4-3. Environmental and Social Considerations

4-3-1. Environmental and Social impact assessment

4-3-1-1. Outline of Project component

The Lae Ordi II micro hydropower plant is located in:

-Kecupak I, Simarpara Village, - Pergetteng-getteng Sengkut Sub-District, - West Phakpak District, North Sumatra

The location can be reached by vehicle over the asphalt road from Medan through Berastagi, Kabanjahe, Tigabinanga, Sumbul and Sidikalang. The road continues through the sub-districts of Kerajaan and Salak towards the villages of Pergetteng-Getteng Sengkut, Kecupak I Simarpara. From Simarpara there is a 1 km downhill path to the location.

The project component of Lae Ordi II is shown in **Figure4-7**. Lae Ordi II is diversion type hydroelectricity.

To the intake weir (at the elevation of 624m), there are forestry road which is connected to paved road in the vicinity. The forestry road end at halfway. From there some forest exists at the route. On the way, there are some trees which is to cut when installing access roads

Water for power generation from intake weir goes through settling basin and transferred to head tank by water way with length of 2,426m (gradient: 1/3,052) .

From the head tank, the water transferred to power plant by penstock with length of 320m. (Diverged into 3 penstock just before the plant)

4-3-1-2. Baseline of environmental and social conditions.

(1) Geography and geology

1) Geology of Indonesian archipelago

The Indonesian archipelago occupies the part of earth surface having the most complex form and structure. This is due to the fact that Indonesia is at the meeting point of three primary movement of earth namely: (1) movement of Sundanese system in the west, (2) movement of East Asiatic system (3) movement of circum-Australia.

The geology of the Indonesian archipelago consists of 4 types, namely: Andesite unit, Ignimbrite (Tufa Toba) from the Pleistocene era, river deposit from the Recene era and talus deposit from the Recene era. The andesite and ignimbrite units are separated by an unconformity located under the river deposit and along the river.

Based on the interpretation of the 1:5,000,000 scale seism tectonic map sheet of Indonesia of 1992 issued by Geological Research and Development Center (IPPG) in Bandung, the study area is in region II(North Sumatra), with the earthquake depth at beniof line at 75 km and the distance to the closest fault is 75 km. The distance between the study area and the border fault of Semango Region is 150km.

In general, the area of Pakpak Bharat is covered by a very thick Ignimbrite that is originated from the eruption of Tumor Toba. Based on the observation in the field, Ignimbrite unit has characteristics of somewhat crystallized with massive structure, cleats were found and the surface has experienced decay .The Ignimbrite unit being exposed in the study area has grayish white colour, which is evident from the result of drilling. Under the Ignimbrite there is Andesite Rock unit. The distribution of the unit is also estimated to be quite wide. This Andesite Unit occupies the area having a steep morphology - gradually sloping with many cleats that have been experiencing cracks. The result of the drilling of the Andesite Units is whitish grey in colour consisting of quartz and orthoclase minerals with phenocryst plagioclase, hornblende and agglomerate.

2) Geological Condition at the Location of PLTA Lae Ordi II

(A) Weir and intake

The geology around the weir and intake is enclosed by ignimbrite and river alluvial deposit consisting of unevenly sediment gravels and pebbles on top of conglomeratic sandstone. The permeability of the rock unit is quite high ranging between 1×10-3and5×102cm/sec. Alluvial deposit is observed as developing on both sides along the river and ignimbrite is sporadically uncovered on the left bank of the river.

(B) Waterway

Since the waterway is an open channel on the surface with a slope of 1:2000, the waterway shall pass through the area that is generally in the form of alluvial deposit.

(C) Penstock line and Power House location

The construction is on andesite rock and minor cleat zone.

(D) Structure of Rock and Soil Types at the Location PLTA Lae Ordi II

The area of the planned weir lies at an elevation of ca. 613.86 m/ASL. It is an undulating hilly terrain with slope gradients of 30% to 70%, composed of Paleocene/Neocene coral lime-stone.

Not decomposed limestone is white-gray to light brown, is compact, hard, massive and there are no signs of interrupted sediment structure. The limestone has an irregular morphology, and has no base because of the varying growth conditions during the formation of sediment. Calcite ($CaCO3$) and coral fragments are found floating in the rock matrix and in some places also mollusks are found. Cements are in the form of carbonate minerals. Field testing shows that the porosity of the rock is medium.

Because of the climate in the region most of the exposed rocks are moderately or strongly weathered. The color of the rocks is yellowish, ricks are brittle easily crushed, and with individual rock grains of silt or fine sand size. Dissolution by rain water has caused cracks so that rocks can easily be flushed away

Secondary structures are found outside the planned location of the weir; on the north side is a minor fault. Data were obtained only on shift layers on the bank of the Kalumpang River. From the direction of the fault it can be concluded that the fault does not affect the geological conditions of the study area of the planned weir.

(E) Component of the surface area of the Lae Ordi II plant

(a) Organic humus

Black, fine sand sized, containing much organic materials, with a root thickness of 10-40 cm. Also limestone gravel (0.5 to 3 cm) is found.

(b) Residual Soil

This is weathered limestone, consisting of horizon B and C. Horizon B is of yellow-brown color with grains of fine sand size, -brittle, easily crushed, not very adhesive, containing limestone gravel (5-30 cm), with a thickness of 20-80 cm. Horizon C is of yellow-brown color with grains of fine sand size, brittle, easily crushed, containing more gravel than horizon B (20-30 cm), with a thickness of 10-180 cm.

(c) Coral Dalkeith Limestone

Of yellow-gray, light brown color, medium porosity, and good permeability.

Based on the presence of the constituent materials mentioned above, the geological conditions of the study area can be divided into three zones, namely:

(i) Zone A

Zone A is composed of limestone of which only a small part is covered by residual soil and humus. It is spread over the river banks and the relatively steep hills

(ii) Zone B

Zone B consists of a top layer of humus, with a thickness of 10-40 cm, and a bottom layer of coral limestone. This zone mainly occurs in the southern area, i.e. south of the paved road to the lower parts of the hamlet of Simarpara, and a small part in the center of the study area.

(iii) Zone C

Zone C is a zone composed of a top layer of humus with a thickness of 10-40 cm. Below it, there is residual horizon C soil which in some places has already been transformed into a thick horizon B with a thickness of 10-180 cm. There is coral limestone underneath.

3) Assessment of Geological Conditions at PLTA Lae Ordi II project site

Under these geological conditions, the instability of the area for the planned weir is further influenced by the sloping and the thickness of weathered rocks, and the discontinuity of rock and soil. In this case Zone C is a sloping potentially unstable zone. The vegetation with open surface roots that does not support the soil will increase the likelihood of instability. Field observations show that the instability of the slopes covers more than 75% of the study area.

The instability is caused by continuous dissolution of the limestone by rain water causing fractures and sliding movements of the limestone rocks.

4) Risk of Earthquake at the PLTA Lae Ordi II project site

The world seismicity map shows that Indonesia is located on top of a highly active quake area. The Indonesian archipelago lies on the intersection between two lines is the world's major earthquakes:

1. The Circum-Pacific Zone, commonly known as the Ring of Fire
2. The Trans-Asiatic Zone from the Azores across the Alps in Central Europe, through Burma and the Himalayas in Asia, which then bifurcates, one through the islands of Sumatra, Java, Nusa Tenggara then joining the Ring of Fire in Sulawesi, while the other follows the Yellow river in China.

Based on the Seismic Zone Map for Planning Earthquake Resistant Water Facilities (Figure 4.2), the Lae Ordi II hydropower plant has a z value of z = 0.42. In accordance with the geo-logical situation, the ground shock acceleration (ac) for the return period of 100 years = 160 cm/sec2. By using the formula for the calculation, the earthquake coefficient for the planned hydropower plant is 0.106.

Based on the interpretation of seism tectonic maps of Indonesia (scale 1:5,000,000) issued in 1992 by the Geological Research and Development Center (PPPG) in Bandung, the study area belongs to region II (North Sumatra) where the benioff zone is about 75 km with nearest fault at 75 km. Distance of the study area to the main Sumatra fault is ca. 150 km.

(2) Meteorology and Hydrology

1) Climate

The weather station closest to the project site is the climatology station of Sitinjo, Dairi. Data over 2003 to 2007 include data on temperature, humidity, wind speed, average rainfall and air pressure.

Table 4-61 Lae Ordi II Hydroelectric and Hydro climatology Data

Parameter	Unit	PLTA Lae Ordi II
Temperature	^{o}C	20.34
Rainfall	mm/year	2,340.37
Solar Radiation	%	47.50
Humidity	%	90.03
Wind speed	m/sec	0.45

Source: BMG-Observation Station / Sidikalang Station Dairi Regency

2) The river catchment area

The Lae Ordi II watershed includes the Lae Ordi II River and its tributaries. This watershed extends west to east (Table 4-61). The total area of the Lae Ordi II Watershed upstream of the project site is 218.3 km2.

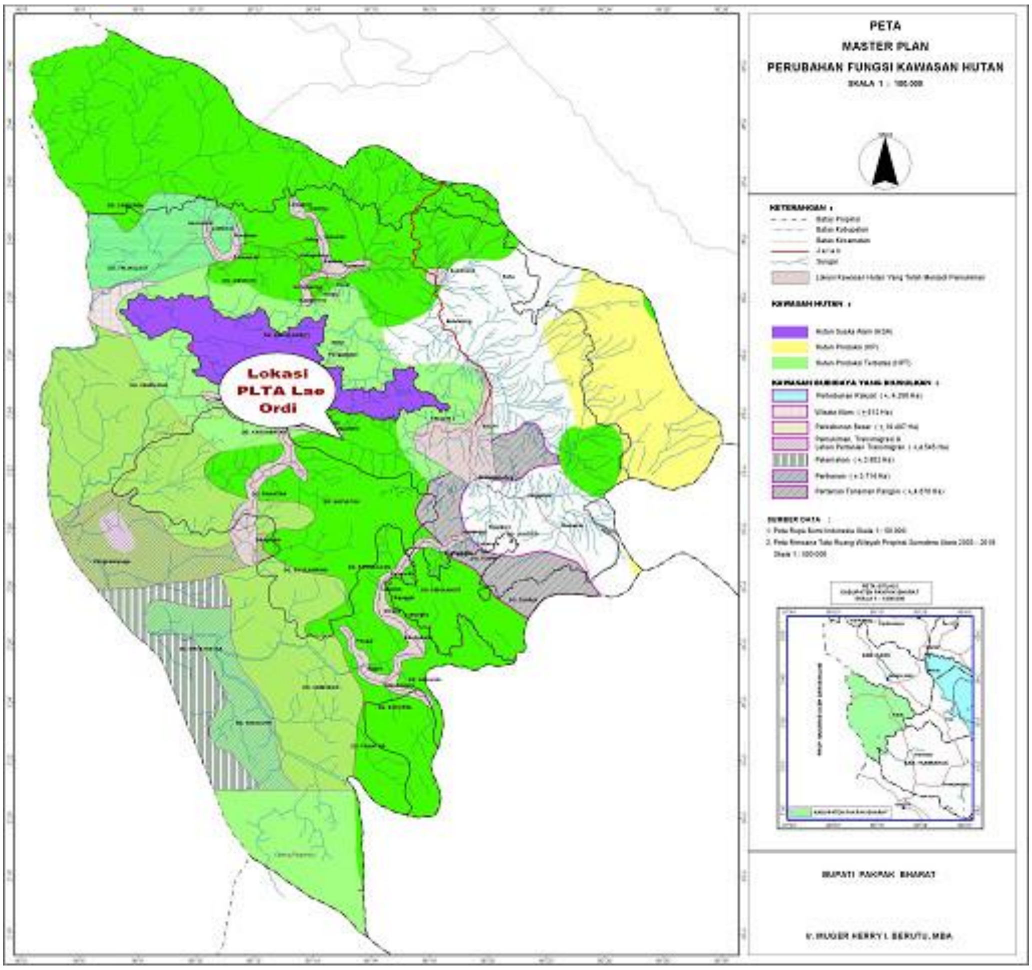


Figure 4-43 Lae Ordi II River and its Tributaries

3) Rainfall

Figure 4-44 and Table 4-62 show rainfall observation data in the premise of the project site. At May to August rainfall is relatively small and there is also yearly fluctuation.

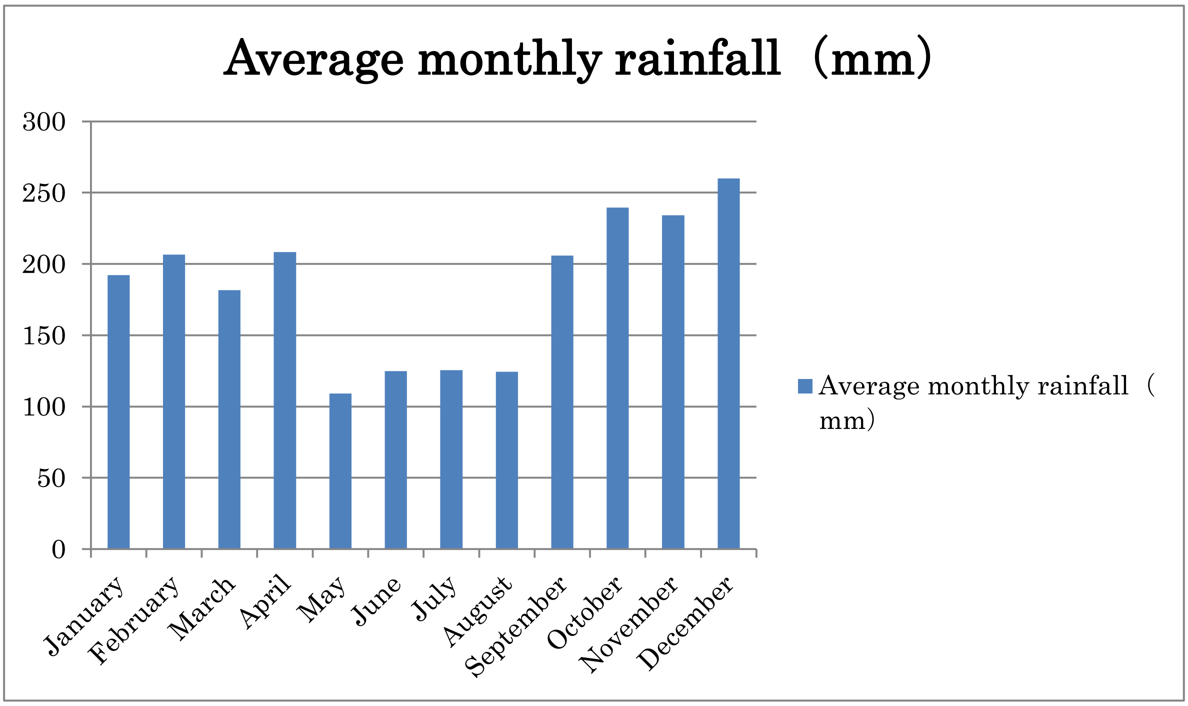


Figure 4-44 Average Monthly Rainfall around Lae Ordi II Mini Hydro Power project site

Source: Prepared by IDI based on the data from BMG-Observation Post / Station Sitinjo, Lau Baleng and Salak

Table 4-62 Average Monthly Rainfall, Station Stinjo, Lau Baleng and Salak

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1996	76	267	238	229	120	180	155	151	63	240	135	145
1997	82	178	192	151	64	124	136	76	85	198	128	130
1998	163	201	136	100	167	106	120	306	157	89	35	231
1999	188	120	260	71	90	104	79	164	290	387	201	261
2000	156	83	170	150	80	22	113	50	291	141	151	297
2001	208	248	81	394	29	174	90	39	202	129	188	315
2002	166	173	191	252	272	85	28	56	271	143	446	329
2003	370	330	224	261	110	323	280	212	144	303	307	291

Source: BMG-Observation Post / Station Sitinjo, Lau Baleng and Salak

(3) Population

Based on the data from sub-districts of Pergetteng-getteng Sengkut and Kerajaan over 2007. The population Pergetteng-getteng Sengkut near the site of the hydropower plant and its surroundings amounts to 758 families, i.e. 3,485 persons (1727 males and 1758 females) who occupy an area of 82.24 km2. Kerajaan has 1,798 households comprising 8237 persons (4119 males and 4118 females). The population occupies five villages scattered in Perget-teng-getteng Sengkut Sub-district and 10 villages in the sub-district of Kerajaan. With an area of 82.24 km2 in Pergetteng-getteng Sengkut and 147.61 km2 in Kerajaan the population density of each sub-district is 43 persons / km2 in Pergetteng-getteng Sengkut and 57.83 per-sons/km2 in Kerajaan.

By age group and sex, the largest group in Pergetteng-getteng Sengkut and Kerajaan is that young people between the ages of 15-19 years (469 youths). The second largest group is the one of children (0-4 years) with 428 children. Details are shown in Table 4-63.

Table 4-63 Population of Pergetteng-getteng Sengkut and Kerajaan by Age Group[23]

Age Group	Population (persons)		
	Male	Female	Group Total
0-4	215	213	428
5-9	202	197	399
10-14	197	199	396
15-19	217	252	469
20-24	173	143	316
25-29	115	112	227
30-34	115	117	232
35-39	105	110	215
40-44	99	98	197
45-49	81	79	160
50-54	60	61	121
55-59	42	48	90
60-64	35	45	80
65-69	37	40	77
70-74	34	44	78
Total	1,727	1,758	3,485

Existing educational facilities in the District Pergetteng-getteng Sengkut and the kingdom is still few: there are seven primary schools with 47 teachers, a private elementary school sup-ported by 12 teachers, a Secondary Junior High School with 6 teachers, 1 Secondary Senior High School with 34 teachers. Further there are 2 Madrasah Ibtidaiyah. The population by profession in Pergetteng-getteng Sengkut consists of 3212 farmers, 126 civil servants / honor and military / police and 147 “others”, and in Kerajaan of 1340 farmers, 111 civil servants / honor and military / police and 428 “others”. Population of each village near the sites was shown as below.

・Kecupak I 156 households, male:369 persons, female: 352 persons
・Kecupac II 384 households, male: 835 persons, female: 798 persons
・Simerpang 82 households, male: 159 persons, female: 170 persons

(4) Living/livelihood

1) Agriculture

It can be said that the development of plantations at the project site and its surroundings has already been carried out since a long time. The types of crops cultivated at the project site are coffee, rice, candle nuts

[23] Pergetteng-getteng Sengkut and Kerajaan in Figures, 2008

2) Livestock

Another source of income is the livestock sector. Common types of livestock are water buffalo, horse, goat, pig and poultry (chicken and duck). Cattle prices vary depending on the size of the animal. Details on livestock in Pergetteng-getteng Sengkut and Kerajaan are shown in Table 4-64

Table 4-64 Common Types of Livestock [24]

No.	Livestock	Total
1.	Buffalo	1518
2.	Goat	700
3.	Cow	90
4.	Pig	1389

(5) Land Use

The location of PLTA Lae Ordi II is situated at Desa Kecupak I and Simarpara in Pergeteng-Geteng Sengkut and Desa Majanggut II Kuta Liang Kerajaan District, Pakpak Bharat Regency, North Sumatera Province. The geographical position is around 98° 10’ East Longitude 02°34’ North Latitude. The Land Use map of Pakpak Bharat Regency is showed as Figure 4-45.

Based on the results of field surveys at the study site a major part of the land in the village of Lae Ordi II is used for of rice, coffee, cassava, sweet potatoes, pine trees, candlenuts and others (tomato, pineapple). A small part of the land is used for settlements. The estimated land area is:

- Rice fields 25% (400 ha)
- Dry land 71.9% (1,150 ha)
- Houses 1.9% (30 ha)
- Other 1.25% (20 ha)

Of the 1,150 ha in the sub-districts of Pergetteng-getteng Sengkut and Kerajaan only about 6.17% ha is productive land (70.91 ha). A large part of the land is empty. Land use is as follows[25]。

59.22 ha coffee plants
· 8.89 ha corn
· 1.5 ha cassava
· 1.3 ha sweet potato
· Other
·

[24] Pergetteng-getteng Sengkut and Kerajaan in Figures, 2007
[25] Central Bureau of Statistics, West Phakpak District, 2007

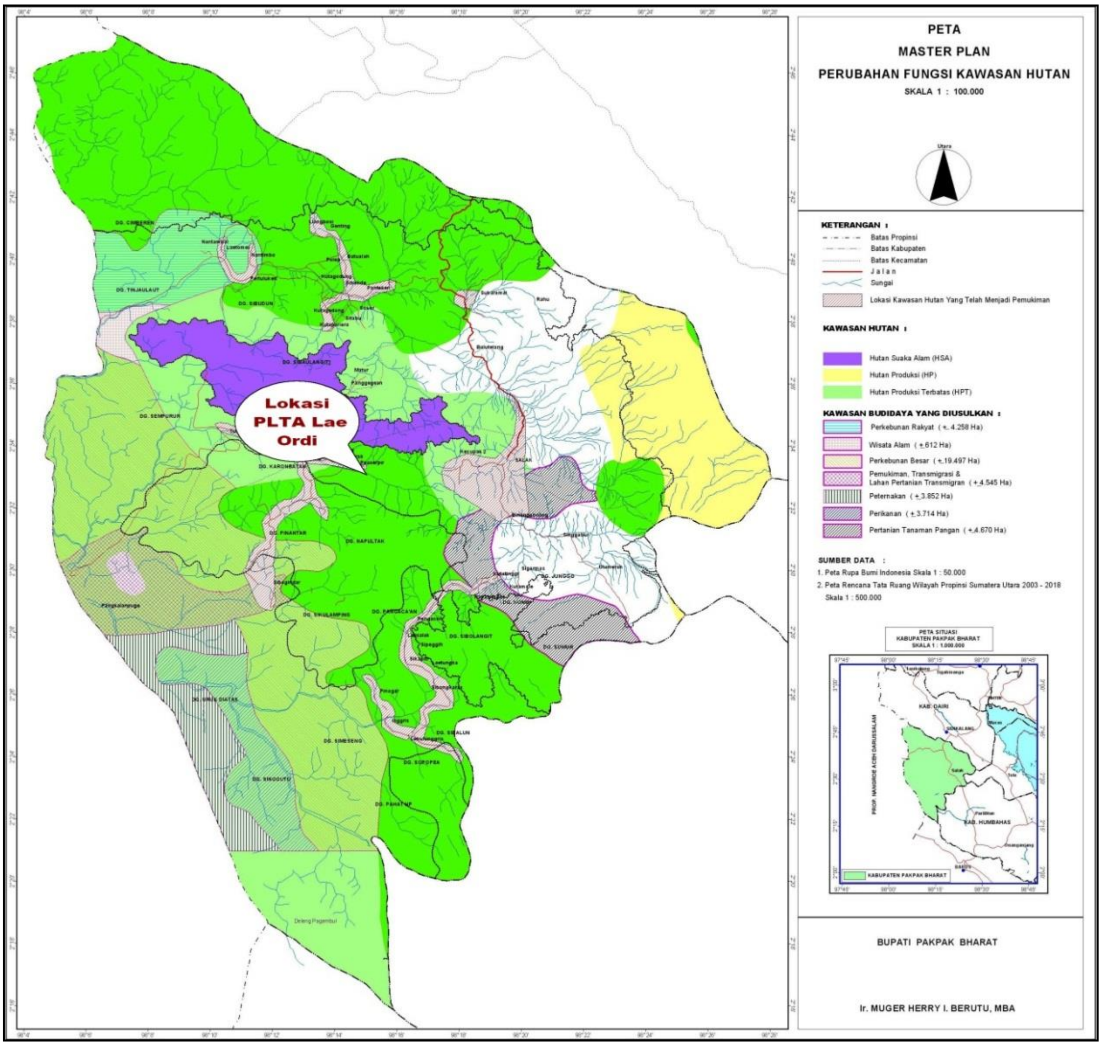


Figure 4-45 Land Use of Pakpak Bharat Regency

(6) Water use

According to the results field reconnaissance of and interviews to the operators, in upstream of the weir and water-reducing section of planned project area of Lae Ordi II, there are no utilization of water for irrigation water, drinking water, water of living, etc.

4-3-1-3. Confirmation of Systems and Organizations Relevant to Environmental and Social Considerations

(1) Laws and References Relevant to Environmental Considerations (Environmental Impact Assessment, Disclosure etc.)

(2) Environmental Assessment Act

(A) “Low No. 32/2009.Environmental Protection and Management” is enacted in 2009

“Low No. 23/1997 Environmental Management”. In the Article 1 of “Low No. 32/2009. Environmental Protection and Management” , it is said that project/activity which may have serious impact to environment requires Environmental Impact Assessment(EIA; AMDAL in Indonesia) and project/activity which doesn’t have serious impact to environment requires Environmental Management Procedure/Environmental Monitoring Procedure(UKL/UPL).

This project requires UKL/UPL and it is approved on March 2013.

See Appendix L4-6.

(B) Government Regulation about Environmental Impact Assessment No.27/1999

The procedure of AMDAL is determined in "Government Regulation about Environmental Impact Assessment No.27/1999" on the basis of Environmental Management Law 1997. Although Environmental Conservation and Management law was established in 2009, the procedure is still effective.

(C) State Minister of Environment Decree No.11/2006, Type of Business and/or Activity Plan requiring AMDAL

In "State Minister of Environment Decree No.11/2006, Type of Business and/or Activity Plan requiring AMDAL" enacted in 2006, the project or the activity that requires AMDAL is determined. Regarding to a dam, a dam whose height of dam body is over 15m requires AMDAL.

(D) State Minister of Environment Decree No.11/2010 about Environmental Management and Monitoring policy and document relevant to implementation of Environmental Management

This determines the guidelines of making UKL/UPL document.

(E) Public Participation and Disclosure in the Environmental Impact Assessment process

Article 33-35 in "Government Regulation about Environmental Impact Assessment No.27/1999" determines the procedure of disclosure of information about environmental impact to the public. The detail is determined in "State Minister of Environment Decree No.8/2006".

(F) Related Organizations

Organizations related to AMDAL are listed below.

(a) Competent organ of project/activity
(b) AMDAL committee：Established in National, Provincial District/city level.
(c) Approval authority: Minister, Governor, regent/mayor.
(d) Procedure of Environmental Impact Assessment

Procedure of Environmental Impact Assessment is showed in Figure 4-46

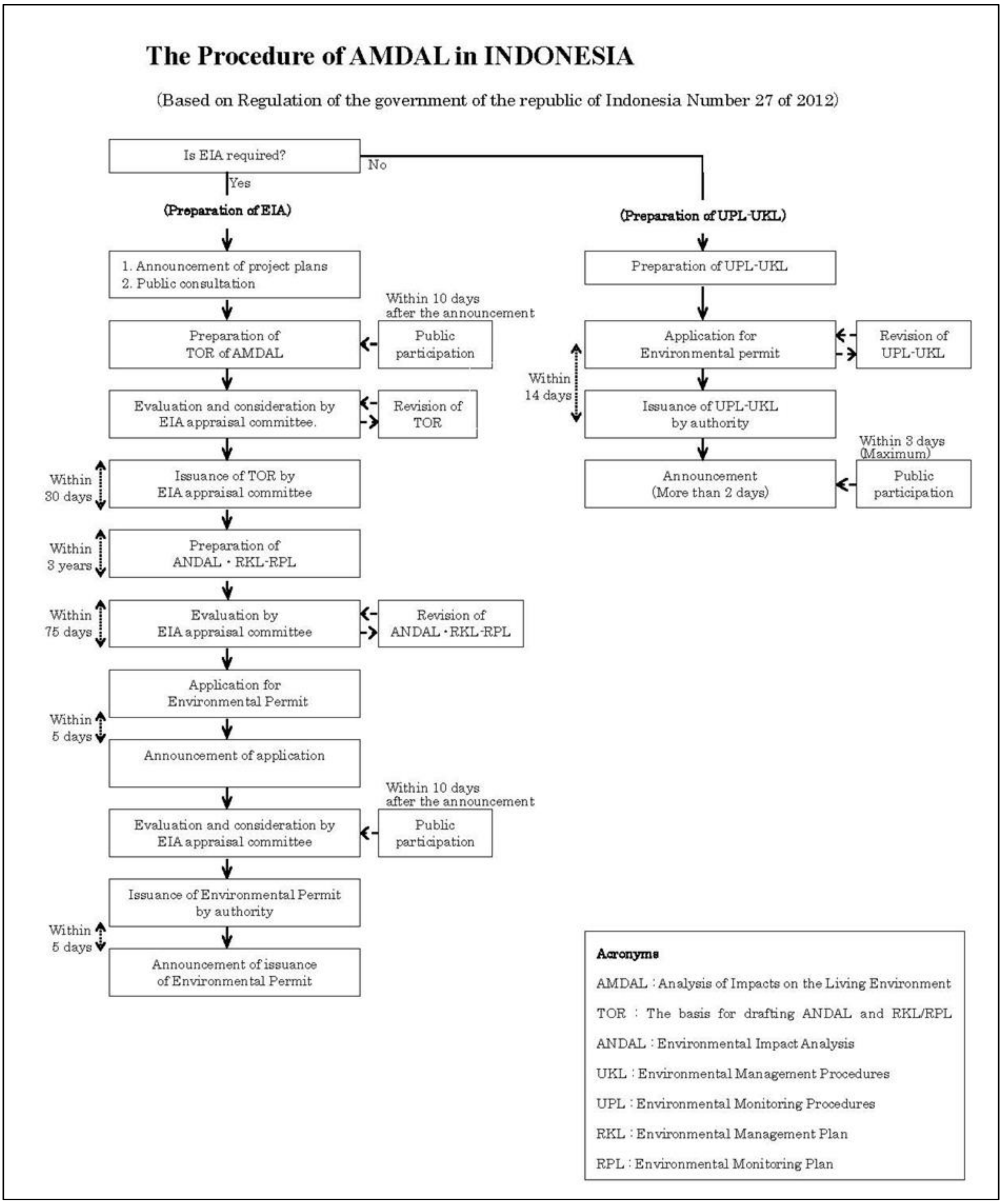


Figure 4-46 Procedure of Environmental Impact Assessment

(3) Laws and Regulations relevant to land procurement and resettlement

1) Laws and Regulations relevant to land procurement

(A) Presidential Regulation No. 36/2005 Land Procurement for Implementation of Public Interest

(B) Presidential Regulation No. 65/2006. Amendment of Presidential Regulation No.36/2005

(C) Decree of the Head of National Land Agency（BPN） No.3/2007. Guidelines for Implementation of Presidential Regulation No.36/2005 on Land Procurement for Implementation of Public Interest as amended by Presidential Regulation No.65/2006

In Indonesia new law on land procurement was promulgated on 2012, but this project take procedures in accordance with the old law because it was planned before 2012

Furthermore, in the new law, every project entity is obligated to create Land Acquisition Plan (LAP) including the definition of land acquisition process, responsible organization, grievance procedure, term of land acquisition.

2) Land Procurement Committee

Land procurement for public facilities construction is to be conducted by the City/District Land Procurement Committee under the Mayor/Regent Decision in cases where the land needed for public facilities is located within a single district. The City/District Land Procurement Committee consists of 9 persons at most as follows (Article 14 of Head of the National Land Board(BPN) Regulation No.3/2007)

- A District Secretary as both Head and Member
- A Functionary from local government as Vice Head and Member
- The Head of the District Land Office or any functionary appointed as Secretary and Member
- A Head of agency/office/board in the city/district level related to the implementation of land procurement or any functionary appointed, as Member
- In case where the land for public facilities is located in two cities/districts or more within one province, A Provincial Secretary should be in charge of Head of Land Procurement committee. (Articles 15 of Head of National Land Board (BPN) Regulation No.3/2007)

In order to establish these Land Procurement Committees for the Project, the Project Implementer shall submit a request letter to the Governor and Regent for establishment prior to the commencement of land compensation procedures.

3) Land Value Appraisal

Land value appraisal is to be done by a Land Value Appraisal Agency that is to be stipulated by Regent/Mayor. In the case of the absence of Land Value Appraisal Agency in or around the respective city / district, Regent / Mayor is to establish a land Value Appraisal Team, which consists of the following organizations.(Articles 25 and 26 of Head of National Land Board (BPN) Regulation No.3/2007)

- Agent from the institution responsible for construction and /or plantations.
- Agent from the institution of Land and Building Tax Service
- Experts or persons with experience in land value appraisal.
- Academic person with the ability to conduct appraisals of land, building, plantations and/or

other objects built on the land.

Land value appraisal is conducted based on Taxed-Object Selling Value (NJOP) or market price by taking into consideration the NJOP price of the current year, as well as the following items
(Article 28 of Head of National Land Board (BPN) Regulation No.3/2007)

- Location and area of land
- Land Status
- Land entitlement
- Synchronization between land and existing spatial planning or city planning
- Facilities and infrastructure available
- Any other factors for increasing land price/value.

Appraisal of building and plantation prices is to be done by government staff of the district government that is responsible for buildings and farming/landscaping, respectively.
(Article 10 of President Regulation No.65/2006, and Article 29 of Head of National Land Board (BPN) Regulation No.3/2007)

4) Land Compensation Procedure

Land Compensation including resettlement will be conducted using the following standard procedures and/or coordinated by the Land Procurement Committee (Article 7 of President Regulation No.36/2005 as amended by Article 6 of President Regulation No.65/2006 and Article 14 of Head of National Land Board (BPN) Regulation No.3/2007):

- Provide explanations or dissemination to the people (Public Counseling)
- Conduct a research and inventory survey on land, buildings, plantations, and any other objects built on the land, of which rights are to be dispossessed or delivered (Inventory Survey)
- Conduct research on legal status of land, of which rights are to be dispossessed, as well as supporting documents (Research of Land Status)
- Announce the outcome of the research and inventory survey, as referred to in (b) and (c) above, in document. (Announcement of Research and Inventory Results)
- Receive the appraisal results on land from the Land Value Appraisal Agency/Team and government staff responsible for conducting appraisal on the buildings, plantations and/or any other objects built on the land.(Land Value Appraisal)
- Determine the amount of compensation on the land in document, of which rights are to be dispossessed. (Determine of Compensation)
- Make an official report on the dispossession or delivery of the rights(Report Preparation of Dispossession of Land Rights)
- Witness the process of compensation delivery to the land owners (Compensation Payment)
- Make an official report on the dispossession or delivery of the rights (Report Preparation of Dispossession of Land Rights).
- Administer and document all land procurement-related documents and submit them to the Project Implementer who requires the land, and also to the District Land Office.(Administration and Documentation of Land Compensation)
- In the case where no agreement is achieves from the discussion, the Land Procurement Committee should report/deliver the problems raised as well as several solution proposals to the

Regent (Bupati) of the related district (Decision for Settlement)

The Provincial Land Procurement Committee, on the other hand, is to facilitate/conduct the following tasks (Article 15 of Head of National Land Board (BPN) Regulation No.3/2007)

- Give explanations and guidelines for the land procurement procedures in the related districts.
- Coordinate and synchronize the land procurement procedures in the two districts.
- Provide considerations to the Governor for the purpose of decision making regarding the form and amount of compensation, proposed by the Mayor (Bupati) of related districts. Supervision and control upon the land procurement procedures in the related districts.
- Procedure of Land acquisition process in Indonesia

Procedure of Land acquisition process in Indonesia is showed in Figure 4-47

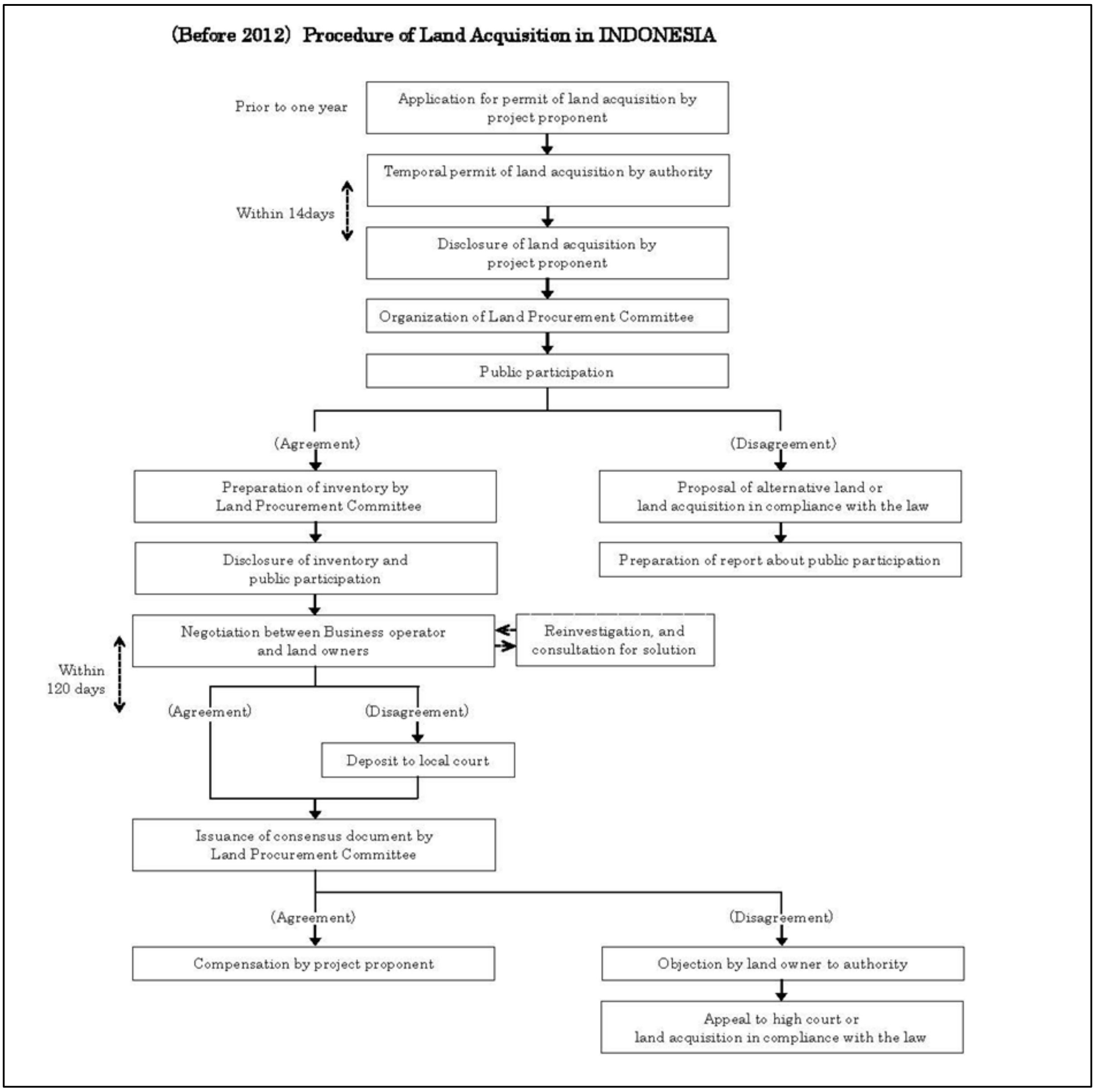


Figure 4-47 Procedure of Land Procurement [26]

5) Gaps of Indonesian Laws and JICA Guideline (Apr. 2010)

Table 4-65 shows comparison between JICA guidelines and relevant laws and regulations in Indonesia and Table 4-66 shows Policies to deal with gap between JICA guidelines and relevant laws and regulations in Indonesia.

[26] Presidential Decree No.36/2006 and Head of National Land Agency Decree No.3/2007
In indoneisa new law on land procurement was promulgated on 2012, but this project took procedures in accordance with the old law because it was planned before 2012. Therefore the figure was prepared in accordance with the old law.

Table 4-65 Comparison between JICA guidelines and relevant laws and regulations in Indonesia

Item	JICA guidelines / OP4.12	Relevant laws and regulations in Indonesia.
Preparation of RAP	Preparation of RAP based on appropriate participation of PAPs. In preparing RAP, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	In Indonesia land law, there is no description regarding preparation of RAP and no description regarding responsibility of project owner neither. Preparation of LAP is required by land acquisition law No.2 of 2012 (enforced at January 2012) but preparation of RAP is not required.
Livelihood recovery support	Host countries must make efforts to enable people affected by projects and improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels. Measures to achieve this may include: providing land and monetary compensation for losses (to cover land and property losses), supporting means for an alternative sustainable livelihood, and providing the expenses necessary for the relocation and re-establishment of communities at resettlement sites.	There is no description in Indonesia land law. It is same in land acquisition law No.2 of 2012 (enforced at January 2012).
Support for squatters	Support for squatters must be provided.	The owner of the religious or legal owner of the building affected are entitled to compensate for loss. It is same in land acquisition law No.2 of 2012 (enforced at January 2012).
Calculation of compensatio n	Prior compensation, at full replacement cost, must be provided as much as possible.	Compensation value is calculated based on the market price calculated by land evaluators as third party or NJOP.
Support for socially vulnerable	Appropriate consideration must be given to vulnerable social groups, such as women, children, the elderly, the poor, and ethnic minorities, all members of which are susceptible to environmental and social impacts and may have little access to	There is no description in Indonesia land law. It is same in land acquisition law No.2 of 2012 (enforced at January 2012.).

	decision-making processes within community.	
Public participation	Appropriate participation by affected people and their communities must be promoted in the planning, implementation, and monitoring of resettlement action plans and measures to prevent the loss of their means of livelihood.	Information about land acquisition and project summary should be open to public within 14 days after approval. In addition, consultation with land owners involved in land acquisition is required, and it is necessary to public through the media and website consultations. In land acquisition law No.2 of 2012 (enforced at January 2012.), public consultation is required in 60 business days of business development stage.
Complaint handling	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	There is no description in Indonesia land law. In land acquisition law No.2 of 2012 (enforced at January 2012.), objection may be filed to the district court within 14 business days.
Monitoring	Appropriate follow up plan such as environmental management plan, environmental monitoring plan should be prepared and cost and sources and method should be planned. Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders.	There is no description in Indonesia land law. In land acquisition law No.2 of 2012 (enforced at January 2012.), monitoring and evaluation of the performance of Acquisition of Land in the Public Interest shall be made by the government and Monitoring and evaluation of the results of the handover of the Acquisition of Land in the Public Interest shall be made by the Land Administrator.

Table 4-66 Policies to deal with gap between JICA guidelines and relevant laws and regulations in Indonesia.

Gap confirmed	Policies
Preparation of RAP	Confirm project operator to prepare RAP.
Livelihood recovery support.	Impact on livelihood due to land acquisition is insignificant, therefore, comprehensive support such as road maintenance and power supply etc. are planned.
Support for the squatters	Basically, support for the squatters will be provided.
Calculation of compensation	Amount of compensation is decided thorough negotiation with land owners and local government agencies. It is regarded as market price.
Support for socially	Support will be provided as necessary.

vulnerable	
Public participation	Public participation is implemented as meeting/presentation of UKL/UPL and public consultation on land acquisition.
Grievance	Project operator will provide consulting service.
Monitoring	Monitoring will be implemented in accordance with Environmental Monitoring Plan described in UKL/UPL, reporting to relevant authorities and employment of professional consultant will ensure transparency and certainty.

4-3-1-4. Analysis of Alternatives (Including Without Project Scenarios)

(1) Alternatives

In Indonesian Laws there are no obligations to consider alternative plan in the UKL/UPL procedure. But Geographical conditions, local people's residence including rice fields were considered at the planning stage.

Although siphon type was considered as alternative, siphon was avoided because siphon is physically weaker than waterway.

(2) Zero Option

If this project is not implemented, the community and the area will not be benefited by following positive impact of this project.

1) Increase the amount of electrical power to meet the electricity needs of the community in order to further support activities in the field of economy and development.
2) Support regional development in Pergeteng-geteng Sengkut Sub-district in particular, and in West Phakpak in general.
   - Can improve and open up new employment opportunities for the population, especially in West Phakpak District (population of Pergeteng-geteng Sengkut).
   - Improve living standards of the population and contribute positively to economic growth and development in West Phakpak District.

4-3-1-5. Scoping and TOR of Environmental and Social Considerations

(1) Scoping

Result of Scoping of Lae Ordi II Mini Hydropower Project is shown in Table 4-67

Table 4-67 Result of Scoping of Lae Ordi II Mini Hydropower Project

Item		Impact	Rating		Result
			Pre-/Construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	B-	**Construction phase** : Although production of Exhaust gas, dust are expected from operation of construction machinery and vehicles, affected term and area are limited. **Operation phase, Operation Phase** : Exhaust gas will be generated by vehicles.
	2	Water Quality	B-	B-	**Construction phase** : Impact such as sediment discharge from construction site, outflow of oil from construction machinery or vehicles etc. and drainage from accommodation for construction are expected. **Operation phase** : Creation of delay and reduce flow section are expected caused by installation of weir and water-intake.
	3	Waste	B-	D	**Construction phase** : Generation of waste dump and scrap material are expected. **Operation phase** : Generation of waste is not expected.
	4	Soil Pollution	B-	D	**Construction phase** : There is a possibility of soil pollution caused by outflow of oil from construction machinery or vehicles etc. **Operation phase** : Not expected
	5	Noise and Vibration	B-	B-	**Construction phase** : Generation of noise and pollution caused by operation of construction machinery and vehicles is expected. **Operation phase** : Operation of power plant will generate noise. Also traffic of relevant vehicles generates noise and vibration.
	6	Odor	D	D	**Construction phase・Operation phase** : Generation of odor is not expected.
Natural Environment	7	Protected Area	D	D	**Construction phase・Operation phase** : There are no protected are around the project area.
	8	Ecosystem	C	C	**Construction phase** : Impact on ecosystem due to construction work is expected, but extent is unknown at the present moment. **Operation phase** : Impact on animals due to noise generated by traffic is expected, but extent is unknown at the present moment.
Social Environment	9	Resettlement	B-	D	**Pre-Construction phase** : In association with land procurement of project site, resettlement is expected.
	10	The poor	D	D	**Pre-Construction phase・Operation phase** : There are no poor people in in target person of resettlement.
	11	Indigenous or minority people	D	D	There are no indigenous or minority people around the project site.
	12	Local economy such as employment or livelihood.	B-/B+	B-/B+	**Pre-Construction phase** : There are shift of livelihood caused by resettlement is expected and decline of income caused by land procurement is expected. **Construction phase** : Local workers are employed for

Item	Impact		Rating		Result
			Pre-/Construction Phase	Operation Phase	
					implementation of this project. **Operation phase :** Loss of livelihood or decline of income in association with resettlement and land procurement may cause poverty. /Increase of employment for operation and maintenance is expected.
	13	Land use and utilization of local resources	B-	B-	**Pre-Construction phase・Operation phase :** Installation of facilities such as water way may cause change of land use.
	14	Water use	B-	B-	**Construction phase :** Impact on water use caused by flow in of earth and sand in river is expected. **Operation phase :** Impact to water use duet to creation of decreased flow section and installation of waterway is expected.
	15	Exsting Infrastructure and social service	B-	B-/B+	**Construction phase :** Increase of traffic at construction phase is expected. **Operation phase :** Increase of traffic is expected./ Infrastructure service may improve because of supply of electricity to local community.
	16	Social Institutions and local decision making institution	B-	D	**Pre-Construction phase :** Impact to local decision making institution is expected during resettlement and compensation procedure. **Operation phase :** Increase of social institution is expected due to implementation of the project.
	17	Misdistribution of benefits and compensation	B-	B-	**Pre-Construction phase・Operation phase :** Feeling of unfairness may caused by resettlement and land procurement. Although supply of electricity will increase benefit, in case there will be misdistribution of supply, it will increase feeling of unfairness.
	18	Local Conflicts of Interest	B-	B-	**Pre-Construction phase・Operation phase :** Certain extent of loss will expected among residents involved in resettlement and land procurement, it may cause local conflict. And, misdistribution of electricity supply may cause local conflicts.
	19	Cultural Heritage	D	D	There is no historical, cultural, archeological heritage.
	20	Landscape	B-	B-	**Construction phase :** Change of landscape is expected due to cut of trees etc. **Operation phase :** Installation of relevant facilities will change landscape.
	21	Gender	D	D	**Construction phase・Operation phase:** There is no impacts expected.
	22	Children's Right	D	D	**Construction phase・Operation phase :** There is no impacts expected.
	23	Infectious Disease such as HIV/AIDS	B-	D	**Construction phase :** There is a possibility of distribution of infectious disease caused by import of construction workers. **Operation phase :** There is no impact expected.
	24	Work conditions (Including work safety)	B-	B-	**Construction phase :** There is a possibility of accident and distribution of infectious disease caused by import of construction workers. Operation phase : There is a possibility of accidents during operation and maintenance.
Other	25	Accidents	B-	B-	**Construction phase :** There are possibilities of accidents during construction works and traffic accidents relevant

Item		Impact	Rating		Result
			Pre-/Construction Phase	Operation Phase	
					to construction vehicles. **Operation phase :** There are possibilities of accidents during operation and maintenance phase and traffic accidents relevant to construction vehicles.
	26	Cross-boundary impacts and Climate Change	D	D	**Construction phase：** Although there is generation of CO_2 due to construction machinery and relevant vehicles, impact is temporal and local. Therefore there is no impact on climate change expected. **Operation phase：** Generation of CO_2 due to generation of electricity is relatively small to other power generation method. Therefore there is no impact on climate change expected.

A+/-: Significant positive/ negative impact is expected.

B+/-: Positive/negative impact is expected to some extent

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and impact may be clarified as the study progresses.)

D: No impact is expected

(2) TOR of Environmental and Social Consideration

TOR of Lae Ordi II Mini Hydropower Project is shown in Table 4-68.

Table 4-68 TOR of Lae Ordi II Mini Hydro Power Project

Category	Environmental Item		Survey Item	Survey Method.
Pollution Control	1	Air Quality	1)Relevant environmental standards etc. 2)Meteorology 3) Current status of air quality 4)Traffic	①Obtaining existing document ②Field survey
	2	Water Quality	1)Relevant environmental standards etc. 2)Current status of water quality	①Obtaining existing document ②Field survey ③Interview survey
	3	Waste	1)Relevant environmental standards etc. 2)Method of waste disposal	①Obtaining existing document ②Interview survey
	4	Soil Pollution	1)Relevant environmental standards etc. 2)Management of construction machinery.	①Obtaining existing document ②Interview survey
	5	Noise and Vibration	1)Relevant environmental standards etc. 2)Current status of noise and vibration 3)Traffic	①Obtaining existing document ②Field survey ③Interview survey
	6	Odor	1)Relevant environmental standards etc. 2)Current status of odor	①Obtaining existing document ②Field survey ③Interview survey
Natural Environment	7	Protected Area	1)Relevant environmental standards etc. 2)Current protected area	①Obtaining existing document ②Interview survey
	8	Ecosystem	1)Current status of ecosystem 2)Appearance of rare species	①Obtaining existing document ②Field survey ③Interview survey
Social Environment	9	Resettlement	1)Relevant environmental standards etc. 2)Status of residents affected by land procurement and involuntary resettlement 3)Affected property	①Obtaining existing document ②Field survey ③Interview survey
	10	The poor	1)Existence of poor people in affected resident	①Obtaining existing document ②Interview survey
	11	Indigenous or minority people	1)Status of indigenous or minority people	①Obtaining existing document ②Interview survey
	12	Local economy such as employment or livelihood.	1)Status of local economy	①Obtaining existing document ②Interview survey
	13	Land use and utilization of local resources	1)Status of land use	①Obtaining existing document ②Field survey ③Interview survey。
	14	Water use	1)Status of water use	①Obtaining existing document ②Field survey ③Interview survey
	15	Existing	1)Status of existing	①Obtaining existing document

Category	Environmental Item		Survey Item	Survey Method.
		Infrastructure and social service	infrastructure	②Field survey ③Interview survey
	16	Social Institutions and local decision making institution	1)Current status of social institutions and organizations	①Obtaining existing document ②Interview survey
	17	Misdistribution of benefits and compensation	1)Status of local economy 2)Livelihood of affected residents	①Interview survey
	18	Local Conflicts of Interest	1)Status of local economy 2)Livelihood of affected residents	①Interview survey
	19	Cultural Heritage	1)Status of cultural heritage	①Obtaining existing document ②Interview survey
	20	Landscape	1)Status of scenic spot	①Obtaining existing document ②Field survey ③Interview survey
	21	Infectious Disease such as HIV/AIDS	None	None
	22	Work conditions (Including work safety)	None	None
Other	27	Accident	None	None
	28	Cross-boundary impacts and Climate Change	None	None

4-3-1-6. Result of Environmental and Social Survey

(1) Pollution Abatement (Air Quality, Water Quality, Waste)

1) Air Quality and Noise

The results of Air and Noise parameters are showed below.

Table 4-69 The Results of Air and Noise Parameters

No.	Parameter	Analysis Result	Quality	Unit	Reference Method
1.	SO_2	68.8	900	μ/Nm^3	Pararosaniline
2..	NO_2	97.5	400	μ/Nm^3	Saltzman
3.	H_2S	0.003	2.0	Ppm	Methylene blue
4.	NH_3	0.008	0.002	Ppm	Salicylate method
5.	TSP	88.9	230	$\mu g/Nm^3$	Gravimetric
6.	Noise	58.3	70	dB	Sound meter level

Source: UKL / UPL (Result of laboratory test, 2009)

2) Water Quality

With reference to Government Regulation Number 20 of Year 1990 concerning Water Pollution Control, the Lae Ordi River can be categorized as a class D, river used for agricultural, urban business, industrial and hydropower purposes.

Table 4-70 Results of Water Parameters

	Parameter	Unit	Result	Applicable Standard Value (class D)
1	pH		7.20	5-9
2	DHL	mg/L	98.7	
3	TDS	mg/L	330	
4	Temp*	° C	26.8	Normal water temperatures
5	Cl*	mg/L	2.7	
6	CR6+*	mg/L	0.01	1
7	TSS	mg/L	72	
8	BOD	mg/L	14.2	
9	MBAS*	mg/L	0.01	
10	COD	mg/L	20.8	
11	H2S	mg/L	0.01	
12	TOC*	mg/L	10.1	
13	Phenol*	mg/L	0.01	
14	Oil and fats	mg/L	0.2	
15	NO3-N*	mg/L	1.5	
16	NO2-N*	mg/L	0.005	
17	PO4	mg/L	1.4	

18	NH3	mg/L	0.02	
19	Hg*	mg/L	<0.001	0.005
20	AS*	mg/L	<0.054	1.0
21	Cd	mg/L	<0.005	0.01
22	Mn	mg/L	0.1	2.0
23	Zn	mg/L	0.05	2
24	E.Coli	mg/L	-	
25	Total Coli	mg/L	-	

Source: UKL / UPL (Result of laboratory test, 2009)

3) Waste

Waste of this region is gathered and disposed by Regional government.

(2) Natural environment

1) National Park

National park closest to planned project area is Gunung Leuser National Park. The park is about 60km away.

Figure 4-48 National Park Location Map of North Sumatra

2) Protected Areas

There is no protected area. Confirmation on protected area described in “Reproduced from Indonesia Protected Areas Map (The Department of Forestry, December 2001) and hearing from local residents during field survey have conducted.

3) Natural conservation forest

Location of natural conservation forest around planned project area is shown in Figure 4-49. Planned project area does not include natural conservation forest.

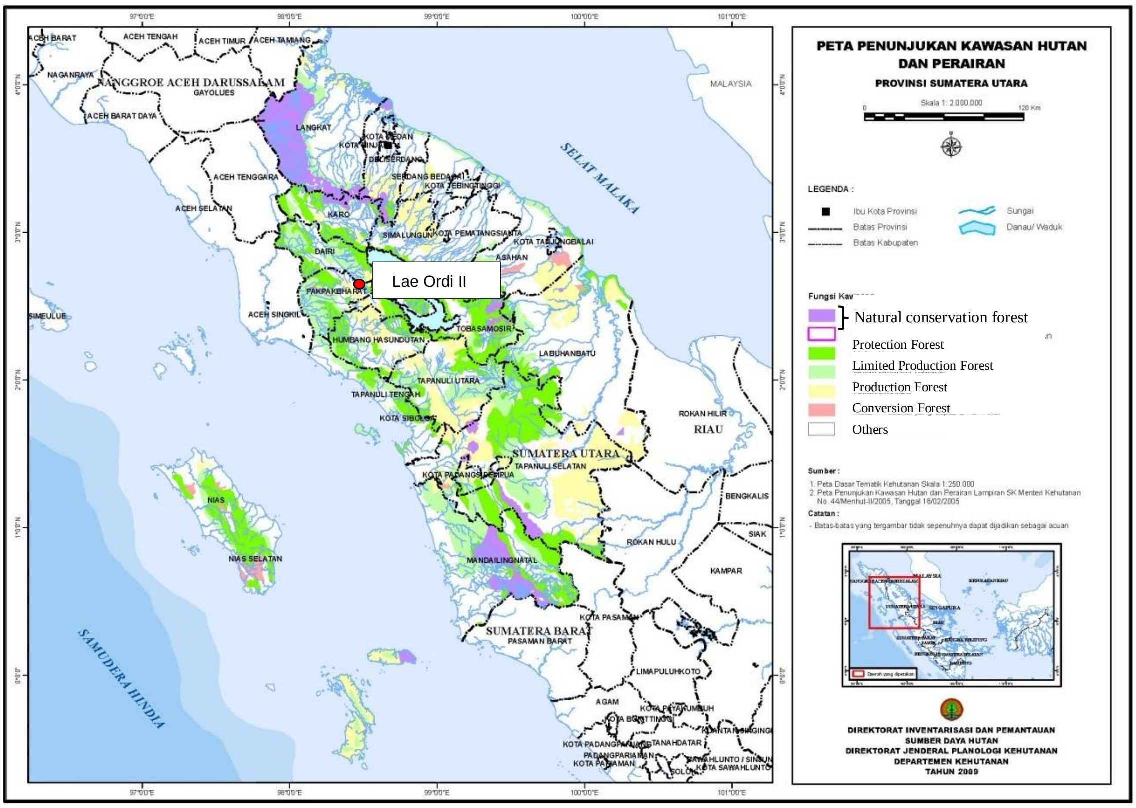


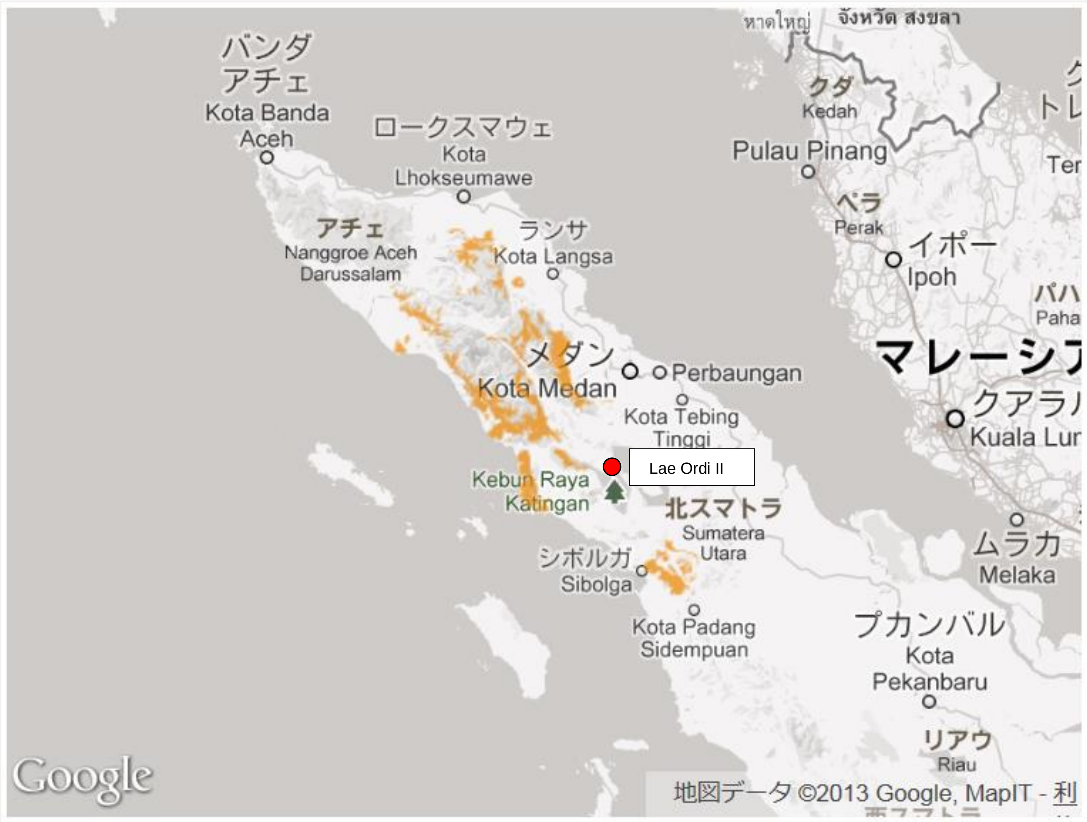
Figure 4-49 Natural conservation forest around planned project area

4) Ecosystem

(A) Rare Species

In the project area, there are no rare species based on the information from UKL/UPL and Government Regulation No.7 1999 and hearing from local residents.

Habitat of orangutans around planned project area is shown in Figure 4-50.Planned project area does not include habitat of orangutans.



Map data provided by IUCN.

Figure 4-50 Habitat of orangutans around planned project area

(B) Vegetation

Natural forest ecosystems are found upstream of the project location. Ecologically, these forests serve as water catchment areas. According to information from the Forest Office of Humbang Hasundutan District, the forests in this area belong to the category protected forest and there are no activities that utilize forest resources. Rare or protected vegetation species were not found. The main types of forest vegetation in this area and its surroundings are shown in Table 4-71

Table 4-71 Main Types of Forest Vegetation in Project Areas and its Surroundings

No.	Local name	Species
1.	Pine	*Pinus Merkusi*
2.	Sugar palm	*Arenga Saccharifera*
3.	Reed	*Imperata Cylindrica*
4.	Ferns	*Cycadaceae* sp.

Source: UKL / UPL (Survey Results, 2009)

The vegetation around the project sites was classified into the following types. The area around the sites has been largely cultivated into planted rubber tree forests, corn fields, rice fields and other crop fields such as coffee farm. Shrubs have also developed in abandoned rubber tree forests and crop fields. The high tree forests, which can be good habitats for birds and animals, distributes only on the steep narrow slope along Ordi River, or at much higher altitudes than the residential area. Residential area includes 22 households of the village of Dinaan and is located along the main paved road near the Power House. There is also another residential area with about 50 households north from Dinaan. The main road passes from Salak toward Aceh. Some unpaved roads extend from the main road downwards to Ordi River.

Table 4-72 Type of Vegetation

No.	Type	Notes
1.	High Tree Forest	Forests of Shorea, Fagaceae and others (Production forests or Secondary forests)
2.	Cultivated Land	Planted rubber tree forests, corn fields, rice fields, other crop fields, shrubs established on abandoned crop fields
3.	River	Ordi River and rocky river banks
4.	Residential Area	Houses, gardens, churches, graves
5.	Road	Paved roads, unpaved roads

Source: Prepared by IDEA based on the result of field survey(June, 2012)

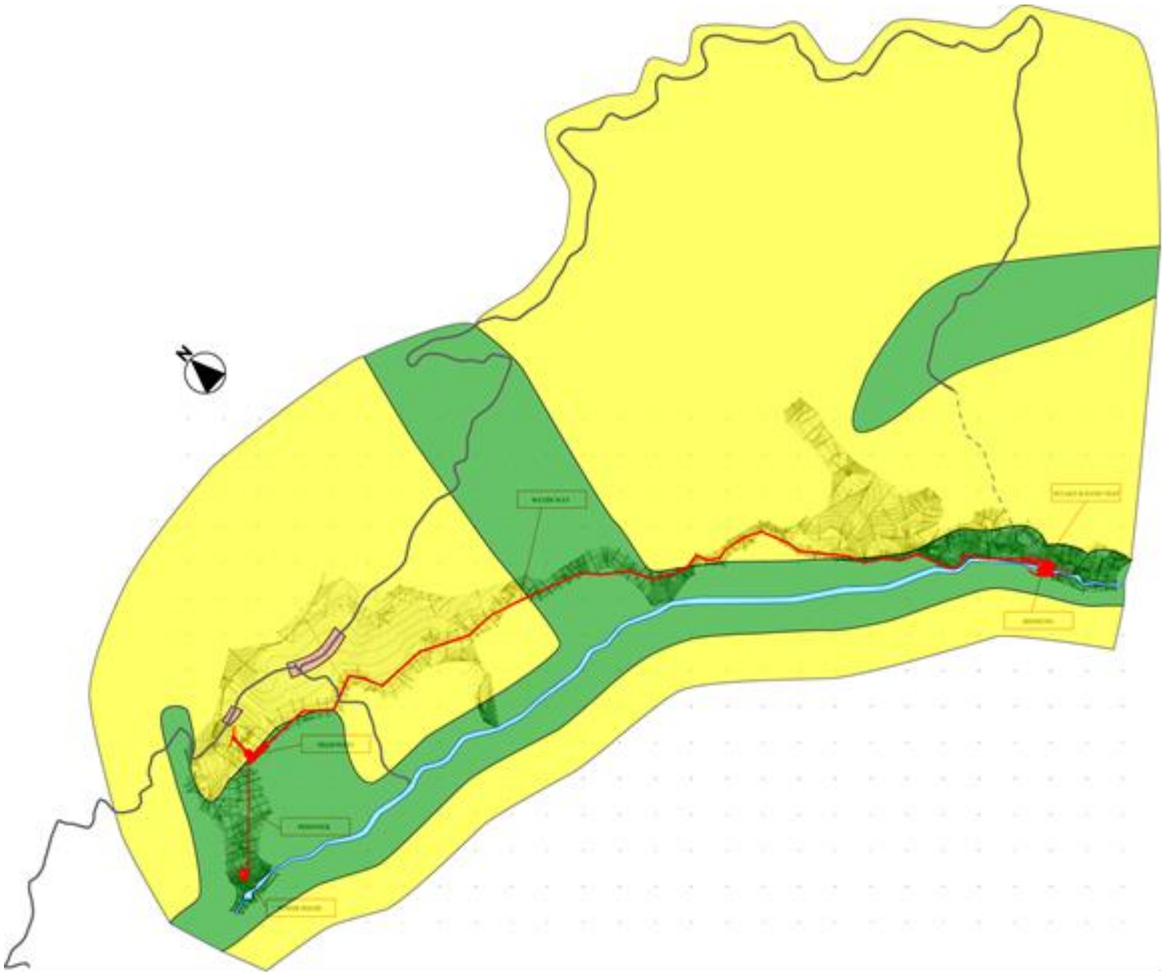


Figure 4-51 Vegetation Distribution Map for the Project Site

Source: Prepared by IDEA based on the result of field survey(June, 2012)

(1) High tree forests

(2) Cultivated land (Planted rubber trees)

(3) Ordi river and rocky banks

(4) Cultivated land (Crop field)

(5) Residential Area

(6) Paved Road

Figure 4-52 General Condition Around the Project Site

Common species such as *Melastomataceae* sp., humble plant, bamboo, *Macaranga* sp. and *Dicranopteris* sp. were widely found. In the high tree forests along Ordi River, Shorea, commonly called as Meranti, and *Fagaceae* sp. and other trees formed the canopy while several kinds of ferns such as tree fern were seen on the moist ground. In shrubs, there were *Mallotus* sp., *Archidendron pauciflorum*, commonly called as Jengkol, cacao trees, coffee trees and fruit trees.

(1) Humble Plant (*Mimosa pudica*)

(2) *Macaranga* sp.

(3) Bamboo(*Bambusoideae* sp.)

(4) Fern (*Dicranopteris* sp.)

Figure 4-53 Vegetation around the Project Site (Part 1)

(5) *Arundina* sp.

(6) *Bidens* sp.

(7) *Stachytarpheta jamaicensis.*

(8) *Melastomataceae* sp.

(9) *Alocasia* sp.

(10) *Asplenium* sp.

Figure 4-54 Vegetation around the Project Site (Part 2)

(11) *Impatiens balsamina*

(12) *Lamiaceae* sp.

(13) *Rubus* sp.

(14) *Mallotus* sp.

(15) *Pongamia* sp.

(16) *Ixora chinensis*

Figure 4-55 Vegetation around the Project Site (Part 3)

(17) *Spathoglottis* sp.

(18) *Mussaenda* sp.

(19) *Fagaceae* sp.

(20) *Polypodiaceae* sp.

(21) *Orchidaceae* sp.

(22) Jengkol (*Archidendron pauciflorum*)

Figure 4-56 Vegetation around the Project Site (Part 4)

Figure 4-57 High Tree Forests and Ferns along Ordi River

(C) Fauna

(a) Mammal

The calling of Black Monkey was heard near the village.

According to the residents, Black Monkey is one of common mammals in the area. Also the residents often see Grey Monkeys and wild pigs, but do not find Orangutan near the village or the sites.

Livestock such as dogs, cats and cattle were seen around the residential area and in the crop fields.

Figure 4-58 Cattle near the Access Road

(b) Amphibious

Eggs and tadpoles of *Macrohylidae* sp. were found in a pond and in a ditch along the main road near the village, respectively.

(1) Eggs of *Microhylidae* sp.

(2) Tedpoles of *Microhylidae* sp

(3) A marsh by the main road expected to be a good habitat for aquatic animals such as frogs.

Figure 4-59 Inhabitations of Amphibious

(c) Reptile

Two snakes of *Colubridae* sp. were seen. According to the residents, snakes and pythons were common near the village.

(1) *Achalinus* sp.

(2) *Colubridae* sp.

Figure 4-60 Reptiles Seen at the Project Site

(d) Bird

Forest birds such as Flycatcher-Shrike, Zebra Dove, Wood-Swallow and Cuckoo were seen or heard throughout the survey area. A Wagtail which prefers waterside was seen at Ordi River. Common species around residential area such as Eurasian Tree Sparrow and Feral Pigeon were also seen.

(1) *Pericrocotus divaricatus*

(2) *Motacilla* sp.

(3) *Geopelia* sp.

(4) *Artamidae* sp.

(5) *Passer montanus*

(6) *Columba livia*

Figure 4-61 Birds Seen at Field Survey

(e) Insect

Common insects of Hemiptera, Odonata, Diptera, Coleoptera, Isoptera, Hymenoptera, Lepidoptera and Orthoptera were observed throughout the survey area.

(1) Dragonfly (*Neurothemis* sp.)

(2) Dragonfly (*Orthetrum* sp.)

(3) *Cerambycidae* sp.

(4) *Copris* sp.

(5) *Pyrrhocoridae* sp.

(6) Cicada (*Cicadoidea* sp.)

Figure 4-62 Insects Seen at the Field Survey (Part 1)

(7) Ant (*Formicidae* sp.)

(8) *Grasshopper* (*Catantopidae* sp.)

(9) *Eurema* sp.

(10) *Nymphalidae* sp.

(11) *Nymphalidae* sp.

(12) *Neptis* sp.

Figure 4-63 Insects Seen at the Field Survey (Part 2)

(13) *Satyrinae* sp.

(14) *Amata* sp.

Figure 4-64 Insects Seen at the Field Survey (Part 3)

(f) Fish

Based on the result of hearing conducted during the field survey (June, 2012), there are few fish in surrounding rivers because they are very rapid. Fishery is not conducted.

(3) Cultural Heritage

As a result of information collection and observation, there is no historical architecture.

(4) Landscape

Landscape around the project site is showed in Figure 4-65, Figure 4-66 and Figure 4-67. Landscape from the existing road and the village is showed in Figure 4-2 18. Since there are cultivated land and secondary forest, we cannot see the surface of Ordi River.

Both side of river bank are consisted of steep secondary forest. A Place where people can approach the river surface in the project area is the point where existing farm road

Still, upstream of the weir, there is a waterfall with a fall of approximately 10m called Ordi fall. Since the fall location is outside of the project site, the fall will not be affected by the project.

Figure 4-65 Landscape from the Upstream of Right bank of Planned Weir Site to the Downstream

Figure 4-66 Water fall located at upstream of the planned weir point (Ordi Fall)

Figure 4-67 Water way

(5) Labor Environment

Sources of income of the population at the project site and its surroundings are dry land agriculture, plantation agriculture, trade and services.

(6) Living Areas of Indigenous People

Based on the information of UKL/UPL and the field survey (June, 2012).There are no living areas of indigenous people and valuable places for indigenous people in the vicinity of the Project site.

4-3-1-7. Environmental Impact Assessment

Table 4-73 Result of Environmental Impact Assessment of Lae Ordi II

Item		Impact	Assessment based on Scoping result		Assessment based on survey result		Results
			Pre-/Construction phase	Operation phase	Pre-/Construction phase	Operation phase	
Pollution Control	1	Air Quality	B-	B-	B-	B-	**Construction phase：** Although production of Exhaust gas, dust are expected from operation of construction machinery and vehicles, affected term and area are limited. **Operation phase, Operation Phase：** Exhaust gas will be generated by vehicles.
	2	Water Quality	B-	B-	B-	B-	**Construction phase：** Construction work will be implemented at dry season to minimize the sediment discharge from construction site. Appropriate care will be taken to avoid outflow of oil from construction machinery or vehicles etc. Drainage from accommodation for construction are expected to very small and processed by soil infiltration. Therefore impact is considered as minor. **Operation phase：** Although Creation of delay and reduce flow section are expected caused by installation of weir and water-intake, delayed flow section is limited at immediately upper stream of the weir and reduced flow section is monotone river channel. Therefore impact is considered as minor.
	3	Waste	B-	D	B-	D	**Construction phase：** Excavated earth are backfilled or utilized as earth fill to minimize the surplus and waste are processed in accordance with local policy. Therefore impact is expected as minor. **Operation phase：** Daily generation of waste is not expected. At the maintenance stage there are some waste may generated. Generated waste will be processed properly. Therefore impact is expected as minor.
	4	Soil Pollution	B-	D	B-	D	**Construction phase：** Although there is a possibility of soil pollution caused by outflow of oil from construction machinery or vehicles etc. but appropriate management effort taken. Therefore impact is considered as minor. **Operation phase：** Not expected
	5	Noise and Vibration	B-	B-	B-	B-	**Construction phase：** Generation of noise and pollution caused by operation of construction machinery and vehicles is expected but term and area is limited. Therefore impact is expected as minor. **Operation phase：** Although operation of power plant will generate noise, but there are no residents around the site. Impact of noise and vibration is minor because increase of traffic is little.
	6	Odor	D	D	D	D-	**Construction phase・Operation phase：** Generation of odor is not expected.
	7	Protected Area	D	D	D	D	**Construction phase・Operation phase：** There are no protected are around the project area.
Natural Environment	8	Ecosystem	C	C	B-	B-	**Construction phase：** Impact on ecosystem due to construction work is expected, but extent is unknown at the present moment. Land of plant site is comprised of secondary forest and cultivated land. Furthermore, there are no rare species.

Item	Impact		Assessment based on Scoping result		Assessment based on survey result		Results
			Pre-/Construction phase	Operation phase	Pre-/Construction phase	Operation phase	
							Therefore impact of construction is expected as minor. At the river there are no migratory fish confirmed and number of species is small. Therefore impact is expected as minor. **Operation phase：**Impact on animals due to noise generated by traffic is expected, but impact is minor because there are no rare species confirmed.
	9	Resettlement	B-	D	B-	B-	**Pre-Construction phase：**In association with land procurement of project site, no household will be resettled.
Social Environment	10	The poor	D	D	D	D	**Pre-Construction phase・Operation phase：**There are no poor people in in target person of resettlement.
	11	Indigenous or minority people	D	D	D	D	There are no indigenous or minority people around the project site.
	12	Local economy such as employment or livelihood.	B-/B+	B-/B+	B-/B+	B-/B+	**Pre-Construction phase：**There are shift of livelihood caused by resettlement is expected and decline of income caused by land procurement is expected. Construction phase：Local workers are employed for implementation of this project. **Operation phase：**Loss of livelihood or decline of income in association with resettlement and land procurement may cause poverty. /Increase of employment for operation and maintenance is expected.
	13	Land use and utilization of local resources	B-	B-	B-	B-	**Pre-Construction phase・Operation phase：**Installation of facilities such as water way may cause change of land use.
	14	Water use	B-	B-	B-	B-	**Construction phase：**Although impact on water use caused by flow in of earth and sand in river is expected, but the term is limited. Therefore impact is expected as minor. **Operation phase：**Because creation of reduced flow section and waterway are located at precipitous part of the river, impact on water use is expected as minor.
	15	Existing Infrastructure and social service	B-	B-/B+	B-	B-/B+	**Construction phase：**Increase of traffic at construction phase is expected. But measures such as security training for driver will minimize the impact. **Operation phase：**Increase of traffic is expected to very small extent./ Infrastructure service may improve because of supply of electricity to local community.
	16	Social Institutions and local decision making institution	B-	D	B-	D	**Pre-Construction phase：** Impact to local decision making institution is expected during resettlement and compensation procedure. **Operation phase：** Increase of social institution is expected due to implementation of the project.
	17	Misdistribution of benefits and compensation	B-	B-	B-	B-	**Pre-Construction phase・Operation phase：**Feeling of unfairness may be caused by land procurement. Although supply of electricity will increase benefit, in case there will be misdistribution of supply, it will increase feeling of unfairness.
	18	Local Conflicts of Interest	B-	B-	B-	B-	**Pre-Construction phase・Operation phase：** Certain extent of loss will expected among residents involved in

Item	Impact		Assessment based on Scoping result		Assessment based on survey result		Results
			Pre-/Construction phase	Operation phase	Pre-/Construction phase	Operation phase	
							resettlement and land procurement, it may cause local conflict. And, misdistribution of electricity supply may cause local conflicts.
	19	Cultural Heritage	D	D	D	D	There is no historical, cultural, archeological heritage.
	20	Landscape	B-	B-	B-	B-	**Construction phase :** Change of landscape is expected due to cut of trees etc. **Operation phase :** Installation of relevant facilities will change landscape.
	21	Gender	D	D	D	D	**Construction phase・Operation phase:** There is no impacts expected.
	22	Children's Right	D	D	D	D	**Construction phase・Operation phase :** There is no impacts expected.
	23	Infectious Disease such as HIV/AIDS	B-	D	B-	D	**Construction phase :** There is a possibility of distribution of infectious disease caused by import of construction workers. Therefore hygiene instruction is completed. **Operation phase :** There is no impact expected.
	24	Work conditions (Including work safety)	B-	B-	B-	B-	**Construction phase :** There is a possibility of accident and distribution of infectious disease caused by import of construction workers. **Operation phase :** There is a possibility of accidents during operation and maintenance.
	25	Accidents	B-	B-	B-	B-	**Construction phase :** There are possibilities of accidents during construction works and traffic accidents relevant to construction vehicles. Therefore safety guidance is completed. **Operation phase :** There are possibilities of accidents during operation and maintenance phase and traffic accidents relevant to construction vehicles. Therefore safety guidance is completed.
Others	26	Cross-boundary impacts and Climate Change	D	D	D	D	**Construction phase :** Although there is generation of CO_2 due to construction machinery and relevant vehicles, impact is temporal and local. Therefore there is no impact on climate change expected. **Operation phase :** Generation of CO_2 due to generation of electricity is relatively small to other power generation method. Therefore there is no impact on climate change expected.

A+/-: Significant positive/negative impact is expected
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progress)
D: No impact is expected

4-3-1-8. Mitigation Measures and Expense for Implementation of Mitigation Measures

Mitigation Measures will be taken in accordance with "4-3-3-3 Environmental Management Plan" which is described in the following section. The expense for implementation for mitigation measures will be borne by PT. BAKARA BUMI ENERGI.

4-3-1-9. Monitoring Plan

Monitoring by the Project proponent is planned as Table 4-74.

Table 4-74 Monitoring Plan for Lae Ordi II

Environmental Item	Monitoring items	Locations	Frequency of monitoring	Implemanter
【Pre-Construction Phase】				
Social Environment	Status of Land Ownership	The project site	Once/ every six months	PT. Bakara Earth Energy
	Livelihoods / Incomes	The project site	Once during the surveys	PT. Bakara Earth Energy
	Complaints of the Population	The project site	Once during the land acquisition process	PT. Bakara Earth Energy
	Land Acquisition	The project site	Once during the surveys	The Ministry of Forestry
【Construction Phase】				
Water quality	Turbidity	Location of the planned weir and irrigation channels	Once/ every six months	PT. Bakara Earth Energy
Ecosystem	Flora	The project site	Once/ every six months	PT. Bakara Earth Energy
	Water Biota	The project site and the nearest residential areas	Once/ every six months	PT. Bakara Earth Energy
	Disturbance of Wildlife	The project site and the nearest residential areas	Once/ every six months	PT. Bakara Earth Energy
Topography and Geology	Physiography	The project site	Once during the construction phase	PT. Bakara Earth Energy
Social Environment	Demography / Social Interaction	The project site and the nearest residential areas	Once/ every six months	PT. Bakara Earth Energy
	Incomes of the Population	The nearest residential areas	Once/ every six months	PT. Bakara Earth Energy
	Livelihoods / Incomes	The project site	Once/ every six months	PT. Bakara Earth Energy
	Public Facilities	Along the planned access road	Once/ every six months	PT. Bakara Earth Energy
	Community Complaints	Close by settlements along the river especially downstream of the project location	Once/ every six months	PT. Bakara Earth Energy
	Aesthetics	The project site	Once/ every three months	PT. Bakara Earth Energy
【Operaton Phase】				
Water quality		Settlements along the river especially downstream of the project location	Once/ every six months (Operaton Phase)	PT. Bakara Earth Energy
Social Environment	Safety and Security	The project site	Once/ every six months (Operaton Phase)	PT. Bakara Earth Energy
Others	Electrical Energy	The project site	Once/ every six months (Operaton Phase)	PT. Bakara Earth Energy
【Post-Operation Phase】				
Social Environment	Land Use	The project site	Once during the implementation of activities	PT. Bakara Earth Energy
	Livelihoods	The project site	Once during the termination of employee contracts	PT. Bakara Earth Energy

4-3-1-10. Stakeholder Meeting

Public consultations were held three times (The first: unknown, The second: 18 July 2009, The third: 27 June 2012).

4-3-2. Land Procurement and Resettlement

4-3-2-1. Necessity of Land Procurement and Resettlement

Land Procurement and spatial plan at the project site is approved by local government and national government. There are 15 households affected by the project in any kinds. All have received compensation.

Road maintenance will be conducted by BBE as CSR. During construction, the impact caused by vehicles during construction should be considered. Positive impacts by the project are employment of local people, road maintenance, tax income, promotion of local economy and so on.

(1) Land procurement

The total area for the project is 29.1 ha of which the detail designs such as the locations of land cut and landfill are now on progress. During construction phase, BBE is going to hire some land in Salak Town for office and also stocking materials.

(2) Land Tenure and Ownership

The status of land ownership in the planned project area is (a) community owned (adat) land, (b) titled land, and (c) untitled land. At the location of the planned weir, conduits and sedi-mentation basin, land is adat land and untitled land. Land for the construction of the penstock, the power house and tail race as well as the access road is village owned adat land, untitled and titled land as well as land for village roads. A total of 75 land owners is involved. However, to simplify the land acquisition process representatives from each village have been appointed at a total of seven with names of land owners, size of land and status of land.

4-3-2-2. Scale and Area of Land Procurement and Resettlement

(1) Scale of land acquisition

For the implementation of Lae Ordi II mini hydroelectricity project, required land is 30.68ha and all are planned to be secured by the Ministry of Forestry. Land acquired from residents is approximately 4.6ha and major components are shown below.

- Dams, intake and channels: 4,553 m2
- Sedimentation basin: 980 m2
- Penstock: 16,500 m2
- Power house: 550 m2
- Access road: 10,000 m2

(2) Impact of land acquisition

Overview of the impact of land acquisition is as shown Table 4-75
The resettlement by land acquisition for the Project does not occur.
All sites of interest are the property of the Ministry of Forestry, local residents have used as a plantation by convention, it is a land without certification.

Table 4-75 Overview of the impact of land acquisition

Number of affected households				Land area affected (ha)	Affected structures (Cases)	Affected trees
Affected households	Landowner	Land user				
		With certification	Without certification			
0	0	0	15	4.6	0	1,941

(3) Resettlement

The resettlement by the Project does not occur.

(4) Affected households

15 households are subjected to land acquisition, all households has a cultivated land in other area, do not expect to acquire new land.

4-3-2-3. Concrete Measure for Compensation and Support

The process follows government procedures, and establishes a "Land Procurement Committee" which aims to improving living standards and incomes. The average size of the amount of replacement is in accordance with the size and class of the land regardless of social status of the land owner

The size of the area procured is not limited to the size of the land required. If the remainder of the procured land cannot be utilized for the project it will nevertheless be procured. Apart from that, replacement will also be provided for assets affected by the project, either permanently or temporarily. Currently, assets of the land affected by the project are coffee trees, candle nut trees, pineapples and rice.

In this project residents are used land of the Ministry of Forestry conventionally as arable land. The project operator will secure land by lease from the Ministry of Forestry, for land users are paid as a compensation for disclaimer of land(farmland) and crop(trees mainly).

Compensation value is decided by consultation with land user and project operator, therefore, it is comparable to market price.

Since, land users have major cropland in a different location, compensation is sufficient without secure of alternative land.

From the above point, it can be regarded land acquisition related to the project was conducted according to guidelines JICA.

4-3-2-4. Complaint Procedure

The Project proponent will establish grievance mechanism for the Project.

4-3-2-5. Implementation System

Land subjected to acquired are land of the Ministry of Forestry and residents are using conventionally as a arable land. Therefore, compensation of disclaimer of arable land are implemented by project operators responsibility. Since then, project operator will make an rental agreement with the Ministry of Forestry.

4-3-2-6. Implementation Schedule

Land acquisition of Lae Ordi II hydroelectric power plant has already been completed, construction period is more than two years.

During operation period, PPA contract with PLN is 20 years, rental agreement of land with the Ministry of Forestry is 20 years and project life of the facility is expected to be 20years. According to situation, contracts are able to be updated after consultation.

4-3-2-7. Expense and Financial Resources

(1) Land acquisition

1) Compensation cost

Total compensation cost of 15 households is IDR 112 million. Breakdown is shown in Table 4-76 .

Table 4-76 Breakdown of Compensation Cost

No.	Compensation cost (IDR)	Land area (m2)	Affected trees
1	5,628,700.00	2,093.70	139
2	4,962,400.00	2,159.90	54
3	1,489,690.00	654.69	16
4	10,324,980.00	10,244.98	4
5	17,302,040.00	9,819.54	258
6	18,548,280.00	7,573.28	332
7	751,690.00	211.69	15
8	24,947,290.00	3,089.79	677
9	826,960.00	231.96	11
10	222,310.00	222.31	0
11	240,630.00	61.11	3
12	8,537,920.00	3,320.42	176
13	2,788,560.00	161.06	54
14	12,253,480.00	4,503.48	165
15	3,275,750.00	1,650.75	37
Total	112,100,680.00	45,998.66	1941

As compensation for land user of land of the Ministry of Forestry, debt and self-finance was appropriated.

For environmental management and monitoring, following fund is allocated at a year base.

2) Land rent cost.

Total land rent cost to the Ministry of Forestry is IDR 97 million. Breakdown is shown in Table 4-77.

Annual rent is determined by area (ha) multiplied unit price (IDR 1,200,000/ha).

Table 4-77 Annual rent by year

Year	Rent (Rp)
1st year	3,465,600.00
2nd year	3,465,600.00
3rd year	3,465,600.00
4th year	3,465,600.00

5th year	3,465,600.00
6th year	3,465,600.00
7th year	3,465,600.00
8th year	3,465,600.00
9th year	3,465,600.00
10th year	3,465,600.00
11th year	3,465,600.00
12th year	3,465,600.00
13th year	3,465,600.00
14th year	3,465,600.00
15th year	3,465,600.00
16th year	3,465,600.00
17th year	3,465,600.00
18th year	3,465,600.00
19th year	3,465,600.00
20th year	Under confirmation
Total	97,036,800.00

As a land rent cost for the Ministry of Forestry, debt from financial institutions and self-finance will be appropriated in construction period. After construction, revenue from electricity sales will be appropriated.

3) Environmental management and monitoring cost.

In construction period, debt from financial institutions and self-finance will be appropriated. After construction, revenue from electricity sales will be appropriated.

4-3-2-8. Monitoring System and Monitoring Form by Executing Agency

UKL and UPL documents of the Lae Ordi II micro hydropower plant are a main reference in the context of environmentally sound development projects, especially in the case of the Lae Ordi II micro hydropower plant.

Application of the UKL/UPL documents for the Lae Ordi II micro hydropower plant in the pre-construction, construction, operations and maintenance phase as well as the post-operations phases will be reported by the implementer, PT. Bakara Earth Energy, to the Directorate General of Electricity and Energy Development once every six months, with a copy to:

- Governor of North Sumatra Province, c.q. Head of Bapedal of North Sumatra Province.
- Head of West Phakpak District through the Offices of Forestry, Environment and Mining of West Phakpak.
- Office of Industry and Trade of West Phakpak District.

4-3-2-9. Public Consultation

The public hearing has been held 3 times so far but unfortunately for the first public hearing, the date is unknown. The second one was held 18 July 2009, and the third one was held 27 June 2012. The locations conducted were around the local community.

In the meeting/presentation of UKL/UPL, which was conducted on August 5, 2009, local government officer, community leaders, NGO and local residents were participated. Opinions and comments submitted are aggregated to environment, land acquisition and effect on community.

Regarding environment, comments were submitted on impact on water quality, waste management, impact on the landscape, the involvement of relevant agencies and conservation of the basin, and Project Company explained about environmental evaluation result and implementation of environmental management plan and environmental monitoring plan. Regarding land acquisition, comments were submitted on procedure of consensus agreement; Project Company explained implementation of land acquisition in accordance with the law and provision of satisfactory compensation. Regarding effect on community, comments were submitted on contribution of project on community and Project Company explained about utilization of local labor.

See Appendix L4-7.

Regarding employment of local residents, PT. Bakara Bumi Energi has signed a MOU with local government.

See Appendix L4-8.

4-3-3. Others

4-3-3-1. Draft Monitoring Form

・See Appendix L4-9.

4-3-3-2. Environmental Check List

・See Appendix L4-10.

4-3-3-3. Environmental Management Plan

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
Pre-Construction Phase							
9	Resettlement	Local residents may assume that the local government is the owner of the project.	-----	Agreement is to be concluded between the District Government of Humbang Hasundutan and PT. Northsum Hydro concerning the construction of the micro hydropower plant Simonggo Tornauli.	PT. Northsum Hydro assisted by the Government of Humbang Hasundutan District	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
12	Local economy such as employment or livelihood.	Field survey will offer local residents an opportunity to work as local laborer.	-----	1) Engage local residents as much as possible. 2) Explanations will be provided to the public in the vicinity of the site about the plans and the types and kinds of labor needed.	PT. Northsum Hydro assisted by the Government of Humbang Hasundutan Districts.	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
13	Land use and utilization of local resources	Construction of access road and operator house may change physiographic and land use around the project site.	-----	1) Take advantage of existing land contours for staking out of the building in accordance with the design.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor
16	Social Institutions and local decision making institution	- Changing peoples` thinking through interacting with local government officers, local residents and others in the land acquisition	-----	- Developing an appropriate "land acquisition plan"	- Office of the Deputy Commissioner - Executing agency	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
		procedure					
17	Misdistribution of benefits and compensation	- Can occur among residents, workers, government officers, and local politicians	-----	- Developing an appropriate "land acquisition plan"	- Office of the Deputy Commissioner - Executing agency	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
18	Local Conflicts of Interest	- Can occur among residents, workers, government officers, and local politicians	-----	Developing an appropriate "land acquisition and resettlement action plan", including "livelihood restoration program". The program will cover; (1) provide small scale trade facilities at new bridge sites, (2)provide employment opportunity during construction period and operation & maintenance period - Developed access road will function as a vital access/supply route in time of disaster for communities along the road and bridges	- Office of the Deputy Commissioner - Executing agency	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
Construction Phase							
1	Air Quality	Operation of vehicles and equipment during the construction	-----	1) Sprinkle the area with water.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
		work.					
2	Water Quality	Erosion and sedimentation cause a decrease of quality of water of the river.	-----	1) Direct the flow of drainage water to densely planted areas. 2) Carry out construction activities during the dry season.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor
5	Noise and Vibration	Operation of vehicles and equipment during the construction work.	-----	1) Avoid construction activities after 7pm.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor
8	Ecosystem	1) Land clearing may lead to a reduction of plants (grasses and shrubs), trees and animal populations. 2) Contamination of river water because of erosion reduces its quality and disturbs water biota in the river.	-----	1) Clearing of bushes and tree cutting is limited in the project site and kept to a minimum. 2) Erosion water should not flow to the river, but directed to planted land. Construction activities carried out in dry season.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor
12	Local economy such as employment or livelihood.	Involvement of people in the construction activities will increase incomes.	-----	Recruit local residents as much as possible.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The Contractor
13	Land use and utilization of local resources	Construction of access road and operator house may change physiographic and	-----	1) Take advantage of existing land contours for staking out of the building in accordance with the design.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
		land use around the project site.					
14	Water use	Land clearing, excavation, material piling and construction of slope may cause the land to erode by rain and other water flows.	-----	1) Land clearing is kept to a minimum tailored to the needs of construction. 2) Excavation and materials piling are kept to a minimum. 3) Piled materials are to be compacted as soon as possible. 4) Slope must not exceed the design drawings. 5) Carry out construction activities during the dry season.	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor
15	Existing Infrastructure and social service	1) Increased road and navigation traffic may disturb the existing traffic including 2) Traffic jams caused by increased vehicles during construction	1), 2) - Road and vessel traffic volume around the construction site	1) River traffic - Consulting with related authorities on schedule of vessels - Determining a water route after consultation with related authorities 2) Land traffic - Optimization of vehicle schedule. - Reducing the number of vehicles by using buses - Consulting with related authorities on schedules	- Implementation: Contractor/ Environmental Consultant - Supervisor: Executing agency/ Supervision Consultant	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	Expense is included in contract cost by Contractor.
18	Local Conflicts of Interest	External laborers working on the project may cause social jealousy among the local	-----	The population in the project area must be informed about the need to recruit trained laborers for the project. Furthermore, it	The contractor	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	The contractor

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
		population.		is necessary to explain the recruitment process.			
20	Landscape	Tree cutting	-----	Tree cutting will be avoided as much as possible.	- Implementation: Contractor/ Environmental Consultant - Supervisor: Executing agency/ Supervision Consultant	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	Expense is included in contract cost by Contractor.
23	Infectious Disease such as HIV/AIDS	Migrate of worker may cause infectious disease.	-----	Hygiene instruction will be implemented.	- Implementation: Contractor/ Environmental Consultant - Supervisor: Executing agency/ Supervision Consultant	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	Expense is included in contract cost by Contractor.
24	Work conditions (Including work safety)	1) Labor accidents 2) Diseases caused by air pollutants, water pollutants, and noise by construction work	1) Labor accidents - Handling heavy loads - Working at heights - Electric shocks 2) Environment pollution - Ambient Air Quality Standards - Noise level standards - Waste	1) Labor accidents - Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment such as helmets - Install fire extinguishers in fire handling places - Inspect and ensure that any lifting devices such as cranes are appropriate for expected loads - Keep lifting devices well	- Implementation: Contractor/ Environmental Consultant - Supervisor: Executing agency/ Supervision Consultant	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	Expense is included in contract cost by Contractor.

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
			management rule - IFC guideline value for ambient air quality (General/ 2007) and noise (General/ 2007)	maintained and perform maintenance checks as appropriate during the period of construction. - Use equipment that protects against electric shocks. 2) Environment pollution - Observe related standards and provide workers with appropriate equipments such as masks, ear plugs, etc.			
25	Accidents	- Traffic accidents	1) Land traffic 2) River traffic	1) Land Traffic - Observation of traffic regulations, installation of traffic signs, and education on safe driving - Training safe operation of vehicles. - Informing vehicle schedules to the surrounding villages 2) River Traffic - Setting proper signs around construction area for navigation safety - Informing vessel operation schedule to local fishermen etc.	- Implementation: Contractor/ Environmental Consultant - Supervisor: Executing agency/ Supervision Consultant	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	Expense is included in contract cost by Contractor.
Operation and Maintenance Phase							
1	Air Quality	1) Exhaust gas from vehicles used for	1), 2) - Ambient air quality standards	1), 2) - Monitoring the ambient air quality along the road	PT. Northsum Hydro	1) Department of Forestry, Environment	PT. Northsum Hydro

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
		mobilization of equipment and workers 2) Dust from road	- IFC guideline values for ambient air quality (General/ 2007)			and Mining District of Humbang Hasundutan	
2	Water Quality	- Waterway in salt/ paddy fields	- Ambient water standards	- Waterway in salt/paddy fields - Monitoring water quality in the waterway once a week	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
5	Noise and Vibration	Operation of the micro hydropower plant increase noise caused by the turbines and generators.	-----	The noise levels from operation of turbines and generators in buildings generate not much effect on the population because: Residents live not close to the location. Noise from buildings located along the river is muffled by the many trees and overgrowth.	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
8	Ecosystem	1) Mangrove forest 2) Tidal flats	1), 2) - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline (2010) -World Bank OP4.04	1), 2) - Developing “protective measures” - Prohibit disturbance - Monitoring of water quality, sedimentation and topographical features	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
12	Local economy such	Recruitment of power plant employees opens	-----	Workers should be hired from local people as much as possible.	PT. Northsum Hydro.	1) Department of Forestry, Environment and Mining District of	PT. Northsum Hydro

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
	as employment or livelihood.	up job opportunities for local residents.				Humbang Hasundutan	
13	Land use and utilization of local resources	- Changing traditional land use patterns and utilization of local resources	-----	- Improved transportation will maintain land use and utilization	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
15	Existing Infrastructure and social service	1) Traffic jams caused by increased vehicles 2) Improved roads	-----	1) Traffic volume - Minimizing traffic volume by using buses for employees of power plant 2) Access to social services - The access road can be used even in the rainy season.	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
17	Misdistribution of benefits and compensation	Can occur among residents, workers, government officers, and local politicians	-----	Establish a consultation section for any grievance	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
18	Local Conflicts of Interest	External laborers working on the project may cause social jealousy among the local population.	-----	The population in the project area must be informed about the need to recruit trained laborers for the project. Furthermore, it is necessary to explain the recruitment process.	PT. Northsum Hydro.	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
20	Landscape	Existence of related facilities.	-----	Take advantage of existing land contours for the staking out of the building in accordance with the design.	PT. Northsum Hydro.	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro

No	Impacts	Sources of Potential Impact	Benchmark	Management Effort	Implementing Organization	Responsible Organization	Cost
24	Work conditions (Including work safety)	Potential for accident arising during operation of facility	Incidence of accidents during operation of facility.	Safety training will be implemented.	PT. Northsum Hydro.	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
25	Accidents	- Traffic accidents	- Land traffic	- Observation of traffic regulations, installation of traffic signs, and education on safe driving - Informing vehicle schedules to the surrounding villages	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
Post- Operation Phase							
12	Local economy such as employment or livelihood.	Termination of employment will result in reduced income of the workers.	-----	Provide the rights of employees in accordance with their labor contract or government regulations.	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro
18	Local Conflicts of Interest	With the cessation of operations a part of the population has concerns about reduced electricity supply to their area.	-----	Providing explanations to public in the area about electricity needed by community.	PT. Northsum Hydro	1) Department of Forestry, Environment and Mining District of Humbang Hasundutan	PT. Northsum Hydro

4-3-4. Quantitative analysis of emission-reduction

4-3-4-1. Explanation of emission-reduction scheme of GHG

(1) CDM

1) Purpose

The purpose of CDM' is to achieve sustainable development for developing countries, so called host countries (Non Annex I countries), to contribute the ultimate purpose of Kyoto protocol and United Nations Framework Convention on Climate Change, and to support the achievement of numerical goals for Annex I countries(developed countries which are obliged to conduct emission-reduction of GHG). In order to achieve above objectives, emission-reduction projects in which Annex I countries are involved in host country are conducted, and emission credits called CER are issued based on the achieved emission-reduction.

Annex I countries can utilize CER for the achievements of numerical goals of Kyoto Protocol. By enhancing the liquidity with these credits, it can be applied to the framework of market mechanism of international credit emission deals, and as a result, it is possible to decrease the overall costs to achieve the numerical goals.

2) Summary and Structure

CDM has various conditions and considerations, so it is necessary to consider them from the planning phase of projects. Also, various reviews and exemptions are required for CER issuance, and third parties conduct them in a precise manner.

To execute projects, participants create Project Design Document (PDD) which explains important technical and structural information regarding projects. From the contents of PDD, whether CDM is qualifiable or not and the calculation of emission reduction is precise or not are judged and evaluated. This process is called "Validation", and projects which pass "Validation" are registered along with the right procedure through the CDM Executive Board. At the time of project registration, the approval process varies depending on the country even though it is possible to be registered without the involvement of Annex I countries. After registration, project participants execute CDM projects and conduct necessary monitoring to calculate their emission reduction.

Regarding monitoring results, independent reviews are conducted periodically, and the emission reduction by registered CDM projects will be determined later. This process is called "Verification". Designated Operational Entity (DOE) conducts it by following procedures ; Emission reduction amount is verified by giving assurances in writing from DOE based on the verified results. After "Verification", the equivalent amount of CER which DOE verified is issued from the CDM Executive Board. CER are issued after paying CDM operation costs, and then the credit amounts are transferred or distributed to project participants and the Party's accounts.

3) Implementation Status of CDM

As of December 2012, the number of registered CDM projects reached 5,383, and the number of countries where the projects were registered hit 74 . CDM projects in early time were mainly high GWP (Global Warming Potential) projects such as collection and dismantlement of HFC and collection of marsh gas from coal mines and waste dumps. However, the number of CDM projects on renewable energy such as energy conservation, hydro power, and wind power is on the increase recently.

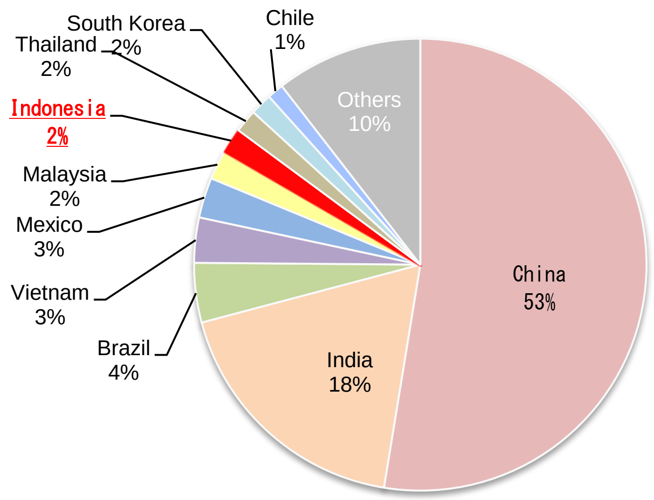


Figure 4-68 Registered Projects by the CDM Executive Board: Breakdown of Host Country

Source：OECC, Kyoto Mechanism Information Platform

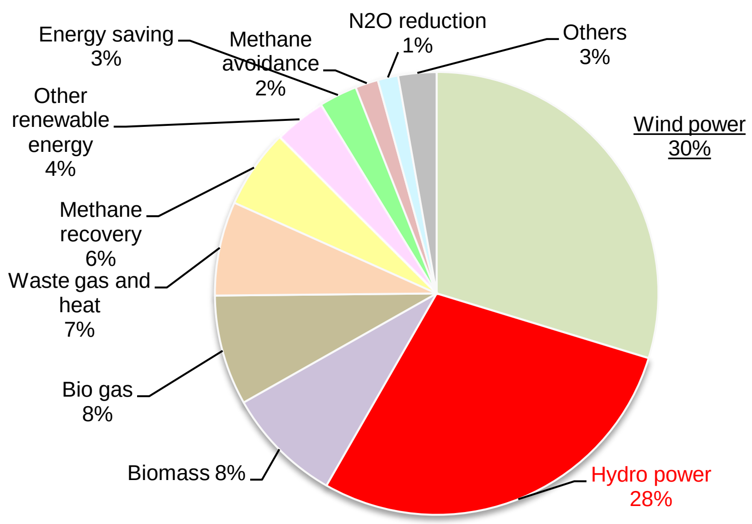


Figure 4-69 Registered Projects by the CDM Executive Board: Breakdown of Sectors

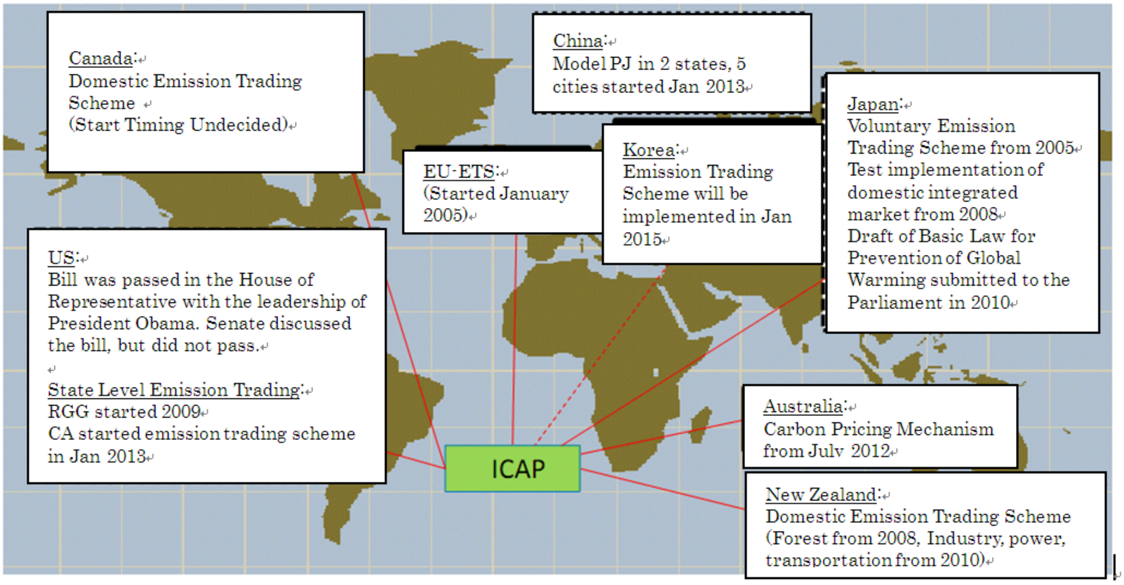
Source：OECC, Kyoto Mechanism Information Platform

Because of various conditions and considerations for CDM projects, there are some risks as such as "Validation Risk" in which the project cannot pass CDM reviews to be "validated". Also, there is "Register Risk" in which the CDM Executive Board does not approve as CDM. In addition, there are "Technical Risk" in which the projects do not produce planned emission reduction due to the technical factor and "Delivery Risk" in which the necessary amounts of emission credits are not delivered despite of execution of emission credit sale's contract. These various risks need to be considered.

(2) Emission Trading Systems except CDM

Main emission-reduction scheme of GHG is currently CDM, and it is mainly used by EU market. However, the introduction of emission-reduction scheme of GHG in countries outside of EU is increasing. Below chart shows the current status of progress and implementation of overseas carbon credit trading. Also, key countries from EU, some states from US and Canada, and New Zealand set up International Carbon Action Partnership (ICAP) and start to create rules which link each country's framework internationally.

Figure 4-70 Progress and Implementation of Overseas Carbon Credit Trading



Source: Ministry of the Environment "http://www.env.go.jp/"

4-3-4-2. Problems of CDM and expectation of structuring JCM/BOCM

(1) Problems of CDM

Regarding CDM applications, many problems are being pointed out, and business operators of small hydro power projects and people involved in global warming countermeasures in Indonesia recognize below problems.

- The application process of CDM is complex and takes time and cost. It does not befit small projects.
- Even though CDM is applied by spending time and cost, current market price of CDM is quite low. The system of CDM is not easy to use. .
- Because of absence of Indonesian DOE and limited number of foreign DOE, there is a long waiting line for reviews.

(2) Problem consciousness toward CDM in Indonesia

In September 2011, Indonesian government drew up National Action Plan which aims at cutting 26% emission of greenhouse effect gas by 2020, comparing with the situation of taking no action (the business as usual situation). At the same time, the task force to check up domestic emission-credit trades was established, and various approaches to achieve the emission-reduction goal are being conducted. In the light of these efforts, it seems that new mechanism which replaces CDM is needed.

(3) Purpose of structuring JCM/BOCM

1) Purpose of JCM/BOCM

To contribute emission-reduction globally, Japanese government proposes JCM/BOCM between two nations to structure a framework of technical transfer and response measures which flexibly keep pace with the conditions of developing countries.

JCM/BOCM quantitatively evaluates Japanese contributions toward the spread and countermeasures of technique, products, service, and infrastructure regarding emission-reduction of GHG in developing countries for its realized emission-reduction. Those contributions will be utilized for the achievements of Japanese emission-reduction goal. Currently, Japanese government and developing countries in Asia are discussing the possibility of JCM/BOCM structure.

2) Expectations toward JCM/BOCM

Some business operators in Indonesia state that it is quite helpful if the process of application in JCM/BOCM can be simple and they can gain some earnings from credits. Compared with CDM, the process of JCM/BOCM is assumed to be simpler, therefore, the scheme of JCM/BOCM is being considered beneficial for people involved in global warming countermeasures and business operators of renewable energy in Indonesia. The meaning of structuring a realistic scheme of JCM/BOCM which meets local business operators' needs is significant to build up the win-win relationship between Indonesia and Japan, which would like to develop global warming countermeasures.

4-3-4-3. Calculation of emission-reduction of greenhouse effect gas in three projects in this preparatory survey

(1) Calculation method of emission-reduction of greenhouse effect gas

The methodology to set up calculations of emission-reductions of greenhouse effect gas by small hydro power generations in JCM/BOCM has not been determined yet. However, the same kind of approach as CDM is assumed to be taken. That is to say, assumed annual emission reduction is calculated as the product of assumed annual electric power supply and Grid's emission factor as follows;

Assumed annual emission reduction ＝ Assumed annual electric power supply × Grid's emission factor

Assumed annual electric power supply is the amount of annual power supply to the grid, and the emission factor of its grid for the calculation is the emission factor that Indonesian government set to each grid. The emission factor of each grid is referred from the below chart.

Table 4-78 Each Grid's Emission Factor in Indonesia

Each Grid	Emission Factor in 2010
Sumatra	0.748
Minahasa-Kotamobagu	0.319
South and West Sulawesi	0.601
Jamali	0.741
Khatulistiwa	0.748
Barito	1.003
Mahakam	0.820
Batam	0.568

Source：National Council on Climate Change, Carbon Trading Mechanism Division Website ”

(2) Calculation of emission-reduction of greenhouse effect gas in three projects in this preparatory survey

1) Assumed annual emission reduction of Lae Ordi project

Assumed annual electric power supply of Tournauli project is 60,948MWh, and its grid emission factor is 0.748t-CO2/MWh. Therefore, assumed annual emission reduction is calculated as below.

45,589tons ＝60,948MWh × 0.748t-CO2/MWh

45,589tons of greenhouse effect gas expected to be reduced from the product of assumed annual electric power supply of 60,948MWh and its grid emission factor which of 0.748t-CO2/MWh.

4-3-4-4. Deliberation to sell emission credit

(1) Concerns regarding selling CDM

Buyers of CDM are limited in effect to players in EU countries. In addition, CDMs which are not registered at this moment cannot be amortized within the scheme of EU. At the same time, the price of CER is currently fluctuating under the price of 0.3 euro per ton. From these reasons, there are many problems in purchase and sale of emission credit by using the framework of CDM. Therefore, it is difficult to sell emission credit from the three projects as CDM.

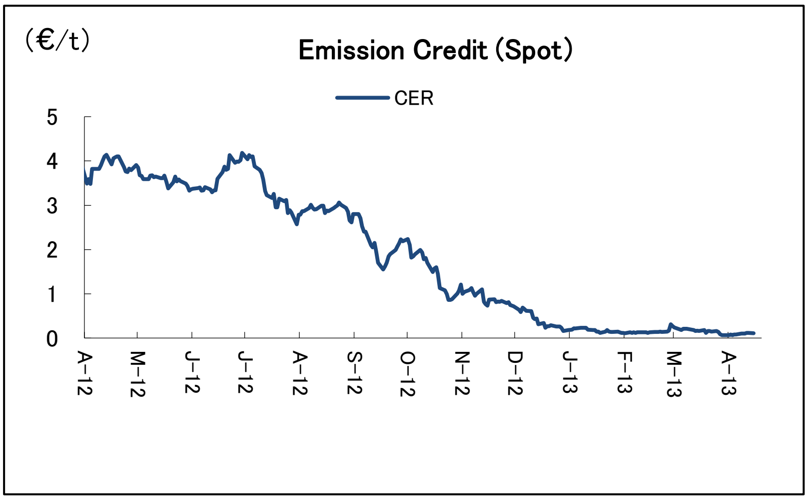


Figure 4-71 Emission Credit's Price Movement in the Last 12 Months

Source：Bloomberg

(2) JCM/BOCM as a new selling method

For now, the framework and prices of emission credit in JCM/BOCM in which Japanese government proposes have some uncertainty. However, it is assumed that Japanese government is a credit buyer in this framework as this scheme is a bilateral one between 2 countries. So JCM/BOCM is expected to be the new form of emission credit trading. The likelihood of introducing the bilateral emission credit trading is enhanced because Japanese government already entered into Memorandum Of Understanding (MOU) with Mongolian and Bangladesh government. The Japanese government is considering entering into MOU with Vietnamese, Indonesian, and Indian governments, and there is a high likelihood that JCM/BOCM scheme is structured in those countries. In this scheme of emission credit trading, the significant amount of emission credit is considered to be sold. If the execution of JCM/BOCM with Indonesian government is realized, it becomes possible to sell emission credit arising from three projects surveyed, resulting in the increase of the profitability of the projects.

4-3-5. Conclusion

The Lae Ordi II small hydropower plant is located in Kecupak I, Simarpara Village, Pergetteng-getteng Sengkut Sub-District, West Phakpak District, North Sumatra.

Area of the planned Lae Ordi II micro hydropower plant is mostly covered with shrubs and mixed farming. The site is located on the lower right bank of the Ordi Lae River. The area is mostly covered with neglected shrubs and gardens.

The construction of the Lae Ordi II micro hydropower plant is estimated to last for over two years. The life time of the plant is estimated at thirty years.

This project will cause negative environmental and social impacts, but all impacts will not be significant. There will be 15 affected persons because of land acquisition, but no resettlement. The community has been welcoming the project because of its positive impacts.

Base on proper implementation of the environmental management plan and monitoring plan, the negative impacts will be reduced/minimized, and the positive impact will be maximized.

Furthermore, assumed annual electric power generation of Lae Ordi II project is 60,948MWh, and its grid emission factor is 0.748t-CO2/MWh. Therefore, assumed annual emission reduction is 45,589ton.

Chapter.5 Outline of Conditions and Issues in the Finance Mechanism with Energy Fund

5-1. Outline and Purpose of the Fund Establishment

5-1-1. Purpose for utilizing the fund

5-1-1-1. Outline of existing fund

(1) Definition of the infrastructure fund and energy fund

In this report, energy fund is a type of infrastructure funds investing into the energy assets including power plants. Infrastructure fund is categorized as one of the alternative investments along with private equity and real estate as opposed to traditional investments targeting stocks, bonds, and exchange. The characteristics of infrastructure fund are laid out below.

- ✓ Stable return is expected based on the stable cash flow attributed to the characteristics of the infrastructure business
- ✓ Low elasticity of demand and low correlation with traditional assets (stocks, bonds, etc)
- ✓ Risk profile varies depending on the stage of the project development

Table 5-1 Characteristics of Infrastructure Fund Compared to Other Types of Funds

	Infrastructure Fund	Venture Fund	Buy-out Fund	Real Estate Fund
Investment Terms	Super-long (10 year & up)	About 3 years	5 to 10 years	About 5 years
Source of Return	Income gain	Capital gain	Income gain + Capital gain	Income gain + Capital gain
Level of Expected Return	Relatively low but stable income-type return expected	High return can be expected from successful IPO (possible zero return on the other hand)	Reasonable return expected from combination of income gain and capital gain	Relatively low but stable susceptive to macro economy (economic cycle, market demand /supply

The source of return of the infrastructure fund is the income gain from the stable cash flow, often invested for super-long period of more than 10 years. Comparison with other alternative fund is shown in the Table 5-1.

Table 5-2 Infrastructure Assets as Investment Target

Economic Infrastructures	Utility	Power, Renewable Energy, Gas Pipeline, Water and Sewage, Communication, etc
	Transportation	Toll road, Bridges, Tunnels, Airports, Ports, Railways, etc
	Others	Warehouses, Parking, etc
Social Infrastructures		Education Facilities, Hospitals, Prisons, Residential Facilities, etc

Source: OECD report[27]

The assets that infrastructure fund targets are divided into economic and social infrastructures as shown in the Table 5-2. Energy fund targets power, renewable energy, gas pipeline, etc in the utility category of economic infrastructures.

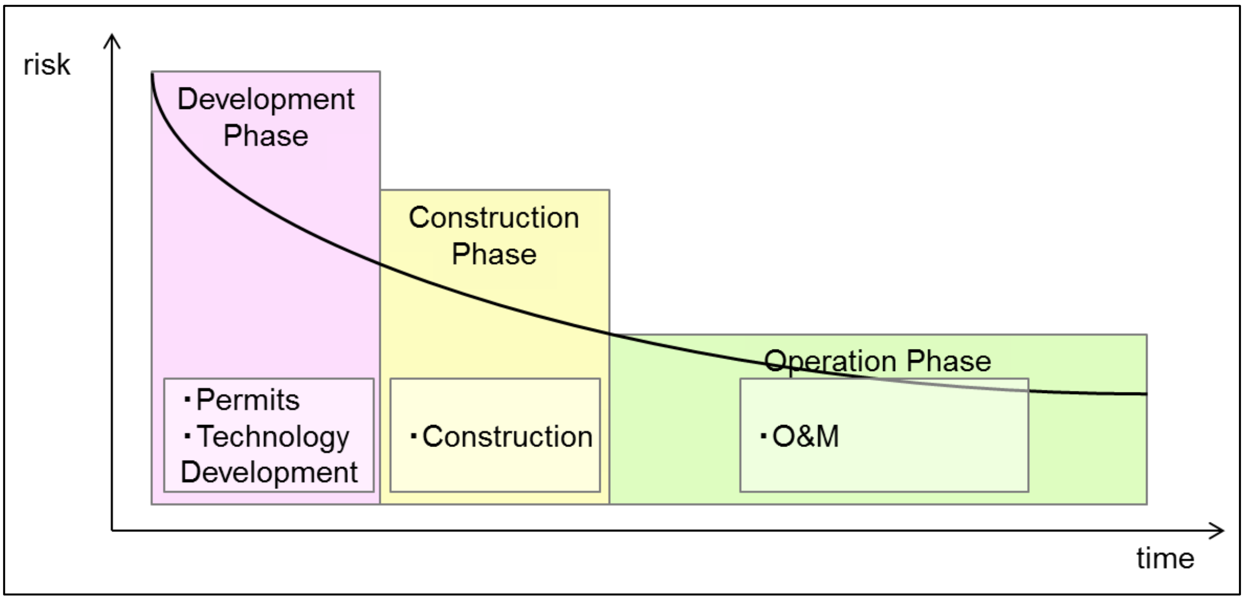


Figure 5-1 Relationship between Development Stages and Risks

Risk of the investment of infrastructure fund or energy fund varies widely depending on the development stage of the investment. In the development phase, risk of not being able to obtain permits and risk of the technology not reaching commercialized level exist while construction phase bears completion risk. Once the construction is completed and operation started, then the risk is relatively low, but the operation risk exists.

[27] Inderst, G. (2009), "Pension Fund Investment in Infrastructure", OECD Working Papers on Insurance and Private Pensions, No. 32, OECD publishing, © OECD.

(2) Outline of existing funds

In utilizing funds, there are three perspectives: strategically focusing on particular geographical area, investing into other funds, and focusing on particular area of investment targets. Therefore, the same perspectives are used in outlining existing energy funds.

In terms of targeted geographical area, there are four categories: global, multiple regional, single regional, and nation focus.

- Asia Pacific (India, China)
- Asia Pacific (Southeast Asia)
- Asia Pacific (South Korea, Australia, Others)
- North America
- Central and South America
- Europe (including Russia)
- Middle East
- Africa

From investor's perspective, when the fund invests into other funds, diversification is enhanced at the expense of transparency of invested portfolio. If the investors have strategic purposes in relation to investees such as co-investment, it would be better to select funds that do not invest into other funds.

Funds are also categorized whether it is focused on energy or not. More detailed analysis should find funds with focus on renewable energy or new energy including technology development. However, detailed categorization will not be used in this report as it is sometimes difficult to make a clear line between these two categories. From the perspective of utilization of the fund, it will be necessary to invest sizable amount against the fund size in order to have an influence on the fund concept. In this report, funds with following characteristics are in the scope: fund size is USD 500m or lower, finished fundraising in the year 2009, and some investment activities are already conducted. Existing funds are laid out below with categorizations by area of investment and geographical area.[28]

[28] In this report, existing fund data are taken from Tim Friedman, "The Preqin Infrastructure Review 2009", and additional fund information is complemented for case studies.

1) Asia Pacific (India, China)

Table 5-3 Asia Pacific Funds (India and China)

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71) Koenig&Cie (M, 33)	HCP FF I (G, 43) HCP FF II (G, 48)
	No	Old Lane India (N, 475) IDFC Private Equity (N, 418) Macquarie Global II (G, 381) Macquarie Global III (G, 292) Asian Infrastructures (M, 234) India Development (N, 174) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109) AIG Indian Sectoral (N, 105) AMPCI Infra (N, 97) IFC Infra (M, 95) Srei Venture (N, 9)	Reliance Energy India (N, 190) Mistral Energy II (G, 104)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

In this survey scope, there are some nation focused funds in India. Reliance Energy India is the only energy focused fund among them, established by the Indian infrastructure conglomerate Reliance Group. Its investment targets include companies and projects related to power generation, transmission, and distribution. The Reliance Group, which has a power company, established the fund taking 10% - 30% minority stakes in principle. The fund is invested by the Temasek Holdings, an investment company owned by the Government of Singapore.

2) Asia Pacific (Southeast Asia)

Table 5-4 Asia Pacific Funds (Southeast Asia)

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71) Koenig&Cie (M, 33)	HCP FF I (G, 43) HCP FF II (G, 48)
	No	Saratoga Asia II (R, 429) Macquarie Global II (G, 381) Macquarie Global III (G, 292) Asian Infrastructures (M, 234) Saratoga Asia I (R, 144) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109) IFC Infra (M, 95)	Southeast Asia Strategic Assets (R, 150) Mistral Energy II (G, 104) Asia Clean Energy Fund (R, 85) Mekong Brahmaputra Clean Development Fund (R, 45) JAIC-IDI Asian Energy Fund (R, 10)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

Compared to other areas, there are few funds with geographical focus in the Southeast Asia, indicating that the area is in the earliest days of the infrastructure fund. On the other hand, establishment of the Southeast Asia Strategic Assets Fund managed by the Malaysian CIMB Group should receive a particular attention as energy focused infrastructure fund in Southeast Asia with USD 150m size.

3) Asia Pacific (South Korea, Australia, Others)

Table 5-5 Asia Pacific Funds (South Korea, Australia, Others)

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71) Koenig&Cie (M, 33)	HCP FF I (G, 43) HCP FF II (G, 48)
	No	Macquarie Korea Opportunities (N, 886) Korea Emerging Infrastructure (N, 423) Macquarie Global II (G, 381) Macquarie Global III (G, 292) Asian Infrastructures (M, 234) Macquarie Global (M, 230) Santander Infrastructure I (M, 185) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109)	Mistral Energy II (G, 104)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

There was no energy focused fund limiting geographical area of investment to South Korea or Australia. Investments in energy assets in these countries are made as one of the investment areas of infrastructure funds with regional or nation focus.

4) North America

Table 5-6 North America Funds

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71) Koenig&Cie (M, 33)	Sterling Stamos II (R, 475) UBS AFA Global (M, 345) Sterling Stamos I (R, 190) Tuckerbrook II (R, 143) Tuckerbrook I (R, 52) HCP FF I (G, 43) HCP FF II (G, 48)
	No	Innisfree PFI III (M, 540) Macquarie Essentia Assets (M, 414) Highstar Capital (R, 386) Macquarie Global II (G, 381) Macquarie Global III (G, 292) Macquarie Global I (M, 230) Santander Infrastructure I (M, 185) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109) Infrastructure & Environment (N, 95)	URSG Power & Biofuels II (N, 451) Starwood Energy (G, 411) Energy Spectrum IV (N, 335) US Power (N, 238) Energy Spectrum II/III (N, 178) Energy Spectrum I (N, 133) Mistral Energy II (G, 104) DREAM Infrastructure (R, 95)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

In the North America, there are many infrastructure funds including ones with energy focus. This can be because of its history of the utilization of infrastructure funds from early days. In the United States, system design of the industry contributes to high liquidity of power assets and in turn sets up the environment where energy focus funds have opportunities to grow. Lastly, energy focus funds in the U.S. are not concentrated on the new energy as it is the case in the Europe.

5) Central and South America

Table 5-7 Central and South America Funds

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71)	HCP FF I (G, 43) HCP FF II (G, 48)
	No	Macquarie Global II (G, 381) AG Angra (Brazil) (N, 349) Macquarie Global III (G, 292) Macquarie Global I (M, 230) Santander Infrastructure I (M, 185) Darby Brazil (N, 194) Darby Latin America (R, 186) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109) IFC Infra (M, 95)	Latin Power III (R, 372) Latin Power II (R, 149) Mistral energy II (G, 104) Latin Power I (R, 95)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

In the Central and South America, Conduit as general partner (GP) manages three Latin Power funds that focus on this area and energy. Conduit is the unique GP managing energy funds successfully.

Investment size the Conduit’s funds target range from USD 60m to 1b in terms of the project total cost. Many projects are co-invested with the local and other sponsors, but targeting shares of 51% or more. For the development stage of the project, Conduit develops the green field projects or acquires operating assets. It focuses on projects in a region which have high economic growth expectation and high creditworthiness of off-takers.

6) Europe

Table 5-8 European Funds

		Not Focus on Energy	Focus on Energy
Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71) Koenig&Cie (M, 33)	UBS AFA Global (M, 345) HCP FF I (G, 43) HCP FF II (G, 48)
	No	Innisfree PFI III (R, 540) Innisfree PFI Continuation II (R, 525) AIG Emerging Europe Infra (R, 499) NIBC European Infra (R, 399) Innisfree M&G PPP (R, 338) Innisfree PFI Continuation I (R, 338) AIG Brunwick Millenium (R, 334) Macquarie Global II (G, 381) Macquarie Global III (G, 292) Macquarie Global I (M, 230) Innisfree PFI II (N, 225) Santander Infrastructure I (M, 185) Great Circle Fund (M, 181) DG Infra + (N, 155) PPP Italia (N, 138) Innisfree PFI I (128) Pareto WW Offshore (127) Barclays UK (110) Israel Infrastructure I (109)	Fortis Clean Energy (M, 460) European Clean Energy (R, 407) Ampere Equity (R, 368) Hg Renewables Power (R, 345) Englefield Renewables (N, 230) DIF Renewables (R, 155) Impax New Energy Investors (N, 144) EnerCap Power (G, 113) Eolia Mistral (G, 109) Enfia Infrastructure I (N, 104) Mistral Energy II (G, 104) Taiga inversións (N, 85)
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

Many infrastructure funds with energy focus have been established similar to North America. In this area, infrastructure investments by the fund started from early days, since 1990s, and M&A in the industry has been relatively active. One unique point of the energy funds in this area is that compared to the North America, many of energy funds limit investment concentration in new energy business.

7) Middle East

Table 5-9 Middle East Funds

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71)	HCP FF I (G, 43) HCP FF II (G, 48)
	No	Macquarie Global II (G, 381) Macquarie Global III (G, 292) Alcazar Capital Partners (M, 285) Zanes Corp Infrastructures (N, 250) Macquarie Global (M, 230) Santander Infrastructure I (M, 185) Great Circle Fund (M, 181) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109)	GCC Energy Fund (R, 345) Mistral Energy II (G, 104)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

Infrastructure building has been accelerated during the past years in the Middle East, and infrastructure funds became one of the venues for infrastructure investments. However, there are few funds focused on the Middle East area, and the funds usually include Africa or Asia as their investment target. For example, Alcazar Capital Partners includes Sub-Sahara African and CIS countries in addition to the Middle East as its investment area.

8) Africa

Table 5-10 Africa Funds

Invest to other funds	Yes	SOPEP Infrastructures (G, 345) Capital innovations FF (G, 143) Syndicated Access FF (G, 71)	HCP FF I (G, 43) HCP FF II (G, 48)
	No	AIG African Infrastructures (N, 388) Macquarie Global II (G, 381) Macquarie Global III (G, 292) Alcazar Capital Partners I (M, 285) Macquarie Global I (M, 230) Pareto WW Offshore (G, 127) Israel Infrastructure I (G, 109) Moroccan Infra (N, 100) IFC Infra (M, 95)	GCC Energy Fund (M, 345) Mistral Energy II (G, 104)
		Not Focus on Energy	Focus on Energy
		Area of Investment	

Legend: <Geographical Target> (G) Global, (M) Multiple Areas, (R) Single Geographical Area, (N) National Focus

Note: Figure in ( ) is fund size in million USD

There are some infrastructure funds with regional focus including Africa, though not many. However, most of the funds are not only Africa focus but also includes Middle East or other emerging countries as their investment focus. This may be because of the high country risk associated with the African countries giving difficult time to infrastructure funds that are characterized as relatively low risk assets. Yet, there are a few funds with focus on country with relatively low country risk such as South Africa. Infrastructure investments in Africa have started not long ago, and thus are still limited to particular country or region.

As explained above, small to medium size energy focused funds of USD 500m or lower are often found in the North America and Europe, On the other hand, in the emerging markets such as the Middle East, Africa, and Southeast Asia, regional focused small to medium size energy funds have just started to be established, possibly in response to investment opportunities arisen from the deregulation.

Characteristic of the investment area is that there are many funds focused on new energy in Europe, mostly promoting new energy installation. In the Southeast Asian funds, there is Vietnamese fund focusing on hydro development in the Mekong River area. Development policies of particular country or international society seem to have impacts on the type of energy fund that have been developed.

In the emerging countries, small to medium size energy funds with regional focus have just started to be established. Such funds source projects in independent networks based on many investment opportunities from deregulation. Such projects are mostly club deal type requiring local network and sponsor risk is usually high compared to the big projects. On the other hand, by handling the project "bilaterally", cutting off competitors, there are chances for a high expected return.

5-1-1-2. Europe/US/Southeast Asian Fund Case Study

(1) Taiga Mistral (Europe)

Taiga Mistral is the fund management company managing a fund focusing on developing countries' specific type of projects in energy in Europe. The company was established in 2007 as the wind farm fund management company establishing Polish wind farm focus fund (Taiga Poland I) and Spanish wind farm and solar focus fund (Taiga III) ever since. Currently, Taiga Mistral manages about EUR 200m assets including more than 190MW wind farm assets. The company's funds are unique in a sense that it is focused in particular country and utilizes management networks and knowhow.

Marta Fernández, former marketing manager at the major European wind farm developer Gamesa Energie in charge of Poland, Bulgaria, and Romania, and Mikel Garay, former Acciona Energia in charge of Poland were the core members providing Polish networks from its initiation.

Table 5-11 Major Members of Taiga Mistral

Name	Background
Antonio Tuñón	Director at power companies such as OMEL, chairman of CEO at CVC (Investment Fund) and established Taiga Mistral
Mikel Garay	Acciona Energia S.A (European major wind farm company) in charge of Poland, and joined Taiga Mistral
Cristina Tuñón	UBS Wealth Management (Asset management company), and joined Taiga Mistral

Source: Taiga Mistral Website

Taiga Mistral seems to utilize business experience of the management rather than financial background, and targets value addition to the project utilizing experience and knowhow on power project development.

> *"Once Taiga Mistral is in charge of the management and administration of a farm, the management team must carry out an initial study and analysis of the situation and its background. <u>Taiga Mistral will carry out a comprehensive analysis of the wind farm's operation contracts with the dual aim of optimising costs and controlling the scope of all the</u>*

services provided to the farm, and will make use of the economies of scale to join suppliers and lower costs wherever possible, thus improving the project's expected profitability."[29]

As its investment policy, green field projects before commercial operation date (COD) are targeted. 41.4MW Kobylnica project and 8MW Radostowo project have reached COD by now. European Bank for Reconstruction and Development (EBRD) has committed to invest 20% of total fund size of Taiga Poland II based on the track record of bringing wind farm green field projects to COD in Poland. EBRD plans to utilize the fund's sourcing ability in Poland to promote development of the wind farm projects in the country through investing into the fund. It also seems to intend to transfer technology to the invested projects.

Project Description

The EBRD is considering making an equity investment of up to €20 million in Taiga Poland II SICAR ("TP II" or the "Fund"), a private equity investment fund to be registered as a partnership limited by shares under the laws of Luxembourg.

The Fund will seek equity and equity-related investments in the development and construction of wind power projects in Poland, with the aim to bring such projects to successful commissioning of operation. TP II will have a similar investment focus to the precedent fund, Taiga Poland I, and will benefit from the already existing platform and pre-identified potential target projects.[30]

Transition Impact

The transition impact and demonstration effects of the proposed project are expected to be achieved by the:

(a) support of the development of the private equity for the energy sector, particularly for the renewable energy sector in Poland;

(b) expansion of the financial intermediation for the Polish energy and renewable energy sectors;

(c) transfer of the relevant technical and operational skills set to the investee projects;

(d) promotion and enhancement of high standards of corporate governance and integrity in the investee projects[31]

(2) Energy Spectrum (US)

There are some nation focused energy funds in the United States. Energy Spectrum Capital (ESC) receives particular attention as a unique fund management company utilizing its expertise. ESC was established in 1996 as a private equity management company targeting mid to upstream energy assets.

[29] Abstract from the website of Taiga Mistral
[30] Abstract from the EBRD website
[31] EBRD Website

Currently ESC manages USD 230m, targeting medium size oil and gas refineries, production, storage, and transporting facilities. Size of the investment projects range from USD 25m to 100m. Stages of the project targeted are greenfield with potential growth or expansion, pursuing capital gain as private equity.

ESC is unique in a way that it utilizes knowhow of the energy fund focusing on oil and gas. Founding members established Energy Trust Partners to invest into the upstream asset, and also established Energy Spectrum Advisors that is the advisory arm of the group. Therefore, Energy Spectrum Group consists of one advisory company and two private equity management companies.

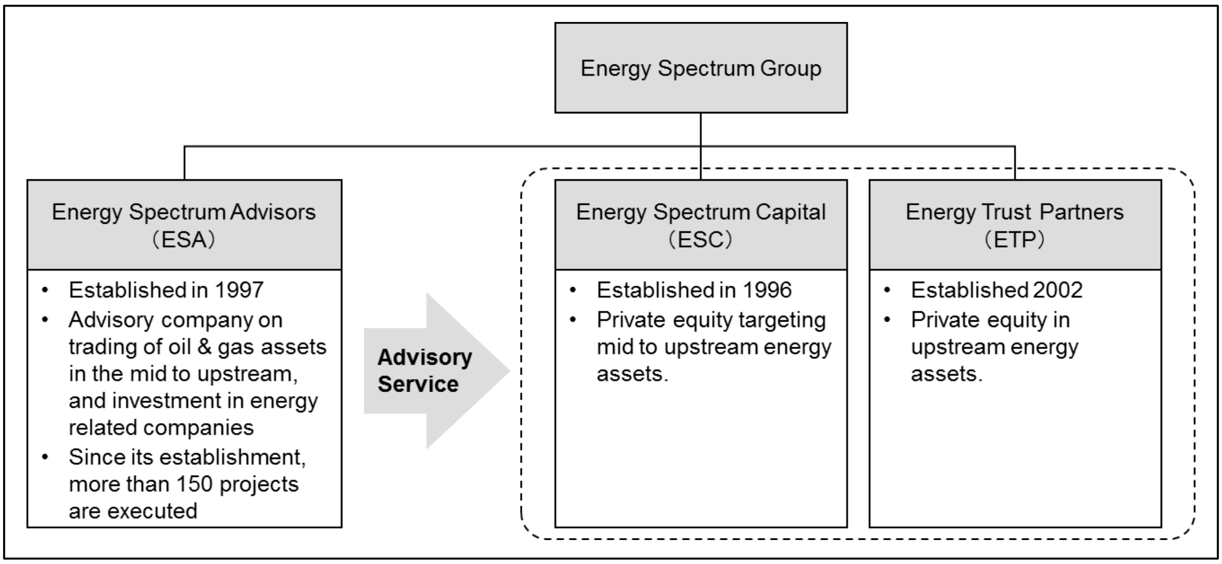


Figure 5-2 Vehicles of Energy Spectrum Group

There are some cases where management positions are concurrently served by the same person across the three companies, thus they seem to be co-managed as a group. Energy Spectrum Advisors may be involved in the investment, additional acquisition after the investment, or selling the assets by the Energy Spectrum Capital and Energy Trust Partners. Management of Energy Spectrum Capital has extensive network in oil and gas industry, but establishing advisory firm shall make it possible to capture more deal opportunities and accumulate experiences and knowhow.

Table 5-12 Management Members of Energy Spectrum Capital

Name	Background
Thomas O. Whitener, Jr.	After InterFirst Bank Dallas, Dean Witter Reynolds, R. and Reid Investments, established Energy Spectrum. Extensive experience on energy investments for long term.
James P. Benson	After InterFirst Bank Dallas and R. Reid Investments, established Energy Spectrum. Long term experience in

	investment and M&A in the energy sector.
James W. Spann	After CIGNA Private Securities, established Energy Spectrum. Extensive track record and knowhow in mainly oil and gas investments and M&A business.
Leland B. White	After R. Reid Investments and InterFirst Bank Dallas, established Energy Spectrum. Extensive track record and knowhow in mainly oil and gas investments and M&A business.
Peter W. Augustini	After Metropolitan Life Insurance, Atlantic Richfield, McKinsey & Company, joined Energy Spectrum Capital in 2004, giving strategic planning and monitoring business of the investees.
Benjamin H. Davis	After R. Reid Investments, joined Energy Spectrum Capital 2006, marketing oil and gas industry with his extensive industry network

Source: Energy Spectrum Capital Website

Co-management of the three entities under the group platform may be contributing to Energy Spectrum Capital's good judgment on investment project and value up capability after the investment.

(3) South East Asian Strategic Assets Fund（SEASAF） (Southeast Asia)

SEASAF is the energy fund in the Southeast Asia that also focuses on the region. Malaysian financial group, CIMB Group, and South African Standard Bank formed the South East Asian Strategic Assets as JV in 2006. In the next year, it created South East Asian Strategic Assets Fund (SEASAF) by co-investment with the Employees Provident Fund of Malaysia. In addition, Asian Development Bank (ADB) invested in 2009, and CIMB bought shares of Standard Bank in 2011. In 2012, CIMB sold its 60% shares to the new JV partner, Rohatyn group, changing JV name to CapAsia.

Investment areas of the fund are energy, infrastructure, and natural resources. Geographical focus is mainly Malaysia and Indonesia, followed by Singapore, Thailand, Brunei, Myanmar, Lao, Philippines, Cambodia, and Vietnam. It seems to balance countries that have established their positioning as emerging countries and countries that future growth is expected. Basically, the fund opts for operating assets producing stable and assured cash flow, limiting development risk and construction risk. However, in some countries the fund invests to the green field projects.

5-1-1-3. Purpose and Effects of the Fund Utilization

In the case studies of the fund, EBRD has made a commitment to Taiga Mistral which focused on Polish wind farm. As already mentioned above, EBRD seems to highly evaluate the fund as having capability to source wind farm projects, having experience and knowhow to support development and operation that will contribute to promoting domestic wind farm projects in Poland.

Many of the renewable projects are small to medium size. Targeting this kind of projects that the investment banks or the major funds do not or cannot approach, the fund may have more possibility to bring it to the bilateral negotiation without competitions. Although in many cases, the sponsor risk is relatively high, but less competition means less option for the counter-party. Therefore, by understanding the needs of the counter-party, it may be possible to keep the acquisition price low and make investment. The project of this size often come from club deal, thus the fund's sourcing ability will be the key. High sourcing ability stems from the network in the country, the region, and the particular industry or business area. In the case of Taiga Mistral, EBRD is supposed to have made a decision to support the fund based on the following facts: Taiga Mistral's first fund has track record of investing in multiple wind farm projects in Poland, it already has existing network in the market, and it already has project pipelines. By supporting the fund that is able to access small to medium size projects through club deal, it would be possible to make investments to good projects.

As the purpose and effect of the fund utilization, development and operation support by the fund with experience knowhow and experts may contribute to the higher probability of completion and safe operation of the project. Therefore, such fund that does not only provide finance and conducts financial monitoring but also supports project owners in its business, tends to be utilized. Especially for the project development in the developing countries, in addition to the finance, technologies are in need. Thus, it is expected that the fund utilization alleviates business risk by playing not only financing function but also transferring technology and business knowhow, or providing business support function.

5-2. Outlines of Investment Policies and Investment Area

5-2-1. Investment Policies and Investment Area

5-2-1-1. Type of Generation/Business Size

The Indonesian government installed FIT on renewable energy projects of 10MW or lower. The government designed FIT in a way that depending on the area and connected grid voltage, the price is different giving incentives for much needed area. It is also possible to sign long-term PPA without price negotiation with PLN.

Table 5-13 FIT Pricing Structure

System	Hydro Wind Solar Power etc. (<10MW)		Biomass (<10MW) (*)		Thermal
	Moderate Pressure (Rp/kWh)	Light Pressure (Rp/kWh)	Moderate Pressure (Rp/kWh)	Light Pressure (Rp/kWh)	High Pressure (USD/kWh)
Java, Madura, Bali	656	1,004	975	1,325	9.7cent ⇒11～15cent
Sumatera, Sulawesi	787	1,205	1,170	1,590	
Kalimantan, Nusa Tenggara	853	1,305	1,268	1,723	
Maluku, Papua	984	1,506	1,463	1,988	

Source: The Regulation of Ministry of Energy and Mineral Resources No. 31 Year 2009

(*) The price varies if final disposal technology is used.

For geothermal that has underground resource risk, FIT price is USD base, and the price is higher preferentially than other generation types. Among small scale projects of hydro, solar, and biomass eligible for FIT, underdeveloped biomass though high potentiality receives higher price preferentially as below table shows.

For the small hydro, the FIT price is low compared to biomass and geothermal, but the development record of the hydro as a whole is relatively high. This can be explained by its lower generation cost due to no fuel cost comparing to biomass and relatively lower development cost comparing to geothermal.

Table 5-14 Development Potential of Renewable Energy in Indonesia (2011)

NO	NEW/RENEWABLE ENERGY	RESOURCES (RS)	INSTALLED CAPACITY (IC)	IC/RS RATIO
1	2	3	4	5 = 4/3
1	Hydro	75.670 MW	6.654,29 MW	8,79 %
2	Geothermal	29.038 MW	1.226 MW	4,22 %
3	Mini/Micro Hydro	769,69 MW	228,983 MW	29,75 %
4	Biomass	49.810 MW	1.618,40 MW	3,25 %
5	Solar	4,80 kWh/m²/day	22,45 MW	-
6	Wind	3 – 6 m/s	1,87 MW	-
7	Uranium	3.000 MW (e.q. 24,112 ton) for 11 years*)	30 MW	1,00 %

Source: Directorate General of New Renewable Energy and Energy Conservation

Hydro power can be used as base load, operating 24 hours a day, same as nuclear power, thus it is expected to provide power to the area where few large size thermal power plant is built because of its power demand size. Given the conditions above, small hydro projects that are in the scope of this survey meet the requirements of the investment target of energy fund because small hydro projects 1) are able to sign long-term PPA based on the FIT system, 2) have high development potential, and 3) have high social meaning thanks to stable power generation.

Size of the project targeted will be 10MW or lower as it meets the requirement of adopting FIT for long-term PPA with PLN. With the long-term fixed price power purchase agreement, unless the power plant is shut down for a long time due to the equipment failure, etc, stable cash flow can be expected. It is very meaningful to support small hydro growth financially for meeting power demand of surrounded areas, especially in Sumatra and Sulawesi where the electrification rates are low but have rivers with rich water flow. Therefore, as investment policy of energy fund in Indonesia, having high potential small hydro power projects of 10MW or lower as main target and consider larger size hydro, and other types of renewable energy such as geothermal and biomass as complementary investments.

5-2-1-2. Stage of Development

In the stage of development, as already noted, there are mainly three types: “Development Phase”, “Construction Phase”, and “Operation Phase”. Merits and demerits of each phase are outlined below table.

The risk is limited in the later stage projects, but the cost of acquisition is increased giving low return in general, which creates low risk low return investment. On the other hand, the risk of failing a project is increased in the earlier stage projects, but it may be possible to invest equity at par value in some cases, creating high risk high return investment.

Table 5-15 Merits and Demerits in Each Development Stage

Development Stage	Merits	Demerits
Development Phase	Many investment opportunities Relatively low acquisition cost Possible high return Wider scope of possible involvement in the development process	Relatively high possibility of failing projects on the way due to permit issues, etc
Construction Phase	Possible involvement in construction and engineering	Completion risk and risk of cost overrun
Operation Phase	Low risk of failing on the way as it is already completed and operating	High acquisition cost due to low risk of project failing

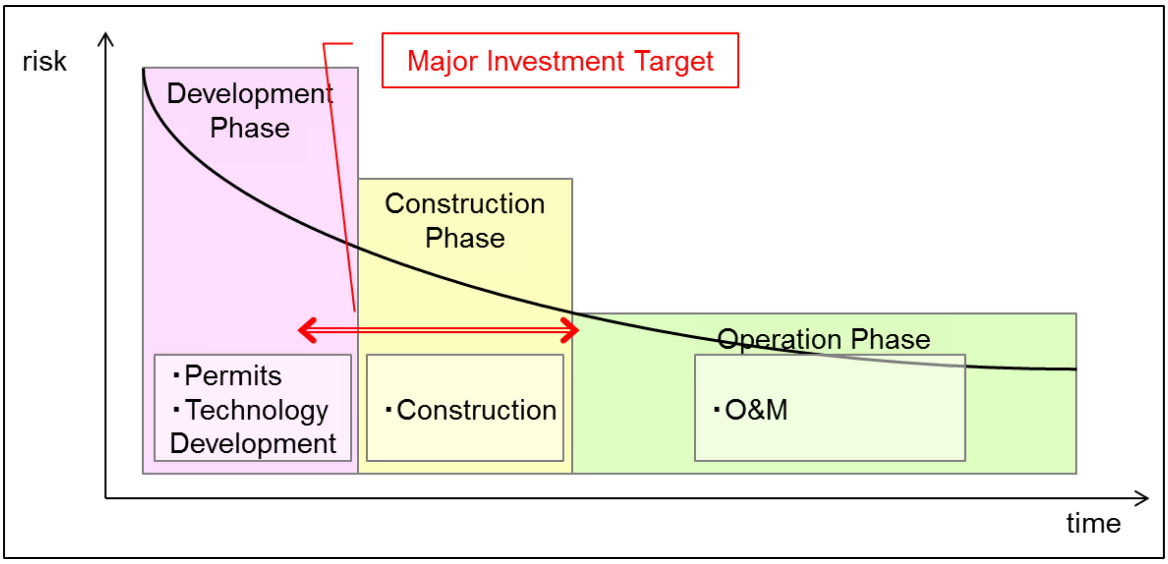


Figure 5-3 Development Stages and Investment Target

It is around 2012 when FIT system was in place and development of small renewable energy projects started to move forward, thus most of the projects are still in the development phase. One of the purposes of utilizing the energy fund is supposed to be to support the development of the projects in the country, thus projects in development phase are the primary target. If projects in the development phase have already obtained major primary permits: the Research Permit, Location Permit, and MOU with PLN on the power purchase, risk is somewhat mitigated for investment consideration. However, it will be a requisite condition to have signed PPA with PLN in order to consider financing terms.

In near future, there may be a project interrupted in the middle of construction with cost overrun especially with technical problems. It will be worth considering to support this kind of project in technical issues by the Japanese technical consulting company and in financial issues by the energy fund.

5-2-1-3. Development Area

In Indonesia small hydro potential is widely spread instead of disproportionately located in the particular island. Yet, it is necessary to consider the FIT price difference as discussed above. In the Java-Bali grid, purchase price is relatively low at Rp.656/kWh, giving difficult time to keep positive cash flow. On the other hand, in Sumatra and Sulawesi where many potential sites with rich water flow exist, the potential is high due to the purchase price that is 20% higher than Java-Bali. Kalimantan and Papua’s hydro potential is also high, but there is not much track record of projects being developed. It seems to be realistic to focus on Sumatra and Sulawesi for the project development. However, if the project is considerable in both technical and financial perspectives, then anywhere in Indonesia shall be considered for investment.

5-2-1-4. Conditions on Project Developers

In considering making investment, it is preferable that the developer of the potential investee have small hydro development experience. However, there are not so many developers with small hydro business experience. In reality, it is recommended that the energy fund supports in this respect for developers who have some kind of knowhow or experience that are related to the small hydro business.

There are many local companies that have accumulated wealth from construction, mining, plantation or other businesses who try to enter into the small hydro business after FIT was installed. Some developers have advantage of being able to proceed with the land acquisition without problem based on the existing relationship with the locals through its main business.

Some construction companies that usually worked on the power projects as contractors sometimes develop their own project and conduct construction work as well. Since the completion risk in small hydro is sizable, even in the case construction companies do not provide the service for their project, it will alleviate some risk as they can be a backstop once risk becomes imminent.

On the other hand, developers with operational experience in power business will be able to utilize their knowhow in O&M after COD. There are some cases that coal fired power developers or plantation owners with biomass power project development experience come into the small hydro business. This kind of power business background will be evaluated positively in selecting project developers as the investee.

In sum, it is preferable for the developers to have some kind of knowhow related to the small hydro business in selecting the investees. For example, construction knowhow for hydro, experience in obtaining permits for mining or plantation, and power generation knowhow from coal fired power plant or biomass power plant can be utilized in small hydro business, mitigating some risks.

5-2-1-5. Summary

Based on the discussion above, the scope of small hydro investment can be summarized below.

Table 5-16 Scope of Small Hydro Investment

1. Scale of Project	✓ Up to 10MW, that is in the range of FIT is considerable.
2. Development Phase	✓ Research Permit, Location Permit, and MOU with PLN is considered as a pre-requisite condition. ✓ However, it is a precondition that PPA with PLN is already obtained at the timing of the full-scale financing consideration.
3. Development Area	✓ If the project is technically and financially feasible, projects in any part of Indonesia can be considerable. ✓ In the early phase, Sumatra and Sulawesi will be the primary target.
4. Conditions on the Developers	✓ It is required to have some kind of expertise related to small hydro projects. ✓ It is desirable to have the track record in hydro project business, contractor work experience, or power business expertise.

For the investment into other types of renewable energy, geothermal and biomass power projects can be in the scope of target. Project size of the geothermal power is often more than 50MW that is much bigger than the small hydro projects. Thus it is necessary to take cautious steps in order not to lose balance in the portfolio with heavy geothermal. Biomass is usually the same scale as small hydro as the Government of Indonesia gives incentives to the projects of 10MW or lower.

5-2-2. Portfolio Building

In building portfolio of the energy fund, perspectives in project scale, development stage, development area, developers are outlined below.

5-2-2-1. Project Scale

In the small hydro business, basically scale of economy works. There is no strong reason to diversify the project scale in the portfolio. Especially projects below 5MW are usually less competitive in the sourcing stage. If project cost is managed to be low, then this size can also become a target for the fund. However, projects close to 10MW are desirable based on the investment efficiency.

5-2-2-2. Development Stage

Among the three development stages: "Development Phase", "Construction Phase", and "Operation Phase", main target will be the later stage of "Development Phase". Depending on the situation, "Construction Phase" with financial needs may also become primary target. If 1) investors desire low risk low return stable income gain, and 2) liquidity of operating assets is increased, then acquiring projects in "Operation Phase" for the energy fund portfolio can be considered as this will mitigate development risk and completion risk.

5-2-2-3. Development Area

In Indonesia, as discussed earlier, the hydro potential is widely spread, making it possible to diversity development area. Merits and demerits of geographical diversification are laid out in the below table.

Table 5-17 Merits and Demerits of Development Area

	Merits	Demerits
Same Area	Mitigate monitoring cost Possible utilization of relationship with local government/governor	Limited sourcing opportunities
Multiple Area	Many sourcing opportunities	Increased monitoring cost Necessary to find new local partner in the new area

5-2-2-4. Project Developer

There are many new entrants in the Indonesian small hydro business. Effects of diversifying project developers in the portfolio are outlined in the below table. By diversifying project developer, DD cost and partner risk will be affected. By investing into multiple developers' projects and supporting their pipeline projects, potentially DD cost can be mitigated and good project pipelines can be secured.

Table 5-18 Merits and Demerits of Developers

	Merits	Demerits
Single Project Developer	DD cost of the partner reduced	Partner risk concentrated
Multiple Project Developer	Partner risk diversified	DD cost for the partner is increased

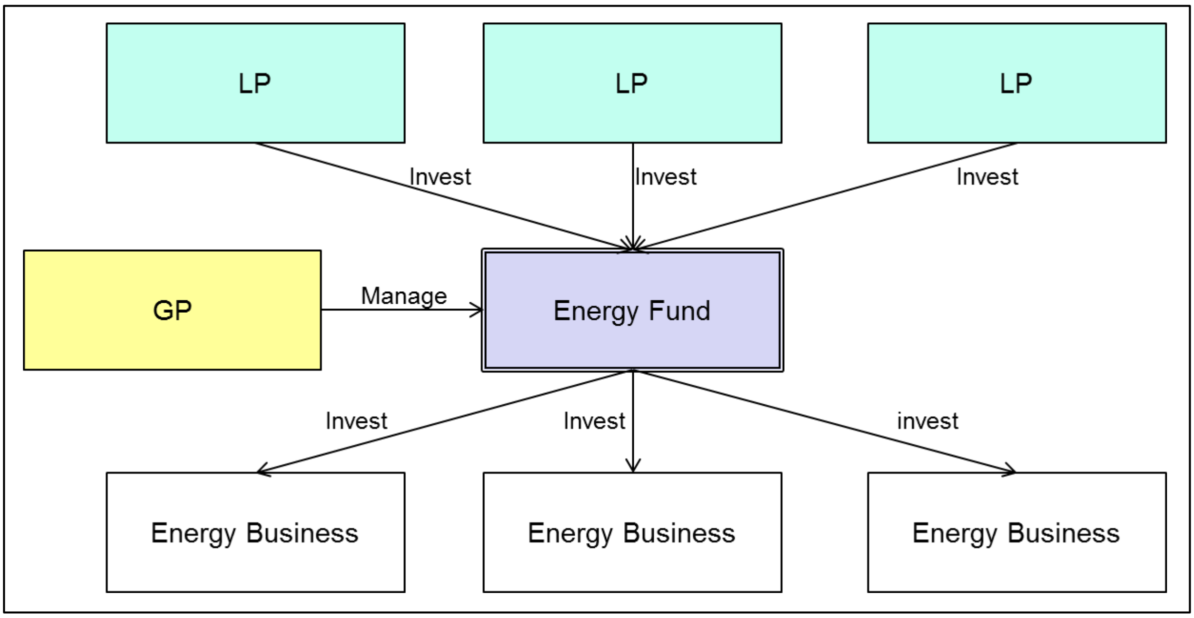
5-3. Considerations on Fund Operation System

5-3-1. Setting up GP and LP

In deciding the fund operation system, GP who creates the fund, sources potential investees, executes investments, conducts monitoring, makes exits, reports to investors, and manages the fund needs to be decided. GP, after deciding on the concept of the fund, has to submit required documents before inviting LP investors. When an investor utilizes fund to enhance its main business, it is called strategic investor. For energy fund potential strategic investors are energy companies, engineering companies, manufacturers, and financial institutions. In establishing a fund, the first investor who makes a commitment into the fund is called anchor investor. With anchor investor's investment into the fund, the fund is able to start its business officially. Therefore, the existence of an anchor investor is critical to the fund, and the fund may flexibly coordinate the concept of the fund with the anchor investor.

LP needs to make it clear the purpose of the fund investment, synergy with the main business, pure return, etc, as depending on the purpose, the fund to be invested may be different. It is necessary to make clear the acceptable risks and expected return, and then finds the fund that matches its needs or coordinates with the GP to establish a fund that meets its requirements. As noted above, if the fund is at the early stage of its establishment without the anchor investor, then the GP may have more flexibility to coordinate. Therefore, detailed discussion with GP is required for the process.

Figure 5-4 General Fund Structure



5-3-2. Setting up Investment Committee

GP, in making investment, has to hold an investment committee to discuss appropriateness of the investment. In general, investment committee is joined by the representative from GP, advisors, and outside experts depending on the situation.

Based on the decisions at the investment committee, cost reimbursement of the due diligence, investment decision making, executing exit will be carried out, thus the committee is the central part of the fund management. LP may join the investment committee as observer, but it is not common to join as investment committee member. Under the general scheme of the fund, LP invests into the fund and entrust GP to manage including the decision on investment.

Decision making process of the investment committee can take consensus by members, majority vote, and combination of the two. Decision making process is usually defined in the Limited Partnership Agreement (LPA) that is drafted at the time of fund establishment.

5-3-3. Setting up Advisory Committee

It is not a requirement for managing a fund to establish advisory committee, but commonly utilized for the reasons below. When there is an issue that requires deep expertise that is difficult for only investment committee to handle, experts may be gathered to discuss the matter. For consideration of the investment that requires high level expertise, advisory committee could be set up in advance so that LPs are more confident to consider investment to the fund.

5-3-4. Fund Management Policy and Size

Fund management policy is defined in the Private Placement Memorandum (PPM) that is made when GP conducts fund raise. Fund management policy may include investment term, investment target, size of one transaction, monitoring method, exit policy, expected return, decision making in the investment committee, and they may be different depending on the fund concept and fund size.

A fund under a particular fund concept may not adopt the same policy for the succeeding larger fund such as investment size per transaction and monitoring method since it may create inefficiencies. Without larger investment size per one investee, there will be so many investment projects in order to build portfolio of the fund size, leading to huge cost for due diligence and monitoring. Therefore, some of the mega funds become fund of funds for its efficient investment diversification, investing into other funds.

5-4. Review of the Funding Scheme Including JICA Private Sector Investment Finance Scheme

5-4-1. Review of the Investment into Small Hydro Project through the Energy Fund Backed by JICA Private Sector Investment Finance Scheme

Due to the restriction of FIT, the power generation capacity is currently at most 10 MW for small hydropower projects in Indonesia[32]. It is probable that an independent small hydropower project may be too small for JICA Private Sector Investment Finance Scheme. And it is expected that the communication with the project owners and the management procedures can be cumbersome when they make the investments directly to several projects. It is one idea to effectively invest in energy funds by using the Private Sector Investment Finance Scheme and entrusting the operational matters to GP who manages the funds.

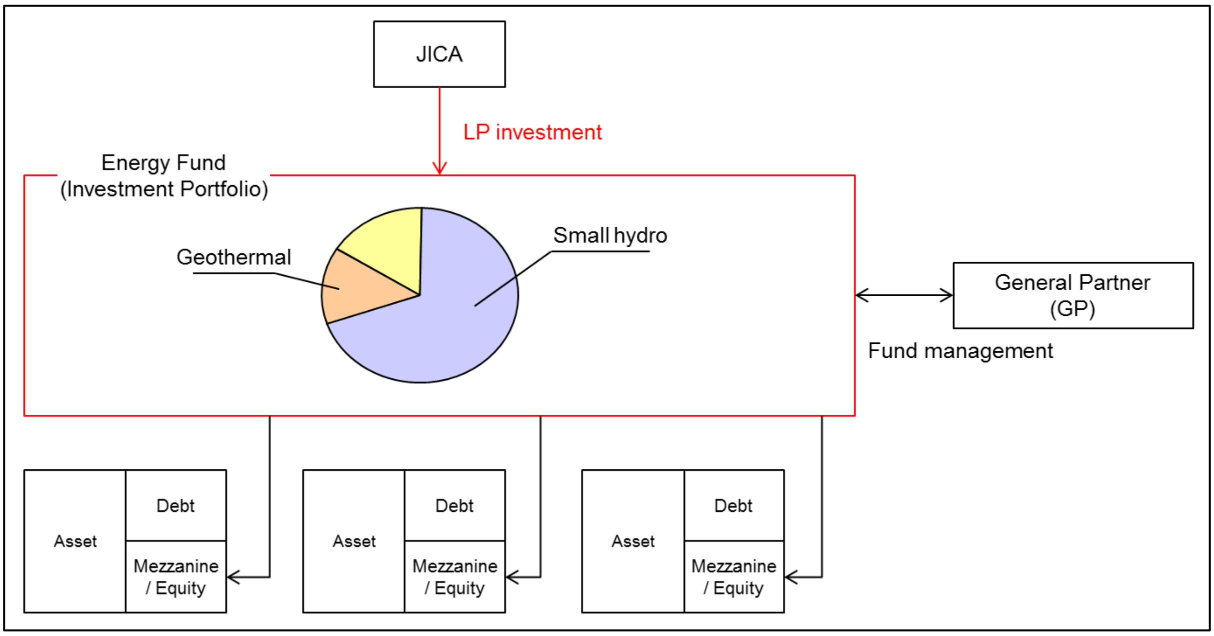


Figure 5-5 Finance Structure Example with Utilization of Energy Fund

Before investing in energy funds under JICA Private Sector Investment Finance Scheme, it is necessary to confirm and arrange the following matters in order not to have any misunderstanding with GP of the funds.

5-4-1-1. Check Points in Investing into the Funds

(1) Check Points for Coordination with Fund Management

1) GP Portfolio Strategy

(A) Targeted Investment Geographic Area

It is necessary to confirm three points for the investment area. Firstly, the area can be a) only

[32] Even if the project size is above 10MW, PLN is obligated to purchase up to 10MW. In some cases, PLN guarantees to purchase what is above 10MW when there is a need for PLN.

Indonesia, b) ASEAN nations including Thailand, Vietnam and the Philippines, or c) entire Asia including Japan and China. Secondly, allocation of investment in each country needs to be defined. Thirdly, if there is any upper and lower limitation of the investment amount for one country.

(B) Targeted Project Types

It is necessary to confirm three points for the project types of its target. Firstly, whether it is targeting only renewable energy or energy including other types such as coal and gas power needs to be clarified. Secondly, whether they invest only in projects or possibly projects and corporations needs to be looked at. Thirdly, whether they invest only in greenfield project or both greenfield and operating project shall be confirmed.

(C) Investment Forms

It is necessary to confirm the investment form that they invest only in equity by common stock or mezzanine financing such as subordinated loans and preferred stocks.

(D) Expected Returns

In the infrastructure funds, the fundamental targets are the revenue stream from the long term stable cash flow. Therefore, they are fundamentally considered as low-risk and low-return investments. Thus, the expected return ratio is generally somewhere around 10%. For example, in the case of investment in the power plants, they will repay the loan on long-term and stable bases from the sales of electric power, because the value of assets will not rise drastically after starting the commercial operation. The risk is limited, but the return will be reasonable and equivalent to the underlying risk.

(2) Check Points for Coordination with Other Investors

When considering investment in energy funds, it is necessary to confirm whether they have the preferential negotiation right for the investments among other LP investors and GP. In general, the general partners are entrusted for decision making because investment projects have high confidential matters and require swift decision making. But if there are some limited partners, having the preferential negotiation right, it is possible that their intentions are reflected into the investment decisions.

5-5. Plans for Investing to Exit by Funds

Because Indonesian small hydropower project owners are small to medium size organizations, there is a strong desire for the financial needs by equity and mezzanine loans. The followings are the examples of exit case when the investment is done by equity or subordinated loans.

5-5-1. IPO or Sales of Stocks to the Third Party such as M&A (Sales of Common Stock)

The project owners who are running several projects can sell common stocks that the funds invested by realizing IPO in the future. In this case, there is a high possibility of getting more returns than the original investments, depending on the market environment at the time of IPO. On another front, there is a risk that IPO cannot be done. Therefore, it is important for the project owners to have some future projects in hand and to be in the position to anticipate the timing of IPO. If they do not intend to conduct IPO, they can sell stocks to the third party through M&A, in that case, they can acquire the preferential sellout right by entering into buy-back conditions in advance. Although the sales of stocks to the third party can be a coincidental event, it is likely that the corporate value is higher from the time when the investment was first executed because of the commencement of next projects and decreasing debt amounts. Therefore, it is anticipated that the project owners are able to sell common stocks at more expensive prices than ones the funds originally purchased.

5-5-2. Return of Subordinated Loans (Repayment of Mezzanine Loans)

The project owners repay subordinated loans annually from the revenue arising from the projects on the same term as senior loans. The schedule of repayment is generally under the period of deferment for 2 years during the construction and it is assumed that they repay the loan between 5 and 7 years after the start of commercial operation. . Thus, the principal and the interest will be recouped within 7 to 9 years. The small hydropower plant project owners usually enter in PPAs with PLN for 20 years, therefore it is possible to get returns as scheduled if the power plants operate in a stable manner. However, it is unlikely to have better returns and the originally defined interest earning is the return on investment.

5-5-3. Exit Plan by Refinancing from the Local or Major Financial Institutions in ASEAN

After starting commercial operation, it is expected that they repay subordinated loans and refinance in the case that the local banks or large financial institutions in ASEAN countries provide senior loans with lower interest rates. They can repay the whole amount or a part of subordinated loans before maturity. In general, there is a clause for a penalty for repaying loans before their maturities, the infrastructure funds can acquire higher return than the scheduled interest amount. However, since the repayment is done earlier, depending on the amount of penalty, the total interest earning can be less than originally expected.

5-6. Consideration on Support Structure for Individual Project after the Execution of Investment by Funds

After the execution of investments, in order to improve the value of the project and to maximize the return, it is important that not only monitoring each project but also creating the support structure to secure the improvement of business of the sponsor companies in the medium to long-term business plans.

5-6-1. Monitoring the Projects

After execution of the loans, the project is divided into two phases, during the construction period and after completion of the construction. During the construction period, it is necessary to visit the construction site constantly to check the progress work in order not to have any delay, and also to check the issues which might lead to the trouble. If there is any delay, they will confer with EPC contractors according to the contract. It is often the case that the infra funds already have people acquainted with the operation of EPC contractors, in that case, it is possible for them to give advises to the project owners before execution of the contract.

After the construction is complete, its focus will shift to the operation of the power plants. As the infra funds appoint at least one board member from them to SPC, they are able to receive operational data from the power plant monthly such as the flow rate, output capacity of electricity, operating time in a timely manner and they can make necessary recommendation for more suitable operations to the project owners.

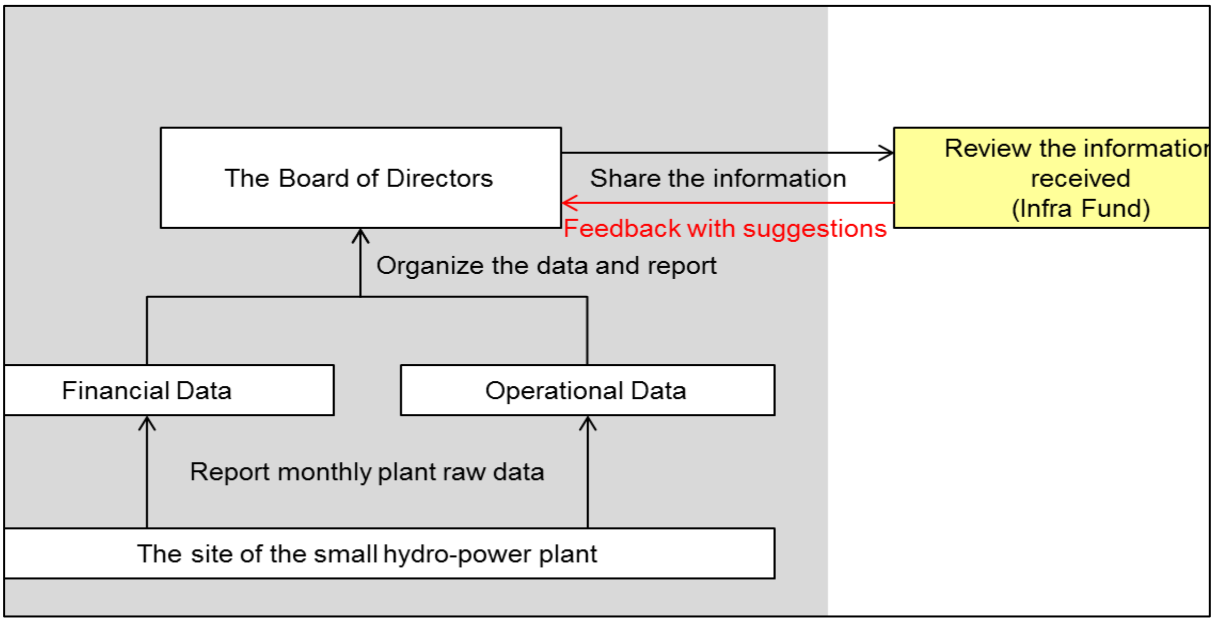


Figure 5-6 Flow of the Monitoring

5-6-2. Improving the Value of the Sponsor Companies

Because the sponsor companies have not only ongoing projects but also future projects in the pipeline, they need a support structure in line with the growth strategy, aiming for IPO in the future.

The important support structure for the sponsor companies is the ordinary support function by people within the funds who are knowledgeable with the power plants and their management, in addition to the above, it is important to have a financial advisory function for fund raising or consulting functions utilizing the network of the funds.

5-6-2-1. Support by the Advisory Functions

It requires a large amount of funds in order to develop a number of projects in parallel. . In order to fund the development costs at the initial stage of the projects, and to deal with the equity payment for each individual project, it is necessary to consider inviting strategic investors. It is also important to construct a structure to support various financing arrangements to satisfy needs from the sponsor companies.

5-6-2-2. Support by the Consulting Functions

For example, it is possible to help the small hydropower projects to apply for CDM business to the United Nations, and support in acquiring CDM credit. It may be difficult for the project owners to independently arrange some research by a third party and to make documentation for application, when it comes to apply. Since it is also important to make arrangement for the carbon credit buyers as well as supporting the application matters for CDM, a consulting function is considered to be important to deal with CDM related issues all together.

5-7. Outline of Conditions and Issues Required for Fund Establishment

5-7-1. Detailed Analysis for Comparisons with Similar Funds (investment target, investment policy, track record)

The following three funds are examples of energy funds that invest into the energy project including renewable energy in mostly Southeast Asia;

・Asia Clean Energy Fund（Armstrong Asset Management）
・Mekong Brahmaputra Clean Development Fund（Dragon Capital）
・JAIC-IDI Asian Energy Fund（Asian Energy Investments）

The overview of each fund, investment target, investment policy and track record are shown below.

5-7-1-1. Asia Clean Energy Fund（Armstrong Asset Management）

Asia Clean Energy Fund, which was established in Singapore by English fund manager as clean energy fund, seems to consider investment in small hydro projects including green field ones. The overview of the GP, Armstrong Asset Management, is shown below.

Table 5-19 Overview of Armstrong Asset Management

Overview	The fund management company which manages the private equity fund that invests in renewable energy projects in Southeast Asia. European Investment Bank (EIB), Deutsche Investitions- und Entwicklungsgesellschaft (DEG) and IFC invest in the fund as LP.
History	2011 Armstrong Asset Management was established Aug, 2012 Achieved first closing at US$66 million by the investment commitments from the fund of funds, Global Energy Efficiency and Renewable Energy Fund and DEG. May, 2013 It achieved second closing by US$20 million commitment from IFC
Management	Mr. Andrew Affleck, Managing Partner Former CEO of Low Carbon Investors Ltd. Prior to engaging in the current position, he had been active mainly in Asia as co-founder of Devonshire Capital, and established Armstrong Asset Management. Dr. Stephen Mahon, Partner He has a PhD in Geophysics and Planetary Physics. He joined Armstrong Asset Management, after efforts to improve business value for a lot of low carbon technology companies as director of Low Carbon Investors. Mr. Edward Douglas, Investment Director He has been engaging in investment business as Senior Investment Director

	of FE Clean Energy Group, which is private equity fund focusing on renewable energy after his tenure at Siemens, Cummins Power, SP International, and Temasek Holings.

The high specialized team consists of the management, based upon specific clean energy fund group, and investment managers who have background of engineering.

The investment targets of Asia Clean Energy Fund are outlined by sector, area and stage of investment below.

Table 5-20 Investment Scope

Category	Renewable Energy Generation Project – Wind, Solar, Hydro, Biomass, Waste to energy – Small scale of 10MW or lower Resource Efficiency – Clean water supply, Waste recycling, Energy efficiency
Area	Southeast Asia (with a focus on Indonesia, Philippines, Malaysia, Thailand, Vietnam)
Stage	Development phase (Pre-Permit), Green Field (After Permit), Operating phase

It aims to achieve IRR 20% returns in 10 years fund term, by 10-15 investment projects, USD 5-12 million per project as its investment policy. Specific policies are shown as following;

- ✓ An obvious market need supported by strong economic fundamentals
- ✓ A commitment to positive social and environmental impact
- ✓ Risk minimization through a portfolio of small-scale projects
- ✓ No technology risk
- ✓ The ability to generate early cash flows
- ✓ Excellent entry valuations due to lack of investor competition
- ✓ Competitive advantage as a result of the team's local operating experience
- ✓ A clear exit strategy.

Therefore, they aim to more than 20% IRR by the combination of the operating projects that can create cash flow early and projects in pre-permitting and development phase with desire to gain upside by the low price acquisition cost. In addition, the fund intends to limit the risk by not taking technology risk.

As investment track record, they made a strategic partnership with Symbior Solar Siam, which is energy developer and subsidiary of Symbior Energy (Hong Kong), and plan to acquire 60% share of Symbior Elements, a subsidiary of Symbior Solar Siam, which develop and operate the solar power project. They plan to invest in the development and construction of a 30 MW solar projects in Central and Northeast of Thailand. Although, they are planning to invest in 3-4 projects including small hydro power project, it is difficult to evaluate their performance at the moment.

5-7-1-2. Mekong Brahmaputra Clean Development Fund (Dragon Capital)

Specialized energy fund has been established by Dragon Capital, which is local institution in Vietnam, as GP, and their overview is shown below,

Table 5-21 Overview of Dragon Capital

Overview	Dragon Capital is local financial institution in Vietnam. A number of funds specializing Southeast Asia have been established by Dragon Capital, and they launched energy focused fund in July, 2010. FMO (Netherlands), BIO (Belgium), Finnfund (Finland) and ADB invest in its energy fund as LP.
History	1994 Dragon Capital was established 1995 Vietnam Enterprise Investments (listed on the Irish Stock Exchange) was established as first fund by Dragon Capital 2005 Vietnam Dragon Fund (listed on the Irish Stock Exchange) was established by investment from Japanese investors. 2010 Mekong Brahmaputra Clean Development Fund was established as energy specialized fund (July)
Management	Mr. Dominic Scriven, CEO He established Dragon Capital in 1994, after his experience at M&G (UK), Citicorp (HK), and Sun Hung Kai (HK). Mr. Alex Pasikowski, Deputy CEO He was in charge of proprietary trading of Australia, Pacific and Southeast Asia in Morgan Stanley. He has been stationed in London, New York, Tokyo, Hong Kong branch. He joined Dragon Capital in 2001, after Swiss Bank, Lehman Brothers, and Deutsche Securities.

Because Dragon Capital is originally local financial institution in Vietnam, their management is organized by members having financial sector background. The investment targets of Mekong Brahmaputra Clean Development Fund is outlined by sector and area below.

Table 5-22 Investment Scope (Mekong Brahmaputra Clean Development Fund)

Sector	Renewable Energy Generation Project, Resource Efficiency, Water treatment, Waste treatment
Area	Vietnam, Thailand, Laos, Cambodia, Nepal, Bhutan, Bangladesh, Sri Lanka

They cover the neighboring countries connected with Vietnam by land except Sri Lanka as investment area, and exclude the huge market such as India and China.

As investment policy, they are aiming that each investment projects have a positive impact on environment and contribute the sustainable growth of society by evaluating companies to be met the principle of economics, social, environmental aspects, which is called triple bottom lines. They set the specific policy of economic aspect that they are aiming more than IRR 15% return in 10 years period by USD 1-7 million scaled projects.

This Fund has three investment track records as below;

Table 5-23 Track Records of Mekong Brahmaputra Clean Development Fund

Project/Company	Country	Type	Scale	Note
Hoa Phu hydro power project	Vietnam	Hydro power generation	29MW	Debt financed from Vietcombank
Electricite du Laos Generation Plc.	Laos	Power company	―	Power generation subsidiary company of EdL
Phnom Penh Water Supply Authority (PPWSA)	Cambodia	Water supply	330,000m/day	

5-7-1-3. JAIC-IDI Asian Energy Fund（Asian Energy Investments）

Japan Asia Investment Co., Ltd. (JAIC), a Japanese venture capital, and Industrial Decisions Inc. (IDI), an advisory company that specializes in energy and the environment that is a subsidiary of Mizuho Financial Group, jointly set up the energy fund focusing Southeast Asia. Its business has been carried over by Asian Energy Investments (AEI) at present. The overview of the company is as follows.

Table 5-24 Overview of AEI

Overview	Asian Energy Investments is Japanese fund management company specializing energy sector. Based in Singapore, it held a fund that focus on Southeast Asia with gathering members having background of energy and finance sector. The company is engaging in fund raising for coal fund, renewable energy fund, and new energy fund at present.
History	2008 JAIC and IDI established JAIC-IDI Asian Energy Fund 2011 Invested in Biomass IPP in Thailand 2011 Invested in small hydro power project in Indonesia 2012 Transferred GP functions to Asian Energy Investments

Management	Mr. Ichiro Kawada, Managing Director He has experience of investment in local companies and set up the joint funds with local financial institutions, with residing one year in Thailand, four years in Indonesia, and seven years in Singapore while he was in Japan Asia Investment Co., Ltd. Mr. Takahiro Kasahara, Director He joined IDI, after his experience at Industrial Bank of Japan. He has more than 10 years experiences in the financial sector and fund investment. He has established three energy infrastructure funds so far.

AEI inherits business from JAIC-IDI Asian Energy Fund, the members who are originated in Southeast Asia, Finance and Energy, manage the fund.

The investment targets of JAIC-IDI Asian Energy Fund, as sector and area, are shown below,

Table 5-25 Investment Scope (JAIC-IDI Asian Energy Fund)

Sector	Energy projects with a focus on renewable energy power generation projects, or companies related energy industry.
Area	Asia excluding Japan

As investment policy, they formed a portfolio in environment and energy field based on economic growth of South-East Asian countries. They support the investee company by hands-on consulting, and aim for value-up. The Fund completed two investment, and is currently under the harvest period.

This Fund has two investment track records as below;

Table 5-26 Track Records of JAIC-IDI Asian Energy Fund

Project/Company	Country	Type	Scale	Note
Biomass power company	Thailand	Biomass power generation	6MW + 3.5MW	―
Small hydro power project	Indonesia	Small hydro power generation	7.5MW	Green field project

5-7-2. Issues and conditions regarding to related laws and regulations [33]

The procedures are required based on the Limited Partnership Act for Investment (LPAI) and Financial Instruments and Exchange Act (FIEA), if energy fund is established and operated on

[33] Ministry of Economy, Trade and Industry, "MODEL AGREEMENT FOR INVESTMENT LIMITED PARTNERSHIP", November 2010

Japanese law. Usually, establishments and operations of Investment LPS are conducted based on the Specially Permitted Businesses for Qualified Institutional Investor, etc. under the Article 63(2) of the FIEA. It is necessary that the fund establishment and operation satisfy the following points.

<In establishing the fund>[34]

① When the fund is established, the number of limited partners is less than 500[35].
② When the fund is established, there is not disqualified investor[36] as limited partners.
③ When the fund is established, there is one or more qualified institutional investors as limited partners.
④ When the fund is established, the number of limited partners who are not qualified institutional investor is 49 or less. [37]
⑤ The transfer of LP interest from an investor who is the institutional investor at the time of joining the fund is prohibited by the investment limited partnership agreement unless it is transferred to the qualified institutional investor[38]
⑥ The transfer of LP interest from an investor who is the institutional investor at the time of joining the fund is prohibited by the investment limited partnership agreement unless the investor transfers its interest in whole to a single person. [39]

<In operating the fund＞

① There will be continuously no disqualified investor becoming a limited partner during operating period
② There will be continuously one or more qualified institutional investor existing as a limited partner during operating period.
③ The number of limited partners except qualified institutional investor continues to be 49 or less during operating period. [40]

It is necessary to confirm to GP of the fund regarding above issues, and these should be guaranteed by investment limited partnership agreement made based on the Limited Partnership Act for Investment.

In the case of a Japanese investor investing to the offshore private placement fund, it is subject to the Japanese Financial Instruments and Exchange Act as well. In the case that a Japanese investor considering an off-shore fund is not an institutional investor and there is no other qualified investor, GP of the fund has to register as Financial Instruments Business Operator (Type II Financial

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[34] Financial Instruments and Exchange Ac, Article 63-1-1
[35] Financial Instruments and Exchange Ac, Article 2-3-3 and Enforcement Order of the Limited Partnership Act for Investment, Article1-7-2, provided that it comes under criteria 4
[36] Financial Instruments and Exchange Ac, Article 63-1-1, which fall under イ-ハ
[37] Financial Instruments and Exchange Ac, Article 17-12-1,2
[38] Financial Instruments and Exchange Ac, Article 12-3-1
[39] Financial Instruments and Exchange Ac, Article 12-3-2, イ
[40] Financial Instruments and Exchange Ac, Article 17-12-1,2

Instruments Business, investment Management Business). Therefore, usually qualified institutional investors are invited or existing investor applies for a qualified institutional investor for obtaining the status of the Specially Permitted Businesses for Qualified Institutional Investor. The above is the condition as formal requirements.

On the other hand, it is one of the important practical issues for an investor how to be involved in the investment decision making and utilize the fund. Basically, LP investors entrust GP to make a judgment for an investment, and do not participate in the investment committee as member. However, some investors who hope to have influence on decision making as much as possible or hope to receive information on the investment project for consideration of the co-investment sometimes require GP to establish an advisory body such as advisory committee. Such investors aim to assure a certain influence in a fund by stating their opinion via advisory committee. However, it must be noted that attendance of advisory body is generally limited to investors with certain size of LP interest.

It will be difficult to coordinate such arrangement with the stake-holder including other LP unless they do so in the early stages of establishment of the fund. Therefore, these conditions are normally built into investment limited partnership agreement at the timing of the fund establishment.

5-7-3. Summary of other issues

Energy funds focused on South-East Asia have just started to take off compared to European and American energy funds which have plenty of investment track records already. Typically, Energy infrastructures can be considered as potential investment by institutional investors such as pension fund, based on the fact that these provide stable cash flow in a long term. However, in the market where liquidity of energy assets are low, projects in the development phase will be primary investment target, having to bear the development and construction risk. It is a dilemma that taking such risks by energy funds has its own social meaning from view of promoting development, but at the same time it tends to prevent investments from institutional investor.

As the survey shows through some case studies, energy funds in Southeast Asia reaching the decent size receive support from development financial institutions. If the investment support from development financial institutions becomes seed money and it encourages other institutional investors, energy fund will be able to make multiple and sizable investment. This will create better environment for energy funds to build a stable portfolio, and contribute the activation of energy market.

Chapter.6 Summary

The Indonesian government has formulated the “Second Crash Program” with the intention to increase the volume of electricity supply due to the increase in electricity demand. Previously, in the “First Crash Program”, the Indonesian government focused on coal fired power plants. However, in the second one, they diversified their focus to include renewable energy sources such as small hydro power plants.

Compared to other renewable energy sources, hydro has huge development potential at about 75GW, and it has more development track record. In addition, development potential of small hydro power plants in Indonesia has two merits: small initial investment in the development phase and short-term development. Also, from the point of view of the spread of renewable energy sources and the development of power resources in Indonesia, this research has concluded that small hydro power plants are one of the most promising projects.

However, the development of small hydro power projects have seen difficulties with some issues: 1) creditworthiness of project owners, 2) capability of local financial institutions on risk assessment of the project, and 3) neglecting the importance of technical matters and engineering by project owners. Therefore, in consideration of investment of the small hydro project, it is necessary to look into not only financial aspect but also various aspects including technical, environmental and social aspects.

In the Survey, high potential projects are selected based on its status of obtaining permit, and conducted surveys on technical, environmental/social and financial issues. The following is a summary of the results and issues concerning the technical, environmental and social, and business scheme/financing method of the Lae Ordi II Small Hydro Project based on the Survey.

Firstly, the technical survey led to the conclusion that the effective head difference is aligned with the local plan based on the calculation result of loss drop. In the case of using the maximum quantity of water according to the plan by the local consulting company, the calculation on generation capacity by the survey is 10,300kW, while that of the plan by the local consulting company is 10,000kW. Comparing the documents submitted by the local consulting company, the power generation volume is almost the same, approximately 760MWh, despite the differences in conditions for calculation of generation capacity, generation efficiency and method of setting the maintenance flow discharge etc. On the basis of the hydrological calculation, the capacity of passing water through the waterway is fully sufficient. It was also confirmed that the scale of water tank capacity was sufficient.

On the other hand, the main issues for future investigation are as follows: 1) evaluation on the reliability of rainfall data and accuracy of the calculation model used for estimation of water flow from rainfall data, 2) confirmation of the reliability of data by simple measurement of water flow at the planned site, 3) consideration of the design of the structure and construction schedule for more accuracy of estimation, 4) regarding the effective head, designing appropriate headrace including constraints of construction and economical efficiency leads economical improvement.

Secondly, environmental and social impact assessment led to the conclusion that from pollution control perspective, there will be some impact to air quality, water quality, waste, soil pollution, noise and vibration during construction, but the impact is minor. Land of plant site is comprised of secondary forest and cultivated land. There is neither protected area nor a report of rare species. From social environment perspective, there have been three public consultation meeting conducted. Although there will be 15 households that will be impacted by the project, but there is no resettlement of the residents due to the acquisition of the land. The local community is welcoming the project based on the positive impact from the project. Based on the proper implementation of the environmental management plan and monitoring plan, the negative impacts will be reduced/minimized, and the positive impact will be maximized.

Lastly, regarding the business scheme and fund raising, the evaluation of this project is based on the provisional numeric values, referring to similar projects as the cost of EPC, borrowing of money from financial institutions, and the operational cost are not been finalized yet. As a result, if this project is conducted on the basis of a PPA contract with PLN, it is certain that the repayment of loans to senior and mezzanine-lender is possible by revenue from sales of electricity.

The coming issues are to identify the costs of the project and confirm the grounds of the cost, to ensure equity capital is provided by the project owner, and selection of senior lender with continuous confirmation on detailed conditions and amounts of loan.

As discussed above, issues and concerns for going forward with the project are clarified based on the Survey. In summary, for further consideration, issues below need to be addressed for proper structure of the project scheme.

<Technical Aspects>

- evaluation on the reliability of rainfall data and accuracy of the calculation model used for estimation of water flow from rainfall data
- Simple measurement, continuous check on local construction material and labor cost for improved reliability of data
- Consideration on changes in layouts during detailed design

<Environmental/Social Aspects>

- Proper implementation of the environmental management plan and monitoring plan

<Financial Aspects>

- Finalizing the cost for EPC, etc/confirmation of the grounds of the cost
- Ensuring the project owner provides required equity capital

- Selection of senior lender/confirming

By 1) conducting FS review by the Japanese technical consulting company with track records, and 2) considering utilization of funding from Japan including JICA Private Sector Investment Finance Scheme and Japanese energy fund, feasibility of the small hydro power projects will increase. Providing technical and financial supports for the Indonesian small hydro power project owners shall contribute to the promotion of further development.

Appendix L4-1
Calculation of Head Loss
(LaeOrdiⅡ Location)

(by Local Materials)

Chapter 1 Calculation of head loss

Section 1 Head loss at intake

1. Head loss due to inflow

$$h_e = f_e \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right)$$

where,

h_e: Head loss due to inflow		*(m)*
f_e: Inflow loss coefficient	*0.1*	
V_1: Velocity before inflow		*(m/s)*
V_2: Velocity after inflow		*(m/s)*

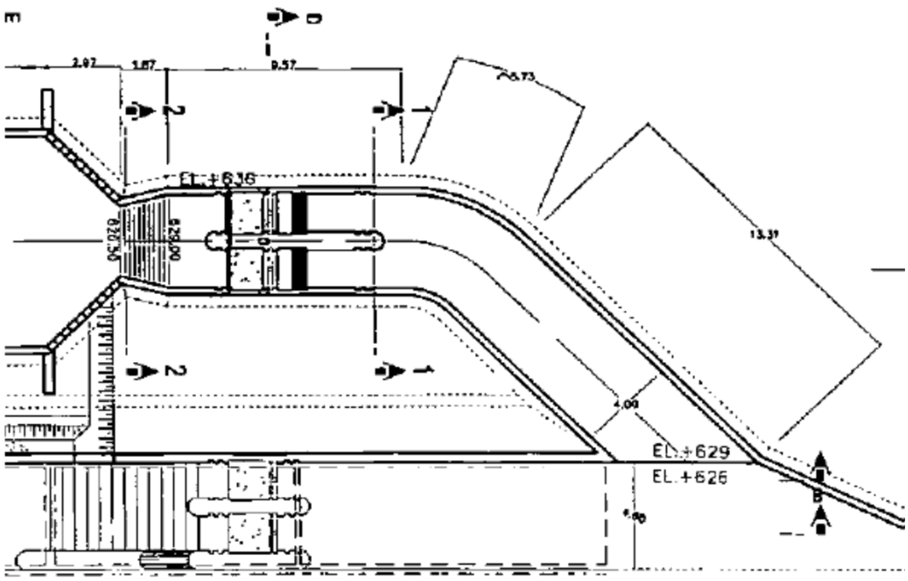
considering V_1=0, thus it could transform to following equation.

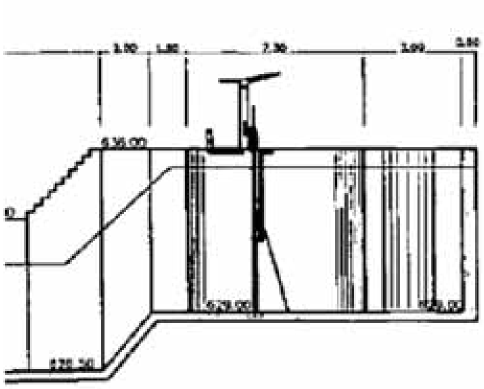
$$h_e = (1 + f_e) \cdot \frac{V_2^2}{2g}$$

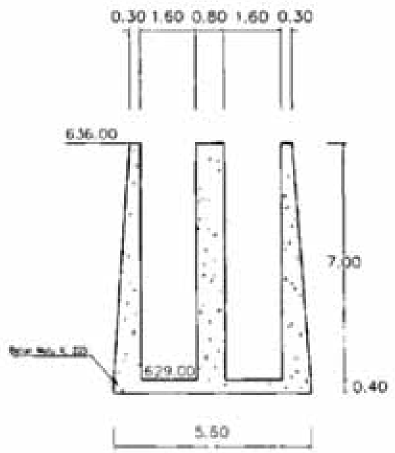
Head loss due to inflow is shown below.

Item	Upstream water level WL_1 (m)	Downstream water level WL_2 (m)	Intake sill Z_2 (m)					
MAX	631.000	630.854	629.000					
Regular	631.000	630.968	629.000					

Item	Flow Q (m^3/s)	Width of intake B (m)	Downstream depth H_2 (m)	Velocity after inflow V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficient $1+f_e$	Head loss h_e (m)	
MAX	11.630	4.000	1.854	1.568	0.125	1.170	0.146	0.000
Regular	5.710	4.000	1.968	0.725	0.027	1.170	0.032	0.000







POTONGAN 1 - 1

· Calculation of critical depth

$$\frac{\alpha Q^2}{g} = \frac{A^3}{T} \cdots\cdots ②$$

Critical depth	$:hc$	(m)	
Plant discharge	$:Q$	(m^3/s)	
Correction coefficient of velocity distribution	$:\ \alpha =$	1.0	
Gravitational acceleration	$:g=$	9.8	(m^2/s)
Width of headrace	$:B=$	4.000	(m)
Slope of side wall	$:m=$	0.000	
cross-sectional area	$:A=(B+m\cdot hc)hc$		(m^2)
Width of water surface	$:T=B+2m\cdot hc$		(m)

substituting *mean velocity* : $V=Q/A$, and *hydraulic radius* $:D=A/T$ for equation②:

$$\alpha\frac{V^2}{2g} = \frac{D}{2} \cdots\cdots ③$$

$$V = \frac{Q}{A} \cdots\cdots ④$$

$$D = \frac{A}{T} \cdots\cdots ⑤$$

substituing ④ and ⑤ for ③:

$$\alpha\frac{Q^2}{g} = \frac{A^3}{T} \cdots\cdots ⑥$$

thus, h satisfied equation ⑥ could be hc.

Item	Flow $Q\,(m^3/s)$	Critical depth h_c (m)	Width of headrace B (m)	Correction coefficient α	Cross-sectional area $A\ (m^2)$	Left side $\alpha Q^2/g$	Right side A^3/T	(Left side) — (Right side)
MAX	11.630	0.952	4.000	1.000	3.808	13.802	13.802	0.000
Regular	5.710	0.592	4.000	1.000	2.370	3.327	3.327	0.000

2．Head loss due to Pier

$$h_p = \frac{Q^2}{2g}\left[\frac{1}{C^2 B_2^2 (H_1 - h_3)^2} - \frac{1}{B_1^2 H_1^2}\right]$$

where,

h_p:	Head loss due to pier		(m)
Q:	Flow		(m^3/s)
C:	Pier shape coefficient	0.92	(m/s)
B_1:	Channel width before pier	4.00	(m)
B_2:	Channel width deducted pier width		
t:	Width of 1 unit of pier	0.80	(m)
H_1:	Water depth of upstream side		

assuming *hp/H1=0, hp* is calculated by following equation.

$$h_p = \left\{\frac{1}{C^2}\left(\frac{B_1}{B_2}\right)^2 - 1\right\}\frac{V_1^2}{2g},\quad V_1 = \frac{Q}{B_1 H_1}$$

Considered this as the first approximate value, calculate the values of two equations to be matched.
Head loss due to pier at Max and regular is shown below.

Item	Upstream level WL_1 (m)	Intake sill Z_1 (m)	Upstream depth H_1 (m)	Channel width before pier B_1	Deducted channel width B_2	Pier coefficient C	$C^2 B_2^2$	$B_1^2 H_1^2$
Max	630.854	629.000	1.854	8.000	7.200	0.920	43.877	219.988
Regular	630.968	629.000	1.968	8.000	7.200	0.920	43.877	247.874

Item	Flow Q (m^3/s)	$Q^2/2g$	Head loss h_p	Downstream depth H_2	Downstream level WL_2 (m)	h_p'		h_p-h_p'
Max	11.630	6.901	0.015	1.839	630.839	0.015		0.000
Regular	5.710	1.663	0.003	1.965	630.965	0.003		-0.000

3．Total of head loss at intake

$$h_I = h_e + h_p + h_c$$

where,

h_e:	Head loss due to inflow	(m)
h_p:	Head loss due to pier	(m)
h_c:	Surplus	(m)

Head loss at intake is shown below.

Part/type of loss		Head loss MAX	Head loss Regular
Flow	h_e	0.146	0.032
Pier	h_p	0.015	0.003
Surplus	h_c	0.285	0.324
Total	h_I	0.446	0.359

Water level at start of intake is shown below.

Plant discharge	MAX	Regular
Water level at start of intake	631.000	631.000
Head loss at intake	0.446	0.709
Water level at start of settling basin	630.554	630.291

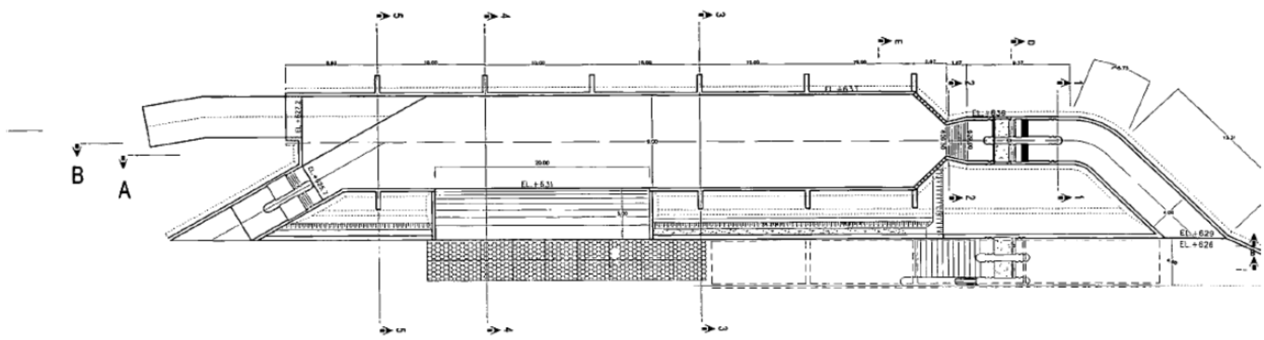
Section 2　Head loss at settling basin

1．Head loss due to cross section changes

In inlet area of settling basin,

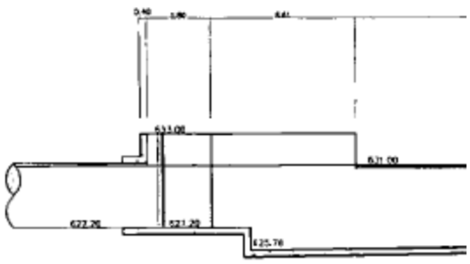
・flow velocity after inflow V_2 < flow velocity before inflow V_1

Thus, difference of velocity heads is negative.
Also flow velocity is slow, and loss head of cross section change due to sudden enlargement is not to be calculated.
Thus, head loss　0



2. Head loss due to inflow

・Calculation of head loss in inflow area from settling basin to headrace



$$h_e = f_e \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right)$$

where, h_e: Head loss due to inflow (m)

f_e: Inflow loss coefficient 0.2

V_1: Velocity befor inflow (m/s)

V_2: Velocity after inflow (m/s)

considering V_1=0, thus it could transform to following equation.

$$h_e = (1 + f_e) \cdot \frac{V_2^2}{2g}$$

Head loss due to inflow is shown below.

Item	Upstream level WL_1 (m)	Downstream level WL_2 (m)	Channel sill Z_2 (m)					
MAX	630.554	630.507	627.200					
Regular	630.291	630.278	627.200					

Item	Flow Q (m^3/s)	Width of headrace B (m)	Downstream depth H_2 (m)	Velocity after inflow V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficient $1+f_e$	Head loss h_e (m)	$WL_1-WL_2-h_e$
MAX	11.630	4.000	3.307	0.879	0.039	1.200	0.047	0.000
Regular	5.710	4.000	3.078	0.464	0.011	1.200	0.013	0.000

Head loss at settling basin is shown below.

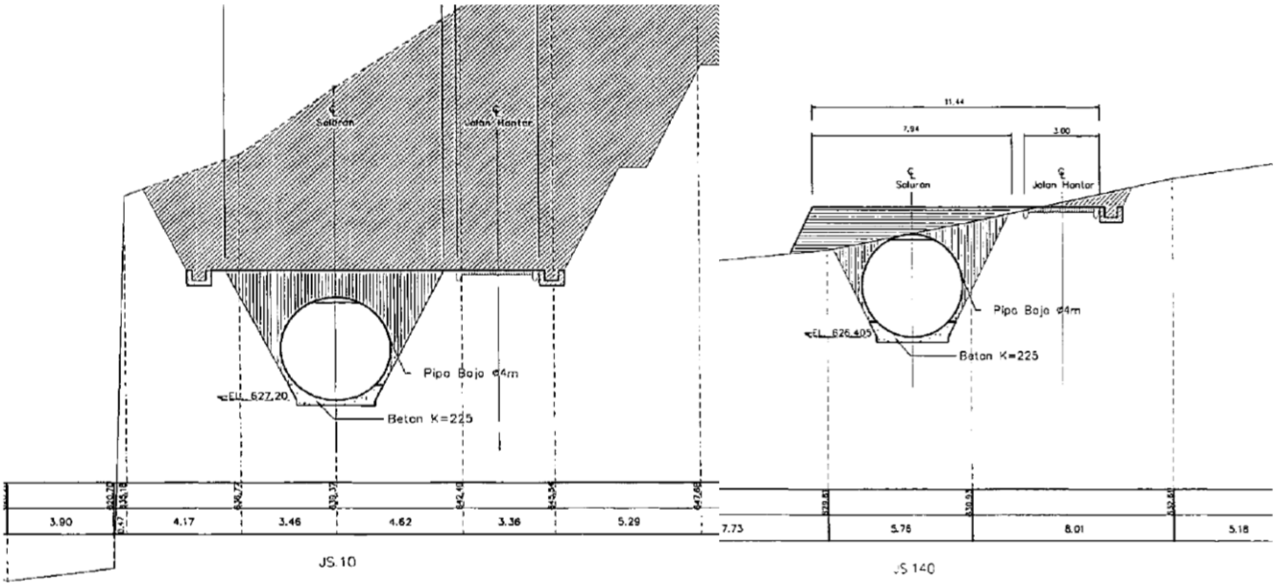
Part/type of loss		Head loss MAX	Head loss Regular
Cross-section change	h_{ge}	0.000	0.000
Inflow	h_e	0.047	0.013
Surplus	h_c	0.000	0.000
Total	h_{II}	0.047	0.013

Section 3 Head loss at Headrace

1. Loss head due to slope

Head loss at headrace means difference between water level at start of headrace and water level at end of head tank.
Water level at starting point of headrace is estimated by backwater calculation from head tank.

Name	Station point SP.m	Length of interval m	Slope of headrace		Starting point sill height EL.m	End point sill height EL.m
Headrace start	JS 10	2426.37	3052.04	0.0328%	627.200	626.400
Headrace end	JS140					



Diameter of pipe D: 4.00 m
Roughness coefficient n: 0.013

2. Calculation of water level at starting point of headrace

Water level at each station point is shown below.

Plant discharge			MAX	11.63	Regular	5.71
Name	Station point SP.m	Length m	Head loss m	Estimated water level EL.m	Head loss m	Estimated water level EL.m
Headrace start	JS 10	2426.37	0.307	630.507	0.078	630.278
Headrace end	JS140	0.00		630.200		630.200

End of headrace is water level of head tank.

$$h_{IV} = WL_1 - WL_2$$

WL_1: water level of start of headrace (m)
water level of end of headrace
WL_2: (water level of tank) (m)

Head loss at headrace is shown below.

Part/type of loss		Head loss MAX	Head loss Regular
Water level at start of headrace	WL_1	630.507	630.278
Water level at end of headrace (water level of tank)	WL_2	630.200	630.200
Total	h_{IV}	0.307	0.078

Flow depth is calculated by Manning's equation

$$AR^{2/3} = \frac{Qn}{\sqrt{I}} \quad \cdots\cdot ①$$

(Calculation of Uniform flow depth)

Uniform flow depth	$:h_o$		(m)
Plant discharge	$:Q$		(m^3/s)
Slope of headrace	$:I=$	0.00033	
Manning roughness coefficient	$:n=$	0.013	
Width of headrace	$:D=$	4.000	(m)
Cross-sectional area of flow	$:A$		(m^2)
Wetted perimeter	$:S$		(m)
Hydraulic radius	$:R=A/S$		(m)

Item	Flow $Q\ (m^3/s)$	Right side $Q\cdot n/I^{0.5}$	Uniform flow depth $h_0\ (m)$	Cross-sectional $A\ (m^2)$	Wetted $S\ (m)$	Hydraulic radius $R\ (m)$	Left side $AR^{2/3}$	(Left side)-(Right side)
MAX	11.630	8.353	2.383	7.807	7.055	1.107	8.353	0.000
Regular	5.710	4.101	1.572	4.585	5.421	0.846	4.101	0.000

$$\frac{\alpha Q^2}{g} = \frac{A^3}{T} \quad \cdots\cdot ②$$

(Calculation of Critical water depth)

Critical water depth			(m)
Plant discharge			(m^3/s)
Correction coefficient of velocity distribution		1.0	
Gravitational acceleration	$:g=$	9.8	(m^2/s)
Width of headrace	$:B=$	4.000	(m)
Cross-sectional area of flow	$:A$		(m^2)
Width of water surface	$:T$		(m)

substituting *mean velocity* : $V=Q/A$ and *hydraulic radius* : $D=A/T$ for equation ②:

$$\alpha\frac{V^2}{2g} = \frac{D}{2} \quad \cdots\cdot ③$$

$$V = \frac{Q}{A} \quad \cdots\cdot ④$$

$$D = \frac{A}{T} \quad \cdots\cdot ⑤$$

substituting ④ and ⑤ for ③:

$$\alpha\frac{Q^2}{g} = \frac{A^3}{T} \quad \cdots\cdot ⑥$$

thus, h satisfied ⑥ can be hc.

Item	Flow $Q\ (m^3/s)$	Critical water depth $h_c\ (m)$	Width of water surface $T\ (m)$	Calibration coefficient α	Cross-sectional area of $A\ (m^2)$	Left side $\alpha Q^2/g$	Right side A^3/T	(Left side)-(Light side)
MAX	11.630	1.352	3.784	1.000	3.738	13.802	13.802	0.000
Regular	5.710	0.937	3.389	1.000	2.242	3.327	3.327	0.000

Calculation of non-uniform flow

$$\left(\frac{\alpha_2 Q^2}{2gA_2^2}+h_2+z_2\right)-\left(\frac{\alpha_1 Q^2}{2gA_1^2}+h_1+z_1\right)=-\frac{1}{2}\left(\frac{Q^2}{K_1^2}+\frac{Q^2}{K_2^2}\right)(L_2-L_1)$$

Cross section shape circular
Pipe diameter *D:* 4.000 *(m)*

Roughness coefficient *n:* 0.013
Slope of Headrace *i:* 0.00033
Correction coefficient α : 1.000

MAX

Flow *Q:* 11.630 (m^3/s)

No	channel length L (m)	Additional length dL (m)	Water depth h (m)	Cross-sectional area A (m^2)	Hydraulic radius R (m)	Flow velocity V (m/s)	Water level H (m)	Channel sill height Z (m)	Specific energy E	Conveyance K	Friction loss h_f (m)	
1	0.00		3.8000	12.3315	1.1458	0.9431	630.200	626.400	630.2454	1038.673		
2	100.00	100.00	3.7795	12.2948	1.1522	0.9459	630.212	626.433	630.2579	1039.466	0.0125	0.000
3	200.00	100.00	3.7589	12.2565	1.1582	0.9489	630.224	626.466	630.2704	1039.806	0.0125	0.000
4	400.00	200.00	3.7178	12.1752	1.1689	0.9552	630.249	626.531	630.2954	1039.261	0.0250	0.000
5	600.00	200.00	3.6767	12.0883	1.1782	0.9621	630.273	626.597	630.3205	1037.270	0.0251	0.000
6	800.00	200.00	3.6357	11.9963	1.1861	0.9695	630.298	626.662	630.3458	1034.012	0.0252	0.000
7	1,000.00	200.00	3.5948	11.8999	1.1930	0.9773	630.322	626.728	630.3712	1029.633	0.0254	0.000
8	1,200.00	200.00	3.5541	11.7996	1.1988	0.9856	630.347	626.793	630.3969	1024.260	0.0257	0.000
9	1,400.00	200.00	3.5137	11.6958	1.2036	0.9944	630.372	626.859	630.4229	1017.999	0.0259	0.000
10	1,600.00	200.00	3.4736	11.5890	1.2076	1.0035	630.398	626.924	630.4492	1010.950	0.0263	0.000
11	1,800.00	200.00	3.4338	11.4797	1.2109	1.0131	630.424	626.990	630.4759	1003.200	0.0267	0.000
12	2,000.00	200.00	3.3944	11.3682	1.2134	1.0230	630.450	627.055	630.5031	994.831	0.0271	0.000
13	2,200.00	200.00	3.3554	11.2550	1.2152	1.0333	630.476	627.121	630.5307	985.920	0.0276	0.000
14	2,426.37	226.37	3.3119	11.1253	1.2166	1.0454	630.507	627.195	630.5626	975.269	0.0318	0.000
Total	2,426.37						630.507				0.3169	

Regular

Flow *Q:* 5.710 (m^3/s)

No	channel length L (m)	Additional length dL (m)	Water depth h (m)	Cross-sectional area A (m^2)	Hydraulic radius R (m)	Flow velocity V (m/s)	Water level H (m)	Channel sill height Z (m)	Specific energy E	Conveyance K	Friction loss h_f (m)	
1	0.00		3.8000	12.3315	1.1458	0.4630	630.200	626.400	630.2109	1038.673		
2	100.00	100.00	3.7704	12.2780	1.1550	0.4651	630.203	626.433	630.2142	1039.671	0.0030	0.000
3	200.00	100.00	3.7405	12.2207	1.1632	0.4672	630.206	626.466	630.2171	1039.753	0.0030	0.000
4	400.00	200.00	3.6810	12.0976	1.1773	0.4720	630.212	626.531	630.2234	1037.539	0.0060	0.000
5	600.00	200.00	3.6217	11.9637	1.1886	0.4773	630.218	626.597	630.2299	1032.630	0.0061	0.000
6	800.00	200.00	3.5619	11.8190	1.1977	0.4831	630.224	626.662	630.2359	1025.356	0.0062	0.000
7	1,000.00	200.00	3.5024	11.6660	1.2048	0.4895	630.230	626.728	630.2422	1016.087	0.0063	0.000
8	1,200.00	200.00	3.4428	11.5049	1.2102	0.4963	630.236	626.793	630.2486	1005.026	0.0064	0.000
9	1,400.00	200.00	3.3837	11.3375	1.2140	0.5036	630.242	626.859	630.2553	992.452	0.0065	0.000
10	1,600.00	200.00	3.3250	11.1647	1.2162	0.5114	630.249	626.924	630.2625	978.548	0.0067	0.000
11	1,800.00	200.00	3.2660	10.9851	1.2172	0.5198	630.256	626.990	630.2696	963.315	0.0069	0.000
12	2,000.00	200.00	3.2072	10.8002	1.2169	0.5287	630.263	627.055	630.2768	946.942	0.0071	0.000
13	2,200.00	200.00	3.1486	10.6108	1.2154	0.5381	630.269	627.121	630.2842	929.579	0.0074	0.000
14	2,426.37	226.37	3.0826	10.3918	1.2124	0.5495	630.278	627.195	630.2930	908.894	0.0087	0.000
計	2,426.37						630.278				0.0804	

Section 4 Head loss at Head tank

1. Head loss due to sudden enlargement

$$h_{se} = f_{se} \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right)$$

$$f_{se} = \left\{ 1 - \left(\frac{A_1}{A_2} \right) \right\}^2$$

where,

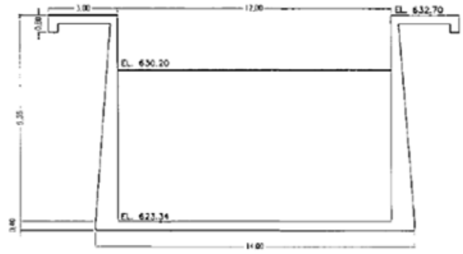
- h_{se}: Head loss due to enlargement of cross section (m)
- f_{se}: Loss coefficient of sudden enlargement
- V_1: Flow velocity before enlargement (m/s)
- V_2: Flow velocity after enlargement (m/s)

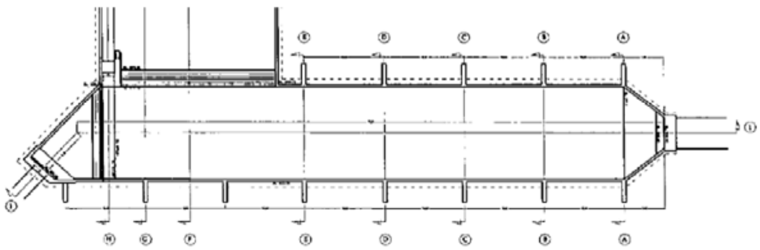
D: Diameter before enlargement 4.00 (m)

Item	Upstream water level WL_1 (m)	Upstream sill Z_1 (m)	Upstream depth H_1 (m)	Upstream cross-section A_1 (m)	Downstream water level WL_2 (m)	Downstream sill Z_2 (m)	Downstream depth H_2 (m)	Downstream effective width B_2 (m)
MAX	630.200	626.400	3.800	12.331	630.200	623.340	6.860	12.000
Regular	630.200	626.400	3.800	12.331	630.200	623.340	6.860	12.000

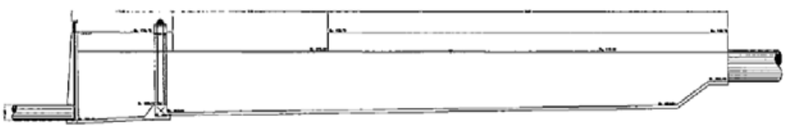
Item	Flow Q (m^3/s)	Velocity before enlargemen V_1 (m/s)	Velocity head $V_1^2/2g$	Velocity after enlargemen V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficien t f_{se}	Loss head h_{se} (m)	WL_1-WL_2-h_2
MAX	11.630	0.943	0.045	0.141	0.001	0.723	-0.043	0.043
Regular	5.710	0.463	0.011	0.069	0.000	0.723	-0.011	0.011

$V_2 < V_1$, Thus, head loss is not calculated because diffrence of velocity head is positive.





DENAH HEAD POND



2. Total of head loss at head tank

$$h_V = h_{se} + h_c$$

where,

- h_{se}: Head loss due to enlargement of cross section (m)
- h_c: Surplus (m)

Total of head loss at head tank is shown below.

Part/type of loss		Head loss MAX	Head loss Regular
Enlargement of the cross section	h_{se}	0.000	0.000
Surplus	h_c	0.000	0.000
Total		0.000	0.000

Section 5 Head loss at Penstock

1. Head loss due to inflow

$$h_e = f_e \cdot \frac{V_2^{\,2}}{2g}$$

where,		
h_e:	Head loss due to inflow		(m)
f_e:	Inflow loss coefficient	0.050	bellmouth
V_2:	Velocity after inflow		(m/s)
D:	Pipe diameter		(m)
A:	Sectional area of pipe		(m^2)

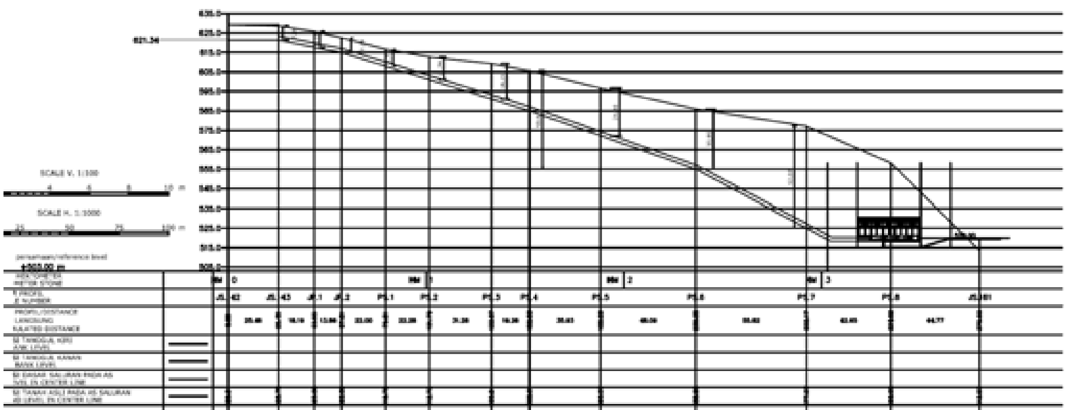
Head loss due to inflow in case of Max and regular plant discharge are shown below.

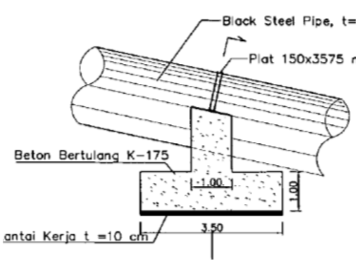
Item	Flow $Q/(m^3/s)$	Pipe diameter D (m)	Sectional area $A(m^2)$	Velocity after inflow V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficient f_e	Head loss h_e (m)	
MAX	11.630	2.000	3.142	3.701	0.699	0.050	0.035	
Regular	5.710	2.000	3.142	1.817	0.168	0.050	0.008	

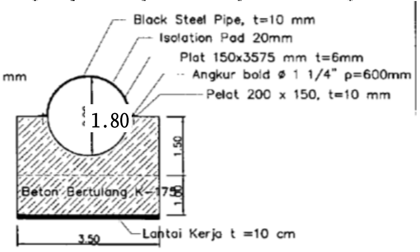
2. Head loss due to friction(before branch)

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

where,			
h_f:	Head loss due to friction		(m)
f:	Friction loss coefficient		
V:	Velocity in pipe		(m/s)
D:	Pipe diameter	2.400	(m)
L:	Pipe length		(m)







Friction loss coefficient of circular cross section channel is calculated by following equation.

$$f = 124.5 \cdot n^2 / D^{1/3}$$

where, n: Manning's roughness coefficient 0.012

Friction loss coefficients of each diameter of pipe are shown below.

No.	Pipe diameter D (m)	Pipe length L (m)	Sectional area $A(m^2)$	Roughness coeffient n	Loss coefficient f	$f \cdot L/D$
1	2.000	310.00	3.142	0.012	0.0142	2.201

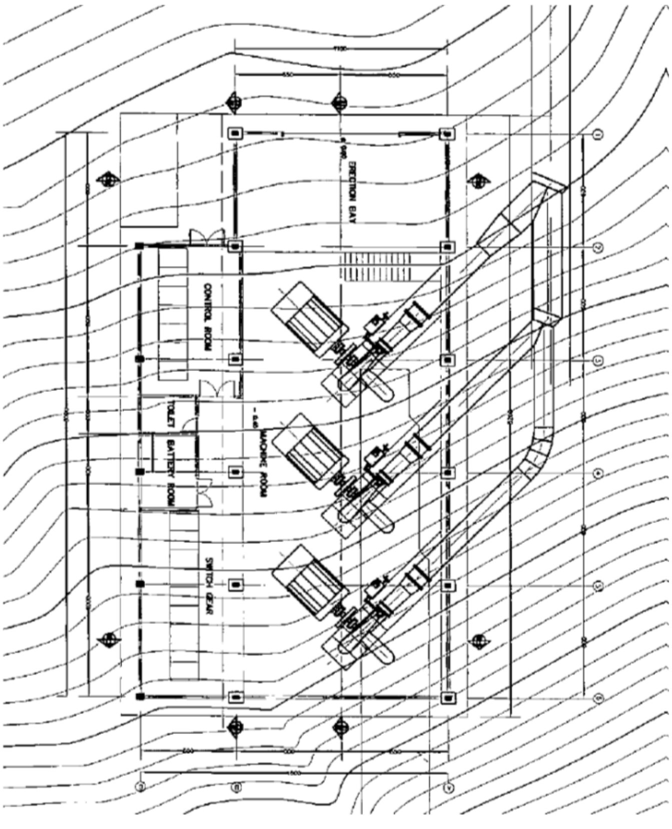
Head loss(before branch) due to friction at Max and regular plant discharge are shown below.

No.	MAX	11.630		Regular	5.710	
	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_f (m)	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_f (m)
1	3.701	0.699	1.538	1.817	0.169	0.372
Total		h_2 =	1.538		h_2 =	0.372

3 .Head loss due to branch

3 units of turbin are used to generate when plant discharge is Max. Thus head loss is calculated with 1/3 of flow after branch.

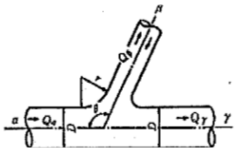
2 units of turbin are used to generate when plant discharge is Regular. Thus head loss is calculated with 1/2 of flow after branch.



$D_{\alpha 1}$:	Diameter(1 branch main pipe)	2.000	(m)
$D_{\beta 1}$:	Diameter(1 branch socket pipe)	1.200	(m)
$D_{\alpha 2}$:	Diameter(2 branch main pipe)	1.600	(m)
$D_{\beta 2}$:	Diameter(2 branch socket pipe)	1.200	(m)
$D_{\gamma 2}$:	Diameter(after branch main pipe	1.200	(m)
ρ:	Radius of curve	2.000	(m)
θ:	Central angle of curve	45.000	°

Head loss due to branch

$$h_1 = H_\alpha - H_\beta = f_\beta \cdot \frac{V_\alpha^2}{2g}$$



where, H_α : Total head (m) of pipe α Branch pipe, T-junction

H_β : Total head (m) of pipe β

V_α : velocity before branch (m/s)

f_β : Loss coefficient due to branch(socket pipe)

$$= 0.95(1-q_\beta)^2 + q_\beta^2(1.3 \cdot \cot\frac{\theta}{2} - 0.3 + \frac{0.4-0.1\phi}{\phi^2})(1-0.9\sqrt{\frac{\rho}{\phi}}) + 0.4q_\beta(1-q_\beta)(1+\frac{1}{\phi})\cot\frac{\theta}{2}$$

f_γ Loss coefficient due to branch(main pipe) +0.03

q_β : Ratio of flow socket pipe flow Qs to flow before branch Qa = Q / Q

Q_α : Flow before branch

Q_β : Flow velocity of branch

ρ Ratio of main pipe diameter to chamfer radius r at junction of main and socket pipe = r / D α

r =0 より ρ =0

θ Crossing angle of main and socket pipe (°)

ϕ Cross section ratio of main to socket pipe A_α

Branch 1

Case	$Q\gamma$	$Q\beta$	$Q\alpha$	$q\beta$	$A\alpha$	$A\beta$	ϕ	θ
MAX	7.753	3.877	11.630	0.333	3.142	1.131	0.360	45
Regular	2.855	2.855	5.710	0.500	3.142	1.131	0.360	45

Case	ρ	$V\alpha$	$V\alpha^2/2g$		$f\beta$	$f\gamma$	h_{1A}	h_{1A}'
MAX	1.00	3.701	0.699		0.877	0.008	0.613	0.005
Regular	1.00	1.817	0.168		0.349	0.045	0.059	0.008

Branch 2

Case	$Q\gamma$	$Q\beta$	$Q\alpha$	$q\beta$	$A\alpha$	$A\beta$	ϕ	θ
MAX	3.877	3.877	7.753	0.500	3.142	1.131	0.360	45
Regular	-	2.855	2.855	1.000	3.142	1.131	0.360	45

Case	ρ	$V\alpha$	$V\alpha^2/2g$		$f\beta$	$f\gamma$	h_{1A}	h_{1A}'
MAX	1.00	2.468	0.311		0.349	0.045	0.109	0.014
Regular	1.00	0.909	0.042		-	-	-	-

5. Head loss due to bend

<Turbine3>

$$h_b = f_{b1} \cdot f_{b2} \cdot \frac{v^2}{2g}$$

where,

h_b: Head loss due to bend (m)

f_{b1}: Loss coefficient decided by radius of curvature of bend ρ and pipe diameter D.

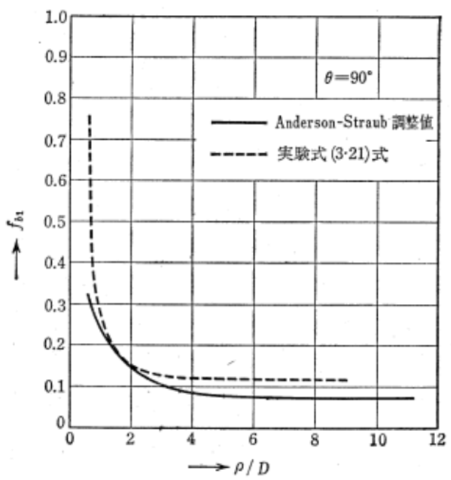
f_{b2}: Loss ratio between central angle θ of arbitrary bend and 90 bend

V: Velocity in pipe (m/s)

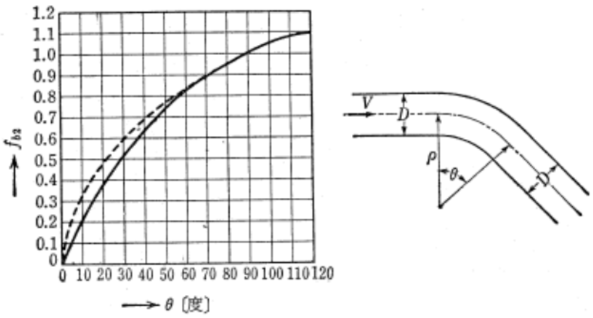
Loss coefficient f_{b1}、f_{b2} is calculated by following equation;

$$f_{b1} = 0.131 + 0.1632 \cdot (D/\rho)^{7/2}$$

$$f_{b2} = (\theta/90)^{1/2}$$



（a） f_{b1} の 値 (θ=90°)



（b） f_{b2} の 値

第 3・13 図 曲がりの損失係数

Loss coefficient of bend on each part is shown below.

IP	Diameter of pipe D (m)	Sectional area $A(m^2)$	Radius of curvature ρ	D/ρ	Loss coefficien f_{b1}	Angle θ	Loss ratio f_{b2}	$f_{b1} \cdot f_{b2}$
1	2.000	3.142	2.000	1.000	0.294	45.000	0.707	0.208

Head loss due to bend at Max and regular plant discharge is shown below.

IP	MAX	3.877		Regular	0.000	
	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_b (m)	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_b (m)
1	1.234	0.078	0.016	0.000	0.000	0.000
Total		h_b =	0.016		h_b =	0.000

6. Head loss due to refraction

$$h_{be} = f_{be} \cdot \frac{v^2}{2g}$$

where, h_{be}: Head loss due to refraction (m)
f_{be}: Refraction loss coefficient
V: Velocity in pipe (m/s)
θ: Refraction angle

Loss coefficient f_{be} is calculated by following equation.

$$f_{be} = 0.946 \sin^2 \frac{\theta}{2} + 2.05 \sin^4 \frac{\theta}{2}$$

Refraction loss coefficient of each part is shown below.

IP	Pipe diameter D (m)	Sectional area $A(m^2)$	Angle θ	Loss coefficient f_{be}	
3	2.000	3.142	45.000	0.183	

Head loss due to refraction at Max and regular plant discharge is shown below.

IP	MAX	0.000		Regular	2.855	
	Velocity in pipe V (m/s)	velocity head $V^2/2g$	Head loss h_{be} (m)	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_{be} (m)
3	0.000	0.000	0.000	0.909	0.042	0.008
Total		$h_{be} =$	0.000		$h_{be} =$	0.008

7. Head loss due to sudden contraction of cross section

$$h_{gc} = f_{gc} \cdot \frac{V_2^{\,2}}{2g}$$

where,

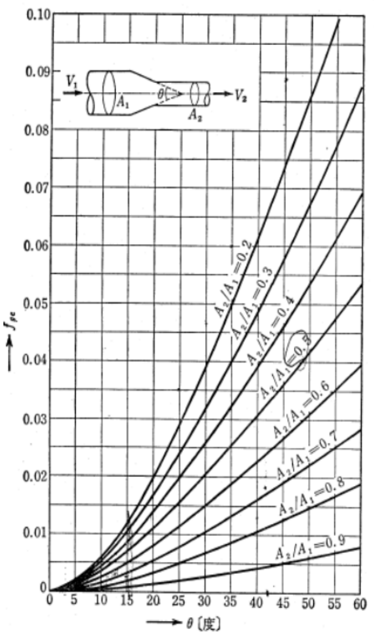
h_{gc}: Head loss due to sudden contraction of cross section (m)

f_{gc}: Contraction loss coefficient

V_2: Flow velocity after contraction (m/s)

Contraction loss coefficient of each part is shown below.

Pipe diameter D (m)	Area before A_1(m2)	Area after contractio A_2 (m2)	Length L	A_2/A_1	Angle of contraction θ	Loss coefficint f_{gc}	
1.68-0.94	3.142	3.142	0.000	1.000	-	0.000	



where,

D: Pipe diameter (m)

A_1: Area before contraction (m^2)

A_2: Area after contraction (m^2)

θ: Angle of contraction = $\tan^{-1}(((A_1/\pi)^{0.5}-(A_2/\pi)^{0.5})/L)\times 2$ (°)

Head loss due to contraction at Max and regular plant discharge is shown below.

No.	MAX	11.630		Regular	5.710	
	Velocity in pipe V_2 (m/s)	Velocity head $V_2^{\,2}/2g$	Head loss h_{gc} (m)	Velocity in pipe V_2 (m/s)	Velocity head $V_2^{\,2}/2g$	Head loss h_{gc} (m)
5	3.701	0.699	0.000	1.817	0.168	0.000
Total		h_{gc} =	0.000		h_{gc} =	0.000

8. Total of head loss in penstock

$$h_{VI} = h_e + h_f + h_a + h_b + h_{be} + h_{gc} + h_c$$

where, h_e: Head loss due to flow (m)
h_f: Head loss due to Friction(before branch) (m)
h_a: Head loss due to Branch (m)
h_b: Head loss due to Bend
h_{be}: Head loss due to Refraction
h_{gc}: Head loss due to Cross section contraction
h_c: Surplus

Total of head loss in penstock is shown below.

Part/type of loss		Head loss					
		MAX			Regular		
		No.1	No.2	No.3	No.1	No.2	No.3
Flow	h_e	0.035			0.008		
Friction(before branch)	h_f	1.538			0.372		
Branch	h_a	0.613	0.114	0.014	0.059	0.008	-
Bend	h_b	-	-	0.016	-	-	-
Refraction	h_{be}	-	-	-		0.008	-
Cross section contracti	h_{gc}	-	-	-	-	-	-
Surplus	h_c	-	0.499	0.583	-	0.043	0.059
Total		2.186	2.186	2.186	0.439	0.439	0.439

Section 6 Total of Head losses

Total of head loss from intake through tailrace channel is shown below.

Part	MAX	Regular
Intake	0.446	0.359
Settling basin	0.047	0.013
Headrace	0.307	0.078
Headtank	0.000	0.000
Penstock	2.186	0.439
Surplus	1.614	0.412
Total	4.600	1.300

Section 7 Calculation of Effective head

Total of head loss from intake through tailrace channel is shown below.

Item	Unit	MAX	Regular
Plant discharge	m^3/s	11.630	5.710
Intake level	m	631.000	631.000
Tailrace level	m	520.000	520.000
Gross head	m	111.000	111.000
Head loss	m	4.600	1.300
Effective head	m	106.400	109.700

Chapter 2 Calculation of theoretical water-power and generating power

Section 1 Calculation of theoretical water-power

$$P_e = 9.8 \cdot H_m \cdot Q_m$$

where,	*Pe:*	Theoretical water-power	*(kW)*
	Hm:	Effective head	*(m)*
	Qm:	Plant discharge	*(m3/s)*

Per Unit

	Unit	MAX	Regular
Plant discharge: Q_m		3.877	1.903
Effective head: H_m	*m*	106.400	109.700
Theoretical water-power: P_e	*kW*	4,042	2,046

Section 2 Calculation of generating power

$$E = P_e \cdot \eta_1 \cdot \eta_2$$

where,	*E:*	Theoretical water power	*(kW)*
	Pe:	Effective head	*(kW)*
	η1:	Plant discharge	
	η2:	Efficiency of generator	

	Unit	MAX	Regular
Theoretical water-power : P_e	*kW*	4,042	2,046
Combined coefficiency : η_2		0.840	0.750
Generating power : E	*kW*	3,395	1,535

		10,186	3,069

Appendix L4-2
Calculation of Head Loss
(LaeOrdi II Location)

(Improvement suggestion)

Chapter 1 Calculation of head loss

Section 1 Head loss at intake

1. Head loss due to inflow

$$h_e = f_e \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right)$$

where,

h_e:	Head loss due to inflow		(m)
f_e:	Inflow loss coefficient	0.1	
V_1:	Velocity before inflow		(m/s)
V_2:	Velocity after inflow		(m/s)

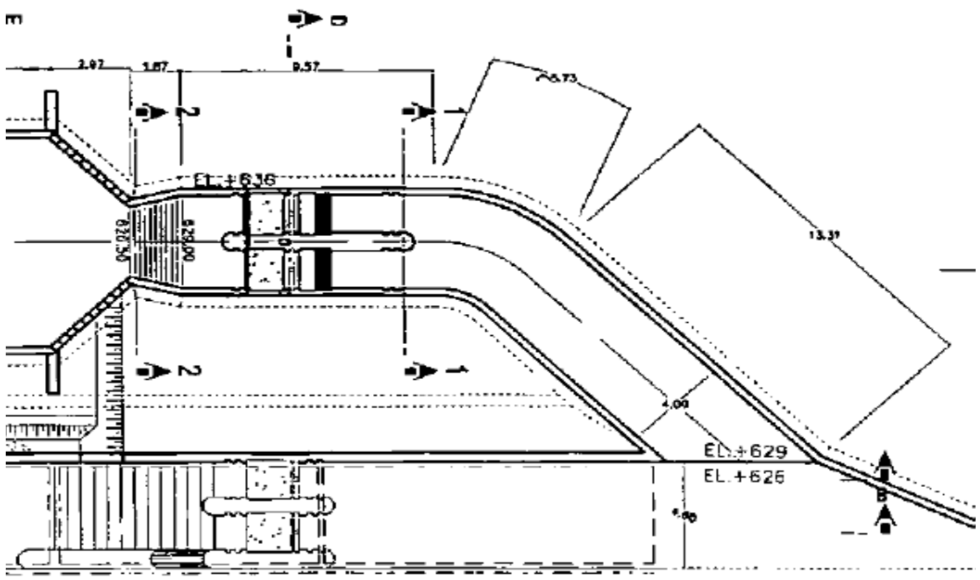
considering V_1=0, thus it could transform to following equation.

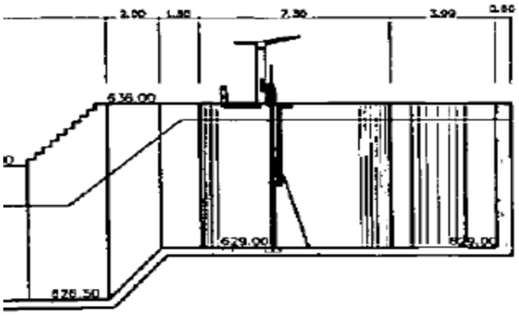
$$h_e = (1 + f_e) \cdot \frac{V_2^2}{2g}$$

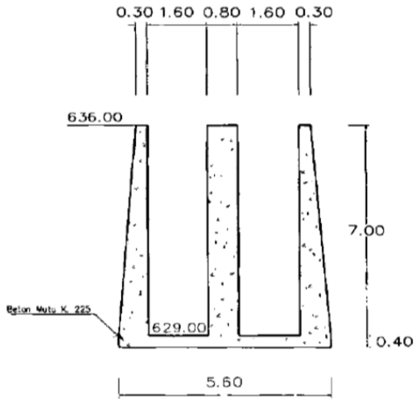
Head loss due to inflow is shown below.

Item	Upstream water level WL_1 (m)	Downstream water level WL_2 (m)	Intake sill Z_2 (m)					
MAX	631.000	630.844	629.000					
Regular	631.000	630.968	629.000					

Item	Flow Q (m^3/s)	Width of intake B (m)	Downstream depth H_2 (m)	Velocity after V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficient $1+f_e$	Head loss h_e (m)	
MAX	11.900	4.000	1.844	1.613	0.133	1.170	0.156	0.000
Regular	5.710	4.000	1.968	0.725	0.027	1.170	0.032	0.000







POTONGAN 1 - 1

・Calculation of critical depth

$$\frac{\alpha Q^2}{g} = \frac{A^3}{T} \quad \cdots\cdot ②$$

Critical depth	$:hc$	(m)	
Plant discharge	$:Q$	(m^3/s)	
Correction coefficient of velocity istribution	$:\ \alpha =$	1.0	
Gravitational acceleration	$:g=$	9.8	(m^2/s)
Width of headrace	$:B=$	4.000	(m)
Slope of side wall	$:m=$	0.000	
cross-sectional area	$:A=(B+m\cdot hc)hc$		(m^2)
Width of water surface	$:T=B+2m\cdot hc$		(m)

substituting *mean velocity* : $V=Q/A$, and *hydraulic radius* : $D=A/T$ for equation②:

$$\alpha \frac{V^2}{2g} = \frac{D}{2} \quad \cdots\cdot ③$$

$$V = \frac{Q}{A} \quad \cdots\cdot ④$$

$$D = \frac{A}{T} \quad \cdots\cdot ⑤$$

substituing ④ and ⑤ for ③:

$$\alpha \frac{Q^2}{g} = \frac{A^3}{T} \quad \cdots\cdot ⑥$$

thus, h satisfied equation ⑥ could be hc.

Item	Flow $Q\,(m^3/s)$	Critical depth h_c (m)	Width of headrace B (m)	Correction coefficient α	Cross-sectional area $A\,(m^2)$	Left side $\alpha Q^2/g$	Right side A^3/T	(Left side) − (Right side)
MAX	11.900	0.967	4.000	1.000	3.866	14.450	14.450	0.000
Regular	5.710	0.592	4.000	1.000	2.370	3.327	3.327	0.000

2. Head loss due to Pier

$$h_p = \frac{Q^2}{2g}\left[\frac{1}{C^2 B_2^2 (H_1 - h_3)^2} - \frac{1}{B_1^2 H_1^2}\right]$$

where,

h_p:	Head loss due to pier		(m)
Q:	Flow		(m^3/s)
C:	Pier shape coefficient	0.92	(m/s)
B_1:	Channel width before pier	4.00	(m)
B_2:	Channel width deducted pier width		
t:	Width of 1 unit of pier	0.80	(m)
H_1:	Water depth of upstream side		

assuming $hp/H1=0$, hp is calculated by following equation.

$$h_p = \left\{\frac{1}{C^2}\left(\frac{B_1}{B_2}\right)^2 - 1\right\}\frac{V_1^2}{2g}, \quad V_1 = \frac{Q}{B_1 H_1}$$

Considered this as the first approximate value, calculate the values of two equations to be matched.
Head loss due to pier at Max and regular is shown below.

Item	Upstream level WL_1 (m)	Intake sill Z_1 (m)	Upstream depth H_1 (m)	Channel width before B_1	Deducted channel width B_2	Pier coefficient C	$C^2 B_2^2$	$B_1^2 H_1^2$
Max	630.844	629.000	1.844	8.000	7.200	0.920	43.877	217.622
Regular	630.968	629.000	1.968	8.000	7.200	0.920	43.877	247.874

Item	Flow Q (m^3/s)	$Q^2/2g$	Head loss h_p	Downstream depth H_2	Downstream level WL_2 (m)	$h_{p'}$		h_p-$h_{p'}$
Max	11.900	7.225	0.016	1.828	630.828	0.016		-0.000
Regular	5.710	1.663	0.003	1.965	630.965	0.003		-0.000

3. Total of head loss at intake

$$h_I = h_e + h_p + h_c$$

where,

h_e:	Head loss due to inflow	(m)
h_p:	Head loss due to pier	(m)
h_c:	Surplus	(m)

Head loss at intake is shown below.

Part/type of loss		Head loss	
		MAX	Regular
Flow	h_e	0.156	0.032
Pier	h_p	0.016	0.003
Surplus	h_c	0.285	0.324
Total	h_I	0.457	0.359

Water level at start of intake is shown below.

Plant discharge	MAX	Regular
Water level at start of intake	631.000	631.000
Head loss at intake	1.717	2.466
Water level at start of settling basin	629.283	628.534

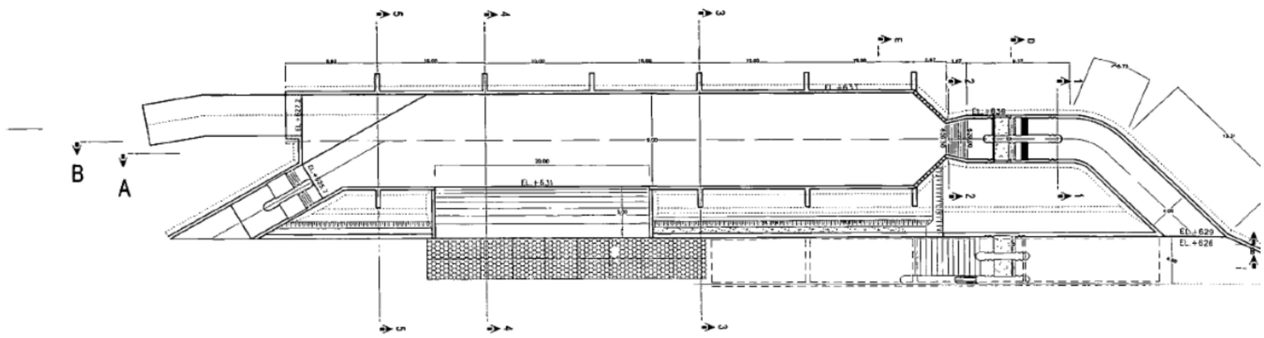
Section 2　Head loss at settling basin

1．Head loss due to cross section changes

In inlet area of settling basin,

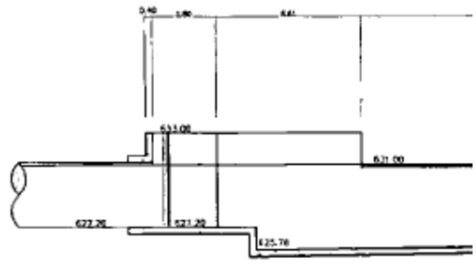
・flow velocity after inflow V_2 < flow velocity before inflow V_1

Thus, difference of velocity heads is negative.
Also flow velocity is slow, and loss head of cross section change due to sudden enlargement is not to be calculated.
Thus, head loss 0



2. Head loss due to inflow

・Calculation of head loss in inflow area from settling basin to headrace



$$h_e = f_e \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$$

where, h_e: Head loss due to inflow (m)
f_e: Inflow loss coefficient 0.2
V_1: Velocity befor inflow (m/s)
V_2: Velocity after inflow (m/s)

considering V_1=0, thus it could transform to following equation.

$$h_e = (1 + f_e) \cdot \frac{V_2^2}{2g}$$

Head loss due to inflow is shown below.

Item	Upstream level WL_1 (m)	Downstream level WL_2 (m)	Channel sill Z_2 (m)					
MAX	629.283	629.139	627.200					
Regular	628.534	628.455	627.200					

Item	Flow Q (m^3/s)	Width of headrace B (m)	Downstream depth H_2 (m)	Velocity after inflow V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficient $1+f_e$	Head loss h_e (m)	WL_1-WL_2-h_e
MAX	11.900	4.000	1.939	1.534	0.120	1.200	0.144	0.000
Regular	5.710	4.000	1.255	1.138	0.066	1.200	0.079	0.000

Head loss at settling basin is shown below.

Part/type of loss		Head loss MAX	Head loss Regular
Cross-section change	h_{ge}	0.000	0.000
Inflow	h_e	0.144	0.079
Surplus	h_c	0.000	0.000
Total	h_{II}	0.144	0.079

Section 3 Head loss at Headrace

1. Loss head due to slope

Head loss at headrace means difference between water level at start of headrace and water level at end of head tank.
Water level at starting point of headrace is estimated by backwater calculation from head tank.

Name	Station point	Length of interval	Slope of headrace		Starting point sill height	End point sill height
	SP.m	m			EL.m	EL.m
Headrace start	JS 10	2451.37	1000.00	0.1000%	627.200	624.750
Headrace end	JS140					

Cross-section of headrace is trapezoid shape(the most economical cross section) with 1：0.5 of slope of side wall.
For trapezoidal cross section, half of a regular hexagon is the more economical cross section.
Thus, assuming the water depth is h, it is calculated by following equations.

$$A = \sqrt{3}h^2$$
$$P = 2\sqrt{3}h$$
$$R = h/2$$
$$Q = \frac{1}{n}AR^{2/3}I^{1/2}$$
$$= \frac{1}{n}\sqrt{3}h^2(h/2)^{2/3}I^{1/2}$$
$$\therefore h = \left\{QnI^{-1/2}\sqrt{3}^{-1}(1/2)^{-2/3}\right\}^{3/8}$$

Roughness coefficient	n:	0.017	
	h:	1.941	m
waterway width	B:	2.400	m
waterway height	H:	2.400	m
	85% depth	2.040	

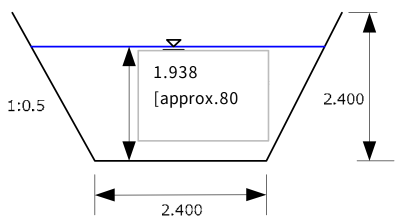
Ensure 85% of height of uniform flow depth

Flow depth is calculated by Manning's equation

$$AR^{2/3} = \frac{Qn}{\sqrt{I}} \quad \cdots\cdots ①$$

Uniform flow depth	$:h_o$		(m)
Plant discharge	:Q		(m^3/s)
Slope of headrace	:I=	0.001	
Manning roughness coefficient	:n=	0.017	
waterway width	:B=	2.400	(m)
Slope of side walls	:m=	0.500	
Cross-sectional area of flow	:A		(m^2)
Wetted perimeter	:S		(m)
Hydraulic radius	:R=A/S		(m)

Item	Flow Q (m^3/s)	Right side $Q \cdot n/I^{0.5}$	Uniform flow depth h_0 (m)	Cross-sectional area of A (m^2)	Wetted perimeter S (m)	Hydraulic radius R (m)	Left side $AR^{2/3}$	(Left side)-(Right side)
MAX	11.900	6.397	1.938	6.530	6.734	0.970	6.397	0.000
Regular	5.710	3.070	1.252	3.790	5.201	0.729	3.070	0.000



2. Calculation of water level at starting point of headrace

Water level at each station point is shown below.

Plant discharge			MAX	11.90	Regular	5.71
Name	Station point SP.m	Length m	Head loss m	Estimated water EL.m	Head loss m	Estimated water level EL.m
Headrace start	JS 10	2451.37	2.439	629.139	1.755	628.455
Headrace end	JS140			626.700		626.700

End of headrace is water level of head tank.

$$h_{IV} = WL_1 - WL_2$$

WL_1: water level of start of headrac (m)
WL_2: (water level of tank) (m)

Head loss at headrace is shown below.

Part/type of loss		Head loss MAX	Head loss Regular
Water level at start of headrace	WL_1	629.139	628.455
Water level at end of headrace (water level of tank)	WL_2	626.700	626.700
Total	h_{IV}	2.439	1.755

Calculation of Uniform flow depth

$$AR^{2/3} = \frac{Qn}{\sqrt{I}} \quad \cdots\cdot ①$$

Uniform flow depth	$:h_o$		(m)
Plant discharge	:Q		(m^3/s)
Slope of headrace	:I=	0.00100	
Manning roughness coefficient	:n=	0.017	
Width of headrace	:B	2.400	(m)
Slope of side walls	:m	0.500	
Cross-sectional area of flow	:A		(m^2)
Wetted perimeter	:S		(m)
Hydraulic radius	:R=A/S		(m)

Item	Flow Q (m^3/s)	Right side $Q \cdot n/I^{0.5}$	Uniform flow depth h_0 (m)	Cross-sectional area of A (m^2)	Wetted perimeter S (m)	Hydraulic radius R (m)	Left side $AR^{2/3}$	(Left side)-(Right side)
MAX	11.900	6.397	1.929	6.489	6.713	0.967	6.343	-0.054
Regular	5.710	3.070	1.252	3.790	5.201	0.729	3.070	0.000

Calculation of critical water depth

$$\frac{\alpha Q^2}{g} = \frac{A^3}{T} \quad \cdots\cdot ②$$

Critical water depth	:hc		(m)
Plant discharge	:Q		(m^3/s)
Correction coefficient of velocity distribution	: α =	1.0	
Gravitational acceleration	:g=	9.8	(m^2/s)
Width of headrace	:B=	2.40	(m)
Slope of side walls	:m	0.500	
Cross-sectional area of flow	:A		(m^2)
Width of water surface	:T		(m)

substituting *mean velocity* : V=Q/A and *hydraulic radius* :D=A/T for equation ②:

$$\alpha \frac{V^2}{2g} = \frac{D}{2} \quad \cdots\cdot ③$$

$$V = \frac{Q}{A} \quad \cdots\cdot ④$$

$$D = \frac{A}{T} \quad \cdots\cdot ⑤$$

substituting ④ and ⑤ for ③:

$$\alpha \frac{Q^2}{g} = \frac{A^3}{T} \quad \cdots\cdot ⑥$$

thus, *h* **s**atisfied ⑥ can be *hc*.

Item	Flow Q (m^3/s)	Critical water depth h_c (m)	Width of water surface T (m)	Calibration coefficient α	Cross-sectional area of A (m^2)	Left side $\alpha Q^2/g$	Right side A^3/T	(Left side)-(Light side)
MAX	11.900	1.234	3.634	1.000	3.724	14.450	14.208	0.242
Regular	5.710	0.786	3.186	1.000	2.197	3.327	3.327	0.000

Calculation of non-uniform flow

$$\left(\frac{\alpha_2 Q^2}{2gA_2{}^2}+h_2+z_2\right)-\left(\frac{\alpha_1 Q^2}{2gA_1{}^2}+h_1+z_1\right)=-\frac{1}{2}\left(\frac{Q^2}{K_1{}^2}+\frac{Q^2}{K_2{}^2}\right)\left(L_2-L_1\right)$$

Cross section shape		Rectangle
Pipe diameter	*2.400*	2.400
Slope of side walls	*m:*	0.500
Roughness coefficient	*n:*	0.017
Headrace gradient	*i:*	0.001
Correction coefficient	*α :*	1.000

MAX

Flow *Q:* 11.900 (m^3/s)

No	channel length L (m)	Additional length dL (m)	Water depth h (m)	Cross-sectional area A (m^2)	Hydraulic radius R (m)	Flow velocity V (m/s)	Water level H (m)	Channel sill height Z (m)	Specific energy E	Conveyance K	Friction loss h_f (m)	
1	0.00		1.9500	6.5813	0.9735	1.8082	626.700	624.750	626.8668	380.265		
2	100.00	100.00	1.9473	6.5697	0.9727	1.8113	626.797	624.850	626.9647	379.376	0.0982	0.000
3	200.00	100.00	1.9451	6.5598	0.9719	1.8141	626.895	624.950	627.0630	378.613	0.0986	0.000
4	400.00	200.00	1.9423	6.5478	0.9710	1.8174	627.092	625.150	627.2608	377.693	0.1981	0.000
5	600.00	200.00	1.9405	6.5401	0.9705	1.8196	627.291	625.350	627.4594	377.095	0.1989	0.000
6	800.00	200.00	1.9394	6.5350	0.9701	1.8210	627.489	625.550	627.6585	376.707	0.1994	0.000
7	1,000.00	200.00	1.9386	6.5317	0.9698	1.8219	627.689	625.750	627.8580	376.456	0.1997	0.000
8	1,200.00	200.00	1.9381	6.5296	0.9697	1.8225	627.888	625.950	628.0576	376.295	0.1999	0.000
9	1,400.00	200.00	1.9378	6.5283	0.9696	1.8228	628.088	626.150	628.2573	376.191	0.2001	0.000
10	1,600.00	200.00	1.9376	6.5274	0.9695	1.8231	628.288	626.350	628.4572	376.125	0.2002	0.000
11	1,800.00	200.00	1.9375	6.5269	0.9695	1.8232	628.487	626.550	628.6571	376.082	0.2002	0.000
12	2,000.00	200.00	1.9374	6.5265	0.9695	1.8233	628.687	626.750	628.8570	376.054	0.2003	0.000
13	2,200.00	200.00	1.9373	6.5263	0.9694	1.8234	628.887	626.950	629.0570	376.037	0.2003	0.000
14	2,451.37	251.37	1.9378	6.5281	0.9696	1.8229	629.139	627.201	629.3087	376.174	0.2516	0.000
Total	2,451.37						629.139				2.4453	

Regular

Flow *Q:* 5.710 (m^3/s)

No	channel length L (m)	Additional length dL (m)	Water depth h (m)	Cross-sectional area A (m^2)	Hydraulic radius R (m)	Flow velocity V (m/s)	Water level H (m)	Channel sill height Z (m)	Specific energy E	Conveyance K	Friction loss h_f (m)	
1	0.00		1.9500	6.5813	0.9735	0.8676	626.700	624.750	626.7384	380.265		
2	100.00	100.00	1.8703	6.2378	0.9477	0.9154	626.720	624.850	626.7631	354.019	0.0243	0.000
3	200.00	100.00	1.7940	5.9147	0.9225	0.9654	626.744	624.950	626.7915	329.712	0.0280	0.000
4	400.00	200.00	1.6530	5.3334	0.8749	1.0706	626.803	625.150	626.8615	286.980	0.0696	0.000
5	600.00	200.00	1.5317	4.8491	0.8325	1.1775	626.882	625.350	626.9524	252.418	0.0908	0.000
6	800.00	200.00	1.4345	4.4718	0.7974	1.2769	626.985	625.550	627.0677	226.200	0.1149	0.000
7	1,000.00	200.00	1.3627	4.1989	0.7709	1.3599	627.113	625.750	627.2070	207.652	0.1393	0.000
8	1,200.00	200.00	1.3149	4.0201	0.7528	1.4204	627.265	625.950	627.3678	195.693	0.1608	0.000
9	1,400.00	200.00	1.2860	3.9133	0.7418	1.4591	627.436	626.150	627.5446	188.631	0.1768	0.000
10	1,600.00	200.00	1.2699	3.8540	0.7356	1.4816	627.620	626.350	627.7319	184.735	0.1872	0.000
11	1,800.00	200.00	1.2613	3.8225	0.7322	1.4938	627.811	626.550	627.9251	182.667	0.1933	0.000
12	2,000.00	200.00	1.2569	3.8063	0.7305	1.5001	628.007	626.750	628.1217	181.611	0.1966	0.000
13	2,200.00	200.00	1.2546	3.7982	0.7297	1.5033	628.205	626.950	628.3199	181.082	0.1983	0.000
14	2,451.37	251.37	1.2534	3.7936	0.7292	1.5052	628.455	627.201	628.5703	180.778	0.2504	0.000
Total	2,451.37						628.455				1.8300	

Section 4 Head loss at Head tank

1. Head loss due to sudden enlargement

$$h_{se} = f_{se} \cdot \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right)$$

$$f_{se} = \left\{ 1 - \left(\frac{A_1}{A_2} \right) \right\}^2$$

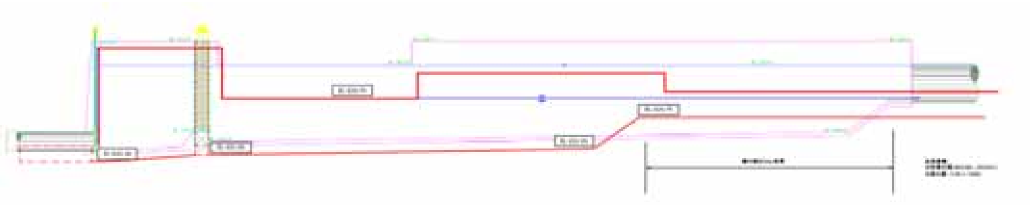
where,

h_{se}: Head loss due to enlargement of cross section (m)
f_{se}: Loss coefficient of sudden enlargement
V_1: Flow velocity before enlargement (m/s)
V_2: Flow velocity after enlargement (m/s)

$V_2<V_1$, Thus, head loss is not calculated because diffrence of velocity head is positive.

Item	Upstream water level WL_1 (m)	Upstream sill Z_1 (m)	Upstream depth H_1 (m)	Upstream effective width B_1 (m)	Downstream water level WL_2 (m)	Downstream sill Z_2 (m)	Downstream depth H_2 (m)	Downstream effective width B_2 (m)
MAX	626.700	624.750	2.600	2.500	626.700	623.340	3.360	10.500
Regular	626.700	624.750	2.600	2.500	626.700	623.340	3.360	10.500

Item	Flow Q (m^3/s)	Flow velocity V_1 (m/s)	Velocity head $V_1^2/2g$	Flow velocity V_2 (m/s)	Velocity head $V_2^2/2g$	Loss coefficien f_{se}	Loss head h_{se} (m)	WL_1-WL_2-h_2
MAX	11.900	1.831	0.171	0.337	0.006	0.665	-0.161	0.161
Regular	5.710	0.878	0.039	0.162	0.001	0.665	-0.037	0.037



2. Total of head loss at head tank

$$h_V = h_{se} + h_c$$

where,

h_{se}: Head loss due to enlargement of cross section (m)
h_c: Surplus (m)

Total of head loss at head tank is shown below.

Part/type of loss		Head loss MAX	Head loss Regular
Enlargement of the cross section	h_{se}	0.000	0.000
Surplus	h_c	0.000	0.000
Total		0.000	0.000

Section 5 Head loss at Penstock

1. Head loss due to inflow

$$h_e = f_e \cdot \frac{V_2^{\ 2}}{2g}$$

where,
h_e: Head loss due to inflow (m)
f_e: Inflow loss coefficient 0.050 Bellmouth
V_2: Velocity after inflow (m/s)
D: Pipe diameter (m)
A: Sectional area of pipe (m^2)

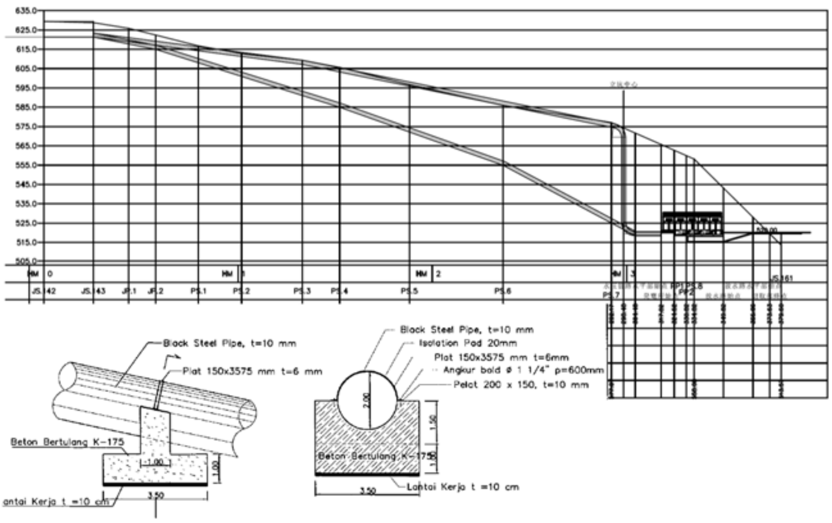
Head loss due to inflow in case of Max and regular plant discharge are shown below.

Item	Flow	Pipe diameter	Sectional area	Velocity after inflow	Velocity head	Loss coefficient	Head loss	
	$Q/(m^3/s)$	D (m)	$A(m^2)$	V_2 (m/s)	$V_2^{\ 2}/2g$	f_e	h_e (m)	
MAX	11.900	2.000	3.142	3.787	0.732	0.050	0.037	
Regular	5.710	2.000	3.142	1.817	0.168	0.050	0.008	

2. Head loss due to friction(before branch)

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

where,
h_f: Head loss due to friction (m)
f: Friction loss coefficient
V: Velocity in pipe (m/s)
D: Pipe diameter 2.000 (m)
L: Pipe length (m)



Friction loss coefficient of circular cross section channel is calculated by following equation.

$f = 124.5 \cdot n^2 / D^{1/3}$

where, n: Manning's roughness coefficient 0.012

Friction loss coefficients of each diameter of pipe are shown below.

No.	Pipe diameter D (m)		Pipe length L (m)	Sectional area $A(m^2)$	Roughness coeffient n	Loss coefficient f	$f \cdot L/D$
1	2.000		347.40	3.142	0.012	0.0142	2.467

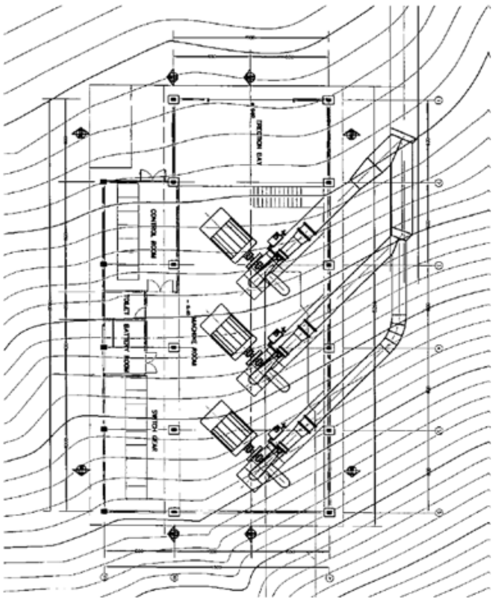
Head loss(before branch) due to friction at Max and regular plant discharge are shown below.

No.	MAX	11.900		Regular	5.710	
	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_f (m)	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_f (m)
1	3.787	0.732	1.806	1.817	0.169	0.417
Total		h_2 =	1.806		h_2 =	0.417

3.Head loss due to branch

3 units of turbin are used to generate when plant discharge is Max. Thus head loss is calculated with 1/3 of flow after branch.

2 units of turbin are used to generate when plant discharge is Regular. Thus head loss is calculated with 1/2 of flow after branch.

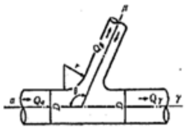


$D_{\alpha 1}$: Diameter(1 branch main pipe) 2.000 (m)
$D_{\beta 1}$: Diameter(1 branch socket pipe) 1.200 (m)
$D_{\alpha 2}$: Diameter(2 branch main pipe) 1.600 (m)
$D_{\beta 2}$: Diameter(2 branch socket pipe) 1.200 (m)
$D_{\gamma 2}$: Diameter(after branch main pipe) 1.200 (m)

ρ: Radius of curve 2.000 (m)
θ: Central angle of curve 45.000 °

分岐による損失水頭

$$h_1 = H_\alpha - H_\beta = f_\beta \cdot \frac{V_\alpha^{\ 2}}{2g}$$



分流管，合流管

ここに，H_α ：管αの全水頭（m）

H_β ：管βの全水頭（m）

V_α ：分岐前流速（m/s）

f_β ：分流による損失係数(支管)

$$= 0.95(1-q_\beta)^2 + q_\beta^{\ 2}(1.3 \cdot \cot\frac{\theta}{2} - 0.3 + \frac{0.4-0.1\phi}{\phi^2})(1-0.9\sqrt{\frac{\rho}{\phi}}) + 0.4q_\beta(1-q_\beta)(1+\frac{1}{\phi})\cot\frac{\theta}{2}$$

f_γ ：分流による損失係数(本管) $=0.58 q_\beta^{\ 2} - 0.26 q_\beta + 0.03$

q_β ：支管流量 Q_β と分流前流量 Q_α との比 $= Q_\beta / Q_\alpha$

Q_α ：分岐前流量

Q_β ：分管流量

ρ ：支管と本管の接続部面取り半径ｒと本管直径 D_α との比 $= r / D_\alpha$

ｒ＝0　より　$\rho = 0$

θ ：本管と支管の交角（°）

ϕ ：本管と支管の断面積比 $= A_\beta / A_\alpha$

Branch 1

Case	$Q\gamma$	$Q\beta$	$Q\alpha$	$q\beta$	$A\alpha$	$A\beta$	ϕ	θ
MAX	7.933	3.967	11.900	0.333	3.142	1.131	0.360	45
Regular	2.855	2.855	5.710	0.500	3.142	1.131	0.360	45

Case	ρ	$V\alpha$	$V\alpha^2/2g$		$f\beta$	$f\gamma$	h_{1A}	h_{1A}'
MAX	1.00	3.787	0.732		0.877	0.008	0.642	0.006
Regular	1.00	1.817	0.168		0.349	0.045	0.059	0.008

Branch 2

Case	$Q\gamma$	$Q\beta$	$Q\alpha$	$q\beta$	$A\alpha$	$A\beta$	ϕ	θ
MAX	3.967	3.967	7.933	0.500	3.142	1.131	0.360	45
Regular	-	2.855	2.855	1.000	3.142	1.131	0.360	45

Case	ρ	$V\alpha$	$V\alpha^2/2g$		$f\beta$	$f\gamma$	h_{1A}	h_{1A}'
MAX	1.00	2.525	0.325		0.349	0.045	0.114	0.015
Regular	1.00	0.909	0.042		-	-	-	-

5. Head loss due to bend

<Turbine3>

$$h_b = f_{b1} \cdot f_{b2} \cdot \frac{v^2}{2g}$$

where,

h_b: Head loss due to bend (m)

f_{b1}: Loss coefficient decided by radius of curvature of bend ρ and pipe diameter D.

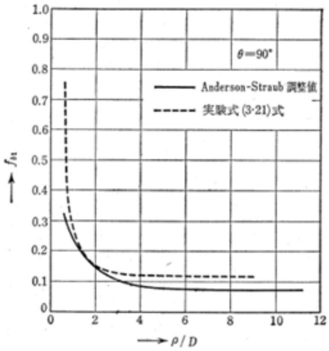
f_{b2}: Loss ratio between central angle θ of arbitrary bend and 90° bend

V: Velocity in pipe (m/s)

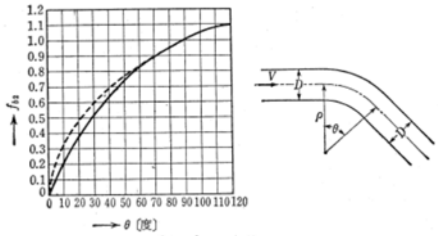
Loss coefficient f_{b1}、f_{b2} is calculated by following equation;

$$f_{b1} = 0.131 + 0.1632 \cdot (D/\rho)^{7/2}$$

$$f_{b2} = (\theta/90)^{1/2}$$



（a） f_{b1} の 値 (θ=90°)



（b） f_{b2} の 値

第 3·13 図 曲がりの損失係数

Loss coefficient of bend on each part is shown below.

IP	Diameter of D (m)	Sectional area $A(m^2)$	Radius of curvature ρ	D/ρ	Loss coefficien f_{b1}	Angle θ	Loss ratio f_{b2}	$f_{b1} \cdot f_{b2}$
1	2.000	3.142	2.000	1.000	0.294	45.000	0.707	0.208

Head loss due to bend at Max and regular plant discharge is shown below.

IP	MAX	3.967		Regular	0.000	
	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_b (m)	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_b (m)
1	1.262	0.081	0.017	0.000	0.000	0.000
Total		h_b =	0.017		h_b =	0.000

6. Head loss due to refraction

$$h_{be} = f_{be} \cdot \frac{v^2}{2g}$$

where, h_{be}: Head loss due to refraction (m)
f_{be}: Refraction loss coefficient
V: Velocity in pipe (m/s)
θ: Refraction angle

Loss coefficient f_{be} is calculated by following equation.

$$f_{be} = 0.946 \sin^2 \frac{\theta}{2} + 2.05 \sin^4 \frac{\theta}{2}$$

Refraction loss coefficient of each part is shown below.

IP	Pipe diameter D (m)	Sectional area $A(m^2)$	Angle θ	Loss coefficient f_{be}	
3	2.000	3.142	45.000	0.183	

Head loss due to refraction at Max and regular plant discharge is shown below.

IP	MAX	0.000		Regular	2.855	
	Velocity in pipe V (m/s)	velocity head $V^2/2g$	Head loss h_{be} (m)	Velocity in pipe V (m/s)	Velocity head $V^2/2g$	Head loss h_{be} (m)
3	0.000	0.000	0.000	0.909	0.042	0.008
Total		$h_{be}=$	0.000		$h_{be}=$	0.008

7. Head loss due to sudden contraction of cross section

$$h_{gc} = f_{gc} \cdot \frac{V_2^{\,2}}{2g}$$

where,

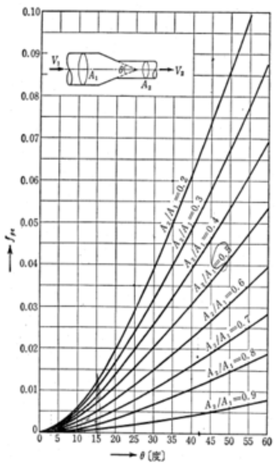
h_{gc}: Head loss due to sudden contraction of cross section (m)

f_{gc}: Contraction loss coefficient

V_2: Flow velocity after contraction (m/s)

Head loss due to contraction at Max and regular plant discharge is shown below.

Pipe diameter D (m)	Area before A_1 (m2)	Area after contractio A_2 (m2)	Length L	A_2/A_1	Angle of contraction θ	Loss coefficint f_{gc}	
1.68-0.94	3.142	3.142	0.000	1.000	-	0.000	



where,

D: Pipe diameter (m)

A_1: Area before contraction (m^2)

A_2: Area after contraction (m^2)

θ: Angle of contraction (°)

Head loss due to contraction at Max and regular plant discharge is shown below.

No.	MAX	11.900		Regular	5.710	
	Velocity in pipe V_2 (m/s)	Velocity head $V_2^2/2g$	Head loss h_{gc} (m)	Velocity in pipe V_2 (m/s)	Velocity head $V_2^2/2g$	Head loss h_{gc} (m)
5	3.787	0.732	0.000	1.817	0.168	0.000
Total		h_{gc} =	0.000		h_{gc} =	0.000

8. Total of head loss in penstock

$$h_{VI} = h_e + h_f + h_a + h_b + h_{be} + h_{gc} + h_c$$

where, h_e: Head loss due to flow (m)
h_f: Head loss due to Friction(before branch) (m)
h_a: Head loss due to Branch (m)
h_b: Head loss due to Bend
h_{be}: Head loss due to Refraction
h_{gc}: Head loss due to Cross section contraction
h_c: Surplus

Total of head loss in penstock is shown below.

Part/type of loss		Head loss					
		MAX			Regular		
		No.1	No.2	No.3	No.1	No.2	No.3
Flow	h_e	0.037			0.008		
Friction(before branch	h_f	1.806			0.417		
Branch	h_a	0.642	0.119	0.015	0.059	0.008	-
Bend	h_b	-	-	0.017	-	-	-
Refraction	h_{be}	-	-	-		0.008	-
Cross section contract	h_{gc}	-	-	-	-	-	-
Surplus	h_c	-	0.499	0.583	-	0.043	0.059
Total		2.485	2.461	2.458	0.484	0.484	0.484

Section 6 Total of Head losses

Total of head loss from intake through tailrace channel is shown below.

Part	MAX	Regular
Intake	0.457	0.359
Settling basin	0.144	0.079
Headrace	2.439	1.755
Headtank	0.000	0.000
Penstock	2.485	0.484
Surplus	0.175	0.124
Total	5.700	2.800

Section 7 Calculation of Effective head

Total of head loss from intake through tailrace channel is shown below.

Item	Unit	MAX	Regular
Plant discharge	m^3/s	11.900	5.710
Intake level	m	631.000	631.000
Tailrace level	m	525.000	525.000
Gross head	m	106.000	106.000
Head loss	m	5.700	2.800
Effective head	m	100.300	103.200

Chapter 2 Calculation of theoretical water-power and generating power

Section 1 Calculation of theoretical water-power

$$P_e = 9.8 \cdot H_m \cdot Q_m$$

where,	*Pe:*	Theoretical water-power	*(kW)*
	Hm:	Effective head	*(m)*
	Qm:	Plant discharge	*(m3/s)*

Per Unit

	Unit	MAX	Regular
Plant discharge: Q	m^3/s	3.967	1.903
Effective head: H_m	m	100.300	103.200
Theoretical water-power: P_e	kW	3,899	1,925

Section 2 Calculation of generating power

$$E = P_e \cdot \eta_1 \cdot \eta_2$$

where,	*E:*	Theoretical water power	*(kW)*
	Pe:	Effective head	*(kW)*
	η1:	Plant discharge	
	η2:	Efficiency of generator	

	Unit	MAX	Regular
Theoretical water-power：P_e	kW	3,899	1,925
Combined coefficiency：η_2		0.865	0.750
power：E	kW	3,333	1,444

		10,000	2,888

Appendix L4-3
Stability calculation of Intake weir
(Lae Ordi II Location)

(1)Design condition

1) Reference

①	Ministry of construction River errosion control technical standard	1997	Japan rivers association
②	The structural mechanics handbook	1997	Japan society of civil engineer
③	Feasibility Study Basic Engineering Design	2011	

2) Material condition

Concrete				
Unit weight	γ_c	kN/m^3	24.0	Reference③
Masonry block				
Unit weight	γ_s	kN/m^3	22.0	Reference③
Design strength	σ_{ck}	N/mm^2	-	
Allowable bending compressive stress intensity	σ_{ca}	N/mm^2	-	
Allowable shearing stress intensity	τ_a	N/mm^2	-	

3) Natural condition

(a)Soil condition (sedimentation)					
Unit weight (wet)	γ_t	kN/m^3	17.65		Reference①
Unit weight (Underwater)	γ_s	kN/m^3	9.81		Reference①
(b)Foundation ground					
Compressive strength	q_u	kN/m^2	9810		Reference①
Allowable bearing capacity (At normal)	σ	kN/m^2	588		Reference①
Allowable bearing capacity (During earthquake)		kN/m^2	883		Reference①
Internal friction angle	φ	°	35.0		Reference①
Cohesion	C	kN/m^2	0.0		Reference①
(C)Design horizontal seismic coefficient					
Standard seismic coefficient	κ_o		0.20		Reference①
Zoning factor	γ_1		1.00		Reference①
Ground condition factor	γ_2		1.20		Reference①
Design horizontal seismic coefficient	κ_h		0.24		Reference①
Overdesign factor (Normal)	α		1.00		Reference①
Overdesign factor (Short time)	α		1.50		Reference①
(d)Design water level					
Dam top height	EL	m	631.00		Reference③
At design flood level	WL	m	635.20		Reference③
At normal water level	WL	m	631.00		Reference③
Design sedimentation level(No sediment)	EL	m	624.10		Reference③
Design sedimentation level(Full sediment)	EL	m	631.00		Reference③
Elevation of dam foundation rock	EL	m	624.10		Reference③
			At top watrer level (During earthquake)	At design flood level(Normal)	
Wave caused by wind	h_w	m	-	-	Reference①
Wave caused by earthquake	h_e	m	0.63	-	Reference①
Design seismic coefficient	κ_h		0.24	-	Reference①
Earthquake frequency	τ		1.00	1.00	Reference①
Reservoir water depth	H_o		6.90	11.10	
Design water level (Upstream)	WL	m	631.63	635.20	Reference①
Design water level (Downstream)	WL	m	624.10	624.10	Reference③

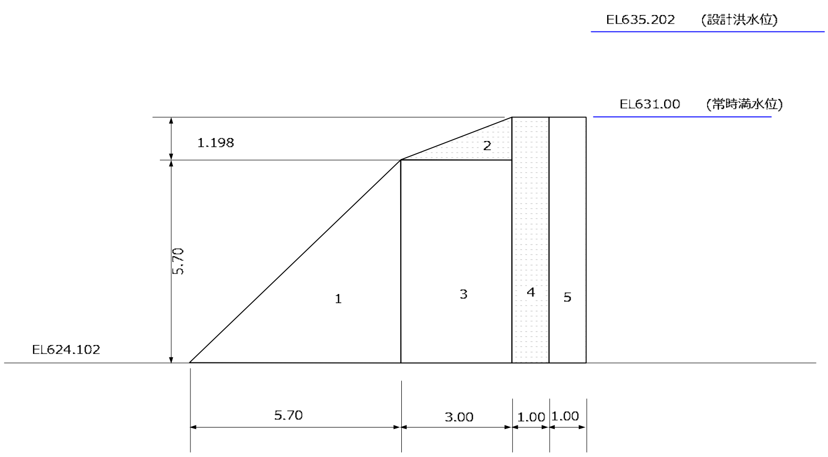
4) Loading condition

			At top watrer level (During earthquake)	At design flood level(Normal)	
(a)Dead load	W	kN/m^2	821.32	821.32	
(b)Soil and water weight					
(c) Seismic inertia force					
Inertia force by dam dead load	P_f	kN/m^2	197.12	-	Reference①
(d)Static water pressure (Upstream)					
Static water pressure from water surface to depth h	$P_{w'}$	kN/m^2	74.85	78.48	Reference①
Total of static water pressure from water surface to depth h	P_w	kN/m^2	285.55	313.92	Reference①
Unit weight of water	γ_w	kN/m^3	9.81	9.81	
Depth from surface	h_1	m	7.63	8.00	
Static water pressure (Downstream)					
Static water pressure from water surface to depth h	$P_{w'}$	kN/m^2	-	-	Reference①
Total of static water pressure from water surface to depth h	P_w	kN/m^2	-	-	Reference①
Unit weight of water	γ_w	kN/m^3	9.81	9.81	Reference①
Depth from surface	h_2	m	-	-	
(e)Uplift pressure (Buoyancy)					
Uplift pressure on upstream end	P_u	kN/m^2	2.54	2.67	Reference①
Uplift pressure on downstream end	$P_{u'}$	kN/m^2	-	-	Reference①
Uplift coefficient	μ		0.3333	0.3333	Reference①
(f)Mud pressure					
Horizontal direction mud earth pressure from sediment surface to depth d	$P_{e'}$	kN/m^2	-	-	Reference①
Total of horizontal direction mud earth pressure from seddiment surface to depth d	P_e	kN/m^2	-	-	Reference①
Mud pressure coefficient	C_e		0.5	0.5	Reference①
Unit weight of sedimentation (underwater)	W_1	kN/m^3	9.81	9.81	Reference①
Depth from sediment surface (No sediment)	d		-	-	
Depth from sediment surface (Full sediment)	d		7.00	7.00	
(g)Dynamic water pressure during earthquake					
Dynamic water pressure from water surface to depth h	$P_{d'}$	kN/m^2	15.72	-	Reference①
Total dynamic water pressure from water surface to depth h	P_d	kN/m^2	79.96	-	Reference①
Unit weight of water	γ_w	kN/m^3	9.81	9.81	Reference①
Design horizontal seismic coefficient	κ_h		0.24	-	Reference①
Depth from water surfece to foundation ground	H	m	7.63	8.00	
Depth from surface	h	m	7.63	8.00	

5) Stability condition

			At top watrer level (During earthquake)	At design flood level(Normal)	
(a)Stability against sliding					
Vertical load on dam base bottom	ΣV				
Horizontal load on dam base bottom	ΣH				
Friction factor between dam bottom and bearing ground	f		0.70	0.70	Reference①
Shear strength of rock mass	τ_B		618	411	Reference①
Friction angle between dam base bottom and bearing ground	φ_B	°	35.0	35.0	Reference③
Cohesion between dam base bottom and bearing ground	c		0.0	0.0	Reference③
Allowble bearing capacity	σ		883	588	Reference③
Bottom width of Dam(Overflow section)	L		10.7	10.7	Reference③
Bottom width of Dam (Dam pillar section)	L				
(b)Stability against overturning					
Distance from point of application of resultant force R to around toe of dam bottom	d				
Resisting moment around toe of dam base	ΣM_r				
Overturning moment around toe of dam base	ΣM_o				
Vertical component of load acting to dam	V_i				
Horizental distance from toe of dam bottom to point of application of V_i	a_i				
horizontal component of load acting to dam	H_j				
Height of point application of H_j from dam bottom	b_j				
Bottom width of Dam(Overflow section)	L		7.38	7.38	Reference③
(c) Stability against bearing capacity of bearing ground					
Allowble bearing capacity of ground	q_a				
Modulus of subgrade reaction	q_1				
Modulus of subgrade reaction	q_2				

6) Model of loading calculation



(2)Stability calculation (No sediment-top water level-during earthquake)

1) Loading calculation

(a) Dead load

Loading item	Cross section shape	Vertical force Calculation	V(kN)	Arm x(m)	Resisting moment V・x(kN・m)
1	Triangle W1	24 ×16.245	389.880	3.800	1,481.529
2	Triangle W2	24 ×1.797	43.128	7.700	332.085
3	Rectangle W3	24 ×17.100	410.400	7.200	2,954.880
4	Rectangle W4	24 ×6.898	165.552	9.200	1,523.078
5	Rectangle W5	24 ×6.898	165.552	10.200	1,688.630
Total			1,174.512		7,980.202

(b) Water weight or Mud weight

Loading item	Cross section shape	Vertical force Calculation	V(kN)	Arm x(m)	Resisting moment V・x(kN・m)
Total			0.000		0.000

(c) Horizontal force due to static water pressure

Loading item	Pressure distribution	Horizontal force Calculation	H(kN)	Arm y(m)	Overturning moment H・y(kN・m)
Upstream	Triangle(H1)	9.81 × 7.528 ^{2} × 0.5	277.970	2.509	697.427
Downstream		9.81 × 0.000 ^{2} × 0.5	0.000	0.000	
Total			277.970		697.427

(d) Uplift pressure

Loading item		Vertical force Upstream end(kN/m^2)	Downstream end(kN/m^2)		V(kN)	Arm x(m)	Resising moment V・x(kN・m)
Bottom	Triangle(U1)	-2.509	0.000	→	-13.423	3.567	-47.880
	Rectangle	0.000	0.000	→	0.000	5.350	
Total					-13.423		-47.880

(e) Horizontal force due to mud pressure

Loading item	Pressure distribution	Horizontal force Calculation	H(kN)	Arm y(m)	Overturning moment H・y(kN・m)
Upstream	Triangle(D1)	0.5×9.81× 0.0 ^{2} × 0.5	0.000	0.000	
Downstream	None				
Total			0.000		0.000

(f) Dam dead load, Inertia force (kh= 0.24)

Loading item	Cross section shape	Vertical force V(kN)	Horizontal force H(kN)	Arm y(m)	Overturning moment H･y(kN･m)
1	Triangle W1	389.880	93.571	1.900	177.767
2	Triangle W2	43.128	10.351	6.099	63.134
3	Rectangle W3	410.400	98.496	2.850	280.714
4	Rectangle W4	165.552	39.732	3.449	137.036
5	Rectangle W5	165.552	39.732	3.449	137.036
Total			281.882		795.687

(g) Horizontal force due to dynamic water pressure

Loading item	Pressure distribution	Horizontal force Calculation	H(kN)	Arm y(m)	Overturning moment H･y(kN･m)
Upstream	Westergaard	(7／12)×9.81×0.112× 7.528 2	77.832	3.011	234.352
Downstream		(7／12)×9.81×0.112× 0.000 2	0.000	0.000	0.000
Total			77.832		234.352

(h) Total of applied loading

Loading item	Verical force V(kN)	Resisting moment Mr(kN･m)	Horizontal force H(kN)	Overturning moment Mo(kN･m)
Dead load	1,174.512	7,980.202	—	—
Water and mud weight	0.000	0.000	—	—
Static water pressure (Horizontal force)	—	—	277.970	697.427
Uplift pressure	-13.423	-47.880	—	—
Mud pressure	—	—	0.000	0.000
Inertia force	—	—	281.882	795.687
Dynamic water pressure	—	—	77.832	234.352
Total	1,161.089	7,932.322	637.684	1,727.466

2) Stability analysis

(a) Stability analysis against sliding

Safety factor against sliding Fs is calculated by Henny's equation.

$$y\ \frac{f\cdot\Sigma V+\tau\cdot L}{\Sigma H}=\frac{0.7\times 1161.089+617\times 10.700}{637.684}=11.63$$

where, ΣV : Vertical load on dam base bottom (= 1161.089 kN/m)

ΣH : Horizontal load on dam base bottom (= 637.684 kN/m)

f : Friction factor between dam bottom and bearing ground

$f=\mu=\tan\phi_B=$ 0.7

τ : Shearing strength of rock mass (kN/m^2)

use coulomb's equation provided this, 「$C_B=0$、σ=allowable bearing capacity」

$\tau=(C_B+\sigma\cdot\tan\phi_B)\times 1.5=$ 617

B : Bottom width for sliding analysis (= 10.700 m)

Thus, stability analysis against sliding is following, which is stable.

Fs= 11.63 ≧ 1.2 (Safety factor)

(b) Stability analysis against overturning

Distance d from point of application of resultant force R to around toe of dam bottom:

$$d=\frac{\Sigma Mr-\Sigma Mo}{\Sigma V}=\frac{7{,}932.322-1{,}727.466}{1{,}161.089}=5.344\ \text{(m)}$$

where, ΣMr : Resisting moment around toe of dam bottom (= 7,932.322 kN·m)

ΣMo : Overturning moment around toe of dam bottom (= 1727.466 kN·m)

Distance|e| from point of application of resultant force R to center of bottom:

$|e|=|(B/2)-d|=|(10.700/2)-5.344|=|0.006|=0.006$ (m)

where, B : Bottom width for overturning analysis (10.700 m)

Thus, results of stability analysis against overturning shows below.

Case : during earthquake

$|e|=0.006\leqq B/6=1.783$ (m)··Equation of analysis at regular(reference value)

$|e|=0.006\leqq B/3=3.567$ (m)··Equation of analysis under seismic motion

(Result:ok)

(c) Stability analysis against bearing capacity of foundation ground

Point of application of resultant force R is in 1/3 of bottom width.

Thus, modulus of subgrade reaction shows trapezoidal distribution that express following equation.

$$q1,q2=\frac{\Sigma V}{B}\left(1\pm\frac{6\cdot e}{B}\right)$$

Thus, allowable bearing stress of ground at normal in this design: 588 (kN/m^2)

Stability anaylysis against bearing capacity of foundation ground is following which is stable.

$q1=108.878\leqq 882$ (kN/m^2)

$q2=108.148\leqq 882$ (kN/m^2)

(3)Stability calculation (No sediment-Design flood level-Normal)

1) Loading calculation

(a) Dead load

Loading item	Cross section shape	Vertical force Calculation	V(kN)	Arm x(m)	Resisting moment V・x(kN·m)
1	Triangle W1	24 ×16.245	389.880	3.800	1,481.529
2	Triangle W2	24 ×1.797	43.128	7.700	332.085
3	Rectangle W3	24 ×17.100	410.400	7.200	2,954.880
4	Rectangle W4	24 ×6.898	165.552	9.200	1,523.078
5	Rectangle W5	24 ×6.898	165.552	10.200	1,688.630
Total			1,174.512		7,980.202

(b) Water weight or Mud weight

Loading item	Cross section shape	Vertical force Calucution	V(kN)	Arm x(m)	Resisting moment V・x(kN·m)
Total			0.000		0.000

(to static water pressure

Loading item	Pressure	Horizontal force Calcuration	H(kN)	Arm y(m)	Overturning moment H・y(kN·m)
Upstream	Triangle(H1)	9.81 × 11.100 ^{2} × 0.5	604.345	3.700	2,236.077
Upstream	Triangle(deducted)	9.81 × -4.200 ^{2} × 0.5	-86.524	11.700	-1,012.331
Downstream		9.81 × 0.000 ^{2} × 0.5	0.000	0.000	
Total			517.821		1,223.746

(d) Uplift

Loading item		Vertical force upstream(kN/m^2)	Downstream(kN/m^2)		V(kN)	Arm x(m)	Resisting moment V・x(kN·m)
Bottom	Triangle(U1)	-3.700	0.000	→	-19.795	3.567	-70.609
	Rectangle	0.000	0.000	→	0.000	5.350	
Total					-19.795		-70.609

(e) Horizontal force due to Mud pressure

Load item	Pressure distribution	Horizontal force Calculation	H(kN)	Arm y(m)	Overturning moment H・y(kN·m)
Upstream	Triangle(D1)	0.5×9.81× 0.0 ^{2} × 0.5	0.000	0.000	
Downs	None				
Total			0.000		0.000

(f) Total of applied loading

Load item	Vertical force V(kN)	Resisting moment Mr(kN·m)	Horizontal force H(kN)	Overturning moment Mo(kN·m)
Dead load	1,174.512	7,980.202	—	—
Water or Mud weight	0.000	0.000	—	—
Static pressure	—	—	517.821	1,223.746
Uplift	-19.795	-70.609	—	—
Mud pressure	—	—	0.000	0.000
Total	1,154.717	7,909.593	517.821	1,223.746

2) Stability analysis

(a) Stability analysis against sliding

Safety factor against sliding Fs is calculated by Henny's equation.

$$y\ \frac{f\cdot\Sigma V+\tau\cdot L}{\Sigma H} = \frac{0.7 \times 1154.717 + 411 \times 10.700}{517.821} = 10.05$$

where, ΣV : Vertical load on dam base bottom (= 1154.717 kN/m)

ΣH : Horizontal load on dam base bottom (= 517.821 kN/m)

f : Friction factor between dam bottom and bearing ground

$f=\mu=\tan\phi_B=$ 0.7

τ : Shearing strength of rock mass (kN/m^2)

use coulomb's equation provided this,「$C_B=0$、σ=allowable bearing capacity」

$\tau=C_B+\sigma\cdot\tan\phi_B=$ 411

B : Bottom width for sliding analysis (10.700 m)

Thus, stability analysis against sliding is following, which is stable.

Fs= 10.05 ≧ 1.5 (safety factor)

(b) Stability analysis against overturning

Distance d from point of application of resultant force R to around toe of dam bottom:

$$d = \frac{\Sigma Mr-\Sigma Mo}{\Sigma V} = \frac{7{,}909.593 - 1{,}223.746}{1{,}154.717} = 5.790 \text{ (m)}$$

where, ΣMr : Resisting moment around toe of dam bottom (= 7,909.593 kN·m)

ΣMo : Overturning moment around toe of dam bottom (= 1,223.746 kN·m)

Distance |e| from point of application of resultant force R to center of dam bottom:

$|e| = |(B/2)-d| = |(10.700 / 2)- 5.790 | = | -0.44 | = 0.440$ (m)

where, B : Bottom width for overturning analysis (= 10.700 m)

Thus, result of stability analysis against overturning shows below.

Case : Normal

|e|= 0.440 ≦ B/6 = 1.783 (m)··Equation of analysis at regular(Result:OK)

|e|= 0.440 ≦ B/3 = 3.567 (m)··Equation of analysis during earthquake (Reference value)

(c) Stability analysis against bearing capacity of foundation ground

Point of application of resultant force R is in 1/3 of bottom width. Thus, modulus of subgrade reaction show trapezoidal distribution that express following equation below.

$$q1,q2=\frac{\Sigma V}{B}\left(1 \pm \frac{6\cdot e}{B}\right)$$

Thus, allowable bearing stress of ground at normal in this design is 588 (kN/m^2)

Stability analysis against bearing capacity of foundation ground is following, which is stable.

q1 = 81.291 ≦ 588 (kN/m^2)

q2 = 134.544 ≦ 588 (kN/m^2)

(4)Stability calculation (Full sediment-Top water level- during earthquake)

1) Loading calculation

(a) Dead load

Loading item	Cross section shape	Vertical force Calculation	V(kN)	Arm x(m)	Resisting moment V・x(kN・m)
1	Triangle W1	24 ×16.245	389.880	3.800	1,481.529
2	Triangle W2	24 ×1.797	43.128	7.700	332.085
3	Rectangle W3	24 ×17.100	410.400	7.200	2,954.880
4	Rectangle W4	24 ×6.898	165.552	9.200	1,523.078
5	Rectangle W5	24 ×6.898	165.552	10.200	1,688.630
Total			1,174.512		7,980.202

(b) Water weight or Mud weight

Loading item	Cross section shape	Vertical force Calculation	V(kN)	Arm x(m)	Resiting moment V・x(kN・m)
Total			0.000		0.000

(to static water pressure

Loading item	Pressure distribution	Horizontal force Calculation	H(kN)	Arm y(m)	Overturning moment H・y(kN・m)
Upstream	Triangle(H1)	$9.81 \times 7.528^2 \times 0.5$	277.970	2.509	697.427
Downstream		$9.81 \times 0.000^2 \times 0.5$	0.000	0.000	
Total			277.970		697.427

(d) Uplift pressure

Loading item		Upstream end(kN/m^2)	Downstream end(kN/m^2)		V(kN)	Arm x(m)	Resisting moment V・x(kN・m)
Bottom	Triangle(U1)	-2.509	0.000	→	-13.423	3.567	-47.880
	Rectangle	0.000	0.000	→	0.000	5.350	
	Total				-13.423		-47.880

(e) Horizontal force due to mud pressure

Loading item	Pressure distribution	Horizontal force Calculation	H(kN)	Arm y(m)	Overturning moment H・y(kN・m)
Upstream	Triangle(D1)	$0.5 \times 9.81 \times 6.9^2 \times 0.5$	116.696	2.299	268.284
Downstream	None				
Total			116.696		268.284

(f) Dead load/innertia force (kh= 0.24)

Loading item	Cross section shape	Vertical force	Horizontal force	Arm	Overturning moment
		V(kN)	H(kN)	y(m)	H・y(kN·m)
1	Triangle W1	389.880	93.571	1.900	177.767
2	Triangle W2	43.128	10.351	6.099	63.134
3	Rectangle W3	410.400	98.496	2.850	280.714
4	Rectangle W4	165.552	39.732	3.449	137.036
5	Rectangle W5	165.552	39.732	3.449	137.036
Total			281.882		795.687

(g) Horizontal force due to dynamic water pressure

Loading item	Pressure distribution	Horizontal force		Arm	Overturning moment
		Calculation	H(kN)	y(m)	H・y(kN·m)
Upstream	Westergaard	$(7/12)\times9.81\times0.112\times\ 7.528^{2}$	77.832	3.011	234.352
Downstream		$(7/12)\times9.81\times0.112\times\ 0.000^{2}$	0.000	0.000	0.000
Total			77.832		234.352

(h) Total of applied loading

Loading item	Vertical force	Resisting moment	Horizontal force	Overturning moment
	V(kN)	Mr(kN·m)	H(kN)	Mo(kN·m)
Dead load	1,174.512	7,980.202	—	—
Water or Mud weight	0.000	0.000	—	—
Static water pressure (Horizontal force)	—	—	277.970	697.427
Uplift pressure	-13.423	-47.880	—	—
Mud pressure	—	—	116.696	268.284
Inneria force of dead load	—	—	281.882	795.687
Dynamic water pressure	—	—	77.832	234.352
Total	1,161.089	7,932.322	754.380	1,995.750

2) Stability analysis

(a) Stability analysis against sliding

Safety factor against sliding Fs is calculated by Henny's equation.

$$y\ \frac{f \cdot \Sigma V + \tau \cdot L}{\Sigma H} = \frac{0.7 \times 1161.089 + 617 \times 10.700}{754.380} = 9.83$$

where, ΣV : Vertical load on dam base bottom (= 1161.089 kN/m)

ΣH : Horizontal load on dam base bottom (754.380 kN/m)

f : Friction factor between dam bottom and bearing ground

$f = \mu = \tan\phi_B =$ 0.7

τ : Shearing strength of rock mass (kN/m^2)

use coulomb's equation provided this,「C_B=0、σ=allowable bearing capacity」

$\tau = (C_B + \sigma \cdot \tan\phi_B) \times 1.5 =$ 617

B : Bottom width for sliding analysis (= 10.700 m)

Thus, stability analysis against sliding is following, which is stable.

Fs= 9.83 ≧ 1.2 (Safety factor)

(b) Stability analysis against overturning

Distance d from point of application of resultant force R to around toe of dam bottom:

$$d = \frac{\Sigma Mr - \Sigma Mo}{\Sigma V} = \frac{7{,}932.322 - 1{,}995.750}{1{,}161.089} = 5.113 \quad (m)$$

where, ΣMr : Resisting moment around toe of dam bottom (= 7,932.322 kN・m)

ΣMo : Overturning moment around toe of dam bottom (= 1,995.750 kN・m)

Distance |e| from point of application of resultant force R to center of dam bottom:

$|e| = |(B/2) - d| = |(10.700 / 2) - 5.113 | = | 0.237 | = 0.237$ (m)

where, B : Bottom width for overturning analysis 10.700 m)

Thus, result of stability analysis against overturning shows below.

Case : during earthquake

|e|= 0.237 ≦ B/6 = 1.783 (m)・・・・ Equation of analysis at regular (reference value)

|e|= 0.237 ≦ B/3 = 3.567 (m)・・・・ Equation of analysis during earthquake

(Result:OK)

(c) Stability analysis against bearing capacity of foundation ground

Point of application of resultant force R is in 1/3 of bottom width. Thus, modulus of subgrade reaction show trapezoidal distribution that express following equation below.

$$q1,q2 = \frac{\Sigma V}{B}\left(1 \pm \frac{6 \cdot e}{B}\right)$$

Thus, allowable bearing stress of ground at normal in this design is 588 (kN/m^2)

Stability analysis against bearing capacity of foundation ground is following, which is stable.

q1 = 122.934 ≦ 882 (kN/m^2)

q2 = 94.092 ≦ 882 (kN/m^2)

(5)Stability calculation (Full sediment-Design flood level-Normal)

1) Loading calculation

(a) Dead load

Loading item	Cross section shape	Vertical force		Arm	Resisting moment
		Calculation	V(kN)	x(m)	V・x(kN・m)
1	Triangle W1	24 ×16.245	389.880	3.800	1,481.529
2	Triangle W2	24 ×1.797	43.128	7.700	332.085
3	Rectangle W3	24 ×17.100	410.400	7.200	2,954.880
4	Rectangle W4	24 ×6.898	165.552	9.200	1,523.078
5	Rectangle W5	24 ×6.898	165.552	10.200	1,688.630
Total			1,174.512		7,980.202

(b) Water weight or Mud weight

Loading item	Cross section shape	Vertical force		Arm	Resisting moment
		Calculation	V(kN)	x(m)	V・x(kN・m)
Total			0.000		0.000

(c) Horizontal force due to static water pressure

Loading item	Pressure distribution	Horizontal force		Arm	Overturning momnst
		Calculation	H(kN)	y(m)	H・y(kN・m)
Upstream	Triangle(H1)	$9.81 \times 11.100^{2} \times 0.5$	604.345	3.700	2,236.077
Upstream	Triangle(deducted)	$9.81 \times -4.200^{2} \times 0.5$	-86.524	11.700	-1,012.331
Downstream		$9.81 \times 0.000^{2} \times 0.5$	0.000	0.000	
Total			517.821		1,223.746

(d) Uplift pressure

Loading item		Vertical force				Arm	Resisting moment
		Upstream(kN/m^2)	Downstream(kN/m^2)		V(kN)	x(m)	V・x(kN・m)
Bottom	Triangle(U1)	-3.700	0.000	→	-19.795	3.567	-70.609
	Rectangle	0.000	0.000	→	0.000	5.350	
Total					-19.795		-70.609

(e) Horizontal force due to Mud pressure

Loading item	Pressure distribution	Horizontal force		Arm	Overturning moment
		Calculation	H(kN)	y(m)	H・y(kN・m)
Upstream	Triangle(D1)	$0.5 \times 9.81 \times 6.9^{2} \times 0.5$	82.056	2.299	188.647
Downstream	None				
Total			82.056		188.647

(f) Total of applied loading

Loading item	Vertical force V(kN)	Resisting moment Mr(kN・m)	Horizontal force H(kN)	Overturning moment Mo(kN・m)
Dead load	1,174.512	7,980.202	—	—
Water of Mud weight	0.000	0.000	—	—
Static pressure	—	—	517.821	1,223.746
Uplift	-19.795	-70.609	—	—
Mud pressure	—	—	82.056	188.647
Total	1,154.717	7,909.593	599.877	1,412.393

2) Stability analysis

(a) Stability analysis against sliding

Safety factor against sliding Fs is calculated by Henny's equation.

$$y\ \frac{f\cdot\Sigma V+\tau\cdot L}{\Sigma H} = \frac{0.7 \times 1154.717 + 411 \times 10.700}{599.877} = 8.68$$

where, ΣV : Vertical load on dam base bottom (= 1154.717 kN/m)

ΣH : Horizontal load on dam base bottom (= 599.877 /m)

f : Friction factor between dam bottom and bearing ground

$f=\mu=\tan\phi_B=$ 0.7

τ : Shearing strength of rock mass (kN/m^2)

use coulomb's equation provided this, 「C_B=0、σ=allowable bearing capacity」

$\tau=C_B+\sigma\cdot\tan\phi_B=$ 411

B : Bottom width for sliding analysis (10.700 m)

Thus, stability analysis against sliding is following, which is stable.

Fs= 8.68 ≧ 1.5 (Safety factor)

(b) Stability analysis against overturning

Distance d from point of application of resultant force R to around toe of dam bottom:

$$d = \frac{\Sigma Mr-\Sigma Mo}{\Sigma V} = \frac{7{,}909.593 - 1{,}412.393}{1{,}154.717} = 5.627 \quad (m)$$

where, ΣMr : Resisting moment around toe of dam bottom (= 7,909.593 kN・m)

ΣMo : Overturning moment around toe of dam bottom (= 1,412.393 kN・m)

Distance|e| from point of application of resultant force R to center of bottom:

$|e| = |(B/2)-d| = |(10.700 / 2)- 5.627 | = | -0.277 | = 0.277$ (m)

where, B : Bottom width for overturning analysis (= 10.700 m)

Thus, results of stability analysis against overturning shows below.

Case : Normal

$|e|=$ 0.277 ≦ B/6 = 1.783 (m)・・・Equation of analysis at regular(Result:OK)

$|e|=$ 0.277 ≦ B/3 = 3.567 (m)・・・Equation of analysis under seismic motion (Reference value)

(c) Stability analysis against bearing capacity of foundation ground

Point of application of resultant force R is in 1/3 of bottom width. Thus, modulus of subgrade reaction show trapezoidal distribution that express following equation below.

$$q1,q2=\frac{\Sigma V}{B}\left(1 \pm \frac{6\cdot e}{B}\right)$$

Thus, allowable bearing stress of ground at normal in this design is 588 (kN/m^2)

Stability analysis against bearing capacity of foundation ground is following, which is stable.

q1 = 91.155 ≦ 588 (kN/m^2)

q2 = 124.680 ≦ 588 (kN/m^2)

(6) Result of stability calculation

1) No sediment

cross section				At top water level	At design flood level
				During earthquake	Normal
Overflow section	Active force	Vertical force	(kN)	1,161.089	1,154.717
		Horizontal force	(kN)	637.684	517.821
		Resisting moment	(kN･m)	7,932.322	7,909.593
		Overturning moment	(kN･m)	1,727.466	1,223.746
	sliding	Safety factor		11.630	10.050
		Required safety factor		1.200	1.500
		Result		OK	OK
	Overturning	Eccentric throw	(m)	0.006	0.440
		Standard value	(m)	3.567	1.783
		Result		OK	OK
	Bearing capacity	Applied stress coefficient	(kN/m^2)	108.878	134.544
		Allowable bearing capacity	(kN/m^2)	882.000	588.000
		Result		OK	OK

2) sediment

Cross section				At top water level	At design flood level
				During earthquake	Normal
Overflow section	Active force	Vertical force	(kN)	1,161.089	1,154.717
		Horizontal force	(kN)	754.380	599.877
		Resisting moment	(kN･m)	7,932.322	7,909.593
		Overturning moment	(kN･m)	1,995.750	1,412.393
	Sliding	Safety factor		9.830	8.680
		Required safety factor		1.200	1.500
		Result		OK	OK
	Overturning	Eccentric throw	(m)	0.237	0.277
		Standard value	(m)	3.567	1.783
		Result		OK	OK
	Bearing capacit	Applied stress coefficient	(kN/m^2)	122.934	124.680
		Allowable bearing capacity	(kN/m^2)	882.000	588.000
		Result		OK	OK

Appendix L4-4
Calculation of pressure of penstock and the steel pipe (Lae Ordi II Location)

(by Local materials)

(1)Design detail

The calculation is besed on technical standard of hydraulic power generating installation and Japan hydraulic gate & penstock association.

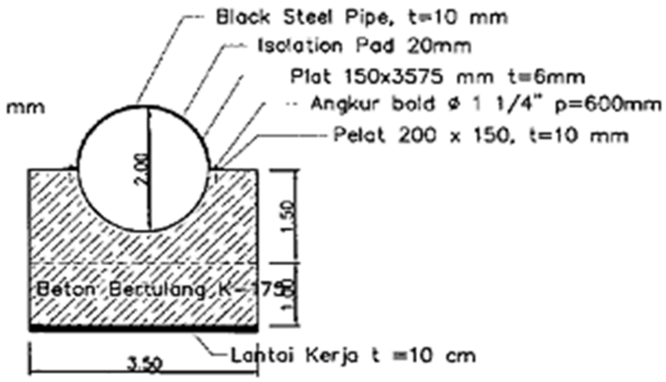
Type	:	Exposed penstock and concrete revetted embedded penstock
Number of pipe	:	1 waterway
Inner diameter size	:	2.000 m
Pipe thickness	:	10～24 mm
Pipe length	:	310.000 m (Curve length from start of penstock to branch pipe)
Maximum static head	:	110.850 m (Head from tank water level WL 630.20m to center of inlet valve EL 519.35 m)
Maximum water hammer pressure head	:	33.000 m (Center of inlet valve)
Attack wave head	:	0.000 m
Maximum design head	:	143.850 m (Center of inlet valve)
Maximum discharge	:	11.63 m^3/s
Turbin closing time	:	4 sec
(ICorrosion allowance	:	1.5 mm
Safety factor against external pressure	:	1.5 over
Temperature change	:	20 ℃

Type of material :

Allowble stress

Material	Thickness (mm)	Tensile stress (N/mm^2)	Compressive stress (N/mm^2)	Shearing stress (N/mm^2)	Bearing stress (N/mm^2)
ISO E275 A-D	t ≦16	150	150	85	255
	16< t ≦40	145	145	80	245
	40< t ≦63	140	140	80	235

Elastic modules of steel	:	206 kN/mm^2
Linear expansion coefficient of steel	:	1.2×10^{-5} /℃
Poisson's ratio of steel	:	0.3
Weld efficiency	:	Plant 0.85 Site 0.80



(2 Calculation of design head

(a) Symbols definition

T : Closing time of valve = 4.0 sec (expected value)

L : Pipe length = 310.000 m (Curve length from start of tank to center of inlet valve

Q : Maximum discharge = 11.63 m^3/s

α : Propagation velocity of pressure wave = 821 m/s

H_0 : Hydrostatic head after valve closed in turbin end = 110.850 m

(Tank water level WL 630.200 m − center of inlet valve EL 519.:m)

V_0 : Mean velocity in pipe (m/s)

h_0 : Rising head by water hammering at closed valv (m)

T_1 : Turnaround time of pressure wave in pipe

= 2 L/α = 0.76 < 4.0 sec : slow closure

(b) Calculation of mean velocity in pipe

V_0 : Effective mean velocity (m/s)

Q : Flow (m^3/s)

(LaeA_0 : Effective mean sectional area (m^2)

Dn : Inner pipe diameter (m)

Ln Pipe length for each pipe (m)

An : Sectional area = Q/Vn (m^2)

{ for reducer pipe $Vn = \frac{V_{n+1} + V_{n-1}}{2}$ }

n	Dn	An	Qn	Vn	Ln	Vn・Ln
1	2.000	3.142	11.63	3.701	32.670	120.912
2	2.000	3.142	11.63	3.701	99.450	368.064
3	2.000	3.142	11.63	3.701	89.220	330.203
4	2.000	3.142	11.63	3.701	77.320	286.161
5	2.000	3.142	11.63	3.701	11.340	41.969
Σ					310.000	1,147.309

$$V_0 = \frac{\Sigma\ (Vn \cdot Ln)}{\Sigma\ Ln} = \frac{1,147.309}{310.000} = 3.701\ m/s$$

(c) Calculation of propagation velocity of pressure wave

$$\alpha = \frac{1}{\sqrt{\frac{W}{g}\left(\frac{1}{K}+\frac{1}{E}\cdot\frac{D}{t}\right)}}$$

where, α : Propagation velocity of pressure wave (m/s)
D : Inner pipe diameter (m)
t : Pipe thickness (m)
W : Unit weight of water = 1 t/m^3
g : Gravitational acceleration = 9.8 m/s^2
K : Bulk modulus of water 200,000 t/m^2
E : Elastic modulus of stee = 21,000,000 t/m^2

n	Dn	t (mm)	α	Ln	α・Ln
1	2.000	10	821	32.670	26,822
2	2.000	10	821	99.450	81,648
3	2.000	10	821	89.220	73,250
4	2.000	10	821	77.320	63,480
5	2.000	10	821	11.340	9,310
Σ				310.000	254,510

$$\alpha = \frac{\Sigma(\alpha \cdot Ln)}{\Sigma Ln} = \frac{254,510}{310.000} = 821 \ m/s$$

(d) Calculation of Water hammer pressure

Rising pressure(rising head) by water hammering at closed valve is calculated.
Assuming there is not sluice valve, Allievi's calculation is used here.

① Pipeline constant of Allievi

$$\rho = \frac{\alpha V_0}{2 g H_0} = \frac{821 \times 3.701}{2 \times 9.8 \times 110.85} = 1.399$$

② Closing time constant of valve

$$\theta = \frac{\alpha T}{2 L_0} = \frac{821 \times 4.0}{2 \times 310.000} = 5.297$$

③ Ratio of pipeline constant to closing time constant

$$n = \frac{\rho}{\theta} = \frac{1.399}{5.297} = 0.264$$

④ Calculation of water hammer pressure

Pipeline constant of Allievi : $\rho = 1.399 > 1$

Thus, water hammer pressure is calculated using following eqation from "Japan hydraulic gate and penstock association".

$$\frac{h_0}{H_0} = \frac{2n}{1 + n\ (\theta - 1)} = \frac{2 \times 0.264}{1 + 0.264\ (5.297 - 1)}$$

$$= 0.247$$

$$\therefore\ h_0 = 0.2470 \times 110.85 = 27.38 \qquad 28.00\ \mathrm{m}$$

⑤ Overdesign of water hammer pressure

Measured value and calculated value of risieng pressure often don't match due to turbin's affection. Thus, water hammer pressure head could have 20% of allowance.

$$\therefore\ h_0 = 27.38 \times 1.2 = 33.00\ \mathrm{m}$$

(e) Design head

Design head is calculated by following equation.

Design head = hydrostatic head + attack wave head + water hammer pressure head

Hydrostatic head is from tank water level (WL 630.200 m) to pipe center height.

Depth of overflow spillway is not considered here, thus wave head is 0.

Water hammer pressure head is maximum at center of turbin, 0 at head tank, and vary in linear fashion in propotion to pipe length at middle part. Water hammer pressure head is calculated by following equation below.

$$H_3 = h_0 \times \frac{L_i}{L_0}$$

where, h_0 : Maximum watter hammer pressure head = 33.00 m

L_i : Pipe length from tank to each cases location (m)

L_0 : Pipe length from tank to center of inlet valve.

= 310.000 m

Design head of cross section for each cases

No.	Cross section of cases	Length L_i (m)	Static water head H_1 (m)	Attack wave head H_2 (m)	Watter hammer pressure head H_3 (m)	Design head H (m)
1	D=2 t=10	32.670	14.300 (EL615.900)	0.000	3.478	17.78
2	D=2 t=10	99.450	44.300 (EL585.900)	0.000	14.065	58.37
3	D=2 t=10	89.220	74.300 (EL555.900)	0.000	23.563	97.86
4	D=2 t=10	77.320	110.850 (EL519.350)	0.000	31.794	142.64
5	D=2 t=10	11.340	110.850 (EL519.350)	0.000	33.001	143.85

( ) Pipe center height

(3)Calculation of pipe thickness

(a) Calculation of minimum pipe thinckness

Minimum pipe thickness is calculated by following equation.

$$t_0 = \frac{D_0 + 800}{400} \quad \text{(only more than 6mm)}$$

where, t_0 : Minimum thickness including corrosion allowance (mm)

D_0 : Inner diameter (mm)

Inner diameter D_0 (mm)	Minimum thickness t_0 (mm)	Thickness t (mm)	Result
1800	6.50	10	≧6mm OK

(b) Allowable head

Allowable head for each material and thickness bearing all the internal pressure on pipe itself is calculated by equation below.

$$Ha = \frac{2000 \cdot \sigma a \cdot \eta \ (t_0 - \varepsilon)}{g \cdot (D_0 + \varepsilon)}$$

where, Ha : Allowble head (m)

σa : Allowble stress (steel material : ISO E275)

= 150 N/mm^2 ($t \leqq 16mm$)

= 145 N/mm^2 ($16mm < t \leqq 40mm$)

η : Weld efficiency = 0.80 (Field weld)

ε : Corrosion allowance = 1.5 mm

t_0 : Thickness (mm)

D_0 : Inner diameter (mm)

No.	Inner diameter D_0 (mm)	Thickness t_0 (mm)	Corrosion allowance ε (mm)	Material	Allowble stress σa (N/mm^2)	Weld efficiency η	Allowble head Ha (m)
1	2000	10	1.5	ISO E275	150	0.80	104.00
2	2000	10	1.5	ISO E275	150	0.80	104.00
3	2000	10	1.5	ISO E275	150	0.80	104.00
4	2000	10	1.5	ISO E276	150	0.80	104.00
5	2000	10	1.5	ISO E277	150	0.80	104.00

(c) Pipe thickness

Table below shows comparison between Design head and allowble head.

No.	Inner diameter D_0 (mm)	Thickness t_0 (mm)	Design head H (m)	Material	Allowable stress σa (N/mm^2)	Allowble head Ha (m)	Result
1	2000	10	17.78	ISO E275	150	104.00	OK
2	2000	10	58.37	ISO E275	150	104.00	OK
3	2000	10	97.86	ISO E275	150	104.00	OK
4	2000	10	142.64	ISO E275	150	104.00	NG★
5	2000	10	143.85	ISO E275	150	104.00	NG★

(d) Consideration for inner pressure

① Circumferential stress

$$\sigma_1 = \frac{P \cdot D}{2(t_0 - \varepsilon)}$$

where,
σ_1 : Circumferential stress (N/mm^2)
P : Design inner pressure (MPa)
D : Inner diameter exempt corrosion allowance $= D_0 + \varepsilon$ (mm)
t_0 : Thickness (mm)
ε : Corrosion allowance = 1.5 mm

No.	Design inner pressure P (MPa)	Inner diameter D (mm)	Material t0 (mm)	Circumferential stress σ1 (N/mm2)	Weld efficiency η	Allowable stress η・σa (N/mm2)	Result
1	0.174	2000	10	20.5	0.80	120.0	OK
2	0.572	2000	10	67.3	0.80	120.0	OK
3	0.959	2000	10	112.8	0.80	120.0	OK
4	1.398	2000	10	164.5	0.80	120.0	NG★
5	1.410	2000	10	165.9	0.80	120.0	NG★

(4)Calculation of pipe axis direction stress

(a) Temperature stress

$$\sigma_{21} = \pm \alpha \cdot E \cdot \Delta T$$

where, σ_{21} : Temperature stress (N/mm^2)
α : Linear expansion coefficient of steel = 1.2×10^{-5}/℃
E : Elastic modulus of steel = 206000 N/mm^2
ΔT : Temperature change = 20 ℃

No.	Linear expansion coefficient α (/℃)	Elastic modules E (N/mm^2)	Temperature change ΔT (℃)	Temperature stress σ_{21} (N/mm^2)
1	0.000012	206000	20	49.4
2	0.000012	206000	20	49.4
3	0.000012	206000	20	49.4
4	0.000012	206000	20	49.4
5	0.000012	206000	20	49.4

(b) Stress due to Poisson effect

$$\sigma_{22} = \nu \cdot \sigma r$$

where, σ_{22} : Stress due to Poisson effect (N/mm^2)
ν : Poisson's ratio of steel = 0.3
σr : Circumferential stress = σ_1 (N/mm^2)

No.	Poisson's ratio ν	Circumferentia l σr (N/mm^2)	Poisson stress σ_{22} (N/mm^2)
1	0.3	20.5	6.2
2	0.3	67.3	20.2
3	0.3	112.8	33.8
4	0.3	164.5	49.4
5	0.3	165.9	49.8

(c) Stress due to inclined pipe

In this case, axial load due to all the pipe weight above the part of this case is considered.

$$\sigma_{24} = \frac{\Sigma(\pi \cdot Dmn \cdot tn \cdot Ln)}{As} \gamma s \cdot \sin\theta$$

where,
- σ_{24} : Stress by inclined pipe (N/mm^2)
- tn : Pipe wall thickness of particular part (mm)
- Dmn : Wall thickness central diameter of tn (mm)
- Ln : Length of pipe of thickness tn (mm)
- γs : Load due to unit mass of pipe
  $\gamma s = \gamma p \cdot g$
- γp : Unit weight of pipe
  $\gamma p = 7.850$ t/m^3
- g : Gravitational acceleration
  $g = 9.8$ t/m^2
- θ : Angle of pipe axis and water surface (°)
  Mean angle of each part in this case.
- As : Cross section for pipe of particular part considered stress
  $As = \pi \cdot Dm \cdot t_0$
- Dm : Wall thickness central diameter for part cosidered stress (mm)
- t_0 : Wall thickness for part considered stress (mm)

No.	Inner diameter D_0 (mm)	Thickness t_0 (mm)	Diameter Dm (mm)	Length Ln (m)	Weight of section (t)	Slope angle θ (°)	Pipe slope load (pipe axis direction) (KN/m)	Inclined stress σ_{24} (N/mm^2)
1	2000	10	2010	32.670	1,619.439	11.2	3,082.597	0.5
2	2000	10	2010	99.450	4,929.699	27.3	25,240.439	4.0
3	2000	10	2010	89.220	4,422.601	22.6	41,896.371	6.6
4	2000	10	2010	77.320	3,832.723	23.6	56,933.755	9.0
5	2000	10	2010	11.340	562.119	24.6	59,226.949	9.4

(d) Bending stress assuming pipe as beam

$\sigma_{25} = M / Z$

where,

σ_{25} : Bending stress assuming pipe as beam (N/mm^2)

Z : Section modulus (mm^3)

$Z = (\pi / 32) \cdot \{(D_0 + t_0 - \varepsilon)^4 - (D_0 + \varepsilon)^4\} / (D_0 + t_0 - \varepsilon)$

M : Bending moment where requesting stress (N・mm)
In this case, interval of bearing support is considered as span length to simplify the case. Then use it as simple beam, and bending moment of center of span is used.

$M = P \cdot L^2 / 8$

L : Span length (m)

L = 10.000 m

P : Load in direction to perpendicular to pipe axis

$P = (Wp + Ww) \cdot \cos\theta$

θ : Angle of pipe axis and horizontal plane (°)
Mean angle of each area in this case.

Wp : Pipe self weight/1m (kN)

$Wp = \gamma p \cdot (\pi / 4) \cdot \{(D_0 + t_0)^2 - D_0^2\}$

γp : Unit weight of pipe

γp = 7.850 t/m^3

Ww : Water weight in pipe/1m

$Ww = \gamma w \cdot (\pi / 4) \cdot D_0^2$

γw : Unit weight of water

γp = 1.000 t/m^3

g : Gravitational acceleration

g = 9.8 t/m^2

D_0 : Inner diameter

t_0 : Wall thickness

ε : Corrosion allowance

ε = 1.5 mm

No.	Inner diameter D_0 (m)	Thickness t_0 (mm)	Slope angle θ (°)	Span length L (m)	Axial load P (kN/m)	Bending moment M (kN・m)	Section modulus Z (mm^3)	Bending stress σ_{25} (N/mm^2)
1	2000	10	11.2	10.000	34.967	437.088	26,858,144	16.3
2	2000	10	27.3	10.000	31.676	395.950	26,858,144	14.7
3	2000	10	22.6	10.000	32.909	411.363	26,858,144	15.3
4	2000	10	23.6	10.000	32.665	408.313	26,858,144	15.2
5	2000	10	24.6	10.000	32.411	405.138	26,858,144	15.1

(e) Shearing stress of vertical direction to pipe axis

$$\tau = \frac{2 \cdot S \cdot \cos\theta}{As}$$

where,

τ : Shearing stress of vertical direction to pipe axis (N/mm^2)

S : Shearing stress where requiring stress (N)

In this case, interval of bearing support is considered as span length to simplify the case. Then use it as simple beam, and shearing force at end of span is used.

$S \cdot \cos\theta = P \cdot L / 2$

L : Span length (m)

L = 10.000 m

P : Load in direction to perpendicular to pipe axis

$P = (Wp + Ww) \cdot \cos\theta$

θ : Angle of pipe axis and horizontal plane (°)

Mean gngle of each area in this case.

Wp : Pipe self weight /1m (kN)

$Wp = \gamma p \cdot (\pi / 4) \cdot \{(D_0 + t_0)^2 - D_0^2\}$

γp : Unit weight of pipe

γp = 7.850 t/m^3

Ww : Water weight in pipe/1m

$Ww = \gamma w \cdot (\pi / 4) \cdot D_0^2$

γw : Unit weight of water

γp = 1.000 t/m^3

g : Gravitational acceleration

g = 9.8 t/m^2

As : Cross section for pipe of particular part considered stress

$As = \pi \cdot Dm \cdot t_0$

Dm : Pipe wall thickness center diameter for part considered stress (mm)

t_0 : Pipe wall thickness for part considered stress (mm)

No.	Inner diameter D_0 (m)	Thickness t_0 (mm)	Diameter Dm (mm)	Slope angle θ (°)	Span length L (m)	Axial load P (kN/m)	Shearing force $S \cdot \cos\theta$ (kN)	Shearing stress τ (N/mm^2)
1	2000	10	2010	11.2	10.000	34.967	174.835	2.8
2	2000	10	2010	27.3	10.000	31.676	158.380	2.5
3	2000	10	2010	22.6	10.000	32.909	164.545	2.6
4	2000	10	2010	23.6	10.000	32.665	163.325	2.6
5	2000	10	2010	24.6	10.000	32.411	162.055	2.6

(f) Total of axial stress

when temperature rise $\sigma_2 = -\sigma_{21} + \sigma_{22} + \sigma_{23} - \sigma_{24} + \sigma_{25}$

when temperature drop $\sigma_2' = +\sigma_{21} + \sigma_{22} + \sigma_{23} - \sigma_{24} + \sigma_{25}$

No.	Temperature stress σ_{21} (N/mm^2)	Poisson's stress σ_{22} (N/mm^2)	Local stress σ_{23} (N/mm^2)	Inclined stress σ_{24} (N/mm^2)	Bending stress σ_{25} (N/mm^2)	Total of axial stress σ_2 (N/mm^2)	Total of axial stress σ_2' (N/mm^2)
1	49.4	6.2	—	0.5	16.3	-27.5	71.4
2	49.4	20.2	—	4.0	14.7	-18.6	80.3
3	49.4	33.8	—	6.6	15.3	-6.9	92.0
4	49.4	49.4	—	9.0	15.2	6.1	105.0
5	49.4	49.8	—	9.4	15.1	6.0	104.9

(Axial stress:tensile direction is plus.)

(5)Analysis by equivalent stress

$$\sigma eq = \sqrt{(\sigma_1{}^2 + \sigma_2{}^2 - \sigma_1 \cdot \sigma_2 + 3\tau^2)}$$

where, σeq : Equivalent stress (N/mm^2)

$\sigma 1$: Circumferential direction stress (N/mm^2)

$\sigma 2$: Axial stress (N/mm^2)

τ : Shearing stress of vertical to pipe axis (kgf/cm^2)

No.	Circumferential stress σ_1 (N/mm^2)	Total of axial stress σ_2 (N/mm^2)	Total of axial stress σ_2' (N/mm^2)	Shearing stress τ (N/mm^2)	Equivalent stress σeq (N/mm^2)	Equivalent stress $\sigma eq'$ (N/mm^2)	Allowble stress σa (N/mm^2)	Result
1	20.5	-27.5	71.4	2.8	42.0	63.8	120	OK
2	67.3	-18.6	80.3	2.5	78.4	74.8	120	OK
3	112.8	-6.9	92.0	2.6	116.5	104.1	120	OK
4	164.5	6.1	105.0	2.6	161.6	144.3	120	NG★
5	165.9	6.0	104.9	2.6	163.0	145.4	120	NG★

(6) Result of hydraulic head and stress analysis

No.	Inner diameter	Pipe thickness	Pipe length	Pipe wall thickness			Inner pressure		
				Design head	Allowable head	Result	Circumferential	Allowable stress	Result
	D_0	t_0	Ln	H	Ha		σ 1	η・σa	
	(mm)	(mm)	(m)	(m)	(m)		(N/mm²)	(N/mm²)	
1	2000	10	32.670	17.78	104.00	OK	20.50	120.00	OK
2	2000	10	99.450	58.37	104.00	OK	67.30	120.00	OK
3	2000	10	89.220	97.86	104.00	OK	112.80	120.00	OK
4	2000	10	77.320	142.64	104.00	NG★	164.50	120.00	NG★
5	2000	10	11.340	143.85	104.00	NG★	165.90	120.00	NG★

No.	Inner diameter	Pipe thickness	Pipe length	Axial stress			
				Equivalent stress		Allowable stress	Result
	D_0	t_0	Ln	σeq	σeq'	σa	
	(mm)	(mm)	(m)	(N/mm²)	(N/mm²)	(N/mm²)	
1	2000	10	32.670	42.00	63.85	120	OK
2	2000	10	99.450	78.40	74.80	120	OK
3	2000	10	89.220	116.50	104.06	120	OK
4		10	77.320	161.60	144.33	120	NG★
5	2000	10	11.340	163.00	145.41	120	NG★

As a result of this analysis conducted by Japanese method, it is proved that pipe thickness of some section is not satisfied for penstock steel pipe on this site.

Appendix L4-5
Calculation of pressure of penstock and the steel pipe
(Lae Ordi II Location)

(Improvement suggestion)

(1)Design detail

The calculation is based on technical standard of hydraulic power generating installation and Japan hydraulic gate & penstock association.

Type : Exposed penstock and concrete revetted embedded penstock

Number of pipe : 1 waterway

Inner diameter size : 2.000 m

Pipe thickness : 10～24 mm

Pipe length : 310.000 m (Curve length from start of penstock to branch pipe)

Maximum static head : 110.850 m (Head from tank water level WL 630.20m to center of inlet valve EL 519.35 m)

Maximum water hammer pressure head : 32.000 m (Center of inlet valve)

Attack wave head : 0.000 m

Maximum design head : 142.850 m (Center of inlet valve)

Maximum discharge : 11.63 m^3/s

Turbin closing time : 4 sec

Corrosion allowance : 1.5 mm

Safety factor against external pressure : 1.5 over

Temperature change : 20 °C

Type of material :

Allowble stress

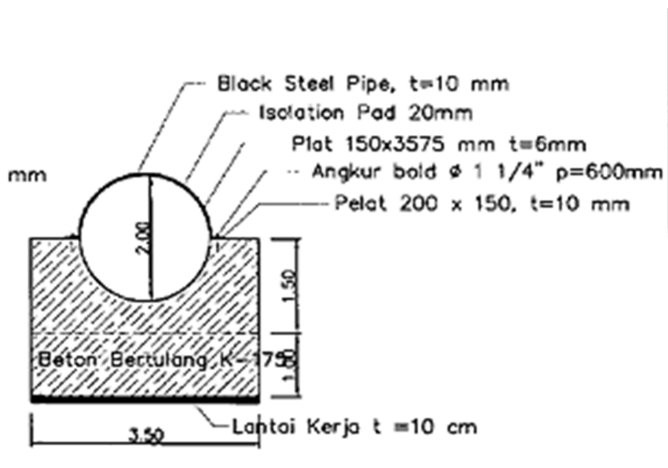
Material	Thickness (mm)	Tensile stress (N/mm^2)	Compressive stress (N/mm^2)	Shearing stress (N/mm^2)	Bearing stress (N/mm^2)
ISO E275 A-D	$t \leqq 16$	150	150	85	255
	$16 < t \leqq 40$	145	145	80	245
	$40 < t \leqq 63$	140	140	80	235

Elastic modules of steel : 206 kN/mm^2

Linear expansion coefficient of steel : 1.2×10^{-5} /°C

Poisson's ratio of steel : 0.3

Weld efficiency : Plant 0.85 Site 0.80



(2) Calculation of design head

(a) Symbols definition

T : Closing time of valve = 4.0 sec (expected value)

L : Pipe length = 310.000 m (Curve length from start of tank to center of inlet valve)

Q : Maximum discharge = 11.63 m^3/s

α : Propagation velocity of pressure wave = 847 m/s

H_0 : Hydrostatic head after valve closed in turbin end = 110.850 m

(Tank water level WL 630.200 m − center of inlet valve EL 519.3 m)

V_0 : Mean velocity in pipe (m/s)

h_0 : Rising head by water hammering at closed valve (m)

T_1 : Turnaround time of pressure wave in pipe

= $2L/\alpha$ = 0.73 < 4.0 sec : slow closure

(b) Calculation of mean velocity in pipe

V_0 : Effective mean velocity (m/s)

Q : Flow (m^3/s)

A_0 : Effective mean sectional area (m^2)

Dn : Inner pipe diameter (m)

Ln : Pipe length for each pipe (m)

An : Sectional area = Q/Vn (m^2)

{ for reducer pipe $Vn = \frac{V_{n+1}+V_{n-1}}{2}$ }

n	Dn	An	Qn	Vn	Ln	Vn・Ln
1	2.000	3.142	11.63	3.701	32.670	120.912
2	2.000	3.142	11.63	3.701	99.450	368.064
3	2.000	3.142	11.63	3.701	89.220	330.203
4	2.000	3.142	11.63	3.701	77.320	286.161
5	2.000	3.142	11.63	3.701	11.340	41.969
Σ					310.000	1,147.309

$$V_0 = \frac{\Sigma\ (Vn \cdot Ln)}{\Sigma\ Ln} = \frac{1{,}147.309}{310.000} = 3.701\ \ m/s$$

(c) Calculation of propagation velocity of pressure wave

$$\alpha = \frac{1}{\sqrt{\frac{W}{g}\left(\frac{1}{K} + \frac{1}{E} \cdot \frac{D}{t}\right)}}$$

where,
α : Propagation velocity of pressure wave (m/s)
D : Inner pipe diameter (m)
t : Pipe thickness (m)
W : Unit weight of water = 1 t/m^3
g : Gravitational acceleration = 9.8 m/s^2
K : Bulk modulus of water 200,000 t/m^2
E : Elastic modulus of steel = 21,000,000 t/m^2

n	Dn	t (mm)	α	Ln	α・Ln
1	2.000	10	821	32.670	26,822
2	2.000	10	821	99.450	81,648
3	2.000	10	821	89.220	73,250
4	2.000	14	911	77.320	70,439
5	2.000	14	911	11.340	10,331
Σ				310.000	262,490

$$\alpha = \frac{\Sigma(\alpha \cdot Ln)}{\Sigma Ln} = \frac{262{,}490}{310.000} = 847 \text{ m/s}$$

(d) Calculation of Water hammer pressure

Rising pressure(rising head) by water hammering at closed valve is calculated.
Assuming there is not sluice valve, Allievi's calculation is used here.

① Pipeline constant of Allievi

$$\rho = \frac{\alpha V_0}{2 g H_0} = \frac{847 \times 3.701}{2 \times 9.8 \times 110.85} = 1.443$$

② Closing time constant of valve

$$\theta = \frac{\alpha T}{2 L_0} = \frac{847 \times 4.0}{2 \times 310.000} = 5.465$$

③ Ratio of pipeline constant to closing time constant

$$n = \frac{\rho}{\theta} = \frac{1.443}{5.465} = 0.264$$

④ Calculation of water hammer pressure

Pipeline constant of Allievi : $\rho = 1.443 > 1$

Thus, water hammer pressure is calculated using following eqation from "Japan hydraulic gate and penstock association".

$$\frac{h_0}{H_0} = \frac{2n}{1 + n\ (\theta - 1)} = \frac{2 \times 0.264}{1 + 0.264\ (5.465 - 1)}$$

$$= 0.242$$

$$\therefore\ h_0 = 0.2420 \times 110.85 = 26.83 \quad 27.00 \quad \text{m}$$

⑤ Overdesign of water hammer pressure

Measured value and calculated value of risieng pressure often don't match due to turbin's affection. Thus, water hammer pressure head could have 20% of allowance.

$$\therefore\ h_0 = 26.83 \times 1.2 = 32.00 \quad \text{m}$$

(e) Design head

Design head is calculated by following equation.

Design head = hydrostatic head + attack wave head + water hammer pressure

Hydrostatic head is from tank water level (WL 630.200 m) to pipe center height.

Depth of overflow spillway is not considered here, thus wave head is 0.

Water hammer pressure head is maximum at center of turbin, 0 at head tank, and vary in linear fashion in propotion to pipe length at middle part. Water hammer pressure head is calculated by following equation below.

$$H_3 = h_0 \times \frac{L_i}{L_0}$$

where, h_0 : Maximum watter hammer pressure head = 32.00 m
L_i : Pipe length from tank to each cases location (m)
L_0 : Pipe length from tank to center of inlet valve.
= 310.000 m

Design head of cross section for each cases

No.	Cross section of cases	Length L_i (m)	Static water head H_1 (m)	Attack wave head H_2 (m)	Water hammer pressure head H_3 (m)	Design head H (m)
1	D=2 t=10	32.670	14.300 (EL615.900)	0.000	3.372	17.67
2	D=2 t=10	99.450	44.300 (EL585.900)	0.000	13.638	57.94
3	D=2 t=14	89.220	74.300 (EL555.900)	0.000	22.848	97.15
4	D=2 t=14	77.320	110.850 (EL519.350)	0.000	30.829	141.68
5	D=2 t=14	11.340	110.850 (EL519.350)	0.000	32.000	142.85

( ) Pipe center height

(3)Calculation of pipe thickness

(a) Calculation of minimum pipe thinckness

Minimum pipe thickness is calculated by following equation.

$$t_0 = \frac{D_0 + 800}{400} \quad \text{(only more than 6mm)}$$

where, t_0 : Minimum thickness including corrosion allowance (mm)

D_0 : Inner diameter (mm)

Inner diameter D_0 (mm)	Minimum thickness t_0 (mm)	Thickness t (mm)	Result
1800	6.50	10	≧6mm OK

(b) Allowable head

Allowable head for each material and thickness bearing all the internal pressure on pipe itself is calculated by equation below.

$$Ha = \frac{2000 \cdot \sigma a \cdot \eta \, (t_0 - \varepsilon)}{g \cdot (D_0 + \varepsilon)}$$

where, Ha : Allowble head (m)

σa : Allowble stress (steel material : ISO E275)

= 150 N/mm^2 ($t \leqq 16mm$)

= 145 N/mm^2 ($16mm < t \leqq 40mm$)

η : Weld efficiency = 0.80 (Field weld)

ε : Corrosion allowance = 1.5 mm

t_0 : Thickness (mm)

D_0 : Inner diameter (mm)

No.	Inner diameter D_0 (mm)	Thickness t_0 (mm)	Corrosion allowance ε (mm)	Material	Allowble stress σa (N/mm^2)	Weld efficiency η	Allowble head Ha (m)
1	2000	10	1.5	ISO E275	150	0.80	104.00
2	2000	10	1.5	ISO E275	150	0.80	104.00
3	2000	10	1.5	ISO E275	150	0.80	104.00
4	2000	14	1.5	ISO E276	150	0.80	152.95
5	2000	14	1.5	ISO E277	150	0.80	152.95

(c) Pipe thickness

Table below shows comparison between Design head and allowble head.

No.	Inner diameter D_0 (mm)	Thickness t_0 (mm)	Design head H (m)	Material	Allowable stress σa (N/mm^2)	Allowble head Ha (m)	Result
1	2000	10	17.67	ISO E275	150	104.00	OK
2	2000	10	57.94	ISO E275	150	104.00	OK
3	2000	10	97.15	ISO E275	150	104.00	OK
4	2000	14	141.68	ISO E275	150	152.95	OK
5	2000	14	142.85	ISO E275	150	152.95	OK

(d) Consideration for inner pressure

① Circumferential stress

$$\sigma_1 = \frac{P \cdot D}{2(t_0 - \varepsilon)}$$

where, σ_1 : Circumferential stress (N/mm^2)

P : Design inner pressure (MPa)

D : Inner diameter exempt corrosion allowance $= D_0 + \varepsilon$ (mm)

t_0 : Thickness (mm)

ε : Corrosion allowance $= 1.5$ mm

No.	Design inner pressure P (MPa)	Inner diameter D (mm)	Material t_0 (mm)	Circumferential stress σ_1 (N/mm^2)	Weld efficiency η	Allowable stress $\eta \cdot \sigma a$ (N/mm^2)	Result
1	0.173	2000	10	20.4	0.80	120.0	OK
2	0.568	2000	10	66.8	0.80	120.0	OK
3	0.952	2000	10	112.0	0.80	120.0	OK
4	1.389	2000	14	111.1	0.80	120.0	OK
5	1.400	2000	14	112.0	0.80	120.0	OK

(4)Calculation of pipe axis direction stress

(a) Temperature stress

$$\sigma_{21} = \pm\alpha \cdot E \cdot \Delta T$$

where, σ_{21} : Temperature stress (N/mm^2)
α : Linear expansion coefficient of steel $= 1.2 \times 10^{-5}$ /℃
E : Elastic modulus of steel $=$ 206000 N/mm^2
ΔT : Temperature change $=$ 20 ℃

No.	Linear expansion coefficient α (/℃)	Elastic modules E (N/mm2)	Temperatur e change ΔT (℃)	Temperature stress σ21 (N/mm2)
1	0.000012	206000	20	49.4
2	0.000012	206000	20	49.4
3	0.000012	206000	20	49.4
4	0.000012	206000	20	49.4
5	0.000012	206000	20	49.4

(b) Stress due to Poisson effect

$$\sigma_{22} = \nu \cdot \sigma r$$

where, σ_{22} : Stress due to Poisson effect (N/mm^2)
ν : Poisson's ratio of steel $=$ 0.3
σr : Circumferential stress $= \sigma_1$ (N/mm^2)

No.	Poisson's ratio ν	Circumferential stress σr (N/mm2)	Poisson stress σ22 (N/mm2)
1	0.3	20.4	6.1
2	0.3	66.8	20.0
3	0.3	112.0	33.6
4	0.3	111.1	33.3
5	0.3	112.0	33.6

(c) Stress due to inclined pipe

In this case, axial load due to all the pipe weight above the part of this case is considered.

$$\sigma_{24} = \frac{\Sigma\ (\pi \cdot Dmn \cdot tn \cdot Ln)}{As} \gamma s \cdot \sin\theta$$

where,

σ_{24}	:	Stress by inclined pipe	(N/mm^2)
tn	:	Pipe wall thickness of particular part	(mm)
Dmn	:	Wall thickness central diameter of tn	(mm)
Ln	:	Length of pipe of thickness tn	(mm)
γs	:	Load due to unit mass of pipe $\gamma s = \gamma p \cdot g$	
γp	:	Unit weight of pipe $\gamma p = 7.850$ t/m^3	
g	:	Gravitational acceleration $g = 9.8$ t/m^2	
θ	:	Angle of pipe axis and water surface (°) Mean angle of each part in this case.	
As	:	Cross section for pipe of particular part considered stress $As = \pi \cdot Dm \cdot t_0$	
Dm	:	Wall thickness central diameter for part cosidered stress	(mm)
t_0	:	Wall thickness for part considered stress	(mm)

No.	Inner diameter D_0 (mm)	Thickness t_0 (mm)	Diameter Dm (mm)	Length Ln (m)	Weight of section (t)	Slope angle θ (°)	Pipe slope load (pipe axis direction) (KN/m)	Inclined stress σ_{24} (N/mm^2)
1	2000	10	2010	32.670	1,619.439	11.2	3,082.597	0.5
2	2000	10	2010	99.450	4,929.699	27.3	25,240.439	4.0
3	2000	10	2010	89.220	4,422.601	22.6	41,896.371	6.6
4	2000	14	2014	77.320	3,840.350	23.6	56,963.679	6.4
5	2000	14	2014	11.340	563.238	24.6	59,261.438	6.7

(d) Bending stress assuming pipe as beam

$$\sigma_{25} = M / Z$$

where,

σ_{25} : Bending stress assuming pipe as beam (N/mm^2)

Z : Section modulus (mm^3)

$$Z = (\pi/32) \cdot \{(D_0 + t_0 - \varepsilon)^4 - (D_0 + \varepsilon)^4\} / (D_0 + t_0 - \varepsilon)$$

M : Bending moment where requesting stress (N・mm)

In this case, interval of bearing support is considered as span length to simplify the case. Then use it as simple beam, and bending moment of center of span is used.

$$M = P \cdot L^2 / 8$$

L : Span length (m)

$$L = 10.000 \quad m$$

P : Load in direction to perpendicular to pipe axis

$$P = (Wp + Ww) \cdot \cos\theta$$

θ : Angle of pipe axis and horizontal plane (°)

Mean angle of each area in this case.

Wp : Pipe self weight/1m (kN)

$$Wp = \gamma p \cdot (\pi/4) \cdot \{(D_0 + t_0)^2 - D_0^2\}$$

γp : Unit weight of pipe

$$\gamma p = 7.850 \quad t/m^3$$

Ww : Water weight in pipe/1m

$$Ww = \gamma w \cdot (\pi/4) \cdot D_0^2$$

γw : Unit weight of water

$$\gamma p = 1.000 \quad t/m^3$$

g : Gravitational acceleration

$$g = 9.8 \quad t/m^2$$

D_0 : Inner diameter

t_0 : Wall thickness

ε : Corrosion allowance

$$\varepsilon = 1.5 \quad mm$$

No.	Inner diameter D_0 (m)	Thickness t_0 (mm)	Slope angle θ (°)	Span length L (m)	Axial load P (kN/m)	Bending moment M (kN・m)	Section modulus Z (mm^3)	Bending stress σ_{25} (N/mm^2)
1	2000	10	11.2	10.000	34.967	437.088	26,858,144	16.3
2	2000	10	27.3	10.000	31.676	395.950	26,858,144	14.7
3	2000	10	22.6	10.000	32.909	411.363	26,858,144	15.3
4	2000	14	23.6	10.000	34.457	430.713	39,577,505	10.9
5	2000	14	24.6	10.000	34.189	427.363	39,577,505	10.8

(e) Shearing stress of vertical direction to pipe axis

$$\tau = \frac{2 \cdot S \cdot \cos\theta}{As}$$

where,

τ : Shearing stress of vertical direction to pipe axis (N/mm^2)

S : Shearing stress where requiring stress (N)

In this case, interval of bearing support is considered as span length to simplify the case. Then use it as simple beam, and shearing force at end of span is used.

$S \cdot \cos\theta = P \cdot L/2$

L : Span length (m)

$L = 10.000$ m

P : Load in direction to perpendicular to pipe axis

$P = (Wp + Ww) \cdot \cos\theta$

θ : Angle of pipe axis and horizontal plane (°)

Mean gngle of each area in this case.

Wp : Pipe self weight /1m (kN)

$Wp = \gamma p \cdot (\pi/4) \cdot \{(D_0 + t_0)^2 - D_0^2\}$

γp : Unit weight of pipe

$\gamma p = 7.850$ t/m^3

Ww : Water weight in pipe/1m

$Ww = \gamma w \cdot (\pi/4) \cdot D_0^2$

γw : Unit weight of water

$\gamma p = 1.000$ t/m^3

g : Gravitational acceleration

$g = 9.8$ t/m^2

As : Cross section for pipe of particular part considered stress

$As = \pi \cdot Dm \cdot t_0$

Dm : Pipe wall thickness center diameter for part considered stress (mm)

t_0 : Pipe wall thickness for part considered stress (mm)

No.	Inner diameter D_0 (m)	Thickness t_0 (mm)	Diameter Dm (mm)	Slope angle θ (°)	Span length L (m)	Axial load P (kN/m)	Shearing force $S \cdot \cos\theta$ (kN)	Shearing stress τ (N/mm^2)
1	2000	10	2010	11.2	10.000	34.967	174.835	2.8
2	2000	10	2010	27.3	10.000	31.676	158.380	2.5
3	2000	10	2010	22.6	10.000	32.909	164.545	2.6
4	2000	14	2014	23.6	10.000	34.457	172.285	1.9
5	2000	14	2014	24.6	10.000	34.189	170.945	1.9

(f) Total of axial stress

when temperature rise $\sigma_2 = -\sigma_{21} + \sigma_{22} + \sigma_{23} - \sigma_{24} + \sigma_{25}$

when temperature drop $\sigma_2' = +\sigma_{21} + \sigma_{22} + \sigma_{23} - \sigma_{24} + \sigma_{25}$

No.	Temperature stress σ_{21} (N/mm^2)	Poisson's stress σ_{22} (N/mm^2)	Local stress σ_{23} (N/mm^2)	Inclined stress σ_{24} (N/mm^2)	Bending stress σ_{25} (N/mm^2)	Total of axial stress σ_2 (N/mm^2)	σ_2' (N/mm^2)
1	49.4	6.1	—	0.5	16.3	-27.5	71.4
2	49.4	20.0	—	4.0	14.7	-18.7	80.2
3	49.4	33.6	—	6.6	15.3	-7.1	91.7
4	49.4	33.3	—	6.4	10.9	-11.6	87.3
5	49.4	33.6	—	6.7	10.8	-11.7	87.1

(Axial stress:tensile direction is plus.)

(5)Analysis by equivalent stress

$$\sigma eq = \sqrt{(\sigma_1{}^2 + \sigma_2{}^2 - \sigma_1 \cdot \sigma_2 + 3\tau^2)}$$

where, σeq : Equivalent stress (N/mm^2)
$\sigma 1$: Circumferential direction stress (N/mm^2)
$\sigma 2$: Axial stress (N/mm^2)
τ : Shearing stress of vertical to pipe axis (kgf/cm^2)

No.	Circumferential stress σ_1 (N/mm^2)	Total of axial stress σ_2 (N/mm^2)	σ_2' (N/mm^2)	Shearing stress τ (N/mm^2)	Equivalent stress σeq (N/mm^2)	$\sigma eq'$ (N/mm^2)	Allowble stress σa (N/mm^2)	Result
1	20.4	-27.5	71.4	2.8	41.9	63.8	120	OK
2	66.8	-18.7	80.2	2.5	78.0	74.5	120	OK
3	112.0	-7.1	91.7	2.6	115.8	103.5	120	OK
4	111.1	-11.6	87.3	1.9	117.4	101.4	120	OK
5	112.0	-11.7	87.1	1.9	118.4	101.9	120	OK

As a result of this analysis conducted by Japanese method, it is proved the stability for penstock in relevant location.

(6) Result of hydraulic head and stress analysis

No.	Inner diameter	Pipe thickness	Pipe length	Pipe wall thickness			Inner pressure		
				Design head	Allowable head	Result	Circumferential stress	Allowable stress	Result
	D_0	t_0	Ln	H	Ha		σ 1	η・σa	
	(mm)	(mm)	(m)	(m)	(m)		(N/mm²)	(N/mm²)	
1	2000	10	32.670	17.67	104.00	OK	20.40	120.00	OK
2	2000	10	99.450	57.94	104.00	OK	66.80	120.00	OK
3	2000	10	89.220	97.15	104.00	OK	112.00	120.00	OK
4	2000	14	77.320	141.68	152.95	OK	111.10	120.00	OK
5	2000	14	11.340	142.85	152.95	OK	112.00	120.00	OK

No.	Inner diameter	Pipe thickness	Pipe length	Axial stress			
				Equivalent stress		Allowable stress	Result
	D_0	t_0	Ln	σeq	σeq '	σa	
	(mm)	(mm)	(m)	(N/mm²)	(N/mm²)	(N/mm²)	
1	2000	10	32.670	41.90	63.85	120	OK
2	2000	10	99.450	78.00	74.52	120	OK
3	2000	10	89.220	115.80	103.47	120	OK
4	2000	14	77.320	117.40	101.36	120	OK
5	2000	14	11.340	118.40	101.92	120	OK

This analysis was conducted by Japanese method based on pipe thickness above, and the stability was proved. Also, increasing the size of pipe thickness gradually by some section could be more economical.

Appendix L4-6
UKL/UPL
(Lae Ordi II Location)

BUPATI PAKPAK BHARAT

Salak, 14 September 2009

Kepada Yth

PT. BAKARA BUMI ENERGI

Jl. H. Abd. Rahman Syihab No. 1-A

di -

Medan

Nomor : 660/4056/KLHP/VIII/2009
Sifat : Penting
Lampiran : 1 (Satu) Set
Perihal : **Persetujuan UKL dan UPL PLTA Lae Ordi II Kec. Pergetteng-getteng Sengkut**

Menindaklanjuti Surat saudara Nomor : 0007/B1/DU/BKR-MDN/III/2009 Tanggal 25 Maret 2009 perihal Pengesahan Dokumen UKL dan UPL yang ditindaklanjuti dengan Surat Bupati Pakpak Bharat No. 005/3351/KLHP/VI/2009 Tanggal 31 Juli 2009 perihal Undangan ekspose dan telah dilaksanakan ekspose oleh PT. Bakara Bumi Energi pada tanggal 5 Agustus 2009 di Ruang rapat Setda Kab. Pakpak Bharat.

Dengan dilaksanakannya ekspose maka UKL dan UPL PLTA Lae Ordi II dapat kami setujui dengan ketentuan sebagai berikut :

a. Melaksanakan pengelolaan dan pemantauan lingkungan hidup sesuai dengan yang tercantum di dokumen UKL dan UPL yang disetujui;
b. Mempertahankan dan meningkatkan kualitas air;
c. Melaksanakan koordinasi dengan instansi terkait dan masyarakat sekitar lokasi kegiatan.
d. Selalu memantau kualitas lingkungan disekitar lokasi terkait kegiatan pembangunan dampak yang ditimbulkan dihilir sungai;
e. Siap menerima inspeksi dari instansi Pemerintah yang membidangi Pengawasan di bidang lingkungan.

Demikian persetujuan UKL dan UPL PLTA Lae Ordi II ini diberikan untuk dapat dipergunakan sebagaimana mestinya dan atas kerjasamanya diucapkan terima kasih.

BUPATI PAKPAK BHARAT

H. MAKMUR BERASA

Tembusan Kepada Yth. :

1. Bapak Menteri Energi dan Sumber Daya Mineral Republik Indonesia di Jakarta;
2. Bapak Gubernur Sumatera Utara di Medan,
3. Sdr. Kepala Dinas Pertambangan Propinsi Sumatera Utara di Medan;
4. Sdr. Kepala Badan Lingkungan Hidup Propinsi Sumatera Utara di Medan;
5. Sdr. Kepala Dinas Kehutanan, Lingkungan Hidup dan Pertambangan di Salak;
6. Pertinggal

Appendix L4-7
Briefing of Project Concept for Public Hearing
Minutes of Meeting
(Lae Ordi II Location)

MINUTES OF MEETING/PRESENTATION UKL/UPL PLTA LAE ORDI I (PT. BAKARA BUMI ENERGI) YEAR 2009

Day/Date : WEDNESDAY, AUGUST 5 , 2009
Venue : MEETING ROOM SETDA,PAKPAK BARAT

NO	NAME	INSTITUTION	COMMENTS / OPINIONS	ANSWER PT.BBE
1.	Ir. Muh.Aris Gajah	Head of Estates Department of Agriculture	From the point of aesthetics: Structuring Projects must coordinate with the Department of Tourism to be used as a natural tourist attraction and source of electrical power.	Implementation of the project effort to combine these elements for coordination with related agencies that have multiple benefits and improve the aesthetic value.
2.	Jonner Nadaek,SH	NGOs PILIHI	In the phase of the development that NGOs are involved as a supervisor in the environmental.	It is recommended that NGOs to coordinate with local government, because in principle a public company in terms of supervision.
3.	Mitong manik	Community leaders Kecupak	In the construction of the hydroelectric project, what is its contribution to the surrounding community?	Effort in the implementation of the project will use local labor in accordance with the field and expertise needed by the company as a contribution to society.
4.	Efendi Berutu, SP	Head of Physical and Infrastructure BAPPEDA	1.Is the construction of hydropower projects Lae Ordi I do not have a negative impact on the environment?	1. As electric power is sourced from the water,the project would not interfere and reduce the need for public water consumption for everyday needs as well as rice fields and irrigation development will not pollute the water and the environment.

NO	NAME	INSTITUTION	COMMENTS / OPINIONS	ANSWER PT.BBE
			2.How does the company embrace the community in the land acquisition. 3.How Community Development for the community? 4.BAPPEDA To be involved in the construction of hydropower and facilities to the community.	2.The problem of land acquisition will be implemented with the best agreement with landowners and local governments. 3.Setting the amount of Community Development funds will be discussed further and the allocation to improve the welfare of the public and transparent. 4. BAPPEDA Involvement in development issues power plant to the regional governments.
5.	Pestakem Habeahan, S.Pd	Camat Pergetteng-getteng Sengkut	1.Whether justified the formation of teams for the acquisition of public land. 2.The archives of the company not yet submitted to the sub-district .	1.Formation of the problems that we submit to the Government and after agreement with the government there will be no further discussion meeting on the implementation of land acquisition by inviting relevant parties. 2. Will be completed by the company.

NO	NAME	INSTITUTION	COMMENTS / OPINIONS	ANSWER PT.BBE
6.	Augusman Padang	Head of the Public Works Department of Human Settlements	1.How to invest will be invested by the company? 2.What kind monitor can be done by the government? 3.Because of this hydroelectric dams, if there is no inundating water that can be caused by environmental damage? 4. Is this power plant will be sold to PLN or free to the public? 5. Is it after 30 years of power plant will be donated to the people of West Pakpak?	3. Investment that will be invested by the company ranges from Rp. 380 Ms / d 500 M depending on the value of a dollar. 2. Supervision that can be done by the local government is in accordance with task, such as overseeing the Office of Public Works in terms of its IMB, Planning, and in terms of spatial planing allocation. Department of Forestry, Environment and mining in terms of mining and the environment through routine monitoring, and so forth. 3 .Hydropower uses the Run of River system, which means the water will keep flowing like a water cycle by making use of the river discharge completely so that no inundation water will occur. 4. This power plant will not be sold to PLN, but the energy is hydroelectric power produced is sold to PLN Because private parties may not sell; own power. 5. This power plant will not be granted to the public because of this power plant has a contract with PLN for 20 years and can be rolled back.

NO	NAME	INSTITUTION	COMMENTS / OPINIONS	ANSWER PT.BBE
7.	Kastro Manik	Head of Land Protection and Rehabilitation of Forestry, Environment and Mining	In the Pre-construction phase, there is a component of land acquisition activities, one of the impact it will have is a sense of dissatisfaction over the implementation of public release, how does that mean?	If hydropower is about the forest then the company would be willing to do revegetation broad area of 2x regulaation harvested in accordance with legislation, and for public land acquisition is done by consensus agreement.
8.	Berari Manik	Community leaders (Landowner)	At the pre-existing components konstrusi land acquisition activities, one of the impact it will have is a sense of dissatisfaction over the implementation of public release, how does that mean?	Public land acquisition process will be implemented by the land acquisition committee that will involve local community leaders and local government based on consensus. The company will provide a satisfactory compensation to landowners based on mutual agreement.
9.	Adios Veros Bancin	Head of Environment Department of Forestry, Environment and Mining	1.Generally, after completion of the project UKL and UPL less attention. Suggestion PT. BBE should implementing UKL and UPL perform their best.	1.UKL and UPL is an environmental document that is a major requirement for hydropower and as a follow-up PT. BBE will implement environmental management and monitoring activities on a regular basis in accordance with those set out in the document UKL-UPL with the best.

NO	NAME	INSTITUTION	COMMENTS / OPINIONS	ANSWER PT.BBE
			2. Order PT. BBE makes Statement of Commitment to UKL / UPL 3. So that water quality be maintained! 4.In order for waste management is done well 5.Saving watershed area of 15 hectares, in order to do so in the form of revegetation water flow required by the hydropower fulfilled.	2.Statement of ability to carry out the UKL and UPL is a condition of completeness so that will be complete. 3.Hydropower development is not going to change and generating the water quality pollution. 4.Hydropower does not produce of waste or B3 5. In order to maintain the discharge, it is necessary to the conservation of watershed areas. Conservation is the responsibility of the district government.
10.	Drs. Kadim Tumangger	Head of Mining Department of Forestry, Environment and Mining	1. These activities have a legal basis for such engagement letter with the authority to include the responsibility of each party 2. What extent Contribution of PT. BBE to the community?	1.Permit Principles and other documents in the construction of hydropower Lae Ordi II will be included in the appendix. 2.At this early stage of PT. BBE has not been much to contribute to society, however, we will seek care for hydropower Lae Ordi II to the surrounding communities
11.	Parulian Sinaga, S. Pd	Secretary of the Department of Perindakop	In order for the company to grant all requests from the public, mainly the surrounding communities.	Our suggestion would be carried out provided they do not conflict with existing rules.

Appendix L4-8
MOU on Local People Hiring
(Lae Ordi II Location)

NOTA KESEPAHAMAN KERJASAMA

Nomor Pihak Pertama : 0022 TAHUN 2009

Nomor Pihak Kedua : 0001/SPK/DU/BKR-MD/I/2009

Tentang
PEMBANGUNAN PEMBANGKIT LISTRIK TENAGA AIR (PLTA)
DI KABUPATEN PAKPAK BHARAT

Antara
PEMERINTAH KABUPATEN PAKPAK BHARAT
Dengan
PT. BAKARA BUMI ENERGI

Pada hari ini Selasa, tanggal dua puluh tujuh bulan Januari tahun dua ribu sembilan (27-01-2009), kami yang bertanda tangan di bawah ini;

1 H. Makmur Berasa : Bupati Kabupaten Pakpak Bharat Propinsi Sumatera Utara, yang berkedudukan di Salak, Kabupaten Pakpak Bharat, Propinsi Sumatera Utara, dalam hal ini bertindak untuk dan atas nama Pemerintah Kabupaten Pakpak Bharat, selanjutnya disebut sebagai **PIHAK PERTAMA.**

2 Don A. Mahjuddin : Direktur Utama PT. Bakara Bumi Energi, yang berkedudukan di Gedung Prince Center Building Lt. V R. 0501 Jl. Jend Sudirman Kel. Karet Tengsin, Kec. Tanah Abang Jakarta Pusat, dalam hal ini bertindak untuk dan atas nama PT. Bakara Bumi Energi, selanjutnya disebut sebagai **PIHAK KEDUA.**

PIHAK PERTAMA dan **PIHAK KEDUA** sepakat untuk membuat Nota Kesepahaman Kerjasama dalam hal Pembangunan Pembangkit Listrik Tenaga Air (PLTA) Lae Ordi II, yang memanfaatkan aliran Lae Ordi dari Desa Kecupak I melalui Desa Simerpara, Kecamatan Pergeteng-geteng Sengkut sampai Desa Majanggut II Kuta Liang, Kecamatan Kerajaan , Kabupaten Pakpak Bharat, Propinsi Sumatera Utara dengan ketentuan-ketentuan sebagai berikut :

PASAL 1
MAKSUD DAN TUJUAN

PIHAK PERTAMA dan **PIHAK KEDUA** mengadakan kesepakatan kerjasama untuk memfasilitasi pembangunan Pembangkit Listrik Tenaga Air (PLTA) Lae Ordi II, yang memanfaatkan aliran Lae Ordi dari Desa Kecupak I melalui Desa Simerpara, Kecamatan Pergeteng-geteng Sengkut sampai Desa Majanggut II Kuta Liang, Kecamatan Kerajaan , Kabupaten Pakpak Bharat, Propinsi Sumatera Utara.

PASAL 2
TUGAS DAN KEWAJIBAN

Dalam rangka kerjasama ini tugas dan kewajiban masing-masing Pihak adalah sebagai berikut :

a. PIHAK PERTAMA
- Memberikan Izin lokasi dan Izin Mendirikan Bangunan (IMB) Pembangkit Listrik Tenaga Air (PLTA) Lae Ordi II.
- Memfasilitasi pembebasan lahan untuk kebutuhan pembangunan PLTA tersebut di atas.

b. PIHAK KEDUA
- Pembangunan PLTA.
- Pendanaan

c. **PIHAK KEDUA** akan memberdayakan Sumber Daya Manusia Lokal sesuai dengan bidang dan kemampuan masing-masing.

d. **PIHAK KEDUA** akan memanfaatkan Sumber Daya Alam Lokal yang dibutuhkan sesuai dengan syarat-syarat dan spesifikasi.

e. Kontribusi **PIHAK KEDUA** kepada **PIHAK PERTAMA** mengenai hasil penjualan Energi dan lain-lain akan diatur lebih lanjut sesuai dengan kesepakatan dan ketentuan yang berlaku.

PASAL 3
MASA BERLAKU NOTA KESEPAHAMAN KERJASAMA

1. **PIHAK PERTAMA** dan **PIHAK KEDUA** sepakat bahwa Nota Kesepahaman ini berlaku 1 (satu) tahun dan dapat diperpanjang. **PIHAK KEDUA** harus sudah memulai kegiatan *(fisik maupun non fisik)* paling lambat 3 (tiga) bulan terhitung sejak Nota Kesepahaman Kerjasama ini ditandatangani oleh KEDUA BELAH PIHAK.

2. Selama masa berlaku Nota Kesepahaman ini, **PIHAK PERTAMA** tidak akan memberikan izin ataupun membuat perjanjian dengan pihak lain atas lokasi yang dimaksud di dalam Nota Kesepahaman ini.

PASAL 4
ENERGI YANG DIHASILKAN

PIHAK KEDUA akan menjual tenaga listrik yang dihasilkan dari proyek ini kepada PT PLN (Persero) Wilayah Sumatera Utara.

PASAL 5
KERAHASIAAN

KEDUA BELAH PIHAK sepakat untuk menjaga kerahasiaan dokumen-dokumen perizinan dan hanya menggunakannya untuk kepentingan sebagaimana tujuan dari Nota Kesepahaman ini, serta tidak akan memberikannya kepada siapapun tanpa persetujuan dari KEDUA BELAH PIHAK.

PASAL 6
PERUBAHAN

PIHAK PERTAMA dan **PIHAK KEDUA** sepakat bahwa setiap perubahan ketentuan dari kesepakatan ini hanya dapat dilakukan atas persetujuan KEDUA BELAH PIHAK yang akan dituangkan di dalam suatu Amandemen.

PASAL 7
LAIN-LAIN

Hal-hal lain yang belum diatur dalam Nota Kesepahaman ini akan diatur lebih lanjut sesuai dengan Peraturan Perundangan yang berlaku.

PIHAK KEDUA PT. BAKARA BUMI ENERGI DIREKTUR UTAMA	PIHAK PERTAMA BUPATI KABUPATEN PAKPAK BHARAT PROPINSI SUMATERA UTARA
BAKARA BUMI ENERGI, PT	6000 METERAI TEMPEL
DON A. MAHJUDDIN	H. MAKMUR BERASA

Appendix L4-9
Monitoring Form
(Lae Ordi II Location)

MONITORING FORM
for Lae Ordi II Mini Hydro Power Plant Project

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.

-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase) should be considered.

1. Pre-Construction Phase
1.1. Social Environment

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Status of Land Ownership		The project site	Once / every six months
Livelihoods / Incomes		The project site	Once during the surveys
Complaints of the Population		The project site	Once during the land acquisition process

2. Construction Phase
2.1. Water quality

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Turbidity		Location of the planned weir and irrigation channels	Once / every six months

2.2. Ecosystem

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Flora	Fill in the table below.	The project site	Once / every six months
Water Biota	Fill in the table below.	The project site and the nearest residential areas	Once / every six months
Disturbance of Wildlife	Fill in the table below.	The project site and the nearest residential areas	Once / every six months

If any endangered species are recorded, please fill in the table below.

(Date:)

Scientific name	Local name	English name	Total No.of individual	Conservation Status		Remarks
				IUCN	Local	

2.3. Topography and Geology

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Physiography		The project site	Once during the construction phase

2.4. Social Environment

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Demography / Social Interaction		The project site and the nearest residential areas	Once / every six months
Incomes of the Population		The nearest residential areas	Once / every six months
Livelihood / Incomes		The project site	Once / every six months
Public Facilities		Along the planned access road	Once / every six months
Community Complaints		Close by settlements along the river especially downstream of the project location	Once / every six months (Operation Phase)
Aesthetics		The project site	Once / every three month

3. Operation phase

3.1. Water quality

Location: settlement along the river especially downstream of the project location
Frequency of monitoring: Once / every six months (Operation phase)

Item (Unit)	Measured Value (Average)	Measured Value (Maximum)	Country's standard	Remarks(Method etc)
pH			Class I 6-9 Class II 6-9 Class III 6-9 Class IV 5-9	
Suspended matter			—	
BOD/COD			Class I 2/10 Class II 3/25 Class III 6/50 Class IV 12/100	
DO			Class I 6 Class II 4 Class III 3 Class IV 0	
Total Nitrogen			Class I 10 Class II 10 Class III 20 Class IV 20	
Total Phosphorus			Class I 0.2 Class II 0.2 Class III 1 Class IV 5	
Heavy metal			-	
Hydrocarbon / Mining Oil			-	

Phenols			-	
Cyanide			-	
Water temperature			Class I 3℃ Class II 3℃ Class III 3℃ Class IV 5℃	

3.2. Social Environment

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Safety and Security		The project site	Once / every six months (Operation phase)

3.3. Others

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Electrical Energy			

4. Post-Operation Phase

4.1. Social Environment

Monitoring items	Monitoring Results during Report Period	Locations	Frequency of monitoring
Land Use		The project site	Once during the implementation of activities
Livelihoods		The project site	Once during the termination of employee contracts

4.2. Noise

Item (Unit)	Measured Value (Average)	Measured Value (Maximum)	Country's Standard	Guidelines for Community Noise, World Health Organization (WHO), 1999	Remarks (Measurement Point, Frequency, Method, etc.)
Noise Level			55dB (Residence)	Daytime 07:00 - 22:00 55dBA Nighttime 22:00 - 07:00 45dBA	

Appendix L4-10
Environment Check-list
(Lae Ordi II Location)

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 been already prepared in 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) Y (b) Y (c) Y (d) N	(a) In case of Lae Ordi II Hydro Power Plant Project (hereinafter shown as "the Project"), UKL/UPL was required in accordance with the Indonesian law. (b)UKL/UPL for the Project was approved from Office of Forestry, Humbang Hasundutan district in September, 2012. (c)Following conditions are imposed on the approval of UKL/UPL for The Project: ①To maintain quality of water, ②To coordinate with the relative government, ③To monitor the environmental aspects, ④To prepare for inspection by the government. The Project proponent will report to the local government on compliance with these conditions regularly. (d)Subsequently to the approval of UKL/UPL, the Project proponent is going to apply for the Permit for Land Use.
	(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 comment from the stakeholders (such as local residents) been reflected to the project design?	(a)Y (b)Y	(a)Public consultations were held three times (The first: unknown, The second: 18 July 2009, The third: 27 June 2012). Agreement with affected households has been already obtained. UKL/UPL was disclosed to Bupati and house of representatives. (b)The local people's attitude toward the Project is basically positive. Since local people request electric power supply to the local community, the Project proponent will supply 10% of electricity generated to the local community.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a)Y	(a) In Indonesian Laws there are no obligations to consider alternative plan in the UKL/UPL procedure. But Geographical conditions, local people's residence including rice fields were considered at the planning stage. Although siphon type was considered as alternative, siphon was avoided because siphon is physically weaker than waterway.
2 Pollution Control	(1) Water Quality	(a) Does the water quality of dam pond/reservoir comply with the country's ambient water quality standards? Is there a possibility that proliferation of phytoplankton and zooplankton will occur? (b) Does the quality of water discharged from the dam pond/reservoir comply with the country's ambient water quality standards? (c) Are adequate measures, such as clearance of woody vegetation from the inundation zone prior to flooding planned to prevent water quality degradation in the dam pond/reservoir? (d) Is there a possibility that reduced the river flow downstream will cause water quality degradation resulting in areas that do not comply with the country's ambient water quality standards? (e) Is the discharge of water from the lower portion of the dam pond/reservoir (the water temperature of the lower portion is generally lower than the water temperature of the upper portion) planned by considering the impacts to downstream areas?	(a)Y (b) - (c) - (d)N (e) -	(a)With reference to Government Regulation Number 20 of Year 1990 concerning Water Pollution Control, the Lae Ordi River can be categorized as a class D, river used for agricultural, urban business, industrial and hydropower purposes. According to survey result, there are no items which exceed the "Class D" standard. (b)There is no discharge water quality standard. (c) NOT APPLICABLE (d) Since the river channel including reduced flow river caused by diversion is steep, narrow and surrounded by rocks, it is hard to occur stagnant area even if the water level of the river is lowered. So adverse impacts on water quality is not expected. (e) NOT APPLICABLE

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Wastes	(a) Are earth and sand generated by excavation properly treated and disposed of in accordance with the country's regulations?	(a)Y	(a) All earth and sand generated by excavation will be used for backfill and mounding at the Project site in accordance with the local regulation.
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)N	(a) The project area is not located in protected area. Forest reserve is located upstream of the project location. Ecologically, these forests serve as water catchment areas. According to information from the Forest Office of Humbang Hasundutan District, the forests in this area belong to the category protected forest and there are no activities that utilize forest resources. Rare or protected vegetation species were not found.
	(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) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that installation of structures, such as dams will block the movement of the migratory fish species (such as salmon, trout and eel those move between rivers and sea for spawning)? Are adequate measures taken to reduce the impacts on these species?	(a)N (b)N (c)N (d)N	(a)The area around the Project sites have been largely cultivated into planted rubber tree forests, corn fields, rice fields and other crop fields such as coffee farm. Shrubs have also developed in abandoned rubber tree forests and crop fields. The high tree forests, which are planted forests or secondary forests, distributes only on the steep narrow slope along Ordi River, or at much higher altitudes than the residential area. There are no ecologically valuable habitats in the Project site. (b)According to UKL/UPL, Government Regulation No.7 and the result of field survey (Jun, 2012), no endangered species designated by Indonesian law or international treaties are confirmed. (c) It is considered that the river is not suitable for inhabitation of fishes since the river channel is steep and rock bed. At driving channel, culverts and covers will be installed to prevent collapse at crossing point of forest road. They are effective to avoid migration inhibition of small animals. (d) No migratory fish is confirmed in and around the Project site.
	(3) Hydrology	(a) Is there a possibility that hydrologic changes due to the installation of structures, such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)?	(a)N	(a) Impacts on surface water flow will be minimized by proper installation of culvert at the driving channel. Adverse impacts on groundwater flow are also not expected because the driving channel has 2.6 meters depth.

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Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(4) Topography and Geology	(a) Is there a possibility that reductions in sediment loads downstream due to settling of suspended particles in the reservoir will cause impacts, such as scouring of the downstream riverbeds and soil erosion? Is there a possibility that sedimentation of the reservoir will cause loss of the storage capacity, water logging upstream, and formation of sediment deposits at the reservoir entrance? Are the possibilities of the impacts studied, and adequate prevention measures taken? (b) 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)?	(a) - (b)N	(a) NOT APPLICABLE (b) Since the hydro power plant and the weir are constructed utilizing rock beds, adverse impacts on geological features. The driving channel that has 2.1m width and 2.6m depth is open channel. Measures to prevent collapse will be installed at driving channel in steep areas. The water tank will be constructed utilizing flat plateau. The pipeline will be constructed on ground surface of slope land. Because of these things, adverse impacts on geological features are not expected.
	(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 on 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? (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 the grievance redress mechanism established?	(a)N (b)Y (c)- (d)- (e)Y (f)- (g)- (h)- (i)- (j)Y	(a)Land Procurement and spatial plan at the project site is approved by local government and national government. A total of 15 land owners are involved. However, to simplify the land acquisition process representatives from each village have been appointed at a total of seven with names of land owners, size of land and status of land. The resettlement by the Project does not occur. All land owners affected by land acquisition received compensation. (b) Public consultations were held two times. (c) The resettlement by the Project does not occur. In Indonesian Laws there are no obligations to prepare the resettlement plan. (d) The resettlement by the Project does not occur.All land owners affected by land acquisition received compensation. (e) The Project proponent prepared the document for compensation agreement called “Documen Pembebasan Lahan PLTA LAE ORDI II”. (f) NOT APPLICABLE (g) The resettlement by the Project does not occur. The document for compensation agreement called “Documen Pembebasan Lahan PLTA LAE ORDI II” for 15 people of affected landowners was prepared. (h) NOT APPLICABLE (i) NOT APPLICABLE (j) The Project proponent will establish grievance mechanism for the Project.

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Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(2) Living and Livelihood	(a) Is there any 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 any possibility that the project causes the change of land uses in the neighboring areas to affect adversely livelihood of local people? (c) Is there any possibility that the project facilities adversely affect the traffic systems? (d) Is there any possibility that diseases, including infectious diseases, such as HIV, will be brought due to the immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (e) Is the minimum flow required for maintaining downstream water uses secured? (f) Is there any possibility that reductions in water flow downstream or seawater intrusion will have impacts on downstream water and land uses? (g) Is there any possibility that water-borne or water-related diseases (e.g., schistosomiasis, malaria, filariasis) will be introduced? (h) Is there any possibility that fishery rights, water usage rights, and common usage rights, etc. would be restricted?	(a)N (b)N (c)N (d)N (e)N (f)N (g)N (h)N	(a)No adverse impacts on the living conditions of inhabitants are expected. Positive impacts by the project are employment of local people, road maintenance, tax income, promotion of local economy and so on. The Project proponent is going to employee local people, about 10-20 during operation phase and about 300 during construction phase.10% of electric power generation will be supplied to local communities. (b)Since the Project does not involve construction of any other off-site facilities including newly constructed roads, adverse impacts on geological features are not expected. (c) There is no transportation on the water since the river channel is steep around the Project area. In addition, it is hard for local people to access the Project site easily since the landform around the Project site is steep. At driving channel, culverts and covers will be installed to prevent collapse at crossing point of forest road. So adverse impacts on existing traffic systems are not expected. In addition, access road maintenance will be conducted by the Project proponent as CSR. (d) The Project proponent is going to make efforts to education and health supervision for all workers concerned. (e) the minimum flow will be maintained. (f)There is no use of the river water at reduced flow river caused by diversion and downstream. (g)There is no possibility of water quality deterioration such as appearance of stagnant area, and there is no river water use in the downstream. So the increase of possibility that water-borne or water-related diseases are introduced is not expected. (h) There is no irrigation system affected by the Project. There is no activity of finishing around the Project site
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)N	(a) There are no scenic areas within and around the Project site. In case those archaeological remains are found during construction, the Project proponent will deal with them appropriately in accordance with the Indonesia regulations.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)N	(a) There are no scenic areas within the Project site. There is a waterfall with a fall of approximately 10m called Ordi fall upstream of the weir. The fall location is outside of the project site. The fall will not be affected by the project.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations 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 to be respected?	(a)N (b)N	(a) , (b) There are no living areas of indigenous people and valuable places for indigenous people in the vicinity of the Project site.

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Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(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 not to violate safety of other individuals involved, or local residents?	(a)Y (b)Y (c)Y (d)Y	(a) The Project proponent will comply with all Indonesian regulations and laws regarding working conditions. (b) Protective fence and safety signs will be installed in the Project site.(c) The Project proponent will provide education about health and safety and about social considerations to all workers.(d) The Project proponent will employ local people preferentially. The Project proponent will direct workers from other areas to pay respect to local culture.
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 the impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?	(a)Y (b)N (c)N	(a) In order to mitigate impact during construction, the Project proponent will minimize the amount of works, and avoid working in pluvial period. (b)The Project site is located in secondary forests and crop fields. In addition, geography around the Project site is steep. So adverse impact on natural environment is not expected. (c)The Project proponent is going to make efforts to education for all workers in order to mitigate impacts during construction. During construction phase, the Project proponent is going to hire some land in Salak Town for office and also stocking materials to manage negative impact and positive spreading effect on the local community. The impact caused by vehicles during construction will be considered.

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Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Accident Prevention Measures	(a) Is a warning system established to alert the inhabitants to water discharge from the dam?	(a) -	(a) NOT APPLICABLE
5 Others	(3) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish 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?	(a)Y (b)Y (c)Y (d)Y	(a)Monitoring by the Project proponent is planned as following: ・ Pre-Construction Phase：Social environment ・ Construction Phase：Physiography, Water quality, Ecosystems, Social environment etc. ・ Operation Phase： Water quality, Electrical Energy, Social environment ・ Post-Operation Phase：Social environment (b)Methods and frequencies of the monitoring items above are established in UKL/UPL. (c)On an annual basis, the management of the Project will allocate funds for cost of environmental management, monitoring, and reporting. (d)UKL/UPL establishes that the Project proponent must report results of environmental management and monitoring to following organizations every 6 months. • Governor of North Sumatra Province, c.q. Head of Bapedal of North Sumatra Province. • Head of West Phakpak District through the Offices of Forestry, Environment and Mining of West Phakpak. • Office of Industry and Trade of West Phakpak District.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects in the mountains including large areas of deforestation). (b) In the case of dams and reservoirs, such as irrigation, water supply, and industrial water purposes, where necessary, pertinent items described in the Agriculture and Water Supply checklists should also be checked. (c) 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).	(a) - (b) - (c) -	NOT APPLICABLE
	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) -	NOT APPLICABLE

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 requested 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.