and Energy Decree No.1268.k/20/M.PE/1993 on 7 February 1993.

Surface Water Utilization

PERTAMINA had been allowed to utilize surface water for geothermal exploration drilling activity by the Muara Enim Regency under Decree No.739/KPTS/Tamben/2007 on 25 July 2007. And this permission was extended for 2 years for PGE by Muara Enim Regency under Decree No. 668/KPTS/TAMBEN/2009 on 12 November 2009 in response to request No. 789/PGE1P2/2009-SO on 21 July 2009 by PGE.

EIA

The EIA Reports were approved by the Governor of Muara Enim Regency decree No.758/KPTS/BLH-I/2008 on 21 August 2008.

Based on the map from Ministry of Forestry published in November 2008, border line between Muara Enim regency and OKU (Ogan Komering Ulu) regency is drawing in the center of the Lumut Balai geothermal field. Border line between regencies should be determined officially by National survey and investigation board but is not confirmed it has already changed or not. AMDAL law (Article 24 of No. 27/1999) defines the valid period and cancellation conditions of approved AMDAL, but change of the border line of approved regency is not written in it. So this AMDAL is still valid.

Land Acquisition

As the project will take place in a protected forest area (Hutan Lindung) of 102 ha, there is no cost for land acquisition, but permission for the utilization of the forest area from the Ministry of Forests is required. 19 ha is already permitted, and PGE is still waiting for permission for the use of the remaining 83 ha. PGE expects to receive permission for that 83 ha in December 2010.

Resettlement

There will be no resettlement activities because the Project will take place within a protected forest area.

EIA Review and Field Survey

The EIA reports are considered to satisfy with the “JBIC Guidelines for Confirmation of Environmental and Social Considerations (April, 2002). The results of environmental confirmation are shown in Table 13.

Table 13 Environmental Check List for the Power Plant

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
Permits and Explanation	(1) EIA and Environmental Permits	Have EIA reports been officially completed? Have EIA reports been approved by authorities of the host country's government? Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	Yes Yes, on 21 August 2008 by Muara Enim Regency Yes Yes, the project has applied for a water intake permit to take water from the river.
	(2) Explanation to the Public	Are contents of the project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public? Are proper responses made to comments from the public and regulatory authorities?	Yes, The explanation of the potential impacts of projects to the public has been done through a public hearing and discussion with state government authorities and the local people since survey activities began. The people in the project area support the geothermal power plan, and they request electric power for their houses, especially for public facilities like mosques.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
2 Mitigation Measures	(1) Air Quality	When electric power is generated by combustion, such as biomass energy projects, do air pollutants, such as sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust emitted by power plant operations comply with the country's emission standards and ambient air quality standards? Do air pollutants, such as hydrogen sulfide emitted from geothermal power plants comply with the country's standards? Is there a possibility that emitted hydrogen sulfide will cause impacts on the surrounding areas, including vegetation? Do air pollutants emitted from other facilities comply with the country's emission standards?	Yes, each the electric power plant emission must comply with the local regulatory emissions standard and air ambient standards. Ambient standard (Gov. Regulation No. 41/1999): SOx = 900 ug/m3 ; NOx = 30.000 ug ; dust = 235 ug/m Yes, Indonesia Government regulation Number 50 / 1996 regarding National standards for olfactory emissions of electric power plant generation specifies a ceiling for H2S emission of 0.02 ppm. Over a long time period, the hydrogen sulfide will cause impacts on the surrounding areas, such as people and vegetation. For this reason the project must completed by an impact management program.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Water Quality	In the case of geothermal power plants, is there a possibility that geothermal utilization will cause water pollution by pollutants, such as As and Hg, contained in geothermal fluids? If water pollution is anticipated, are adequate measures considered? Do leachates from the waste disposal sites comply with the country's effluent standards and ambient water quality standards? Are adequate measures taken to prevent contamination of soil, groundwater, and seawater by leachates?	Yes, there is the possibility that geothermal utilization will cause water pollution with pollutants such as As and Hg. The Waste water must be treated before discharge to environment. Indonesia standards for river water specify a maximum concentration of As < 1.00 mg/l, and Hg < 0.002 mg/l. Before effluent discharge to the ground water or river, the effluent of a geothermal plant must be treated by a waste water treatment plant. They must. If the leachates from the waste disposal plant do not comply with the Indonesia effluent standards, the leachates must not be discharged into the environment. Yes, there are many measures taken to prevent contamination of soil, ground water and seawater by leachates, one of which is to manage them in a waste water treatment plant.
	(3) Wastes	Are wastes generated by the plant operations properly treated and disposed of in accordance with the country's standards (especially for biomass energy projects)?	Yes, there is a manual of treatment management detailing how to manage waste water from plant operations.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(4) Soil Contamination	Has the soil in the project site been contaminated in the past, and are adequate measures taken to prevent soil contamination?	No, the soil in project site is in good condition, because the project site is located in protected virgin forest, and there have been no activities in this area before. To prevent the contamination of soil by project waste, we must manage properly all of the wastes that come from the project.
2 Mitigation Measures	(5) Noise and Vibration	Do noise and vibrations comply with the country's standards?	Yes, the standards for (ambient) noise specified in Decree of Indonesia Minister of Environment number 48 / 1996,are 55 dBA in housing areas and 70 dBA in business areas. The Lumut Balai Geothermal power plant is located far from any housing complex, and the noise from the power plant will sharply decrease with distance. Regarding vibration, there is so far no standard.
	(6) Subsidence	In the case of extraction of a large volume of groundwater or extraction of steam by geothermal power generation, is there a possibility that the extraction of groundwater or steam will cause subsidence?	Yes, there are several areas in Lumut Balai that could experience subsidence, if the project extracts a large volume of ground water or steam. An EIA study is required to predict where there will be subsidence.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(7) Odor	Are there any odor sources? Are adequate odor control measures taken?	Yes, there are many odor sources in geothermal electric power generation. One of them is H2S. Odor will be controlled by controlling SO2 emissions.
3 Natural Environment	(1) Protected Areas	Is the project site located in a protected area designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	Yes, wells and Geothermal power plant of Lumut Balai including some of the transmission line are located in protected forest area, so that the development of the project will affect the protected area.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Ecosystem	Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	Yes, the project site including transmission line will encompass primeval forest (protected forest) which has rain forest habitats.
		Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	Yes, in this protected forest live some endangered species designated by Indonesia regulations, as well as Bears (Helarctos sp, Sumatera Tigers (Panthera spp), deer (Muntiacus muntjak) etc.
		If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	To reduce impact on those endangered species, the project must restore vegetation in the surrounding area and instruct workers not to hunt the fauna.
		Is there a possibility that localized micro-meteorological changes due to wind power generation will affect valuable vegetation in the surrounding areas? (Is there valuable vegetation in the vicinity of the wind power generation facilities?) If impacts on vegetation are anticipated, are adequate measures considered?	N/A
		Are the wind power generation facilities (wind turbines) sited in consideration of the habitats and migration routes of sensitive or potentially affected bird species?	N/A

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(3) Hydrology	Is there a possibility that hydrologic changes due to installation of structures such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)?	N/A
	(4) Topography and Geology	Is there a possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas (especially in run of the river generation projects and geothermal power generation projects)?	The project will have an impact on topography but it is very small, because the area project only 28 ha.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4 Social Environment	(1) Resettlement	Is adequate explanation on relocation and compensation given to affected persons prior to resettlement?	No, the project will not require resettlement, so there is no need for a resettlement plan.
		Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	N/A
		Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	N/A .
		Are agreements with the affected persons obtained prior to resettlement?	N/A
		Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	N/A
		Is a plan developed to monitor the impacts of resettlement?	N/A
		Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	N/A
		Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	N/A
		Are agreements with the affected persons obtained prior to resettlement?	N/A
		Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	N/A
		Is a plan developed to monitor the impacts of resettlement?	

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Living and Livelihood	Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	Yes, if the project uses the river as a source of water. This is will have an impact on inhabitants ability to irrigate, and automatically will have an impact on the living conditions of the inhabitants. To reduce the impact, the project should avoid directly taking water from the river, but must rather develop a lagoon for water collection.
		Is there a possibility that the amount of water (e.g., surface water, groundwater) used and discharge of effluents by the project will adversely affect the existing water uses and water area uses?	Yes, if the effluent is discharged into ground water or other water resources, it will have an impact on water use, since the local people around the project use the river water for irrigation and drinking water .
	(3) Heritage	Is there a possibility that the project will damage the local archaeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	No, based on surveys and interviews with some respondents, there is nothing of archeological or cultural value near the geothermal power plant. There is thus no possibility that the project will damage the local archeological, historical, cultural or religious heritage.
	(4) Landscape	Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	No, there is no specific or unique landscape in the project area.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(5) Ethnic Minorities and Indigenous Peoples	Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples? Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	No, the people in the area are not categorized as ethnic minorities or indigenous people. N/A
5 Others	(1) Impacts during Construction	Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	The main impact during construction is air pollution, especially concentrations of dust and damage to roads due to heavy equipment transportation. Another impact is river water turbidity caused by soil erosion. All of the impacts can be reduced by several mitigation activities. Yes, the project personnel including workers will receive traffic safety and public health education. It is part of the mitigation of impacts.
	(2) Monitoring	Does the proponent develop and implement a monitoring program for the environmental items that are considered to have potential impacts? Are the items, methods and frequencies included in the monitoring program judged to be appropriate? Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	At this stagge the proponent has not developed a monitoring program, because the proponent has not completed and EIA study. N/A No, the proponent has not yet developed a monitoring program

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
		Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Yes. The government has proposed the format of monitoring reports
6 Note	Reference to Checklist of Other Sectors	Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	Yes. (See 6.2.5)
	Note on Using Environmental Checklist	If necessary, the impacts on transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	No, there is no impact on transboundary or global issues from this project.

Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international

standards, appropriate environmental considerations are made, if necessary.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries

(including Japan's experience).

The Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the

particular circumstances of the country and locality in which it is located.

To confirm the real situation in the field of precious fauna and flora, an additional field survey was conducted.

1) Objective

The objective of the additional field survey for evaluation of the environmental impact on precious fauna and flora, which was already outlined on the basis of a literature investigation and hearings, is to confirm the actual living and breeding situations of these species on the site in the Lumut Balai geothermal development field. These results of the site survey should contribute to the environmental impact evaluation for those species and also to recommendations of plans to mitigate the anticipated impacts on these species.

2) Methodology of the survey

The precious fauna and flora living and growing in the area which contains Lumut Balai geothermal development field should be delineated based on the EIA report of PGE, the relevant documents and information from the local residents. Then, in order to confirm the actual situation of living and breeding of the species which should be carefully considered among them, site surveys should be carried out to observe the animals themselves or traces of them such as hair, waste, tracks and trails, and to study their habitat. In addition, hearings should be conducted with participation of the local residents to collect relevant information required.

3) Survey area

Field surveys were conducted mainly for the area of well pads, power plants and access roads (existing and planned) of Lumut Balai geothermal development field.

Survey tracks are shown as lines in Fig. 19. Light green color tracks are shown for the herpetofauna and fish, and orange color tracks are for Aves and mammals, all near the well pads and power plant.

4) Survey period

From February 3 to February 16, 2011

It was a typical rainy season in Muara Enim.

5) Survey team

Since there are many kinds of fauna and flora in the Lumut Balai geothermal development field, it was necessary to enlist experts for each field to distinguish species. Therefore, the survey team consisted of six experts; a mammal expert, reptile expert, Aves expert, aquatic biota expert, flora expert, and biology expert.

6) Listed up categories of precious flora and fauna

In this survey, the species which are protected by Indonesian law/regulation were listed up.

Laws/Regulations used as references are:

- Law No. 5 / 1990 on Conservation of Biological Resources and Ecosystems;
- Government Regulation No. 7 of 1999 concerning the Preservation of Plants and Animals.
- Government Regulation No. 60 of 2007 on the Conservation of Fish Resources

7) Survey results

Regarding precious fauna and flora, the existence of eight species of mammals, ten species of Aves and one species of flora were confirmed. Aves, mammals and flora are thought to be distributed all through the forest area in and around the Lumut Balai geothermal development field (Fig. 19). Results of the survey are summarized in Table 14.

8) Discussion

a) Environmental assessment for precious flora and fauna potentially affected by the Lumut Balai geothermal power development

Land clearing in the area of Lumut Balai geothermal development field, of course, will have an impact either directly or indirectly on wildlife. The impact will occur in the form of habitat loss or habitat fragmentation.

But the habitat and breeding area of each precious species confirmed in this survey is not thought to be limited to the development field, but to be widely distributed in and around the development field. Therefore, the environmental impact on the precious flora and fauna will be small given the application of appropriate mitigation measures. General information about precious flora and fauna in and around the Lumut Balai geothermal power development area were obtained by this short-term field survey. Considering seasonal changes in situation of flora and fauna, it is desired that further impact assessment and considering about mitigation of preservation should be conducted after the survey about vegetation and ecological characteristic of each species as possible as they can.

b) Mitigation of impacts on precious flora and fauna in the Lumut Balai geothermal power development field

Based on the results of the environmental survey, the following mitigation of impacts on precious flora and fauna should be implemented.

- Preventing the clearing of land beyond what is absolutely necessary.
- Replanting the precious flora that is found in the development field
- Taking care to ensure water quality during construction work (sand basin, treatment for turbid water)
- Creation of habitat with vegetation harmonized with the environment (with plants found in the power plant site as far as possible)
- Road and site preparation that do not create turbid water (during construction and operation)
- Considering all the conditions, preserving animal trails by lifting up part of the pipeline or lowering the ground level, if necessary
- Patrolling to prevent hunting wild animals, and safety patrols around the project site

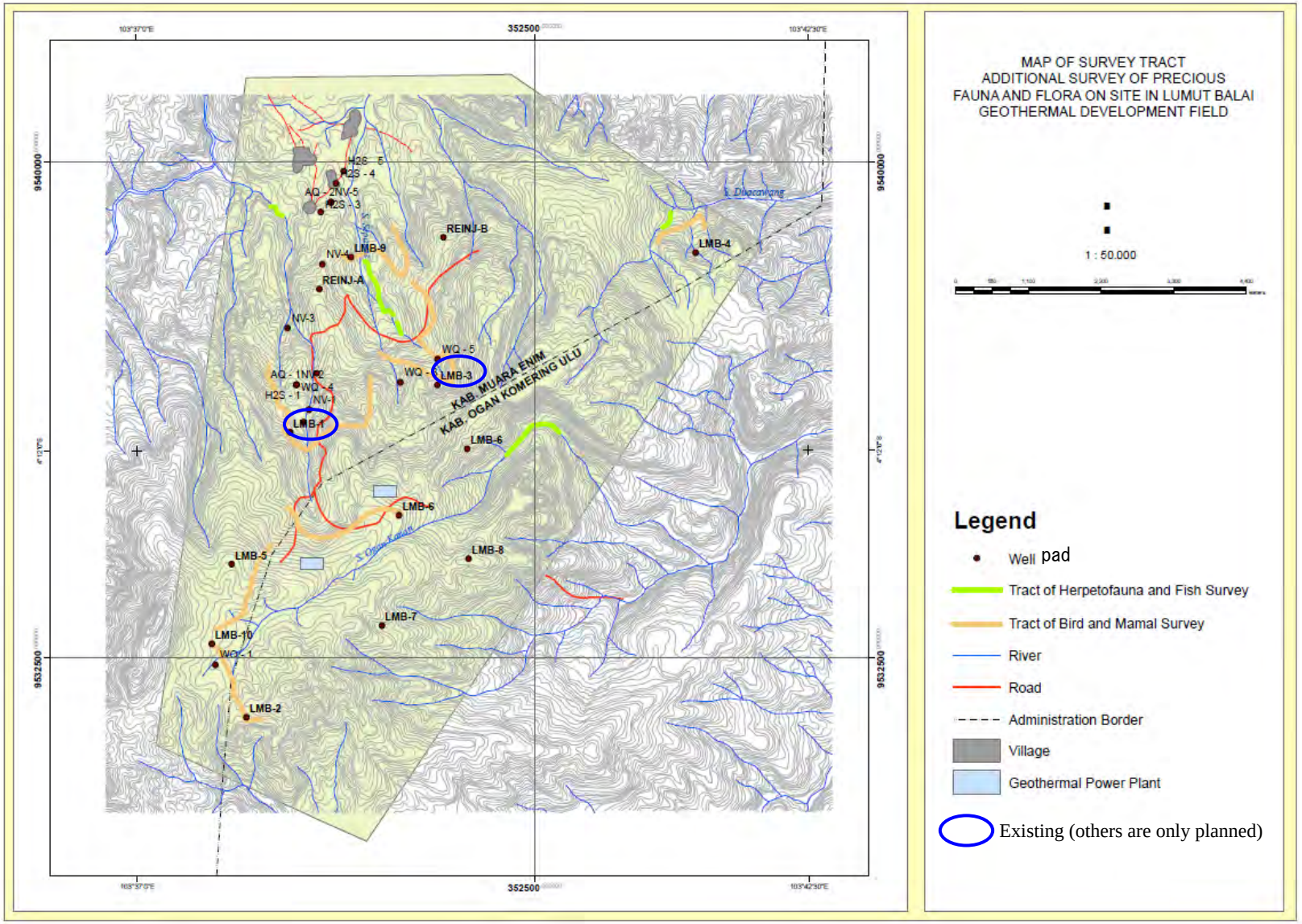
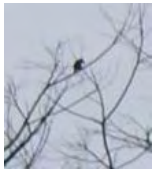
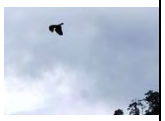


Fig. 19 Map of surveyed precious flora and fauna

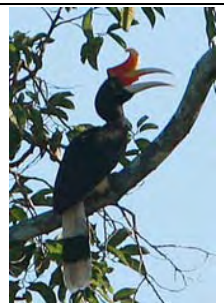
Table 7 Precious fauna and flora confirmed of the existence in this survey

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (track, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
AVES							
 Name : Plain sunbird (*Anthreptes simplex*) Local name : Burung madu polos IUCN: LC	In the course of survey at well pad LMB-4	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Cost of building green zone : 250 million Rp. **(0.027millionUS$)** • Sand basin should be tentatively prepared in civil work during construction
 Name : Collared kingfisher (*Todirhamphus chloris*) Local name : Cekakak sungai IUCN: LC	On the track of survey at well pads RenjA - RenjB	Sighting and call 	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
AVES							
 Name : Changeable hawk-eagle (*Spizaetus cirrhatus*) Local name : Elang brontok IUCN: LC	On the track of survey at the well pads RenjA - RenjB	Sighting 	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction
  Name : Black eagle (*Ictinaetus malayensis*) Local name : Elang hitam IUCN: LC	On the track of survey at well pads LMB 6 – LMB 7	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
AVES							
 Name : Crested serpent eagle (*Spilornis cheela*) Local name : Elang ular bido IUCN: LC	On the track of survey at well pad LMB 1	Sighting and call	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction
 Name : Oriental pied hornbill (*Anthracoceros albirostris*) Local name : Kangkareng perut putih IUCN: LC	On the track of survey at well pad LMB 1	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
AVES							
 Name : Pied fantail (*Rhipidura javanica*) Local name : Kipasan belang IUCN: LC	On the track of survey at well pads LMB 2 – LMB 5	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction
 Name : Schneider's pitta (*Pitta schneideri*) Local name : Paok Schneider IUCN: VU	On the track of survey at well pad LMB 4	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
AVES							
 Name : Rhinoceros hornbill (Buceros rhinoceros) Local name : Rangkong badak IUCN: NT	On the track of survey at well pad LMB 3	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction
 Name : Rueck's blue-flycatcher (*Cyornis ruckii*) Local name : Sikatan aceh IUCN: CR	On the track of survey at well pad LMB 4	Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work.	• Included in the cost above • Sand basin should be tentatively prepared in civil work during construction

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
MAMMALS							
 Name : Agile gibbon (*Hylobates agilis*) Local name : Siamang/Ungko IUCN: EN	On the track of survey at well pads • LMB 3; • LMB 2 – LMB 5; • LMB 6 – LMB 7; • LMB 1; • RenjA-RenjB	• Direct observation • Call	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, preserving the animals trails by lifting up the part of the pipeline or lowering the ground level, if necessary	• Included in the cost for aves • Sand basin should be tentatively prepared in civil work during construction • Operational cost of patrol =75 million Rp. per year(0.008MUS$) • Lifting up the part of pipeline or lowering the ground level =6.6 billion Rp.(0.73MUS$)
 Name : Barking deer (*Muntiacus muntjak*) Local name : Kijang IUCN: LC	On the track of survey at well pads • LMB 3; • LMB 2 – LMB 5; • LMB 6 – LMB 7	Footprints 	Brush/shrub	All the forest area in and around the LMB GPP field. Surrounding rivers near to LMB GPP where they seek drinking water	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
MAMMALS							
 Name : Malayan porcupine (*Hystrix brachyuran*) Local name : Landak IUCN: LC	On the track of survey at well pad LMB 1	• Nest • Information from local people 	Nest in the ground	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above
 Name : Malayan sunbear (*Helarctos malayanus*) Local name : Beruang IUCN: VU	On the track of survey at well pads • LMB 1; • RenjA-RenjB	Scratches and nest 	Trees and ground	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
MAMMALS							
 Name : Malayan pangolin (*Manis javanica*) Local name : Trenggiling IUCN: EN	On the track of survey at well pad LMB 3	Nest 	Nest in the ground	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above
 Name : Malayan tapir (*Tapirus indicus*) Local name : Tapir IUCN: EN	On the track of survey at well pad LMB 4	Footprint 	Brush/shrub	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above
 Name : Bearcat (*Arctictis binturong*) Local name : Binturung IUCN: VU	On the track of survey at well pads • LMB 4; • LMB 6 – LMB 7	• Nest • Information from local people 	Brush/shrub	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above

Name of Observed Precious Species (Photo)	Item						
	Observation point	What Signature (foot print, spoor, hair, feather, egg etc)	Breeding place	Inhabited area (assumed inhabited area in and around the LMB GPP field)	Assumed degree of impact of development of LMB GPP	Necessary mitigation	Estimated cost for mitigation (for unit 1 - 4)
 Name : Three-striped ground squirrel (*Lariscus insignis*) Local name : Bajing tanah bergaris tiga IUCN: LC	On the track of survey at well pads • LMB 4; • RenjA-RenjB	Direct watching/Sighting	Trees	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible. • Measures to preserve water quality during construction work. • Patrol for hunting • Considering all the conditions, keep the pathway by lifting up the part of pipeline or lowering the ground level, if necessary	Included in the cost above
FLORA							
Name :  Nepenthes (*Nepenthes gynamphora*) Local name : Kantong semar IUCN: Not registered	On the track of survey at well pads • LMB 3; • LMB 4 • LMB 2 – LMB 5; • LMB 6 – LMB 7; • LMB 1; • RenjA-RenjB	Direct observation	On the ground	All the forest area in and around the LMB GPP field	• Little impact because there is a possibility that breeding and inhabited area is not limited to the development area, but widely distributed in the development field.	• Reducing the land clearing to the minimum possible.	Included in the cost above

Listed in PGE's AMDAL

IUCN category
CR: Critically Endangered EN: Endangered
VU: Vulnerable NT: Near Threathened
LC: Least Concern

<Total>
Initial investment 0.75 MUS$
- Cost of build green zone 0.027 MUS$
- Lifting up the part of pipeline or lowering the ground level 0.73 MUS$

O&M 0.008 MUS$ per year
- Operational cost of patrol

(Source) JICA study team

Transmission Line

- ✓ EIA

  Part of the land for the transmission line is in the protected forest (Hutan Lindung). The voltage of the line is 275kV. Indonesian environmental regulations require an EIA, which will be conducted by PLN. The results of environmental confirmation are shown in Table 15.

- ✓ Land acquisition

  Land acquisition will be conducted by PLN. In the protected forest (Hutan Lindung), PLN will obtain permission for utilization from the Ministry of Forestry after the EIA is approved.

- ✓ Compensation of ROW

  Compensation of ROW will be conducted by PLN.

Table 8 Environmental Check List for the Transmission Line

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports already been prepared in the official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a)N (b)N (c)N (d)N	(a) Now in preparation and will be finished in June 2011 (b) Will be approved in July 2011 by South Sumatra province (c) -- (d) After approved of EIA, usage permit for protected forest will be necessary
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected in the project design?	(a) Y (b) --	(a) PLN have explained to local stakeholders (b) They should be
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) N	(a) Route will be modified
2 Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	(a) --	(a) Will be comfirmed in the EIA
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) Y	(a) Protected forest needs a usage permit from the Ministry of Forestry
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock? (e) Is there any possibility that the project will cause negative impacts,	(a) -- (b) -- (c) -- (d) -- (e) N (f) N	(a) Will be comfirmed in the EIA (b) Will be comfirmed in the EIA (c) They should be (d) They should be (e) -- (f) The land other than the protected forest consists of rice paddy, fields, coffee plantations and scrub and is less natural than protected forest. The area for transmission towers is small (900m2). So the impact on the environment will be small even near the borderline of regency of Lahat and

		such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?		Muara Enim though it's between HSAW and HL.
3 Natural Environment	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there any possibility that civil work, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(a) -- (b) -- (c) --	(a) Should be comfirmed in the EIA (b) Should be comfirmed in the EIA (c) Should be comfirmed in the EIA
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation of compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document form? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is a grievance redress mechanism established?	(a) N (b) -- (c) -- (d) -- (e) -- (f) -- (g) -- (h) -- (i) -- (j) --	(a) There is no resettlement plan (b) -- (c) -- (d) -- (e) -- (f) -- (g) -- (h) -- (i) -- (j) --
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (c) Is there any possibility that installation of structures, such as power line towers will cause radio interference? If any significant radio interference	(a) -- (b) -- (c) -- (d) --	(a) Should be comfirmed in the EIA (b) Should be comfirmed in the EIA (c) Should be comfirmed in the EIA (d) They should be

		is anticipated, are adequate measures considered? (d) Are the compensations for transmission wires given in accordance with the domestic law?		
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) --	(a) Should be comfirmed in the EIA
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) --	(a) Should be comfirmed in the EIA
	(5) Ethnic Minorities and Indigenous Peoples	(a) Is consideration given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) -- (b) --	(a) Should be comfirmed in the EIA (b) They should be
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project do not violate the safety of other individuals involved, or local residents?	(a) -- (b) -- (c) -- (d) --	(a) Should be comfirmed in the EIA (b) Should be comfirmed in the EIA (c) Should be comfirmed in the EIA (d) Should be comfirmed in the EIA
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) -- (b) -- (c) --	(a) Will be comfirmed in the EIA (b) Will be comfirmed in the EIA (c) Will be comfirmed in the EIA
	(2) Monitoring	(a) Does the proponent develop and implement a monitoring program for the environmental items that are considered to be vulnerable to potential impacts? (b) What are the items, methods and frequencies of the monitoring program?	(a) -- (b) -- (c) -- (d) --	(a) Will be comfirmed in the EIA (b) Will be comfirmed in the EIA (c) Will be comfirmed in the EIA (d) Will be comfirmed in the EIA

		(c) Has the proponent established an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?		
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) N	(a) Roads will not be newly constructed
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) None are assumed

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards,
appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries
(including Japan's
experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the
country and locality in which it is located.

5. CONFIRMATION OF THE CURRENT STATUS OF SIMILAR JAPANESE ODA LOAN PROJECT

- ✓ In the Lahendong geothermal field, North Sulawesi, well LHD-23 is one of production wells which produce acid fluids, and this fluid is separated into two branch lines. One is made from carbon steel line (CSL) and the other one is a stainless steel line (SSL). A caustic soda of 48% is already dosed into the bleed pipe of LHD-23 to shift the pH value slightly to the alkaline side.
- ✓ Two 48% caustic soda tanks whose capacity is $30m^3$ were installed just beside LHD-23 in order to inject caustic soda into it. When the neutralization system is adopted, this equipment is utilized. Alkaline concentration is an important factor because hydrogen cracking occurs at high temperature. Therefore, 48% caustic soda should be reduced to 30% to avoid this cracking. At the site, fresh water from the river is supplied to the caustic soda line to dilute it. 10 mg/L dissolved Oxygen is usually contained in it, and Oxygen in fresh water is also one reason for corrosion problems. So, this gas should be removed by de-gassing equipment.
- ✓ The pH value of the acidic fluids in the reservoir is around 5 due to the un-dissociated condition of sulfuric acid. After flushing, protons are dissociated and leached from the sulfuric acid to lower the pH value. Therefore, the optimum dispersion depth of caustic soda should be below the flashing point. Judging from PTS data, it is recommended that the dispersion depth of caustic soda be in the range from a depth of 1650m to 1700 m at a well-head pressure of 0.84 MPa.
- ✓ Eight month of experiments on the CS line at pH 4.5 showed that the scale deposition rate was 18mm/year near the dosing point. This causes a clogged condition near the dispersion point, and steam production decreases. There are two ways to solve this problem. One is for pH modification to be in the range from 4 to 4.5. In this case, at the beginning stage (the first one or two months), pH is modified to 4.5 to make a thin scale film on the pipe to protect it from corrosion, and next, the pH value is shifted to 4.0 to control the growth rate of scale on the pipe. This is the best way to operate the system. The implementation plan for corrosion and scale testing should be carried out to estimate the actual scale thickness. Rough cost estimates for 5 MW and 15 MW of LHD-23 were calculated, and these are itemized below. The whole system for the neutralization method is also shown below.

Table 9 Cost Estimates for LHD-23 in the Case of 5 MW and 15 MW

Chemical cost		unit	5MW	15MW	Remarks
A	The amount of 48%-NaOH	t/D	2.4	7.2	From field data
B	Purchase price of 48%-NaOH	US$/t	300	300	
C	Dosing day	day/y	340	300	
(1)	Annual cost	US$/y	244,800	648,000	
Surface equipment cost					
D	Dosing pump	US$	15,000	15,000	one unit
E	Monitoring system	US$	70,000	70,000	pH & Fe
F	Pipe	US$	12,000	20,000	
G	Weight Bar	US$	1,500	3,000	
H	Lubricator	US$	2,000	2,000	
I	winch truck	US$	150,000	150,000	8 years for service life
J	Service life	y	8	4	
(2)	Annual cost		31,313	46,250	
Well bore equipment cost					
K	Coiled tubing(1500m)	US$	14,000	14,000	
L	Service life	y	0.5	0.3	
(3)	Annual cost		28,000	46,666	
aaa	Total cost=(1)+(2)+(3)	US$/y	304,113	740,916	

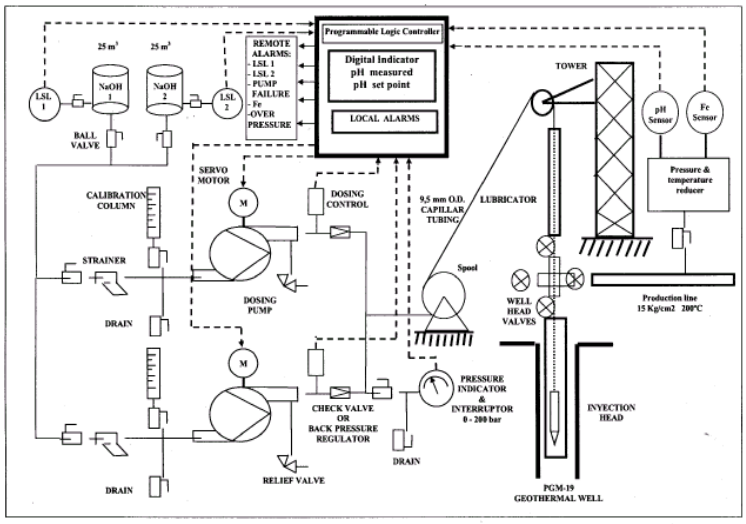


Fig.20 Permanent Dosing System for LHD-23

6. CONCLUDING REMARKS

Resource Development

- ✓ The reservoir will be able to sustain the power generation of 110 MW for Units 3 and 4 for 30 years as well as Units 1 and 2.
- ✓ 17 production wells and 8 reinjection wells (7 for brine and 1 for steam condensate) will be required to commission the power plant operation of Units 3 and 4.
- ✓ Well pads LMB5 (6 wells), LMB10 (6 wells) and LMB2 (5 wells) should be used as production well pads for Units 3 and 4.

Environmental and social considerations

- ✓ There are no serious constraints on the construction of a geothermal power plant due to the social/natural environment.
- ✓ As a result of the site survey, the existence of eight species of mammals, ten species of aves and one species of flora were confirmed. Aves, mammals and flora are thought to be distributed all through the forest area in and around the Lumut Balai geothermal development field. These results should contribute to the environmental impact evaluation for those species and also to recommendations of plans to mitigate the anticipated impacts on these species.
- ✓ Land clearing in the area of Lumut Balai geothermal development field will have an impact either directly or indirectly on wildlife. The impact will occur in the form of habitat loss or habitat fragmentation. But the habitat and breeding area of each precious species confirmed in this survey is not thought to be limited to the development field, but to be widely distributed in and around the development field. Therefore, the environmental impact on the precious flora and fauna will be small given the application of appropriate mitigation measures.
- ✓ For the transmission line, PLN is now preparing to deal with environmental and social considerations on the basis of the regulations.

8. RECOMMENDATIONS

Additional Survey and Analysis

- ✓ Detailed MT survey

  In order to secure and raise the success rate of well drilling in the development area for Units 3 and 4, an additional detailed MT survey is recommended that should be conducted with high density measurement points for the purpose of clarifying the drilling targets for wells. For example, the following specifications for a detailed MT survey should be implemented.

  - ➢ Remote reference measurement

    The location for remote reference should be in a place which is sufficiently far from the survey area to avoid electro-magnetic noise.

  - ➢ Space between the measurement points

    The space between measurement points should be decided based on the survey area and survey cost. The recommended spacing is 500 to 1000 m.

- Measurement time

  The measurement time should be around 15 hours from 17:00 to 8:00 AM. If the data quality is bad, it is recommended to continue measurement for a few days or change the direction of the measurements.

- Measurement frequency

  More than 60 kinds of frequency are recommended within the range between 300 HZ to 0.005 HZ.

- Measurement factors

  Five factors (Ex, Ey, Hx, Hx, Hy and Hz) are recommended.

- Measurement points

  Assuming the space between the measurement points is 1000 m, around 40 points for the survey area of around 6 km^2 are recommended.

✓ Update of Simulation Study

In order to optimize field development plan, resource assessment should be updated through further reservoir modeling and simulation study after the drilling of wells for Units 3 and 4.

✓ Horizontal discharge tests are strongly recommended to be conducted as soon as possible to confirm deliverability and the chemical features of discharged fluids, including non-condensable gas contents in the steam and contents in the discharged brine of the existing wells.

✓ These tests will make clear the quality and quantity of produced steam/brine and provide essential data for detailed plant design. Moreover, the required number of start-up wells and of make-up wells can be examined in detail, using data obtained from these tests.

Power Plant

✓ FCRS

For detailed planning/design, a topographic survey of pipeline routes should be carried out by PGE.

✓ Power Plant

For detailed planning/design of the power plant, a topographic survey and soil boring should be carried out by PGE. Also, meteorological investigation at the prospective site should be carried out by PGE for one (1) year for detailed planning/design of the power plant layout, storm water drainage, cooling tower, plant performance, etc. The purpose of meteorological investigation is to collect data including temperature (dry bulb, wet bulb), humidity, rain fall intensity, wind direction, and wind speed.

✓ Transportation

Several truss and concrete bridges, including a railway overpass, are found on both of the transportation routes, i.e. Panjang seaport to site and Palembang river port to site. Accordingly, it is strongly recommended that the EPC Contractor carry out detailed surveys, including inspection of the heights of the truss bridges and their strength for safe transportation of the equipment and materials, once the EPC Contractor for the power plant has been selected, so that the EPC Contractor can confirm for itself if its equipment and materials can be transported without

problem.

✓ O&M

In order to achieve efficient and effective O&M management, Lumut Balai Units 1 and 2 should be the principle power plant of the whole Lumut Balai geothermal field. Under such a scheme, Lumut Balai Units 3 and 4 would be operated remotely from Units 1 and 2. Likewise, heavy equipment for maintenance, common spare parts, manpower, etc. could be centralized at the Unit 1 and 2 power plant.

Transmission Line and Substation

✓ Summary

It is important that PLN should control the construction schedule for the transmission line from Lumut Balai Geothermal power plant to Lahat substation.

✓ 275 kV Transmission line

1) Construction schedule

The transmission line from Lumut Balai Geothermal power plant to Lahat Substation must be completed before receiving power from Lumut Balai units 1&2. If PLN applies consulting service using JICA loan, the completion of the transmission line will not be in time by the commissioning of Lumut Balai units 1&2. Since PLN has already substantial construction experience of 275kV transmission line over 500km between Lahat S/S and Kiliranjao S/S, consulting service for the 275kV transmission line is not mandatory for PLN.

2) 275 kV Lahat substation

155/20kV Lahat substation will be upgraded to a 275/150/20kV substation. According to RUPTL 2010 - 2019, the construction of Lahat 275kV substation and 275kV upgrading work are scheduled for completion in 2012 by World Bank loan. The transmission line from Lumut Balai geothermal power plant will be connected to the 275kV Lahat substation. It is recommended that the upgrading schedule for Lahat substation should be followed.

3) Interconnection line between Lumut Balai units 1&2 and 3&4

A transmission line connecting Lumut Balai units 1&2 and units 3&4 should be constructed. It is recommended that early negotiations be held with PLN and PGE to agree who will construct the transmission line, and preparation of AMDAL should be commenced for construction of the transmission line.

Environmental and social considerations

✓ General information about precious flora and fauna in and around the Lumut Balai geothermal power development area were obtained by this short-term field survey. Considering seasonal changes in situation of flora and fauna, it is desired that further impact assessment and considering about mitigation of preservation should be conducted after the survey about vegetation and ecological characteristic of each species as possible as they can.

✓ Based on the results of the environmental survey, the following mitigation of impacts on precious flora and fauna should be implemented.

- Preventing the clearing of land beyond what is absolutely necessary.

- Replanting the precious flora that is found in the development field
- Taking care to ensure water quality during construction work (sand basin, treatment for turbid water)
- Creation of habitat with vegetation harmonized with the environment (with plants found in the power plant site as far as possible)
- Road and site preparation that do not create turbid water (during construction and operation)
- Considering all the conditions, preserving animal trails by lifting up part of the pipeline or lowering the ground level, if necessary
- Patrolling to prevent hunting wild animals, and safety patrols around the project site

✓ Study of the environmental impact of the construction of a transmission tie – line between units 1,2 and units 3,4 should be conducted after the transmission line route and responsible company have been decided.

Implementation Plan and Costs

✓ The feasibility of a brine binary system to get additional electricity output may be studied in the future on the basis of the chemical and delivery data for wells which will be accumulated during commercial operation of the power plants.