The Republic of Indonesia
Ministry of Energy and Mineral Resources
PT PLN (Persero)

Project for the Master Plan Study of Hydropower Development in Indonesia

FINAL REPORT

VOL. I　EXECUTIVE SUMMARY

August 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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EXECUTIVE SUMMARY

1. BACKGROUND AND OBJECTIVES OF THE STUDY

More than ten years have already passed since the second nation-wide hydropower potential study (HPPS2; Hydro Inventory and Pre-feasibility Studies in 1996-99). It can be assumed possible that the development scales and schemes which were recommended in that study may not conform to present guidelines for environmental and social considerations, and also not to present electric power supply and demand balance appropriately.

In the light of the afore-mentioned background, it becomes necessary to review and update the existing hydropower development plan, and thus the Government of Indonesia requested the Government of Japan to fulfill such necessity by conducting JICA's technical assistance.

The Study aims at technical assistance in formulating the hydropower development master plan which accords with the economic and industrial development of Indonesia in future. Followings are taken into account for formulating the master plan.

- The master plan will be based on the power sector plan, and be consistent with the latest power demand forecast and the transmission line plan.
- Role of hydropower in each region/river/system will be examined.
- Prioritization of candidate sites for hydropower development will be conducted, and concrete investment program will be established.
- Pre-feasibility level study shall be conducted for selected prospective plans taking account of financing by ODA.

Transfer of knowledge and capacity building are conducted through the joint implementation of the study. The Study aims to contribute to the stable power supply necessary to support the economic growth of Indonesia through the hydropower development based on the formulated master plan.

The Study covers the whole country of Indonesia. More specifically, the Study focuses on the hydropower development potential sites listed in the inventory attached in the Minutes of Meeting agreed between MEMR, PLN and JICA on 2nd March, 2009.

2. NATIONAL ENERGY POLICY

The targets prescribed in the energy policies are summarized in below.

National Targets on Energy

	National Energy Policy (KEN) 2003-2020	**National Energy Management Blueprint (BP-PEN) 2005-2025**	**National Energy Policy (KEN)**	**National Energy Management Blueprint (BP-PEN) 2006-2025**
Legal Basis	Kepmen ESDM No. 0983 K/16/MEM/2004		Perpres RI No. 5/2006	
Date of Issue	March 10, 2004		January 25, 2006	
Targets:				
Electrification Ratio	90 % in 2020	95 % in 2025	--	95 % in 2025
Energy Consumption	--	10 BOE/capita in 2025	--	10 BOE/capita in 2025
Primary Energy Mix	--	Oil: 26.2 % Gas 30.6 % Coal: 32.7 % Hydro: 2.4 %	To national energy consumption: Oil: less than 20 % Gas: more than 30 % Coal: more than 33 %	
Alternative (New and Renewable) Energy	at least 5 % in 2020 by geothermal, biomass and micro/mini hydro, excluding large scale hydro	Geothermal: 3.8 % Others: 4.4 %	Biofuels: more than 5 % Geothermal: more than 5 % Liquefied Coal: more than 2 % Others (biomass, nuclear, hydropower, solar, and wind power): more than 5 %	
Energy Intensity	1 % reduction p.a.	--	--	--
Energy Elasticity	--	--	less than 1 in 2025	

Source: Assembled by JICA Study Team from the original documents.

Among various targets, high-lighted boxes are considered to be currently active. Projection of energy mix as seen in National Energy Management Blueprint (BP-PEN) 2006-2025 is tabulated in below.

Projection of Energy Mix (RIKEN scenario)

(Unit: million BOE)

Type of Energy	**2005**	**2010**	**2015**	**2020**	**2025**	
Crude Oil	524.0	550.7	578.0	605.8	638.9	19.6%
Coal	160.4	210.3	349.7	743.8	1,099.4	33.8%
Gas	212.8	363.7	382.5	477.1	832.0	25.6%
Coal Bed Methane	--	--	23.0	74.6	127.8	3.9%
Biofuel	--	32.5	89.0	102.4	166.9	5.1%
Geothermal	23.7	23.7	61.8	115.8	167.5	5.2%
Liquefied Coal	--	--	14.2	47.4	80.5	2.5%
Hydropower	**34.0**	**41.7**	**56.6**	**60.5**	**65.8**	**2.0%**
Nuclear	--	--	--	27.9	55.8	1.7%
Other alternative energy	1.6	3.5	7.4	11.7	17.4	0.5%
TOTAL	956.5	1,226.1	1,562.1	2,266.9	3,252.2	100.0%

Source: Blueprint *Pengelolaan Energi Nasional* 2006 – 2025, MEMR

The table below presents the estimation of required capacity for hydropower generation to realize the figure indicated in the above table. The required generation capacity will account for 20 to 30 GW of hydro.

Required Capacity deduced from RIKEN Scenario

Type of Energy	Percentage to total energy consumption	Energy consumption		Capacity Factor* (%)	Capacity** (MWe)
		million BOE	GWh		
Hydropower	2.0 %	65.8	104,865	40	30,000
				50	24,000
				60	20,000

*: Assumption by JICA Study Team
**: rounded to GW.

Source: JICA Study Team based on RIKEN 2005 scenario.

3. HYDROPOWER POTENTIALS

The candidate hydro projects to be considered in this study were given by MEMR and PLN in the minutes of meeting dated March 2, 2009, which have been passed through the 3rd screening in the 2nd Hydro Power Potential Study (HPPS2) and ongoing and planned projects which have been under construction, or have experienced pre F/S, F/S or D/D.

The projects focused in this study are summarized in below along with existing hydropower plants.

Summary of Hydropower Projects focused in the Study

Region	Existing			Planning & Ongoing			HPPS2			Total		
	Loc	Capacity (MW)	Energy (GWh)	Loc	Capacity (MW)	Energy (GWh)	Loc	Capacity (MW)	Energy (GWh)	Loc	Capacity (MW)	Energy (GWh)
Sumatera*	13	1,443	8,223	20	2,110	10,384	55	3,586	15,334	88	7,139	33,941
Kalimantan	1	30	136	8	1,038	6,949	9	5,456	14,520	18	6,523	21,605
Sulawesi	6	352	1,210	11	1,050	6,092	17	4,357	13,046	34	5,759	20,348
Maluku				2	66	472	4	132	554	6	198	1,026
Papua				2	72	316	20	2,273	15,190	22	2,345	15,506
Nusa Tenggara				4	38	174	6	146	549	10	184	723
Java-Bali	27	2,513	8,098	14	1,583	4,112	4	78	522	45	4,174	12,732
Total	**47**	**4,338**	**17,667**	**61**	**5,956**	**28,499**	**115**	**16,027**	**59,714**	**223**	**26,321**	**105,880**

Note) Existing capacity and Energy of Sumatra includes those of Asahan II project.
Source: JICA Study Team.

4. PROJECT CLASSIFICATION

Evaluation items to identify the degree of difficulty in development activities are categorized from less difficulty to seriously difficult (*i.e.*, from A to D; D is regarded as the most difficult degree) at each evaluation item based on development possibility. Project classification is conducted in the manner as below.

Classification Criteria for Environmental Aspects

Items \ Rank	A	B	C	D
Definition	Difficulties are expected to be less.	Although certain difficulties are expected, the solution could be found.	The solution for the constraints is considered as difficult.	The solution for the constraints is considered as very difficult.
Forest type	NA	Production Forest(HP), and Conversion Forest(HK)	Protection Forest(HL)	Nature Forest Reserve and Tourism/Recreation Forest (Hutan Suaka Alam:HSA)
Resettlement	0~50 HH	50~400 HH	400~1,000 HH	1,000~HH
Reservoir Area	0~100 ha	100~1,000 ha	1,000~10,000 ha	10,000~ ha

Source: JICA Study Team

Mechanically applying the above screening criteria and according to the following procedures, we determined the priority of the schemes;

i) which passed the 3rd screening of HPPS 2, and
ii) which D/D, F/S and pre F/S were conducted for.

1. The schemes which have i) D rank in environment, ii) installed capacity of less than 10 MW, iii) IPP status of PPA or more advanced, or iv) less project economy , v) project scale is too large to the system are shaded by red color in respective cells.
2. The schemes which have i) RES type and C rank in environment, or ii) IPP status of MOU are shaded by yellow color in respective cells.
3. Schemes which are shaded by red color are classified as "✕".
4. Schemes which are shaded in yellow color are classified as "△".
5. Among the schemes which are classified as "△", if C is given in two environmental aspects (e.g. inundation of 1,000ha or more in HL), or ii C is given to resettlement (i.e. 400HH or more), those schemes are classified as "△△".
6. Schemes which are not shaded by red nor yellow colors are classified as "○".
7. Priority might be given to schemes in order of "○" > "△" > "△△" > "✕".

5. HYDROPOWER DEVELOPMENT MASTER PLAN

While hydropower development has been stalling in recent years, the Government has advocated ambitious targets for hydropower development. In this background, keeping the hydro potential and the electricity demand described in the previous section in mind, we established three development scenarios and examined them.

i) Policy Oriented Scenario

In this scenario, all the potential projects indicated in the hydro project list were taken into consideration as much as possible. However, even this scenario missed the target in the National Energy Policy due to constraint in the combination of hydro potential and electricity demand.

ii) Realistic Scenario

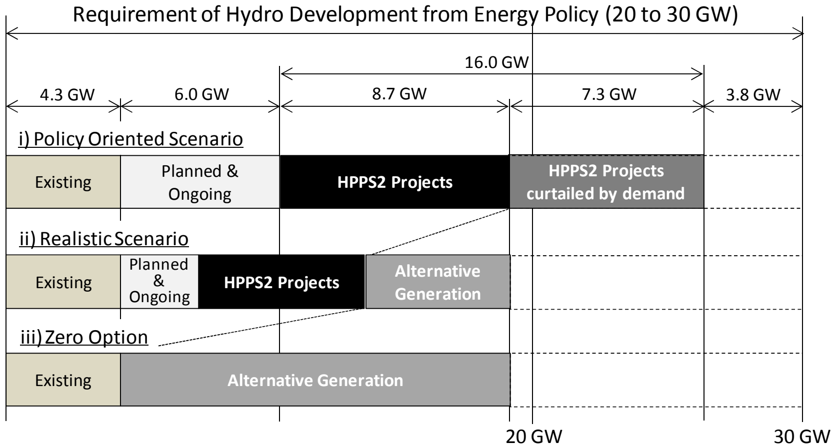
Reviewing the recent experience, social and environmental impacts were one of the most dominant causes to hinder hydro projects. For example, Poigar 2 project in North Sulawesi has long been stalling, part of which project is located within the Conservation Forest (*Hutan Konservasi*) area defined by the Government. Also, implementation of Kusan project in South Kalimantan is suspended due to a rare mammal's inhabitance in the project area. In addition, project economy and electricity demand in the supply area were considered, and more realistic development scenario was made.

The lost hydro capability compared to that of the above scenario has to be made up for by other generation options to meet power demand, and coal thermal generation was taken for base load, and gas turbine generation for peak load, same as the manner in the economic valuation.

iii) Zero Option

We examined an extreme scenario that no hydropower development was realized, as a "Zero Option", and even the projects for which some actions such as construction financing, detailed studies etc. has been set about, were to be abandoned in this scenario. The alternative supply capability was taken in the same manner as in the "realistic scenario".

The graphic image of the above three scenarios is illustrated in below.



Source: JICA Study Team

Graphic Image of Development Scenarios

Each scenario has advantages and disadvantages derived from the characteristics of hydropower generation, and it is difficult to weigh such advantages and disadvantages in a balance. In this background, realistic scenario is well-balanced, and remarkably the number of involuntary resettlement, the number of projects violating protected area, which are selected as screening criteria in this study, are well managed unproportional to the amount of hydro development, while other items are almost proportional to them. Consequently, we took realistic scenario as the recommendable scenario as below.

Hydro development in Realistic Scenario to 2027

Region	Total			
	Loc	Capacity (MW)	Energy (GWh)	Capital Cost (mil. $)
Sumatra	44	3,548	14,222	7,510
Kalimantan	2	366	2,478	935
Sulawesi	16	3,137	13,232	5,662
Maluku	4	156	872	342
Papua	1	49	248	154
Nusa Tenggara	1	11	59	33
Java-Bali	6	773	2,081	1,435
Total	**74**	**8,040**	**33,193**	**16,070**

Source: JICA Study Team

Comparison among Development Scenarios

Item			Policy Oriented Scenario		Realistic Scenario		Zero Option
Generation indicators	(1) Hydro Capacity to be developed	-	14,762 MW at 149 locations (19,100 MW in total)	-	8,040 MW at 74 locations (12,378 MW in total)	-	Nil (4,338 MW in total)
	(2) Hydro energy production	-	60,098 GWh p.a.	-	33,193 GWh p.a.	-	Nil
	(3) Alternative generation	-	Nil.	-	PLTU: 1,297 MW PLTG: 5,425 MW	-	PLTU: 2,933 MW PLTG:11,829 MW
Policy consistency	(4) Consistency with Energy Policies	○	Nearly equivalent to the target in KEN.	△	Miss the target by half.	×	Miss the target widely.
	(5) Utilization of indigenous energy	○	100 % renewable and indigenous energy.	△	Fossil fuels are indigenous, but unevenly distributed. Expensive and imported oil will be required for PLTG in the region with no gas supply.	×	Fossil fuels are indigenous, but unevenly distributed. Expensive and imported oil will be required for PLTG in the region with no gas supply.
Economic and Financial Aspects	(6) Require capital for hydro development	×	$ 31.2 billion (2011US$)	△	$ 16.1 billion (2011US$)	○	Nil
	(7) Total capital investment	×	$ 31.2 billion (2011US$)	△	$ 21.0 billion (2011 US$)	○	$ 10.9 billion (2011 US$)
	(8) Economic efficiency	○	Expected high percentage of local procurement in civil works.	△	Relatively high percentage of local procurement.	×	Low percentage of local procurement.
	(9) Uncertainty of operating cost	○	Almost no influence by the change of fuel price.	△	PLTG will be vulnerable to the change of fuel prices, particularly in the region with no gas supply.	×	PLTG will be vulnerable to the change of fuel prices, particularly in the region with no gas supply.
Social and Natural Environmental Aspects	(10) Involuntary resettlement	×	46,000 HHs	△	2,500 HHs	○	Can be nil.
	(11) Local economy such as employment and livelihood	○	Contribution to creating jobs mostly in poverty areas	△	Contribution to creating jobs in poverty areas	×	Contribution to creating jobs mostly in urban area
	(12) Land use and utilization of local resources	×	Projects located in protected areas: 20 Nos.	○	Projects located in protected areas: Nil.	○	Projects located in protected areas: Nil.
		×	Inundated Area: 298,000 ha	△	Inundated Area: 114,000 ha	○	Inundated Area: Nil.

Item		Policy Oriented Scenario		Realistic Scenario		Zero Option	
	(13) Air pollution as of 2027	○	SOx: Nil	∆	SOx: 18,177 tons/year	×	SOx: 41,104 tons/year
			NOx: Nil		NOx: 118,383 tons/year		NOx: 264,431 tons/year
	(14) Global warming as of 2027	○	CO2 emission: Nil	∆	CO2 emission: 16.6 MT/year	×	CO2 emission: 37.1 MT/year

Legend) ○: favorable, ∆: neutral or medium, and ×: unfavorable

6. SELECTION OF PROJECTS FOR PRE F/S

Eight projects are selected as candidates for Pre F/S to be worked in this Study considering that; i) those projects are categorized as Rank "A" or "B" as for development difficulty due to environmental aspects, with high project economy, and ii) there are no IPP projects in stages of construction or PPA process, which are mutually exclusive with those candidate projects.

As a result of site reconnaissance and updated project cost estimation, it is found that Simanggo-2 has the highest economy among the 8 projects. Masang-2 is ranked as the second best in project economy. Difficulties to be encountered in environmental and technical aspects are assumed to be less at this stage.

7. SIMANGGO-2 HYDROELECTRIC POWER PROJECT

Location

The Simanggo-2 Hydroelectric Power Project (hereinafter referred to as "the project") is situated approximately at 2°16' to 2°20' of the north latitude and 98°22' to 98°26' of the east longitude on the middle course of the Simanggo River.

The project is administratively located in Humbang Hasundutan Regency (Kabupaten), North Sumatra Province. The project is located approximately 40 km west of Doloksanggul, the capital city of Humbang Hasundutan Regency. Main structures of the project such as intake weir, waterway and powerhouse are located in Parlilitan and Tarabintang Subdistricts (Kecamatan).

Topography

Physiographically the project site is located on the Barisan Mountains, which are rugged hills with summits from 700m to 2,000m above sea level. The Simanggo River runs on the west slope of the Barisan Mountains and originates from Mt. Simangan Dungi (El. 1,460.0m) and the Mt. Ginjang (El. 1,685.2m). The river first flows to southwest, then joins the Lae Cinendang River and finally discharges into the Indian Ocean.

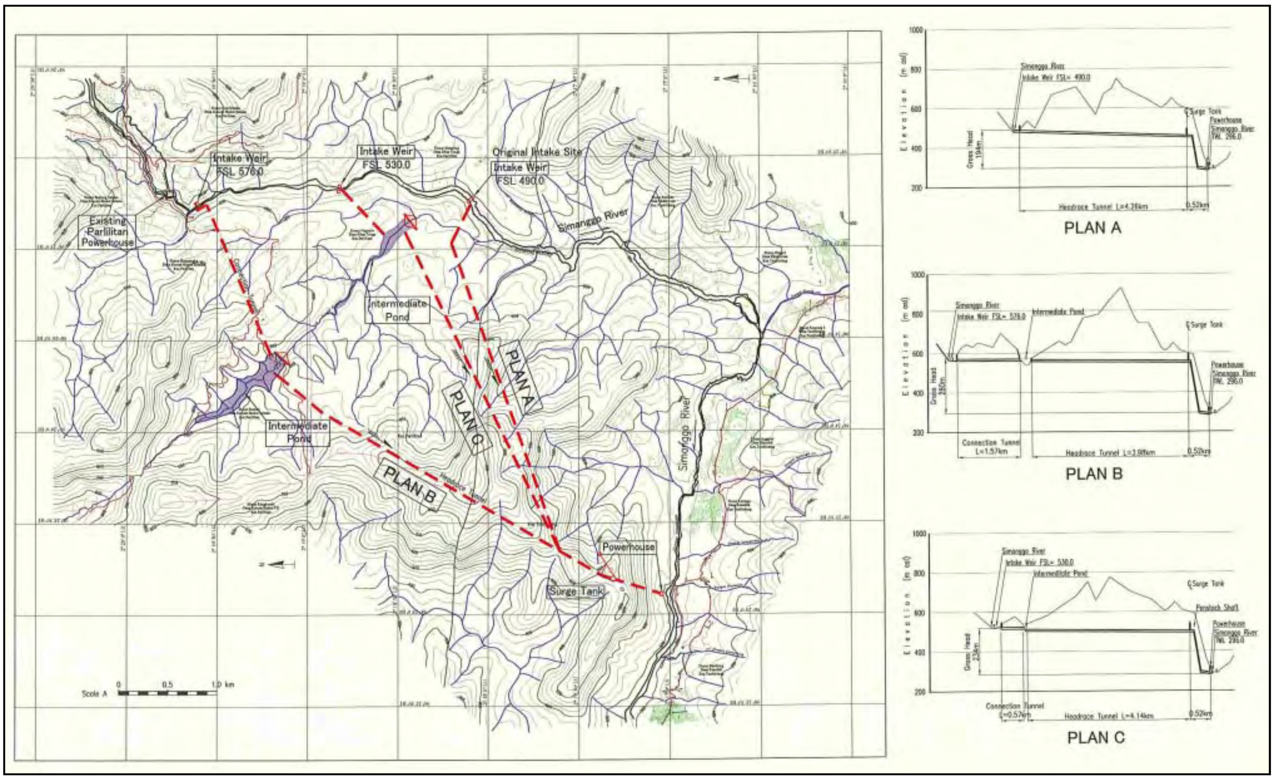
Geology

The geology of the project site consists mainly of Early Permian to Late Carboniferous metamorphic sandstone/slate and Quaternary tuff B with a limited occurrence of Quaternary tuff A. Except for several local and inactive faults no major faults were observed within the project site.

The proposed weirs were expected to be founded on the tuff A at the river valley and tuff B at the abutments, the intermediate pond dikes on the tuff B, the connection tunnel on the tuff B, the headrace tunnel on the sandstone, the surge tank and penstock on the sandstone, and the powerhouse on the tuff A. These foundation rocks were not expected to cause any major geological problems associated with the construction of the proposed project structures.

The geological conditions at alternative Plan B and Plan C are similar considering rock mass quality and geological profiles.

Sandstone quarry sites around the project site were available in quality and quantity as potential construction material sources. On the other hand, alluvial sands along the Simanggo River and Riman River in the proximity of the project site are available in quality but small in quantity.



Source: JICA Study Team

Alternative Layout Plans of Simanggo-2 Scheme

<u>Hydrology</u>

The hydrological conditions related to the preliminary design are listed below:

Description	Unit	A Intake Weir	B Interm't Pond	A + B	Power-house
Catchment area	km^2	478.3	2.3	480.6	936
Average river runoff (1977-1998)	m^3/s	25.1	0.1	25.2	48
95% dependable runoff	m^3/s	9.00	0.04	9.04	17
Design flood (200-yr flood)	m^3/s	1,100	33	=	1,540
Construction flood (2-yr flood)	m^3/s	490	15	=	690
Sediment inflow	m^3/yr	96,000	460	=	=

Source: JICA Study Team

Project Formulation

Three alternative layout plans are taken up for optimization study. The Plan A is a pure run-of-river type scheme since it is not practical to build regulation pond on the route of waterway. Its power output is governed by river run-off at the time of generation. No peaking generation is possible. Operation mode is a 24-hour continuous base load generation. The maximum plant discharge is decided so that the plant factor approximately becomes 70% which is generally applied for usual run-of-river plants.

Plan A is environmentally most superior than other Plans as water-reduced river section is shortest in length and river flow downstream of the powerhouse does not fluctuate. However, dependable power output is only 13 MW in drought year and this does not contribute for easing of system peak demand.

The Plan B has an intermediate pond which is capable of regulating river flow on daily basis for peaking generation. A 5-hour peaking mode is adopted for layout optimization. The required active storage of the pond is 0.55 mil. m^3 for 5-hour peaking mode. A pond with sufficient storage space can be provided on the natural creek crossing the waterway route.

Plan B is not superior than Plan A since forestland has to be submerged for the regulation pond and river flow downstream from the powerhouse fluctuate between peak and off-peak times. However, the village people around the powerhouse normally do not use the river water for living. Therefore, provision of warning system (siren system) is considered enough at this moment. Technically, the Plan B is most superior than the others since the peaking generation capacity is highest.

The Plan C also has an intermediate pond but its active storage volume is limited to 0.3 mil. m^3 because of narrow valley topography. In case of full utilization of the firm discharge (95% dependable) in daily 5-hour peak generation, storage volume of at least 0.55 mil. m^3 is necessary in the pond. Thus, the semi peaking generation mode is applied, i.e. peak power output (installed capacity) is limited by the pond storage capacity but, instead, off-peak time power output increases.

The Plan C is second superior among the three Plans. However, its peak generation capacity is limited to only 48 MW due to the limited pond storage capacity.

Based on the foregoing economical comparison and engineering assessment, the Plan B is selected as the most optimal development layout for the Simanggo-2 HEPP. The intake site of the Plan B is located immediate downstream of the existing Parlilitan powerhouse.

Preliminary Design

The Simanggo-2 HEPP is a run-of-river type development with an installed capacity of 90 MW and annual energy production of 416 GWh. Maximum plant discharge is 38.1 m^3/s and average net head is 260.3 m.

The intake weir is designed as a un-gated weir of 10.0 m in height. The waterway comprises a 1,570 m long connection tunnel of 3.9 m diameter, a 3,980 m long headrace tunnel of 3.9 m diameter, a 615 m long penstock of 3.2 m mean diameter and a tailrace channel.

The intermediate pondage has an active storage capacity of 0.6 mil. m^3 to regulate the river flow on a daily basis. FSL would be EL. 572.6 m and MOL at EL. 567.0 m for this capacity.

The powerhouse is an open-air type and located at the valley on the right bank of the Simanggo river. Tailwater level is EL. 296.0 m at the powerhouse outlet. The powerhouse will accommodate two units of 45 MW each (90MW in total). The switchyard will be located in the right bank near the powerhouse.

A new double circuits transmission line of 150 kV is constructed between the Simanggo-2 power station and the Doloksanggul (Parlilitan) substation.

Preliminary Cost Estimate and Construction Plan

Total project cost of the Simanggo-2 HEPP is estimated at US$ 210.0 mil., which covers all costs for project implementation including those for construction, engineering services, administration, land compensation and contingencies.

This study assumes that the Simanggo-2 HEPP would be come on stream in the year of 2017.

Justification of the Project

Economic viability of the Simanggo HEPP is proved in terms of EIRR at 21.8% and FIRR at 10.7%. The sensitivity analysis has confirmed that the hydropower project in question economically feasible.

Economic Indicators

Cases	B/C	ENPV	EIRR	Notes
Base Case	1.83	117.9	21.8%	the base case
+ Depletion Premium	1.84	118.9	21.8%	depletion premium added to the base case
+ CDM	2.02	144.5	23.9%	CER benefit added to the base case
– 10% Annual Energy	1.61	86.5	18.4%	less hydropower generation by 10%

+ 10% CAPEX & OPEX	1.67	103.8	19.2%	greater cost by 10%
– 10% Fuel Prices	1.72	102.7	20.5%	Fuel cost is less expensive by 10%

Source: Study Team

The sensitivity analysis has confirmed that changes of the financial indicators still remain in a viable range, as compared below.

Financial Indicators

Sensitivity Analysis	FIRR	US$M	ROI	US$M	
0. Base Case	10.7%	10.6	24.5%	75.3	the base case
1. +CDM	11.2%	17.6	25.5%	82.4	CDM benefit added to the base case
2. –10% Tariff	9.5%	-6.3	22.0%	58.5	electricity tariff 10% less
3. –10% Energy	9.5%	-6.3	22.0%	58.5	less annual energy by 10%
4. +10% CAPEX	9.7%	-5.0	22.5%	66.5	greater cost by 10%
5. COD Delayed by 1 yr	9.9%	-1.0	21.4%	65.1	commissioning delayed by 1 year

Columns with US$M correspond to respective net present values
Source: Study Team

The financial analysis finally concludes that:

- The Simanggo-2 Hydropower Project will show a good financial profitability.
- The Simanggo-2 Hydropower Project should be developed as either a PLN project or a DBFO based PPP project.

Environmental Study

The lesson-learnt from the existing IPP project is importance of public involvement and dissemination of adequate information to local people. Although positive and supportive comments were obtained from key persons at the site interview, there is a possibility that a conflict might occurred if sufficient socialization was not held. Since the project will require some area regarded as community land for local people, socialization with local people including project affected persons in timely manner is necessary to go forward.

The project will require land acquisition at paddy field and plantation though necessary area is considered as small. Although acquired area is expected as small, it may cause a loss or reduce of livelihood means for local people. Same as land acquisition, the project also has a possibility to affect socio-economic and nutritional condition to those who obtain supplemental income and nutrition from fishes they caught due to generation of water recession section by project implementation though impact is considered as not significant based on the site confirmation and interview to key persons.

In order to examine appropriate compensation and necessary assistance for livelihood stabilization, impact caused by the project is necessary to be understood. For this purpose, detailed examination of socio-economic and nutritional condition on local people in the project area including confirmation of income source and property loss shall be done in the next stage.

The following species of flora and fauna which categorized as endangered or vulnerable according to IUCN were found in the study at surround area of the site of Simanggo-2.

- Flora：”Endangered” 3 tree speicies of Dipterocarpaceae
- Fauna：”Endangered” 1species of reptile (Heosemys spinosa : identified in dead)

  “Vulnerable”4species of Mammal（Macaca fascicularis, Macaca nemestrina, Aonyx cinerea and Sus barbatus）

All species greatly rely on the existence of forest. Therefore, it is considered as effective mitigation measure to conserve the existing forest as much as possible.

The amount of stream flow for maintenance is proposed as 1.00m^3/sec in this Pre-FS. Given that the Simanggo River will be joined with Rambe River at approximately 6km downstream of the intake in the water recession section of Simanggo-2 which is approximately 9km, substantial amount of river water will be inflow to the Simanggo River at the point of the river joint.

The project components are located inside limited production forest and protected forest.

As the result, it is concluded that there is no “irreversible environmental negative impacts” in the stage of Pre-Feasibility Study for the project based on the environmental study. However, further examination should be conducted at the next step.

8. MASANG-2 HYDROELECTRIC POWER PROJECT

Location

The Masang-2 Hydroelectric Power Project is situated approximately at 0°5’ to 0°10’ of the south latitude and 100°11’ to 100°15’ of the east longitude on the upper course of the Masang River.

The project is administratively located in Agam Regency (Kabupaten), West Sumatra Province. The project is located approximately 30 km northwest of Bukit Tinggi city, 100 km northwest of Padang city, the capital city of west Sumatra. Main structures such as intake weir, waterway and powerhouse are located in Palembayan Subdistrict (Kecamatan).

Topography

Physiographically the project site is located at the central Barisan system, which consists of a number of NW-SE trending block mountains. The Masang River originates from Mt. Marapi (El. 2,891.3m) and runs between these NW-SE trending block mountains. Around the project site the river flows to northwest, subparallel to Great Sumatra Fault System.

The major tributaries flowing into the Masang river are Sianok, Guntung and Alahanpanjang rivers. The project is sited between the confluence of Sianok and Guntung rivers, which is the most upstream of the Masang river, and the confluence of Masang and Alahanpanjang rivers.

Geology

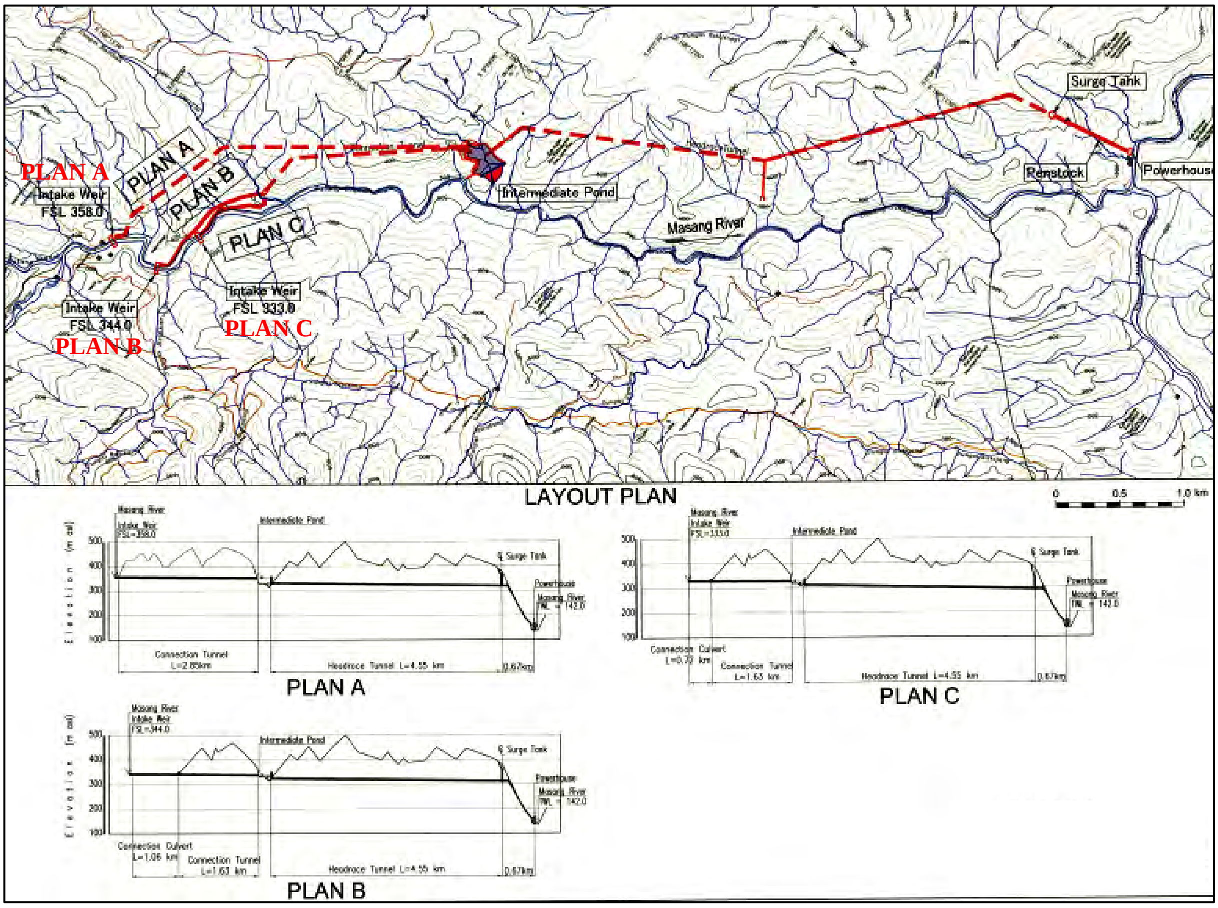
The basement rocks of the project site are Permian limestone rocks with some thin intercalations of slate. The limestone rock is extensively covered by Quaternary tuff and tuff breccia from the volcanic activity of the Maninjau Volcano.

In comparison with the weir sites A and C the weir site B is more suitable for founding of the weir construction because at the site the overburden is shallow and the foundation rock of limestone is hard and strong enough to support the planned weir foundation.

The intermediate pond site was favorable in terms of bearing capacity; however the permeability and leakage of the foundation rocks should be considered especially leakage from the right abutment of thin ridge.

The planned connection and headrace tunnels would be expected to be founded mostly on CM to CH class rock masses. No major geological problems are to be expected at tunneling.

Limestone quarry sites around the project site appeared available in quality and quantity as potential construction material sources but the strength characteristics should be confirmed at next survey stage.



Source: JICA Study Team

Alternative Layout Plans of Masang-2 Scheme

Hydrology

The hydrological conditions related to the preliminary design are listed below:

Description	Unit	Intake Weir	Interm't Pond	Power-house
Catchment area	km^2	444	0.9	920
Average river runoff	m^3/s	17.71	=	=
95% dependable runoff	m^3/s	10.05	=	=
Design flood (200-yr flood)	m^3/s	1,341	15.2	1,939
Construction flood (2-yr flood)	m^3/s	456	5.2	659
Sediment inflow	m^3/yr	222,000	450	=

Project Formulation

The layout Plan B is most economical among the three Plans as the net benefit is highest. The second economical layout is Plan C of which the net benefit is about 86% of Plan B. The net benefit of Plan A is much less than those of Plans B and C.

Plan A is environmentally inferior because the existing paddy filed is partly occupied by the intake facilities. The Plans B and C are environmentally more superior than the Plan A. From the environmental point of view, there is no significant difference between the Plans B and C.

Plan B is technically most superior because relatively sound base rock is exposed in the intake site and construction of the intake facilities is easy. Intake site for the Plan A is inferior since the foundation geology is bad. Rock exposed in the Plan C intake site seems to be in deeply weathered condition. The Plan C is therefore second superior among three Plans.

As the result, Plan B is selected as the optimal layout.

Preliminary Design

The Masang-2 HEPP is a run-of-river type development with an installed capacity of 52 MW and annual energy production of 240 GWh. Maximum plant discharge is 32.0 m^3/s and average net head is 178.8 m.

The intake weir is designed as a un-gated weir of 7.0 m in height. The waterway comprises a 1,060 m long connection culvert of 3.75 m wide, a 1,630 m long connection tunnel of 3.75 m diameter, a 4,550 m long headrace tunnel of 3.75 m diameter, a 677 m long penstock of 3.1m mean diameter and a tailrace channel.

The intermediate pondage has an active storage capacity of 0.322 mil. m^3 to regulate the river flow on a daily basis. FSL would be EL. 339.9 m and MOL at EL. 329.9 m for this capacity.

The powerhouse is an open-air type and located at the valley on the left bank of the Masang river. Tailwater level is EL. 142.0 m at the powerhouse outlet. The powerhouse will accommodate two units of 26 MW each (52MW in total). The switchyard will be located in the left bank near the powerhouse.

Preliminary Cost Estimate and Construction Plan

Total project cost of the Masang-2 HEPP is estimated at US$ 193.4 mil., which covers all costs for project implementation including those for construction, engineering services, administration, land compensation and contingencies.

This study assumes that the Masang-2 HEPP would be come on stream in the year of 2017.

Justification of the Project

Economic viability of the Masang-2 HEPP is proved in terms of EIRR at 12.0 % and FIRR at 6.6 %. The sensitivity analysis has confirmed that the hydropower project in question economically feasible,.

Economic Indicators

Cases	B/C	ENPV	EIRR	Notes
Base Case	1.15	19.2	12.0%	the base case
+ Depletion Premium	1.15	19.7	12.0%	depletion premium added to the base case
+ CDM	1.27	34.5	13.4%	CER benefit added to the base case
– 10% Annual Energy	1.00	0.5	10.1%	less hydropower generation by 10%
+ 10% CAPEX & OPEX	1.04	6.3	10.6%	greater cost by 10%
– 10% Fuel Prices	1.08	10.7	11.1%	Fuel cost is less expensive by 10%

Source: Study Team

The sensitivity analysis has confirmed that changes of the financial indicators still remain in a viable range, as compared in below.

Financial Indicators

Sensitivity Analysis	FIRR	US$M	ROI	US$M	
0. Base Case	6.6%	-40.5	15.0%	19.1	the base case
1. +CDM	7.0%	-36.4	15.9%	23.2	CDM benefit added to the base case
2. –10% Tariff	5.6%	-50.6	12.5%	9.0	electricity tariff 10% less
3. –10% Energy	5.6%	-50.6	12.5%	9.0	less annual energy by 10%
4. +10% CAPEX	5.8%	-54.5	12.8%	11.1	greater cost by 10%
5. COD Delayed by 1 yr	6.2%	-47.0	13.4%	13.9	commissioning delayed by 1 year

Columns with US$M correspond to respective net present values
Source: Study Team

The financial analysis finally concludes that:

- The Masang-2 Hydropower Project should be developed and operated by PLN, as the executing agency of the public sector.
- The financing source for the Masang-2 Hydropower Project should be of affordable loan conditions that are possible from the bilateral funding agencies like JICA or multilateral development banks such as ADB and WBG.

Environmental Study

There was a mini-hydro power project close to the Masang-2 project area. Land acquisition was smoothly conducted in this project due to following to the local procedure and involving local people. Since the project locates in the *Tanah Ulayat*, sufficient socialization before going to the field study is indispensable as the next step.

In order to examine appropriate compensation and necessary assistance for livelihood stabilization, impact caused by the project is necessary to be understood. For this purpose, detailed examination of socio-economic and nutritional condition of local people in the project area including confirmation of income source and property loss shall be done.

The following species of fauna which categorized as endangered or vulnerable its conservation status according to IUCN were found in the study at surround area of the site of Masang-2.

Fauna：”Endangered” 3species of Mammal (Presbytis melalophos, Hylobates agilis, Tapirus indicus)

“Vulnerable” 2species of Mammal（Macaca fascicularis, Macaca nemestrina,）

All species greatly rely on the existence of forest. Therefore, it is considered as effective mitigation measure to conserve the existing forest as much as possible.

The amount of stream flow for maintenance is proposed as approximately 0.39 m^3/s in this Pre-FS. The length of water recession section of Masang 2 is approximately 8km. Given that the tributary will be joined to Masang River at just downstream of intake point and the additional tributary will be joined at approximately 1km downstream of the river joint, substantial amount river water will be inflow to the water recession section of the Simanggo River.

The project components are located inside limited production forest and protected forest.

As the result, it is concluded that there is no “irreversible environmental negative impacts” in the stage of Pre-Feasibility Study for the project based on the environmental study. However, further examination should be conducted at the next step.

9. CONCLUSIONS AND RECOMMENDATIONS

Master Plan Study

(1) Public vs. Private

Capacity of the public investment in hydropower development is not enough. Accordingly, private investment in hydropower needs be maximized.

Hydropower projects that expect high return shall be developed by private investors, so that public budgets can be saved. A return on equity (ROE) can be an indicator to which extent the in-question hydropower is profitable. If ROE is 18% or greater, it may be good enough for private investors to develop the in-question hydropower as an IPP. If the project economy is less, such project shall be implemented by PPP or ODA basis.

For a hydropower IPP, an electricity tariff should be set to a level such that a private investor can expect reasonable return from it. The reasonable tariff level can be estimated to be the average generation cost by PLN in the area concerned.

(2) Different development plans to a single potential site

PLN, as the public utility company, should place a hydro plant as one of its many elements of the electricity system, while a private investor does it as an investment opportunity. One instance is the fact that PLN needs a peak hydro, which is more expensive than an off-peak hydro but can contribute to stabilizing the electricity system. For example, a 50 MW off-peak hydro can possibly be re-designed to be a 100 MW peak hydro by adding a regulating pond and increasing the machine capacity. Despite a significant difference in capacity, the annual energies expected by the two different hydropower plans are nearly equal, because the in-coming river water never changes. A peak hydro can benefit PLN in the form of the system stabilization, while it can bring less profit to a private investor unless special considerations are paid in a PPA.

The Public Sector should encourage private investors in hydropower development, because the public budget cannot be allocated enough to develop all of hydropower potential in the country. In this context, the private investors should not be pressurized to add a peaking power function in their hydropower development proposals, if such addition does not substantially contribute to the power system. Instead, for the projects which have substantial scale to contribute the system if developed as an peak hydro, best effort should be made to maximize the potential in the hydropower development plans.

(3) Two Regulators

The land and water required for hydro plants are regulated by the local government(s), while the electricity business is regulated by MEMR. A mini hydro proposal may possibly exclude a large hydro potential, if different plans are developed in a same river.

MEMR, as the sole legal regulator of the electricity, should confirm his regulatory power, to which extent it can be exercised. If it is powerful enough not to issue an electricity business license, any private proposals that may enormously hamper the hydropower potential of the country may be rejected. From the regional autonomy policy, however, all of hydropower development plans raised up through regional governments should be respected maximum.

It is highly recommended that all of hydropower development plans (even if they are for 10 MW or less) should be listed up in the Electricity Supply Plan (RUPTL) prepared by PLN and approved by MEMR, so that both of private investors and regional government can be motivated to have mutual understanding to the hydropower development.

Pre-Feasibility Studies for Simanggo-2 and Masang-2

This pre-feasibility study has revealed that both the Simanggo-2 and Masang-2 HEPPs are viable from technical and economical aspects. It is also concluded that there is no “irreversible environmental negative impacts” identified in this stage. It is therefore recommended that the projects should be soon proceeded to the further implementation in accordance with the plans and design principles proposed.

Installation of the Simanggo-2 and Masang-2 HEPPs will contribute the power system in Sumatra by supplying economical and stable peak power. Furthermore, using the energy generated by the projects instead of other thermal plants would be in line with the national policy to save unrenewable and exportable sources of energy.

Especially for the Simanggo-2 HEPPs, conducting additional geological survey such as core boring is mandatorily required.

Environmental survey in the next stage shall be conducted especially emphasizing the followings.

(1) Necessary Items to be Studied for Preparation of LARAP

It was concluded that there is no significant adverse impact to social environment caused by project implementation from the site confirmation. However, information obtained at the site in the Pre-Feasibility Study is very much limited, and therefore further examination and considerations to the items described below are requested at the next study stage such as feasibility study.

1) Conducting Detailed Household Survey

It was identified at Pre-Feasibility study that involuntary resettlement due to project implementation might not be caused. However, there might be some negative impact to livelihood stabilization due to acquisition of cultivated area or generation of water recession section. Thus, impact level is necessary to be confirmed in detail. For this purpose, it is recommended to conduct detailed household survey described below as the first step to understand impact due to project implementation as well as baseline information to prepare LARAP.

2) Preparation of LARAP

In the case of Japanese ODA project, preparation and disclosure of Resettlement Action Plan (RAP) is necessary if a project requires land acquisition and/or involuntary resettlement in large scale. In the course of preparation of RAP, consultation with PAPs on project description including expected magnitude due to project implementation and compensation policies shall be made in timely manner. PLN has experience to prepare Land Acquisition and Resettlement Action Plan (LARAP) for donor funding projects. Thus, PLN is considered as capable of preparing LARAP by considering JICA guidelines (April, 2010) and World Bank Safeguard Policy OP4.12 as well as reflecting consultation result with PAPs.

(2) Necessary Items to be Studied at AMDAL

It was concluded that there is no "irreversible environmental negative impacts" in the stage of Pre-Feasibility Study for the project based on the environmental study. However, the following items should be considered at next step (AMDAL in Feasibility Study for the Project).

1) Detailed field survey for flora and fauna

Species which categorized as endangered or vulnerable according to IUCN were identified through the environmental study. There are certain possibilities that the number of those rare species will be increased with more detailed field survey for flora and fauna.

The additional field survey will be necessary to prepare appropriate environmental mitigation measures against the environmental impact in both construction and operation stages.

Attention shall be paid not only to the rare species, but also the species that are treated as resources for living of the local inhabitants.

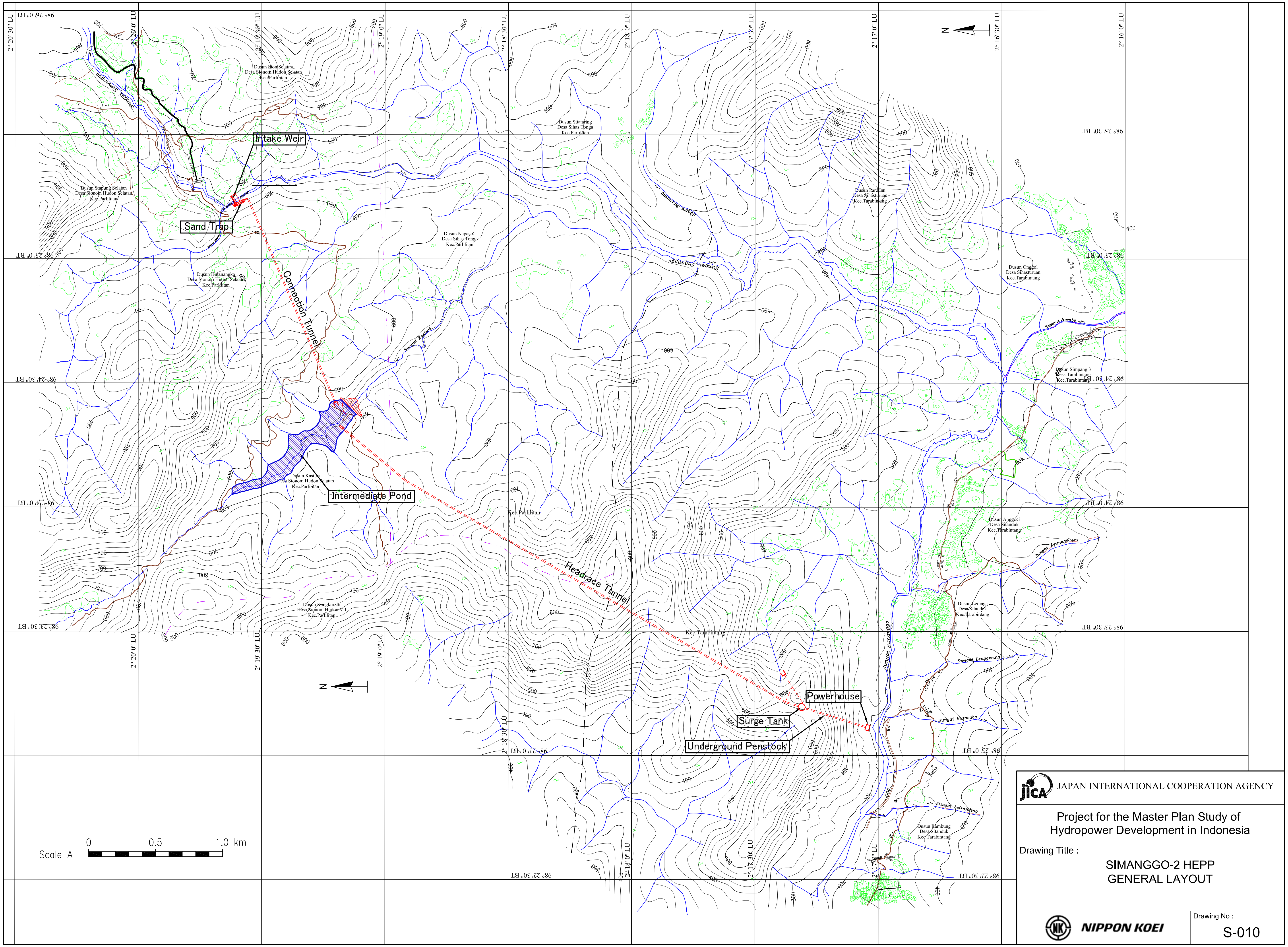
2) Detailed Study on Aquatic Environment

It will be necessary to grasp project impact caused by change of the water level in the "water recession section" on aquatic fauna in detail. In addition, actual condition of inland fisheries by local people should be also confirmed in detail.

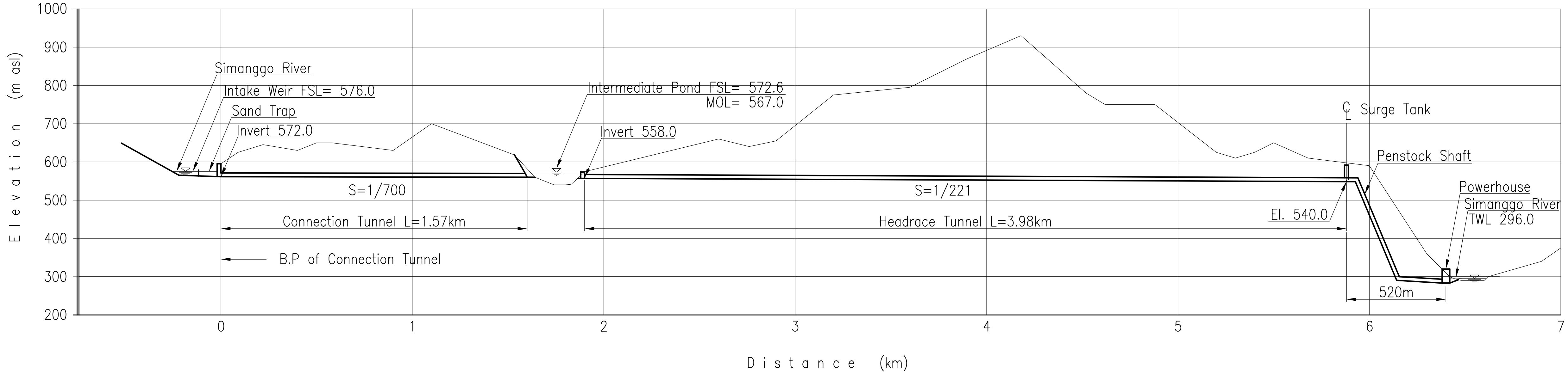
3) Stake Holders Meeting

The limited interviews to specific persons such as village chiefs were conducted to absorb their preliminary opinions to the project in the environmental study. It is anticipated, however, that opinions of the local people may be variant if their position are different.

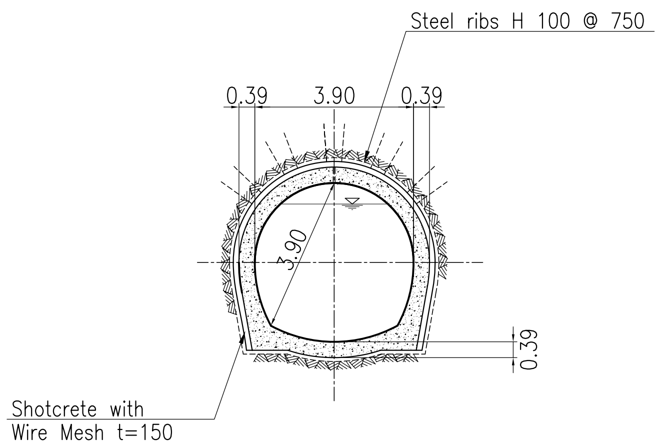
Therefore, it is essential that the stake holders meeting with local people from various positions shall be held to obtain their different opinions to the project properly in the stage of Feasibility Study. Local people shall be invited not only from within the project site, but also from the outside but affected by the project, such as downstream of the powerhouse or beneficiary area of power distribution.



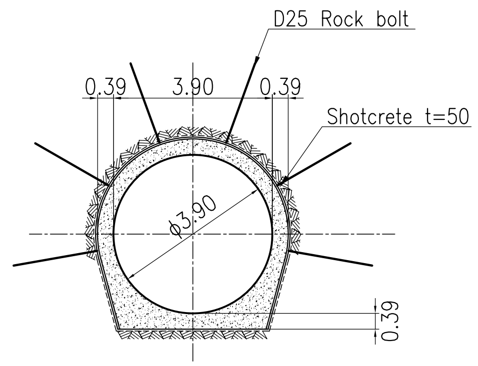
Intake Weir
Sand Trap
Connection Tunnel
Intermediate Pond
Headrace Tunnel
Powerhouse
Surge Tank
Underground Penstock
Scale A
0
0.5
1.0 km
JAPAN INTERNATIONAL COOPERATION AGENCY
Project for the Master Plan Study of
Hydropower Development in Indonesia
Drawing Title :
SIMANGGO-2 HEPP
GENERAL LAYOUT
NIPPON KOEI
Drawing No :
S-010



PROFILE Horizontal Scale A
Vertical Scale B



CONNECTION TUNNEL Scale C



HEADRACE TUNNEL Scale C

TYPICAL TUNNEL SECTIONS

Scale A 0 0.5 1.0km

Scale B 0 500m

Scale C 0 4.0 8.0m

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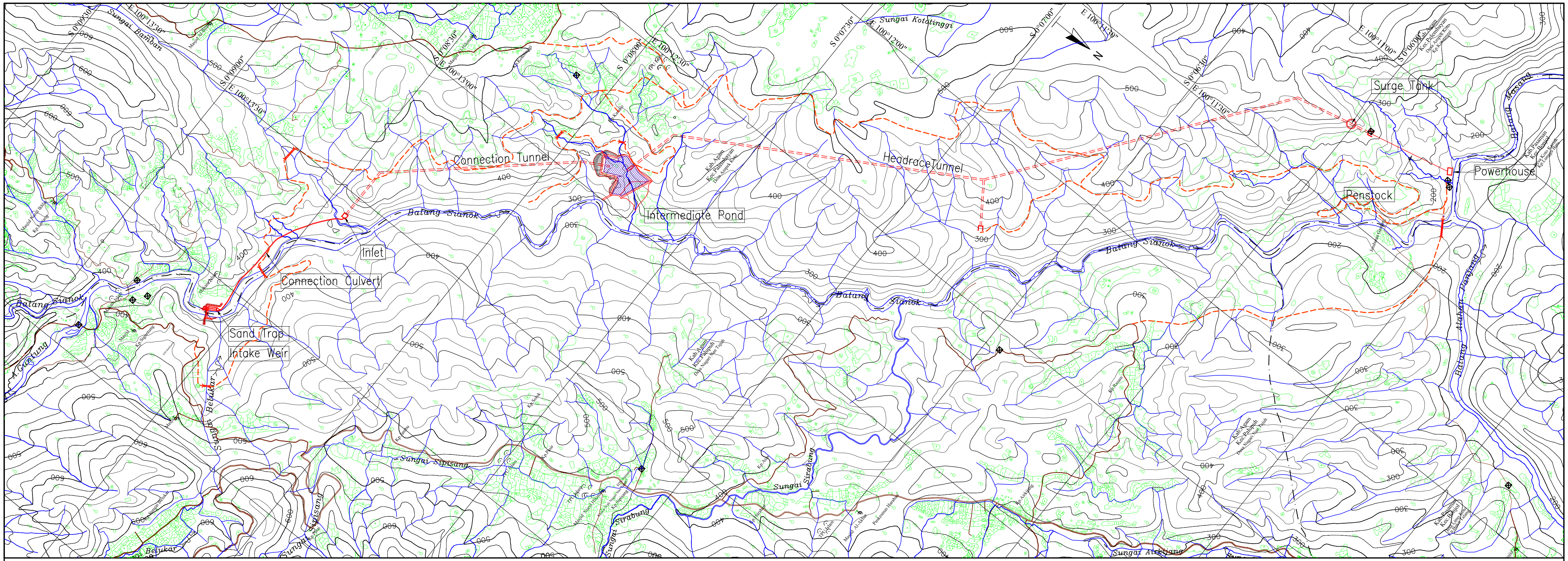
Project for the Master Plan Study of
Hydropower Development in Indonesia

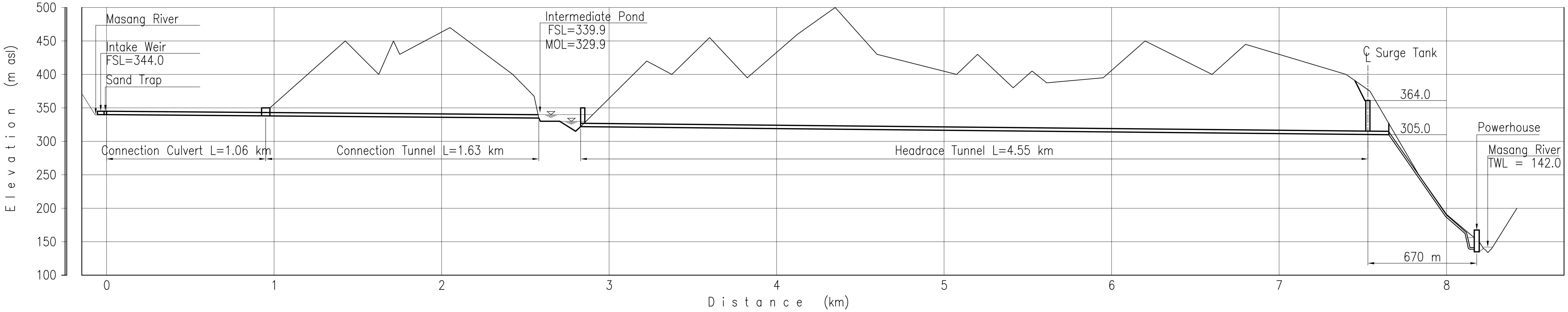
Drawing Title :
SIMANGGO-2 HEPP
GENERAL PROFILE AND
TUNNEL SECTIONS

NIPPON KOEI

Drawing No :
S-011

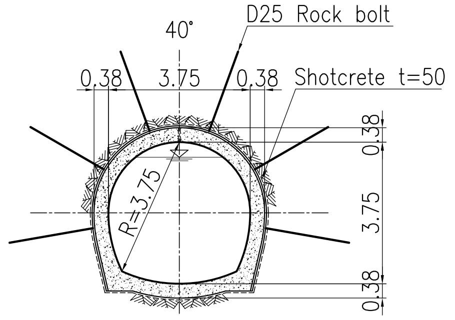


PLAN Scale A

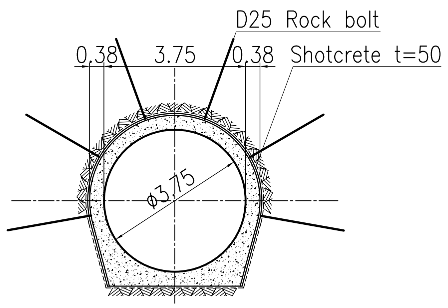


PROFILE

Horizontal Scale A
Vertical Scale B



CONNECTION TUNNEL Scale C



HEADRACE TUNNEL Scale C

Scale A: 0 – 0.5 – 1.0 km
Scale B: 0 – 100 – 200 – 250 m
Scale C: 0 – 4.0 – 8.0 m

JAPAN INTERNATIONAL COOPERATION AGENCY

Project for the Master Plan Study of Hydropower Development in Indonesia

Drawing Title :

MASANG-2 HEPP
GENERAL LAYOUT AND PROFILE

NIPPON KOEI

Drawing No : M-010