Chapter 12

Case Studies

Chapter 12. Case Studies

12.1. Distribution Grid Extension

12.1.1. Selection of the Distribution Line for Case Study

The purpose of this case study is to make counterparts become the engineers who can review this master plan by themselves in the future. Therefore, the pilot study projects were selected based on the following points with counterparts.

- Around 10 RGCs is included
- Only one project is selected in one province
- Site survey is carried out easily and safely

As a result, following distribution lines were selected as a case study.

- Distribution line from Chilundu new substation (Distribution number 2) Lusaka
- Distribution line from Fig Tree existing substation (Distribution number 1) Central
- Distribution line from Mazabuka existing substation (Distribution number 1) Southern

12.1.2. Method of Case Study

Information data of RGC, substation, road, etc is input on GIS map used by master plan, and almost all data are not acquired by GPS. First of all, actual position of those data should be confirmed with GPS.

Then, the situation RGC should be confirmed, and the transformer installation position will be selected. Moreover, the distribution line route will be selected in consideration of present situation, development plan, road condition and so on at the site.

Based on the data obtained at the site, distribution system prepared for master plan will be revised. Next, voltage calculation will be carried out again and review the results.

12.1.3. The Results of Site Survey

The results in each case are shown as follows, and the maps of the results are attached in Appendix C.

(1) Distribution line from Chilundu new substation (Distribution number 2)

GIS data used for master plan did not have so much difference from actual position. It is considered that the situation of RGCs in this area is along the main road.

The condition of RGCs, except for Boma, was as follows.

- The center of RGC is school and/or hospital, and the scale of RGC is not so large.
- Many households are situated at the center of RGC, but some households are scattered in the surrounding area of RGC.
- RGCs are situated along the main road or approximately 1 or 2km away from main road.

Therefore, it is considered that transformers will be installed near the main road.

The condition of Boma was as follows.

- There are important facilities such as public office, telephone company, etc, and the scale of RGC is large.
- Diesel power generation (800kVA) has already been set up, and power is supplied by 11kV distribution line.

- Five transformers (50kVA x 1, 100kVA x 2, 200kVA x 1, 250kVA x 1) have already been set up.

Therefore, it is considered that 33kV new distribution facilities will be replaced with existing 11kV distribution facilities.

There are two routes for supplying electric power to Kavalamanja. One is the extension of distribution line from Kakaro, and the other is the extension of distribution line from Boma. Construction of lodge, campsite, etc is planned along the road between Boma and Kavalamanja, but there is no household and no future plan between Kakaro and Kavalamanja. Therefore, it is determined that electric power for Kavalamanja will be supplied from Boma as well as the master plan.

Based on the result of site survey, voltage analysis was carried out again. As a result, one line was eliminated between Boma and Kavalamanja.

The construction cost is shown as follows, and the cost of this case study was cheaper than the one of the master plan because of the reduction of distribution line length.

Original/ Case Study	Unit Cost (US$) & Amount				FC (US$)	LC (US$)			Total (US$)
	33kV DL	66kV TL	66/33 Tr 100kVA	New SS 10MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
	(36,000)	(40,000)	(13,700)	(1,000,000)	(0.80166747)	(0.11816629)	(0.032067)	(0.04810005)	
Original	216	90	51	0.5	10,080,728	1,485,906	403,229	604,844	12,574,700
Case Study	186.4	90	51	0.5	9,226,471	1,359,988	369,059	553,588	11,509,100

(2) Distribution line from Fig Tree existing substation (Distribution number 1)

GIS data used for master plan had so much difference from actual position of RGC and substation, and some RGCs should be supplied the electric power from other substations. In addition, there were some mistakes of RGC's name (e.g. Waya -> 4Ways).

The condition of RGCs was as follows.

- The center of RGC is school and/or hospital, and the scale of RGC is not so large.
- At Monboshi, there is nothing except for river.
- Many households are situated at the center of RGC, but some households are scattered in the surrounding area of RGC.
- RGCs are situated along the main road or approximately 1 or 2km away from main road.

Therefore, it is considered that transformers will be installed near the main road.

Kasosolo, Kabanga and Mukulushi are situated near Kabwe substation rather than Fig Tree substation, and Chombela and Kayosha are situated near Coventry substation. As a result, the RGCs supplied from Fig Tree substation are 5 RGCs, which are Simukuni, 4Ways, Lifwambula, Momboshi and Kabangala.

The voltage descent has decreased because the entire demand decreases, and the distance shortened about other 3RGC.

Based on the result of site survey, voltage analysis was carried out again. Although the distance from substation to Simukunin and 4Ways became longer comparing with the distance of master plan, the voltage was satisfied with the regulation. The value of voltage drop at other 3 RGCs was reduced because of the decreased demand and the shortened distance.

The construction cost is shown as follows, and the cost of this case study was decreased greatly comparing with the cost of master plan. It depends on the shortened distribution lines and the decreased demand by the exclusion of 4 RGCs. However, the difference of cost will be added to other projects.

Original/ Case Study	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
	33kV DL	66/33 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
	(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.032067)	(0.04810005)	
Original	206	29	1	6,343,274	935,003	253,731	380,596	7,912,600
Case Study	124.2	15	1	3,828,764	564,362	153,151	229,726	4,776,000

(3) Distribution line from Mazabuka existing substation (Distribution number 1)

GIS data used for master plan had much difference from actual position of RGC and substation, and there were some roads which were not input on the map of master plan. In addition, there were many 33kV distribution lines which were not be able to obtain from ZESCO.

The condition of RGCs was as follows.

- The center of RGC is school and/or hospital, and the scale of RGC is not so large.
- Many households are situated at the center of RGC, but some households are scattered in the surrounding area of RGC.
- RGCs are situated along the main road or approximately 1 or 2km away from main road.

Therefore, it is considered that transformers will be installed near the main road.

Distribution line route prepared by master plan was revised depending on the actual location of RGC and substation and road condition.

Based on the result of site survey, voltage analysis was carried out again. Although the revised distribution line route was different from the route prepared by master plan, the value of voltage was satisfied with the regulation because of the small demand.

The construction cost is shown as follows, and the cost of this case study was decreased comparing with the cost of master plan because of the shortened distribution lines.

Original/ Case Study	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
	33kV DL	66/33 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
	(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.032067)	(0.04810005)	
Original	163	25	1	5,058,361	745,606	202,334	303,502	6,309,800
Case Study	148.9	25	1	4,651,435	685,624	186,057	279,086	5,802,200

12.1.4. Result of Case Study

As a result of case study, it was confirmed that it was necessary to revise this master plan greatly. This is because the position data of RGC, substation, distribution line, etc input on the GIS map lacks accuracy, and some road information is missing. Accurate information data is indispensable for distribution system planning. Therefore, we recommend that counterparts acquire all relating information data with GPS, and input these information to GIS map.

12.2. Small Hydropower Plant Development

12.2.1. Purpose of Case Study

Case Studies were undertaken of the only two hydropower potential sites selected among all the hydropower potential sites surveyed by the Study Team (refer to Chapter 8-4). The purposes of the Case Studies were the following:

- To carry out detailed surveys and produce basic designs of hydropower plants, and then verify the technical and economical feasibility of the development at the site,

- To suggest the possible organization of plant management after the development, and
- To transfer to the counterparts the technical skills related to the small hydropower plant development.

12.2.2. Selection of Case Study Sites

(1) Criteria of Case Study Site Selection

Two Case Study sites were selected among 25 hydropower potential sites surveyed by the Study Team based on the following criteria:

- One site should be selected among the sites in Northwestern Province and another in Northern or Luapula Province,
- Two sites should be selected among the sites which are regarded as the best electrification method in the Master Plan, and
- Priority of the electrification of RGC to be electrified by the hydropower plant is high.

(2) Selection of Case Study Sites

The Study Team visited 25 hydropower potential sites from which and nine sites were considered suitable for development as discussed later in the Chapter on the Master Plan. Table 12-1 shows these nine selected sites. In the bottom line of this table, “Hydro” means that the Hydropower Plant Development was selected for the best electrification method in the Master Plan. (D/L means that Distribution Line Extension was selected). Among these nine sites, Upper Zambezi and Mujila Falls Lower sites were marked “Hydro”, which made them natural candidates for Case Study sites. However, the RGCs to be electrified by Upper Zambezi site are Ikelenge RGC and Nyakaseya RGC, which have been already electrified by 700 kW Zengamina Small Hydropower Plant since July 2007. Therefore, the Upper Zambezi site should be developed just as a back up power plant to the Zengamina HP. Also the Study Team considered that selecting both Case Study Sites from Mwinilunga District in Northwestern Province was undesirable. Therefore, the Study Team chose Mujila Falls Lower (MFL) site as the first Case Study site.

The second Case Study site was selected among the four sites in Northern and Luapula Province in Table 12-1. Based on the third criteria above, Namukale Falls site should be selected because the site is located near Mpulungu Central RGC, which is listed on the top of the priority order of the Master Plan. However, the Namukale Falls site could only be accessed by boat, which which would considerably to the surveyed period. Therefore, the Study Team skipped Namukale Falls site and selected Chilambwe Falls site for the second Case Study site. This site was selected not only because the related RGCs have high priority, but also that the target RGCs were located far from the existing substation and that the site could be developed as a conventional hydropower plant. This woule be highly instructional for the transfer of technical skills.

These two Case Study sites, MFL and Chilambwe Falls, were selected after discussions with DoE and REA.

Table 12-1 Probable Hydropower Potential Sites

Name of the Site	Upper Zambezi	Mujila Falls Lower	Mujila Falls Upper	Kasanjiku Falls	Chauka Matambu Falls	Namukale Falls	Chilambwe Falls	Mumbuluma Falls	Chilongo Falls
Province	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern	Northern	Northern	Northern	Luapula
District	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mpulungu	Mporokoso	Mporokoso	Kawambwa
Name of the River	Zambezi	Mujila	Mujila	Kasanjiku	West Lumuwana	Lunzua	Kafubu	Luangwa	Lufubu
Effective Head [m]	8.0	17.1	13.2	9.0	9.1	15.0	37.8	13.0	37.2
Designed Dischirge [m^3/s]	6.0	10.0	4.0	4.5	2.5	2.3	1.0	9.0	1.7
Potential [kW]	380	1400	420	320	180	270	300	930	500
Electrified RGC 1	Ikelenge	Kanyama (incl. 2 villages)	Kanyama	Ntambu	Lumuwana	Mpulungu Central	Kapatu	Kalabwe	Kanengo
Number of Households in 2006	1763	921	521	416	310	2000	512	425	60
Potential Demand in 2030 [kW]	1995	1065	598	532	371	2201	610	471	79
Priority Order	57	671	671	322	526	1	95	453	1029
Priority in the District	2	4	4	1	5	4	14	10	3
Electrified RGC 2	Nyakaseya	Kakoma					Sibwalya Kapila	Sunkutu	Chibote
Number of Households in 2006	400	301					3646	350	90
Potential Demand in 2030 [kW]	483	350					4013	386	133
Priority Order	445	551					13	512	907
Priority in the District	3	17					2	8	4
Cost Estimation [thousand US$]	2,290	9,782	2,264	3,521	2,000	2,068	3,604	5,504	5,763
Electrification Method in the Master Plan	**Hydro**	**Hydro**	D/L	D/L	D/L	D/L	D/L	D/L	D/L

12.2.3. Result of Case Study 1: Mujila Falls Lower Site

(1) Demand Forecast

The possible electrified RGCs by MFL site are Kanyama RGC and Kakoma RGC. The Study Team curried out the survey of Kanyama RGC to determine the number of households, hammer mills, public facilities, and business entities, which are the essential factors for estimating the potential demand. Although the scope of the Rural Electrification Master Plan is only the RGCs, the Study Team decided that Mujila Village and Kapundu Village should be included in the area to be electrified by MFL site because Mujila Village has large agricultural centre and located on the way from MFL site and Kanyama RGC, and Kapundu Village has the most advanced clinic in Kanyama area and only 8km down from MFL site. Therefore, the Study Team also conducted the survey in these two villages. Table 12-2 shows the results of social survey. The data for Kakoma RGC are quoted from the data submitted by the Mwinilunga District Planners at the Second Workshop because the Study Team could not approach Kakoma RGC due to the bad condition of the road. Figure 12-1 shows the location of MFL site and supplied areas.

The Study Team estimated the potential demand for every five years, and the results are described in Table 12-3. This table shows that the potential demand in 2030, which is the target year of the Master Plan, is about 1,400 kW.

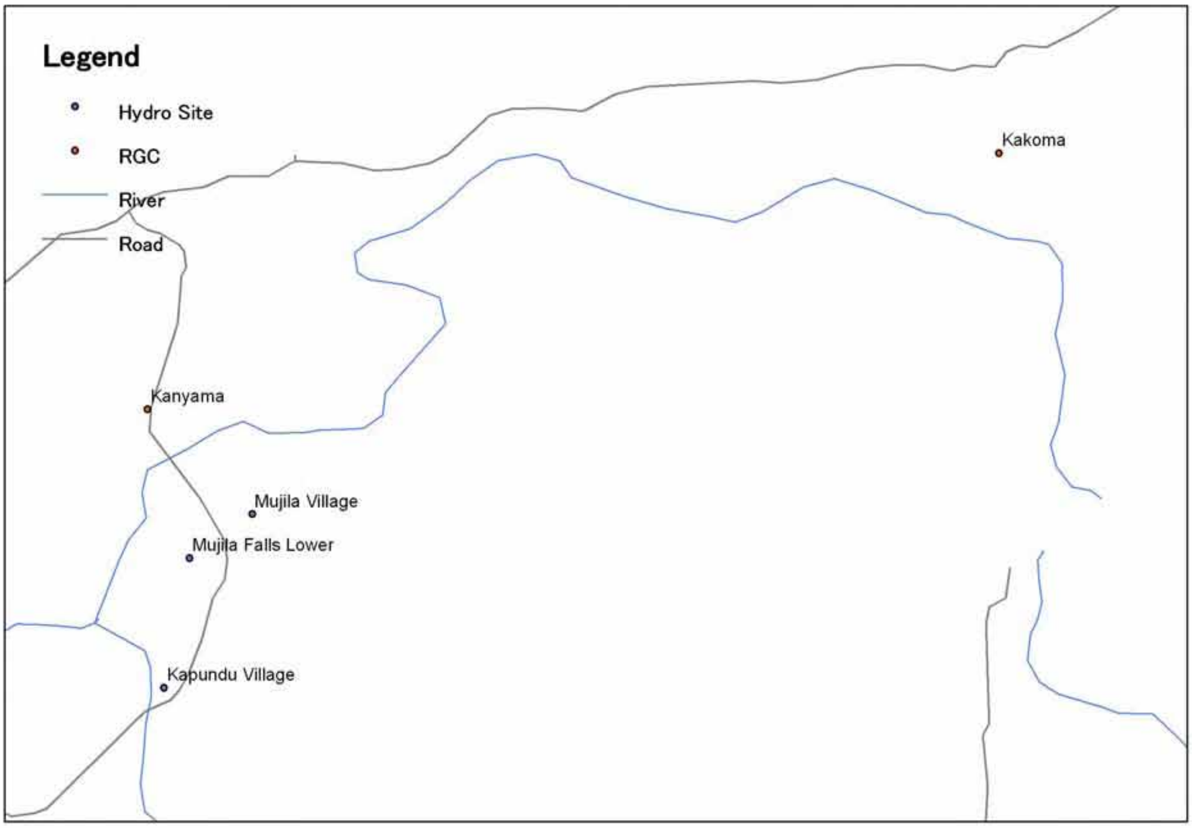


Figure 12-1 Location of MFL Site and RGCs

Table 12-2 Result of Social Survey in Kanyama and Kakoma RGCs

	Kanyama Area			Kakoma RGC
	Kanyama RGC	Mujila Village	Kapundu Village	
No. of Households (as of 2006)	521	200	200	301
No. of Population (as of 2006)	4,000	-	-	1,806
No. of Hammer Mills (as of 2006)	5	2	1	0
Number of Existing Public Facilities	15	2	2	5
1) Basic / Primary School	1	1	1	1
2) Secondary School [under construction]	[1]			
3) Tertiary School				
4) Hospital				
5) Health Centre (Clinic) / Health Post	1		1	1
6) Police Office / Station				
7) Post Office				
8) Church	9			2
9) Mosque				
10) Community Centre				
11) (Agricultural) Depot	2	1		
12) Orphanage				
13) Central Government Office				
14) Provincial Government Office				
15) District Government Office				
16) Other Local Administration Offices				
17) Court	1			1
18) Others				
Number of Existing Business Entities	16	2	0	6

Table 12-3 Demand Forecast for Kanyama and Kakoma RGCs

	Kanyama Area [kW]			Kakoma RGC [kW]	Total [kW]
	Kanyama RGC	Mujila Village	Kapundu Village		
Current (2006)	301	125	125	176	727
2010	349	138	139	196	822
2015	393	154	154	235	936
2020	458	173	173	264	1,068
2025	531	194	195	297	1,217
2030	598	234	234	350	1,416

(2) Generation Capacity

Figure 12-2 shows the flow duration curve at MFL site. The Study Team measured the actual river flow on 1st June 2007 and 17th October 2007, and the results were 15.02m^3/s and 13.38m^3/s respectively. Compared with these actual results, this flow duration curve is reliable enough to estimate the flow characteristic at MFL site.

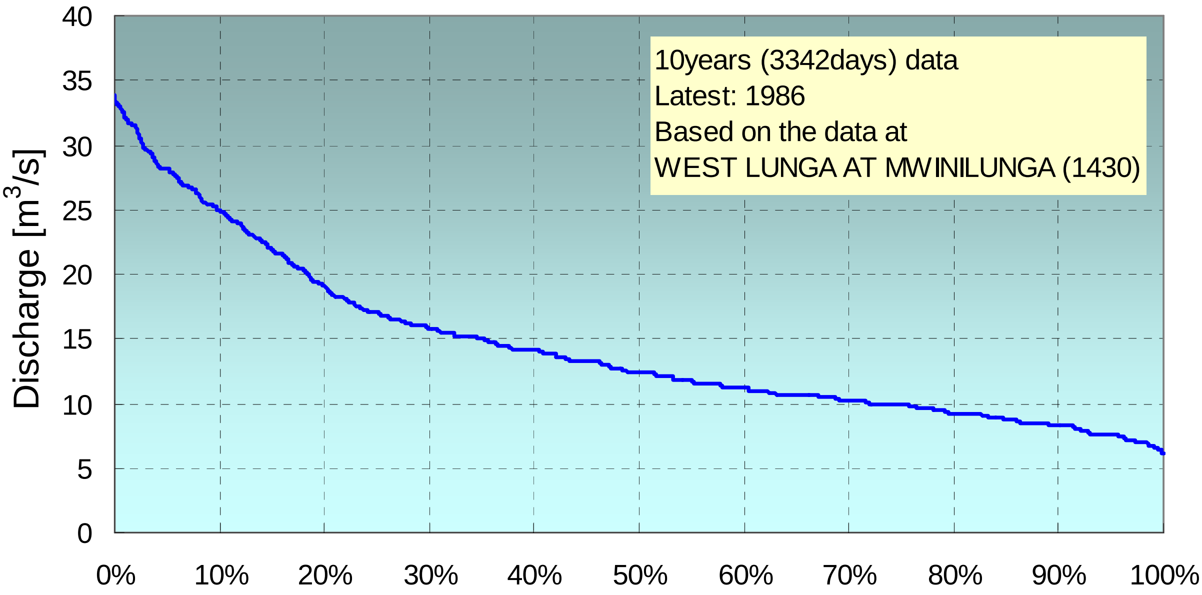


Figure 12-2 Flow Duration Curve at MFL Site

Table 12-4 indicates the river flow at 70%, 80%, 90%, and 100% availabilities and also the generation capacities assuming 17.1m of effective head. To achieve the 1,400kW of generation capacity, river flow at 70% availability is required. Usually, the river flow at 80% to 90% availability is applied to the designed discharge of run-off-river type hydropower plant for rural electrification project, but the low weir to be installed will produce the kind of reservoir with at least 200,000m^3 of storage capacity. This storage capacity would enable a discharge of 4.0m^3/s of additional water during 6 hours of peak demand time. Therefore, the Study Team decided the generation capacity at 1,400kW assuming 10.4m^3/s of designed discharge.

Table 12-4 Generation Capacity of MFL Site

	River Flow [m^3/s]	Generation Capacity [kW]
100% availability	6.12	828
90% availability	8.27	1,120
80% availability	9.21	1,246
70% availability	10.20	1,380

(3) Design of Hydropower Plant

Table 12-5shows the results of the design for civil facilities and electrical equipment.

Table 12-5 Features of Plant and Facilities of Mujila Falls Lower Project

Plant parameters	Mujila Falls Lower Project
Rated output	1,400kW
No. of units	Two [700kW x 2 units]
Design discharge	10.4m^3/s
Effective head	17.1m
Civil facilities	
Weir	Stone masonry with flushing gate H=5m, L=35m
Intake channel	Open channel B=3.5m, H=3.0m, L=20m
Silt basin	No need
Headrace	Non-pressure tunnel B=2.4m, H=2.8m, L=284m
Tailrace	Open channel B=3.0m, H=2.5m, L=10m x 2 lines
Spillway	Open channel B=1.5m, H=1.2m, L=36m
Head tank	Open channel B=7.0m, H=5.5m, L=20m
Penstock	Exposed type D=1.6m, t=6mm, L=20m x 2 lines
Powerhouse	Stone masonry, Aboveground type 10m x 20m x 8m
Electrical Equipment	
Turbine	Closs-flow turvine with sprit guide-vane H_{max}=17.1m, Q_{max}=5.2m^3/s, Pt_{max}=740kW
Generator	3-phase synchronouse generator Rated output: 800kVA, Voltage: 6.6kV Power factor: 0.9, Frequency: 50Hz
Main transformer	Outdoor type Capacity: 1600kVA, Voltage: 6.6kV/33kV
Distribution line	3 phase, 3 wires, Overhead distribution line Voltage: 33kV, L=85km
Pole transformer	Outdoor type Voltage: 33kV/400V, Capacity: 100kVA x 17 units

(4) Project Cost Estimation

Table 12-6 shows the result of MFL project cost estimation.

Table 12-6 Cost Estimation For Mujila Falls Lower Project

	Quantity	Unit Price	Price
I. Construction Cost			**6,165,040 US$**
i) Civil Engineering			1,235,030 US$
[Weir, Intake, Headtank and Power house]			
Concrete	200 m^3	600 US$/$m^3$	120,000 US$
Rebar	20 t	1,400 US$/t	28,000 US$
Masonry	1,201 m^3	150 US$/$m^3$	180,150 US$
Excavation, common	504 m^3	10 US$/$m^3$	5,040 US$
Excavation, rock	2,015 m^3	60 US$/$m^3$	120,900 US$
[Channel and Tailrace]			
Masonry	200 m^3	150 US$/$m^3$	30,000 US$
Excavation, common	73 m^3	10 US$/$m^3$	730 US$
Excavation, rock	291 m^3	60 US$/$m^3$	17,460 US$
Concrete	532 m^3	600 US$/$m^3$	319,200 US$
Tunnel	284 m	1,000 US$/m	284,000 US$
[Penstock and Spillway]			
Concrete	59 m^3	600 US$/$m^3$	35,400 US$
Rebar	6 t	1,400 US$/t	8,400 US$
Excavation, common	63 m^3	10 US$/$m^3$	630 US$
Excavation, rock	252 m^3	60 US$/$m^3$	15,120 US$
[Steel Structures]			
Gate and Screen	15 t	2,800 US$/t	42,000 US$
Penstock	10 t	2,800 US$/t	28,000 US$
ii) Mechanical & Electrical Equipment			4,450,900 US$
Turbine, Gen and Tr	2 Unit	579,000 US$	1,158,000 US$
33kV distribution line	85 km	36,000 US$/km	3,060,000 US$
33kV/400V Transformer	17 Unit	13,700 US$/Unit	232,900 US$
iii) Temporary Works			479,110 US$
Access Road	5 km	30,000 US$	150,000 US$
Road maintenance	1 LS	3,000 US$	3,000 US$
Others [30% of i)]	1 LS	326,110 US$	326,110 US$
II. Engineering Service Cost			**493,204 US$**
8.0% of Item I	1 LS	493,204 US$	493,204 US$
III. Overhead Cost			**1,541,260 US$**
25.0% of Item I	1 LS	1,541,260 US$	1,541,260 US$
IV. Profit Margin			**1,233,008 US$**
20.0% of Item I	1 LS	1,233,008 US$	1,233,008 US$
Grand Total			**9,432,512 US$**

(5) Financial Analysis

As Proposed MFL hydropower plant will be installed two units of 700 kW turbine-generators, the timing of the second turbine installation will affect the financial statement. The Study Team prepared two cases for financial analysis, one is that two turbines, 1,400 kW generation capacity in total, are installed at the same time (Case A-1) and another is that one unit with 700 kW generation capacity is installed only for Kanyama RGC and Mujila Village as the first stage and another 700 kW unit is installed later as the second stage (Case A-2). In Case A-2, the second unit should be installed when the total demand of Kanyama RGC and Kapundu Village exceeds 700kW, and the Study Team estimated that installation work for second unit will be necessary in 2024. The construction works in the second stage will consists of only installation of second turbine, generator and penstock, and extension of 33 kV distribution line 60 km east for Kakoma RGC and 9 km south for Kapundu Village. The Study Team estimated that the construction cost of first stage and second stage will be 4,547,283UD$ and 4,892,604US$ respectively. Table 12-7 shows the results of financial analysis for Case A-1 and Case A-2.

Table 12-7 Comparison of FIRR between One Phase and Two Phase Installation

Tariffs	Case A-1 ZESCO Charge		Case A-2 ZESCO Charge	
	K	US $	K	US $
Households tariffs	102	0.026	102	0.026
Monthly fixed charge	8,475	2.12	8,475	2.12
Commercial tariffs	245	0.06	245	0.06
Monthly fixed charge	43,841	10.96	43,841	10.96
Social tariffs	201	0.05	201	0.05
Monthly fixed charge	34,839	8.71	34,839	8.71
FIRR	-1.16 %		-1.75 %	

In each case, FIRR resulted in negative percentage. In the development of small-scale hydropower plant, construction cost per generation capacity (kW) is much higher than that of large-scale project in general, and the installed capacity must be much bigger than the actual demand in the early stage of electrification because the plant capacity should be decided considering the demand in the future. Since the power plant is isolated from the grid the excess power cannot be sent to the grid, so the generator must be operated in low output for long hours. These are why the financial feasibility of small hydropower project with micro gird is usually low.

In this analysis, electricity tariff is settled at the current tariff of ZESCO. These prices are relatively low, so the Study Team calculated FIRR for eace case using the actual commodity charge and fixed charge of existing Zengamina HP, which is described in Chapter 3.3.2 (3) a), and the results of analysis are shown in Table 12-8 and Table 12-9.

Table 12-8 Comparison of FIRR among Three Tariff Settings for Case A-1

Tariffs	Case A-1-1 ZESCO Charge		Case A-1-2 Zengamina HP Commodity Charge		Case A-1-3 Zengamina HP Fixed Charge	
	K	US $	K	US $	K	US $
Households tariffs	102	0.026	440	0.11	–	–
Monthly fixed charge	8,475	2.12	50,000	12.50	40,000	10.00
Commercial tariffs	245	0.06	440	0.11	600	2.00
Monthly fixed charge	43,841	10.96	50,000	12.50	50,000	15.00
Social tariffs	201	0.05	440	0.11	600	2.00
Monthly fixed charge	34,839	8.71	50,000	12.50	50,000	15.00
FIRR	-1.16 %		6.56 %		1.62 %	

Table 12-9 Comparison of FIRR among Three Tariff Settings for Case A-2

Tariffs	Case A-2-1 ZESCO Charge		Case A-2-2 Zengamina HP		Case A-2-3 Zengamina HP	
	K	US $	K	US $	K	US $
Households tariffs	102	0.026	440	0.11	–	–
Monthly fixed charge	8,475	2.12	50,000	12.50	40,000	10.00
Commercial tariffs	245	0.06	440	0.11	600	2.00
Monthly fixed charge	43,841	10.96	50,000	12.50	50,000	15.00
Social tariffs	201	0.05	440	0.11	600	2.00
Monthly fixed charge	34,839	8.71	50,000	12.50	50,000	15.00
FIRR	-1.75 %		7.69 %		1.76 %	

Case A-2-2 shows the acceptable FIRR, which indicates that MFL project can be approved due to the higher tariff setting. Therefore, phased instration of two turbines are recommended under the higher selectricity charge setting. The details of each analysis are shown Table 12-10 toTable 12-15.

Table 12-10 Financial Statements of Case A-1-1

FIRR = −1.16%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue US$	Net Present Value US$
0	2,642,714		2,642,713.73	2,642,713.73			(2,642,713.73)	(2,642,713.73)
1	5,285,427		5,285,427.47	4,719,131.67			(5,285,427.47)	(4,719,131.67)
2	2,642,714	107,271.73	2,749,985.46	2,192,271.57	3,409,337	138,337.33	(2,611,648.13)	(2,081,989.90)
3		107,271.73	107,271.73	76,353.90	3,564,356	146,775.18	39,503.45	28,117.78
4		107,271.73	107,271.73	68,173.12	3,665,069	151,766.95	44,495.22	28,277.52
5		107,271.73	107,271.73	60,868.86	3,740,695	155,762.75	48,491.02	27,515.11
6		107,271.73	107,271.73	54,347.19	3,831,394	160,397.13	53,125.41	26,914.98
7		107,271.73	107,271.73	48,524.28	3,991,472	169,189.77	61,918.05	28,008.58
8		107,271.73	107,271.73	43,325.25	4,095,167	174,234.05	66,962.32	27,044.96
9		107,271.73	107,271.73	38,683.26	4,179,735	178,811.14	71,539.41	25,797.83
10		107,271.73	107,271.73	34,538.62	4,284,527	184,382.70	77,110.97	24,827.67
11		107,271.73	107,271.73	30,838.06	4,456,530	194,063.19	86,791.46	24,950.47
12		107,271.73	107,271.73	27,533.98	4,572,731	199,931.95	92,660.23	23,783.57
13		107,271.73	107,271.73	24,583.91	4,679,844	206,278.04	99,006.31	22,689.69
14		107,271.73	107,271.73	21,949.92	4,859,796	216,641.82	109,370.10	22,379.29
15		107,271.73	107,271.73	19,598.14	4,980,487	223,432.97	116,161.24	21,222.22
16		107,271.73	107,271.73	17,498.34	5,112,255	230,245.36	122,973.63	20,059.66
17		107,271.73	107,271.73	15,623.52	5,289,080	241,067.51	133,795.79	19,486.60
18		107,271.73	107,271.73	13,949.57	5,412,662	247,840.30	140,568.58	18,279.48
19		107,271.73	107,271.73	12,454.97	5,540,941	254,988.25	147,716.52	17,150.89
20		107,271.73	107,271.73	11,120.51	5,770,627	268,816.15	161,544.43	16,746.79
21		107,271.73	107,271.73	9,929.03	5,890,366	275,822.46	168,550.73	15,600.99
22		107,271.73	107,271.73	8,865.20	6,028,763	283,706.50	176,434.77	14,581.01
23		107,271.73	107,271.73	7,915.36	6,222,990	296,372.02	189,100.30	13,953.32
24		107,271.73	107,271.73	7,067.29	6,363,714	304,622.59	197,350.87	13,001.89
25		107,271.73	107,271.73	6,310.08	6,538,609	316,863.50	209,591.77	12,328.88
26		107,271.73	107,271.73	5,634.00	6,675,921	325,672.71	218,400.99	11,470.60
27		107,271.73	107,271.73	5,030.36	6,864,559	338,593.24	231,321.51	10,847.49
28		107,271.73	107,271.73	4,491.39	7,012,775	347,901.66	240,629.94	10,075.00
29		107,271.73	107,271.73	4,010.17	7,185,843	360,950.52	253,678.79	9,483.34
30		107,271.73	107,271.73	3,580.51	7,320,823	369,764.31	262,492.59	8,761.46
31		107,271.73	107,271.73	3,196.88	7,524,792	384,802.33	277,530.60	8,270.89
32		107,271.73	107,271.73	2,854.36	7,693,922	395,764.50	288,492.77	7,676.41
33		107,271.73	107,271.73	2,548.53	7,877,404	409,791.97	302,520.25	7,187.20
34		107,271.73	107,271.73	2,275.48	8,029,715	420,247.13	312,975.40	6,638.92
35		107,271.73	107,271.73	2,031.68	8,252,347	436,784.49	329,512.77	6,240.82
36		107,271.73	107,271.73	1,814.00	8,437,568	448,962.54	341,690.81	5,778.09
37		107,271.73	107,271.73	1,619.64	8,619,958	463,934.77	356,663.04	5,385.07
38		107,271.73	107,271.73	1,446.11	8,819,927	479,867.45	372,595.73	5,022.88
39		107,271.73	107,271.73	1,291.17	8,976,237	491,767.14	384,495.42	4,627.95
40		107,271.73	107,271.73	1,152.83	9,199,931	508,974.15	401,702.42	4,317.01
41		107,271.73	107,271.73	1,029.31	9,357,845	523,944.71	416,672.99	3,998.13
				10,258,175.74			**NPV**	**(8,835,334.85)**

Table 12-11 Financial Statements of Case A-1-2

FIRR = 6.56%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue US$	Net Present Value US$
0	2,642,714		2,642,713.73	2,642,713.73			(2,642,713.73)	(2,642,713.73)
1	5,285,427		5,285,427.47	4,719,131.67			(5,285,427.47)	(4,719,131.67)
2	2,642,714	107,271.73	2,749,985.46	2,192,271.57	3,409,337	534,219.63	(2,215,765.83)	(1,766,394.95)
3		107,271.73	107,271.73	76,353.90	3,564,356	559,089.00	451,817.27	321,594.61
4		107,271.73	107,271.73	68,173.12	3,665,069	578,901.31	471,629.59	299,729.13
5		107,271.73	107,271.73	60,868.86	3,740,695	596,235.66	488,963.93	277,451.27
6		107,271.73	107,271.73	54,347.19	3,831,394	615,736.53	508,464.81	257,604.09
7		107,271.73	107,271.73	48,524.28	3,991,472	642,755.78	535,484.05	242,225.79
8		107,271.73	107,271.73	43,325.25	4,095,167	664,301.72	557,030.00	224,975.07
9		107,271.73	107,271.73	38,683.26	4,179,735	684,194.40	576,922.68	208,044.10
10		107,271.73	107,271.73	34,538.62	4,284,527	707,041.48	599,769.75	193,109.81
11		107,271.73	107,271.73	30,838.06	4,456,530	737,510.33	630,238.61	181,178.54
12		107,271.73	107,271.73	27,533.98	4,572,731	762,238.45	654,966.72	168,113.64
13		107,271.73	107,271.73	24,583.91	4,679,844	787,203.15	679,931.43	155,822.73
14		107,271.73	107,271.73	21,949.92	4,859,796	820,259.23	712,987.51	145,891.37
15		107,271.73	107,271.73	19,598.14	4,980,487	847,569.20	740,297.48	135,249.58
16		107,271.73	107,271.73	17,498.34	5,112,255	876,346.77	769,075.05	125,452.80
17		107,271.73	107,271.73	15,623.52	5,289,080	911,119.36	803,847.63	117,075.86
18		107,271.73	107,271.73	13,949.57	5,412,662	940,118.68	832,846.95	108,303.08
19		107,271.73	107,271.73	12,454.97	5,540,941	970,430.46	863,158.74	100,218.58
20		107,271.73	107,271.73	11,120.51	5,770,627	1,014,048.05	906,776.32	94,002.57
21		107,271.73	107,271.73	9,929.03	5,890,366	1,044,594.27	937,322.54	86,758.21
22		107,271.73	107,271.73	8,865.20	6,028,763	1,078,045.14	970,773.42	80,227.15
23		107,271.73	107,271.73	7,915.36	6,222,990	1,119,459.59	1,012,187.87	74,687.27
24		107,271.73	107,271.73	7,067.29	6,363,714	1,154,632.42	1,047,360.69	69,002.33
25		107,271.73	107,271.73	6,310.08	6,538,609	1,195,202.50	1,087,930.77	63,995.69
26		107,271.73	107,271.73	5,634.00	6,675,921	1,231,655.06	1,124,383.33	59,053.52
27		107,271.73	107,271.73	5,030.36	6,864,559	1,275,389.97	1,168,118.24	54,777.25
28		107,271.73	107,271.73	4,491.39	7,012,775	1,314,728.34	1,207,456.61	50,555.32
29		107,271.73	107,271.73	4,010.17	7,185,843	1,358,464.39	1,251,192.66	46,773.68
30		107,271.73	107,271.73	3,580.51	7,320,823	1,397,441.96	1,290,170.23	43,063.20
31		107,271.73	107,271.73	3,196.88	7,524,792	1,447,290.93	1,340,019.21	39,934.87
32		107,271.73	107,271.73	2,854.36	7,693,922	1,492,950.73	1,385,679.01	36,871.08
33		107,271.73	107,271.73	2,548.53	7,877,404	1,541,525.42	1,434,253.69	34,074.64
34		107,271.73	107,271.73	2,275.48	8,029,715	1,586,552.71	1,479,280.99	31,378.91
35		107,271.73	107,271.73	2,031.68	8,252,347	1,642,950.68	1,535,678.96	29,085.04
36		107,271.73	107,271.73	1,814.00	8,437,568	1,694,560.55	1,587,288.82	26,841.52
37		107,271.73	107,271.73	1,619.64	8,619,958	1,747,078.49	1,639,806.77	24,758.59
38		107,271.73	107,271.73	1,446.11	8,819,927	1,803,151.48	1,695,879.75	22,861.79
39		107,271.73	107,271.73	1,291.17	8,976,237	1,854,015.15	1,746,743.43	21,024.53
40		107,271.73	107,271.73	1,152.83	9,199,931	1,915,560.68	1,808,288.96	19,433.32
41		107,271.73	107,271.73	1,029.31	9,357,845	1,969,003.09	1,861,731.37	17,863.97
				10,258,175.74			**NPV**	**(4,839,175.84)**

Table 12-12 Financial Statements of Case A-1-3

FIRR = 1.62%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue US$	Net Present Value US$
0	2,642,714		2,642,713.73	2,642,713.73			(2,642,713.73)	(2,642,713.73)
1	5,285,427		5,285,427.47	4,719,131.67			(5,285,427.47)	(4,719,131.67)
2	2,642,714	107,271.73	2,749,985.46	2,192,271.57	3,409,337	248,288.01	(2,501,697.44)	(1,994,337.89)
3		107,271.73	107,271.73	76,353.90	3,564,356	264,602.74	157,331.02	111,985.11
4		107,271.73	107,271.73	68,173.12	3,665,069	271,992.27	164,720.55	104,682.88
5		107,271.73	107,271.73	60,868.86	3,740,695	277,706.93	170,435.21	96,709.51
6		107,271.73	107,271.73	54,347.19	3,831,394	284,192.72	176,920.99	89,633.68
7		107,271.73	107,271.73	48,524.28	3,991,472	300,679.08	193,407.36	87,487.67
8		107,271.73	107,271.73	43,325.25	4,095,167	307,422.48	200,150.75	80,837.53
9		107,271.73	107,271.73	38,683.26	4,179,735	313,805.68	206,533.95	74,478.21
10		107,271.73	107,271.73	34,538.62	4,284,527	321,747.09	214,475.37	69,055.33
11		107,271.73	107,271.73	30,838.06	4,456,530	339,466.93	232,195.20	66,750.57
12		107,271.73	107,271.73	27,533.98	4,572,731	347,161.00	239,889.27	61,573.60
13		107,271.73	107,271.73	24,583.91	4,679,844	356,807.75	249,536.02	57,187.22
14		107,271.73	107,271.73	21,949.92	4,859,796	375,457.80	268,186.07	54,876.18
15		107,271.73	107,271.73	19,598.14	4,980,487	384,968.91	277,697.18	50,734.24
16		107,271.73	107,271.73	17,498.34	5,112,255	393,698.66	286,426.94	46,722.44
17		107,271.73	107,271.73	15,623.52	5,289,080	413,217.88	305,946.16	44,559.33
18		107,271.73	107,271.73	13,949.57	5,412,662	421,984.60	314,712.88	40,925.13
19		107,271.73	107,271.73	12,454.97	5,540,941	431,244.10	323,972.37	37,615.39
20		107,271.73	107,271.73	11,120.51	5,770,627	455,452.71	348,180.99	36,094.80
21		107,271.73	107,271.73	9,929.03	5,890,366	464,547.49	357,275.77	33,069.31
22		107,271.73	107,271.73	8,865.20	6,028,763	474,567.63	367,295.91	30,354.26
23		107,271.73	107,271.73	7,915.36	6,222,990	497,000.07	389,728.34	28,757.26
24		107,271.73	107,271.73	7,067.29	6,363,714	507,455.55	400,183.82	26,364.95
25		107,271.73	107,271.73	6,310.08	6,538,609	529,650.11	422,378.38	24,845.69
26		107,271.73	107,271.73	5,634.00	6,675,921	541,727.17	434,455.44	22,817.95
27		107,271.73	107,271.73	5,030.36	6,864,559	564,198.12	456,926.40	21,426.91
28		107,271.73	107,271.73	4,491.39	7,012,775	576,099.86	468,828.13	19,629.49
29		107,271.73	107,271.73	4,010.17	7,185,843	599,660.16	492,388.43	18,407.09
30		107,271.73	107,271.73	3,580.51	7,320,823	610,859.77	503,588.05	16,808.72
31		107,271.73	107,271.73	3,196.88	7,524,792	637,406.12	530,134.39	15,798.92
32		107,271.73	107,271.73	2,854.36	7,693,922	651,636.64	544,364.91	14,484.83
33		107,271.73	107,271.73	2,548.53	7,877,404	675,948.06	568,676.34	13,510.47
34		107,271.73	107,271.73	2,275.48	8,029,715	689,272.89	582,001.17	12,345.57
35		107,271.73	107,271.73	2,031.68	8,252,347	717,603.16	610,331.43	11,559.39
36		107,271.73	107,271.73	1,814.00	8,437,568	732,644.92	625,373.20	10,575.25
37		107,271.73	107,271.73	1,619.64	8,619,958	758,720.02	651,448.30	9,835.88
38		107,271.73	107,271.73	1,446.11	8,819,927	785,841.59	678,569.86	9,147.65
39		107,271.73	107,271.73	1,291.17	8,976,237	801,810.42	694,538.69	8,359.76
40		107,271.73	107,271.73	1,152.83	9,199,931	829,743.44	722,471.71	7,764.26
41		107,271.73	107,271.73	1,029.31	9,357,845	856,537.99	749,266.26	7,189.48
				10,258,175.74			**NPV**	**(7,781,221.39)**

Table 12-13 Financial Statements of Case A-2-1

FIRR = -1.75%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue MWh	Net Present Value US$
0	1,319,490		1,319,489.80	1,319,489.80			(1,319,489.80)	(1,319,489.80)
1	2,638,980		2,638,979.59	2,356,231.78			(2,638,979.59)	(2,356,231.78)
2	1,319,490	51,714.20	1,371,204.00	1,093,115.43	3,409,337	81,667.75	(1,289,536.24)	(1,028,010.40)
3		51,714.20	51,714.20	36,809.14	3,564,356	83,808.97	32,094.77	22,844.43
4		51,714.20	51,714.20	32,865.31	3,665,069	86,567.21	34,853.01	22,149.72
5		51,714.20	51,714.20	29,344.02	3,740,695	92,727.91	41,013.71	23,272.28
6		51,714.20	51,714.20	26,200.02	3,831,394	95,926.07	44,211.87	22,399.11
7		51,714.20	51,714.20	23,392.88	3,991,472	98,788.31	47,074.11	21,293.94
8		51,714.20	51,714.20	20,886.50	4,095,167	101,597.70	49,883.50	20,147.11
9		51,714.20	51,714.20	18,648.66	4,179,735	104,337.65	52,623.46	18,976.55
10		51,714.20	51,714.20	16,650.59	4,284,527	107,520.98	55,806.78	17,968.29
11		51,714.20	51,714.20	14,866.60	4,456,530	114,838.25	63,124.05	18,146.66
12		51,714.20	51,714.20	13,273.75	4,572,731	118,085.21	66,371.01	17,035.78
13		51,714.20	51,714.20	11,851.56	4,679,844	121,830.04	70,115.84	16,068.74
14		51,714.20	51,714.20	10,581.75	4,859,796	125,297.26	73,583.06	15,056.55
15		51,714.20	51,714.20	9,447.99	4,980,487	129,005.50	77,291.30	14,120.83
16	2,650,961.86	51,714.20	2,702,676.06	440,865.01	5,112,255	132,988.60	(2,569,687.46)	(419,171.69)
17	2,650,961.86	51,714.20	2,702,676.06	393,629.47	5,289,080	241,067.51	(2,461,608.55)	(358,519.36)
18		107,355.59	107,355.59	13,960.48	5,412,662	247,840.30	140,484.71	18,268.57
19		107,355.59	107,355.59	12,464.71	5,540,941	254,988.25	147,632.65	17,141.15
20		107,355.59	107,355.59	11,129.21	5,770,627	268,816.15	161,460.56	16,738.09
21		107,355.59	107,355.59	9,936.79	5,890,366	275,822.46	168,466.86	15,593.23
22		107,355.59	107,355.59	8,872.14	6,028,763	283,706.50	176,350.90	14,574.08
23		107,355.59	107,355.59	7,921.55	6,222,990	296,372.02	189,016.43	13,947.14
24		107,355.59	107,355.59	7,072.81	6,363,714	304,622.59	197,267.00	12,996.36
25		107,355.59	107,355.59	6,315.01	6,538,609	316,863.50	209,507.90	12,323.95
26		107,355.59	107,355.59	5,638.40	6,675,921	325,672.71	218,317.12	11,466.19
27		107,355.59	107,355.59	5,034.29	6,864,559	338,593.24	231,237.64	10,843.56
28		107,355.59	107,355.59	4,494.90	7,012,775	347,901.66	240,546.07	10,071.49
29		107,355.59	107,355.59	4,013.30	7,185,843	360,950.52	253,594.93	9,480.21
30		107,355.59	107,355.59	3,583.31	7,320,823	369,764.31	262,408.72	8,758.66
31		107,355.59	107,355.59	3,199.38	7,524,792	384,802.33	277,446.73	8,268.39
32		107,355.59	107,355.59	2,856.59	7,693,922	395,764.50	288,408.90	7,674.18
33		107,355.59	107,355.59	2,550.53	7,877,404	409,791.97	302,436.38	7,185.21
34		107,355.59	107,355.59	2,277.26	8,029,715	420,247.13	312,891.53	6,637.14
35		107,355.59	107,355.59	2,033.26	8,252,347	436,784.49	329,428.90	6,239.23
36		107,355.59	107,355.59	1,815.41	8,437,568	448,962.54	341,606.94	5,776.67
37		107,355.59	107,355.59	1,620.91	8,619,958	463,934.77	356,579.17	5,383.80
38		107,355.59	107,355.59	1,447.24	8,819,927	479,867.45	372,511.86	5,021.75
39		107,355.59	107,355.59	1,292.18	8,976,237	491,767.14	384,411.55	4,626.94
40		107,355.59	107,355.59	1,153.73	9,199,931	508,974.15	401,618.55	4,316.11
41		107,355.59	107,355.59	1,030.12	9,357,845	523,944.71	416,589.12	3,997.32
				5,989,863.75			**NPV**	**(4,994,613.61)**

Table 12-14 Financial Statements of Case A-2-2

FIRR = 7.69%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue MWh	Net Present Value US$
0	1,319,490		1,319,489.80	1,319,489.80			(1,319,489.80)	(1,319,489.80)
1	2,638,980		2,638,979.59	2,356,231.78			(2,638,979.59)	(2,356,231.78)
2	1,319,490	51,714.20	1,371,204.00	1,093,115.43	3,409,337	310,945.14	(1,060,258.85)	(845,231.86)
3		51,714.20	51,714.20	36,809.14	3,564,356	320,455.36	268,741.16	191,284.65
4		51,714.20	51,714.20	32,865.31	3,665,069	331,511.96	279,797.76	177,816.54
5		51,714.20	51,714.20	29,344.02	3,740,695	348,436.05	296,721.85	168,367.95
6		51,714.20	51,714.20	26,200.02	3,831,394	360,643.94	308,929.74	156,513.42
7		51,714.20	51,714.20	23,392.88	3,991,472	372,240.89	320,526.69	144,990.00
8		51,714.20	51,714.20	20,886.50	4,095,167	384,439.52	332,725.33	134,382.18
9		51,714.20	51,714.20	18,648.66	4,179,735	396,096.46	344,382.26	124,187.70
10		51,714.20	51,714.20	16,650.59	4,284,527	409,144.52	357,430.32	115,083.00
11		51,714.20	51,714.20	14,866.60	4,456,530	429,624.87	377,910.67	108,640.29
12		51,714.20	51,714.20	13,273.75	4,572,731	443,633.90	391,919.70	100,596.02
13		51,714.20	51,714.20	11,851.56	4,679,844	458,257.56	406,543.36	93,169.25
14		51,714.20	51,714.20	10,581.75	4,859,796	472,827.50	421,113.30	86,168.12
15		51,714.20	51,714.20	9,447.99	4,980,487	488,115.91	436,401.71	79,728.96
16	2,650,961.86	51,714.20	2,702,676.06	440,865.01	5,112,255	504,693.56	(2,197,982.50)	(358,538.56)
17	2,650,961.86	51,714.20	2,702,676.06	393,629.47	5,289,080	911,119.36	(1,791,556.71)	(260,930.10)
18		107,355.59	107,355.59	13,960.48	5,412,662	940,118.68	832,763.09	108,292.17
19		107,355.59	107,355.59	12,464.71	5,540,941	970,430.46	863,074.87	100,208.84
20		107,355.59	107,355.59	11,129.21	5,770,627	1,014,048.05	906,692.45	93,993.87
21		107,355.59	107,355.59	9,936.79	5,890,366	1,044,594.27	937,238.68	86,750.45
22		107,355.59	107,355.59	8,872.14	6,028,763	1,078,045.14	970,689.55	80,220.22
23		107,355.59	107,355.59	7,921.55	6,222,990	1,119,459.59	1,012,104.00	74,681.09
24		107,355.59	107,355.59	7,072.81	6,363,714	1,154,632.42	1,047,276.82	68,996.80
25		107,355.59	107,355.59	6,315.01	6,538,609	1,195,202.50	1,087,846.90	63,990.75
26		107,355.59	107,355.59	5,638.40	6,675,921	1,231,655.06	1,124,299.46	59,049.12
27		107,355.59	107,355.59	5,034.29	6,864,559	1,275,389.97	1,168,034.37	54,773.31
28		107,355.59	107,355.59	4,494.90	7,012,775	1,314,728.34	1,207,372.75	50,551.81
29		107,355.59	107,355.59	4,013.30	7,185,843	1,358,464.39	1,251,108.79	46,770.54
30		107,355.59	107,355.59	3,583.31	7,320,823	1,397,441.96	1,290,086.36	43,060.40
31		107,355.59	107,355.59	3,199.38	7,524,792	1,447,290.93	1,339,935.34	39,932.37
32		107,355.59	107,355.59	2,856.59	7,693,922	1,492,950.73	1,385,595.14	36,868.85
33		107,355.59	107,355.59	2,550.53	7,877,404	1,541,525.42	1,434,169.82	34,072.64
34		107,355.59	107,355.59	2,277.26	8,029,715	1,586,552.71	1,479,197.12	31,377.13
35		107,355.59	107,355.59	2,033.26	8,252,347	1,642,950.68	1,535,595.09	29,083.45
36		107,355.59	107,355.59	1,815.41	8,437,568	1,694,560.55	1,587,204.95	26,840.10
37		107,355.59	107,355.59	1,620.91	8,619,958	1,747,078.49	1,639,722.90	24,757.32
38		107,355.59	107,355.59	1,447.24	8,819,927	1,803,151.48	1,695,795.89	22,860.66
39		107,355.59	107,355.59	1,292.18	8,976,237	1,854,015.15	1,746,659.56	21,023.52
40		107,355.59	107,355.59	1,153.73	9,199,931	1,915,560.68	1,808,205.09	19,432.42
41		107,355.59	107,355.59	1,030.12	9,357,845	1,969,003.09	1,861,647.50	17,863.17
				5,989,863.75			NPV	(2,224,043.00)

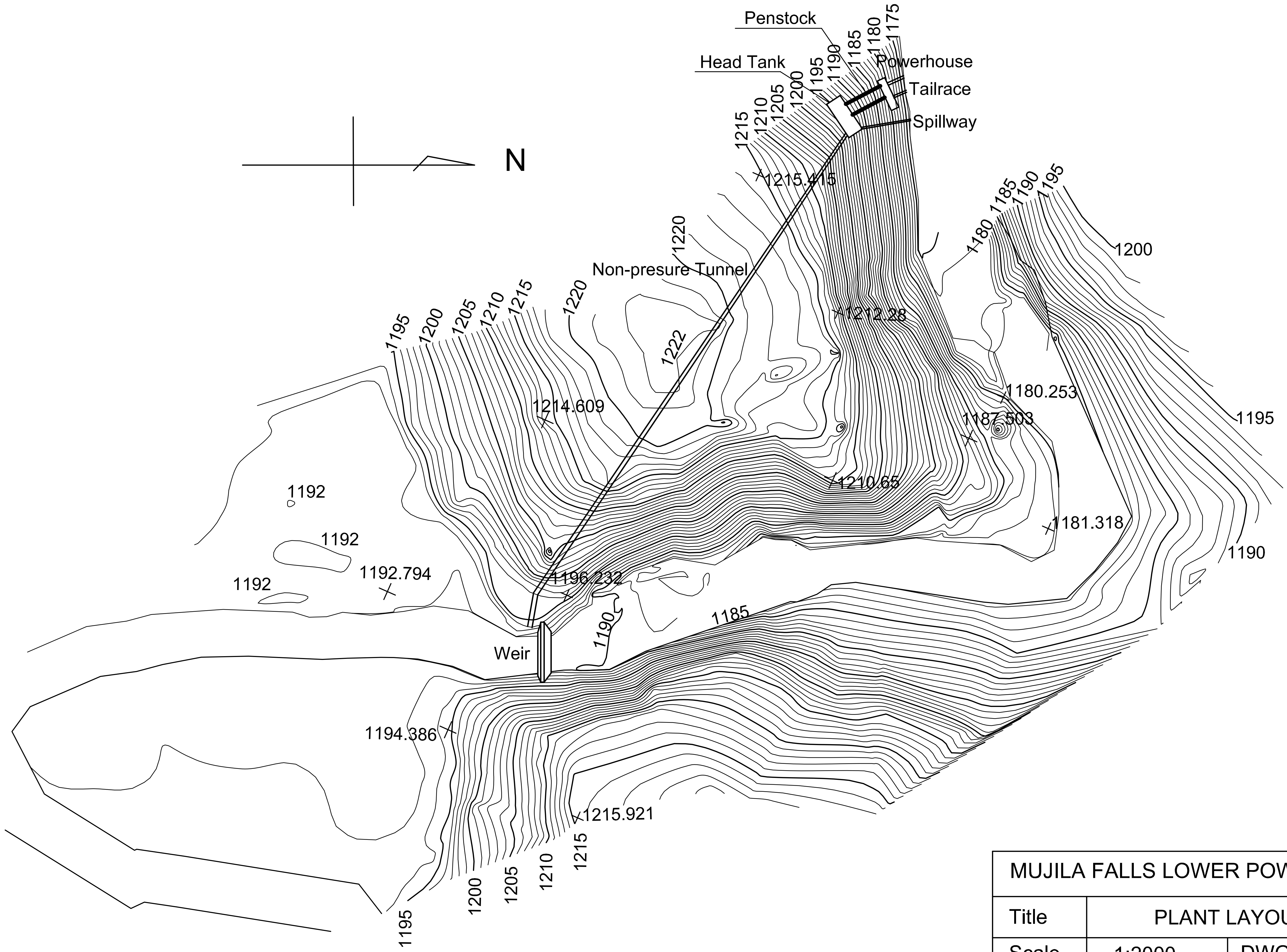
Table 12-15 Financial Statements of Case A-2-3

FIRR = 1.76%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue MWh	Net Present Value US$
0	1,319,490		1,319,489.80	1,319,489.80			(1,319,489.80)	(1,319,489.80)
1	2,638,980		2,638,979.59	2,356,231.78			(2,638,979.59)	(2,356,231.78)
2	1,319,490	51,714.20	1,371,204.00	1,093,115.43	3,409,337	149,172.43	(1,222,031.57)	(974,196.09)
3		51,714.20	51,714.20	36,809.14	3,564,356	152,215.47	100,501.27	71,534.82
4		51,714.20	51,714.20	32,865.31	3,665,069	156,162.04	104,447.84	66,378.49
5		51,714.20	51,714.20	29,344.02	3,740,695	168,911.85	117,197.65	66,501.09
6		51,714.20	51,714.20	26,200.02	3,831,394	173,992.27	122,278.07	61,949.87
7		51,714.20	51,714.20	23,392.88	3,991,472	178,136.90	126,422.71	57,187.21
8		51,714.20	51,714.20	20,886.50	4,095,167	181,950.67	130,236.48	52,600.33
9		51,714.20	51,714.20	18,648.66	4,179,735	185,903.51	134,189.31	48,390.01
10		51,714.20	51,714.20	16,650.59	4,284,527	190,415.69	138,701.49	44,658.17
11		51,714.20	51,714.20	14,866.60	4,456,530	204,910.13	153,195.93	44,040.17
12		51,714.20	51,714.20	13,273.75	4,572,731	209,230.29	157,516.10	40,430.46
13		51,714.20	51,714.20	11,851.56	4,679,844	214,953.46	163,239.26	37,410.23
14		51,714.20	51,714.20	10,581.75	4,859,796	219,706.11	167,991.91	34,374.47
15		51,714.20	51,714.20	9,447.99	4,980,487	224,819.94	173,105.74	31,625.77
16	2,650,961.86	51,714.20	2,702,676.06	440,865.01	5,112,255	230,078.04	(2,472,598.02)	(403,334.30)
17	2,650,961.86	51,714.20	2,702,676.06	393,629.47	5,289,080	413,217.88	(2,289,458.18)	(333,446.63)
18		107,355.59	107,355.59	13,960.48	5,412,662	421,984.60	314,629.01	40,914.23
19		107,355.59	107,355.59	12,464.71	5,540,941	431,244.10	323,888.50	37,605.65
20		107,355.59	107,355.59	11,129.21	5,770,627	455,452.71	348,097.12	36,086.10
21		107,355.59	107,355.59	9,936.79	5,890,366	464,547.49	357,191.90	33,061.54
22		107,355.59	107,355.59	8,872.14	6,028,763	474,567.63	367,212.04	30,347.32
23		107,355.59	107,355.59	7,921.55	6,222,990	497,000.07	389,644.48	28,751.07
24		107,355.59	107,355.59	7,072.81	6,363,714	507,455.55	400,099.95	26,359.43
25		107,355.59	107,355.59	6,315.01	6,538,609	529,650.11	422,294.51	24,840.76
26		107,355.59	107,355.59	5,638.40	6,675,921	541,727.17	434,371.57	22,813.55
27		107,355.59	107,355.59	5,034.29	6,864,559	564,198.12	456,842.53	21,422.98
28		107,355.59	107,355.59	4,494.90	7,012,775	576,099.86	468,744.27	19,625.98
29		107,355.59	107,355.59	4,013.30	7,185,843	599,660.16	492,304.57	18,403.96
30		107,355.59	107,355.59	3,583.31	7,320,823	610,859.77	503,504.18	16,805.92
31		107,355.59	107,355.59	3,199.38	7,524,792	637,406.12	530,050.53	15,796.42
32		107,355.59	107,355.59	2,856.59	7,693,922	651,636.64	544,281.05	14,482.60
33		107,355.59	107,355.59	2,550.53	7,877,404	675,948.06	568,592.47	13,508.48
34		107,355.59	107,355.59	2,277.26	8,029,715	689,272.89	581,917.30	12,343.79
35		107,355.59	107,355.59	2,033.26	8,252,347	717,603.16	610,247.57	11,557.80
36		107,355.59	107,355.59	1,815.41	8,437,568	732,644.92	625,289.33	10,573.83
37		107,355.59	107,355.59	1,620.91	8,619,958	758,720.02	651,364.43	9,834.61
38		107,355.59	107,355.59	1,447.24	8,819,927	785,841.59	678,486.00	9,146.52
39		107,355.59	107,355.59	1,292.18	8,976,237	801,810.42	694,454.82	8,358.75
40		107,355.59	107,355.59	1,153.73	9,199,931	829,743.44	722,387.84	7,763.36
41		107,355.59	107,355.59	1,030.12	9,357,845	856,537.99	749,182.39	7,188.67
				5,989,863.75			**NPV**	**(4,252,024.18)**

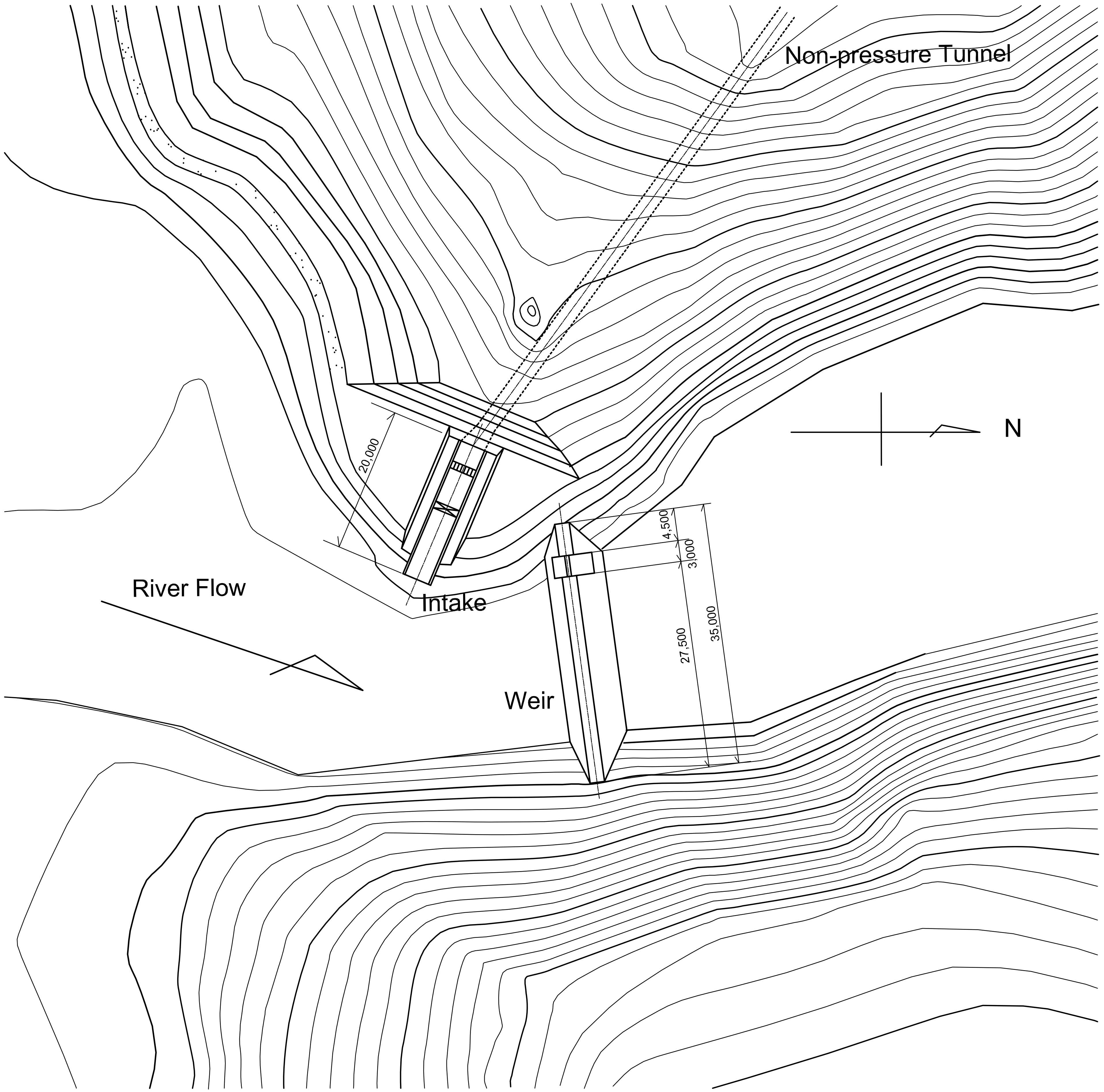
(6) Drawings

Followings are the drawings of Mujila Falls Lower site.

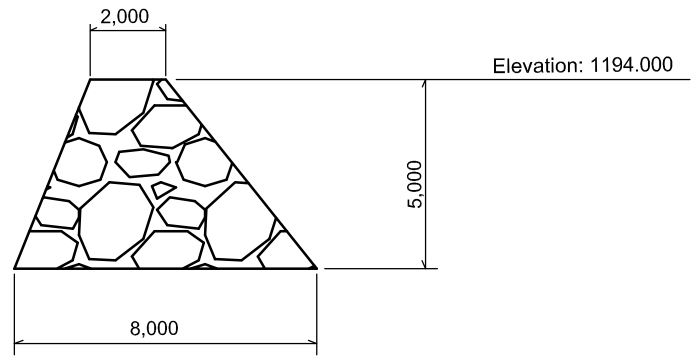


MUJILA FALLS LOWER POWER STATION			
Title	PLANT LAYOUT		
Scale	1:2000	DWG No.	MFL-1
TEPCO JICA STUDY TEAM		16-JAN-2008	

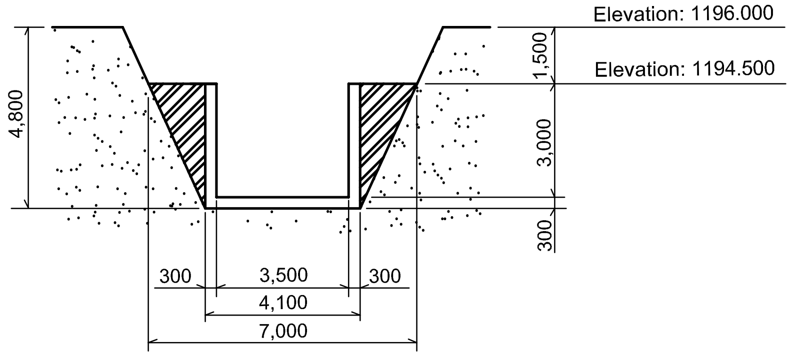
Weir and Intake Plan



Weir Section (1:200)

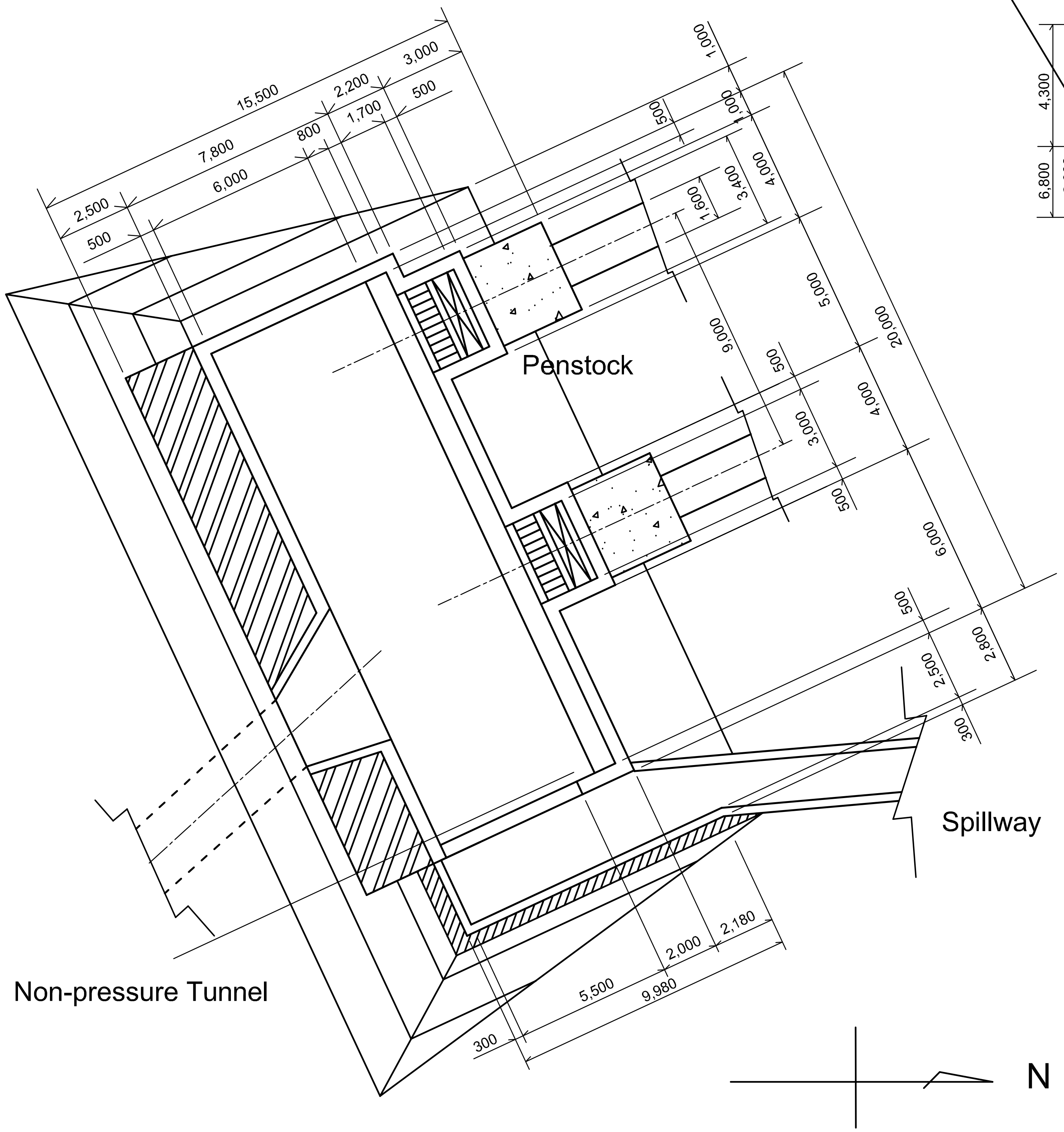


Intake Section (1:200)

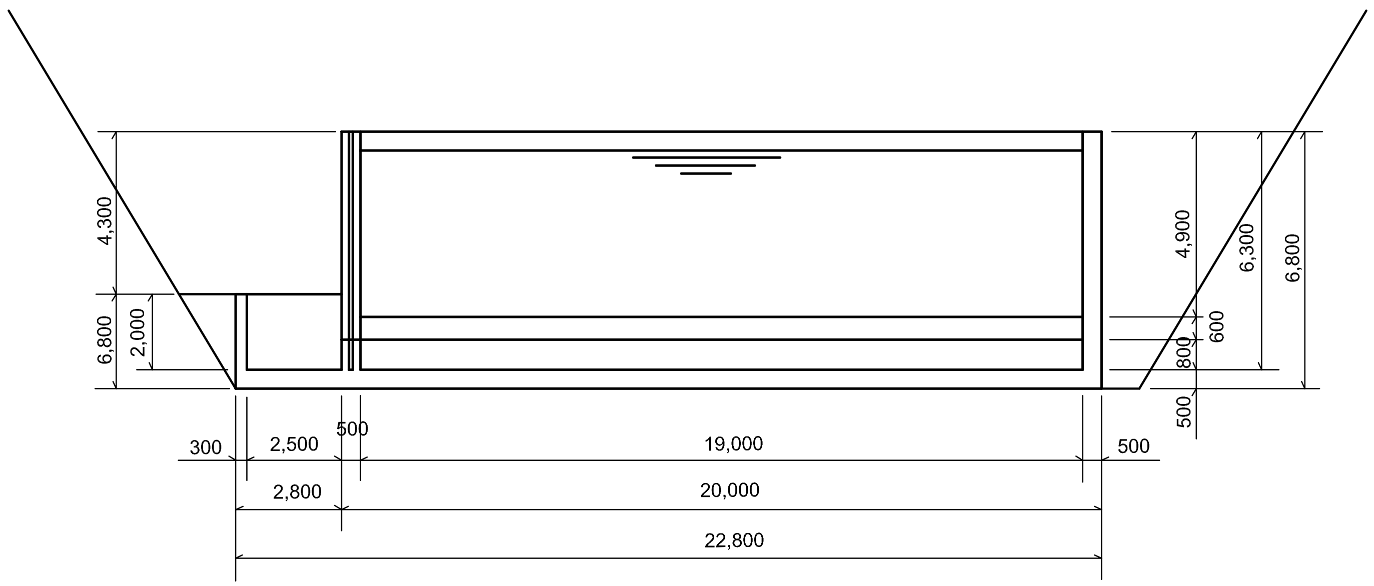


MUJILA FALLS LOWER POWER STATION			
Title	WAIR AND INTKE		
Scale	1:600	DWG No.	MFL-2
TEPCO JICA STUDY TEAM		16-JAN-2008	

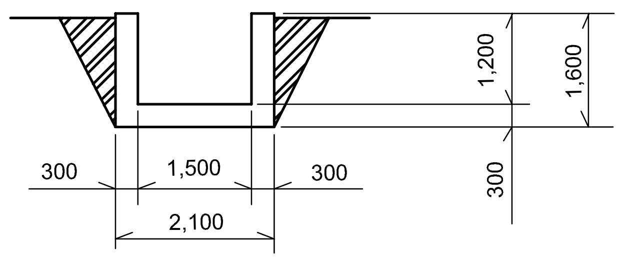
Head Tank Plan



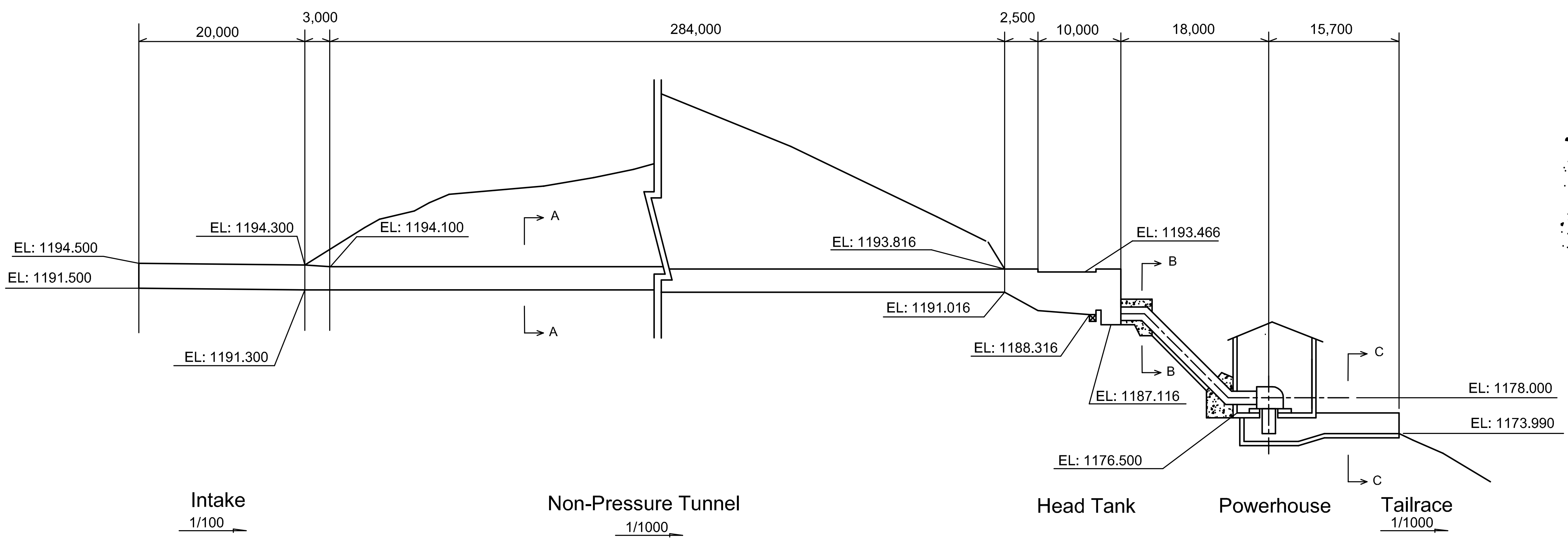
Head Tank Section



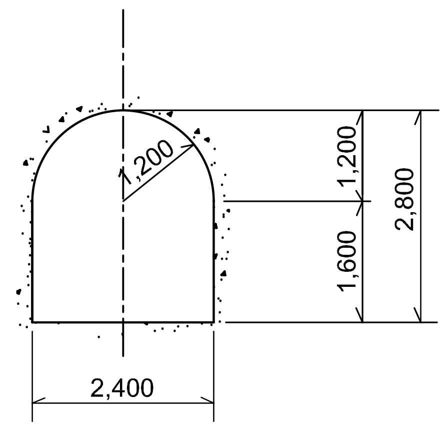
Spillway Section (1:100)



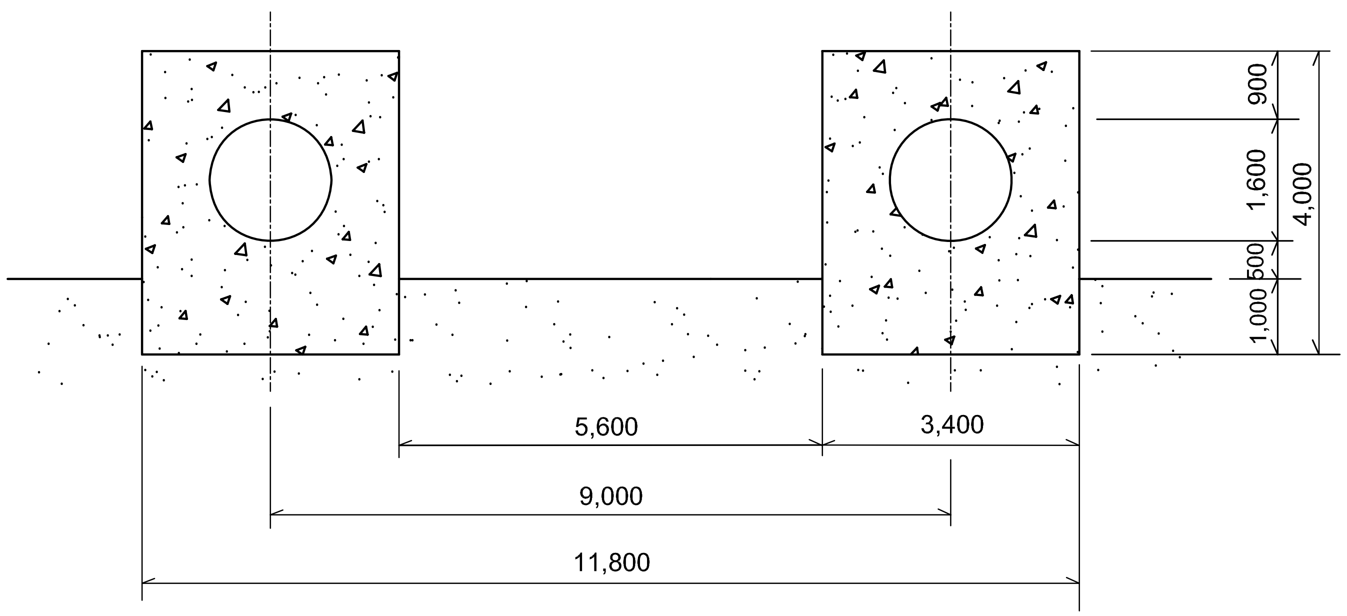
MUJILA FALLS LOWER POWER STATION			
Title	HEAD TANK		
Scale	1:200	DWG No.	MFL-3
TEPCO JICA STUDY TEAM		16-JAN-2008	



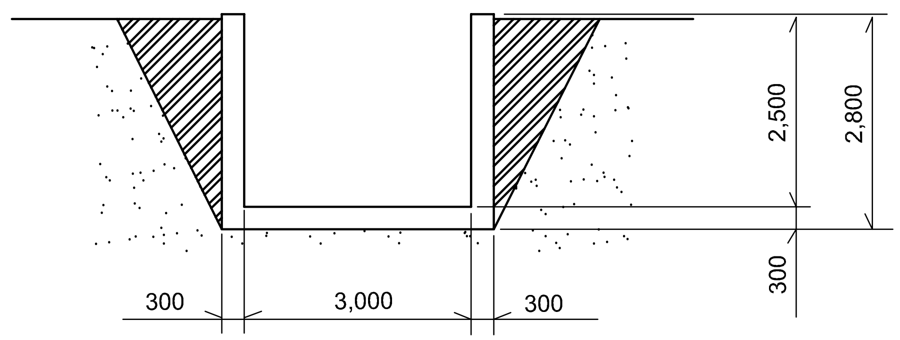
A - A Section (1:100)



B - B Section (1:100)



C - C Section (1:100)



MUJILA FALLS LOWER POWER STATION			
Title	WATER WAY SECTION		
Scale	1:600	DWG No.	MFL-4
TEPCO JICA STUDY TEAM		16-JAN-2008	

12.2.4. Result of Case Study 2 : Chilambwe Falls Site

(1) Demand Forecast

Figure 12-3 shows the location of Chilambwe Falls site and surrounding RGCs, Kapatu RGC and Sibwalya Kapila RGC. Both RGC has very big potential demand based on the preliminary demand forecast, and the potential generation capacity of this site is about 300 kW, which is too small to supply electricity for both RGCs, and distribution line extension has been selected as the optimum electrification mode in the Master Plan. Therefore, the Study Team selected only Kapatu RGCs in this Case Study. Table 12-16 shows the result of social survey in Kapatu RGC, and the Study Team estimated the potential demand, which is shown in Table 12-17.

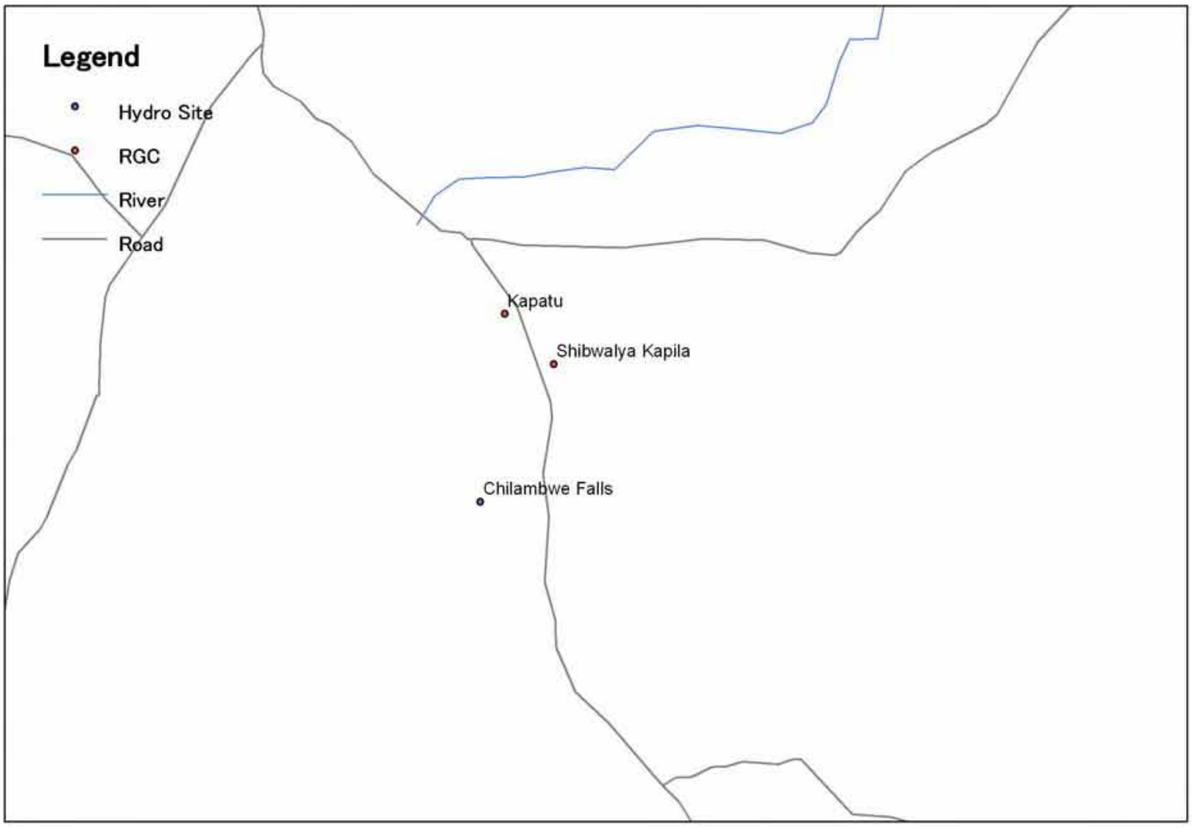


Figure 12-3 Location of Chilambwe Falls Site and RGCs

Table 12-16 Result of Social Survey in Kapatu RGC

	Kapatu RGC
No. of Households (as of 2006)	535
No. of Population (as of 2006)	2,750
No. of Hammer Mills (as of 2006)	2
Number of Existing Public Facilities	13
1) Basic / Primary School	1
2) Secondary School [under construction]	[1]
3) Tertiary School	
4) Hospital	
5) Health Centre (Clinic) / Health Post	1
6) Police Office / Station	
7) Post Office	
8) Church	1
9) Mosque	
10) Community Centre	7
11) (Agricultural) Depot	2
12) Orphanage	
13) Central Government Office	
14) Provincial Government Office	
15) District Government Office	
16) Other Local Administration Offices	
17) Court	
18) Others	
Number of Existing Business Entities	22

Table 12-17 Demand Forecast for Kapatu RGC

	Kapatu RGC [kW]
Current (2006)	303
2010	366
2015	413
2020	481
2025	559
2030	647

(2) Generation Capacity

Figure 12-4 indicates the flow duration curve at Chilambswe Falls Site, which is edited converting the river flow data measured at Kasama-Kuwing Road Bridge Gauging Station on Lukulu River. The actual river flow amount at Chilambwe Falls site measured on 14th August 2007 was 1.47 m^3/s, which corresponds to about 50% available discharge in Figure 12-4. The actual river flow is a bit large in mid August if the duration curve is reliable. This is due to the much more amount of rainfall in the last rainy season than usual.

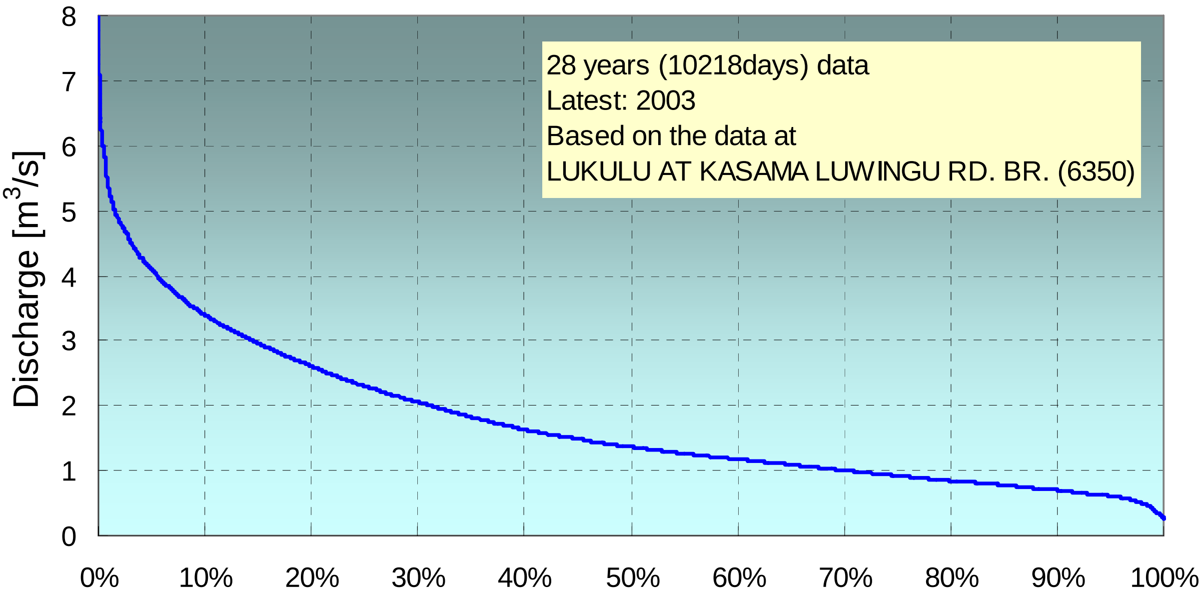


Figure 12-4 Flow Duration Curve at Chilambwe Falls Site

Table 12-18 shows the 70%, 80%, 90% and 100% available discharge at Chilambwe Falls site, and also the generation capacity assuming 36.9 m of effective head.

Table 12-18 Generation Capacity of Chilambwe Falls Site

	River Flow [m^3/s]	Generation Capacity [kW]
100% availability	0.26	78
90% availability	0.70	210
80% availability	0.85	253
70% availability	1.01	302

The Study Team estimated the total electricity supply quantity from proposed Chilambwe hydropower station up to 2030 in order to compare the generation cost (US$/kWh) among 1.0$m^3$/s, 0.85$m^3$/s, and 0.70$m^3$/s of designed discharge. Table 12-19 shows the result for each designed discharge, and the case designed at 1.0m^3/s indicates the lowest construction cost per kWh. Therefore, the generation capacity is decided at 300kW with 1.0m^3/s of designed discharge.

Table 12-19 Comparison for Designed Discharge and Generation Cost

		70% Available Discharge		80% Available Discharge		90% Available Discharge	
Plant Reliability		95 %		95 %		95 %	
Days of Planed Outage (Low Flow Season)		10 days		10 days		10 days	
Design Discharge		**1.00 m^3/s**		**0.85 m^3/s**		**0.70 m^3/s**	
Max. Output		300 kW		254 kW		209 kW	
Days at Max. Output		243 days		277 days		312 days	
Ave. Low Discharge		0.76 m^3/s		0.68 m^3/s		0.57 m^3/s	
Ave. Output at Low Dis.		226 kW		203 kW		171 kW	
Days at Low Output		94 days		59 days		25 days	
Actual Generation							
Year	Demand [kWh]	Supply [kWh]	S/D	Supply [kWh]	S/D	Supply [kWh]	S/D
2010	1,604,540	1,434,037	89.4%	1,406,780	87.7%	1,351,440	84.2%
2011	1,642,865	1,462,543	89.0%	1,435,149	87.4%	1,371,677	83.5%
2012	1,681,190	1,490,390	88.7%	1,462,407	87.0%	1,391,890	82.8%
2013	1,723,165	1,520,799	88.3%	1,490,458	86.5%	1,414,114	82.1%
2014	1,766,235	1,551,653	87.9%	1,517,658	85.9%	1,435,664	81.3%
2015	1,806,385	1,580,338	87.5%	1,542,936	85.4%	1,454,694	80.5%
2016	1,921,725	1,661,412	86.5%	1,608,372	83.7%	1,497,178	77.9%
2017	1,969,905	1,694,372	86.0%	1,633,354	82.9%	1,512,922	76.8%
2018	2,014,070	1,722,790	85.5%	1,655,186	82.2%	1,526,260	75.8%
2019	2,058,600	1,749,415	85.0%	1,676,761	81.5%	1,539,286	74.8%
2020	2,106,780	1,778,547	84.4%	1,700,120	80.7%	1,549,265	73.5%
2021	2,170,655	1,816,346	83.7%	1,731,085	79.7%	1,564,222	72.1%
2022	2,221,025	1,843,557	83.0%	1,752,284	78.9%	1,574,201	70.9%
2023	2,271,395	1,868,262	82.3%	1,771,818	78.0%	1,584,517	69.8%
2024	2,402,795	1,921,688	80.0%	1,810,948	75.4%	1,597,165	66.5%
2025	2,454,990	1,945,328	79.2%	1,825,806	74.4%	1,605,921	65.4%
2026	2,514,120	1,972,015	78.4%	1,841,179	73.2%	1,616,023	64.3%
2027	2,580,550	1,999,226	77.5%	1,854,907	71.9%	1,627,809	63.1%
2028	2,638,950	2,020,980	76.6%	1,866,615	70.7%	1,637,600	62.1%
2029	2,705,015	2,045,145	75.6%	1,880,402	69.5%	1,649,501	61.0%
2030	2,838,605	2,080,342	73.3%	1,892,783	66.7%	1,659,644	58.5%
Total	45,093,560	37,159,185	82.4%	35,357,008	78.4%	32,160,992	71.3%
Construction Cost		3,397,121 US$		3,288,093 US$		3,210,568 US$	
Const. Cost / kWh		**9.14 US Cents**		**9.30 US Cents**		**9.98 US Cents**	

(3) Design of Hydropower Plant

Table 12-20 shows the results of the design for civil facilities and electrical equipment.

Table 12-20 Features of Plant and Facilities of Chilambwe Falls Project

Plant parameters	Chilambwe Falls Project
Rated output	300kW
No. of units	One
Design discharge	$1.0m^3/s$
Effective head	36.9m
Civil facilities	
Weir	Stone masonry with flushing gate H=2m, L=50m
Intake channel	Open channel B=2.0m, H=1.5m, L=12m
Silt basin	No need
Headrace	Open channel B=1.5m, H=1.5m, L=208m
Tailrace	Open channel B=2.0m, H=2.3m, L=55m
Spillway	Open channel B=0.8m, H=1.0m, L=45m
Head tank	Open channel B=3.0m, H=3.5m, L=12m
Penstock	Exposed type D=0.75m, t=5mm, L=200m x 1 line
Powerhouse	Stone masonry, Aboveground type 5.5m x 10m x 4m
Electrical Equipment	
Turbine	Closs-flow turvine with sprit guide-vane H_{max}=36.9m, Q_{max}=$1.0m^3/s$, Pt_{max}=310kW
Generator	3-phase synchronouse generator Rated output: 330kVA, Voltage: 6.6kV Power factor: 0.9, Frequency: 50Hz
Main transformer	Outdoor type Capacity: 330kVA, Voltage: 6.6kV/33kV
Distribution line	3 phase, 3 wires, Overhead distribution line Voltage: 33kV, L=34km
Pole transformer	Outdoor type Voltage: 33kV/400V, Capacity: 100kVA x 6 units

(4) Project Cost Estimation

Table 12-21 shows the result of Chilambwe Falls project cost estimation.

Table 12-21 Cost Estimation For Chilambwe Falls Project

	Quantity	Unit Price	Price
I. Construction Cost			**2,220,340 US$**
i) Civil Engineering			406,840 US$
[Weir, Intake, Headtank and Power house]			
Concrete	80 m^3	600 US$/$m^3$	48,000 US$
Rebar	8 t	1,400 US$/t	11,200 US$
Masonry	321 m^3	150 US$/$m^3$	48,150 US$
Excavation, common	170 m^3	10 US$/$m^3$	1,700 US$
Excavation, rock	679 m^3	60 US$/$m^3$	40,740 US$
[Channel and Tailrace]			
Masonry	525 m^3	150 US$/$m^3$	78,750 US$
Excavation, common	278 m^3	10 US$/$m^3$	2,780 US$
Excavation, rock	1,112 m^3	60 US$/$m^3$	66,720 US$
[Penstock and Spillway]			
Concrete	41 m^3	600 US$/$m^3$	24,600 US$
Rebar	5 t	1,400 US$/t	7,000 US$
Excavation, common	40 m^3	10 US$/$m^3$	400 US$
Excavation, rock	160 m^3	60 US$/$m^3$	9,600 US$
[Steel Structures]			
Gate and Screen	5 t	2,800 US$/t	14,000 US$
Penstock	19 t	2,800 US$/t	53,200 US$
ii) Mechanical & Electrical Equipment			1,616,200 US$
Turbine, Gen and Tr	1 LS	310,000 US$	310,000 US$
33kV distribution line	34 km	36,000 US$/km	1,224,000 US$
33kV/400V Transformer	6 Unit	13,700 US$/Unit	82,200 US$
iii) Temporary Works			197,300 US$
Access Road	3 km	30,000 US$	90,000 US$
Road maintenance	1 LS	3,000 US$	3,000 US$
Others [30% of i)]	1 LS	104,300 US$	104,300 US$
II. Engineering Service Cost			**177,628 US$**
8.0% of Item I	1 LS	177,628 US$	177,628 US$
III. Overhead Cost			**555,085 US$**
25.0% of Item I	1 LS	555,085 US$	555,085 US$
IV. Profit Margin			**444,068 US$**
20.0% of Item I	1 LS	444,068 US$	444,068 US$
Grand Total			**3,397,121 US$**

(5) Financial Analysis

Table 12-22 shows the results of financial analysis for Chilambwe Falls project. As same as the MFL project, FIRR resulted in negative percentage. In case the tariff level is set at commodity charge in Zengamina HP (Case B-2), FIRR increased up about 7 %. The financial statement for each case is shown from Table 12-23 to Table 12-25.

Table 12-22 Results of Financial Analysis for Chilambwe Falls Project

Tariffs	Case B-1 ZESCO Charge		Case B-2 Zengamina HP Commodity Charge		Case B-3 Zengamina HP Fixed Charge	
	K	US $	K	US $	K	US $
Households tariffs	102	0.026	440	0.11	–	–
Monthly fixed charge	8,475	2.12	50,000	12.50	40,000	10.00
Commercial tariffs	245	0.06	440	0.11	600	2.00
Monthly fixed charge	43,841	10.96	50,000	12.50	50,000	15.00
Social tariffs	201	0.05	440	0.11	600	2.00
Monthly fixed charge	34,839	8.71	50,000	12.50	50,000	15.00
FIRR	-1.42 %		6.97 %		2.20 %	

Table 12-23 Financial Statements of Case B-1

FIRR = -1.42%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues US$	Net Revenue US$	Net Present Value US$
0	951,651		951,650.94	951,650.94			(951,650.94)	(951,650.94)
1	1,903,302		1,903,301.88	1,699,376.68			(1,903,301.88)	(1,699,376.68)
2	951,651	38,633.93	990,284.87	789,449.04	1,434,037	62,667.96	(927,616.91)	(739,490.52)
3		38,633.93	38,633.93	27,498.87	1,462,543	64,323.14	25,689.22	18,285.08
4		38,633.93	38,633.93	24,552.56	1,494,591	66,108.31	27,474.38	17,460.46
5		38,633.93	38,633.93	21,921.93	1,520,799	67,740.52	29,106.60	16,515.86
6		38,633.93	38,633.93	19,573.15	1,551,653	69,671.37	31,037.44	15,724.53
7		38,633.93	38,633.93	17,476.03	1,580,338	71,423.71	32,789.78	14,832.43
8		38,633.93	38,633.93	15,603.60	1,666,091	76,833.96	38,200.03	15,428.35
9		38,633.93	38,633.93	13,931.78	1,694,372	78,824.78	40,190.85	14,493.22
10		38,633.93	38,633.93	12,439.09	1,722,790	80,679.62	42,045.70	13,537.59
11		38,633.93	38,633.93	11,106.33	1,749,415	82,340.51	43,706.58	12,564.60
12		38,633.93	38,633.93	9,916.37	1,783,553	84,450.39	45,816.46	11,759.94
13		38,633.93	38,633.93	8,853.90	1,816,346	87,232.40	48,598.47	11,137.52
14		38,633.93	38,633.93	7,905.27	1,843,557	89,169.23	50,535.31	10,340.52
15		38,633.93	38,633.93	7,058.27	1,868,262	91,043.56	52,409.63	9,575.04
16		38,633.93	38,633.93	6,302.03	1,927,092	96,114.97	57,481.04	9,376.40
17		38,633.93	38,633.93	5,626.81	1,945,328	97,832.27	59,198.34	8,621.90
18		38,633.93	38,633.93	5,023.94	1,972,015	100,023.11	61,389.18	7,983.02
19		38,633.93	38,633.93	4,485.66	1,999,226	102,475.65	63,841.72	7,412.46
20		38,633.93	38,633.93	4,005.05	2,026,659	104,624.70	65,990.77	6,841.05
21		38,633.93	38,633.93	3,575.94	2,045,145	106,657.78	68,023.85	6,296.26
22		38,633.93	38,633.93	3,192.80	2,080,342	110,908.60	72,274.67	5,972.96
23		38,633.93	38,633.93	2,850.72	2,098,008	112,809.57	74,175.64	5,473.27
24		38,633.93	38,633.93	2,545.28	2,121,940	115,316.38	76,682.46	5,052.00
25		38,633.93	38,633.93	2,272.58	2,129,051	116,023.41	77,389.49	4,552.31
26		38,633.93	38,633.93	2,029.09	2,144,556	117,124.72	78,490.79	4,122.40
27		38,633.93	38,633.93	1,811.68	2,159,295	119,763.57	81,129.64	3,804.46
28		38,633.93	38,633.93	1,617.57	2,181,734	121,159.78	82,525.85	3,455.30
29		38,633.93	38,633.93	1,444.26	2,189,633	121,974.57	83,340.64	3,115.55
30		38,633.93	38,633.93	1,289.52	2,203,103	122,967.71	84,333.78	2,814.89
31		38,633.93	38,633.93	1,151.36	2,219,971	124,350.71	85,716.79	2,554.51
32		38,633.93	38,633.93	1,028.00	2,239,682	127,197.42	88,563.49	2,356.56
33		38,633.93	38,633.93	917.86	2,244,261	127,863.62	89,229.69	2,119.90
34		38,633.93	38,633.93	819.51	2,256,640	129,006.89	90,372.97	1,917.02
35		38,633.93	38,633.93	731.71	2,267,563	130,002.13	91,368.21	1,730.47
36		38,633.93	38,633.93	653.31	2,286,829	132,807.47	94,173.55	1,592.50
37		38,633.93	38,633.93	583.31	2,292,078	133,573.68	94,939.75	1,433.45
38		38,633.93	38,633.93	520.82	2,305,428	134,769.47	96,135.54	1,295.98
39		38,633.93	38,633.93	465.01	2,319,020	135,982.05	97,348.12	1,171.72
40		38,633.93	38,633.93	415.19	2,338,671	138,767.41	100,133.49	1,076.11
41		38,633.93	38,633.93	370.71	2,342,322	139,557.12	100,923.19	968.39
				3,694,043.53			**NPV**	**(3,105,752.15)**

Table 12-24 Financial Statements of Case B-2

FIRR = 6.97%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues US$	Net Revenue US$	Net Present Value US$
0	951,651		951,650.94	951,650.94			(951,650.94)	(951,650.94)
1	1,903,302		1,903,301.88	1,699,376.68			(1,903,301.88)	(1,699,376.68)
2	951,651	38,633.93	990,284.87	789,449.04	1,434,037	230,194.38	(760,090.49)	(605,939.48)
3		38,633.93	38,633.93	27,498.87	1,462,543	237,072.06	198,438.14	141,244.35
4		38,633.93	38,633.93	24,552.56	1,494,591	244,382.96	205,749.03	130,757.23
5		38,633.93	38,633.93	21,921.93	1,520,799	251,172.36	212,538.44	120,600.02
6		38,633.93	38,633.93	19,573.15	1,551,653	258,784.47	220,150.54	111,535.12
7		38,633.93	38,633.93	17,476.03	1,580,338	266,113.49	227,479.56	102,900.20
8		38,633.93	38,633.93	15,603.60	1,666,091	279,981.24	241,347.32	97,476.13
9		38,633.93	38,633.93	13,931.78	1,694,372	287,751.43	249,117.51	89,834.27
10		38,633.93	38,633.93	12,439.09	1,722,790	295,614.83	256,980.91	82,740.97
11		38,633.93	38,633.93	11,106.33	1,749,415	303,361.85	264,727.92	76,102.95
12		38,633.93	38,633.93	9,916.37	1,783,553	312,285.54	273,651.62	70,239.55
13		38,633.93	38,633.93	8,853.90	1,816,346	321,828.68	283,194.76	64,900.93
14		38,633.93	38,633.93	7,905.27	1,843,557	330,295.85	291,661.92	59,679.81
15		38,633.93	38,633.93	7,058.27	1,868,262	338,559.43	299,925.50	54,795.27
16		38,633.93	38,633.93	6,302.03	1,927,092	351,362.09	312,728.17	51,012.74
17		38,633.93	38,633.93	5,626.81	1,945,328	359,204.01	320,570.08	46,689.22
18		38,633.93	38,633.93	5,023.94	1,972,015	368,506.14	329,872.21	42,896.45
19		38,633.93	38,633.93	4,485.66	1,999,226	378,225.57	339,591.65	39,428.89
20		38,633.93	38,633.93	4,005.05	2,026,659	387,789.09	349,155.16	36,195.79
21		38,633.93	38,633.93	3,575.94	2,045,145	396,631.06	357,997.14	33,136.08
22		38,633.93	38,633.93	3,192.80	2,080,342	407,715.87	369,081.94	30,501.86
23		38,633.93	38,633.93	2,850.72	2,098,008	416,751.00	378,117.07	27,900.49
24		38,633.93	38,633.93	2,545.28	2,121,940	427,039.80	388,405.88	25,589.00
25		38,633.93	38,633.93	2,272.58	2,129,051	430,574.60	391,940.67	23,055.25
26		38,633.93	38,633.93	2,029.09	2,144,556	435,219.53	396,585.60	20,829.00
27		38,633.93	38,633.93	1,811.68	2,159,295	439,832.17	401,198.25	18,813.62
28		38,633.93	38,633.93	1,617.57	2,181,734	445,507.23	406,873.30	17,035.49
29		38,633.93	38,633.93	1,444.26	2,189,633	449,366.07	410,732.14	15,354.51
30		38,633.93	38,633.93	1,289.52	2,203,103	454,009.88	415,375.96	13,864.39
31		38,633.93	38,633.93	1,151.36	2,219,971	459,171.37	420,537.44	12,532.74
32		38,633.93	38,633.93	1,028.00	2,239,682	464,790.07	426,156.14	11,339.45
33		38,633.93	38,633.93	917.86	2,244,261	468,431.84	429,797.91	10,211.03
34		38,633.93	38,633.93	819.51	2,256,640	473,188.57	434,554.64	9,217.89
35		38,633.93	38,633.93	731.71	2,267,563	477,807.67	439,173.74	8,317.74
36		38,633.93	38,633.93	653.31	2,286,829	483,658.35	445,024.42	7,525.49
37		38,633.93	38,633.93	583.31	2,292,078	487,608.90	448,974.97	6,778.84
38		38,633.93	38,633.93	520.82	2,305,428	492,765.40	454,131.47	6,122.05
39		38,633.93	38,633.93	465.01	2,319,020	498,027.64	459,393.72	5,529.45
40		38,633.93	38,633.93	415.19	2,338,671	504,246.33	465,612.41	5,003.84
41		38,633.93	38,633.93	370.71	2,342,322	508,197.40	469,563.48	4,505.63
				3,694,043.53			**NPV**	**(1,524,773.40)**

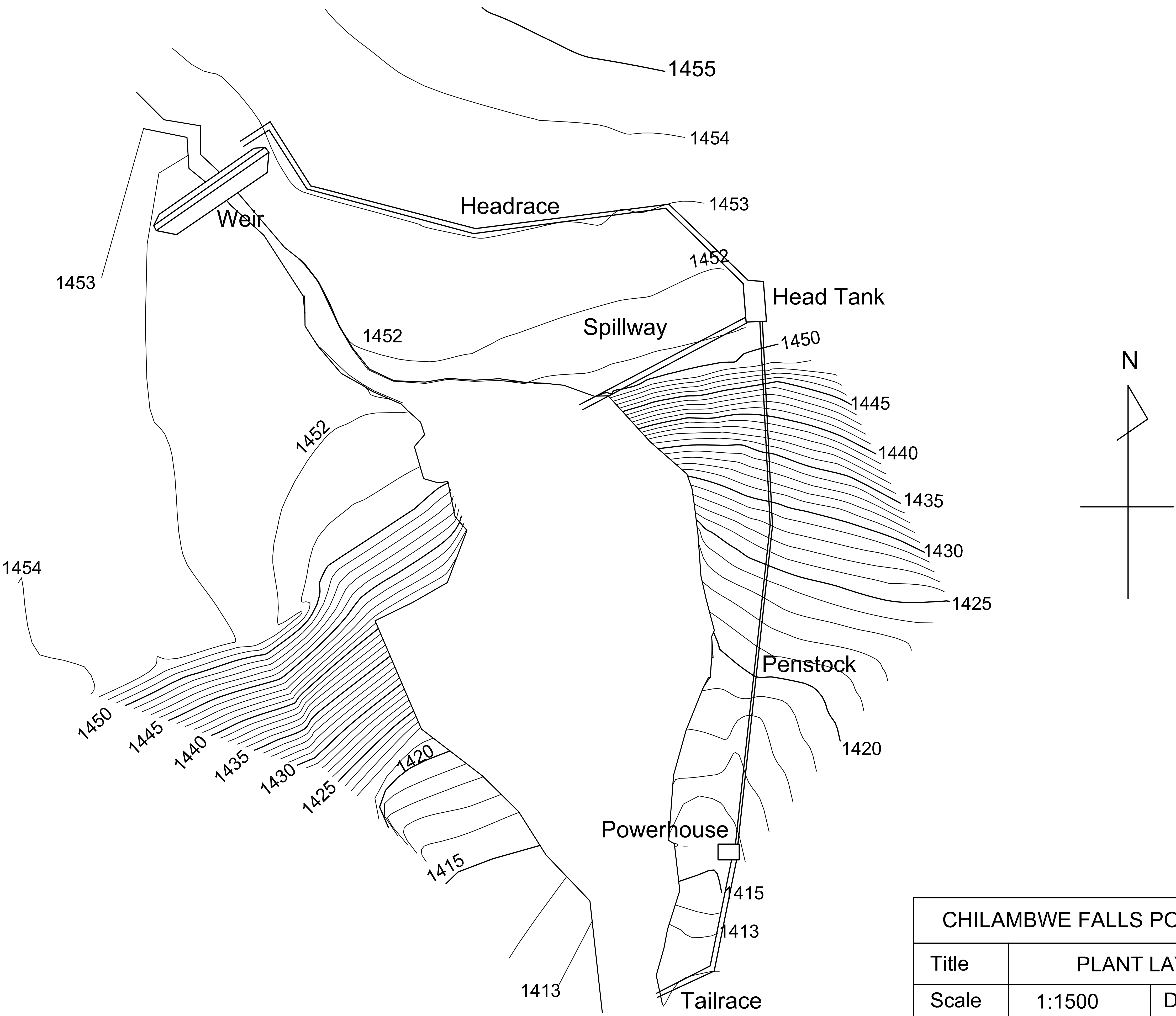
Table 12-25 Financial Statements of Case B-3

FIRR = 2.20%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues US$	Net Revenue US$	Net Present Value US$
0	951,651		951,650.94	951,650.94			(951,650.94)	(951,650.94)
1	1,903,302		1,903,301.88	1,699,376.68			(1,903,301.88)	(1,699,376.68)
2	951,651	38,633.93	990,284.87	789,449.04	1,434,037	118,825.67	(871,459.20)	(694,721.93)
3		38,633.93	38,633.93	27,498.87	1,462,543	121,443.75	82,809.82	58,942.39
4		38,633.93	38,633.93	24,552.56	1,494,591	124,191.77	85,557.84	54,373.55
5		38,633.93	38,633.93	21,921.93	1,520,799	127,111.80	88,477.87	50,204.72
6		38,633.93	38,633.93	19,573.15	1,551,653	130,289.35	91,655.42	46,435.49
7		38,633.93	38,633.93	17,476.03	1,580,338	133,020.72	94,386.79	42,695.79
8		38,633.93	38,633.93	15,603.60	1,666,091	144,783.18	106,149.25	42,871.90
9		38,633.93	38,633.93	13,931.78	1,694,372	148,312.65	109,678.72	39,551.25
10		38,633.93	38,633.93	12,439.09	1,722,790	151,238.30	112,604.37	36,255.59
11		38,633.93	38,633.93	11,106.33	1,749,415	153,834.67	115,200.74	33,117.46
12		38,633.93	38,633.93	9,916.37	1,783,553	157,090.85	118,456.93	30,404.94
13		38,633.93	38,633.93	8,853.90	1,816,346	162,507.60	123,873.68	28,388.65
14		38,633.93	38,633.93	7,905.27	1,843,557	165,613.99	126,980.06	25,982.64
15		38,633.93	38,633.93	7,058.27	1,868,262	168,652.43	130,018.50	23,753.89
16		38,633.93	38,633.93	6,302.03	1,927,092	180,782.56	142,148.63	23,187.52
17		38,633.93	38,633.93	5,626.81	1,945,328	183,704.44	145,070.51	21,128.70
18		38,633.93	38,633.93	5,023.94	1,972,015	187,461.51	148,827.58	19,353.48
19		38,633.93	38,633.93	4,485.66	1,999,226	191,932.80	153,298.87	17,799.04
20		38,633.93	38,633.93	4,005.05	2,026,659	195,434.53	156,800.61	16,255.01
21		38,633.93	38,633.93	3,575.94	2,045,145	199,357.75	160,723.83	14,876.53
22		38,633.93	38,633.93	3,192.80	2,080,342	210,161.14	171,527.21	14,175.44
23		38,633.93	38,633.93	2,850.72	2,098,008	213,544.29	174,910.37	12,906.28
24		38,633.93	38,633.93	2,545.28	2,121,940	218,247.96	179,614.03	11,833.35
25		38,633.93	38,633.93	2,272.58	2,129,051	217,738.55	179,104.63	10,535.53
26		38,633.93	38,633.93	2,029.09	2,144,556	218,018.76	179,384.84	9,421.44
27		38,633.93	38,633.93	1,811.68	2,159,295	224,571.62	185,937.69	8,719.28
28		38,633.93	38,633.93	1,617.57	2,181,734	225,094.92	186,460.99	7,806.99
29		38,633.93	38,633.93	1,444.26	2,189,633	224,718.70	186,084.77	6,956.46
30		38,633.93	38,633.93	1,289.52	2,203,103	224,338.76	185,704.83	6,198.44
31		38,633.93	38,633.93	1,151.36	2,219,971	225,611.38	186,977.45	5,572.25
32		38,633.93	38,633.93	1,028.00	2,239,682	232,158.41	193,524.49	5,149.43
33		38,633.93	38,633.93	917.86	2,244,261	231,359.43	192,725.50	4,578.72
34		38,633.93	38,633.93	819.51	2,256,640	231,759.10	193,125.18	4,096.62
35		38,633.93	38,633.93	731.71	2,267,563	231,400.32	192,766.40	3,650.91
36		38,633.93	38,633.93	653.31	2,286,829	237,543.01	198,909.08	3,363.61
37		38,633.93	38,633.93	583.31	2,292,078	236,860.02	198,226.10	2,992.91
38		38,633.93	38,633.93	520.82	2,305,428	236,998.48	198,364.55	2,674.11
39		38,633.93	38,633.93	465.01	2,319,020	237,100.48	198,466.55	2,388.83
40		38,633.93	38,633.93	415.19	2,338,671	242,708.77	204,074.85	2,193.15
41		38,633.93	38,633.93	370.71	2,342,322	242,282.88	203,648.96	1,954.08
				3,694,043.53			**NPV**	**(2,593,003.18)**

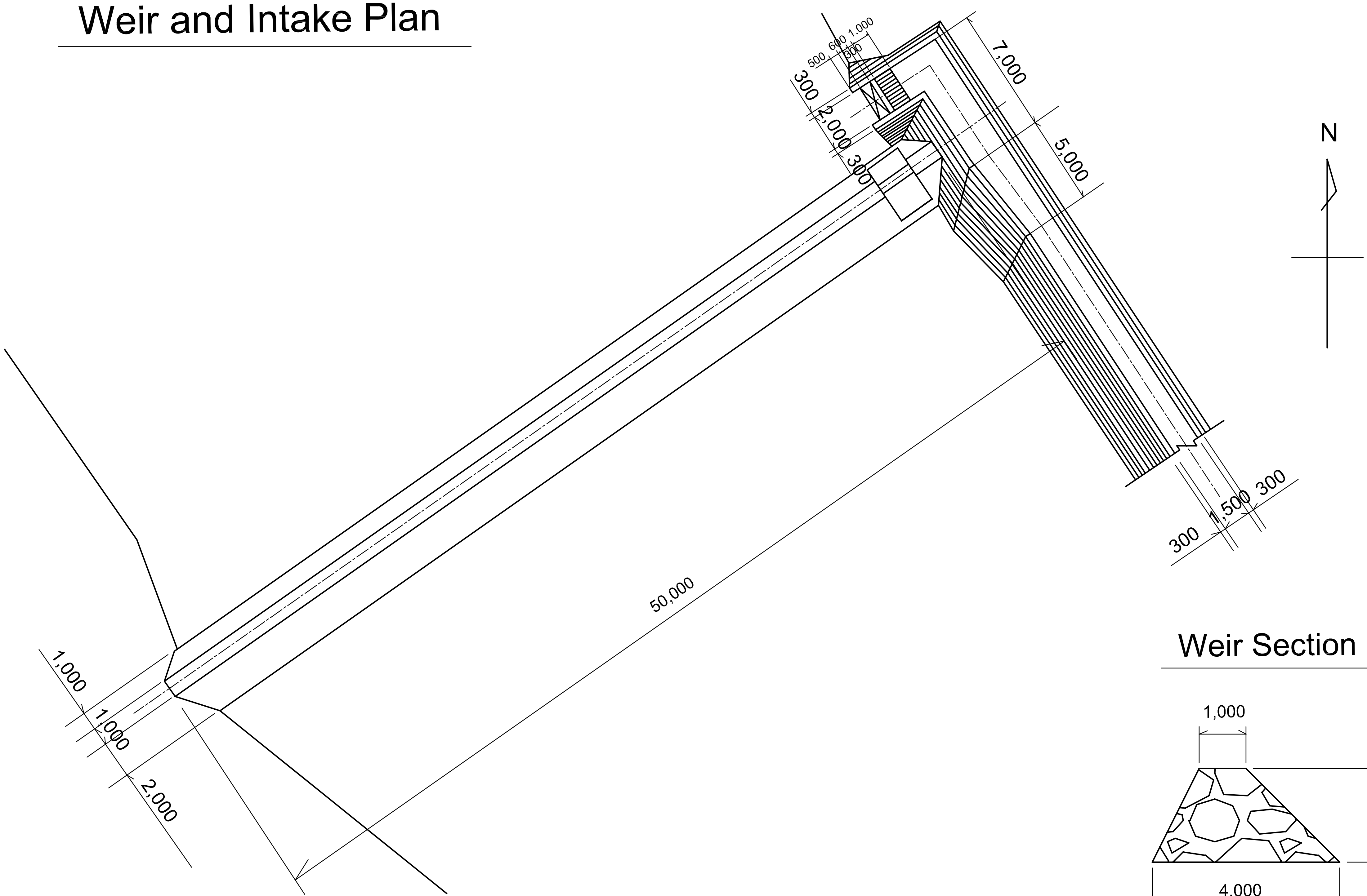
(6) Drawings

Followings are the drawings of Chilambwe Falls site.

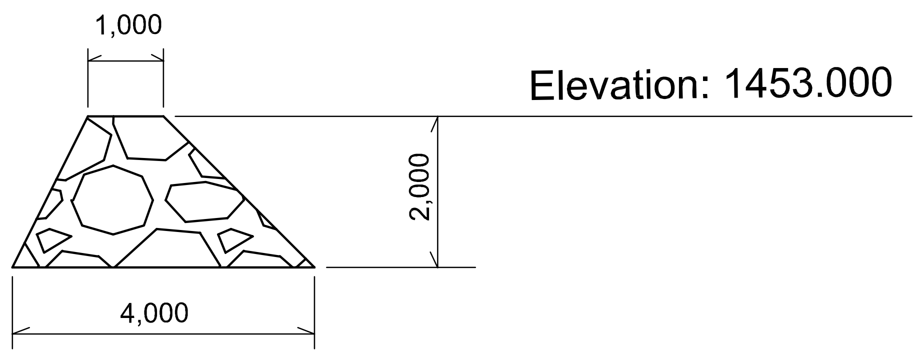


CHILAMBWE FALLS POWER STATION			
Title	PLANT LAYOUT		
Scale	1:1500	DWG No.	CBF-1
TEPCO JICA STUDY TEAM		16-JAN-2008	

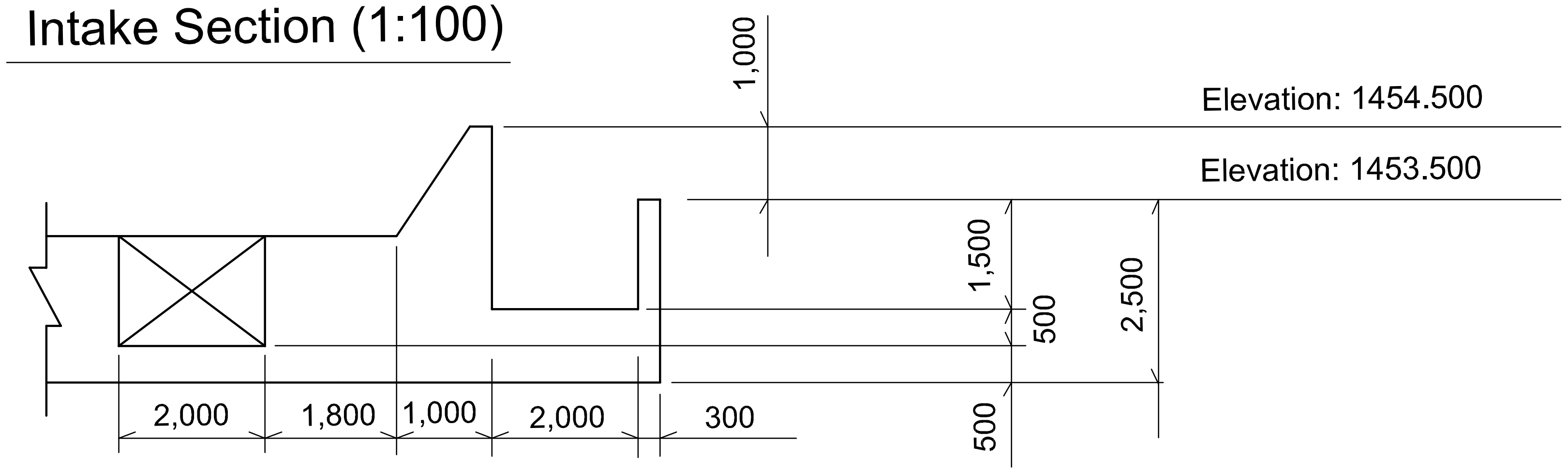
Weir and Intake Plan



Weir Section (1:100)

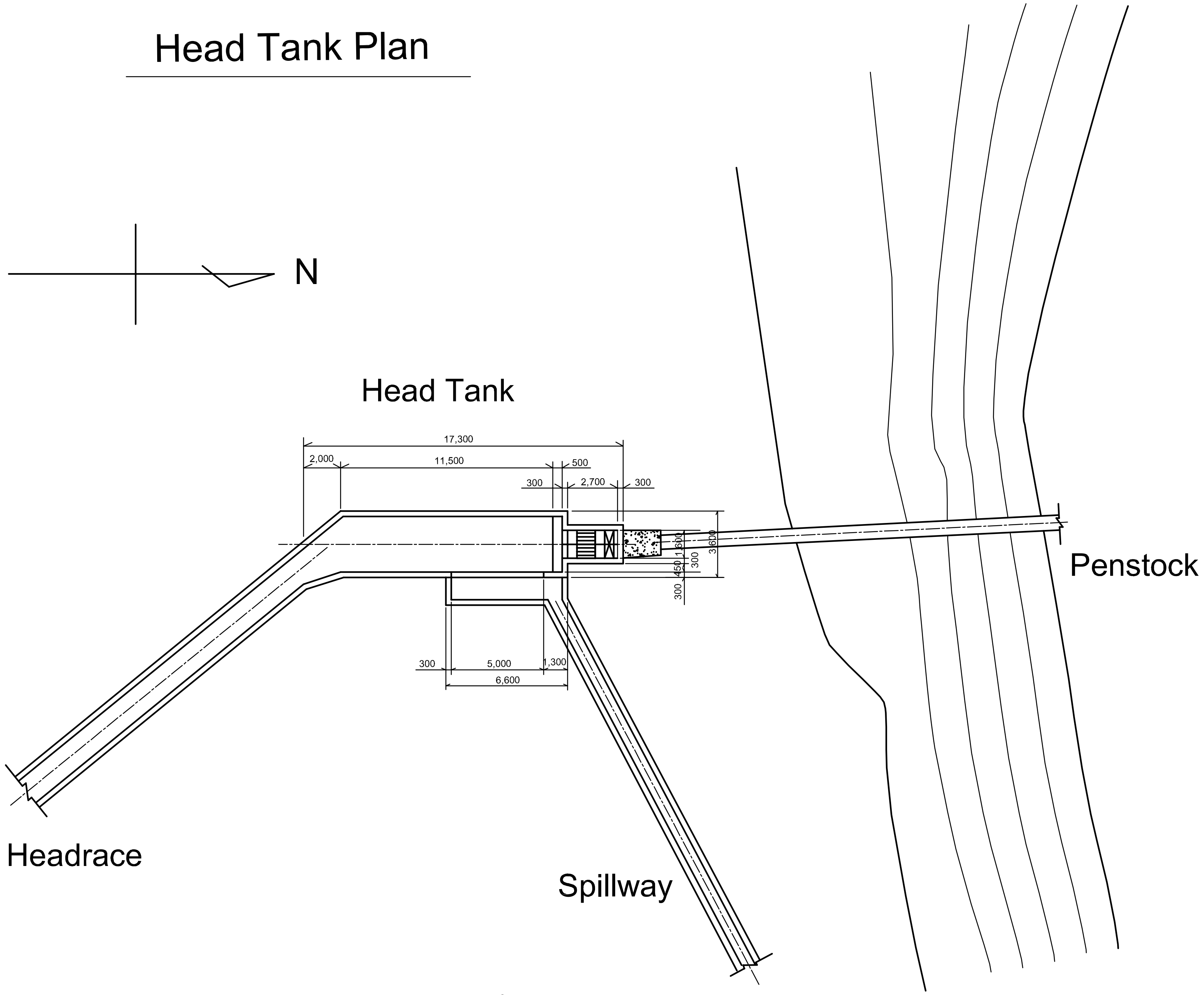


Intake Section (1:100)

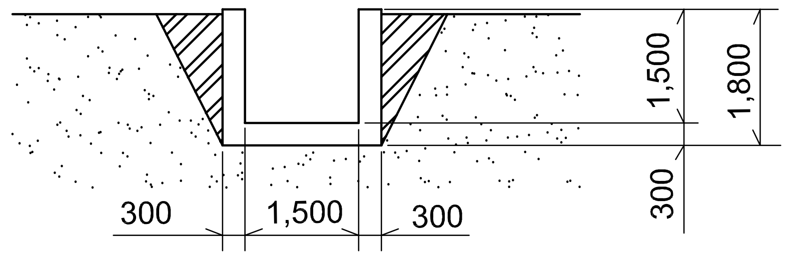


CHILAMBWE FALLS POWER STATION			
Title	WEIR AND INTAKE		
Scale	1:250	DWG No.	CBF-2
TEPCO JICA STUDY TEAM		16-JAN-2008	

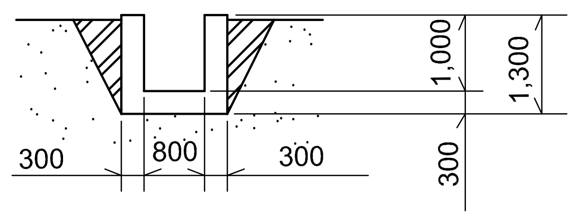
Head Tank Plan



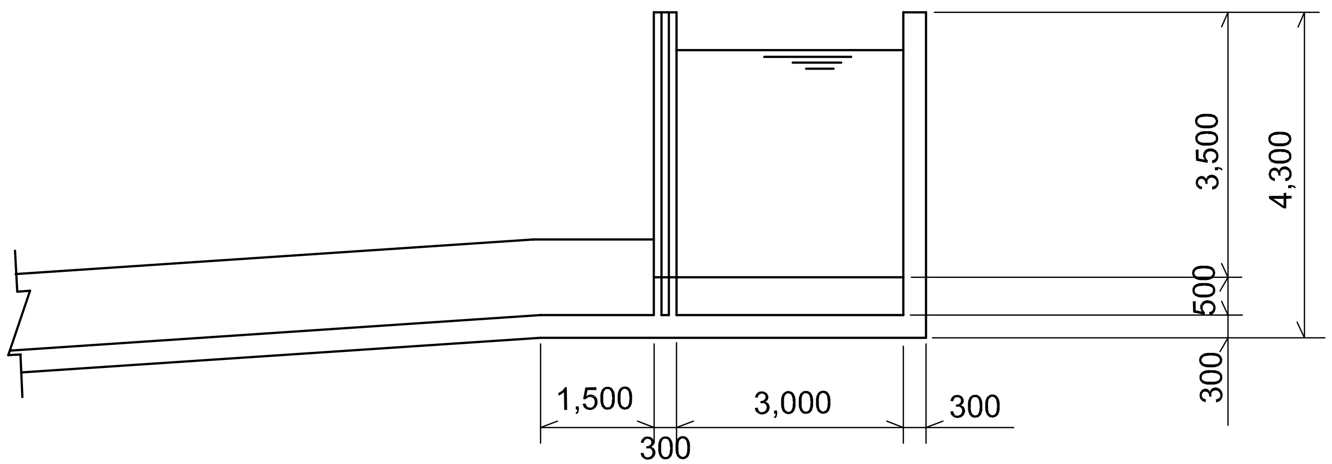
Headrace Section (1:100)



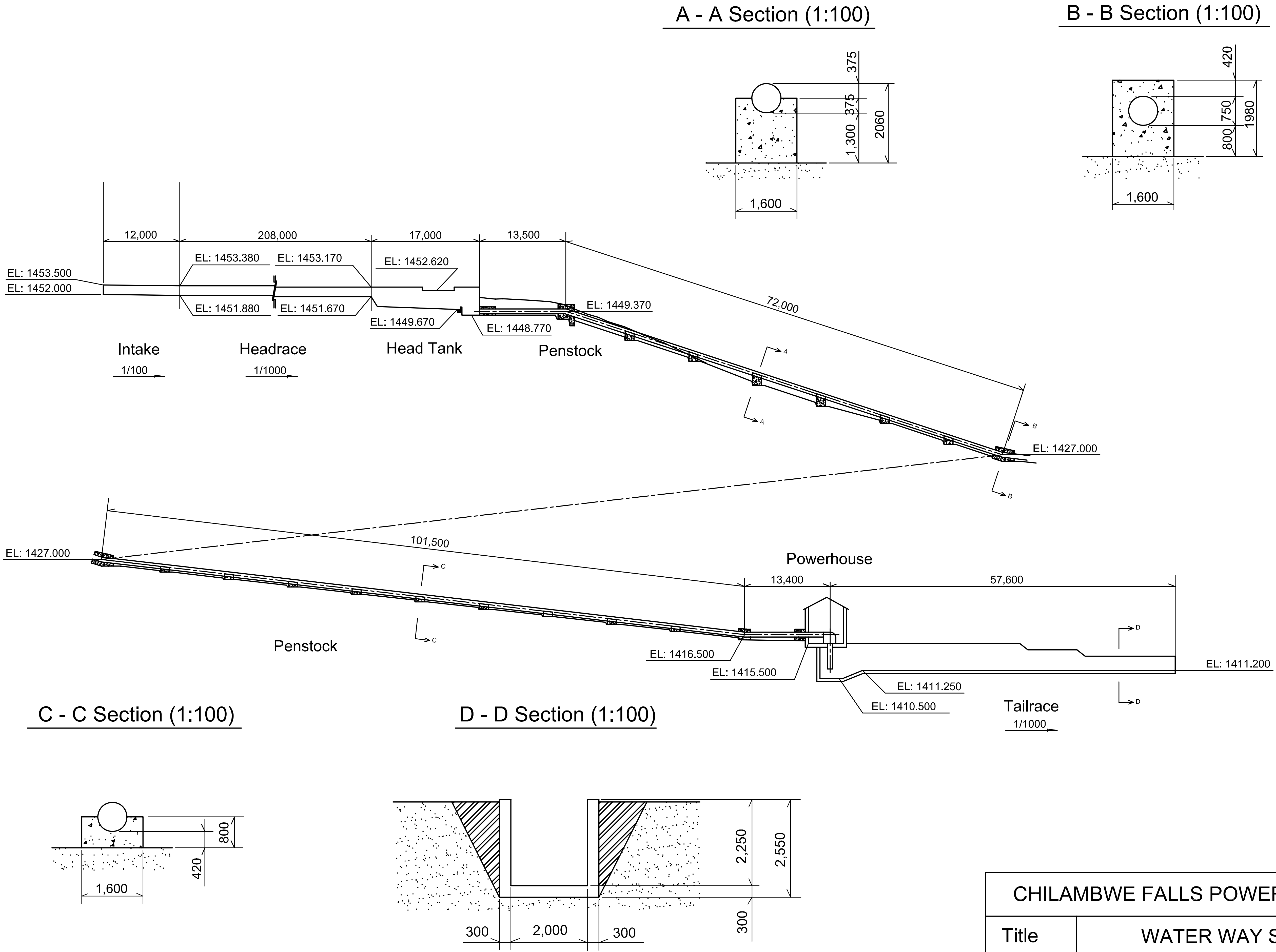
Spillway Section (1:100)



Headrace Section (1:100)



CHILAMBWE FALLS POWER STATION			
Title	HEAD TANK		
Scale	1:300	DWG No.	CBF-3
TEPCO JICA STUDY TEAM		16-JAN-2008	



CHILAMBWE FALLS POWER STATION			
Title	WATER WAY SECTION		
Scale	1:600	DWG No.	CBF-4
TEPCO JICA STUDY TEAM		16-JAN-2008	

12.2.5. Proposed Method of Hydropower Plant Management

Here The Study Team proposes an approache to the management of small hydropower plant in rural areas.

The easiest way of the plant management would be for REA to own the plant and to outsource all plant management to an experienced company such as ZESCO. The plant manager would collect the service revenues and transfer the money to the REA. Then REA would reimburse the management fee to the company and provide funds for purchasing spare parts. The remainder would be kept in the Rural Electrification Fund to meet the costs of future capital replacement costs.

It would be ideal if plant management were the responsibility of the local community. Such a community could handle all the works such as plant operation, maintenance, revenue collection, accounting, security and so on.

But in reality it is difficult to implement this idea especially in the initial stage of electrification. Therefore, the Study Team recommends establishing the structure shown in Table 12-26. Key personnel such as the Manager and Accountant should be seconded by REA, and at least one skilled electrical engineer, to supervise the daily operations, maintenance, and troubleshooting, should be hired by REA. It is desirable that a skilled Mechanical Engineer and a Civil engineer are also resident, but part-time working would be sufficient if the permanent Electrical Engineer had basic skill and knowledge for civil and mechanical facilities. Two sub-accountants and four operators (at least) should be selected from the local residents. Sub-accountants help the Manager and the Accountant. Operators work on a three-shift-a-day basis, which means one of them stays in the plant 24 hours 365 days (three work for 8 hours in turn and one is off), and curry out the daily operation and also have a responsibility for the plant security. If the local residents are very cooperative, it is recommended expanding the number of operators to eight and forming four Operation Couples to be engaged in 8 hours shift work.

The most important thing is, of course, that the local residents should acquire the skills and knowledge of accounting and O&M through On the Job Training, and the REA staff and Outsourced Engineers hand over their responsibilities to talented local residents. In this way, the plant would be managed sustainably without relying on the REA. The Study Team estimates that the REA would need to take care of the plant with its permanent staff for at least three years.

Finally, the Study Team strongly recommend that some periodical checking function especially for revenue and expenditure should be remained and also assistant structure for serious trouble should be established in REA continuously.

Table 12-26 Proposed Staff Members of Hydropower Plant

	No.	Working Form	Status
Manager	1	Day shift	REA
Accountant	1	Day shift	REA
Sub-accountant	2	Day shift	Local
Electrical Engineer	1	Day shift	Outsource
Mechanical Engineer	1	Temporary/Periodical	Outsource
Civil Engineer	1	Temporary/Periodical	Outsource
Operator	4(8)	Shift work	Local

12.2.6. Capacity Development

Some counterparts from DoE and REA accompanied the Study Team during the whole Hydropower Potential Surveys and Detailed Surveys (Case Studies) period, and the following techniques have been transferred:

- Topographic survey
- River flow measurement
- Method for converting an existing river flow data into the river flow data at specific site
- Hydropower potential estimation
- Basic design of hydropower plant layout
- Social survey

12.3. Preliminary Environmental Impact Assessment (EIA) Activities

As a part of case studies, the Study Team in collaboration with Counterpart conducted preliminary environmental impact assessment activities and produced relevant environmental clearance documents (PBs) at the later stage of the Study for the purpose of capacity development.

12.3.1. Targets of Studies

The Study Team selected two mini-hydropower project sites and their surrounding areas and the areas along the associated 33kV distribution line. These targets were selected based on the mini-hydropower potential survey conducted in North-western, Luapula, and Northern Provinces, respectively. The followings are the description of the two project sites.

(1) Mujila Falls Lower Mini-Hydropower Station Site

The proposed Mujila Lower mini-hydropower station is located about 50km east of Mwinilunga town. It is about 2km off district road number RD 277 on the Mujila River. The proposed power plant is located about 50m from the weir site. The project component has a distribution network of 33kV lines from the power plant to various schools, health centres and traditional administrative centres at Kanyama and Kakoma. Figure 12-5 outlines the location of the Mujila Lower Fall Power Plant and its associated distribution network.

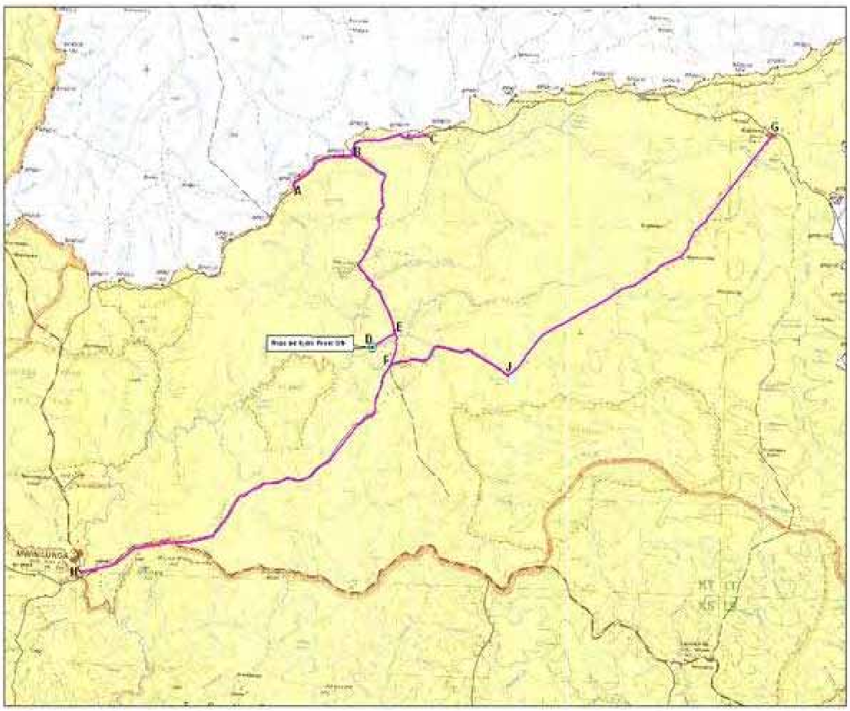


Figure 12-5 Location of Mujila Mini-Hydropower Station and proposed electricity grid

(2) Chilambwe Falls Mini-Hydropower Station Site

The proposed Chilambwe falls mini-hydropower station is located about 80 km North of Kasama town. It is a 20 km distance on the Kasama – Luwingu road and is 57 km on the D20 Mpororkoso road to Chilambwe falls turn off in Philipo Village. The distance from the turn off to the falls is approximately 2 km.

Figure 12-6 outlines the location of the Chilambwe Falls Power Plant and its associated distribution network.

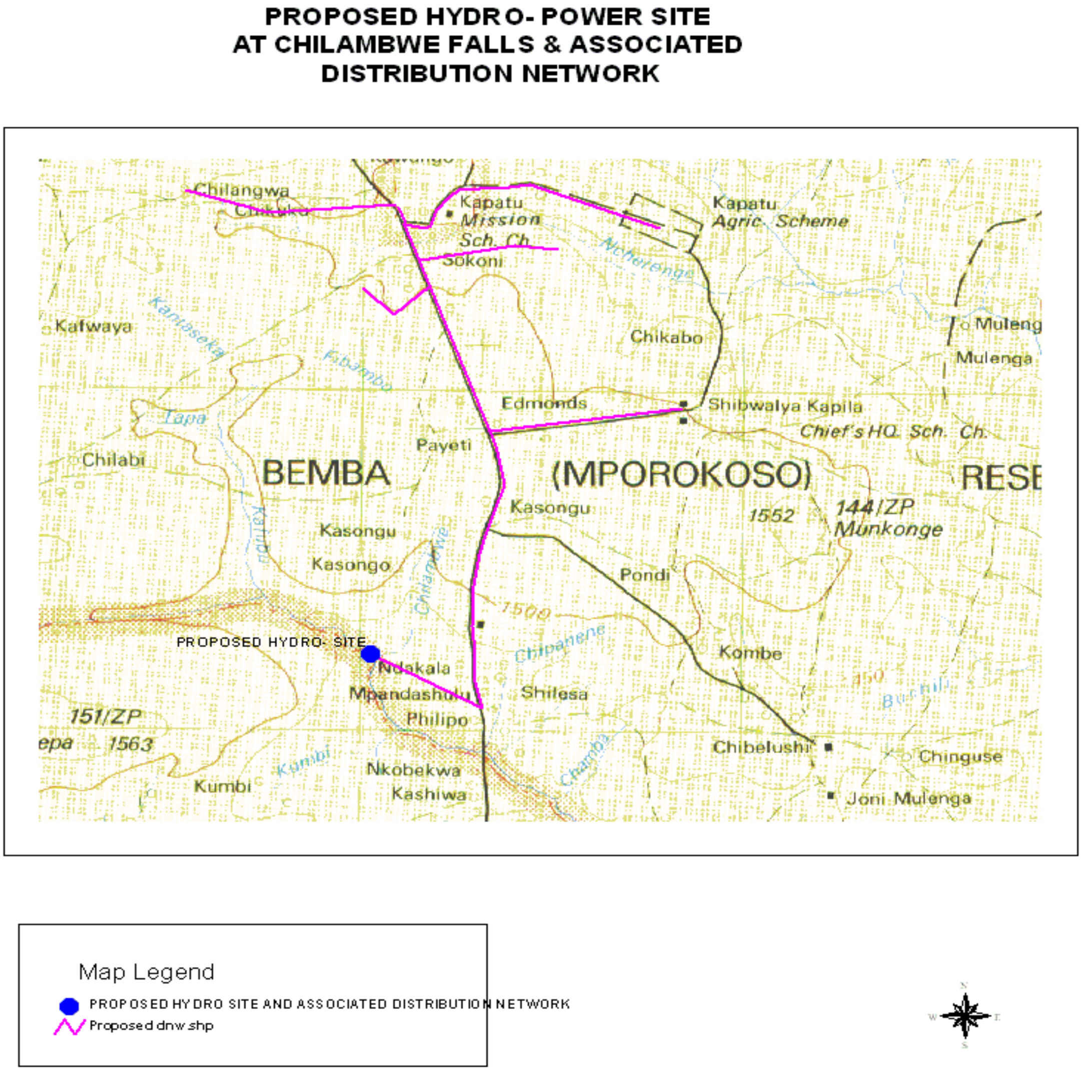


Figure 12-6 Location of Chilambwe Falls Mini-Hydropower Station and proposed electricity grid

Table 12-27 shows the outlines of both Mujila Falls Lower and Chilambwe Falls mini-hydropower projects, respectively.

Table 12-27 Outline of Mujila Falls Lower and Chilambwe Falls mini-hydropower projects

Name	Mujila Falls Lower	Chilambwe Falls
Province	North-western	Northern
Location	S11° 30′ 51.6″ E24° 46′ 23.9″	S09° 49′ 58″ E30° 43′ 26″
Catchment Area	1,146km^2	175km^2
Discharge 80% of time	9.21m^3/s	—
Design Discharge	10.4 m^3/s	0.85 m^3/s
Effective Head	17.1m	36.9m
Generation Capacity	1,400kW	300kW
Length of Channel	284m	208m
Length of Penstock	20m	200m
Length of Tailrace	10m	55m
Length of Spillway	36m	45m
Length of Weir	35m	50m
Height of the Weir	5m	2m
Length of 33kV Line	85km	34km

12.3.2. Survey Items

The study team conducted field studies for both the proposed sites for the mini-hydro power stations and their associated distribution networks to collect information on physical, biological, and socio-economic environment, respectively, then identified potential impacts on these environments. The information collected included:

(1) Physical

Location of the project, climate, topography, soils and geology, hydrology, wetlands, water quality, air quality, noise level, waste management, and landscape

(2) Biological

Flora (woody plant, and understory plant) and fauna (mammals, reptiles, birds, and fish), vegetation, protected areas (National Parks, and Forest Reserves)

(3) Socio-economic

Population, settlements, agricultures and fisheries, local economy, mining, energy, water and sanitation, health, education, employment, infrastructure and social services, archaeological and cultural, and tourism

12.3.3. Methodology

Literature review, scoping, data collection, and public consultation with the Chief and people in the villages in the project areas, and government officers in schools, health centers and agricultural officers in the project areas were conducted to recognize principal environmental problems anticipated.

12.3.4. Description of the Present Environment

(1) Mujila Falls Lower Mini-Hydropower Station Site and areas around the associated 33kV distribution line route

Physical Environment

Climate

Mwinilunga is located in the third agro-ecological region of the country. In this Zone, the rainfall is over 1000mm in a season. Mwinilunga area in particular has average annual rainfall of 1402mm which occurs in about 142 rainy days. The rainfall mainly commences in the month of September and ends in the month of May. The temperatures in this area are moderate with the minimum temperatures of around 6.50C occurring in the month of July while the maximum temperature of around 31.00C occurring in the month of October.

Topography

The study area is generally hilly and gently undulating with some low lying areas. The power plant and weir will be located in a gorge downstream and upstream of Mujila Lower Falls, respectively. The general topography ranges from 1350m above sea level for low lying areas to 1450m above sea level in hilly areas. Moderate and undulating areas occur in the 1400m above sea level topography ranges. Within the gorge which forms the Mujila Lower Falls, steep slopes are a common characteristic of the hills. The general pattern is that the wider parts of the river valleys form wetland type of marshes characterized with grasslands. These are the normal flooding zones when the river flows are at peak flood flows.

Soils and Geology

Soil types in the study area differ from upland to low lying areas: in low lying areas (the valley floors) soils are poorly drained to very poorly drained , very deep, grayish brown to grey, slightly firm, fine loamy to clayey soils with humic top soils (orthic-dystric GLEYSOLS). Soils in upland areas are predominantly Kanyama Series that are some what excessively drained, very deep, very pale brown to yellowish brown, loose to very friable sandy soils (orthic-ferralic ARENOSOLS).

The soils in the study area are mainly derived from acidic rocks that are rich in various minerals such as iron and copper.

Hydrology

The study area is endowed with unpolluted water bodies such as the West Lunga River with its tributaries such as the Mujila River, Kapundu, Mundwiji, and others. Most of the streams are perennial while some recharge zones known as dambos are wide spread in the headwaters and the sides of streams. The presence of dambos account for the high base flows that the rivers in this region have. This confirms their perennial nature even in the years when rainfall is below normal, such as drought years. The dambos are key features that also provide much needed rich breeding grounds for most of the fish found in the area. The side stream dambos are a key feature providing the much needed riverine flood control in this high rainfall area. This means that at peak flood flows, the river would overflow its banks and flood the side stream dambos to reduce the amount of water the river is carrying. The water is then released slowly back to the river when the water level goes down.

Wetlands

Dambos form the main type of wetlands in the study area. There are two types of dambos, the head water dambos and the side stream dambos. The headwater dambos are mainly found at the sources of the streams and the various tributaries while the side stream dambos are found in low laying areas of the river systems. The headwater dambos act as temporal storage for runoff at peak flows and recharge the streams slowly through out the year. The side stream dambos areas are key for flood control as they are able to act as temporal storage for peak flood river flows. Lake Chibeshya is one such head water wetland which is a good tourist attraction.

Water Quality

Water sources in the study area for both domestic and agricultural use, are mainly from surface (stream run off) and underground (wells and boreholes). The water quality in the study area, especially surface water can be said to be of good quality. Both domestic animals and humans use water from streams and dambos for drinking. The baseline data on water quality indicate that the water quality is good for domestic and other uses.

Air Quality

The air quality in the area is generally and naturally good since there are no gas emitting industries nor construction activities. The proposed site for the mini-hydropower station is located in an isolated place away from major settlements. The site is in a gorge where the air quality is good and the area has pristine vegetation. The expected area of inundation upstream of the weir is likely to be disturbed during construction but would soon be filled with water suppressing any dust emissions.

Noise Level

The location of the proposed project site is in a gorge where the main source of noise is the water falls at Mujila Lower Falls. Natural noise levels are generally low in the area. However, it is anticipated that during construction, there will be noise from construction equipment.

Protected Area (National Parks and Forest Reserves)

The proposed site for the Mujila Lower Mini-hydro power station is in a gorge and in an area that is under traditional land ownership system. The nearest protected area, the Kalenga PFA No. 95, is located several kilometers west of the proposed site for the mini-hydro and associated distribution network.

Waste

Waste management in the study area vary from locality to locality. The well-established theological training centres, clinics and schools, use appropriate waste pits and some incineration facilities. However, traditional practices of waste dumping and burning are common in villages. Use of pit latrines is common in the study area although the standard and quality differ from place to place.

Landscape

The Mujila site is located in a gorge and is rarely noticed from the access road to the Discipleship Centre. The weir site too is in a gorge upstream of Mujila Lower Falls.

Biological Environment

Flora

The vegetation in Mwinilunga is quite intact compared to other areas in the province. This can be attributed to the high regeneration rates due to the high rainfall and rich soils in the area. The other reason for the intact forests is the people’s reliance on dry dead wood and not charcoal for their energy needs.

The sawmilling business in the area is also relatively new and therefore, the forests have not yet been exploited.

The vegetation between Mwinilunga District Administrative Centre and the project area forms a thick, three-storeyed forest with a closed evergreen canopy comprising either Parinari or Marquesia species or both existing together. A few open areas are predominantly miombos comprising Jubernardia, Isoberslinia and Brachystegia species. Some sections around the high areas of Mujila are purely Uaapaca forest with a few miombo species.

Common hard wood tree species harvested by the local community include: Pterocarpus angolensis, Guibourtia coleosperma, Faurea intermedia, F. saligna, Afzelia quanzensis (Pod Mahogany), Swartzia madagascariensis, Burkea africana, Pericopsis angolensis, etc.

Charcoal production is not common in the area. Tree cutting for domestic use is done mainly for brick kilns and construction of houses, canoes, furniture, hoe and axe handles and other utensils.

Mujila River is characterized by fast flowing waters and a rich riverine forest. The common plants growing around the river are palms like Phoenix reclinata, and Raphia farinifera, ferns such as Royal fern (Osmunda regalis), Bog scaly lady fern (Thelypteris confluence), and various types of grasses.

Riverine trees that are prominent in the project area include Syzygium cordatum, Syzygium guineense ssp afromontanum, S. owariense, Gardenia imperialis, Rothmmania whitfieldii and Swatrzia madagascariensis.

Due to its meandering nature, Mujila River forms a number of small islands. Most of these islands are sandy and are covered with soft broomy grass. The common tree species on the sandy islands is Gardenia imperialis which in most cases look rather stunted. A sedge like plant that produces red fruit locally known as intungulu, is also common on the islands.

Figure 12-7 and Figure 12-8 show the typical miombo woodland found in the area and the riverine riparian thickforests along the river channels, respectively.

Figure 12-7 Typical Miombo woodland vegetation in the study area

Figure 12-8 Riverine riparian forests along the Mujila stream

Fauna

Traditionally and from time immemorial the people of North-Western Province have been hunters of wildlife. However, following the Government's development of wildlife policies and strict hunting regulations after independence, hunting of wildlife in many parts of the country is now controlled. The establishment of the Zambia Wildlife Authority (ZAWA), a more efficient and semi autonomous body compared to the National Parks and Wildlife Services, has also contributed to the conservation of wildlife in many parts of Zambia.

The project area has remained undisturbed over the years, however, large game such as elephants, do not exist any more in the area. The common mammals found in the study area are antelopes such as Waterbuck, Duiker, Baboons, Monkey, Hippos and various species of rodents such as cane rats.

Reptiles in the project area include Crocodile, Water monitor, Snakes such as Spitting Cobra, Puff adder, Black mamba, Python, green tree snake. Others are common lizards, Chameleon, Blue headed lizards and others.

The project area is a good water fowl habitat. Birds enjoy the nectar rich vegetation alongside the fresh waters. The common birds noticed in the area include the Fish eagle, Sun bird, Cuckoo, King Fisher and owls.

There are no National Parks in the Project area.

Socio-economic Environment

Population

According to the Mwinilunga district office of the Central Statistics office (CSO) estimated the population to be 124, 485. The male comprise of 59, 753 (48%) of the population and female 64, 732 (52%). The population density of the area is 6 people per square kilometer. The study area start about 40.0km from the main town of Mwinilunga and has a population of 7, 920, which was estimated by using the population catered by Kanyama clinic and information from the Ward Councilor.

Settlements

Mwinilunga town is a planned and zoned area into residential and commercial/offices and has settlements in the rural parts of the districts that are organized in form of villages. A village is made up of many households living in a defined geographical area under the leadership of a headman. A group of villages in a defined geographical area make up a chiefdom that is headed by a chief. The project area has 48 settlements all in Chief Kanyama's village. The project area is located on land that belongs to the Lunda speaking people of Mwinilunga district and under Chief Kanyama. The power distribution network however, is expected to be extended to Chief Kakoma's area where a rural load centre was also identified.

Agriculture and Fisheries

Agriculture is the most predominant and important economic activity in the study area, though it is mainly at subsistence level. Most people grow crops for their livelihood and to sale. The crops that are grown for commercial purposes are maize, cassava, beans and pineapples. Chitemene system of agriculture (see Figure 12-9) is also practiced though minimal. Chitemene system is used to grow Finger Millet, which is mostly used to brew beer. Rice and sweet potatoes are also grown on a small scale. In addition, fruit trees such as mango, avocado, guava, lemon, orange and banana are also grown on a small scale. Although production in the district is low, there is great potential for increasing agricultural production. The abundant water in streams, dambos and wetlands can support large-scale irrigation farming.

Figure 12-9 Typical Chitemene system of agriculture

There is some emerging commercial farming in the project area with most farmers getting good maize harvests. The agricultural activities are being spearheaded by the local Chief in the area. Some of the people combine crop farming with rearing of livestock such as cattle, sheep, pigs, goats, village chickens and guinea fowls.

Fishing activities are also significant in the project area since River Mujila and other streams in the area have a wide variety of fish species. There are different species in the river channel along the study area. The dominant ones are also of commercial value and these include; Snake

Barbel (Clarias theodorae), Silver barbel (Shilbe mystus), Blunt toothed barbel (Clarias mellandi), Squaker (Syndontis macrostigma), stripe tailed citharinid (Alestes lateralis), Red breasted bream (Tilapia rendalli), Oreochromis niloticus, Salmon (Anguilla nebullosa labiata), Three spotted bream (Oechromis anersonnii), Mpumbu (Labeo ativelis), Pike (Hepsetus odoe), Parrot fish (Gnathonenus macroleptus), Banded bream (Tilapia sparmannii), Dwarf bream (Haplochronis philander), Climbing perch (Ctenopoma multispine), English eel (Mastasembals mellanchi) , Green headed bream, (Oreochromis machrochir), and Marcusenius macrolepidotus.

Local Economy

The economy of the project area depends largely on farmers who produce maize, cassava, beans and millet and a few civil servants in the Ministries of Agriculture, Health and Education. Other activities that generate income or contribute to the local economy are honey production, handicrafts, timber, bricklaying and fishing. Even though the project is not very big but it is expected to have some improvement in the income levels and in turn, the standard of living. There is great potential in the area in mining, fishing, carpentry, welding, tourism and many others.

Mining

The area is rich in minerals though not fully utilized. The minerals mined in this area are: copper, iron and amethyst.

Energy

The residents of Kanyama village largely depend on firewood and charcoal for energy for cooking and heating. The rural health center, Kanyama clinic and some basic schools use solar panels for their energy requirements, but most of these solar panels are non functional as they have been either vandalized (some components stolen) or batteries discharged and are not working. Isolated places such as the United Methodist Mujila Agricultural Centre, use a combination of solar and diesel generators for energy, especially for water pumping.

Water and Sanitation

Mwinilunga is endowed with abundant water supplies since it is in the equatorial region that is an extension of the rain forest of Congo. Many villages are located near streams and this enhances easy accessibility to water. Villages largely depend on water from the streams and rivers in the area. The water is used for drinking and other domestic uses such as cooking, washing, bathing and watering their gardens along the riverbanks. Despite the abundance of water, accessibility to safe water still remains a challenge.

A number of houses have pit latrines and bathing shelters that are constructed of local materials with thatched roofs. Use of open bush is common in villages without pit latrines.

Health

Kanyama village has one major clinic, Kanyama clinic, which is the second largest from the main District Hospital in Mwinilunga. Kanyama clinic has a medical officer and a nurse with other daily employees. The clinic used to rely on solar panels but the batteries are no longer working. The clinic relies on fuel wood for heating to sterilize equipment and candles for light. There are a number of rural health centers in the area Kapundu and Muuwa centers which also rely on solar panels distributed by the Ministry of Health. The area also has health posts, namely; Nyangala, Nyaminkanda and Chanuvu.

Common diseases in the project area are; malaria, diarrhea, upper respiratory trunk infection, pneumonia, malnutrition and sexually transmitted diseases (STIs) especially among young people. The village has not reported any HIV/AIDS cases as there are no screening facilities hence there is no definite information regarding the magnitude of the problem. The area does get

Voluntary Counseling and Testing (VCT) conducted by a mobile clinic, which comes from the Mwinilunga Hospital when requested upon by the clinic in Kanyama.

The clinic also has provided Traditional Birth Attendants (TBA) to help pregnant women to deliver. The clinic lacks mid wives and nurses and has no maternity ward. The bed space is also limited from the 25 beds there are only 10 in good condition. The infant mortality and mortality rate is quite low in this area and they have not reported any deaths through the clinic and the health centers since 2004.

The capacity of the existing health facilities to meet demand is very low. The health centers do not have any electrical or adequate medical equipment. Drugs and other necessities are in low supply, as the Ministry of Health does not deliver on time. The clinic and health centers do not have ambulance nor mortuary facilities. This makes work difficult since the clinic has to radio Mwinilungu hospital for assistance.

Education

There are a number of schools in the area; primary, basic and secondary. The only secondary school in the area is Kanyama Secondary School with classes from grade 1 to grade 12 and the population of the school is 703. The progression of pupils is generally very low among pupils of both genders however, there are more girl-child pupils dropping out of school in higher grades than among boys. The attribution of low levels of progression among girls is early marriages and lack of role models. The secondary school caters for all the pupils in the area and some students have to travel long distances as far as 12km from the school. The school has 17 teachers though they are supposed to be more but they refuse to come because of the non-availability of power.

The Ministry of Education runs most of the basic schools which are Munwa, Nsweta, Kapundu, Kamaneng'u, Kanyama and the Ministry of Community Development and Social Services runs the community schools which are; Mujila Kansang'a, Lokokwa and Changuvu. The community schools have been established mainly because of the inadequate number of public schools in the area and the long distance it takes for pupils to go to school. The pass mark of the pupils is fairly average and this is attributed to lack of electricity for studying.

Employment

The main activities in the village that involve formal employment are the civil servants (Government) such as teachers, health workers, agricultural extension officers and magistrate.

Subsistence farming is the most common occupation in the project area. During the farming season from October to February people are engaged in cultivation and from April, in sales of agricultural produce and in sale of honey in October.

Infrastructure and Social Services

Basic infrastructure in the area such as: clinics, schools that are government owned and some churches, are poor. There are no recreation centers although the area has national radio coverage. The road leading to the village is not gravelled nor tarred so it is not in good condition. The distance to the village from the main road is 30km and from the main town of Mwinilunga is about 60km.

Archaeological and cultural

The study area has no known archeological sites. However, Kanyama village has a cultural site used for the rain festival called “Chidika cha Mvula.” However, the festival has since evolved from traditional type of worship to a modern Christian festival that attracts various preachers and clergy.

Tourism

The study area has no organized tourism activity although plans are now underway to put up a nature conservation area around Lake Chibeshya. The National Heritage Conservation Commission (NHCC) is spearheading the project in collaboration with the local community.

The site for construction of the power station has no tourist attraction and nor facilities. There are no lodging facilities, restaurants and other facilities that can promote tourism in the area but there is potential for tourism. There is Lake Chibeshya that is within the project area and two waterfalls, Mujila Lower and Mujila upper.

(2) Chilambwe Falls Mini-Hydropower Station Site and areas around the associated 33kV distribution line route

Physical Environment

Climate

The project area experiences four main types of seasons: cool and dry (June to August), hot and dry (September to October), hot and wet (November to February) and cool and wet (March to May). The average annual rainfall ranges between 1,100mm and 1,240mm. The mean annual temperature is around 18OC. The project area lies within Ecological Zone III, which receives high rainfall.

Topography

The study area lies on a plateau, which is generally flat and gently undulating with some low-lying areas. The water diversion and reservoir will be located upstream of Chilambwe Falls while the power plant will be located 30 meters below the falls. The general topography of the area ranges from 1,450m above sea level for low-lying areas to 1,600m above sea level in hilly areas. Moderate and undulating areas occur in the 1,400m above sea level topography ranges.

Soils and Geology

The geology of the project area represents one of Zambia’s rock formations from Precambrian to early Paleozoic. Basement Complex, Muva Super Group, Katanga Super Group lie as base rock of the Northern Province in which the project area lies. Granitic gneisses are widely spread at the central part of the province. Quartzites, shale of Muva Super group are distributed at north western and south western part of the granite zone, and shale, sandstones of Kundelungu group are distributed eastward of Lake Bangweulu. Upper Karoo Super group are distributed along the Luangwa valley. The project area has acidic sand loamy soils, which are also pervious.

Hydrology

The study area lies in the Chambishi River catchment. The Chambeshi catchment and the project area is endowed with a lot of perennial streams and rivers which are unpolluted due to non existence of industries and commercial farming activities. The streams are also surrounded with dambos that act as recharge zones. The main drainage system is the Chambeshi River in the project area. Other river and streams include, Mabale, Katutwa, Mwitakubili, Mukolwe and Kashida.

The proposed power plant shall be located on the Kafubu River. Other streams, which contribute to the Kafubu, are Tapa, 10 kilometres upstream of the proposed location, Nkwale and Kasawa streams after the falls. The Kafubu drains into Lake Tanganyika in Nsumbu National Park.

Wetlands

Dambos form large part of wetlands in the proposed project area. They are situated in areas at the head water before the waterfall. The tributary systems also have similar wetlands in form of dambos.

Water Quality

The water quality in the project area is good since there is no industrial or commercial farming activities or indeed other polluting activities in the study area. The baseline data indicates that the water quality is good and suitable for domestic, agriculture and other uses which include hydropower generation.

Air Quality

The air quality in the area is generally good as there are not industrial, commercial farming or construction activities. The proposed mini hydropower site is in a remote area with very few settlements. Air pollution from chitemene activities (especially burning) is localized and is at intervals.

Noise Level

The location of the proposed project site is in an open and low populated area. Noises experienced at the moment are from nature, which include the waterfall, and this is generally low. Natural noise levels are generally low in the area.

Waste

In the villages in the project area, very little waste is generated. The little waste generated is mainly domestic waste comprising leftover foodstuffs, which are thrown in rubbish pits for disposal. Pit latrines are used for the disposal of human waste.

Biological Environment

Flora

Woody plants

Mporokoso lies within the high rainfall area that is predominantly vegetated by Miombo woodland that is two-storeyed with an open and semi-evergreen canopy 15 – 20m high. The principle trees are Brachystegia, Julbernardia and Isoberlinia species, these include: Brachystegia stipulata, B. allenii, B. Manga, B. boehmii, B. bussei, B. floribunda, B. longifolia, B. microphylla, B. spiciformis, B. taxifolia, B. utilis, Isoberlinia angolensis, Julberlinia globiflora and J.paniculata.

The project site has a mushitu forest around the waterfall and the immediate downstream. A mushitu forest is basically a riparian riverine thicket with a wide range of tree species. Common tree species include Combretum zehyeri, Cassipourea mollis, Croton, Macrostachys, Ficalhoa laurifolia, Olea capensis, Podocarpus latifolius and Polyscias fulva. Figure 12-10 shows the part of riverine riparian forest around Chilambwe Falls.

Figure 12-10 Part of riverine riparian forest around Chilambwe Falls

However, riverine riparian forests in the project area are threatened by human activities. People in the projects area are cutting down the forests to make gardens for vegetable and sugarcane growing along Kafubu River and its tributaries. This practice poses a serious threat to the very survival of the affected rivers and streams and in turn, affects the proposed project since it depends on water for power generation.

The Chitemene system of agriculture (slash and burn), which is widely practiced in the area, has contributed greatly to the depletion of the woodlands. Trees are cut down and branches heaped together before burning. When rains come, the burnt area is planted with finger millet and other crops. The following year, another area is cleared.

Understorey plants

The relatively discontinuous under storey is dominated by Anisophyllea boehmi, Baphia bequaertii, B. massaiensis, Monotes glaber, M. africanus, M. katagensis, Hymenocardia acida, Combretum psidioides, C. celastroides, C. collinum, C. fragrans, C. imberbe, C. molle, C. zeyheri, Terminalia mollis, T. stenostachya, Diplorhynchus condylocarpon, and Uapaca kirkiana.

Common shrubs found in area include Ximenia americana, Oldfielda dactylophylla, Diplorrhynchus mossambicensis, D. condylocarpon. Other common shrubs are members of the following genera:- Lannea and Ziziphus. Grass species present in the area are associated with the Brachystegia-Julbernardia-Isoberlinia Woodland. The common species include Eragrostis brizoide, Alloteropsis semialata, Anthephora acuminata, Aristida adscensionosis, Monocymbium sp Bewsia biflora, Heteropholis sukata, Sporobolus rhodesiensis, Thysia huillensis, Sporobolus pyramidalis, Chloris gayana, Digitaria scalarum, Tristachya hubbardiana, Brachiaira brizantha, Homozeugos cylesi, Piptostachya inamoena, Pennisetum purpureum, Erythrophloeum africanum, Trichopteryx lanata, Andropogon sp., Diheteropogon amplectens, Sporobolus pyramidalis and Hyparrhenia cymbaria, H. filipendula, H. nyassae, H.cymbaria, H. rufa, H. bracteata. The Hyparrhenia sp., tend to congregate on the forest margins.

Fauna

Mammals

The project area is an open area (not protected area), and hence man's activities, especially through poaching and encroachment have led to the reduction in numbers of wild animals in the project area. Common mammals reported to be in the study area include; Bush buck (Tragelaphus scriptus), Bush pig (Potamochoerus porcus), Sitatunga, Common duiker (Sylvicapra grimmia) Blue Duiker (Cephalus monticola) and Puku (Kobus vardonii) are all found in the project area in small pockets.

The natural habitat of the area is still suitable for big game provided measures are put in place to control poaching. Other wildlife species, which exist in the area, are rodents and rabbits.

Reptiles

Reptiles that occur in the project area include common lizards like: Rainbow Skink (Mabuya qumquetaeniata margaritifer), Striped skink (Mabuya striata wahlbergii), Bibrons gecko (Pachydactylus bibronii), House gecko (Hemidactylus mabonia), and the Chameleon (Chamaeleo dilepis). There is also the Crocodile (Crocodylus niloticus)

Species of snakes include Pythons (Morelia viridis), Puff adders (Bitis arietans), Spitting Cobra (Naja nigricollis nigricincta), and Black mambas (Dendroaspis angusticeps).

Birds

Birds common in the area include Guinea fowl (Numida meleagris), Francolin (Francolinus swainsonii), Nubian nightjar (Caprimulgus nubicus), Fish eagle (Heliaeetus vocifer) and species of Doves such as Dusky turtle dove (Streptopelia lugens), Namaqua dove (Oena capensis) and Morning dove (Streptopelia decipiens).

Fish

Subsistence fishing activities are quite significant due to many rivers that exist in the area. Species of dominance in the rivers and streams crossing the corridor which might be harvested by the communities, include: Stripe tailed citharinid (Alestes lateralis), Barbel fish (Clarias gariepinus), Snake Barbel (Clarias theodorae), Dwarf bream (Haplochromis philander), Banded bream (Tilapia sparmanii) and Red-breasted bream (Tilapia rendalli).

Protected Areas (National Parks and Forest Reserves)

There are no protected areas in the project area.

Socio-economic Environment

Population

According to the 2000 Census Summary Report (CSO) the population of Mporokoso District was at 73, 929. The male population comprises 36, 975 (50.2%) of the population and female 36, 954 (49.8%) with an average annual growth rate of 3.0%. The study area starts about 80.0km from the main town of Mporokoso and has a population of 6, 800, which was estimated by using the catchment population of both Kapatu and Shibwalya Kapila Rural Health Centres (RHC).

Settlements

Mporokoso town is planned and zoned into residential and commercial/offices areas and has settlements in the rural parts of the districts that are organized in form of villages. A village is made up of many households living in a defined geographical area under the leadership of a headman. A group of villages in a defined geographical area make up a chiefdom that is headed by a chief.

People in the project area are Bemba by tribe living in 52 settlements under Chief Shibwalya Kapila. The distribution network however, is expected to be extended to Kapatu Mission a growth centre comprising of a Rural Health Centre, a basic school, a parish and a farming block. This is also under Chief Shibwalya Kapila's area.

Most of the houses in the project area are made of mud or burnt bricks with grass thatched roofs. Good standard houses with iron or asbestos roofs are also found in the area and most of them belong to various government departments.

Agriculture and Fisheries

Agriculture is the most predominant and important economic activity in the study area, though it is mainly at subsistence level. Most of the people in the area combine crop farming with rearing of livestock such as pigs, goats, village chickens and guinea fowls. These are both for their livelihood and for sell. The crops mainly grown are maize, cassava, beans groundnuts, and millet. Chitemene system of agriculture is widely practiced in the area. Chitemene system is used to grow finger millet, which is mostly used to brew beer. Rice and sweet potatoes are also grown in the project area though on a small scale.

In addition, there is also a farming block in the project area called Kapatu Farming block/scheme. Farmers in the farming block mainly grow maize, sunflower, groundnuts, soybeans, cassava and different types of vegetables. The farmers also engage in pig rearing and fish farming, though on small scale.

Fruit trees such as mango, avocado, guava, lemon, orange and banana are also grown in the area. Although production in the district is low, there is great potential for increased agricultural production. The abundant water in streams, dambos and wetlands can support large-scale irrigation farming.

Subsistence fishing activities are quite significant in the project area since Kafubu River and other streams in the area such as Lukupa have a wide variety of fish species. There are different species in the river channel along the study area. The dominant species which are also of commercial value include; Yellow-belly Bream (Serranochromis robustus) Bottlenose (Mormyrus lacerda), Red breasted bream (Tilapia rendalli), stripe tailed citharinid (Alestes lateralis), Snake Barbel (Clarias theodorae), Silver barbel (Shilbe mystus), Smooth –Spined Barb (Barbus poechii), Blunt toothed barbel (Clarias mellandi), Three spotted bream (Oechromis anersonnii), Mpumbu (Labeo ativelis), Parrot fish (Gnathonenus macroleptus), Banded bream (Tilapia sparmannii), Dwarf bream (Haplochronis philander) and Green headed bream (Oreochromis machrochir).

The numerous rocks on the riverbed and bank, the side stream dambos along the river channel and the headwater dambos provide good breeding grounds for the fish.

Some of the people combine crop farming with rearing of livestock such as sheep, pigs, goats, village chickens and guinea fowls. Cattle rearing are not common.

Local Economy

The economy of the project area depends largely on farming producing crops such as maize, cassava, beans and millet. Other activities that generate income or contribute to the local economy are pig rearing, handicrafts, timber, bricklaying and fishing farming. Even though the project is not very big, it is expected to have some improvement in the income levels and in turn, the standard of living. There is great potential in the area in fishing farming, carpentry, tourism and many others.

Mining

The area has no mining activities. However, there is some sand mining in the project area at small scale. However, the area is said to have various minerals such as copper, iron and semi precious stones.

Energy

The residents of Chipundu village largely depend on firewood and charcoal for energy (cooking and heating). The rural health centers at Shibwalya Kapila RHC, Kapatu RHC and some basic schools like Kafubu use solar panels for their energy requirements. Isolated places such as the Kapatu Agricultural Centre, use a combination of solar and diesel generators for energy, especially for water pumping.

Water and Sanitation

Mporokoso district is endowed with abundant water supplies. Many villages are located near streams and this enhances easy accessibility to water. Villages largely depend on water from the streams and rivers in the area, and those that are a bit further from these streams and rivers have dug some wells. The water is used for drinking and other domestic uses such as cooking, washing, bathing and watering their gardens along the riverbanks. Despite the abundance of water, accessibility to safe water still remains a problem.

A number of houses have pit latrines and bathing shelters that are constructed of local materials with thatched roofs.

Health

The project area has two health centers, namely; Kapatu and Shibwalya Kapila Rural Health Centres (RHC). Kapatu RHC has one qualified nurse, two other classified daily employees (CDEs) who assist the nurse and one watchman. The clinic relies on solar panels distributed by the Ministry of Health and also uses paraffin for their refrigerator for keeping medicines. The clinic relies on fuel wood for heating to sterilize the equipment.

The catchment area for the clinic extends from Tapa, which is about 18km, Luangwa 22km, Sambala 22km, Chipulya 16km, Miyamba 23km, Chilangwa 9km, and Shimwalota 10km. Other nearby villages in the area that the health centre caters for include Sokoni, Chisembe, Andrew Chisha, Ndaito, Kaungo and Chikuku. The health centre caters for about 9,422 people.

Shibwalya Kapila Rural Health Centre is also understaffed and lacks facilities such as laboratory and admission wards. The clinic relies on solar for lighting and paraffin for their refrigerator for keeping medicines. The clinic relies on fuel wood for heating to sterilize the equipment.

Common diseases in the project area include; malaria, diarrhea, upper respiratory tract infection, Scabies, conjunctivitis, and sexually transmitted diseases (STIs) especially among young people. The village has not reported any HIV/AIDS cases as there are no screening facilities hence there is no definite information regarding the magnitude of the problem. However the clinic has two referral cases from Kasama who are also on T.B treatment. The clinic does conduct sensitization programs on HIV/AIDS Malaria, conducted by a mobile clinic, which also conducts under five clinics in the villages and distributes mosquito nets.

The clinic also has provided Traditional Birth Attendants (TBA) to help pregnant women to deliver in the villages. The clinic lacks mid wives and nurses and has no maternity ward.

The capacity of the existing health facilities to meet demand is very low. The health centers do not have any electrical or adequate medical equipment. Drugs and other necessities are in low supply, as the Ministry of Health does not deliver on time. The two RHCs do not have ambulance and mortuary facilities; this makes work difficult because they have to refer the difficult cases to Mporokosos District Hospital or Kasama General Hospital for assistance.

Education

There are a number of schools in the district mostly run by the Ministry of Education; 20 basic schools, 37 middle basic schools and 1 high School. Some of the basic schools in the project area include Kafubu, Kapatu, Mporokoso, Mukupa Kaoma, Chandamali, Shibwaya Kapila and Chitoshi. The district has only one secondary school in the area Mporokoso Secondary School with classes from grade 10 to grade 12. Basic schools provide education from Grade 1 to Grade 9 and those who pass the Grade 9 examinations are offered places at Mprorokoso High School and other high schools in the Province.

The closest schools to the project area are Kafubu, Shibwalya Kapila and Kapatu Mission basic schools. Kafubu basic school the closest to the project site has an enrolment of about 693 pupils, with about 353 girls and 340 boys. The school catchment area extends from Kasongo, which is about 8km to Chilongoshi, which is about 17km. The school has 9 teachers of which 6 are female and 3 are male. The progression rate of pupils is generally very low among both boys and girls. However, there are more girls dropping out of school in higher grades than boys. This can be attributed to early marriages and lack of role models. The pass mark of the pupils is fairly average and this is attributed to lack of electricity for studying in the evening.

The only secondary school in district caters for all the pupils in the area and some students have to travel long distances as far as 12km to the school.

However, there are plans to build a high school in the area and the construction of Kapatu High School has started already with funding from Ministry of Education.

Because of lack of electricity in schools, Ministry of Education and donors cannot provide some education tools and equipment such as computers and this affects the performance of teachers and pupils as they lag behind in new technology.

Employment

Formal employment in the area is very low as there are no employment opportunities. The few people in formal employment are mainly civil servants (Government employees) such as teachers, health workers and agricultural extension officers.

Subsistence farming is the most common occupation in the project area. During the farming season from October to March people are engaged in cultivation and after April they are engaged in harvesting and selling of their agricultural produce.

Infrastructure and Social Services

Basic infrastructure in the area is generally poor. The main road (Kasama - Mporokoso road) is a gravel road and is in bad condition due to lack of maintenance. Even the 2.8km road to Chilambwe Falls is just a bush truck which may be impassable to motor vehicles in one place during the rainy season because there is no culvert at a small river crossing.

The project area has no telephone services and no television (TV) coverage. Radio reception is bad. Banking services are only available in Kasama. Small shops, stocked with a limited range of commodities are available in the project area. Most of the people (especially Government employees) travel to Mporokoso and Kasama to buy most of the household items. Recreation facilities, except for football pitches at local schools, are very limited.

Archaeological and cultural

The study area has no known archeological sites. People in the project area have a long history of ancestral spirits worship at Chilambwe Falls. Every year at the appointed time after crop harvest, people gather at Chilambwe falls to give various foodsfuffs and locally brewed beer to thank the ancestral spirits for the good harvest and ask for blessings. A cow, sheep or goat is slaughtered and sacrificed to the spirit that resides at the waterfall whose name is Chilambwe.

Tourism

Chilambwe falls has potential to attract both local and foreign tourists. However, the waterfall is not well known to the general public outside the project area because it not marketed. Even on the road to the waterfall, there is no poster to show that there is a beautiful waterfall. Hence, there are very few tourists (local and foreign) who visit the waterfall. According to the information obtained from Mr. Chipundu who lives near the falls, they receive an average of one tourist per month. There are no lodging facilities, restaurants and other facilities that can promote tourism in the area.

12.3.5. Environmental Impacts and Mitigation Measures

Potential impacts on physical, biological, and socio-economic environments in the project sites and along the distribution line routes and corresponding mitigation measures are outlined in Table 12-28 and 12-29.

Table 12-28 Potential Impacts and Mitigation Measures (Mujila Falls Lower Mini-Hydropower Station Site and areas along the route of associated 33kV distribution line)

Item	Potential Impacts	Possible Mitigation Measures
Physical Environment		
Location	- Construction activities will cause introduction of new equipment, people, and services in the locality.	- Necessity of early definition of the power plant zone - Restriction of the distribution lines to road reserves - Protection of the immediate catchment area from land use
Climate	- Changes of local micro climate due to inundation of a defined area and the submerging of some islands	- Weir design taking into consideration confining the inundation zone within the islands and low lying areas
Topography	- Alterations and modifications to the topography caused by tunnelling, blasting, cutting and back filling during construction	- Confine construction work area to designated access area - Protection of slopes from erosion by appropriate vegetation planting and management
Soils and Geology	- Impacts on soils and general geological stability of the area caused by excavation, tunnelling, blasting, cutting and back filling, construction of penstocks of 23m x2. - River bank erosion down stream due to new source of water creation by tailrace (30m)	- Back filling of excavated soils - Rehabilitation of construction area by landscaping and tree and grass planting - Reuse of wasted rocks from tunnelling process to both weir and other infrastructure
Hydrology	- Disturbance to the natural flow regime caused by weir construction. However, the low height of the weir (5m) will encourage free flow of water over the weir to ensure minimal	- Operation rules taking into account the required minimum water flows for ecological restoration - Keeping enough distance from poles to stream banks

	disturbance to the natunal flow regime. - The area extending not more than 1km upstream will be permanently inundated along the river channel and its flood plains on both left and right bank of the Mujila river. - Erosion on the river banks due to modification in the river channel at tailrace discharge point is expected but the gorge has a very stable geological formation, thus entailing confining the river channel within the gorge channel.	
Wetlands	- Expanse of localized wetland on the islands and areas of inundation due to weir construction - Upstream of the proposed weir site exists a natural flood plain which will be permanently inundated for a distance of about 1km.	- Control of access to the new reservoir and all activities around powerhouse site by power station administration - Avoidance of crossing the wetlands by distribution network as much as possible
Water Quality	- Alteration of some water quality parameters due to weir construction However, the potential impacts will be minimal since the area of impoundment will be confined within the natural flood zone of the immediate upstream of the weir site. - Surface and ground water pollution	- Protection of the catchment area for restraint of sediment load and pollutants
Air Quality	- Impact on air quality due to construction works (excavations, blasting(where applicable)) and construction equipment use	- Keeping dust levels low by watering to temporal roads and access areas
Noise Level	- Noise due to construction works and construction equipment use	- Shorting of construction period - Time restriction of heavy construction equipment use
Protected Area	- The proposed project is not in a protected area, however, the site would be declared a protected zone for security of equipment and reservoir protection. - Restriction of farming and/or fishing activities in both power plant zone and immediate catchment area, which will be declared a protected zone	- Designation of power station site and the catchment area as protected area

Waste	- Pollution caused by construction wastes, liquid wastes, domestic wastes, human wastes, etc	- Reuse of construction wastes and disposal of them in designated areas - Appropriate storage and disposal of wastes in an approved way - Installation of appropriate sanitation facilities - Effluent discharge away from river systems and domestic water intake
Landscape	- The proposed project sites are in a gorge hence not visible from the currently access. However, it is anticipated that the inundation zone spread will be visible from the current access in some sections. - Visual impact due to power distribution line construction	- Placement of distribution network in road reserves where regular bush clearing during road maintenance is common - Restriction of reservoir within the area of inundation - Painting the power house and associated infrastructure with the colors, which harmonize surrounding environment
Biological Environment		
Fauna	- The flooding of the inundation zone upstream of the weir is likely to create condition that may displace some animals. However, the flooding could enhance the development of a wider habitat for animals such as Waterbuck, Duiker, Baboons, Monkey, Hippos and various species of rodents such as cane rats. The expanded water habitat will be good for water fowls such as fish eagles, king fishers and others.	- Protection of the area around reservoir and the entire power plant zone - Sensitization against poaching and general conservation methods - Sensitization of local community for sustainable fishing methods and conservation practices
Flora	- Estimated inundation area is about 1km in length upstream of the weir site. In the inundation zone, vegetation such as palms like *Phoenix reclinata*, and *Raphia farinifera*, ferns such as Royal fern, Bog scaly lady fern, and various types of grasses are likely to be affected. Riverine trees such as *Syzygium cordatum*, *Syzygium guineense ssp afromontanum*, *S. owariense*, *Gardenia imperialis*, *Rothmmania whitfieldii*, *Swatrzia*	- Vegetation establishment around the reservoir - Rehabilitation of construction sites through landscaping, planting of trees and grass, and clearing of any disused materials

	madagascariensis will be affected too. Island vegetation such as soft broomy grass, *Gardenia imperialis* and sedge like plant that produces red fruit locally known as *intungulu* is likely to be affected due to flooding arising from weir construction. - Impacts on specific species of plants due to expanse of inundation area resulting from weir construction - Impacts on vegetation due to bush clearing to ensure way-leave for distribution line	- Placement of distribution network in road reserves - Restriction of bush clearing area in the way-leave (22m)
Socio-economic Environment		
Population	- Temporal increase in population due to influx of construction workers from outside the project area	- Insulation of location of camps for construction workers from vicinity of the power plant - Employment of local people as temporal workers - Strict screening of workers from outside the project area
Settlements	- The proposed site is located in an isolated area hence there will be no resettlement.	
Agriculture and fisheries	- Encroachment of farmland - Expropriation of farmland due to power plant construction - Decrease in the number of specific fish species by poaching	- Monitoring of access and use of the water resources in the reservoir - Prohibition of all traditional farming activities near the reservoir - Restriction of fishing activities to defined period
Local Economy	- Improvement in the income level and standard of living fostered by creation of employment opportunities (Positive Impact)	- Power supply to load centers, which are expected to contribute to enhancement of economic growth
Mining	- Enhancement of mining activities (Positive Impact)	- Power supply for enhancement of development of mining
Energy	- Improvement in standard of living - More stable and reliable supply of power to social service facilities (Positive Impact)	—
Water and Sanitation	- Pressure on existing water and sanitation facilities during the construction stage - Impacts on safe water supply due to improper treatment of construction wastes, liquid wastes, domestic wastes, and human wastes	- Construction of appropriate sanitation facilities and domestic water supply services

Health	- Rampancy of communicable diseases by construction workers from outside the project area - Injuries of construction workers - Shortage of medicines due to increase in population - Increased incidence of malaria in the area of impoundment due to increase in breeding ground for mosquitoes - Increased incidence of the bilharzias parasites due to creation of reservoir	- Health education on the dangers and prevention of communicable diseases for construction workers during construction period - Provision of First Aid Kits for emergency
Education	- Improvement in learning environment by supply of power to schools and teachers' residents (Positive Impact)	- Power supply to schools
Employment	- Creation of job opportunities for local people as temporal workers during construction and/or way-leave maintenance staff in operation stage (Positive Impact)	- Priority employment of local people as construction workers - Employment of residents in Kanyama village as maintenance staff in operation stage - Considerations for developing skills to ensure that local people benefit from the project
Infrastructure and Social Services	- Improved social service quality by power supply to social service facilities, etc. (Positive Impact) - Deterioration of road condition due to higher volume of traffic during construction	- Adequate compensation to property owners when facing difficulty in avoiding houses and buildings for distribution line construction
Archaeological and cultural	- The study area has no known archeological sites. However, Kanyama village has a cultural site used for the rain festival called "Chidika cha Mvula." - Impacts on archaeological and/or cultural heritage (if excavated)	- Identifying the places of great cultural significance through consultation with residents - Suspension of excavations in the event of any discovery of any artefact - Consultation with NHCC and local community for advice and/or recovery of the artifact
Tourism	- Enhancement of tourist site development (Positive Impact)	—
Land tenure and land use	- Restriction of land tenure and/or land use during construction and/or operation of power plant	- Restriction of use of reservoir and lands under distribution lines
Safety	- Injuries during construction works and attack by wild animals and/or snakes	- Wearing protective gear - Placing road signs and speed limit signs for road accident prevention - Provision of appropriate medicines and First Aid Kits

Table 12-29 Potential Impacts and Mitigation Measures (Chilambwe Falls Mini-Hydropower Station Site and areas along the route of associated 33kV distribution line)

Item	Potential Impacts	Possible Mitigation Measures
Physical Environment		
Location	- The proposed project site is far from settlements and will not significantly disturb the natural environment.	- Necessity of early definition of the power plant zone - Restriction of the distribution lines to road reserves - Protection of the immediate catchment area from land use
Climate	- Because of the small size of weir (2m high), the proposed project will not have significant impacts on the micro climate of the study area during construction and operation of the hydropower plant.	Impact is insignificant since the scale of the weir is small (height is 2m)
Topography	- The project area is not expected to have significant topographical adverse impacts during the construction and operation phases. However, there may be some impacts on the topography of the slopes from the top of the falls to the bottom where power station will be located	- Minimization of excavation, blasting, and vegetation removal area - Protection of slopes from erosion by appropriate vegetation planting and management
Soil and Geology	- Erosion and destabilization of soils, and landslides due to vegetation removal	- Reuse of excavated soils and blasted rocks for backfilling and stone masonry - Introduction of gabions - Rehabilitation of the construction areas through landscaping and planting trees and grass
Hydrology	- Diversion of the river, from its natural route to the proposed reservoir tank, would affect the natural flow regimes of the Kafubu river at the area between the intake and the tailrace, including the falls. - Erosion and siltation due to pole erection near river banks	- Consideration of required minimum environmental water flows for the river ecology and river ecological restoration between the weir and the tailrace - Keeping enough distance from poles to stream banks - Selection of distribution line routes, which avoid river crossing and/or coming close to river banks
Wetlands	- Diversion and construction of the mini-hydropower plant may cause change in the discharge	- Water reservoir tank shall only be of a limited constructed area (50m x 50m).

	and charging times of the wetlands within the project area. These, however, may not be significant since charging and recharging will largely follow the existing natural cycle which is largely influenced by rain patterns.	- Water reservoir tank shall be constructed away from the recharge zone and 10m away from the slope to the power plant.
Water Quality	- Change in water quality parameters due to change in river flow regimes - Temporal degradation of water quality due to excavations during construction	- Water Quality monitoring of the river and constructed reservoir - Treat water before supply for domestic use - Restriction of both construction and human activities around the reservoir
Air Quality	- Impacts on air quality caused by excavations, blastings, and construction equipment use	- Keeping dust levels low by watering to temporal roads and access areas - Shorting of construction period
Noise Level	- Temporal noise level increase arising from traffic movement, heavy machinery use, blasting and excavation works	- Time restriction of heavy construction equipment use - Prohibition of blasting at night and notification of time of blasting works to local people living near the project site
Landscape	- The project site will have minor visual impacts arising from the penstocks and the powerhouse since they will be on the surface. There will be minor visual impacts from the distribution lines.	- Minimization of vegetation removal area - Replanting of local natural trees and grass - Painting the power house and associated infrastructure with the colors, which harmonize surrounding environment
Waste	- Production of construction wastes, liquid wastes, domestic wastes, etc. - Human wastes at the camping site for workers - Soil disposals and rubble by excavation and blasting works	- Sorting of waste according to types - Reuse of the wastes and/or disposal of them in designated area - Appropriate storage and disposal of wastes in an approved way - Installation of appropriate sanitation facilities
Biological Environment		
Flora /Fauna	- Poaching by construction workers - Destruction and displacement of wildlife habitats due to vegetation removal, blastings, excavations, etc. - Impacts on fish species due to degradation of water quality during construction stage - Creation of fire buffer by bush clearing for way-leave (Positive Impact)	- Worker education to prevent poaching from occurring - Rescue of mammals to a safe area with similar ecological conditions when found in the construction areas - Avoidance of heavy machinery use near the river flow as much as possible - Restriction of excess bush clearing

Socio-economic Environment		
Population	- Growing incidence of crimes due to temporal increase in population during construction stage	- Insulation of location of camps for construction workers from vicinity of the power plant - Employment of local people as temporal workers - Strict screening of workers from outside the project area
Settlements	- The mini-hydropower station will be located in an isolated area, hence there will be no resettlement of people.	-
Agriculture and Fisheries	- Some potential agricultural land will be taken up for construction of the mini-hydropower station. However, the construction of the power station will not cause any land shortage as land is abundant in the project area. - Decrease in the number of specific fish species by poaching	- Monitoring of access and use of the water resources in the reservoir - Prohibition of all traditional farming activities near the reservoir - Restriction of fishing activities to defined period
Local Economy	- Improvement in the income level and standard of living fostered by creation of employment opportunities (Positive Impact)	- Power supply to load centers, which are expected to contribute to enhancement of economic growth
Energy	- Improvement in standard of living - More stable and reliable supply of power to social service facilities (Positive Impact)	-
Water and Sanitation	- Pressure on existing water and sanitation facilities during the construction stage - Impacts on safe water supply due to improper treatment of construction wastes, liquid wastes, domestic wastes, and human wastes	- Construction of appropriate sanitation facilities and domestic water supply services
Health	- Rampancy of communicable diseases (dysentery, HIV/AIDS, etc) by construction workers from outside the project area - Injuries of construction workers - Shortage of medicines due to increase in population - Increased incidence of malaria in the area of impoundment due to increase in breeding ground for mosquitoes - Increased incidence of the bilharzias parasites due to creation of reservoir	- Health education on the dangers and prevention of communicable diseases for construction workers during construction period - Provision of First Aid Kits for emergency

Education	- Improvement in learning environment by supply of power to schools and teachers' residents (Positive Impact)	—
Employment	- Creation of job opportunities for local people as temporal workers during construction and/or way-leave maintenance staff in operation stage (Positive Impact)	- Priority employment of local people as construction workers - Employment of local people as maintenance staff in operation stage - Considerations for developing skills to ensure that local people benefit from the project
Infrastructure and Social Services	- Improved social service quality by power supply to social service facilities, etc. (Positive Impact) - Deterioration of road condition due to higher volume of traffic during construction	- Adequate compensation to property owners when facing difficulty in avoiding houses and buildings for distribution line construction
Archaeological and cultural	- Impacts on the place for harvest festival - Impacts on archaeological and/or cultural heritage (if excavated)	- Identifying the places of great cultural significance through consultation with residents - Suspension of excavations in the event of any discovery of any artefact - Consultation with NHCC and local community for advice and/or recovery of the artifact
Tourism	- Enhancement of tourist site development (Positive Impact)	- Help to put poster on the main road giving direction to the waterfall
Land tenure and land use	- Restriction of land tenure and/or land use during construction and/or operation of power plant	- Restriction of use of reservoir and lands under distribution lines
Safety	- Injuries during construction works and attack by wild animals and/or snakes	- Wearing protective gear - Placing road signs and speed limit signs for road accident prevention - Provision of appropriate medicines and First Aid Kits

12.3.6. Alternative Electrification Schemes

Alternative rural electrification schemes to mini-hydropower mini-grid electrification including more diesel power stations, solar home system (SHS), other renewable energy such as wind power and biomass, and the zero option were compared (Table 12-30).

Table 12-30 Alternative Electrification Schemes

	Mujila Falls Lower	Chilambwe Falls
Diesel Power Stations	- Putting up a diesel power station at a Rural Growth Centre like Kanyama, has very high cost implications, such as the running costs of the plant (due to high cost of diesel). - Spare parts are usually difficult to obtain because of changes in machine design and manufacturers stop making spare parts for older designs. - Generation capacities are normally limited hence there are difficulties in local grid extension to outlying areas for activities such as mining, manufacturing etc. - Diesel stations are a source of air pollution by the very nature of using diesel (emission of sulphur dioxides and other pollutants are common). - Extension of the existing 11kV power network to Kanyama's area was not feasible due to the limited generation capacity from the current diesel generator in Mwinilunga town.	- Same as on the left except for the fifth item
Extension of Existing National Grid	- The current power demand (load) at Kanyama and Kakoma is estimated to be about 600kW, hence it would be very costly to construct a dedicated transmission line to the two load centres and surrounding areas. - Extending the current grid from Mwinilunga to Chief Kanyama's center which is about 54km, would not be feasible due to limited power capacity at the Mwinilunga Diesel Power station. Increased load would have led to increased fuel costs and an increase in sulphur emissions into the atmosphere.	- The 66kV power line which supplies power to Mporokoso town runs from Kasama, passing through Luwingu and Kawambwa. The rest of the district has no electricity. - Extending the national electricity grid to Kapatu, Shibwalwa Kapila and the surrounding areas from Mporokoso town or Kasama is very costly because the grid passes far away.
Mini-Hydropower Stations	- The project area is endowed with high rainfall, reliable river flows throughout the year, and suitable sites (two water falls) hence mini-hydro power development is a viable option. - The development of hydropower is envisaged to be cheaper than many other forms of energy. It is considered clean energy since it has under most conditions less	- Same as on the left

	adverse environmental impacts than for instance diesel or long grid extensions.	
Biomass	- Suitably managed biomass resources can be gasified to produce fuel gas, which in turn, can be fed to gas engines to produce power. ・The power demand in the RGCZ around Mujila is about 1.0MW. Several hectares of land would be required to grow and supply woody vegetation to the bio gasifier, creating competition for land use for other activities such as food production, bee keeping, housing, etc.	- Same as on the left
Wind-power	- According to various studies by various organizations, Zambia has limited wind energy resources as it does not have any significant geographic features that accelerate wind and the country is landlocked. The University of Zambia has evaluated and determined that these low wind speeds are not sufficient for power generation and the wind resources are adequate only for water pumping.	- Same as on the left
Solar Power	- The use of solar would have limited application in the event of full development of the potential in mining, tourism and agriculture. - Vandalism (mainly by foreigners) and lack of technical know-how in maintenance would have make sustainable operation difficult.	- Same as on the left
Zero Option	- Zero Option would not be realistic alternative because the rural area has grown and has potential to contribute to national economic growth. The area has potential in agriculture, manufacturing, mining and tourism. - Power supply is one of the key ingredients to economic growth and subsequently poverty alleviation. Doing nothing therefore would go against Government Policy on rural development.	- The area has great potential for commercial farming, mining and manufacturing. Without implementation of the proposed project, these potential will not be exploited and the area will remain undeveloped. - The provision of quality health care, education and other social services will continue to be difficult without electricity. The area's contribution to the national economy will also remain low.

12.3.7. Environmental Management Plan Framework

The Environmental Management Plan (EMP) is normally provided for in the detailed technical and tender document. Therefore, the section outlines the main components of the EMP.

The main components of the EMP shall include:

(1) Awareness and Training

With general code of conduct (for contractors, employees etc), employment procedures, protection and management of cultural, heritage and archeological sites, protection of infrastructure and property (communal and private), anti-poaching (protection of fauna), health, safety, compensation procedures, working hours

(2) Waste Management

General guidelines on project implementation that shall include: camp site selection, temporal works, road signage, plant and equipment service area, explosives and other construction materials storage, fuel storage and workshop area, borrow pits and quarry sites, access roads and road transport, water supply

(3) Environmental Management

Environmental management: slope protection, erosion protection, noise pollution control, air pollution control, water pollution control, vegetation management (bush clearing, plant species protection, cut wood management), landscaping and rehabilitation of construction sites, monitoring and audit program

(4) Work plan and phasing of environmental management plan implementation activities with responsible persons or parties

The project proponents shall have among the staff on the project, a full time Environmental Coordinator. This will enhance the implementation of the mitigation measures through the Environmental Management Plan.

12.3.8. Conclusions and Recommendations

In the Case Study, pre-F/S level environmental and social impact assessment was conducted for two potential mini-hydropower sites. The anticipated adverse environmental impacts are regarded as minimal and are outweighed by the benefits of the project, in other words, improvement in the electrification rate and standard of living, and stimulation of economic activities for both sites at this time. However, in F/S phase, the followings should be carefully examined as well as review of all impact items considered in this study in response to change in the condition of the circumstances:

- Traditional land ownership system of the villages adjacent to Mujila Falls Lower mini-hydropower potential site and accompanying 33kV power distribution lines
- Impacts of compulsory acquisition of lands resulting from implementation of the proposed projects under current Lands Acquisition Act in Zambia
- In the case of implementation of the proposed projects, identifying the culturally important places used for religious services and confirmation of necessary arrangements, including stakeholder meetings
- Review of details of the Environmental Management Plans of similar type of previous mini-hydropower development projects.