PRE-FEASIBILITY STUDY

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PART 3 BU SRA ELECTRIFICATION PLAN

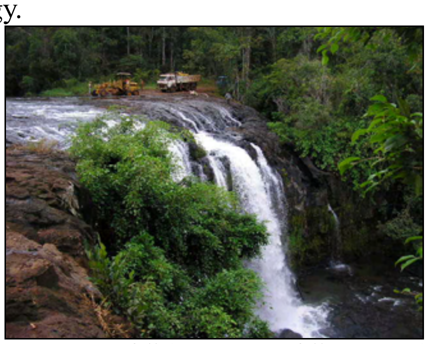
1 INTRODUCTION

1.1 OUTLINE OF THE STUDY AREA

The study area, Bu Sra commune is located in Pecher Chenda district in Mondul Kiri province. The Pecher Chenda district is consists of four (4) communes. Bu Sra Commune has seven (7) villages, and its population is 3,395 (Seila, 2004) as a whole. The commune is located approximately 45 kilometres distant from the provincial town and in close proximity to Vietnam. The road condition towards the waterfall intended to promote tourism has been improved recently, yet during the rainy season, the accessibility become worse even by 4 wheel motor vehicles.

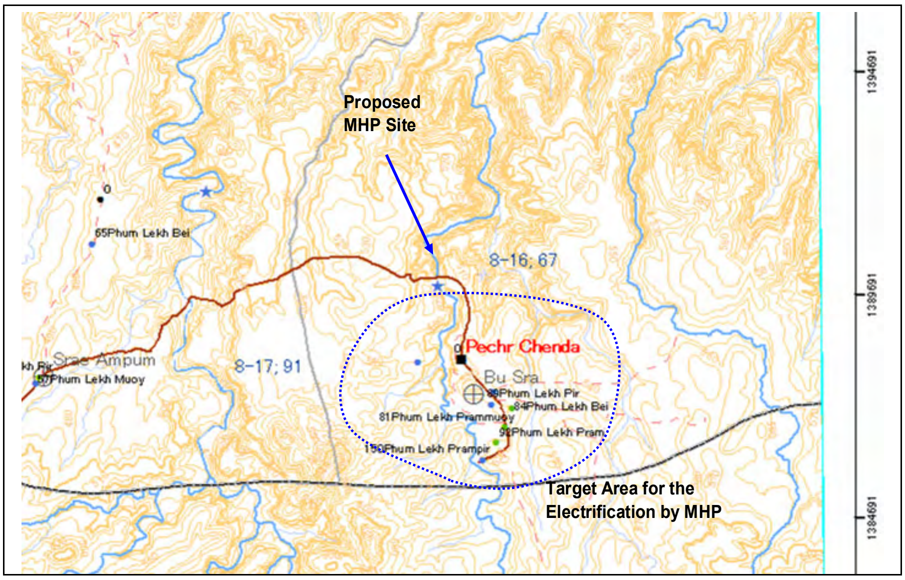
Bu Sra micro hydropower (herein after called MHP) scheme will be used Bu Sra water fall that has a total 65m of gross head and the catchment area is at 197 km^2 at the Preak Poun River (or Prek Por) in the Sre Pok River basin. The Bu Sra commune center is about 3 km upstream from the Bu Sra waterfall. The waterfall has two-stages, the first (upper) stage was measured at 23m and second (lower) stage was estimated at 42m. Hence total head is at 65m. At around upstream of the upper waterfall, it is able to across the river by motor vehicles in the dry season. However in the rainy season; it is difficult to path over the river even by 4-wheel motor vehicles. There is a wooden bridge, which is located at around 70m upstream from the lip of upper waterfall. The existing wooden bridge is not passable by a vehicle.

The Bu Sra waterfall is an important tourism spot in the area. Some tourists including foreigners usually visit the waterfall only in a daytime and they will return to Sen Monorom town. If the proposed Bu Sra MHP scheme will utilize river the water mainly in the night time, the impact on the tourism will be reduced. It has to be noted that the project site area is located in a Bio-diversity Conservation area. Various necessary mitigation measures shall be taken to avoid potential negative impacts to the wildlife and ecology.



Bu Sra Waterfall (Upper waterfall, H = 23m)

Bu Sra Waterfall (Upper waterfall, H = 23m)



Source: JICA Study Team

Figure 3.1 Project Area of Bu Sra MHP Scheme

1.2 OUTLINE OF THE PROPOSED BU SRA MHP SCHEME

Proposed MHP scheme will consist of an intake weir for the river channel regulation pond and intake mouth placed on right bank at approximately 80m upstream from the lip of upper waterfall. From the intake a buried low-pressure conduit will convey the power flow to a buried pipe line. About 330m long low-pressure pipe line by the HDPE pipe will be laid underground at the right bank flatlands. The pipe line will discharge into a penstock through a head tank that connects to the turbines located in the powerhouse. The power house will be located at the base of waterfall about 55m downstream from basin of the lower waterfall. The right bank is chosen as it allows access by operators during times of flood. The low-pressure pipeline length would be in the order of 330m, the penstock length would be about 154m. Summary of the proposed Bu Sra MHP scheme is shown the below.

Table 3.1 Summary of the proposed Bu Sra MHP scheme

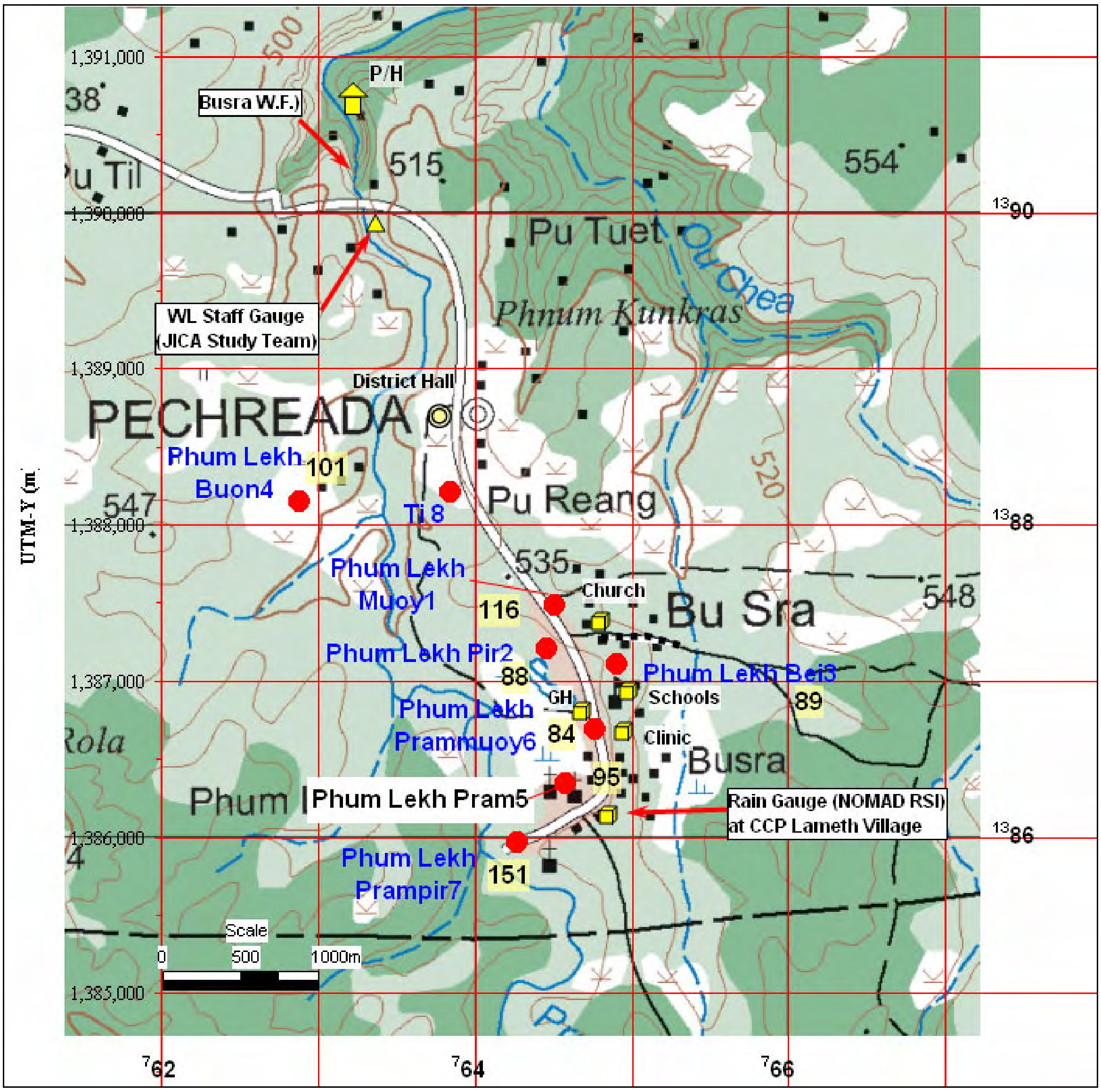
Location	Monul Kiri province, Pecher Chenda district, Bu Sra commune, 7 vilages in Bu Sra commune (based on the classification by Seila database)
Households, Population	Total in Bu Sra commune, 724 families, population = 3,395 (Seila, 2004), 577 households (AAH,2002), Projected 955 households (2020, estimated by JICA Study Team)
Power Demand	Peak = 80 kW, Electrified household (plan) = 936 HHs (2020)
River, Basin	Bu Sra waterfal,l, Preak Poun River, Sre Pok River Basin, Catchment area = 197 km^2
Gross Head	Gross Head = 64.09 m (Intake WL = El. 490.67 m, Center of Turbine = El. 426.58 m), Effective Head = 61.84m
Hydro Power	Installed Capacity of MHP = 80kW, Design Plant Discharge = 0.188 m^3/s, Annual Enegy Production = 260MWh/yr
Measure Facilities	Intake for river channel regulation weir (approx.80m u/s for upper w.f. top., concrete structure, H = 2.5m, W = 20m, effective res. capacity = 3,990 m^3), Intake mouth (near the wieir), Headrace water channel (HDPE pipe, L 30m), Head Tank, Penstock [prresured pipe, HDPE pipe, L=154m), Spillwa, Powerhous (Cross-flow Turbine/Generator 40kVA x 2), Tailrace
Distribution Facilities	Medium Voltage Line (22kV, AAC) = 9.1 km, Low Voltage Line (LV, ABC) = : 10.9 km (MV & LV utilise same pole = 8.1 km)
Direct Cost	Direct Cost = 534,000 US$, (MHP : 363,000 US$, T/L&D/L = 170千ドル)
Project Cost	661,000 US$
Economic & Finalcial Analysis	EIRR = 12.6%, Tariff (50% subsidy) = US$ 0.16 /kWh, FIRR＝7.1%, GHG reduction = 5,900 t-CO_2 (20 years)

Source: JICA Study Team

2 SOCIO-ECONOMIC SITUATION IN THE STUDY AREA

2.1 BASIC INFORMATION ON BU SRA

Bu Sra Commune has seven villages as shown in the figure below, and its population is 3,395 as a whole. The population consists of 92 % Phnong minority and the rest 8 % Khmer and a few migrants from Vietnam are reported. The households are located along the main road except the Phum Lekh Buon village located on the other side of the river. Considerable number of ethnic minorities lives on the fringes of the communities.



Source: Prepared by JIJCA Study Team based on SEILA database and NIS data.

Figure 3.2 Village Location Map of Bu Sra Commune

Name of villages, location, households and population data of the each village in Bu Sra commune is shown in Tables 3.2 and 3.3. There are two kind of statistical data in Cambodia which is "households" and "families". The SEILA database used families. Due to some families are living together in same house, the number of families is larger than the households. Number of households was used for the power demand forecast in this study.

Table 3.2 Name and the Location of Villages in Bu Sra Commune

Village Code	Village Name			Location	
	by SEILA	by Commune	by Meritec Study, 2003	UTM-X	UTM-Y
11040401	Phum 1 Lekh Muoy	Putuet	Pum Bun Duth (Bun Tit)	764,510	1,387,481
11040402	Phum 2 Lekh Pir	Pureang	Pnm Rang	764,459	1,387,201
11040403	Phum 3 Lekh Bei	Busra	Pnm Busra	764,908	1,387,108
11040404	Phum 4 Lekh Buon	Putil	Pum Pu Tham (Bu Til)	762,878	1,388,151
11040405	Phum 5 Lekh Pram	Lames	Pum Lam Bak	764,575	1,386,344
11040406	Phum 6 Lekh Prammuoy	Buja	Pum Pu Char	764,766	1,386,686
11040407	Phum 7 Lekh Prampir	Pulu	Pum Sara Ba (Bu Luk)	764,273	1,385,962
11040408	(Phum 8)		Pum T'mai (Leng Choung) (new village)	763,848	1,388,210

Source: SEILA database, NIS census, Meritec study.

Table 3.3 Number of Families, Households and Population in Bu Sra Commune

Village	1998 National Census			2002 AAH Census			2003 SEILA Database			2004 SEILA Database			2005 JICA Study Team		
	Family	House holds	Popu- lation	Family	House holds	Popu- lation	Family	House holds	Popu- lation	Family	House holds	Popu- lation	Family	House holds	Popu- lation
Phum 1	n.a.	63		n.a.	86	352	108	n.a.	469	116	n.a.	483	116		489
Phum 2	n.a.	43		n.a.	79	330	89	n.a.	415	88	n.a.	480	88		480
Phum 3	n.a.	44		n.a.	67	293	84	n.a.	391	89	n.a.	398	92		394
Phum 4	n.a.	29		n.a.	48	170	100	n.a.	482	101	n.a.	493	101		428
Phum 5	n.a.	60		n.a.	79	320	92	n.a.	425	95	n.a.	462	95		462
Phum 6	n.a.	47		n.a.	71	315	81	n.a.	385	84	n.a.	391	84		396
Phum 7	n.a.	67		n.a.	107	474	150	n.a.	658	151	n.a.	688	151		678
Phum 8	n.a.	26		n.a.	40	171		n.a.			n.a.				
TOTAL		379			577	2,425	704		3,225	724		3,395	727		3,327
Annual Growth (%)					11.1%				33.0%	2.8%		5.3%	0.4%		-2.0%

Source: 1998 National Census, Water Needs Assessment, Mondul Kiri Province (2002), Action Against Hunger (AAH).
SEILA Database (2003 & 2004), and JICA Study Team (Nov., 2005)

2.2 CURRENT HOUSEHOLD SITUATION IN BU SRA FOUNDED BY THE SOCIOECONOMIC SURVEY.

The economic situation with details of the energy usage of the households and willingness to pay for electricity service in the Bu Sra was shown by the socio-economic survey conducted under this study, where 50 sample households in the two villages (Phum Lekh Bei and Phum Lekh Muoy) are interviewed.

2.2.1 Household Economy

(1) Major Income Sources (%)

The first main sources of income are agriculture consisting more than 80% and fishery follows. The livestock and forestry (for collecting non-timber forest products) are the secondary source of income. A few families earn by seasonal labour, midwife, and from private business and salary from NGO.

(2) Land Ownership and Assets

Irrigated paddy land owner is limited to 26 %. Majority of the households depend on the non-irrigated farmland. More than 90 % households own their home lot. 40 % of households own motorbike, besides that less than 10 % own s tractors, bicycle and generator.

Table 3.4 Major income sources (%)

Income Source	Primary	Secondary	Tertiary
Agricultural produce (crops)	90.0	4.3	
Livestock & poultry	-	47.8	26.9
Forestry (timber non-timber forest products	2.0	28.3	34.6
Rice/corn milling	2.0	-	-
Repair shop	-	2.2	-
Bakery/ grocery	2.0	-	-
Salary from private business/ NGO	-	2.2	-
Salary from public service	4.0	10.9	11.5
Wage from seasonal labor	-	4.3	26.9
Total	100.0	100.0	99.9

(3) Monthly Expenditure (Riel)

The survey showed the distinct features of disparity in the community. It represents some-business-owned-richer-households along the main road can spend more than 250 US $ per month, while 70 to 80 percent of the villagers merely spend less than US$50.

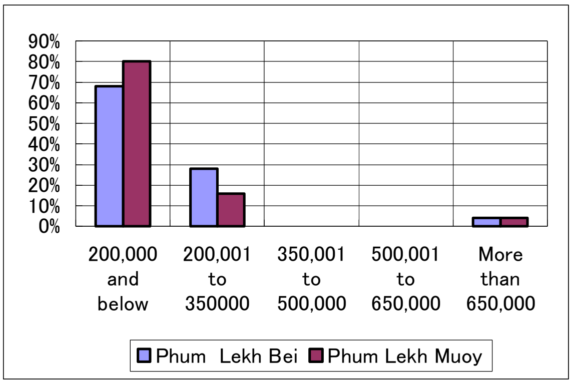


Figure 3.3 Monthly expenditure (Riel)

(4) Household Monthly Expenses by Items (Riel)

The detail items of expense were shown in the table below. While 100 % respondents spend money for food, those who could save money are still minor as 12 %. The poorest spends merely 3,000 Riel (less than a dollar) which represents subsistence economy by barter non-timber forestry products for food and other necessary expenses.

Table 3.5 Household monthly expenses by items (Riel)

Expense item	n	%	Minimum	Median	Maximum
Food	50	100.0	1,000	47,500	600,000
Clothing	11	22.0	2,000	10,000	100,000
Child care	15	30.0	2,000	5,000	60,000
Education	12	24.0	500	5,500	40,000
Medical treatment/medicines	32	64.0	1,000	30,000	200,000
Transportation	8	16.0	3,000	10,000	60,000
Amusement/recreation	19	38.0	2,000	10,000	60,000
Fuel for lighting/cooking	43	86.0	2,000	3,000	300,000
Personal care	46	92.0	500	4,000	15,000
Payment of debt/loan	2	4.0	25,000	37,500	50,000
Saving	6	12.0	30,000	100,000	100,000
Total expenses of each samplehousehold	50	100.0	3,000	116,500	835,000

(5) Credit and Savings

Approximately 80 % of respondents experienced to obtain loans, yet mostly they borrowed from the relative and friends as few money lenders exists and virtually no organization for credits and saving activities exists. Almost 90 % of the respondents don't save regularly and those who save are just put money at home.

2.2.2 Current Situation of Energy Use and Needs

(1) Energy Usage

For lighting source, it is regarded that kerosene is still widely used as 70 % of respondents own. On average, they spend 3,500 Riel per month and normally uses 4 hours a day and owned 1.4 lamps. Car batteries are owned by 30 % and recharged 3.47 times and spent 6,400 Riel per month.

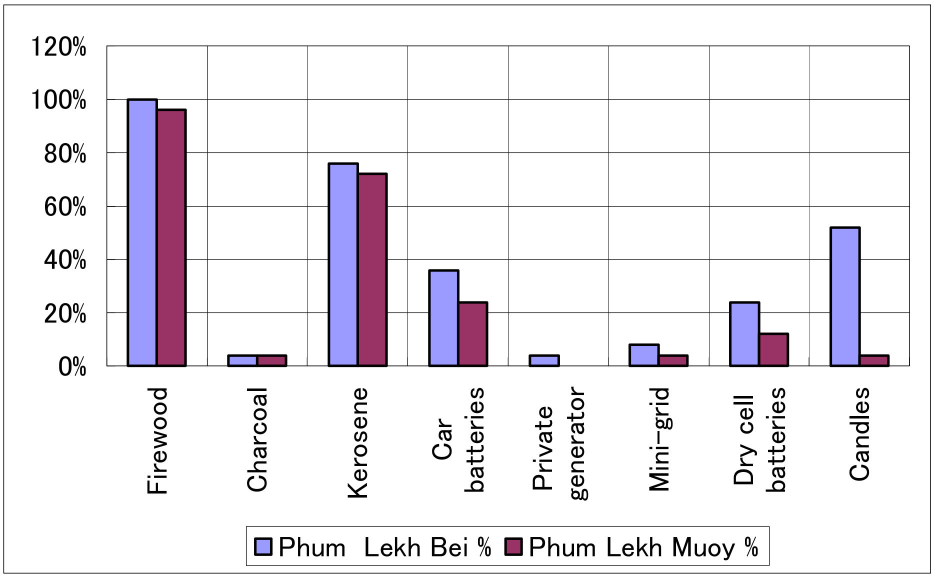


Figure 3.4 Energy Usage in Bu Sra Commune

(2) Current usage of Major Lighting Sources, Kerosene and Battery

Yet, the majority (10 out of 16) of the car batteries are 6V type for hunting purpose. Although the fuel costs is relatively inexpensive compared to other region due to the border trade, the cost of car battery is higher in the area. It is observed that some use both kerosene and car batteries for lighting sources. It is noted that a few mini-grid system is operational in the Commune although the number of households connected are 5 or less than 10. The simple fixed tariff system was used. However, due to recent high price of diesel, the survey team found out that the system is not regularly operated. One BCS also exists in the commune. These households may overlap, but they are the potential large users in the commune.

Table 3.6 Current Usage of Major Lighting Sources, Kerosene and Car Battery

Kerosene (N. of users:37, share 74%)		Car battery (N. of users:15, share 30%)	
Cost of kerosene per liter		Number of baterries owned /household	
Mean	2,322	Mean	1.2
Standard Error of Mean	45.05	Standard Error of Mean	0.11
Minimum	2,000	Minimum	1
Maximum	3,000	Maximum	2
Monthly consumption		Recharging timesper month	
Mean	1.54	Mean	3.47
Standard Error of Mean	0.13	Standard Error of Mean	0.42
Minimum	1	Minimum	1
Maximum	4	Maximum	8
Monthly expenses		Monthly expenses for recharging	
Mean	3,562.16	Mean	6,400.00
Standard Error of Mean	320.83	Standard Error of Mean	2,202.92
Minimum	2000	Minimum	1,000
Maximum	10,000	Maximum	28,000

Table 3.7 Share and Cost Car Battery

Type of battery	Number	Share	Cost of battery
12 Volt - 100 Ah	–	0%	–
12 Volt - 70 Ah	1	7%	130,300
12 Volt - 50 Ah	5	33%	83,000
6 Volt - 5 Ah	10	67%	25,000

(3) Present Ownership and Future Demand of Electric Appliances

Those who own the electric appliances are still small as approximately 20%. VCD, Karaoke are popular appliances for gene-set owner, yet many still needs the lighting source. After electrification, therefore, 95% respondents will buy lighting followed by fan and rice cookers. Electric water pump, TV and VCD are also in demand.

Table 3.8 Present Ownership and Future Demand of Electric Appliances

APPLIANCE	Currently owned		Want to buy	
	n	%	n	%
Electric lighting	10	20.4	47	95.9
Electric rice cooker	-	-	27	55.1
Television (color)	5	10.2	24	49.0
Television (black and white)	1	2.0	8	16.3
Video (VHS/VCD)	5	10.2	21	42.9
Radio/radio cassette	1	2.0	16	32.7
Electric fan	1	2.0	35	71.4
Electric water pump for drinking/household	3	6.1	25	51.0
Electric water pump for irrigation	-	-	7	14.3
Iron	1	2.0	12	24.5
Refrigerator	-	-	6	12.2
Washing machine	3	6.1	4	8.2
Video game	-	-	1	2.0
Karaoke	3	6.1	2	4.1
Grain/cereal/meat grinder	-	-	4	8.2
Others	-	-	-	-
Water pump for washing moto	-	-	-	-
Motor for wood plane	-	-	2	100.0
Sewing machine	-	-	-	-
Electrical pot	-	-	-	-

2.2.3 Economic Activities

The Bu Sra commune mainly produces rice and some beans and vegetables for their own consumption. Some Khmer families have started to plant cash crops such as coffee and pepper, yet the production is still limited. Swidden agriculture is commonly practiced together with rice cropping in the low and irrigated areas. Non-timber forestry products such as raisin are sold to the Khmer merchants.

Rice / corn milling is the only industry existed other than grocery stores, guest houses, repair shops and carpenters. No market exists in the commune. All these local industries are powered by the diesel generator sets.

The famous tourist spot of the Bu Sra waterfall has not stimulated the local economy although the tourists in the Mondul Kiri province have been sharply increased according to the Department of Tourism. Craft making such as traditional baskets and scarf are not organized and nor sold locally for tourists. In the same manner as non-timber forestry products, the marketing are more or less relied on the Khmer merchants.

Table 3.9 Number of Tourists arrived in Mondul Kiri

Number of tourists arrived in Mondol kiri		
Year	Domestic	International
2000	85	213
2002	366	563
2004	8295	1058

2.2.4 Willingness and Ability to Pay for the Electricity Services

(1) Willingness to Pay for Initial Connecting Fees

While the beneficiary-payment principle was reiterated in the workshop, the some group of commune members represented by Phnom Commune chief showed great hesitance on paying more than US$20 for the initial cost. Merely 30 % or fewer respondents showed willingness to pay more than US$40. Having understood that external support won't reach to the commune without sufficient number of beneficiaries including marginal households, the Khmer business person provided ideas of direct employment service for their business in order for the poor to save cash. There is no formal credit association for mutual benefit but moneylenders who normally put extremely high interest rates in the area. Special attention needs to be paid that self-financing for the electricity service will not exacerbate their asset base and not increase their vulnerability.

(2) Willingness to Pay for Monthly Tariff for the Electricity

Since many households consume kerosene and charging car batteries within the range of US$ 1 to 2, those who responded can pay monthly tariff less than US$2 are majority. It is noted that there are considerable number of households who regards electricity is still expensive.

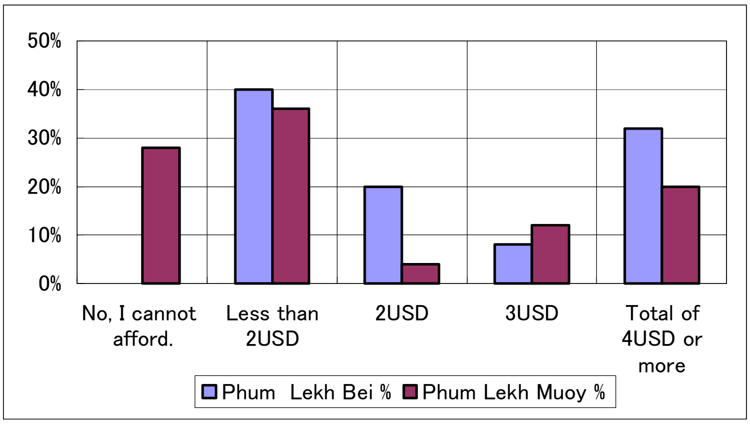


Figure 3.5 Willingness to Pay for Monthly Electricity Tariff

(3) Expected Demand for the MHP

According to the interview regarding the possible businesses that can be started if households are electrified, 30 % showed interest in starting the store, followed by not engaged any (20%), furniture making (12 %), rice/ corn milling (10%). The daytime demand can be expected for these purposes. Besides the household demand which is targeted to 80 % of the total 724 families, the demand from the public utility offices such as schools (2 primary, 1 lower secondary, and 1 health posts, 1 commune centre) will be included.

(4) Appropriate Tariff for the Village for Sustainable Operation

As described in 1.2, the tariff needs to reflect the disparity among the ethnic composition. Tariff for basic needs have to be prepared in order to expand the service areas.

2.3 DEVELOPMENT PLAN AND THE PRESENT DEVELOPMENT EFFORTS (COMMUNITY ACTIVITIES)

There is no specific commune development plans existed, yet development activities are currently executed under the some NGOs and Seila Commune Development Program. The organizations organized by the provincial departments are the water users group, community forestry / fishery association, rice seed bank, health management committee. The Commune also organized a pagoda committee, yet there are Catholic, and Protestant in the area. Self-help groups and informal labour exchange groups are also reported to exist. No credit and saving activities are available in the area.

Table 3.10 Commune Priority Plans for Integrating into Agenda of District Integration Workshop in 2005

No.	Project's Name	Type	Outputs	Budget Estimate (Riel)
Economic Sector				
1	Red road repair	Rural transportation	10300 m	325,480,000
2	Bridge construction		2 places	49,833,334
3	Drainage construction		13 places	45,154,642
4	Dam construction	Irrigation	200x8x5+3	42,000,000
5	Pumping machine		7 units	19,600,000
6	Cow raising	Agriculture	14	16,800,000
7	Buffalo raising		14	16,800,000
8	Pipe		10300 m	41,200,000
9	Machine		7 units	2,800,000
10	Rice seed		700 kg	5,600,000
11	Ko Yon (motor cart)		7 units	39,200,000
12	Mango seed		700 kg	2,100,000
13	Durian seed		2172	13,032,000
14	Rambutan seed		2172	13,032,000
15	Coconut seed		2172	13,032,000
Social Development Sector				
1	Dig hand wells	Clean water supply	31 units	194,804,000
2	Dig deep wells		22 units	88,000,000
3	Water-cleaning basket		724 units	14,480,000
4	Education on health care for women and baby	Health	12 times per year	1,200,000
5	Educate pregnant women on birth giving		12 times per year	1,200,000
6	Train parents on importance of education	Education	2 courses per year	2,000,000
7	Latrine construction	Hygiene	724 units	1,448,000,000
8	Provide nutrition to vulnerable people	Social work	159	4,800,000
9	Visit vulnerable people		2 times	2,400,000
Environment Sector				
1	Establish forest protection community	Natural Resources Management	1 group	2,400,000
2	Set up micro-hydro system for electricity		1 place	12,000,000
3	Promote environment law		2 times per year	2,400,000

Source: Provincial Planning Department
Note that these project items are merely prioritized, not yet budgeted.

The earth road construction is top priority in the commune, followed by electricity service, irrigation, water pumping system, health services and communication services. Seila program tried to support the vast needs of the respective communes, yet its technical and financial capacity could not support the electricity project. Thus, the fund so far, allocated for road, health, water program, and so on. The following table shows the prioritized projects planned by the commune. During the District Integration Workshop held at the end of the year, commune members assessed the feasibility of electricity project since allocated fund is limited. The commune acknowledged that villagers' financial and labour contribution is prerequisite.

The Bu Sra Commune, as it was surveyed by the World Bank consultants previously, well recognized their potential of hydro power and showed great expectation. They tried to prioritise the electricity project under the Commune Development Plan and tried to allocate the commune fund provided by the authority for the electricity. Having understood the allocated fund, which accumulated to 40 million Riel (approximatelyUS$9,000) was not adequate to cover the whole cost for MHP and no technical support available locally, the commune expects the external assistance both financially and technically. According to the Commune, the road construction has been prioritized for funding as this is the major constraints for the development. Nonetheless, electricity is second most important service needed, they would like to utilize the allocated Commune Investment Fund for supplement the MHP project once external technical and financial support are confirmed.

The commune has small experiences of collective works among the villagers except for the NGO led activities of sanitary and education. The below table is the summary of the existing activities in Bu Sra.

Table 3.11 The Assisted by International NGOs and Consultants for Implementation and Monitoring.

	NGO Name	Sector – Description of work
1	Nomad Researche et Soutien International	Health -3-year project Community Malaria Education Project, from 2005 to 2007. Conduct research on malaria in the commune and the project will establish a drama team in order to provide education on malaria to local people so as to prevent malaria transmission in the commune.
2	Health Net International	Health - improving public health especially at the health center
3	International Cooperation Cambodia (ICC)	Education/ Literacy- Working on Non-Formal Education and Veterinary medicine
4	Cambodia Family Development Services (CFDS)	Information - focuses on community information dissemination, including agricultural and health information
5	Action Contre La Fiam (ACF)	Health - Working on water sanitation
6	Strei Santepheap Daoembey Parethan (SSP)	Support the Rights of Ethnic Group for Participatory Development, starting from 2004 by setting up networks with ethnic communities. Its main objectives are to help the minority group understand deeper on their own roles, to establish community forestry for environmental maintenance, and to empower women's capacities.
7	World Wide Fund for Nature (WWF)	Environment and wild life protection - focuses on protection of wild-life from hunting/ trapping and prevention of forest clearance
8	Association for Development and Human Rights of Cambodia (ADHOC)	Human rights - Focuses on advocacy, awareness raising and protection of human rights

Source: JICA Study Team

2.4 RESULT OF WORKSHOP

2.4.1 Outline of Workshop

A workshop was conducted in Bu Sra Commune. The outline is shown in the table below.

Table 3.12 Outline of Workshop

Commune Name	Date	Time	No. of Participants
Bu Sra	Nov. 26, 2005	10:00 – 16:00	48

Source: JICA Study Team

2.4.2 Literacy of Electricity

There were 30 participants out of 48 who possess battery. Most of the people possess battery use kerosene or candle as well.

Table 3.13 Situation of Literacy of Electricity

Types	No. （Total: 48）
Possess TV	4
Possess 12V	7
Possess 6V	11
Not possess battery	30

Source: JICA Study Team

Thirty three (33) participants spend more than 600Riel per day for kerosene and twelve (12) of them spend less than 500Riel. Expense of 600Riel per day is equivalent to 4.5$ per month. They do not buy kerosene or candle monthly but buy every day or every few days. Therefore it seems difficult and not used for them to calculate or prepare money monthly basis.

There are two (2) BCS in Buja village and Pulu village. The unit charging fee of Pulu BCS is shown in the table below. They consume about one (1) litter diesel per day, which is equivalent to 3,000Riel.

Table 3.14 Unit Charging Price of Pulu BCS

Types	Unit Price（Riel）
12V,70A	3,500
12V,50A	2,500
12V,40A	2,000
6V	Not dealt

Source: JICA Study Team

2.4.3 Usage of Bu Sra Water Falls

It is confirmed that they do not use Bu Sra water fall in the daytime in the dry season due to tourists.

2.4.4 Ability to Pay

All participants cannot pay 50$ as an initial connection charge, however most of them can pay 25$ by three (3) months savings. Fourteen (14) participants cannot pay even 25$ but can pay 12.5$.

2.4.5 Demand Power Amount and Charge

Six (6) types of demand power amount and its charges were shown in the workshop. Participants chose the types, which they want to use and can afford to pay the charge as shown in the table below. All participants selected No.2 of 8,600Riel per month. It is lower level than other pre F/S sites as compared with them. Most of the participant in other pre F/S sites selected No.3 of 18,200Riel per month. It seems because of poorer area considering battery possession ratio.

Table 3.15 Demand Power Amount and Charge

No.	Amount of Daily Use	Watt	monthly amount	Estimated Monthly Charge	No.
			kWh	Riel	
1	10W lighting : 1: 3 hours use per day	10	0.9	900	0
2	20 W lighting: 2 : 4 hours use per day	40	4.8	8,600	All
3	20W lighting: 2 : 4 hours use per day Black & White TV(40W) or Fan (40W) : 1:4 hours use per day	80	9.6	18,200	0
4	20W lighting: 2 : 4 hours use per day Color TV (80W) : 1:4 hours use per day	120	14.4	27,800	0
5	20W lighting: 2 : 4 hours use per day Color TV (80W) : 1:4 hours use per day, Fan (40W) : 1:4 hours use per day	160	19.2	37,400	0
6	20W lighting: 3 : 4 hours use per day Color TV (150W) : 1:4 hours use per day	210	25.2	49,400	0

Source: JICA Study Team

2.4.6 Operator and Accountant

There are five (5) to six (6) persons who know about diesel generator, such as REE owner, karaoke owner and repairman of car and motorbike. Many of people can be an accountant. They prefer to have election for choosing staff.

2.4.7 Situation of Commune

This commune consists of seven (7) villages. There are 727 families and 30 families out of them are

Khmer and the others are Phnong people of ethnic group. Fifteen (15) participants cannot read and write Khmer language but all of them can listen to Khmer language.

A situation of the commune is shown in the table below. Most of the resident locates along the main road but some people live far from the road.

Table 3.16 Overall situation in Bu Sra commune

Village name	No. of HHs	No. of people	No. of building	No. of electrified house (generator)	No. of electrified house (battery both 6V and 12V)
Putuet	116	489	73 (all are along the road)	3 (own generator, not provide to other houses)	10
Pureang	88	480	50 (12-13 are far from road about 200m)	2 (own generator, not provide to other houses)	6-7
Busra	92	394	63 (all are along the road)	18 (3 generator owners, 15 connection house)	8
Putil	101	428	89 (all are along the road)	3 (owners)	8
Lames	95	462	82 (all are along the road)	27 (7 generator owners among 27)	11
Buja	84	396	60 (all are along the road)	7 (2 generator owners)	12
Pulu	151	678	127 (13 are far from the road about 20km)	20 (8 generators owners)	18

Source: JICA Study Team

2.4.8 Feasibility in Bu Sra

It seems that the readiness to mini grid electrification is low in terms of ability to pay and possession ratio of battery. It is considered that education and enlightenment of electricity is necessary so as to accelerate battery diffusion for the purpose of mini grid electrification. In addition it is necessary to make a detailed household survey how much they spend for lighting charge including kerosene and candle at present and then to confirm the ability to pay. As for the human resources, such as operator and accountant, it is available if they have training.

3 PLAN FORMULATION

3.1 PRELIMINARY STUDY

There was a preliminary study on the Bu Sra MHP scheme by Meritec in 2003. The study was evaluated on the selected 10 MHP potential sites. The result of the study on the Bu Sra MHP scheme is summarised in table below.

Table 3.17 Summary of the Meritec's Study (2003) on Bu Sra MHP Scheme

Installed Capacity	56 kW = peak demand (annual energy production = 0.103 GWh/year)
Gross Head	58m, Design Plant Discharge = 0.15 m3/s
Target No.of HH	450 HH (75% among total 602 HH in 7 villages in Bu Sra commune)
Construction Cost	USD 137,000
Economic Evaluation	EIRR = 12.3%
Futures of Designed Facilities	(a) frontal type intake placed on the right bank at the head of the Bu Sra waterfall, Peak Poun (Prek Por) River, (b) desand basin, (c) buried pipeline (PVC, L=150m), (d) Penstock (PVC, 150m x 1), (e) Powerhouse at the base of the waterfall on the right bank (2 x 28kW Francis Turbines)

Source : Pre-Investment Study of Community-Scale Hydro Projects, Cambodia" (New Zealand Ministry of Foreign Affairs & Trade, Asian Development Assistance Finance, June 2003

3.2 RESULTS OF FIELD SURVEY BY JICA STUDY TEAM

The Study Team conducted following 3 times of field surveys to confirm the potential of proposed Bu Sra MHP scheme.

Table 3.18 Outline of Field Survey at Proposed Bu Sra MHP Site

No.	Date	Survey Items
1	25 - 28 Jan., 2005	outline field reconnaissance, discharge measurement, socio-economic survey, etc.
2	19 - 22 May, 2005	levelling survey (head), river cross section survey, discharge measurement, installation of staff gauges, socio-economic survey, etc.
3	24 - 27 Nov., 2005	river cross section & longitudinal survey, discharge measurement, layout survey, reconnaissance on upstream from proposed intake site (for regulation pond study), socio-economic survey, community workshop, etc.

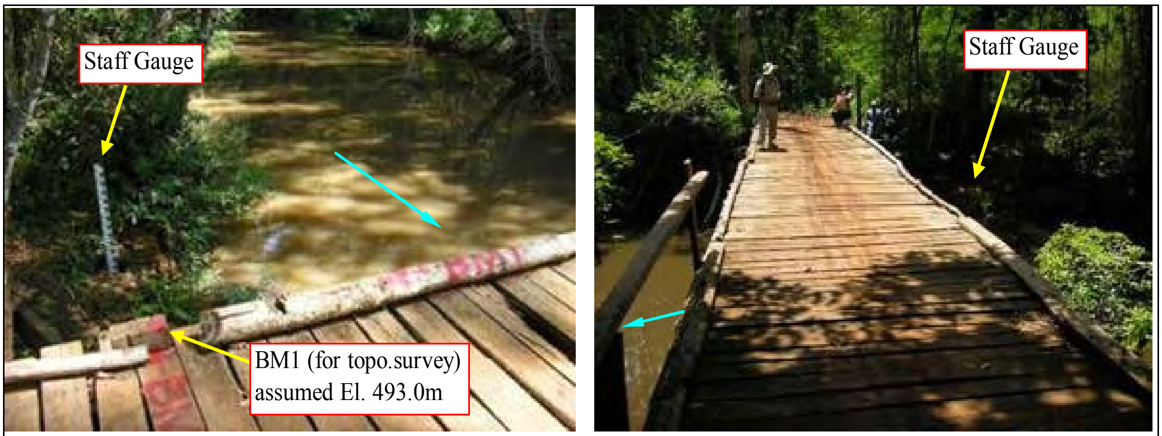
3.2.1 Installation of Staff Gauges

Hydrological data for the Bu Sra MHP scheme was limited. Therefore, the Study Team installed staff gauges at following 2 sites to record daily water level for estimation of daily discharge fluctuations. The O Phlai River is located at west neighbouring of the Prek Poun River. The daily water level was observed every morning once a day by operator who was employed by the Team.

Table 3.19 Installed Water Level Gauging Stations by JICA Study Team

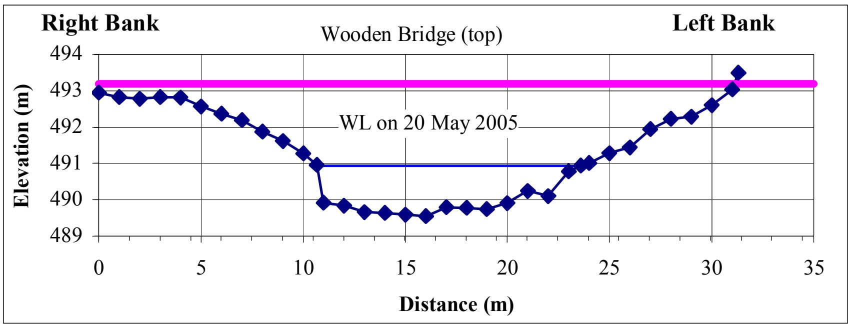
No.	Name of Station	River	Catchment Area (km^2)	UTM-X (m)	UTM-Y (m)	Elevation by GPS (El.m)	Installed date	Staff Height	Location
1	Busra Water fall (Wooden Bridge)	Preak Poun (Prek Por)	197	0763 259	1389 993	493	2005/5/20	2 m	at right bank, approximately 2m upstream from wooden bridge
2	O Phlai Bridge	O Phlai	279	0757 833	1389 169	479	2005/5/21	2 m	at left bank, approximately 10m upstream from stell bridge

The photographs and results of cross section survey at Bu Sra water level gauging station near the wooden bridge that located at around 70m upstream of upper waterfall are shown in Figure 3.6.



Installed Staff Gauge at Busra Wooden Bridge and Bench Mark-1 on the top of Bridge (Right)

Wooden Bridge at approx. 70m upstream from Busra water fall top

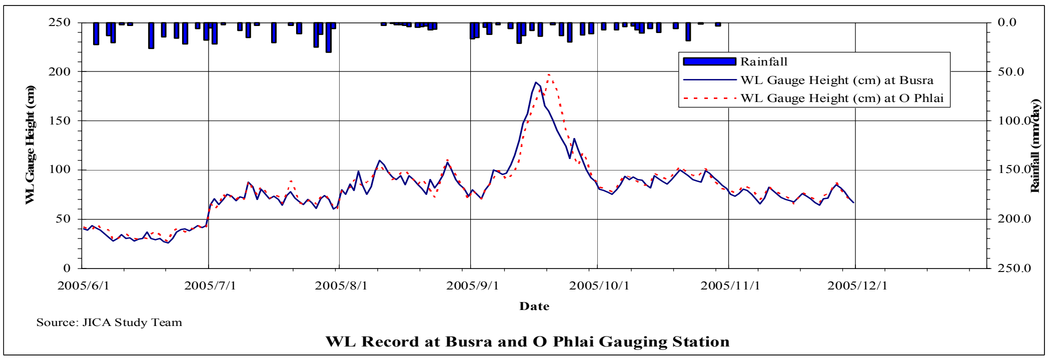


Source: JICA Study Team

Figure 3.6 Result of Cross Section Survey at Bu Sra Water Level Gauging Station

Temporary bench mark (BM1) was set on the wooden bridge (right bank side) located 50m upstream of upper waterfall, and the temporary elevation was assumed as EL. 493.0m by using handy GPS. The elevation of zero (0) gauge height of staff gauge is EL. 490.20m.

Figure 3.7 shows the water level records from May 2005 at Bu Sra and O Phlai gauging stations. The gauge height data at both stations were observed by same operator at around 7:00 AM every morning. However, water level records after October 2005 were unreliable due to results of inspection by the Study Team on 26 November 2005. The gauge height on 26 November 2005 at Bu Sra WL station was observed at 48cm by the Study Team. However, the record by operator on same day was 85cm and the difference of both data was more than 40cm...



Source: JICA Study Team

Figure 3.7 Water Level Records at Bu Sra and O Phlai Gauging Stations

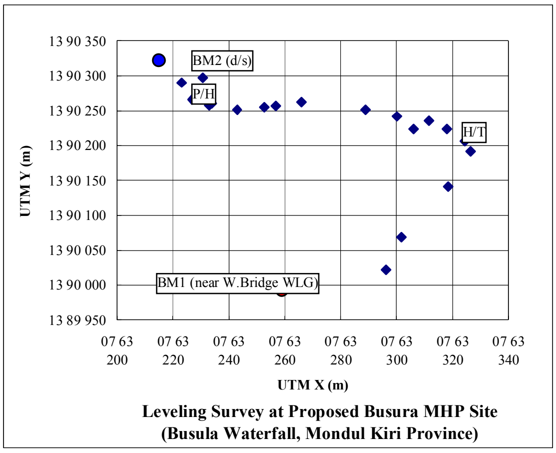
3.2.2 Levelling Survey (Head Measurement)

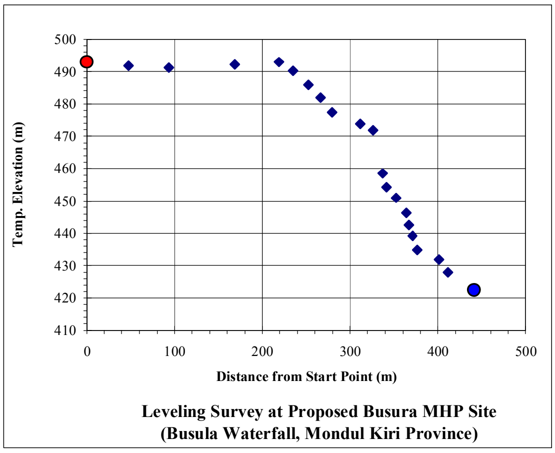
On 20 May 2005, the levelling survey by using Auto-Level was conducted to measure of gross head. The result of levelling survey and the route was shown in Table 3.20 and Figure 3.8. X-Y coordinates of survey route were obtained by using handy GPS. The gross head (total height difference) between water level on 20 May 2005 at proposed intake site (IWL), which is located near the wooden bridge at upstream of upper waterfall, and water level at proposed power house (TWL) is 68.19m. In this study, topographic mapping survey was not conducted. The topographic mapping survey is required for the detail design study.

Table 3.20 Results of Levelling Survey at Bu Sra Waterfall

St. No.	Date & Time	BS (mm)	FS (mm)	H (m)	EL.(m)	Distance (m)	L (m)	GPS. No.	Longitude UTM X (m)	Latitude UTM Y (m)	Notes
1	2005/5/20 11:25	734			493.000	0.00	0.00	**003**	**07 63 259**	**13 89 993**	**BM1** on Wooden Bridge Rigft side at around 100m upsteam of Busura water
			3,018	2.284	**490.716**						**IWL** (river water sruface) at proposed intake site (under the BM1 Bridge)
2		926	1,849	1.115	491.885	47.34	47.34	005	07 63 296	13 90 022	Rigt bank at top of water
3		1,254	1,571	0.645	491.240	46.39	93.73	006	07 63 302	13 90 068	Proposed sandsettring basin (right bank)
4		2,362	245	-1.009	492.249	74.99	168.72	007	07 63 318	13 90 141	
5		1,386	1,690	-0.672	492.921	50.42	219.14	008	07 63 326	13 90 191	
6		19	4,058	2.672	490.249	15.58	234.72	009	07 63 324	13 90 207	
7		306	4,319	4.300	485.949	17.96	252.68	010	07 63 318	13 90 223	
8		26	4,302	3.996	481.953	13.78	266.46	011	07 63 312	13 90 236	
9		308	4,536	4.510	477.443	12.83	279.29	012	07 63 306	13 90 224	diverging point of foot path to d/s of waterfall
10		436	4,013	3.705	473.738	32.39	311.68	013	07 63 289	13 90 252	
11		170	2,245	1.809	471.929	14.87	326.55	014	07 63 300	13 90 242	Top of ladder at right bank of 2nd (lower) waterfall
12		220	4,525	4.355	467.574						(using hand level)
13		107	4,760	4.540	463.034			015	07 63 266	13 90 262	bottom of ladder at right bank of 2nd (lower)
14		325	4,629	4.522	458.512	10.42	336.97	016	07 63 257	13 90 257	
15		294	4,675	4.350	454.162	4.60	341.57	017	07 63 253	13 90 255	
16		74	3,485	3.191	450.971	10.63	352.20	018	07 63 243	13 90 251	
17		144	4,698	4.624	446.347	11.87	364.07	019	07 63 233	13 90 258	
18		246	3,951	3.807	442.540	3.10	367.17	020	07 63 234	13 90 261	
19		51	3,565	3.319	439.221	3.94	371.11	021	07 63 232	13 90 264	
20		23	4,339	4.288	434.933	5.48	376.59	022	07 63 227	13 90 266	
21		149	3,089	3.066	431.867	24.67	401.26	023	07 63 223	13 90 290	
22		234	4,055	3.906	427.961	10.39	411.65	024	07 63 231	13 90 297	Flood water level mark at proposed P/H site
23		728	4,568	4.334	423.627						
			1,832	1.104	**422.523**	29.42	441.07	025	07 63 215	13 90 322	**TWL** at proposed P/H site (around 150m d/s from 2nd (lower) waterfall)
	14:00		1,059	0.331	423.296						**BM2** right bank of proposed P/H site
				Head (m) =	**68.193**	**L (m) =**	**441.07**				

Source: JICA Study Team



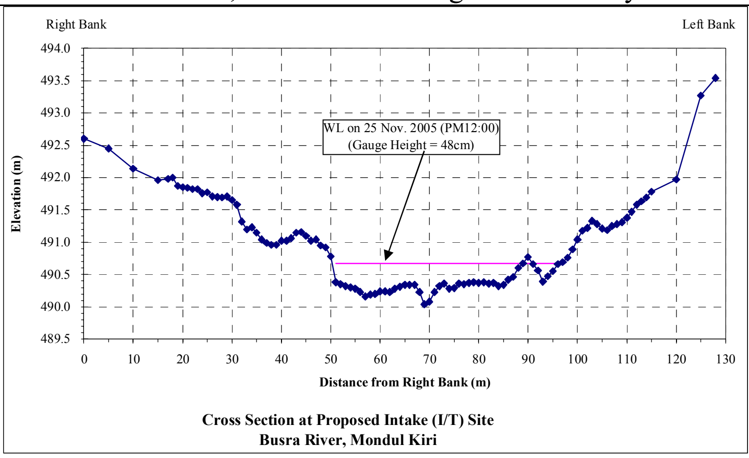


Source: JICA Study Team

Figure 3.8 Route of Levelling Survey at Bu Sra Waterfall

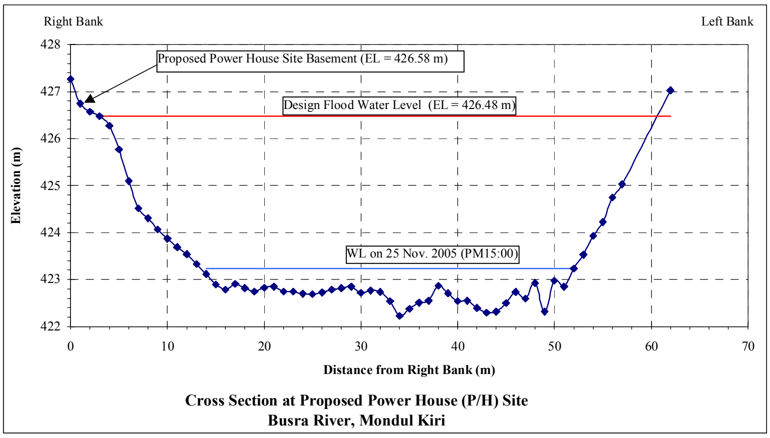
3.2.3 River Cross Section Survey

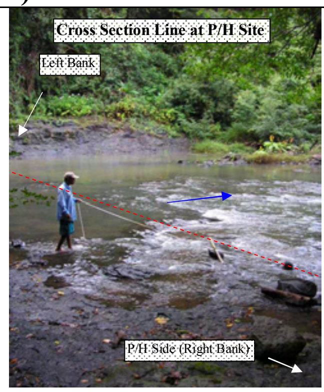
River cross section survey was conducted at water level gauge site (near wooden bridge), alternative intake site and proposed power house site. The results of cross section survey were shown in Figures 3.9 and 3.10. In addition, result of river longitudinal survey is shown in Table 3.21.



Cross Section Survey Line
at Proposed Alternative Intake Site

Figure 3.9 Result of River Cross Section Survey at Proposed Alternative Intake Site (17m upstream of upper Bu Sra waterfall)





Cross Section Survey Line
at Proposed Power House Site

Source: JICA Study Team

Figure 3.10 Result of River Cross Section Survey at Proposed Power House Site (approximately 55m downstream from basin of lower Bu Sra waterfall)

Table 3.21 Result of River Longitudinal Survey (Slope of Water Surface)

Site	Location	Longitudinal Distance (m)	Elevation of W. Surface (m)	Slope of W. Surface	Assumed Roughness
WL Gauge Station	70m u/s of upper W.F	*200 m*	*0.10*	*1 / 2,000*	0.065
Alt. Intake Site 2	17m u/s of upper W.F	33 m	0.360	1 / 94	0.053
Power House Site	55m d/s of lower W.F	47 m	0.465 m	1 / 101	0.053

Source: JICA Study Team

3.2.4 Discharge Measurement

Three times of discharge measurements at Bu Sra waterfall by using a current meter were carried out as shown in the table below. Gauge height for January 2005 was not able due to the staff gauge was installed on 20 May 2005. To improve the precision of stage - discharge rating curve (H-Q curve), continuation of gauge height reading and discharge measurement is required. The results of discharge measurement are shown in Table 3.22.

Table 3.22 Results of discharge measurement at Bu Sra Waterfall (Prek Por River)

No.	Date	Discharge (m^3/s)	C,A, (km^2)	Specific Discharge ($m^3/sec./ km^2$)	Gauge Height (m)
1	2005/1/27	0.154	197	0.00078	–
2	2005/5/20	1.972	197	0.01001	0.49
3	2005/11/26	1.319	197	0.00670	0.48

Source: JICA Study Team

3.2.5 Stage-Flow Rating Curve

The stage (gauge height) and flow (discharge) rating curve (H-Q curve) is required to convert the daily water level data to daily discharge. However, as described in above, discharge measurement data with gauge height were available only two times. Due to these limited observed data, it is not able to prepare the H-Q curve by normal method. Therefore, in this stage, the H-Q curve is estimated by using following *Manning*'s formula based on the river cross section and longitudinal survey data.

Manning's Formula

$$v = \frac{1}{n} R^{2/3} \times I^{1/2}$$

$$C = \frac{1}{n} \times R^{1/6}$$

$$V = \sqrt{\frac{2g}{f}} \times \sqrt{RI} = C \times \sqrt{RI}$$

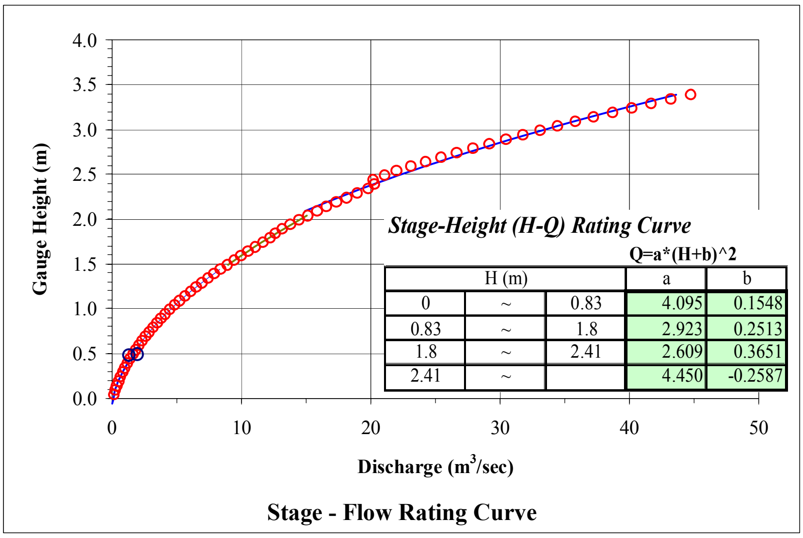
where,

v : mean velocity (m/s)
n : Manning's n-Value (roughness)
C: *Chezy*'s coefficient
R : Hydraulic Radius (m)
I : Slope

Roughness Coefficient *n*

Type of Channel		Roughness *n*	Average
Open Channel	Concrete Channel	0.012 ~ 0.018	0.015
	Woody Channel	0.010 ~ 0.014	0.012
	Stone Channel	0.013 ~ 0.03	0.022
Open Soil Channel	Straight, Smooth	0.017 ~ 0.025	0.021
	Excavation Soil	0.025 ~ 0.033	0.029
	Side=Soil, Bed=Stone	0.028 ~ 0.040	0.034
	Side=Soil, Bed=Soil	0.028 ~ 0.035	0.032
Natural River	Straight, Smooth, Deep	0.025 ~ 0.033	0.029
	Meander with Rapids&Deep	0.033 ~ 0.045	0.039
	Meander, Stone Riverbed, Shallow	0.045 ~ 0.060	0.053
	Meander with water grass	0.050 ~ 0.080	0.065
	(Max. n of natural river = 0.100)		

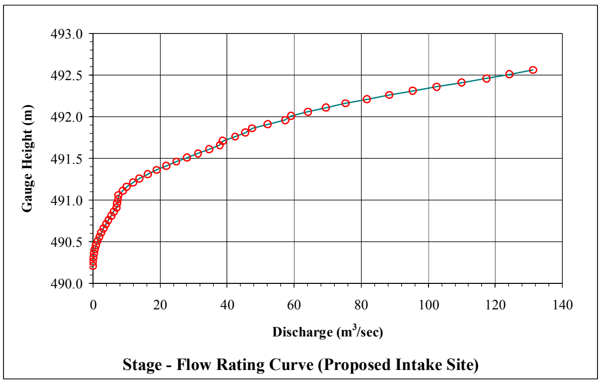
Estimated Stage-Discharge (H-Q) curves at Bu Sra water level gauging station, with assumption of slope I at 1/2,000 and n=0.065, are shown in Figure 3.11. The H-Q curves are divided four (4) parts of water level zone based on the shape of river cross section.



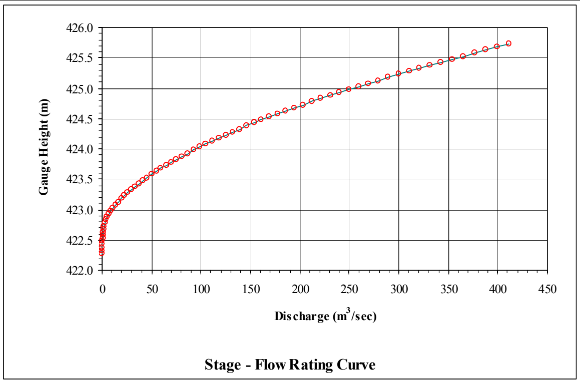
Source: JICA Study Team

Figure 3.11 Stage - Flow Rating Curve at Bu Sra Water Level Gauging Station

In the same way, the stage-flow rating curves at proposed alternative intake site and proposed power house site were estimated as shown in Figure 3.12. Continuation of water level observation and regularly discharge measurement is required to improve the precision of stage-flow rating curves.



H-Q Curve for Alternative Intake Site
(approx. 17m u/s from upper waterfall)



H-Q Curve for Proposed Power House Site
(approx. 55m d/s from lower waterfall)

Source: JICA Study Team

Figure 3.12 Stage-Flow Rating Curves at Alternative Intake Site and Proposed Power House Site

3.2.6 Estimation of Daily Discharge

Using above H-Q rating curve and observed water level records at Bu Sra water level station, the daily discharge data was estimated (Table 3.23).

Table 3.23 Daily Water Level Records and Estimated Daily Discharge at Bu Sra WL Station

Year 2005 Unit: cm

Day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1						40.0	65.0	80.0	79.5	80.5	75.0	
2						39.0	70.5	75.0	75.0	79.0	73.5	
3						43.5	64.5	85.5	70.5	77.5	76.0	
4						41.0	70.0	79.0	80.0	75.0	80.5	
5						38.5	75.0	99.0	85.5	79.5	79.0	
6						35.0	73.0	85.0	100.0	85.0	75.0	
7						31.0	69.0	75.0	98.0	93.5	70.0	
8						27.7	72.5	83.0	95.5	90.0	65.5	
9						30.0	71.5	99.0	97.0	92.5	71.0	
10						34.0	87.5	110.0	105.0	90.0	82.5	
11						30.0	83.0	105.0	115.0	89.5	79.0	
12						31.0	70.0	98.0	130.0	85.0	75.0	
13						28.0	80.5	93.0	147.5	81.5	72.0	
14						29.5	75.0	90.5	157.5	94.0	70.0	
15						30.0	70.5	94.0	178.5	91.0	69.0	
16						37.0	73.0	85.0	189.5	88.5	67.5	
17						30.0	70.0	94.0	185.5	86.0	72.0	
18						29.0	64.0	90.0	165.0	90.0	76.0	
19						30.0	74.0	85.0	160.0	95.0	73.0	
20					49.0	27.0	78.0	81.0	150.0	100.0	70.5	
21						26.0	71.0	75.0	140.5	97.5	67.0	
22						30.0	68.0	90.0	132.0	94.0	64.0	
23						37.0	65.0	81.5	124.0	90.0	70.5	
24						39.5	70.0	87.0	112.0	89.0	71.0	
25						40.0	67.0	95.0	132.0	87.5	80.0	
26						38.0	61.0	108.0	120.5	99.5	85.0	
27						41.0	70.5	100.5	110.0	97.0	81.5	
28						43.0	74.0	90.5	100.0	92.0	78.0	
29						41.5	70.0	85.0	92.0	89.0	71.0	
30						43.0	60.0	81.0	88.5	84.0	67.0	
31							63.0	73.0		81.0		
Ave.						34.7	70.8	88.8	120.5	88.5	73.6	
Max.						43.5	87.5	110.0	189.5	100.0	85.0	
Min.						26.0	60.0	73.0	70.5	75.0	64.0	

Source: JICA Study Team

Year 2005 Unit: m3/s

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1						1.26	2.65	3.73	3.69	3.77	3.35	
2						1.22	3.03	3.35	3.35	3.65	3.24	
3						1.42	2.62	3.58	3.03	3.54	3.43	
4						1.31	2.99	3.65	3.73	3.35	3.77	
5						1.19	3.35	4.50	3.58	3.69	3.65	
6						1.04	3.21	3.55	4.58	3.55	3.35	
7						0.88	2.92	3.35	4.43	4.11	2.99	
8						0.76	3.17	3.42	4.25	3.87	2.69	
9						0.85	3.10	4.50	4.36	4.04	3.06	
10						1.00	3.71	5.34	4.95	3.87	3.93	
11						0.85	3.42	4.95	5.74	3.84	3.65	
12						0.88	2.99	4.43	7.03	3.55	3.35	
13						0.77	3.77	4.08	8.71	3.85	3.13	
14						0.83	3.35	3.91	9.75	4.15	2.99	
15						0.85	3.03	4.15	12.12	3.94	2.92	
16						1.13	3.21	3.55	13.32	3.77	2.82	
17						0.85	2.99	4.15	12.86	3.61	3.13	
18						0.81	2.59	3.87	10.57	3.87	3.43	
19						0.85	3.28	3.55	10.02	4.22	3.21	
20					1.97	0.74	3.58	3.81	8.96	4.58	3.03	
21						0.70	3.06	3.35	8.02	4.40	2.79	
22						0.85	2.85	3.87	7.22	4.15	2.59	
23						1.13	2.65	3.85	6.50	3.87	3.03	
24						1.24	2.99	3.67	5.50	3.81	3.06	
25						1.26	2.79	4.22	7.22	3.71	3.73	
26						1.17	2.39	5.18	6.20	4.54	3.55	
27	0.15					1.31	3.03	4.61	5.34	4.36	3.85	
28						1.40	3.28	3.91	4.58	4.01	3.58	
29						1.33	2.99	3.55	4.01	3.81	3.06	
30						1.40	2.33	3.81	3.77	3.48	2.79	
31							2.52	3.21		3.81		
Ave.						1.0	3.0	4.0	6.6	3.9	3.2	
Max.						1.4	3.8	5.3	13.3	4.6	3.9	
Min.						0.7	2.3	3.2	3.0	3.4	2.6	

Source: JICA Study Team

Source: JICA Study Team

3.2.7 Geology

The Bu Sra waterfall appears to be formed a *basalt* dike. The soil cover at the head of the waterfall and along the headrace pipeline canal would be about 20cm and powerhouse site would be about 1m maximum. The type of soil is predominantly *Ferralsols* or *Leptosols* (*Laterite*).

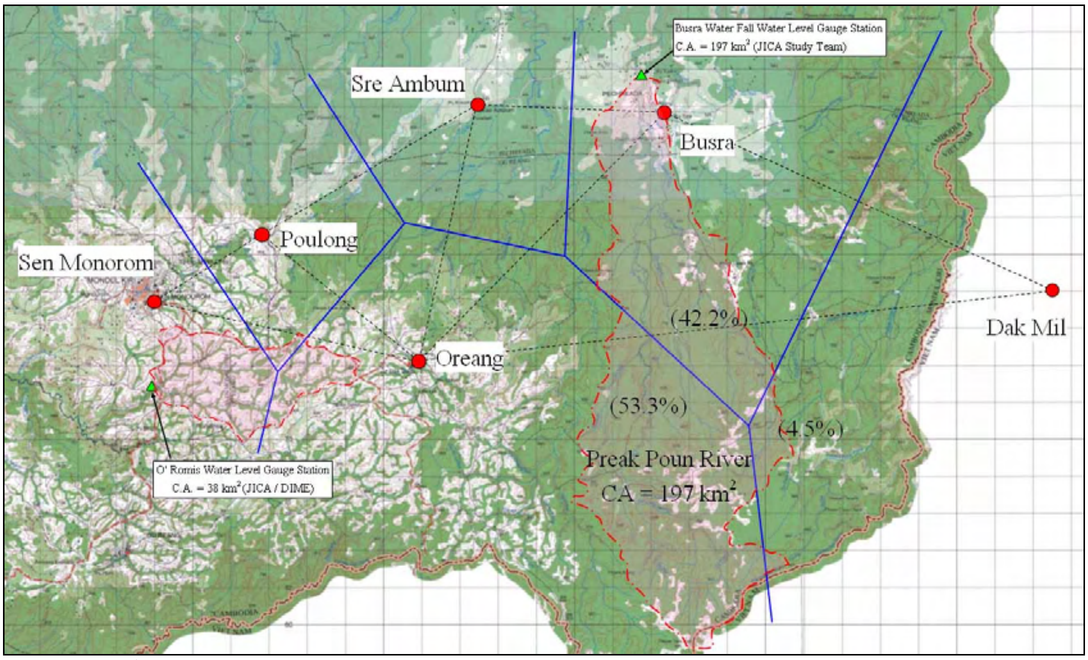
Geology in the catchment of Bu Sra is predominantly *Pliocene-Pleistocene basalt*. The distribution of the soil types are mainly *Ferralsols* and *Leptosols*. According to the existing survey[1], soil depth of *Ferralsols* is thick (>7~12m) and the soil water permeability is very high ($K_0 = 10^{-3} \sim 10^{-2}$ cm/s).

[1] Ohnuki et.al.(2004), Research Revolution 2002 (RR 2002), Forestry and Forest Product Research Institute, Japan.(http://water.cee.yamanashi.ac.jp/RR2002/)

		
Exposed Basalt Rocks (at lip of Bu Sra Waterfall)	Right bank of Upper Waterfall (proposed headrace pipeline route)	*Laterite* Soil at river bank (approx 4km upstream from Bu Sra waterfall)

3.2.8 Topography

As shown in Figure 3.13, shape of the catchment is long from north to south (L 30km x W 6~8km). Elevation of the highest peak of the catchment is 934m (Mt. Phnum Tueu Deh). The height difference from the peak to the Bu Sra waterfall (EL. 490m) is about 500m. Slopes in the upstream mountainous area are steep (30-70^o), but the middle reaches are moderate flat (5-10^o). In the middle reaches near the Bu Sra commune, paddy fields are spread. There are some small rapids or short waterfall (h= 0.1~2m) in the upstream of the Bu Sra waterfall. However, most of the flows in the upstream of the Bu Sra waterfall are gentle and slow with deep pools. Side slope of the Bu Sra river valley downstream of waterfall are steep (30-70^o). The river valley side slopes are vegetated with primary forest. The Bu Sra river valley floor is relatively narrow and varies between 30-40m typically.



Source: JICA Study Team

Figure 3.13 Location of Rainfall and Hydrological Stations near the Bu Sra Catchments

3.2.9 Sediment and Suspended Load

There is no sampling data on sediments or suspended loads in the Bu Sra. Soil erosion of the *Ferralsols* soil in the catchment might be not so much if soil covered with vegetation. During three times of field investigation, there is no observed muddy water in the Preak Poun River. In addition, river channel at the proposed intake site (near the water level station) at Bu Sra is formed like a deep pool and as a natural de-sanding basin. Therefore, the sand settling basin was omitted in the proposed MHP scheme.

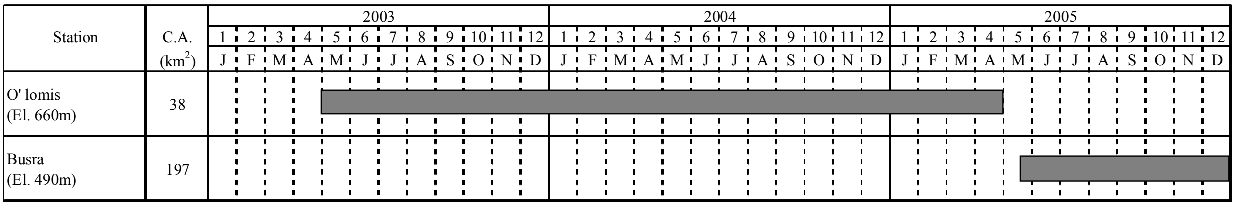
3.3 HYDROLOGICAL ANALYSIS

A long-term record of dry season discharge is essential for the MHP planning. As descried in above, due to the staff gauge at Bu Sra waterfall was installed in May 2005, drop of the river discharge in dry season is unknown. Therefore, in this study, long-term discharge at Bu Sra was estimated by using available hydro-meteorological data. The locations of hydro-meteorological stations in and around the basin are shown in figure above (Figure 3.13).

3.3.1 Neighbouring Existing Hydrological Station (O'lomis WL Station)

There is a water level and discharge gauging station at O'lomis near the Sen Monorom city that was installed by JICA and DIME Mondul Kiri province. The catchment area of O'lomis is 39 km2. Observation of daily water level and twice a month of discharge measurement at O'lomis station are conducted from 1st May 2003 to 30 April 200. However, unfortunately, there is not overlapped period between observed data at the O'lomis[2] and the Bu Sra as shown in the table below.

Table 3.24 Observation Period of Daily Water Level at O'lomis and Busra Stations



Observed discharge data on the same day at both stations is shown in Table 3.25. In spite of small catchment are of the O'lomis at only 38km^2, the specific discharge of the O'lomis station is larger than the Bu Sra.. As a one of this reason, due to high elevation of the O'lomis catchment, the basin mean rainfall at the O'lomis might be larger than the Bu Sra. As shown in the table, hydrological condition of both catchment areas is quite different. Therefore, the discharge data at the O'lomis is not able to utilize for estimation of discharge the Bu Sra directly.

Table 3.25 Comparison of Observed Discharge at O'lomis and Busra Stations

Obs. Date	WL Obs. Station	C.A. (km^2)	Obs.Q (m^3/s)	Specific Q. ($m^3/s/km^2$)	Busra / O'lomis Rattio	Notes
2005/1/27	O' lomis	38	0.520	0.01368		from H-Q curve, source; JICA.
2005/1/27	Busra	197	0.154	0.00078	5.7%	observe Q by JICA Study Team
2005/11/27	O' lomis	38	1.220	0.03211		observe Q by JICA Study Team
2005/11/26	Busra	197	1.320	0.00670	20.9%	observe Q by JICA Study Team

Prepared by JICA Study Team

Hence, in this study, estimation long-term discharge for the Bu Sra was conducted by applying a hydrological model based on the observed discharge data at Bu Sra and available rainfall data.

[2] Water level reading at O'lomis station was resumed in November, 2005 by DIME.

3.3.2 Rainfall Data at Neighbouring Stations

Rainfall Gauge in Bu Sra Village
(Installed by NOMAD RSI, NGO)

In the Mondul Kiri province, total seven (7) rainfall and meteorological (temperature and humidity) stations were installed by NOMAD RSI (http://www.nomadrsi.org/) that is the international NGO. In the Bu Sra commune, daily rainfall data is observing since August 2000 by manual measurement by the village people observer. Also in the Viet Nam, a long-term daily rainfall record from 1977 to 2000 is available at Dak Mil station.

Using results of correlation analysis of available monthly rainfall records between each station, filling of the lacking rainfall data of the Oreang, Bu Sra and Dak Mil stations was conducted. Based on the estimated long-term daily rainfall at above neighbouring three (3) stations and *Thiessen*'s ratio, basin mean daily rainfall at the Bu Sra catchment was estimated for the 29 years from 1977 to 2005. Table 3.26 shows estimated monthly basin mean rainfall at Bu Sra catchment. The estimated mean annual basin rainfall is calculated at 2,222 mm/year.

Table 3.26 Estimated Mean Monthly Basin Rainfall at Bu Sra WL Station

	Year	1 Jan.	2 Feb.	3 Mar.	4 Apr.	5 May	6 Jun.	7 Jul.	8 Aug.	9 Sep.	10 Oct.	11 Nov.	12 Dec.	Annual Total	Rank
		mm/month												mm/year	
1	1977	0.0	0.0	0.0	30.7	140.2	294.8	344.9	394.7	587.0	12.5	41.9	0.0	1,846.7	24
2	1978	0.0	0.0	135.1	289.2	319.7	241.0	572.5	386.3	459.2	294.0	115.0	0.0	2,812.0	4
3	1979	0.0	0.0	100.1	255.5	140.0	474.0	250.0	152.3	227.4	253.5	63.9	9.7	1,926.4	20
4	1980	0.0	3.6	1.0	31.2	350.5	286.3	176.2	184.0	307.0	338.5	154.4	3.8	1,836.5	25
5	1981	0.0	7.4	48.3	184.3	356.3	352.5	408.4	233.9	269.1	508.1	103.8	43.7	2,515.8	9
6	1982	0.0	0.0	5.0	121.0	348.3	183.6	130.4	158.7	360.4	323.7	16.5	0.0	1,647.6	27
7	1983	1.3	27.1	42.2	16.6	296.1	212.2	291.0	418.0	473.2	377.5	63.7	0.0	2,218.9	13
8	1984	0.0	0.0	91.7	364.3	194.4	282.9	337.0	269.7	253.9	258.6	158.6	0.0	2,211.1	15
9	1985	0.0	38.2	31.9	449.4	217.3	122.8	303.0	166.8	311.0	219.0	122.4	14.7	1,996.5	19
10	1986	0.0	5.7	49.0	81.0	137.3	237.8	466.1	594.6	339.3	297.5	69.8	0.0	2,278.1	12
11	1987	0.0	0.0	49.7	45.8	176.7	226.3	324.8	235.0	349.3	164.2	324.6	0.0	1,896.4	23
12	1988	0.0	0.0	0.3	213.1	342.4	133.2	265.8	343.2	444.4	369.9	104.0	1.9	2,218.2	14
13	1989	0.1	0.0	0.3	127.1	427.7	234.1	381.7	345.8	289.3	158.9	119.1	0.0	2,084.1	18
14	1990	0.0	30.7	1.8	143.2	201.9	451.5	212.4	366.0	310.0	167.7	193.6	14.9	2,093.7	17
15	1991	0.0	0.0	0.4	63.1	274.4	216.1	194.5	221.0	487.8	92.0	14.2	3.0	1,566.5	28
16	1992	0.0	4.1	19.5	178.0	204.4	504.2	351.9	346.0	359.1	382.0	7.1	1.3	2,357.6	10
17	1993	0.0	0.0	59.0	132.8	457.1	206.4	453.9	215.0	420.7	444.7	102.1	119.1	2,610.8	7
18	1994	0.0	13.0	23.6	154.4	449.0	376.9	142.6	195.6	226.2	124.9	0.0	21.3	1,727.5	26
19	1995	0.0	0.0	4.2	16.9	381.6	248.2	243.9	273.4	480.5	378.5	83.6	6.2	2,117.0	16
20	1996	0.0	5.8	8.4	151.4	544.3	365.5	374.8	308.2	361.0	424.2	111.6	2.5	2,657.7	6
21	1997	0.0	18.4	0.5	283.0	250.9	119.3	432.8	246.6	396.9	135.1	36.5	0.0	1,920.0	21
22	1998	0.0	34.4	0.0	196.2	186.1	177.7	282.8	476.1	233.6	490.6	535.5	215.7	2,828.7	3
23	1999	9.3	0.0	166.2	371.1	289.6	197.9	194.6	495.3	412.3	391.3	198.9	47.7	2,774.2	5
24	2000	0.0	8.9	0.6	466.9	253.4	462.9	280.3	466.4	355.1	492.4	77.9	97.1	2,961.9	2
25	2001	8.5	0.0	138.5	167.6	329.3	587.6	348.7	810.6	248.6	324.0	153.3	0.0	3,116.7	1
26	2002	0.0	0.0	10.2	96.2	282.6	331.0	319.5	756.7	438.1	216.8	48.9	23.6	2,523.6	8
27	2003	0.0	12.4	50.3	92.9	379.1	253.8	330.4	501.4	534.9	130.8	37.3	0.0	2,323.3	11
28	2004	0.0	0.0	55.2	69.3	296.6	403.6	353.7	299.8	425.0	7.6	0.0	0.0	1,910.8	22
29	2005	0.0	5.0	60.4	177.2	127.9	224.1	195.2	229.0	340.1	96.3	15.9	0.0	1,471.1	29
Average		0.7	7.4	39.8	171.4	288.1	289.9	309.1	347.9	369.0	271.5	106.0	21.6	2,222.4	
Max.		9.3	38.2	166.2	466.9	544.3	587.6	572.5	810.6	587.0	508.1	535.5	215.7	810.6	
Min.		0.0	0.0	0.0	16.6	127.9	119.3	130.4	152.3	226.2	7.6	0.0	0.0	0.0	

Prepared by JICA Study Team

3.3.3 Estimation of Long-term Discharge by Tank Model

As mentioned in above, water level records at the Bu Sra is only after May 2005. Therefore, long-term discharge data for the MHP planning was estimated by applying the "*Tank Model*" that is a kind of hydrological run-off model.

[Concept of the *Tank Model*]

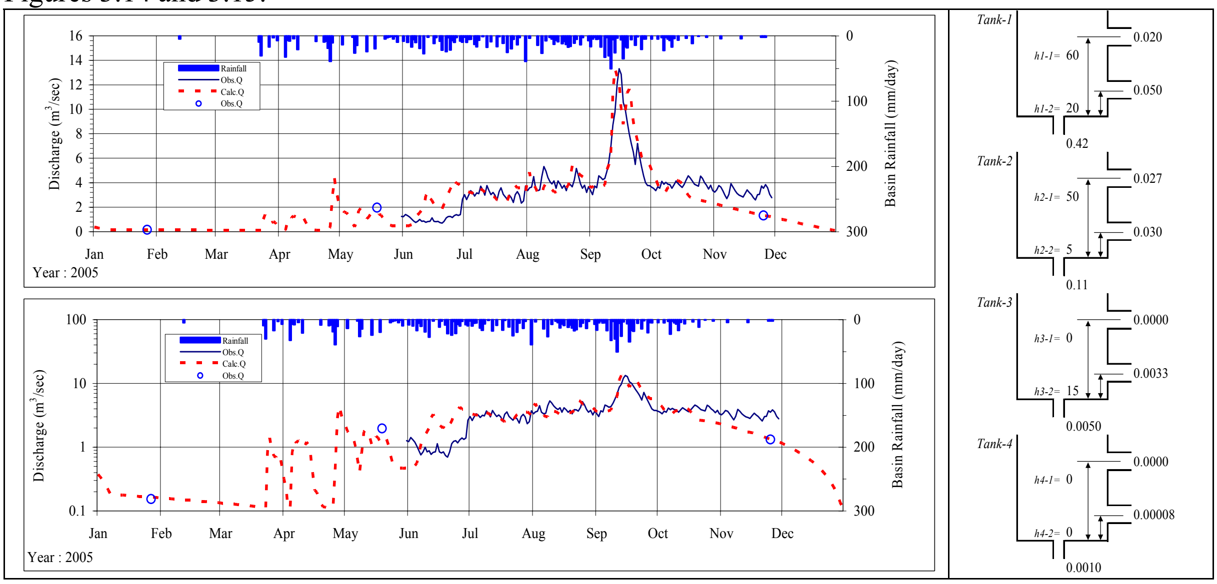
The basic concept of the *Tank model* (*Sugawara*, 1956) is a simple tank with holes to let out water. The outflow from each hole is proportionate to the height between the hole and water surface. Provided that a tank is accommodated with one bottom hole and two side holes, the rule for outflow computation is as follows;

$$y_n = 0 \qquad (X_n \leqq h_1)$$
$$y_n = \alpha_1 (X_n - h_1) \qquad (h_1 < X_n \leqq h_2)$$
$$y_n = \alpha_2 (X_n - h_2) + \alpha_1 (X_n - h_1) \qquad (h_2 < X_n),$$
$$z_n = \beta * X_n,$$
$$X_{n'} = X_n - y_n - z_n,$$
$$Z_n + 1 = X_{n'} + x_n + 1$$

where,
- X_n : water depth of stage (time step n)
- y_n : outflow from side holes of stage n,
- z_n : outflow from bottom hole of stage n,
- x_n : inflow of stage n,
- α_1, α_2 : coefficient of side holes, and
- β : coefficient of bottom hole.

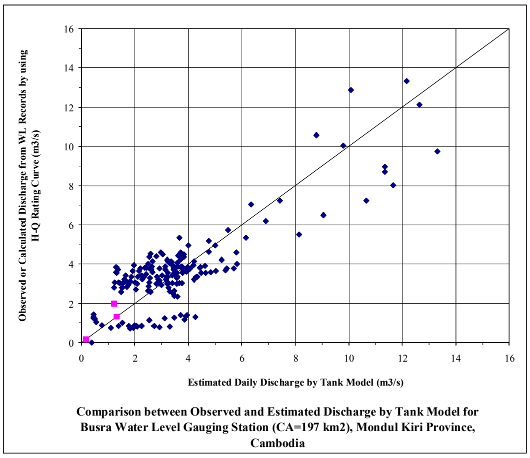
The top tank receives the rainfall as inflow to the tank, while the tanks below get the supply from the bottom holes of the tank directory above. The last or the bottom tank only has a side hole. The aggregated outflow from all the side holes of the tanks constitutes the inflow into the river course. Trial-and-error is needed to determine the tank parameters that minimize the difference between the observed and estimated runoff.

Based on the observed discharge at field survey and calculated daily discharge by using H-Q rating curve and observed daily water level, model parameters were calibrated. The calibrated model parameters and the comparison between observed and estimated discharge for the Bu Sra gauging station are shown in Figures 3.14 and 3.15.



Source: JICA Study Team

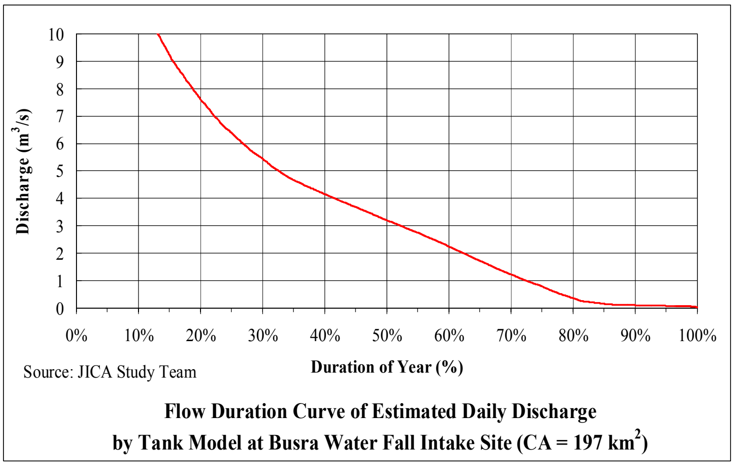
Figure 3.14 Calibrated Tank Model Parameters for Bu Sra WL Station and Comparison between Observed and Estimated Discharge by Tank Model

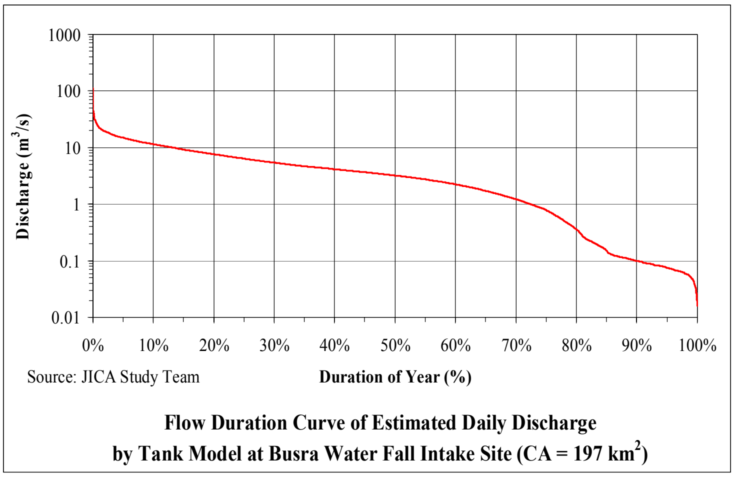


Source: JICA Study Team

Figure 3.15 Comparison between Observed and Estimated Discharge by Tank Model for the Bu Sra WL Station (Year = 2005)

Figure 3.16 shows the flow duration curve at the Bu Sra WL station that was prepared by using above estimated daily discharge by Tank Model for 29 years. Estimated mean monthly discharge at the Busra WL station is summarized in Table 3.27.





Duration of Year (all series from 1977 - 2005)		Estimated Daily Discharge at Proposed Intake Site of Busra MHP (CA=197 km2) (m^3/s)
30%	110 days	5.448
50%	183 days	3.201
60%	219 days	2.248
70%	256 days	1.223
80%	292 days	0.362
85%	**310 days**	**0.150**
87%	**318 days**	**0.119**
90%	329 days	0.100
95%	**347 days**	**0.075**
98%	358 days	0.059

Source: JICA Study Team

Source: JICA Study Team

Figure 3.16 Flow Duration Curve at the Bu Sra WL station by Tank Model

Table 3.27 Mean Monthly Discharge at the Bu Sra WL station by Tank Model

No.	Month / Year	1 Jan.	2 Feb.	3 Mar.	4 Apr.	5 May	6 Jun.	7 Jul.	8 Aug.	9 Sep.	10 Oct.	11 Nov.	12 Dec.	Annual Mean	Rank
		m^3/s												m^3/s	
1	1977	1.60	0.44	0.08	0.14	0.55	3.98	7.02	7.72	14.80	6.44	3.00	1.60	3.95	21
2	1978	0.42	0.08	0.75	2.64	5.25	6.13	14.16	9.96	13.06	11.53	5.98	3.20	6.10	4
3	1979	1.64	0.48	0.53	1.69	2.56	8.93	6.25	4.30	5.57	7.56	2.55	1.37	3.62	23
4	1980	0.32	0.12	0.09	0.12	4.81	4.99	3.47	2.91	7.71	6.71	6.96	2.20	3.37	25
5	1981	0.87	0.12	0.32	1.72	5.56	7.18	8.38	8.72	6.57	13.32	6.18	3.26	5.18	10
6	1982	1.74	0.55	0.11	0.66	3.50	5.92	2.91	2.75	8.37	6.68	3.25	1.37	3.15	27
7	1983	0.30	0.12	0.12	0.05	4.88	2.55	4.58	10.14	12.60	8.43	7.01	2.79	4.46	13
8	1984	1.32	0.27	0.17	6.01	4.33	6.35	5.59	7.00	5.91	8.47	4.32	2.44	4.35	17
9	1985	0.97	0.33	0.17	3.81	7.14	3.52	5.16	4.59	5.74	7.35	3.74	2.14	3.72	22
10	1986	0.59	0.11	0.25	0.48	1.05	3.57	8.19	17.22	8.71	10.29	4.56	2.57	4.80	12
11	1987	1.16	0.21	0.17	0.10	0.84	3.38	5.79	5.00	7.78	5.35	5.23	4.44	3.29	26
12	1988	1.21	0.22	0.08	1.30	5.39	3.49	4.64	6.66	10.81	11.59	5.00	2.73	4.43	14
13	1989	1.29	0.27	0.09	0.42	5.91	4.68	10.61	7.04	7.88	6.95	4.02	1.88	4.25	18
14	1990	0.62	0.15	0.09	1.27	2.84	9.50	4.28	7.81	8.50	6.22	5.90	2.36	4.13	19
15	1991	1.04	0.17	0.08	0.10	2.94	2.22	5.02	4.07	9.78	5.59	2.22	0.95	2.85	28
16	1992	0.13	0.06	0.04	2.19	1.90	11.16	6.67	10.35	8.37	11.36	5.10	2.52	4.99	11
17	1993	1.12	0.18	0.39	0.93	4.79	7.32	8.02	6.99	8.93	16.21	5.12	4.61	5.38	8
18	1994	2.19	0.94	0.19	1.45	5.82	9.46	4.75	3.62	5.90	3.50	1.94	0.80	3.38	24
19	1995	0.14	0.10	0.07	0.05	6.26	3.94	5.47	5.51	11.92	10.94	5.35	2.70	4.37	15
20	1996	1.26	0.24	0.07	0.75	8.01	11.00	9.88	7.61	9.90	9.35	8.32	3.38	5.81	6
21	1997	1.79	0.69	0.13	4.70	2.98	2.72	8.06	5.42	9.80	7.43	2.93	1.41	4.00	20
22	1998	0.33	0.20	0.09	1.70	2.23	3.26	5.11	9.06	6.18	15.94	12.09	10.70	5.57	7
23	1999	3.89	2.25	2.47	5.12	7.59	4.04	4.57	8.16	15.00	11.66	8.15	4.02	6.41	3
24	2000	2.36	1.05	0.24	6.69	5.45	10.39	9.57	11.20	9.73	16.42	5.58	4.91	6.97	2
25	2001	2.50	1.20	0.94	1.00	5.70	9.49	15.10	27.44	7.11	10.01	8.64	3.79	7.74	1
26	2002	2.13	0.87	0.26	0.68	4.06	7.27	6.44	20.93	13.65	7.94	5.36	3.20	6.07	5
27	2003	1.66	0.55	0.51	0.64	6.06	6.39	6.39	13.78	14.40	6.97	4.14	2.41	5.32	9
28	2004	1.05	0.25	0.53	0.41	3.98	9.13	7.61	8.68	13.81	3.78	2.24	0.96	4.37	16
29	2005	0.20	0.15	0.30	0.83	1.19	1.04	3.03	3.96	6.58	3.90	3.24	0.62	2.09	29
Average		1.23	0.43	0.32	1.64	4.26	5.96	6.78	8.57	9.48	8.89	5.11	2.80	4.62	
Max.		3.89	2.25	2.47	6.69	8.01	11.16	15.10	27.44	15.00	16.42	12.09	10.70	27.44	
Min.		0.13	0.06	0.04	0.05	0.55	1.04	2.91	2.75	5.57	3.50	1.94	0.62	0.04	

Source: JICA Study Team

3.3.4 Dry Season Discharge

As shown in the photographs below, river flow in the dry season (January 2005, left) and rainy season (May 2005, right) at the Bu Sra waterfall is quite different. According to above estimated discharge, mean annual discharge of year 2005 is lowest among the 29 years.

Upper Waterfall (H=23m), Dry Season (27 Jan. 2005)

Upper Waterfall (H=23m), Rainy Season (20 May 2005)

Lower Waterfall (H=42m), Dry Season (27 Jan. 2005)

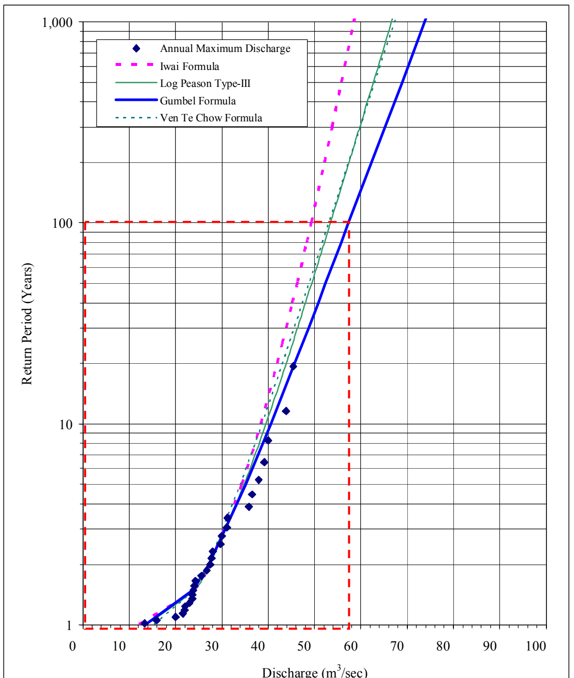
Lower Waterfall (H=42m), Rainy Season (20 May 2005)

Photos: JICA Study Team

As describe later, peak power demand in the target year of 2020 was forecasted at 80kW for Bu Sra MHP scheme. Based on assumption of the gross head of 61.9m and a combined efficiency of turbine and generator at 0.7, required plant discharge is estimated at 0.188 m^3/s [$Q = P/(9.8 *H*\eta)$= 80/(9.8*61.9*0.7)]. According to above flow duration curve, some period in the dry season, river flow will be not sufficient for the required plant discharge. Based on the flow duration curve, the required plat discharge of 0.188m^3/s is equivalent to 87% (318/365 days of a year) dependable discharge. That means shortage of power supply will be occurred during about 47 days of a year. For sufficient power supply for the demand, it is required to prepare backup generator such as diesel, etc or water reservoir to make peak generation by using off-peak discharge.

3.3.5 Flood Water Level

Design flood water level at proposed intake site, near the water level gauging station, and power house site for the Bu Sra MHP scheme is determined based on the results of river cross section survey, flood mark survey and estimated daily discharge of 29 years by the *Tank Model*. The design flood is planned at 1/100 years flood. Using the annual maximum daily discharge of 29 years by the Tank Model, maximum daily discharge at 1/100 year flood is estimated at 55 m^3/s (Q_{df100}) by the figure right (the *Gumbel*'s formula is applied). To estimate peak discharge in the flood, an assumed coefficient of 2.6 times is multiplied to this Q_{dF100}. The design flood peak discharge at 1/100 years is estimated at 143 m^3/s (=Q_{df100} x 2.6 = .55 x 2.6). Flood water level at each site is able to calculate by using H-Q curves by using cross section survey data and the Manning's Formula as above mentioned. However, actual flood water level might be more high due to above calculation includes many assumptions. Due to the flood damages for the small/micro hydropower facilities, especially in the power house, will be aggravated, careful investigation is required in detailed design stage. Therefore, in this study stage, flood water level at the proposed power house site is assumed at EL. 426.5 m for the safety side based on the field survey results.



Frequency Curve for Annual Maximum Discharge at Moscoso Staion (C.A. = 1,074 km^2) Rio Grande de San Miguel

Table 3.28 Design Flood Water Level at Principal Sites of the Bu Sra MHP Scheme (1/100 year flood)

Sites	FWL (1/100 years)	FWL (EL.m)
Proposed intake site (near wooden bridge)	Normal WL + about 3.5 m	El. 494.0 m msl.
Alternative intake site (approx. 17m us from upper W.F.)	Normal WL + about 2.4 m	El. 492.6 m msl.
Proposed Power House site (approx. 55m d/s from lower W.F.)	Normal WL + about 3.4 m	El. 426.5 m msl.

Source: JICA Study Team

3.4 POWER DEMAND FORECAST

3.4.1 Existing Electricity Utilizations

There is 28 diesel generator (herein after D.G.) sets in Bu Sra commune as of November 2005 as shown in Table 3.29. About 81 households (15%) utilises electricity by these D.G.. As one of the sample case of D.G. user in Bu Sra commune, the output capacity of D.G. is 5kW and utilizes 18:00-22:00 every night. The consumption diesel oil is 4 litters per day and its cost is about 90 US$/month (at 3,000 Riel/litter). On the other hand, about 14% (74 households) are utilizing a car battery for the lighting. Therefore, total 30% of the household are utilising electricity at present in the Bu Sra commune.

Table 3.29 Number of Battery and Diesel Generator Users in Bu Sra Commune

Village	No. of buildings				No. of Electrified Buildings				
	Total	along road	far from road	Distance from road	by Battery		by Diesel Generator		No.of D.G.s
Phum 1	73	73	0		10	14%	3	4%	3
Phum 2	50	37	13	200m	7	14%	2	4%	2
Phum 3	63	63	0		8	13%	18	29%	3
Phum 4	89	89	0		8	9%	3	3%	3
Phum 5	82	82	0		11	13%	28	34%	7
Phum 6	60	60	0		12	20%	7	12%	2
Phum 7	127	114	13	2km	18	14%	20	16%	8
Phum 8									
	544	518 95%	26 5%		74	14%	81	15%	28

Source: JICA Study Team (as of November, 2005)

3.4.2 Power Demand Forecast

Power demand forecast in the target area of the Bu Sra MHP scheme was conducted by using results of field surveys/ community workshops/ socio-economic survey by the Team, statistical data, existing study (Meritec, 2003) and electricity utilization data in the electrified areas of other provinces, etc.

In general, hydropower facilities are difficult to increase or expand its capacity after the completion of the project. Therefore, it is essential to design facilities based on the future power demand forecast. This point is different from other power sources such as diesel generator, biomass power or photovoltaic. For the Bu Sra rural electrification planning, independent power supply system only by the MHP (without diesel backup) is evaluated as a first option.

(1) Estimation of Target Number of Electrification Households

Target year of the power demand forecast is set at year 2020. As the above mentioned, there are two kinds of statistical data is available for the Bu Sra commune. Fist is number of households and population in 2002 by the AAH[3] and second is number of families and population in 2003 and 2004 by SEILA database. Due to some families are living together in same house, the number of families is larger than the households. Number of households at 577 HH in 2002 by AAH was used for the base of the power demand forecast. Annual household growth rate of 2.84% per year that is calculated by using

[3] Water Needs Assessment, Mondul Kiri Province, 2002, Action Against Hunger (AAH)

number of families in the Bu Sra commune from 2003 to 2004 is applied. Total number of households in the Bu Sra commune at year 2020 is estimated at 955 HH.

[Projected Number of Households in 2020 in the Bu Sra commune]

577 HH x (1+0.0284)^(2020-2002) = 955 HH

At present, about 98% of households in the Bu Sra commune are living along the main roads as shown in the table above (Table 3.29). Based on this information, the target number of household in the electrified area is planned that 98% of total household in 2020 will be connected to the mini-gird by MHP scheme and the remaining household in remote area will be supplied electricity by the battery charging station. Total number of target household for the project is estimated 936 HH (955 HH x 98% = 936 HH) in 2020 (Table 3.30).

Table 3.30 Projected Number of Household in Bu Sra Commune (Year 2020)

Year	2002	2003	2004	2020
Nos. of Families in Busra Commune	n.a.	704	724	1,133
Annual Growth (%)			2.84%	2.84%
Nos. of Households in Busra Commune	**577**	n.a.	n.a.	**955**
Source:	AAH,2002	Seila,2003	Seila,2004	forecast
Assumed Connection Rate (%)				98%
Estimated No. of Electrified (Target) Households in 2020				**936**

Source: JICA Study Team

(2) Power Demand by Time Zone

In addition to above domestic household, power demand by public sector (such as schools, clinics, public lightings, pagoda, community center, etc.), commercials (shops, guest house, restaurants, etc.) and small industries (rice mill, sawmill, tailoring, irrigation pumps, etc.) were estimated. Furthermore, as for the electrical losses on the transmission/ distribution lines and for the load fluctuations, 10~30% of peak demand was added. Estimated peak demand and the energy by each time zone are shown in Tables 3.31 and 3.32.

Table 3.31 Power Demand Forecast for the Bu Sra MHP Scheme (Year 2020)

Time Zone	Duration [hour]	Peak Demand *1) [kW]	Energy Demand *1) [kWh/day]
Night time 18:00 – 22:00	4	80 (69)	320 (276)
Midnight 22:00 – 06:00	8	6 (4)	48 (32)
Daytime 06:00 – 18:00	12	33 (30)	396 (360)
Total	24		764 (668)

Notes*1): Upper number is supply demand at power plant terminal and lower number is at the user terminal
Source: JICA Study Team

Table 3.32 Results of Power Demand Forecast for the Bu Sra MHP Scheme (Year 2020)

Power Demand in 2020 for Busra MHP

		Number of units	Unit (kW)	Diversity Factor (%)	Peak Demand (kW)	Notes / Assumptions
Nighttime Demand (18:00 - 22:00)						
Domestic (Light users)	90%	842	0.052	1.1	39.80	Assumed 2 x 20W tube+TV/Radio (40W)x30%
Domestic (Large users)	7%	66	0.128	1.2	7.02	2x20W tube + TV 65W, Karaoke/VCD 20W + Fridge 20%*80W*10/60
Commercials/ Business	3%	28	0.970	1.5	18.11	Shop:25, GH:2, 5x20W tube + TV 110W, Karaoke/VCD 20W, fridge 80W, rice cooker 600W, etc.
Sub Total (Domestic & Business)		936			64.93	8.3% = 20 min / (60 min x 4 hr)
Small Scale Industries						
Rice mill/Sawmill, tailoring, etc.		20				not work in night
Water pump, Irrigation pump, etc.		7				not work in night
Sub Total (Industry)		27			0.00	
Public utilities						
School for night class		2	0.160	1.1	0.29	8 tubes /room x 20W
Health center (MDM)		1	1.333	1.2	1.11	(8 tubes/room x 40W + refrigerator 80W*10/60 + water boiler 1kW)
Health posts (detached ward)		3				not work in night
Commune centre/pagoda/church, etc.		2	0.160	1.2	0.27	8 tubes/room x 20W
Public lights		90	0.018	1.0	1.62	Street light along the main road (3.6 km) * 1/40m x CFL 18W
Sub Total (Public)		98			3.29	
Sub-Total (Demand by User)			-		**69**	
T/L & Distribution Loss, etc.	10%				7	Transmission & Distribution Loss and for load fluctuation, etc.
Estimated Peak Load for Generator (Nighttime)			-		**80**	**(rounded)**
Mid-Night time Demand (22:00 - 6:00)						
Domestic (Light users)	90%	842				
Domestic (Large users)	7%	66	0.023	1.5	1.00	1x20W tube + fridge 20%*80W*10/60
Commercials/ Business	3%	28	0.033	1.5	0.62	1x20W tube + fridge 80W*10/60
Sub Total (Domestic & Business)		936			1.62	= 20 min / (60 min x 4 hr)
Small Scale Industries						
Rice mill/Sawmill, tailoring, etc.		20				not work in night
Water pump, Irrigation pump, etc.		7				not work in night
Sub Total (Industry)		27			0.00	
Public utilities						
School for night class		2				
Health center (MDM)		1	0.333	1.1	0.30	(1 tubes/room x 40W + refrigerator 80W*10/60
Health posts (detached ward)		3				not work in night
Commune centre/pagoda/church, etc.		2				8 tubes/room x 20W
Public lights		90	0.018	1.0	1.62	Street light along the main road (3.6 km) * 1/40m x CFL 18W
Sub Total (Public)		98			1.92	
Sub-Total (Demand by User)			-		**4**	
T/L & Distribution Loss, etc.	30%				2	Transmission & Distribution Loss and for load fluctuation, etc.
Estimated Peak Load for Generator (Nighttime)			-		**6**	**(rounded)**
Daytime Demand (6:00 - 18:00)						
Domestic (Light users)	10%	94	0.012	1.5	0.75	Assumed TV or Radio (40W) *30%
Domestic (Large users)	7%	66	0.023	1.5	1.00	1x20W tube + fridge 20%*80W*10/60
Commercials/ Business	3%	28	0.033	1.5	0.62	1x20W tube + fridge 80W*10/60
Sub Total (Domestic & Business)		188			2.37	
Small Scale Industries						
Rice mill/Sawmill, tailoring, etc.		20	2.500	2.0	25.00	1 ~ 8kW; assumed average 2.5kW
Water pump, Irrigation pump, etc.		7	0.200	2.0	0.70	1 water pump average 2kW / village
Sub Total (Industry)		27			25.70	
Public utilities						
Schools (class)		12				8 tubes /room x 20W, 3 schools
Health center (MDM)		1	1.333	1.1	1.21	8 tubes/room x 40W + refrigerator 80W + w.boiler 1kW
Health posts (detached ward)		3	0.040	1.1	0.11	2 tubes/room x 20W
Commune centre/pagoda/church, etc.		2				-
Sub Total (Public)		18			1.32	
Sub-Total (Demand by User)			-		**30**	
T/L & Distribution Loss, etc.	10%				3	Transmission & Distribution Loss and for load fluctuation, etc.
Estimated Peak Load for Generator (Daytime)			-		**33**	**41% of Nighttime demand**

Source: JICA Study Team

3.5 DEMAND & SUPPLY BALANCE AND FORMULATION OF ELECTRIFICATION PLAN

3.5.1 Alternative Cases

As mentioned above, peak power demand was estimated at 80kW in 2020. Based on the flow duration curve, power supply shortage might be occurred about 47 days of a year. For sufficient power supply, it is required to prepare backup diesel generator or a daily regulating pond. Following alternative methods are considerable for the daily regulating pond.

(i) River channel regulating pond : construction of weir/small dam at near the proposed intake site, which the height of weir is raised to reserve water, and utilize natural river channel as a water reservoir.

(ii) Large capacity Head-tank : construction of large size of head tank with a regulating function.

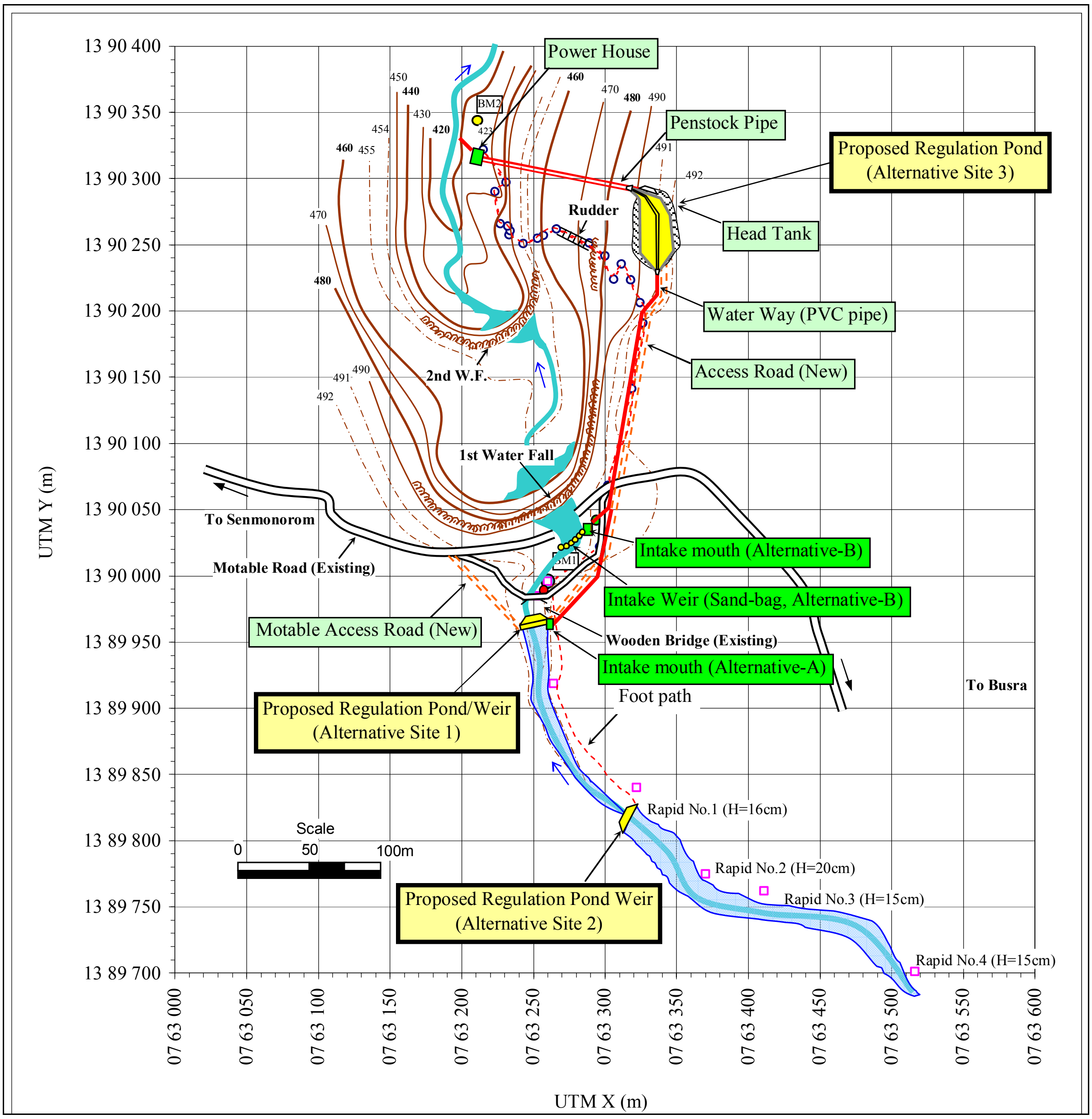
Following three (3)-alternative cases are evaluated to supply peak demand for dry season.

Case-A: MHP (80kW) only + with Regulation Pond (by river channel regulating pond)

Case-B: MHP (80kW) only + with Regulation Pond (by large size head tank)

Case-C MHP (80kW) + Diesel Generator (80kW, only dry season operate)

Layout plan of the alternative cases are shown in Figure.3.17.



Source: JICA Study Team

Figure 3.17 Layout Plan of Alternative Cases for Bu Sra MHP Scheme

For the alternative "Case-A" of the river channel regulation pond method, there are two alternative sites are considerable. The "A-1" site will be located just upstream of the water level gauging station near the wooden bridge where shape of the river channel is like deep pool (see Figure 3.6 above mentioned the cross section at WL station). Half of the proposed weir will be under the river water. On the other hand, alternative site of "A-2" will be located about 170m upstream form wooden bridge where river bed rock is appeared. Construction of weir at "A-2" site will be technically easier than "A-1" site. However, length of the access road and headrace channel to the "A-2" site is long and the construction cost of "A-2" site will be higher than the "A-1" site. Although from the consideration of the operation & maintenance, the "A-1" site was selected for the proposed intake site.

3.5.2 Daily Regulating Pond

Utilising of the daily regulating pond, power generation for the peak demand hours will be able to supply even in the dry season. Required capacity of the daily regulation pond is calculated based on the flow duration curve and the required plant discharge for power demand by each time zone. Table 3.33 shows power demand and the required plant discharge. Calculated annual power output at power plant and annual energy consumption by user is shown in Table 3.34.

In this calculation, a maintenance flow to the downstream of intake weir for the tourism purpose was considered. During daytime from 6:00 to 18:00, the discharge water to the waterfall is assumed to released same volume of inflow water (inflow = outflow). Hence, in the dry season, required water volume for the peak generation in night time zone (18:00-22:00, 4 hours) and for other time zone will be reserved mainly in midnight (22:00-6:00). As shown in Table 3.34, utilizing daily regulation pond, it is available to supply 4 hours/day of peak generation at 80kW during 97% (354 days) of a year and even at minimum discharge (100% of duration) about 1 hour/day of 80kW is available. Although during daytime (6:00-18:00), it is available to supply 12 hours/day at 33kW during 85.1% (311 days) of a year and at 95% (347 days) discharge it is available to supply 33kW for 1.84 hours. Priority for the midnight (22:00-6:00) was planned low to other time zone in the dry season. Therefore, availability of generation for the demand of 6kW in the midnight will be about 85% of a year. Annual output at power plant and annual energy consumption/sales by the user is estimated as follows.

Estimated Annual Output at Power Plant = 260 MWh/year

Estimated Annual Energy Consumption by User = 228 MWh/year

Table 3.33 Power Demand and the Required Plant Discharge by Time Zone

FWL at Intake	490.67	m	Water Loss Head	2.24	m
FWL at P/H	426.58	m			
Gross Head	64.09	m	Effective Head (He)=	61.85	m
			Efficiency η =	0.70	

P (kW) = 9.8 * He * Q * η

Power Demand & Required Discharge

Time Zone in a day	Hour per day (hr/day)	Gene. Demand (kW)	Required Discharge (m^3/s)	Required W.Vol. (m^3/day)	Hour per day (hr/day)	Saleable P.Demand (kW)
6:00-18:00	12 hr	33	0.078	3,370	12 hr	30
18:00-22:00	4 hr	80	0.189	2,722	4 hr	69
22:00-6:00	8 hr	6	0.014	403	8 hr	4
Total	24 hr			6,495	24 hr	

Table 3.34 Available Annual Generation Output and Annual Energy Consumption by User

Duration of Year (all series from 1977 - 2005)		Daily Q Inflow at Busra WL St.	Daily Total W.Vol. (Inflow)	Daytime Maintenance Flow for D/S W.F.(Tourism) Release = Inflow			Usable Water Vol. (except daytime)	Available Generation Output (MHP)											
								18:00-22:00			22:00-6:00			6:00-18:00			Tot. Daily Energy Production	Duration (Period) Days	Annual Energy Production
				Q	Duration	Vol.		Available Output		Energy Output	Available Output		Energy Output	Available Output		Energy Output			
		(m^3/s)	**(m^3/day)**	(m^3/s)	(hour)	(m^3/day)	**(m^3/day)**	(kW)	(hour)	(kWh/day)	(kW)	(hour)	(kWh/day)	(kW)	(hour)	(kWh/day)	(kWh/day)	(days)	(kWh/day)
50.0%	183 days	3.201	**276,566**	3.201	12.0	138,283	**138,283**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	183	**139,430**
60.0%	219 days	2.248	**194,227**	2.248	12.0	97,114	**97,113**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	37	**27,886**
70.0%	256 days	1.223	**105,667**	1.223	12.0	52,834	**52,833**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	37	**27,886**
75.0%	274 days	0.789	**68,170**	0.789	12.0	34,085	**34,085**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	18	**13,943**
79.7%	291 days	0.380	**32,832**	0.380	12.0	16,416	**16,416**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	17	**13,106**
80.0%	292 days	0.362	**31,277**	0.362	12.0	15,638	**15,639**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	1	**837**
81.0%	296 days	0.280	**24,192**	0.280	12.0	12,096	**12,096**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	4	**2,789**
82.0%	299 days	0.233	**20,131**	0.233	12.0	10,066	**10,065**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	4	**2,789**
83.0%	303 days	0.206	**17,798**	0.206	12.0	8,899	**8,899**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	4	**2,789**
84.0%	307 days	0.179	**15,466**	0.179	12.0	7,733	**7,733**	80	4.00	**320**	6	8.00	**48**	33	12.00	**396**	764	4	**2,789**
85.0%	310 days	0.150	**12,960**	0.150	12.0	6,480	**6,480**	80	4.00	**320**	6	7.70	**46**	33	12.00	**396**	762	4	**2,781**
85.1%	311 days	0.146	**12,614**	0.146	12.0	6,307	**6,307**	80	4.00	**320**	6	4.27	**26**	33	12.00	**396**	742	0	**271**
86.0%	314 days	0.128	**11,059**	0.128	12.0	5,530	**5,529**	80	4.00	**320**	0	0.00	**0**	33	10.00	**330**	650	3	**2,135**
87.0%	318 days	0.119	**10,282**	0.119	12.0	5,141	**5,141**	80	4.00	**320**	0	0.00	**0**	33	8.61	**284**	604	4	**2,205**
88.0%	321 days	0.113	**9,763**	0.113	12.0	4,882	**4,881**	80	4.00	**320**	0	0.00	**0**	33	7.69	**254**	574	4	**2,095**
89.0%	325 days	0.106	**9,158**	0.106	12.0	4,579	**4,579**	80	4.00	**320**	0	0.00	**0**	33	6.61	**218**	538	4	**1,964**
90.0%	329 days	0.100	**8,640**	0.100	12.0	4,320	**4,320**	80	4.00	**320**	0	0.00	**0**	33	5.69	**188**	508	4	**1,854**
91.0%	332 days	0.095	**8,208**	0.095	12.0	4,104	**4,104**	80	4.00	**320**	0	0.00	**0**	33	4.92	**162**	482	4	**1,759**
92.0%	336 days	0.089	**7,690**	0.089	12.0	3,845	**3,845**	80	4.00	**320**	0	0.00	**0**	33	4.00	**132**	452	4	**1,650**
93.0%	339 days	0.084	**7,258**	0.084	12.0	3,629	**3,629**	80	4.00	**320**	0	0.00	**0**	33	3.23	**107**	427	4	**1,559**
94.0%	343 days	0.080	**6,912**	0.080	12.0	3,456	**3,456**	80	4.00	**320**	0	0.00	**0**	33	2.61	**86**	406	4	**1,482**
95.0%	347 days	0.075	**6,480**	0.075	12.0	3,240	**3,240**	80	4.00	**320**	0	0.00	**0**	33	1.84	**61**	381	4	**1,391**
96.0%	350 days	0.071	**6,134**	0.071	12.0	3,067	**3,067**	80	4.00	**320**	0	0.00	**0**	33	1.23	**41**	361	4	**1,318**
97.0%	354 days	0.066	**5,702**	0.066	12.0	2,851	**2,851**	80	4.00	**320**	0	0.00	**0**	33	0.46	**15**	335	4	**1,223**
98.0%	358 days	0.059	**5,098**	0.059	12.0	2,549	**2,549**	80	3.75	**300**	0	0.00	**0**	0	0.00	**0**	300	4	**1,094**
99.0%	361 days	0.050	**4,320**	0.050	12.0	2,160	**2,160**	80	3.17	**254**	0	0.00	**0**	0	0.00	**0**	254	4	**927**
100.0%	365 days	0.016	**1,382**	0.016	12.0	691	**691**	80	1.02	**81**	0	0.00	**0**	0	0.00	**0**	81	4	**297**
																	Total =	365	**260,245**

Source: JICA Study Team

Duration of Year (all series from 1977 - 2005)		Energy Consumption by User (kWh)											
		18:00-22:00			22:00-6:00			6:00-18:00			Tot. Daily Energy Sales	Duration (Period) Days	**Annual Energy Consumpt.**
		Available Output	Available Supply	**Energy Production**	Available Output	Available Supply	**Energy Production**	Available Output	Available Supply	**Energy Production**			
		(kW)	(hour)	**(kWh/day)**	(kW)	(hour)	**(kWh/day)**	(kW)	(hour)	**(kWh/day)**	(kWh/day)	(days)	**(kWh/day)**
50.0%	183 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	183	**121,910**
60.0%	219 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	37	**24,382**
70.0%	256 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	37	**24,382**
75.0%	274 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	18	**12,191**
79.7%	291 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	17	**11,460**
80.0%	292 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	1	**731**
81.0%	296 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	4	**2,438**
82.0%	299 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	4	**2,438**
83.0%	303 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	4	**2,438**
84.0%	307 days	69	4.00	**276**	4	8.00	**32**	30	12.00	**360**	668	4	**2,438**
85.0%	310 days	69	4.00	**276**	4	7.70	**31**	30	12.00	**360**	667	4	**2,435**
85.1%	311 days	69	4.00	**276**	4	4.27	**17**	30	12.00	**360**	653	0	**238**
86.0%	314 days	69	4.00	**276**	0	0.00	**0**	30	10.00	**300**	576	3	**1,892**
87.0%	318 days	69	4.00	**276**	0	0.00	**0**	30	8.61	**258**	534	4	**1,949**
88.0%	321 days	69	4.00	**276**	0	0.00	**0**	30	7.69	**231**	507	4	**1,851**
89.0%	325 days	69	4.00	**276**	0	0.00	**0**	30	6.61	**198**	474	4	**1,730**
90.0%	329 days	69	4.00	**276**	0	0.00	**0**	30	5.69	**171**	447	4	**1,632**
91.0%	332 days	69	4.00	**276**	0	0.00	**0**	30	4.92	**148**	424	4	**1,548**
92.0%	336 days	69	4.00	**276**	0	0.00	**0**	30	4.00	**120**	396	4	**1,445**
93.0%	339 days	69	4.00	**276**	0	0.00	**0**	30	3.23	**97**	373	4	**1,361**
94.0%	343 days	69	4.00	**276**	0	0.00	**0**	30	2.61	**78**	354	4	**1,292**
95.0%	347 days	69	4.00	**276**	0	0.00	**0**	30	1.84	**55**	331	4	**1,208**
96.0%	350 days	69	4.00	**276**	0	0.00	**0**	30	1.23	**37**	313	4	**1,142**
97.0%	354 days	69	4.00	**276**	0	0.00	**0**	30	0.46	**14**	290	4	**1,059**
98.0%	358 days	69	3.75	**258**	0	0.00	**0**	0	0.00	**0**	258	4	**944**
99.0%	361 days	69	3.17	**219**	0	0.00	**0**	0	0.00	**0**	219	4	**800**
100.0%	365 days	69	1.02	**70**	0	0.00	**0**	0	0.00	**0**	70	4	**256**
											Total =	365	**227,590** kWh/year
													228 MWh/year

Source: JICA Study Team

Required reservoir capacity (water volume) for the daily regulation pond is estimated at 3,990 m^3 as shown in Table 3.35. Required raise height by the weir from the dry season's normal water level at proposed intake site, which is located near the water level gauge, is estimated about 1.0 m.

Table 3.35 Required Reservoir Capacity of the Daily Regulation Pond for the Peak Generation in Dry Season, Bu Sra MHP Scheme

Duration of Year (all series from 1977 - 2005)		Estimation of Required Reservoir Volume																
		18:00-22:00					22:00-6:00					6:00-18:00					Required Reservoir Vol.
		Available Output		W.Use Vol.	Inflow Vol.	Required Res.Vol	Available Output		W.Use Vol.	Inflow Vol.	Required Res.Vol	Available Output		W.Use Vol.	Inflow Vol.	Required Res.Vol	
		(kW)	(hour)	(m^3/day)	(m^3/day)	(m^3/day)	(kW)	(hour)	(m^3/day)	(m^3/day)	(m^3/day)	(kW)	(hour)	(m^3/day)	(m^3/day)	(m^3/day)	(m^3/day)
50.0%	183 days	80	4.00	2,722	46,094	0	6	8.00	403	92,189	0	33	12.00	3,370	0	3,370	3,370
60.0%	219 days	80	4.00	2,722	32,371	0	6	8.00	403	64,742	0	33	12.00	3,370	0	3,370	3,370
70.0%	256 days	80	4.00	2,722	17,611	0	6	8.00	403	35,222	0	33	12.00	3,370	0	3,370	3,370
75.0%	274 days	80	4.00	2,722	11,362	0	6	8.00	403	22,723	0	33	12.00	3,370	0	3,370	3,370
79.7%	291 days	80	4.00	2,722	5,472	0	6	8.00	403	10,944	0	33	12.00	3,370	0	3,370	3,370
80.0%	292 days	80	4.00	2,722	5,213	0	6	8.00	403	10,426	0	33	12.00	3,370	0	3,370	3,370
81.0%	296 days	80	4.00	2,722	4,032	0	6	8.00	403	8,064	0	33	12.00	3,370	0	3,370	3,370
82.0%	299 days	80	4.00	2,722	3,355	0	6	8.00	403	6,710	0	33	12.00	3,370	0	3,370	3,370
83.0%	303 days	80	4.00	2,722	2,966	0	6	8.00	403	5,933	0	33	12.00	3,370	0	3,370	3,370
84.0%	307 days	80	4.00	2,722	2,578	144	6	8.00	403	5,155	0	33	12.00	3,370	0	3,370	3,514
85.0%	310 days	80	4.00	2,722	2,160	562	6	7.70	388	4,320	0	33	12.00	3,370	0	3,370	3,932
85.1%	311 days	80	4.00	2,722	2,102	620	6	4.27	215	4,205	0	33	12.00	3,370	0	3,370	**3,990**
86.0%	314 days	80	4.00	2,722	1,843	879	0	0.00	0	3,686	0	33	10.00	2,807	0	2,807	3,686
87.0%	318 days	80	4.00	2,722	1,714	1,008	0	0.00	0	3,427	0	33	8.61	2,419	0	2,419	3,427
88.0%	321 days	80	4.00	2,722	1,627	1,095	0	0.00	0	3,254	0	33	7.69	2,159	0	2,159	3,254
89.0%	325 days	80	4.00	2,722	1,526	1,196	0	0.00	0	3,053	0	33	6.61	1,857	0	1,857	3,053
90.0%	329 days	80	4.00	2,722	1,440	1,282	0	0.00	0	2,880	0	33	5.69	1,598	0	1,598	2,880
91.0%	332 days	80	4.00	2,722	1,368	1,354	0	0.00	0	2,736	0	33	4.92	1,382	0	1,382	2,736
92.0%	336 days	80	4.00	2,722	1,282	1,440	0	0.00	0	2,563	0	33	4.00	1,123	0	1,123	2,563
93.0%	339 days	80	4.00	2,722	1,210	1,512	0	0.00	0	2,419	0	33	3.23	907	0	907	2,419
94.0%	343 days	80	4.00	2,722	1,152	1,570	0	0.00	0	2,304	0	33	2.61	734	0	734	2,304
95.0%	347 days	80	4.00	2,722	1,080	1,642	0	0.00	0	2,160	0	33	1.84	518	0	518	2,160
96.0%	350 days	80	4.00	2,722	1,022	1,700	0	0.00	0	2,045	0	33	1.23	345	0	345	2,045
97.0%	354 days	80	4.00	2,722	950	1,772	0	0.00	0	1,901	0	33	0.46	129	0	129	1,901
98.0%	358 days	80	3.75	2,549	850	1,699	0	0.00	0	1,699	0	0	0.00	0	0	0	1,699
99.0%	361 days	80	3.17	2,160	720	1,440	0	0.00	0	1,440	0	0	0.00	0	0	0	1,440
100.0%	365 days	80	1.02	691	230	461	0	0.00	0	461	0	0	0.00	0	0	0	461

Source: JICA Study Team

Max.= **3,990**

3.5.3 Comparison of the Alternative Cases

Additional costs for each alternative case were estimated as shown in the table below. The additional cost is calculated as the cost from normal design layout without peak generation in dry season. As shown in the table below, river channel regulation pond method (Case-a) is the most economical.

Table 3.36 Comparison of Additional Cost of Alternative Cases

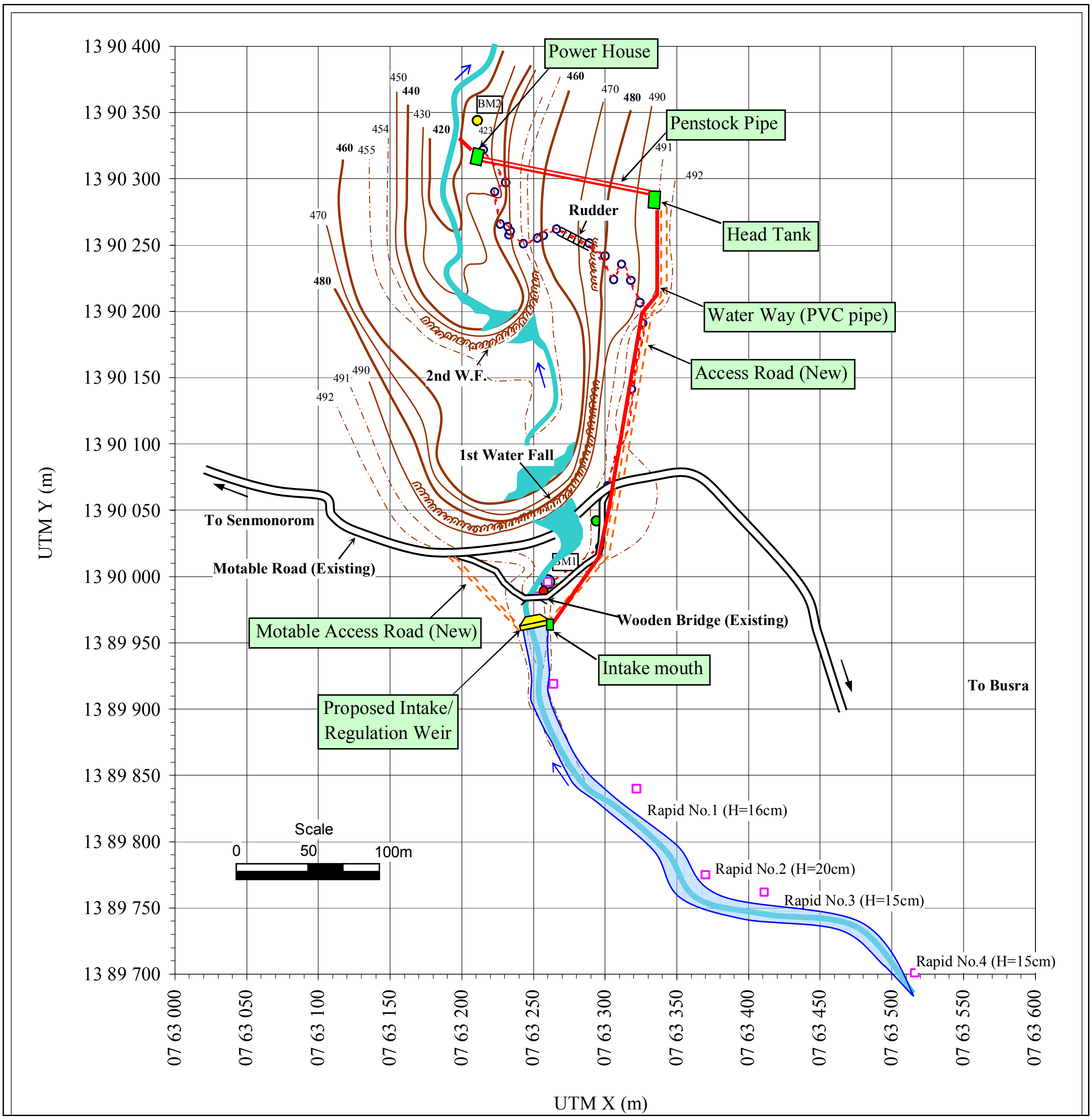
Case	Description	Additional Cost (US$)
(a)	MHP (80kW) only ＋ Regulation Pond (River Channel Regulation Pond by Increase weir height)	51,100
(b)	MHP (80kW) only ＋ Regulation Pond (Increase Head Tank capacity)	55,400
(c)	MHP (80kW) only ＋ Diesel Generator (80kW) only operated in dry season	131,700

Source: JICA Study Team

3.6 PRELIMINARY DESIGN

3.6.1 Layout Plan of Proposed Scheme

Proposed layout plan of the Bu Sra MHP scheme is shown in Figure 3.18.



Source: JICA Study Team

Figure 3.18 Proposed Layout Plan of Bu Sra MHP Scheme

3.6.2 Civil Structures

A summary of preliminary design concept on the civil structures of the proposed Bu Sra MHP scheme is shown in Table 3.37.

Table 3.37 Preliminary Design Concept of Proposed Bu Sra MHP Scheme (Civil Structures)

	Structures	Considered Items, Applied Criteria, Technical Concepts, etc.
1	Intake Weir	・The construction site where the riverbed is stable and firm is to be selected. ・Location and design of the intake weir should be considered on landscape for tourism. Hence, location of the proposed intake weir site should be established at about 80m upstream from upper waterfall (about 10m upstream from existing wooden bridge). ・The intake weir is to be a concrete structure. The function of the weir includes river channel daily regulation pond (V= 3,990m^3). ・Height of the weir to be about 2.5m from river bed (Crest EL. = 429.0m). Maximum

	Structures	Considered Items, Applied Criteria, Technical Concepts, etc.
		reservoir water level by the weir will be increased about 1.0m from the dry season's normal water level at the weir site. ・Width of weir = approx.17m. Downstream side of the weir will be inundated in the river water about 1.0m depth in dry season due to proposed site of weir is like deep pool. The weir will sink during flood. ・A steel or concrete bridge, which is vehicles/truck passable, over the weir is proposed for safety access in flood season. (crest EL. > 493m, L=25m, W=3,3m)
2	Intake Mouth	・Intake will be installed at right bank of just upstream of intake weir due to consideration of safety access in flood period. ・Install a spindle type steel gate (W 0.6m x H 0.55m) to control inflow discharge. The gate control handle will be manual operate by operator. ・Install a screen (V=0.6 m/s, W 0.4m x H 1.1m) on the opening of the intake to prevent ingress of driftwood, etc. Maximum design intake discharge = 0.2 m^3/s. ・Standardize the structure, considering design, construction cost and maintenance.
3	Sand Settring Basin	・Sand settling basin is ommited (not concidered) because of proposed intake site is deep pool and like a natural desanding basin.
4	Headrace Canal	・Embedded (underground) channel in principle for safety and landscape for tourism. ・Low pressure pipe underground channel is selected due to consideration of flood water level and the economical design. ・HDPE (D = 200mm) pipe is proposed for easy installation, transportation and strength. ・Design slope = 1/1,000, L = 330m, Loss head = 0.33m. ・The maximum average velocity is 2.0 m/s for economical diameter and to prevent sediment in the pipe.
5	Head Tank	・Install a head tank at the entrance of the penstock. ・The capacity of the head tank is to be adequate to supply the maximum plant discharge for more than 1~2 minutes. (V= 23m^3, A/Q >50, H 1.5m x W 2.0m x L 7.6m) ・No outlet gate is to be installed but an inlet valve is to be set up at the power plant end of the penstock pipe instead. Install a screen in front of intake yard. ・Set up the free over flow type spillway at the side of head tank. (crest = EL. 490.0m) ・Install a sand flush (scouring) gate for sediments, which is to be a spindle gate for manual operation. Bottom slope = 1/15 ~ 1/50. Average velocity = 0.4 ~ 0.6 m/s。 ・The head tank is to be a reinforced concrete structure.
6	Penstock	・HDPE (D= 310mm) pipe is proposed for easy installation, transportation and strength. ・To be laid underground for protection and tourism landscape. ・Detail investigations and design is required on stability and construction method of the penstock due to steel and unstable geological conditions. ・Hydrostatic pressure = 0.61 MPa (H= 61m). The pressure increasing by water hammer pressure might be small due to manual operation of inlet valve and governor. Assuming increasing of pressure at 10%, the maximum pressure will be at 0.7 MPa. ・The design velocity in the pipe is 2.5 m/sec maximum, and the pipe diameter is to be unified. Pipe length L = 154 m. D = 310mm, Loss head = 3.86 m.
7	Power House	・Retain space for inspection and dismantling of equipments and disassembled components etc. ・Power house building is to have concrete walls 1 m from the foundation. ・Structured to prevent flood/sediment influx and damage by rock falls. ・Generators and equipment are to be installed inside the building. ・Consider ventilation by setting up air vents with insect screens. ・Design flood water level = EL. 426.48 m, turbine center = EL. 426.58 m.
8	Tailrace	・Design to keep the necessary water depth in the bottom outlet and to ensure uniform flow without vortices from the outflow from turbine.

Prepared by JICA Study Team

3.6.3 Electrical Facilities

A summary of preliminary design concept on the electrical facilities of the proposed Bu Sra MHP scheme is descried in Table 3.38.

Table 3.38 Preliminary Design Concept of Proposed Bu Sra MHP Scheme (Electrics)

	Facility	Considered Items, Applied Criteria, Technical Concepts, etc.
1	Turbine	・Two sets of turbines and generators (40 kW x 2 sets) is proposed due to consideration of large gap of power demand in peak and midnight. Same size and same type of turbine/generator sets is proposed for maintenance and spare parts. ・For moderate head (H=61m) and small discharge (Q=0.189 m^3/s), a cross flow type hydraulic turbine is to be adopted, which has a simple structure for maintenance and is economical. ・In the case of around 50 kW output, the method below is to be adopted. Use of an automatic guide-vane servo-motor is not recommended as it makes the mechanism complicated and difficult to maintain, and it is eventually not economical. ➢ Flow regulation : Control the guide-vane manually by the load. ➢ Governor : Use an electronic servo-less governor (speed adjusting device), a static governor that sets up dummy loads to stabilize the frequency to meet the load and control the rotating speed. ➢ Inlet valve : Manual gate valve ・To be designed so as not to suffer mechanical damage under unrestrained rotating speed in case of the failure of the governor
2	Generator	・The plant is under unmanned control and to be designed for proper operation with one check up a day. ➢ Control method : by automatic voltage regulator (AVR) [Generator] ➢ Generator Type : 3-phase AC, brushless synchronous generator ➢ Frequency : 50 Hz ➢ Voltage : AC400V ➢ Connection : Pentagram, 3 phases 4 line conductors ・The generator is to be connected directly to the turbines to prevent a decrease in the connection efficiency and complication in maintenance by belt type connection. ・Two synchronous generator is planned for two turbines. ・A turbine efficiency of 82%, generator efficiency of 85%, and combined efficiency 70% are used in general. ・Install a step-up transformer (400V ==> 22kV) at outside of power house.

Prepared by JICA Study Team

3.7 COST ESTIMATE

3.7.1 Basic Condition

The cost estimate was made on the basis of the following assumptions and conditions:

1) The costs were estimated at the price level of December 2005;
2) Equipment and materials imported includes related taxes (VAT 10%, import duties 15%);
3) Construction work will be implemented under contract basis;
4) Cost of the design, studies, administrative and engineering services was estimated at 15 % of the direct construction cost; and

3.7.2 Construction Cost

(1) Micro Hydro Power (MHP)

Estimated construction cost of the MHP scheme based on the above mentioned proposed layout plan is summarized in Table 3.39. Work quantities of the MHP scheme is estimated mainly based on the “Guide Manual for Development Aid Program and Studies of Hydro Electric Power Projects” by NEF, Japan (1996). Details of the work quantity and cost estimation are shown in Tables 3.41 - 3.42.

Table 3.39 Construction Cost of Micro Hydro Power (Bu Sra MHP Pre-F/S)

Item	Estimated Cost (US$)			Note
	Total	F.C.	D,C,	
Construction Cost				
1. Preparation Works	**11,001**		**11,001**	(3+4)*0.05
2.Mitigation for Environment	**11,001**		**11,001**	(3+4)*0.05
3.Civil Works	**200,178**	**119,441**	**80,737**	
3.0 Access Roads	111,032	103,950	7,082	
3.1 Intake Weir	50,379	2,936	47,443	excluded gate/screen
3.2 Intake	4,805	0	4,805	excluded gate/screen
3.3 Sand Settling Basin	0	0	0	excluded gate/screen
3.4 Headrace	8,107	7,267	840	
3.5 Head Tank	8,179	2,133	6,046	excluded gate/screen
3.6 Penstock	5,701	290	5,410	excluded Pipe cost
3.7 Spillway	1,742	243	1,500	
3.8 Power House	9,998	2,467	7,531	
3.9 Tailrace	236	155	81	
3.10 Outlet	0	0	0	
4.Mechanical Woks	**19,845**	**19,845**	**0**	
4.1 Gate & Schreen	11,747	11,747		
4.2 Penstock Pipe	8,098	8,098		
5.Electrical Works	**290,237**	**289,522**	**715**	
Turbine/Generator	119,798	119,798	0	
Transmission Line & Distribution Facilities	170,439	169,724	715	
6. Transportation	**1,472**	**0**	**1,472**	
7.Direct Cost Total	**533,734**	**428,808**	**104,926**	**1.+2.+3.+4.+5.+6.**
		80.3%	**19.7%**	

Source: JICA Study Team

(2) Distribution Lines

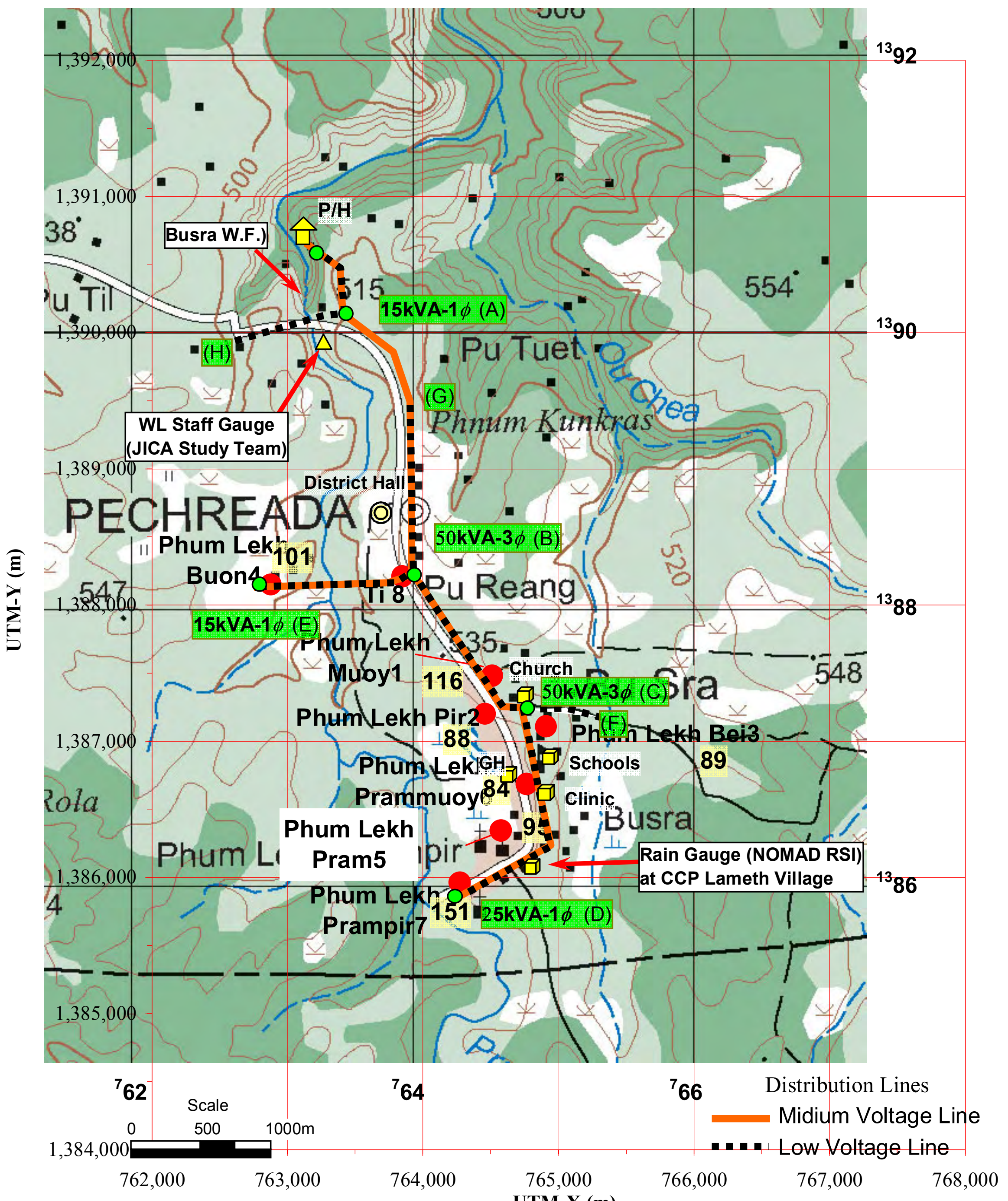
Figure 3.19 shows proposed distribution line layout for the Bu Sra MHP scheme. Work quantities for the distribution line works was estimated as shown in Table 3.40. In the Bu Sra commune, household distribution is dense along trunk road. Thus, route of the medium voltage (MV) lines are also planned along trunk road. Design voltage of MV lines was design 22kV based on the Cambodian standards. About 8 km long of MV line, which is among total length of 9.05 km of MV line, is planned as dual pole line, that is use MV lines and LV lines will use the same transmission pole, to save costs.

For the size of transformer, typical type of 25 kVA and 50 kVA were selected considering the number of households to be electrified. In case village demand size is relatively large as daytime demand, such as sawmills, small industries, irrigation pumps, etc., is expected, three-phase transformer is adopted (2 sites in village center).

Table 3.40 Quantity of Distribution Lines (Bu Sra MHP Pre-F/S)

Construction Cost	Q'ty	Unit
Distribution Line		
Only MV	1.0	km
MV & LV dual	8.0	km
Only LV	2.9	km
Transformer		
15kVA, single phase	2	set
25kVA, single phase	1	set
25kVA, three-phase	0	set
50kVA, three-phase	4	set
Others		L.S.

Source: JICA Study Team



Souorce : number of Family : SEILA data base 2003.

Location Map of Villages in Busra Commune

Distance	Length (m) of Distribution Lines			
	MV&LV	MV only	LV only	
P/H ~ 15kVA(A)	820			
15kVA(A) ~ 50kVA(B)	2,340			
15kVA(E) ~ 50kVA(B)	1,170			MV TOTAL (m)
50kVA(B) ~ 50kVA(C)	1,600			9,050
50kVA(C) ~ 25kVA(D)	2,080			
50kVA(C) ~ (F)			550	LV TOTAL (m)
50kVA(B) ~ (G)			1,300	10,880
(G) ~ 15kVA(A)		1,040		
15kVA(A) ~ (H)			1,020	MV+LV TOTAL (m)
Total	8,010	1,040	2,870	11,920

Prepared by JICA Study Team

Figure 3.19 Layout Plan of Distribution Networks for Bu Sra MHP Scheme

Table 3.41 Design Futures of Proposed Bu Sra MHP Scheme

MHP ID No.		**Name of MHP**	**Busra**	**Name of River**	
Province Code:		**Mondul Kiri**	**District**	**Inst. Capacity**	**80 kW**

Beneficiaries (Village)

Electrified HH =	**936**	**Peak Demand (kW) =**	**80.0**	**EIRR (MHP)**	**12.6%**

Design & Futures of Proposed Micro Hydro Power Scheme

Type of Project (Construction)	by Constructor	1
Type of Intake Weir	Concrete Dam	1
Consider Sandtrap (De-sander) basin (Y / N)		N
Type of Headrace Channel	HDPE Pipe	5
Type of Penstock Pipe	HDPE Pipe	3
Type of Turbine	Cross-Flow (Local made)	1
Helicopter Transportation	Not Use	1

Intake Site Elevation (*IWL*)	490.67	m.a.s.l.
Water way (Canal) Slope *I* (open=1/1000, Tunnel=1/500)	0.1%	1/1000
Head Tank Site Elevation (*HtWL*)	490	m.a.s.l.
Power House Site Elevation (*TcWL*)	430	m.a.s.l.
Elevation of Turbine Center	426.58	m.a.s.l.
Intake Weir Width	18.0	m
Headrace Channel Length L_1	330	m
Penstock Length L_2	154	m
Tailrace Length L_3	10	m
Headrace Flow Velocity V_c (Open=2 ~ 3 m/s)	2.50	m/s
Headrace Water Area (Cross Section)	0.08	m^2
Penstock Design Flow Velocity V_p (ave. V_p=2 ~ 4 m/s)	2.50	m/s
Pestock Pipe Diameter $Dp=(4*Q_d/(pi*V_t))^{(1/2)}$	0.31	m
Penstock Roughness n_p	0.011	-
Penstock Thickness $Tp=0.0362*H_g*D_t+2$ (min=2.0 mm)	2.7	mm
Length of Transmission line (both MV & LV used same pole)	8,010	m
Length of Transmission line (MV only)	1,040	m
Length of Distribution Line (LV only)	2,870	m
New Access Feeder Path Construction to Site	0.20	km
New Motable Access Road Construction	0.45	km
Distance from Border to Province Center /Reference Town)	0	km
Transportation from Provincial Center to Nearest Motable Road	40	km
Transportation by Headloar/ Animals	0.2	km
Transportation of Sand/Stones to Site	1.0	km

(Source: JICA Study Team)

Catchment Area at Intake	197.0	(km^2)
Design Flow Q_d	**0.189**	**m^3/s**
Design Flood Discharge Q_{flood}	**142.0**	**m^3/s**
Gross Head (*IWL* - *TWL*) H_g	**64.09**	m
Net Head (Ht*WL* - *TcWL*) H_{net}	60.76	m
Loss Head $H_1 = L_1/I$	0.33	m
Loss Head $H_2=124.5*0.011^2/D_t^{(1/3)}*L_2/Dt*V_t^2/(2*g)*125\%$	3.526	m
Loss Head H_3	0.00	m
Total Loss Head $H_l = H_1+H_2+H_3$	3.86	m
Effective Head $H_{es} = H_g - H_l$	60.23	m
Turbine Efficiency η_r	0.82	-
Generator Efficiency η_g	0.85	-
Combined Efficiency $\eta = \eta_t * \eta_g$	0.70	-
Firm Plant Capacity $P=9.8*Q_d*H_e*\eta r*\eta_t$	78	kW
Installed Capacity *P*	**80**	**kW**
Annual Energy Generation (Load Factor= 0.33)	228	MWh/yr
Number of Turbine (if P >= 50 kW, n=2)	2	Nos.
Transfomer 15 kVA, single phase	2	nos.
Transfomer 25 kVA, single phase	1	nos.
Transfomer 25 kVA, 3 phase	-	nos.
Transfomer 50 kVA, 3 phase	2	nos.
Transfomer 100 kVA, 3 phase	1	nos.

Summary of Cost Estimation and Economic Analysis

Discout Rate:	10.0%	
Life Cycle Year (MHP) :	20	years
Life Cycle Year (Grid) :	30	years

Investment Cost (MHP)	**660,600**	**US$**
Annualized Investment Cost (MHP)	**69,000**	**US$/yr**
Unit Investment Cost per kW	**8,258**	**US$/kW**
Unit Investment Cost per Household	**706**	**US$/HH**

Prepared by JICA Study Team

3.7.3 Project Cost

Total project cost including soft components such as basic design, detailed design, construction supervision, administration, etc., is estimated at 661,000 US$ as shown in Table 3.42.

Table 3.42 Estimated Total Project Cost of Bu Sra MHP Scheme

		Cost	Economical Price	
1. Hard Costs		533,734	452,667	
1.1 Civil Works		223,652	203,320	1.10
1.2 Power Station		139,643	112,996	
1.2.1 Gate/Screen		11,747	10,679	1.10
1.2.2 Pipe		8,098	6,478	1.25
1.2.3 Turbine/Gen.		119,798	95,838	1.25
1.3 T/D lines		170,439	136,351	1.25
2. Soft Costs(planning/design, supervision, administration, etc: 15% of hard costs)	15%	80,060	72,782	1.10
4. Service Wire, Meter, In-house Wire	US$50	46,800	42,545	1.10
Project Costs Total		**661,000**	567,995	

Prepared by JICA Study Team

3.7.4 Annual Operation and Maintenance Cost of MHP

(1) O&M Cost for Micro Hydro Power (MHP)

Annual operation and maintenance cost for MHP station is estimated as follows.

Table 3.43 Annual Operations and Maintenance Cost for MHP Station

	Work Items	Cost Breakdown	Cost
1	Periodical Maintenance for Whole Power Station	2 persons, Once a year, $500/time	$500
2	Operator's Salary	3 persons x $40 x 12 months	$1,440
3	Maintenance of Civil Structures	$60×12 months	$720
4	Dredging works for reservoir, head-tank, etc.	$500×1 time/year	$500
Total			$3,160 /year (rounded $3,200 /year)

Prepared by JICA Study Team

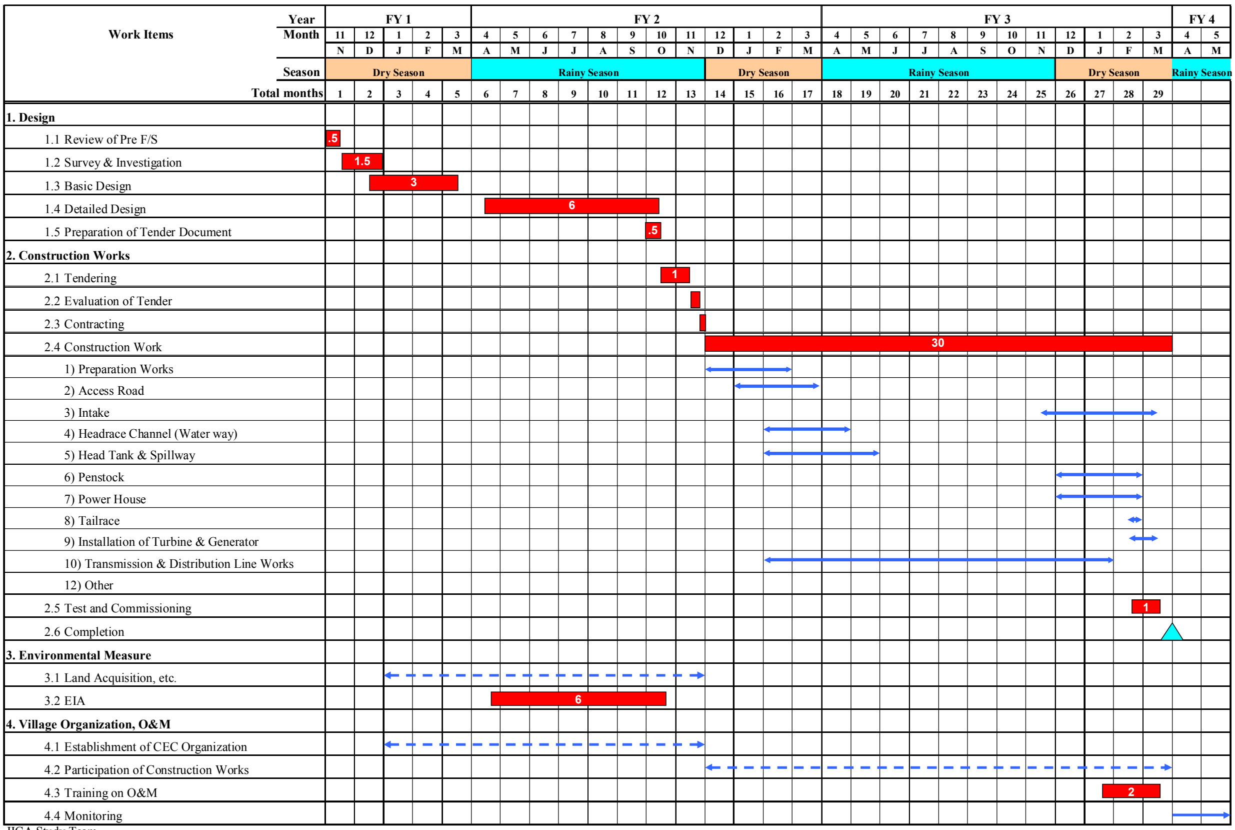
(2) O&M Cost for Distribution Lines

Annual operation and maintenance cost for distribution lines and transformers is tentatively calculated as 0.5% of construction cost, referring to samples in other developing countries as follows.

$170,439 x 0.5% = $852/year = $900/year (rounded-up)

3.8 CONSTRUCTION SCHEDULE

In the proposed construction schedule for the Bu Sra MHP scheme, major civil works are planned to be conducted in the dry season. Assuming that required time for basic design and detailed design is about 1 year, total required period for completion of the project will be around 29 months (2.5 years) as presented in Figure 3.20.



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Note: Construction Works : Preparation works, Construction of Access road, Intake weir, Intake, Headrace Tunnel, Headtank, Penstock, Spillway, Powerhouse, Tailrace, Maintenance Survice Route, etc. Installation of Turbine & Generator (40kW x 2 sets), Electric facilities, Transmission & Distribution Line s

Prepared by JICA Study Team

Figure 3.20 Proposed Construction Schedule for Bu Sra MHP Scheme

4 ECONOMIC AND FINANCIAL EVALUATION

4.1 ECONOMIC EVALUATION

4.1.1 Economic Cost of MHP

The economic viability of the Bu Sra MHP project is examined by computing the economic internal rate of return (EIRR). Economic costs are derived by taking the domestic taxes and subsidies from the financial costs. Economic cost of MHP scheme is estimated as shown in Table 3.44.

Table 3.44 Economic Cost of Bu Sra MHP Scheme (80kW)

	Direct Cost (US$)	Taxes	Economic Cost (US$)
1. Investment Cost	**533,734**		**438,351**
(1) MHP	**363,295**	1.20	**302,000**
(2) Distribution Lines/Transfomer, etc.	**170,439**	1.25	**136,351**
2. Operation & Menternance Cost	**4,100**		**3,727**
(1) MHP	**3,200**	1.10	**2,909**
(2) Distribution Lines/Transfomer, etc.	**900**	1.10	**818**
Total	**537,834**		**442,078**

Source: JICA Study Team

4.1.2 Benefit (Diesel)

(1) Alternative Case for Benefit Estimation

The costs of the least-cost alternative system, i.e., a diesel engine powered generation system with the capacity to generate the same amount of electricity as the proposed micro-hydro power, is considered to be the economic benefit.

(2) Construction Cost of Alternative Diesel Power Plant

Average unit price of diesel generator per kilowatt by supplier is $500/kW. Construction cost of the alternative diesel power plant is estimated by adding miscellaneous costs as follows.

US$ 500/kW (FOB Price, 100%)

+ Freight & Insurance (8%) + Inland Transportation (2%) + Installation (5%) + Buildings (25%)

+ Customs (15%) + Value Added Tax (VAT) (10%) = US$ 825/kW (rounded US$ 830/kW)

By applying the above unit cost, construction costs for diesel power plant with installed capacity of 80 kW is estimated as follows.

Construction cost: 80 kW x US$830/kW = US$ 66,400

In addition, contingency of 20% is added on the above cost.

Contingency (20%): US$ 66,400 x 20% = US$ 13,280

Therefore a construction cost for the alternative diesel power plant is estimated as follows.

Table 3.45 Construction Cost for Alternative Diesel Power Plant (80kW)

Construction Cost of Diesel Power Plant	US$ 66,400
Contingency (20%)	US$ 13,280
Total	US$ 79,680

(3) Economic Price of Diesel Power Plant

Economic cost of the alternative diesel power plant is estimated as shown in Table 3.46.

Table 3.46 Economic Cost of Alternative Diesel Power Plant (80kW)

	Direct Cost (US$)	Taxes	Economic Cost (US$)
1. Investment Cost	211,663		169,331
(1) Diesel	79,680	1.25	63,744
(2) Distribution Lines/Transfomer, etc.	131,983	1.25	105,587
2. Operation & Menternance Cost	57,200		52,000
(1) Diesel	56,500	1.10	51,364
(2) Distribution Lines/Transfomer, etc.	700	1.10	636
Total	268,863		221,331

Source: JICA Study Team

(4) Annual O&M Cost for Diesel Power Plant

Operation and maintenance cost for the diesel power plant is tentatively calculated as 0.5% of construction cost, referring to samples in other rural electrification enterprises by the diesel generator in Cambodia.

US$ 79,680 × 5% = $3,984 (rounded US$ 4,000 /year)

Fuel cost for the alternative diesel power plant is estimated by using a average unit price of diesel oil at 0.23 US$/kWh, referring to the Cambodia's average prices as follows. The annual generation energy (kWh) was applied same as MHP scheme.

228.0 MWh/year × 0.23 US$/kWh × 1,000 = US$ 52,440 (rounded US$ 52,500 /year)

Table 3.47 Annual Operation and Maintenance Cost for Diesel Power

Operation and Maintenance Cost	US$ 4,000
Fuel Cost	US$ 52,500
Total	US$ 56,500

Source: JICA Study Team

4.1.3 Economic Evaluation

The life of the proposed project is assumed to be 20 years after the three-year construction period, taking into account the economic life of the turbine/generator, the main facility of the projects. The applied discount rate is 10%.

As for a replacement cost or overhaul maintenance cost for the turbine, generator, gates and screens, etc. of the MHP, 10% of investment cost is assumed to appropriate every 5 years.

While, for the diesel power plant, 75% of investment cost of diesel generator, including power house building, is assumed as a replacement cost and appropriate every 10 years.

The economic internal rate of return (EIRR) of the Bu Sra MHP project on the basis of the above assumptions are computed to be 12.6% as in Table 3.48, using the economic cost and benefit stream shown above. It indicates that the proposed project is economically viable.

Table 3.48 Economic Analysis of Bu Sra MHP Project

Discount rate 10%

(Unit: US$)

Year	Cost								Benefit					Present Value				
	MHP Capital	Trans-mission, Service Wire etc.	Capital Cost	MHP O&M	Tans-misson O&M	O&M Cost	Total Cost		Annual Energy (MWh)	Capital Benefit	O&M	Total Benefit	Net Benefit	Cost	Benefit	B - C		Reduction of GHG* (t-CO2)
-3								1.0000				0	0		0	0	0	
-2	194,549		194,549				194,549	0.9091				0	-194,549	176,863	0	-176,863	1	
-1	194,549	178,897	373,446				373,446	0.8264		240,739		240,739	-132,707	308,633	198,958	-109,675	2	
1			0	2,909	818	3,727	3,727	0.7513	228		52,000	52,000	48,273	2,800	39,068	36,268	3	296
2			0	2,909	818	3,727	3,727	0.6830	228		52,000	52,000	48,273	2,546	35,517	32,971	4	296
3			0	2,909	818	3,727	3,727	0.6209	228		52,000	52,000	48,273	2,314	32,288	29,974	5	296
4			0	2,909	818	3,727	3,727	0.5645	228		52,000	52,000	48,273	2,104	29,353	27,249	6	296
5			0	2,909	818	3,727	3,727	0.5132	228		52,000	52,000	48,273	1,913	26,684	24,772	7	296
6	9,000		9,000	2,909	818	3,727	12,727	0.4665	228		52,000	52,000	39,273	5,937	24,258	18,321	8	296
7			0	2,909	818	3,727	3,727	0.4241	228		52,000	52,000	48,273	1,581	22,053	20,472	9	296
8			0	2,909	818	3,727	3,727	0.3855	228		52,000	52,000	48,273	1,437	20,048	18,611	10	296
9			0	2,909	818	3,727	3,727	0.3505	228		52,000	52,000	48,273	1,306	18,226	16,919	11	296
10			0	2,909	818	3,727	3,727	0.3186	228		52,000	52,000	48,273	1,188	16,569	15,381	12	296
11	9,000		9,000	2,909	818	3,727	12,727	0.2897	228	47,808	52,000	99,808	87,081	3,687	28,911	25,224	13	296
12			0	2,909	818	3,727	3,727	0.2633	228		52,000	52,000	48,273	982	13,693	12,712	14	296
13			0	2,909	818	3,727	3,727	0.2394	228		52,000	52,000	48,273	892	12,448	11,556	15	296
14			0	2,909	818	3,727	3,727	0.2176	228		52,000	52,000	48,273	811	11,317	10,506	16	296
15			0	2,909	818	3,727	3,727	0.1978	228		52,000	52,000	48,273	737	10,288	9,551	17	296
16	9,000		9,000	2,909	818	3,727	12,727	0.1799	228		52,000	52,000	39,273	2,289	9,353	7,064	18	296
17			0	2,909	818	3,727	3,727	0.1635	228		52,000	52,000	48,273	609	8,502	7,893	19	296
18			0	2,909	818	3,727	3,727	0.1486	228		52,000	52,000	48,273	554	7,729	7,175	20	296
19			0	2,909	818	3,727	3,727	0.1351	228		52,000	52,000	48,273	504	7,027	6,523	21	296
20			0	2,909	818	3,727	3,727	0.1228	228		52,000	52,000	48,273	458	6,388	5,930	22	296
	416,098	178,897	594,995	58,182	16,364	74,545	669,540			288,547	1,040,000	1,328,547	659,007	520,145	578,678	58,534		5,928

1) Discount rate is 10 %.

NPV(B-C)	58,534
B/C	1.113
EIRR	12.6%

Source: JICA Study Team

4.2 FINANCIAL EVALUATION

The financial viability of the Bu Sra MHP project is examined by computing the minimum power tariff to cover the investment and O&M costs of the project. Assumptions such as project life, price level, exchange rate, economic life of the equipment and O&M costs are the same as in the case of the economic evaluation. Plant factor of the proposed MHP station will be 32.5% {228MWh/year÷ (80kW * 24h * 365days)}.

The minimum power tariff is calculated by annualizing the investment by multiplying following CRF (Capital Recovery Factor) of respective discount rates, adding annual O&M cost, and then dividing it by annual power demand.

CRF (capital recovery factor) for MHP	(7%, 20-year repayment)	= 0.094
CRF (capital recovery factor) for Diesel	(10%, 10-year repayment)	= 0.163
CRF (capital recovery factor) for T/L & D/L	(7%, 30-year repayment)	= 0.080

The estimated financial internal rate of return (FIRR) is to be 7.1% as shown in Table 3.49. The applied discount rate is 10%. The estimation of cost of service and the tariff simulation is shown in Table 3.50. The electricity tariff for the Bu Sra MHP scheme, with 50% subsidy, is estimated at 0.16 US$/kWh. If there is no subsidy, the electricity tariff for the Bu Sra MHP scheme will be at 0.30 US$/kWh.

Table 3.49 Financial Analysis of Bu Sra MHP Project

Year	Benefit (US$) Total sales	Energy Sales	Commercial	Public	Total Benefit	Energy sales	Commercial Sales	Public Sales	Connection Fee($50/hh)	Costs (US$) Total Costs	Investment (Power Station)	T/D lines, Service Wire etc	Subsidy	Fuel Cost	O&M	Registration fee (1.6Riel/kWh)	Income Tax	Net Benefit
	(US$ 000)	(MWh)	(MWh)	(MWh)	(Average Tariff $/kWh)	0.166	0.166	0.166	0.00				50%			1.6	0% on net income	(US$)
-3	0	0	0	0	0	0	0	0		0								
-2	0	0	0	0	0	0	0	0		110,839	221,678		-110,839					-110,839
-1	0	0	0	0	0	0	0	0		219,458	221,678	217,239	-219,458					-219,458
1	228	228	0	0	37,805	37,805	0	0	0	4,191				0	4,100	91		33,614
2	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
3	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
4	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
5	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
6	228	228	0	0	37,805	37,805	0	0		14,091	9,900			0	4,100	91		23,714
7	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
8	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
9	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
10	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
11	228	228	0	0	37,805	37,805	0	0		14,091	9,900			0	4,100	91		23,714
12	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
13	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
14	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
15	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
16	228	228	0	0	37,805	37,805	0	0		14,091	9,900			0	4,100	91		23,714
17	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
18	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
19	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614
21	228	228	0	0	37,805	37,805	0	0		4,191				0	4,100	91		33,614

FIRR= 7.1%

Source: JICA Study Team

Table 3.50 Service Cost and Tariff Simulation for Bu Sra MHP Project

Estimation of Costs of Service

(unit: $)

		Subsidy (%): 50%		
1. Annual Costs	63,610	33,755		
1.1 Annual Capital Costs	59,710	29,855		
1.1.1 Power Station etc.	46,075			
1.1.2 T/D line etc.	13,635		Economical Price of OM costs	
1.2 O&M costs	3,900	3,900	3,545	1.1
1.2.1 O&M	3,900			
1.3 Fuel Costs	0	0		
2. Cost of Service ($/kWh)	0.279	0.148		
Annual energy sales(MWh)	228.0	228.0		

Note:Capital recovery factor (10%, 10-year repayment) = 0.163 Diesel
Capital recovery factor (7%, 10-year repayment) = 0.149 Biomas
Capital recovery factor (7%, 20-year repayment) = 0.094 Micro Hydro
Capital recovery factor (7%, 30-year repayment) = 0.080 T/D lines etc.

Tariff Simulation

Cost of service ($/kWh)	0.148	
Profit	0.018	12%
Tariff ($/kWh)	**0.166**	
Monthly Payment per HH (US$/mon/hh)	3.37	
Monthly Payment per HH (US$/mon/hh) 40w x 4h x 30 days = 2.4 kWh/mon	0.80	4.8

ATP (Initial connecting fees)	US$
70%	20
30%	40
Average	26

ATP (Monthly payment)

Lighting souece (/month)	Riel	US$
Kerosene (70%)	3,500	0.88
Battery(30%)	6,400	1.60
	9,900.00	2.48

Source: JICA Study Team

4.3 REDUCTION OF GREEN HOUSE GAS

For the CDM (clean development mechanism), reduction of the green house gas (GHG) such as CO_2, CH_4, etc., by the MHP against diesel generator is estimated by using annual energy output of 228 MWh/year. As shown in Table 3.49 above, the estimated total CO_2 reduction in 20 years by MHP is at 5,900 t-CO_2 by using conversion factor of 1.3 kg-CO_2/kWh for diesel generation (source: 1997, IPCC Guidelines).

5 ENVIRONMENTAL CONSIDERATIONS

For the environmental considerations, JICA's Environmental Guidelines and Checklist have been used for defining project Category (A, B or C) and conducting the environmental assessment. On the other hand, "Annex of Sub-Decree No.72 ANRK. BK." dated August 11, 1999, that is the "List of the Project Require an IEIA or EIA", and other concerned environmental regulations of the MOE of Cambodia have also been referred and applied.

It is noted here that formal guidelines for preparing an Initial Environmental Impact Assessment (IEIA) Reports have not been defined by the MOE. Therefore, the IEIA (IEE) of the project has been conducted based on the requirements of "Guideline for conducting Environmental Impact assessment (EIA) Report" stipulated by the "Prakas on Guidelines for preparing EIA Report", No.49 BST.SSR dated March 9, 2000.

Based on the results of the environmental screening conducted below, it is judged that IEIA is needed for the project. Details of the results of the environmental screening and IEIA conducted are described below.

5.1 ENVIRONMENTAL SCREENING

Attached Table 3.53 shows the details and results of the environmental screening of Bu Sra MHP project. Key results and findings of the environmental screening are summarized below.

(1) Considering the following factors, carrying out IEIA will be required.

1) The project site will be located in a Bio-diversity Conservation area being protected. In addition, the project will use the head difference of the Bu Sra waterfall, which is a tourism spot.

2) Therefore, <u>it is judged that the project belongs to Environmental Category B of "JICA Guidelines for Environmental and Social Consideration". Considering both the JICA Guidelines and also the MOE environmental regulations, carrying out an IEIA will be required for the MHP project.</u>

Project owner/implementing organization will have to conduct the IEIA and/or EIA and prepare the reports for submittal to the MOE for review and approval.

(2) Details of results and findings of the Environmental Screening

1) Potential natural and social environmental impacts

a. Bu Sra MHP project site will be located in a Bio-diversity Conservation Area designated by the MOE. Because this is a micro-hydro power (MHP) project and will utilize underground waterway, there will be little impact to the protected area. On the other hand, through interview conducted on June 8, 2005 with representatives of the concerned Bu Sra Commune and villagers, it was known that there are no any protected wildlife inhabited or found in the project area and its vicinity. Therefore, it can be concluded that there will be no negative impacts to be caused to the wildlife, nor to ecological system of the project site area.

b. The Bu Sra MHP will utilize the head difference of Bu Sra Waterfall, which is a tourism spot. Therefore, the project would have impact on the tourism, if mitigation measures would not be taken. Possible mitigation measure will be to keep at least 10% of water flow as of the end of dry season as minimum water flow for the waterfall. If this minimum flow would be too little to keep the scenery, the plant operation will be stopped during the daytime.

c. Because this is a MHP project, there will be no negative impacts to the water quality in and around the project site area.

d. There will be no negative impacts to groundwater of the project area and its vicinity.

2) Environmental issues in connection with the plant design and construction activities

a. There will be no negative impacts to the agriculture of the project site and its vicinity.

b. Because a small scale weir and underground waterway will be used, there will be no negative impact to the wildlife and ecology system in and around the construction site area...

c. There will have the following positive impacts to the villagers in and around the project site.

i) Electrification if the rural area

ii) Create employment opportunity as labour force source

iii) Create business opportunity to the villagers during project construction

d. Turbid river water and dust could be generated by construction work. Minimize river bed work to avoid high turbidity of the river water. Dust would be generated by construction work. Generating dust will be minimized by spraying water.

(3) Potential environmental impacts during plant operation

a. As mentioned above, the Bu Sra MHP will utilize the head difference of Bu Sra Waterfall, which is a tourism spot. Therefore, the project would have impact on the tourism, if mitigation measures would not be taken. Possible mitigation measure will be to keep at least 10% of water flow as of the end of dry season as minimum water flow for the waterfall. If this minimum flow would be too little to keep the scenery, the plant operation will be stopped during the daytime.

b. In spite of protected/rare wildlife not being found in the project site area and its vicinity, some wildlife might occasionally come into the plant facility area. Therefore, a certain protection measure, such as barrier fence/nets, will be set around outdoor electrical equipment and distribution facilities where necessary to protect the wildlife against suffering electric shock.

c. There will be no negative impacts to agriculture of the project site area and its vicinity.

The following is the results of the IEIA conducted for the project.

5.2 INITIAL ENVIRONMENTAL IMPACT ASSESSMENTS (IEIA) OF BU SRA MHP PROJECT

(1) Project Summary

Bu Sra MHP Project will be located at Bu Sra Commune, Pecher Chenda District, Mondul Kiri Province. There are seven (7) villages in the Commune. The MHP will make use of the head difference of Bu Sra Waterfall, and its capacity will be 80 kW.

It is noted that the waterfall is a tourism spot. Therefore, the power plant will not be operated during the daytime of tourism seasons when deemed necessary. On the other hand, the power plant site is located in a Protected Area (Bio-diversity Conservation, with its total area of about 429,440 ha) designated by the MOE. Based on the field survey and interviews conducted with Deputy Head, a council member of the Commune, and also with the villagers, it was known that there are no specific protected wildlife being inhabited or found in the project site area and its vicinity. Therefore, it can be concluded that there will be no significant negative environmental impacts to the wildlife and ecology system of the Protected Area by implementing the project.

Through various investigations and studied as mentioned above, it is clear that the project will be within the framework of Cambodia's national and international environmental laws and legislation standards.

(2) Purpose of the Project

The MHP project will be able to electrify projected 936 households (HHs in 2020) in the Commune. The projected households in 2020 are 955 HHs in the Commune in total. Electrification of the Commune will upgrade living conditions of the villagers.

(3) Project Description

- Project alternatives:

There are many rural areas which need electricity in Mondul Kiri Province. Through careful study by using GIS, it was found that there are about 20 MHP potential sites for rural electrification. Considering demand and balance among various factors such as cost and benefit, urgency of needs, accessibility of site area for construction machinery, etc., Bu Sra MHP project has been selected.

- It is still in the Master Planning stage, details of the quantity and quality of wastes to be disposed have not yet been estimated.

(4) Description of Environmental Resources and Background

a. Physical resources

1) Because of no any pollutant sources, such as industrial facilities, being existed in and around the project site area and its vicinity, air quality of the project site area and its vicinity is very good. At this moment, there is no any existing data available. Because this is a MHP, it can be anticipated that there will be no negative impacts to the surrounding air quality. The climate in Cambodia is tropical and the climate condition of the project site area is similar to other places in the country in average, i.e. there are a wet season and a dry season in a year. The wet season starts from June until the end of October. Other months are in dry season.
2) Same as the case of air quality, water quality of river water quality is in good condition. At this moment, there is no any existing data available. Because this is a MHP, it can be anticipated that there will be no negative impacts to the river water quality.

b. Ecological resources

1) Through field survey and interviews with the villagers, it was known that there are no any protected wildlife being inhabited or found in the project site area and its vicinity.
2) Most of the forests existing in the site area and its vicinity are secondary forests (about 80%).

c. Socio-economical resources

1) As of June 8, 2005, total population of Bu Sra Commune is 3,326. Total number of families is 712, of which about 8% are Khmer and 92% are minority people (Phnong).
2) There are about 50 D/Gs in the Commune, and about 100 households are using batteries for lighting and TV. There is only one battery charging station in the Commune. Source of water supply is well and brooks.
3) Through discussions made with the Deputy Head of the Commune, it was known that most of the housing lots of the villagers were illegally occupied in long time ago. However, most of them have now been entitled with their land ownership.

4) There is one Health Center, which provides outreach services to 3 Health Posts. No medical doctor resident in the Commune. There are 12 hearth care takers, including nurses.

5) There is one school that provides primary and secondary education. Another new secondary school has just been built.

6) Average monthly income of a household is about 30,000 Riel, of which the main income source is agriculture. About 80% of income is from rice field. Collection of nature resin is also an income source (about 10%)

(5) Public Participation

1) For the purpose of natural and socio-economic field survey, DIME engineers and JICA Study Team members visited the concerned project site and its vicinity. During the visits, they met with the Deputy Head, a Council member and villagers and carried out interview with them. Through the interview, it was known that they all need more reliable electricity for electrification of the villages. On the other hand, improvement of communication road condition and having additional water supply sources are also essential.

2) At the stage of carrying out F/S, stakeholder meeting(s) shall be conducted again to inform the stakeholders about more detailed project plan, and to obtain public opinions for the project.

(6) Initial Environmental Impact Analysis

1) Potential natural and social environmental impacts

a). There will be no negative impacts to be caused on flora and fauna, nor to ecological system of the project site area.

b). Therefore, there will be no any accumulative environmental impacts to be generated.

c). There will be no negative impacts to the watershed of the river.

d). Because this is a MHP project, there will be no negative impacts to the water quality of upstream and downstream river water.

e). There will be no negative impacts to groundwater of the project area and its vicinity.

2) Environmental issues in connection with the plant design and construction activities

a). There will be no negative impacts to the agriculture of the project site and its vicinity.

b). There will be no conflicts with existing river water rights.

c). If some part of quarry needed for construction of the weir and power house will be collected from the Bu Sra river bed, turbid water would be generated to the downstream of the quarry site. Possible measures shall be taken to mitigate the impact of turbid water. In addition, collection of quarry from the river bed shall be kept minimum.

d). There will have the following positive impacts to the villagers in and around the project site.

i) Electrification of the rural area

ii) Create employment opportunity for the villagers as labor force source

iii) Create business opportunities for the villagers during construction.

a. May have negative impacts to river water quality due to liquid effluents from worker' camp. Prepare sewage treatment facility to mitigate this impact.

b. Dust generation shall be minimized during construction activities. Water spray will be used for this purpose.

3) Potential environmental impacts during plant operation

a. Because the water head difference of Bu Sra Waterfall will be used for the MHP generation, there may have some negative impacts on the tourism. To avoid the issue, the plant operate will be stopped during day time of dry season when deemed necessary.

b. There will be no negative impacts to the downstream river water quality.

c. In spite of protected wildlife not being found in the site area and its vicinity, some wildlife might occasionally come into the plant facility area. If this would be the case, the wildlife could suffer electric shock by the electrical equipment. To avoid such things would happen, a certain barrier fence/nets will be set around the outdoor electrical equipment and distribution facilities.

d. There will be no negative impacts to agriculture of the project site area and its vicinity.

Details of the initial environmental impact analysis results have also been summarized in the Table 3.54. For the details, refer to the table.

(7) Environmental Impact Mitigation Measures

1) Details of the Environmental Impact Mitigation Measures have also been shown in the same Table 3.54. The measures have also been described in item (10) "Environmental Management Plan" below.

2) As mentioned above, water flow will become very little during dry season. To avoid negative impact to the tourism of the waterfall during this season, the plant operation will be stopped during the day time when deemed necessary.

3) It has to be noted that the project site area is located in a Bio-diversity Conservation area. Various necessary mitigation measures shall be taken to avoid potential negative impacts to the wildlife and ecology. For details of the measures, refer to Table 3.54.

4) In spite of protected wildlife not being found in the site area and its vicinity, some wildlife might occasionally come into the plant facility area. If this would be the case, the wildlife could suffer electric shock by the electrical equipment. To avoid such things being happen, barrier fence/nets will be set around the outdoor electrical equipment and distribution facilities.

(8) Economic Analysis and the Environmental Value

There will be 936 households (89% of total number of households) to be electrified by the project. By the electrification, the expenditure of battery charging and replace to be needed for villagers can be reduced or even would not be required, and the villagers can obtain high quality electricity and bright lighting instead. In addition, the project will also be able to supply power for pumping river water for domestic use and irrigation activity. On the other hand, the tree cutting for installing the facility will be very few. Reforestation of surrounding area will mitigate the impact. In addition, conflict with tourism of the Bu Sra waterfall can be avoided by adjusting plant operation time period.

(9) Environmental Management Plan

Table 3.51 Environmental Protection Measures

Environmental Issue	Mitigating Measure	Implementation Responsibility
Construction		
Loss of tree resources	Trees to be cleared will be limited to the waterway, penstock and generator facility. The lost trees will be supplemented by reforestation in the surrounding area.	Project IO/operator and contractor(s) (see Remarks for IO)
Air/river water quality	Air dust will be minimized by spraying water. The waste water from construction camps will be properly treated before being discharged to the river. Water supply and waste disposal facilities will be established for workforce camps.	Project IO/operator and contractor(s)

	Keep river bed work as minimum to avoid generating turbid water.	
Loss of rare and endangered species	Identify critical habitats and prepare habitat protection plan	Project IO/operator and contractor(s)
Hazardous materials	Proper storage of chemicals and fuels	Project IO/operator and contractor(s)
Worker/public health and safety	Health care and safety center will be established.	Project IO/operator and contractor(s)
Operation		
Potential impact to tourism	At least keep 10% water flow during daytime, when necessary.	Project IO/operator
Change in water quality (upstream and downstream)	Remove upstream pollution sources.	Project IO/operator
Sediment transport/erosion	Prepare sediment bypass system	Project IO/operator
Electrical shock to wildlife	Set barrier nets around outdoor electrical equipment and distribution facilities	Project IO/operator
Introduction of exotic pest species	Reduce water residence time	Project IO/operator
Public safety	Proper design to avoid tourists and villagers entering the facility areas.	Project IO/operator

Table 3.52 Environmental Monitoring Program

Monitoring Parameter	Monitoring Technique	Monitoring Location	Monitoring Frequency	Monitoring Responsibility
Construction				
Loss of tree resources	Observation of conditions of reforestation	Site surrounding area used for reforestation	Once per two months	Project IO/operator and contractor(s)
Air/river water quality	Observation, turbidity meter	Project site area	Once per week	Project IO/operator and contractor(s)
Loss of rare and endangered species	Observation	Project site area	Once per month	Contractor(s)
Hazardous materials	Observation	Construction site	Once per month	Constructor(s)
Worker/public health and safety	Observation	Whole area of the project site	Every day	Project IO/operator and contractor(s)
Operation				
Possible wildlife intrusion to plant facilities	Observation	Outdoor electrical equipment and distribution facilities	Once per week	Project IO/operator
Reforestation condition	Observation	The areas used for reforestation	Once per six months	Project IO/operator
Change in river water quality	Observation, pH, COD, TSS, etc.	Upstream and downstream	Once per three months	Project IO/operator
Sediment transport/erosion	Turbidity meter	Upstream and downstream	Once per month	Project IO/operator
Introduction of exotic pest species	Observation	Upstream and downstream	Quarterly	Project IO/operator
Public safety	Observation	Whole area of the project site	Once per week during tourism season	Project IO/operator

Remarks: IO stands for Implementing Organization.

(10) The situation without the Project

As of June 8, 2005, there are 712 families in total in Bu Sra Commune. About 90% of income is from agriculture. Rice is their main agriculture product (about 80% of total income). Average income amount is about 30,000Riel/month /HH (about US$7.5), which is very low compared with needed expenditure. The only way to supplement the insufficiency is grow poultry and fruit trees for self use. But this is still not enough to solve their poverty.

There is only one battery charging station in the Commune, and about 100HHs have batteries (14%). However, there are about 50 D/G for self uses.

Urgent needs are 1) Rehabilitation of communication roads and electricity supply, and 2) more seeds and irrigation system for improving agriculture. Only wells are being used for water supply. Need pumps to get water from river and brooks.

From the above, it is clear that the Commune has been under severe poverty conditions to date. The poverty issue would not be resolved if nothing to be improved. Electrification project will not only provide more sufficient electricity, but also enhance the water supply capability for both domestic and irrigation purposes.

(11) Institutional Capacity

The project implementing organization, operator and contractor(s) shall be trained and responsible for conducting EIA. In addition, the project implementing organization, operator and contractor(s) shall be responsible for implementing the Environmental Management Plan. For this purpose, the project implementing organization, operator and contractor(s) shall establish an internal organization to be in charge of the whole environmental assessment activities. Training staff members of the organization will also be needed.

(12) Conclusion and Recommendations

1) Because this is a MHP project, there will be no or minor environmental impacts. The project site area will be located in a Protected Area (Bio-diversity Conservation). However, it was known that there are no any protected wildlife being inhabited or found in this site area. Therefore, there will be no negative impacts to the natural environment. To protect the wildlife, which may occasionally come into the plant facilities, against suffering electric shock, barrier fence/nets will be set around the outdoor electrical equipment and distribution facilities.
2) On the other hand, the need of electrification of concerned villagers is very high. This project will be able to supply electricity not only for domestic uses, but also for the power needed for water pumping and irrigation. This will also be beneficial to resolving poverty issue of the villages. At least, employment opportunity would be given to the villagers during project construction.
3) It is recommended that the Project Implementing Organization will materialize in early stage the contents of the Environmental Protection Measures and Environmental Monitoring Program as shown in the Item (9) Environmental Management Plan (the Plan) above, so that the Plan can be surely implemented.
4) It is desirable that EIA will be conducted for the Project, so that the potential impacts to the ecology of the project site area and its vicinity would be understood in more detail.

Table 3.54 shows the results of the IEIA.

Table 3.53 Environmental Screening for Bu Sra MHP Project (The check list for the proposed MHP project.) (1/2)

1. General Information

Name of the proposed project: **Bu Sra MHP Project**
Name of Project owner/proponent: not decided yet
Project Execution Organization : not decided yet
Name of authorized person(s) responsible for the project : not decided yet

Information regarding the project site
Name of the village, commune, district and province :
Ten villages, Bu Sra Commune, Pecher Chenda District, Mondul Kiri Province

2. Outline of the Proposed Project

2.1 Information on project characteristics

(1) Needs involuntary resettlement		
	Yes	Scale: households, persons
●	No	
(2) Groundwater pumping		
	Yes	Scale: m^3/year
●	No	
(3) Land reclamation, land development and land cleaning		
	Yes	Scale: hectors
●	No	
(4) Logging		
●	Yes	Scale: about o.5 hectors for power house space and waterway construction
	No	

2.2 Description of the project

Main design specifications:
The MHP will utilize the head difference of Bu Sra Waterfall of Prek Por River, which is a tourism spot. If the water from the waterfall of Prek Por River would not be available, Ophlai River water will be used for power generation.

2.3 Is the project consistent with the higher program/policy?

●	Yes	(outline of the higher program/policy) Rural electrification plans of MIME in both of Mondol Kiri and Rattanak Kiri Provinces
	No	

2.4 Any alternatives considered before the project?

●	Yes	(outline of the alternatives) Bay Srok MHP project site. However, the village concerned is existing now due to mining gem stones in and around the village. When the gem stone resource will be exhausted some day in future, the villagers may leave this area to other places to look for other income sources. If this will be case, the village will be discarded.
	No	

2.5 Did the project proponent have meetings with related stakeholders during the project planning?

●	Yes	(mark the corresponding stakeholders)	
		●	Administrative body/local government
		●	Local residents/villagers
			NGOs
			Others (to specify)
	No		

Table 3.53 Environmental Screening for Bu Sra MHP Project (The check list for the proposed MHP project.) (2/2)

2.6 Are any of the following areas located inside or around the project site?

●	Yes		(mark related items listed below)
		●	National park, wildlife sanctuary, bio-diversity conservation, and other protected areas designated by the government
			Virgin forests, tropical forests
			Ecological important habitat areas
			Habitat of valuable species protected by domestic laws or international treaties
			Likely salt cumulus or soil erosion areas on a massive scale
			Remarkable desertification trend areas
			Archaeological, historical or cultural valuable areas
			Living areas of ethnic, indigenous people or nomads who have a traditional lifestyle or specifically valuable areas
	No		

Remarks: Based on the interviews carried out with the representatives of concerned Commune and villagers, protected animals were not found in the site area and its vicinity.

2.7 May the project have potential negative impacts to the environment and local communities?

●	Yes	(brief description of the potential negative impacts) The project site is located in a Bio-diversity Conservation Area being protected. Measures shall be taken to mitigate impacts to the protected animals. The power will use the head of Bu Sra waterfall, which is a tourism spot. Plant operation shall be avoided during the sightseeing time in tourism season.
	No	
	Not identified	

2.8 Mark the related potential environmental and social impacts and describe briefly the contents of the impacts, if any.

Items of potential impacts		Items of potential impacts	
	Air pollution		Local economy, employment, livelihood, etc.
	Water pollution		Land use and utilization of local resources
	Soil pollution		Existing social infrastructures and services
●	Waste (liquid and/or solid)		Poverty issue
	Causing noise and vibration		Ethnic and /or indigenous people
	Ground subsidence		Misdistribution of benefits
	Offensive odors		Local conflict of interests among villagers
	Geographical features		Gender issue
	Bottom sediment		Children's rights
●	Biota and ecosystem		Natural and/or cultural heritages
	Potential conflict on water use rights		Infectious diseases such as HIV/AIDS, etc.
	Public health and hygiene		Others if any
	Global warming		
	Involuntary resettlement		

Remarks:

1) The waste would be generated during construction from worker's camps at site. Such wastes must be treated before being discharged to the environment.
2) As mentioned above, the project site is located in Bio-diversity Conservation area being protected. Mitigation measures shall be taken to avoid impacts to the protected wildlife which may inhabit in or around the site area.
3) 91.4% of people in the Commune are ethnic people (Phnong). No other ethnic people. Remaining 8.6% are Khmer.

3. Key results and findings of the environmental screening

The candidate project site will be located in a Bio-diversity Conservation area being protected. In addition, the project will use the head difference of the Bu Sra waterfall, which is a tourism spot. Therefore, considering both the environmental regulations of JICA and the MOE, carrying out IEIA (IEE) will be required, and the report shall be prepared and submitted by project owner to the MOE for review and approval.

Table 3.54 Results of Initial Environmental Impact Assessment (IEIA) of Bu Sra MHP Project

Environmental Factors	Potential Negative Impact	Mitigation Measures	Potential Environmental Impacts				Remarks
			Positive impacts	Negative Impacts			
				Non, not significant or minor (C)	Moderate impacts (B)	Significant impacts (A)	
I. Natural and Social Environmental Impacts							
1. Watershed erosion and silt runoff/ sedimentation	No negative impact			Non			
2. Encroachment upon precious ecology	May have negative impact	Set barrier nets around electrical equipment and distribution facilities to protect wildlife against electrical shock.		Minor			Protected wildlife has not been found in the project site area.
3. Impact on migration fish species	No migration fish species found in the river.			Non			
4. Effects on groundwater hydrology	No negative impact			Non			
5. Change of river morphology	No negative impact			Non			
6. Change of riverside vegetation	No negative impact			Non			
7. Resettlement	Not needed			Non			
8. Impacts on tourism area	May have impacts	Keep 10% water flow as of the end of dry season during daytime as minimum flow.			●		
9. Encroachment upon natural/cultural heritages	No such heritages being existed			Non			
10. Impairment of navigation	No river navigation			Non			
11. Inundation of agricultural and/or pasture lands	No negative impacts			Non			Because of a MHP, weir size is small.
12. Water right conflicts	No conflicts			Non			
13. Other potential impacts	Not found			Non			
14. Held stakeholder meetings to inform and discuss on the project plan, and points of opinions and comments received	No negative impacts. Through discussions with the Commune Deputy Head, Council members and villagers, found all of them need more electricity.		Yes				Interview and discussions were conducted on June 8, 2005
II. Environmental Issues in connection with project design and construction activities							
1. Negative impacts to existing communication road/system of concerned villages	May have impacts to existing communication road condition.	Improve road conditions before starting construction activities.		Not signific ant			
2. Soil erosion/silt runoff	No negative impact			Non			
3. Noise during construction activities	Minor due to remote from villages			Non			
4. Air pollution during construction activities	Minor impact to the air around the site area.	Spray water to the dust generating work.		Minor			
5. River water pollution during construction activities	May have impact on the turbidity of river water.	Collect high turbidity water to a pond before discharging to the river and minimize river bed work. And minimize river bed work.		Not signific ant			

Environmental Factors	Potential Negative Impact	Mitigation Measures	Potential Environmental Impacts: Positive impacts	Negative Impacts: Non, not significant or minor (C)	Negative Impacts: Moderate impacts (B)	Negative Impacts: Significant impacts (A)	Remarks
6. River water pollution due to waste water discharged from workers' camps	May have impacts on the river water quality	Prepare sewage treatment system			●		
7. Air and/or water borne diseases	May cause such diseases to workers and villagers	Prepare sanitary measures			●		
8. Impacts by quarry sites	Not much quarry will be needed.	Minimize collection of quarry from river bed.		Minor			
9. Odors to be generated	No such impacts			Non			
10. Employment of local villagers	Will create employment as construction workers		Yes				
III. Potential Environmental Impacts during Operation							
1. Downstream river water pollution	No such pollution			Non			
2. Downstream river bed erosion or sedimentation	No such impacts			Non			
3. Eutrophication of reservoir	No such impacts due to small reservoir			Minor			
4. Air/water borne diseases	May cause such impacts	Avoid long term stagnation of reservoir water		Minor			
5. Impacts on downstream fisheries	No such impacts due to no fisheries being existed			Non			
6. Increase of insect vector diseases	May have such impacts	Avoid long term stagnation of reservoir water		Minor			
7. Potential impact to wildlife which come occasionally into the plant site facilities	May have negative impact, such as causing electric shock to the wildlife.	Set barrier nets around the outdoor electrical equipment and distribution facilities			●		
8. Potential impacts to the tourism of Bu Sra waterfall	Would have negative impact to the tourism.	During dry season, river water flow may become quite small. To keep the waterfall scenery, at least 10% water flow as of the end of dry season will be kept as minimum flow.		Not significant			Bu Sra waterfall is not a well known tourism spot.

Source: JICA Study Team

Remarks: 1) Negative impact (A) stands for having "Significant impacts".

2) Negative impact (B) stands for having "Moderate impacts"

3) Negative impact (C) stands for having "Non, not significant or minor impacts"

6 ORGANIZATION FOR MANAGEMENT

6.1 CAPACITY OF THE COMMUNE FOR OPERATION

While there are several NGOs' activities exist, none of them are working in infrastructure related projects. The main focus is health and empowerment of communities and on wildlife protection. However, in networking with these NGOs, the electrification project can take advantage of the other activities, for example, the CFDS involvement in information dissemination work. More information about the project can be channelled through CFDS thus creating popular knowledge and awareness among residents in Bu Sra commune. The same can be done with SSP so that ethnic communities will have a better understanding and acceptance of the electrification project.

6.2 THE PROPOSED OPERATION / MANAGEMENT ORGANIZATION OF THE MHP

The CEC members will be preferred to be erected by the villagers in the same manner as Commune Council members. The indicative CEC will be a representative who will be responsible for recording and contract management, accountants who will collect tariff and keep books of account, and technical operators responsible for regular maintenance. As villagers' education level is limited, adequate support needs to be provided from external organization such as local governments, NGOs, and assigned consultants.

7 OPERATION AND MAINTENANCE

7.1 OPERATION

The plant should be operated based on the operation manual, which specifies the operation procedures during normal operation and the countermeasures required in the event of any abnormality. Operators are required to observe the following:

- Be constantly aware of the conditions of the transmission system and of the load both inside and outside the power plant in order to take speedy and appropriate measure in response to any accident.
- Operation of equipment should be confirmed by the chief operator.
- Check all related instrumentation, display lamps and indicators, both before and after operating each and all components.
- Follow the safety standards at all times. Prevents which may result in injury or death. Improve the equipment and facility as required.

7.1.1 Precautions During Normal Operation

During operation, in addition to the monitoring of all instruments, the power plant should be patrolled at least once a day. The followings are the key check items during normal operation:

- Vibration of abnormal noise of equipment
- Lubricant and cooling water levels and temperature
- Abnormal instrument indication
- Generator load conditions including voltage, electric current, output, etc.
- Performance of compressors and oil pressure pumps
- Abnormality of equipment and other installations inside and outside the plant

7.1.2 Key Items before Start-up

When restarting the turbine and generator after a long shutdown period due to inspection or repair, visual inspection and simple tests and measurements must be conducted to check. The major activities are described below.

- Moisture absorption on the generator coil
- Rust or oil leak on the water tubes and the bearings
- Foreign matter intrusion
- Defective wiring during the said inspection or repair
- Measure the insulation resistance of each circuit
- Inspect the cooling equipment, brushes, regulators, oil pressure supply system, speed governor peripherals and other components

Should the generator automatically stop due to an accident, determine the cause and repair the defect. Ensure complete recover. Restart the operation.

7.1.3 Key Steps to Shutdown

- At parallel off, the generator circuit breaker if opened after main current is set to zero.
- At shutdown, apply brake at approximately 1/3rd rated rotating speed. Prevent long operation at low rotation.
- Stop the cooling water. Close the generator air duct shutters.
- Patrol the plant after shutdown.
- Provide anti-dewing measure for long shutdown.

7.1.4 Countermeasures against Hazards

During flood, it is recommended that the generator be stopped and the intake gates be closed to prevent sediment and driftwood from entering the waterway.

Depending on the seismic intensity, an earthquake could adversely affect the entire power plant facilities. It is, therefore, necessary to inspect (inspect for cracks, breakage, tilting and other structural damages, the turbine and generator shaft centers, electric components and other facilities) all components and facilities.

7.1.5 Other Precautions

- Operation should be conducted within and operative range depending on the discharge and the head. When the river discharge is extremely few, the operation shall be stopped in order to prevent unnecessary wear of the runner.
- Where multiple units are installed, the number of units to be operated should be controlled depending on the inflow, specifically to avoid operation at low level. The operations manual should be prepared by fully understanding the role of the plant.
- Loading in stages is recommended when starting plant operation in an isolated power system as this plan. If the entire load is loaded at once, the generator may trip due to momentary overload.

7.2 MAINTENANCE

For the operation of the micro-hydro power plant and to prevent accidents, it is necessary to conduct patrols and inspections of civil structures and electric facilities. It is also important that the results of these inspections and measurements be recorded and stored in the specified forms. These records are then used to determine the operational trends and patterns of the said equipment and facilities.

It is recommended to conduct the periodic inspections simultaneously for the equipment and facilities that require a turbine/ generator shutdown to minimize the shutdown period.

7.2.1 Patrol

Patrols are conducted to detect abnormalities in the civil structures/ electric facilities and to assess the surrounding conditions. As explained above, it is recommended to pre-determine the patrol route and carry it out approximately once a day.

7.2.2 Inspection

The inspections of civil structures and electric facilities are generally classified below.

Table 3.55 Classification and Frequency of the Inspections for Civil Structures

Classification			Explanation	Frequency
Inspe-ction	Periodic inspection	Visual inspection	Visual inspection is conducted to determine the conditions of civil structures, to detect any abnormalities and to check their performance.	Approximately once every month
		Internal inspection	Internal inspection is conducted by denaturing the waterway to inspect the presence of any abnormalities of channel interior and to observe the functions of water way.	Approximately once every year
	Emergency inspection	Emergency inspection	Emergency inspections are conducted before and after earthquakes, floods, heavy rain, etc., as deemed necessary.	whenever it is necessary
		Emergency detailed inspection	Emergency detailed inspection is conducted when deemed necessary after a patrol, visual inspection, internal inspection, or emergency inspection.	whenever it is necessary

Prepared by JICA Study Team
(based on the Guide Manual for Development Aid Program and Studies of Hydro Electric Power Projects, NEF, Japan 1996)

Table 3.56 Classification and Frequency of the Inspections for Electric Facilities

Classification			Explanation	Frequency
Inspe-ction	Periodic inspection	External inspection	The turbine and generator are shut down during this inspection to check for abnormal and to check their performance.	Approximately once every year
		Internal inspection	The turbine and generator are overhauled, thoroughly cleaned and repaired to restore their performance. It is recommended that the inspection cycle be so set as to consider the inspection results and the operation conditions.	Approximately once every five years
	Emergency inspection	Emergency inspection	Emergency inspection is conducted when an abnormality or problem occurs in an electric component. The turbine and generator are shut down during this inspection.	whenever it is necessary

Prepared by JICA Study Team
(based on the Guide Manual for Development Aid Program and Studies of Hydro Electric Power Projects, NEF, Japan 1996)

Expressly after flood, sediment, leaves or driftwood should be taken clear at the intake, waterway, head-tank. The major periodic inspection items of civil structures and electric facilities are listed in below tables.

Table 3.57 Inspection Items of Civil Structures

Facility	Installations	Inspection items
1. Intake weir	Weir	Damage, frost damage, and cracks on surface, etc.
	Peripheral valley slope	Cracks, collapse, landslide, scouring, etc.
	Other facilities	Damage, loss, rust, etc.
2. Waterway		
(1) Intake	Intake	Damage, deformation, cracks, frost damage, abrasion, scouring, screen clogging, etc.
(2) Headrace	Peripheral bedrock	Collapse, landslide, spring water, etc.
	Headrace interior	Leakage, spring water, cracks, scouring, deformation, sedimentation, paint film deterioration, etc.
(3) Head tank	Head tank	Damage, deformation, cracks, frost damage, abrasion, scouring, etc.
	Peripheral bedrock	Collapse, landslide, spring water and other abnormalities
(4) Penstock and spillway	Steel penstock	Damage, deformation, settlement, etc.
	Penstock and Spillway conduit	Damage, deformation, vibration, leakage, paint film deterioration, etc., on pipe shell and saddle
	Peripheral bedrock	Collapse, landslide, spring water, etc.
3. Powerhouse		
(1) Powerhouse	Foundation and peripheral structures	Deformation, cracks, spring water, etc.
(2) Tailrace	Tailrace	Damage, deformation, cracks, frost damage, abrasion, scouring, etc.
4. Other installations		
(1) Spoil bank	Peripheral bedrock	Collapse, landslide, spring water, etc.
(2) Access road		Surface conditions, abnormalities on retaining wall, bridge and other structures and their state
(3) Screen	Screen	Damage, deformation, loose fixing bolts, paint film deterioration, etc.

(4) Gate	Gate guide	Damage, deformation, etc.
	Gate and hoist	Damage, deformation, abrasion, greasing, paint film deterioration, etc.
	Switchboard terminal (in case of automatic controlled gate)	Abnormalities and the state of switchboard terminal, wiring, electro-magnetic switch contact relay performance, insulation resistance, etc.
	Other components (in case of automatic controlled gate)	Conditions of indicators, switches, display lamps of each component

Prepared by JICA Study Team
(based on the Guide Manual for Development Aid Program and Studies of Hydro Electric Power Projects, NEF, Japan 1996)

Table 3.58 Inspection Items for Electro-mechanical Facilities (External Inspection)

Component	Inspections	Inspection items
1. Turbine	Turbine internal	Inspect and measure for abrasion, crack, erosion, and rust on the runner, guide vane and casing interior. Check the bearing lubricant quality.
2. Speed governing device	Mechanism	Inspect for abrasion of movable parts, loose wiring/ lever, and strainer overhaul.
	Controller	Inspect the conditions of the printed circuit board and position transducer. Measure the insulation resistance.
3. Inlet valve	Inlet valve internal	Measure leakage. Inspect for abrasion and erosion. Measure sheet surface clearance. Inspect position indicator conditions.
4. Oil pressure supply and lubrication oil system	Performance	Measure load operation time. Test oil quality.
	Oil filtration	Test oil quality.
5. Water supply and drainage system	Strainer overhaul	Inspect abrasion and erosion.
6. Automatic turbine control system	Performance test of all relays	(Performance test of all relays)
7. Generator	Generator internal	Inspect for loose electric circuit terminals, discoloured, peeled or loose coil, abrasion and damage to slip ring, loose and rusted revolving part. Measure brush contact pressure and the insulation resistance of electric circuit.
	Control system	Inspect for shoe abrasion loss and operation state.
	Neutral grounding resistor	Measure resistance and insulation resistance.

Prepared by JICA Study Team
(based on the Guide Manual for Development Aid Program and Studies of Hydro Electric Power Projects, NEF, Japan 1996)

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

8.1.1 Estimated Power Demand

Power demand in the target area of the Bu Sra commune at year 2020 was estimated as follows.

Night time (18:00-22:00) 80 kW (Peak Demand)
Midnight (22:00-6:00) 6 kW
Daytime (6:00-18:00) 33 kW

The target household in 2020 is estimated 936 HH.

8.1.2 Plan of Micro Hydro Power Facilities

There is a potential for the micro hydro power at the Bu Sra waterfall. However, in the dry season, river flow will be not enough to supply electricity demand. Therefore, in the proposed scheme, daily regulating pond by using natural river channel was planned. The height of proposed weir near the intake site will be 2.5m and the reservoir capacity is estimated at 3,990 m^3. Utilizing this daily regulating pond, it will be able to supply electricity of 80 kW in peak hour (18:00-22:00) during about 97% of a year.

8.1.3 Economic and Financial Evaluation

Total project cost including soft components such as basic design, detailed design, construction supervision, administration, etc., is estimated at 661,000 US$ According to the economic and financial evaluation for the proposed Bu Sra MHP, the EIRR and FIRR is estimated at 12.6% and 7.1%, respectively. It indicates that the proposed project is economically viable

8.1.4 Ability to Pay

Since the villagers consume the available energy such as kerosene and car battery, once they understand the feature of economical and safe energy source more, electricity will be more accepted even by the poor. Yet, the relatively large amount of initial connection fees needs to have special financing support by leasing or special low interest rate.

8.1.5 Benefit Anticipated

The socioeconomic study also revealed the benefit they anticipated after electrification as above. They appreciated primarily the reduction of air pollution as they currently rely on kerosene or firewood. Secondary, education and health benefits were appreciated followed by information and security benefits.

	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	n	%	n	%	n	%	n	%	n	%
Our life will be better if our village is electrified	-	-	-	-	-	-	-	-	49	100
It is important for information (TV, radio)	-	-	-	-	-	-	4	8.2	45	91.8
Children can study at night	-	-	-	-	-	-	3	6.1	46	93.9
Working at night make cash income	-	-	-	-	2	4.1	10	20.4	37	75.5
Some electric appliances reduce work loads	-	-	-	-	1	2	7	14.3	41	83.7
Food can be better preserved	-	-	-	-	6	12.2	6	12.2	37	75.5
Reduction in door air pollution caused by lamps	-	-	-	-	-	-	1	2	48	98
Fan prevent malaria and make good sleep	-	-	1	2	1	2	7	14.3	40	81.6
Electricity is important for better water supply	-	-	-	-	4	8.2	11	22.4	34	69.4
Electricity is important for our health center	-	-	-	-	-	-	3	6.1	46	93.9
It will improve security at night	-	-	-	-	-	-	5	10.2	44	89.8
It will improve social relations between neighbors	-	-	-	-	1	2	12	24.5	36	73.5
It will create work-time for productive endeavor	-	-	-	-	2	4.1	12	24.5	35	71.4
It will provide more time for family gatherings	-	-	-	-	-	-	12	24.5	37	75.5
I want to start business after electrified	-	-	1	2.1	12	25	1	2.1	34	70.8

8.1.6 Demonstration Effect

The current accessibility of Bu Sra is not satisfactory especially during the rainy season. Once electricity is available by MHP, the other industry such as **tourism** might be promoted and will demonstrate the development pattern utilizing electricity for visitors. It would provide lessons for other potential MHP areas.

8.2 RECOMMENDATIONS

8.2.1 Technical Recommendations

1) Improvement of access road to the site (from Sen Monorom to Bu Sra commune) is required due to present condition of the road become worse even by 4 wheel motor vehicles during the rainy season.
2) Construction of a vehicle passable steel/concrete bridge over the proposed intake weir is proposed for safety access to the commune during flood period. The weir includes a function of daily regulating pond for the peak generation in dry season.
3) It might be technically difficult for the community based project or local contractors to install the penstock pipe at right side precipice due to steep and friable rocks. Detail investigations and design assisted by specialists or foreign donors is required on the stability and construction method of the penstock.
4) Continuation of the daily water level gauging and periodical discharge measurements is required. Also, installation of the automatic rainfall gauge and automatic water level gauge is required.

8.2.2 Social and Environment Issues

1) The project should include a consideration for a minority race such as the Phnom tribe to contribute an improvement in the standard of living by the electrification.
2) As mentioned above, water flow will become very little during dry season. To avoid negative impact to the tourism of the waterfall during this season, the plant operation will be stopped during the day time when deemed necessary.
3) It has to be noted that the project site area is located in a Bio-diversity Conservation area. Various necessary mitigation measures shall be taken to avoid potential negative impacts to the wildlife and ecology.

8.2.3 Challenges for the Sustainable Operation

This project site is **ethnic minority dominant area**. There are major constraints such as low literacy level (68% compared national average 74%), few experiences of monetary economy for the successful implementation. More capacity building activities through information dissemination in local language should be made available so that they will be able to better cooperate with the projects. The **social structure** should be considered as most ethnic minorities are those who have limited financial capability to avail of electricity services while migrants from other provinces are dominant in the business, and vocal for decision making. **Livelihood development strategy**, such as water pumping, craft making, and sustainable utilization of non-timber forestry products needs to be integrated when electricity is introduced. Besides productive use campaign, the linkage to health, education development should be also highlighted. These activities will strengthen their livelihood, which ultimately maximize the benefits of the electricity. **Watershed management** is also important for sustainable water discharge as logging is concerned issue in the border areas. Thus, the campaign for sustainable logging will be one of the important agenda during the preparation for micro hydro power project.

The project implementation, therefore, should take many phases for training villagers and concerned stakeholders; such as local government authorities and NGOs, how to select beneficiaries, to define the obligations of the beneficiaries, how to establish the CEC, and how to supervise and monitor the project.