Other conditions required for the projection of demands in the domestic, industrial and commercial and public sectors followed those set up in the Jumla Strategic Area.

The area has a hydro plant with an installed capacity of 345 kW as mentioned above. The balance between electric power demand and supply capacity will be supplied from the national grid through the Birendranagar sub-station (refer to Figure 2.2.1).

7.3 Dipayal-Silgadhi-Rajpur Strategic Area

Dipayal-Silgadhi and Tikha are the municipality and the VDC to be included in the Dipayal-Silgadhi-Rajpur strategic area as shown in Figure 7.3.1. The area is at present supplied electricity from the hydro plant (Doti) with an installed capacity of 200 kW, suffering from power shortage. To meet the growing demand, the area is expected to be linked to the national power grid with a 33 kV transmission line in year 1993/94 (refer to Figure 2.2.1).

Electric power demand in the strategic area was projected by year 2013 for assessing the capacity of electric power to be developed as follows :

Unit: kW

Demand	1991	1995	2000	2005	2010	2013
Domestic	455.9	518.4	572.7	630.9	693.0	732.6
Industrial and Commercial	159.6	181.4	200.4	220.8	242.6	256.4
Public	91.2	103.7	114.5	126.2	138.6	146.5
Total	706.7	803.5	887.6	977.9	1,074.2	1,135.5

The projection of domestic demand was based on the following conditions :

Population in year 1991	:	19,861 persons
Annual increase rate of population	:	0.9 %
Number of persons in a household	:	5.3 persons/household.

Other conditions necessary for the projection of domestic, industrial and commercial and public demands are referred to those dealt with in the Jumla Strategic Area.

Electric power to meet the demand will be supplied from the 33 kV transmission line which will be linked to the national grid in year 1993/94 (refer to Figure 2.2.1) as mentioned

above, even if supplementary supply is received from the Doti existing hydro plant with an installed capacity of 200 kW.

7.4 Baitadi Strategic Area

The Baitadi strategic area covers the VDCs of Khalanga, Thaligada, Tripurasundari and Dashrath Chand in the Baitadi zone and Patan and Basantpur in the Patan zone as shown in Figure 7.4.1. The area at present receives electric power from the hydro plant (Surnaiya) with an installed capacity of 200 kW.

Electric power demand in the strategic area was projected by year 2013 for assessing the capacity of electric power to be developed as follows:

Unit: kW

Demand	1991	1995	2000	2005	2010	2013
Domestic	408.0	446.7	498.9	555.3	616.8	656.4
Industrial and Commercial	142.8	156.3	174.6	194.4	215.9	229.7
Public	81.6	89.3	99.8	111.1	123.4	131.3
Total	632.4	692.3	773.3	860.8	956.1	1,017.4

The projection of domestic demand was based on the following conditions :

Population in year 1991	:	20,481 persons
Annual increase rate of population	:	1.1 %
Number of persons in a household	:	6.4 persons/household.

Other conditions used to project domestic, industrial and commercial and public demands are the same as those applied for the Jumla Strategic Area.

There is a small hydro plant (Surnaiya) with an installed capacity of 200 kW as mentioned above. It would be appropriate to meet the balance between the demand and the supply capacity by extending the transmission line from Dadeldhura to Baitadi (refer to Figure 2.2.1), since there would be no small hydropower scheme, which is economically viable with a development scale of some 800 kW, in the vicinities of the area. An alternative is to construct the transmission line from the power plant site of CR-2 to Dadeldhura through Baitadi area (refer to Figure 2.2.1), when CR-2, the scheme in the Chamliya River, which is proposed as one of priority schemes, is implemented.

8. RURAL ELECTRIFICATION

8.1 Scheme Identification for Rural Electrification

First priority is placed on the electrification of district headquarters as the rural electrification programme of NEA, which now makes earnest efforts to realize the programme. The district headquarters to require the improvement or new installation of small hydropower plant are Simikot, Gamgadhi, Chainpur, Dailekh, Dunai and Manma in the Study Area as dealt with in the preceding Section 2.3, Rural Electrification in the Study Area. Among them, small hydropower schemes for Dailekh, Dunai and Manma were already identified, the feasibility study for which were carried out. The existing hydropower plant in Chainpur is worn out, requiring rehabilitation. Thus, Simikot and Gamgadhi are the district headquarters to require the identification of small hydropower schemes in the Study Area.

There exist four towns, which are not district headquarters, with a population density of more than 300 persons/km^2 in the Study Area. Those are Binayak, Baldanda, Jayagadh and Gajara in Achham district (refer to Table 2.3.2), and would be the priority towns to be supplied with electricity after all the district headquarters in the Study Area become the beneficiaries of electricity supply.

There are two national parks, Lake Rara and Khaptad National Parks, in the Study Area. As the tourism centre, the lodges and the quarters of rangers of the national parks are desired to be supplied with electricity. However, field survey carried out in Phase III revealed that entrance to the Khaptad National Park is not allowed to foreigners and is only allowed for devotees and holy men, and therefore the identification of small hydropower scheme is only sought for Lake Rara. As a summary, scheme identification was studied for Simikot, Gamgadhi, four towns in Achham district and Lake Rara in the field investigation of Phase III. Furthermore, Jumla was added as the town to study power supply due to the fact that Jumla, selected as one of four strategic areas together with Surkhet, Dipayal/Silgadhi/Rajpur and Baitadi areas, will face power shortage by year 2013, but will not link to the national power grid as discussed in the preceding Section 7.1.

8.2 Simikot Area

At present, a 50 kW solar plant is installed to supply electric power to Simikot, but is in irregular operation. In addition, the remoteness of Simikot lying in the Humla Karnali River basin makes the maintenance of the plant difficult.

The town is short of electric power supply at present due to the irregular operation of the solar plant installed in it as mentioned above, and furthermore power demand in the town is estimated to grow at a level of 148 kW in year 2013 (refer to Table 8.1.1) according to the projection of Small Hydropower Master Plan (SHMP), Small Hydropower Department of NEA, June 1992. This results in making the identification of a small hydropower scheme urgent to supply reliable and sufficient power to Simikot.

SHMP identified two potential sites promising as a small hydropower scheme by desk study: One is the scheme in the Hepkha Khola with an installed capacity of 914 kW (refer to Table 8.1.2) and the other is the one in the Lurupya Khola lying near Simikot with the capacity of 1,701 kW. The reconnaissance made by the Study Team in Phase III confirmed the perennial flow in both rivers, but left the head to be confirmed in the further detailed study stage.

The Study Team at this moment recommends to install the Hepkha Khola scheme, the location of which is as given in Figure 8.1.1, not only on basis of reconnaissance results but also in comparison with the future power demand growth in the area and in consideration of the fact that the application of livestocks as the transportation means is getting hard as the installed capacity becomes larger. According to SHMP, the construction cost required for the implementation of Hepkha Khola scheme is estimated at US$ 5.36 million, of which the transmission line accounts for the cost of US$ 0.6 million. The cost estimate of transmission line relies on the average unit price without considering the local site condition. Further detailed studies will require the review of transmission line costs taking into account the site condition.

8.3 Gamgadhi Area including Lake Rara

Gamgadhi at present receives electricity from the 50 kW solar plant with the problems in operation and maintenance as Simikot does. Lake Rara is expected to be developed as a tourism centre as the construction of air strip is planned, but receives no electricity at present. Since the distance between Gamgadhi and the north shore of Lake Rara, where the lodges and the army camp are located, is 5 km in a direct connection (refer to Figure 8.1.2), those two places are considered as one electric supply system.

Electric demand in this area is estimated to increase at 349 kW in year 2013 by SHMP as the sum of Gamgadhi and Lake Rara (refer to Table 8.1.1). Compared with the installed capacity of the existing plant, a small hydropower scheme shall be identified and be implemented to meet the demand in the area.

A small hydropower scheme with an installed capacity of 599 kW was identified in the Gam Gad by the desk study of SHMP (refer to Table 8.1.2 and Figure 8.1.2), and its development potentiality in flow and head was confirmed with the reconnaissance carried out by the Study Team in Phase III. Since the generating capacity of this plant will meet the power demand of Gamgadhi and Lake Rara in year 2013, the transmission line to supply power to Lake Rara will be extended through Gamgadhi. The cost required for the construction of this scheme is estimated by SHMP at US$ 2.45 million, of which the transmission line accounts for US$ 0.5 million.

8.4 Jumla Area

At present, a 200 kW hydropower station is under operation for the supply of electricity to Jumla area. The electric power demand in this area is estimated to reach a level of 562 kW in year 2013 by this Study as dealt with in the preceding Section 7.1 (refer to Table 8.1.1), requiring the development of 362 kW by year 2013 to meet the demand in the area.

There is an irrigation scheme called Garjyangkot Irrigation Project about 5 km south-east of Jumla as given in Figure 8.1.3. The scheme has finished the construction of its main canal to introduce water to the command area, leaving the intake in the Dudeli Khola as the structure to be constructed in the coming stage.

The Study Team confirmed in the reconnaissance carried out in Phase III that hydropower generation is possible by using this irrigation canal, since a head of 35 m can be created between the terminal point of the canal and the river to return water, and since water is available in the Dudeli Khola beyond the demand required for the irrigation scheme. By introducing water of 0.9 m^3/sec to the turbine and by harnessing head of 35 m mentioned above, the proposed plant will produce power of 250 kW (refer to Table 8.1.2).

The implementation of this scheme is strongly recommended due to the fact that a large cost saving is expected for the scheme, since a headrace canal has already been built, requiring only the construction of intake, head tank, penstock line and powerhouse. The costs estimated for the construction of these structures are US$ 1.35 million, of which the transmission line accounts for US$ 0.35 million.

8.5 Baldanda, Jayagadh and Gajara Areas including Mangalsen

Achham district, the headquarters of which are Mangalsen, has several densely populated towns with the population density of more than 300 persons/km^2 such as Binayak, Baldanda, Jayagadh and Gajara, which are left behind as the ones to be supplied with electricity.

At present, the Achham small hydropower plant with an installed capacity of 400 kW, the main supply areas of which are Mangalsen and its outskirt, Bisiakot, is under construction and is expected to be completed in year 1994. In addition, the extension of 200 kW is expected for the plant by raising the side wall of the headrace canal as the second stage works. The location of the scheme is given in Figure 8.1.4.

Power demand of Mangalsen including Bisiakot is estimated to grow at a level of 405 kW in year 2013 by SHMP (refer to Table 8.1.1). Since Baldanda, Gajara and Jayagadh except for Binayak geographically lie near Mangalsen, electric supply to those three towns will be realized by extending the transmission lines from the plant to those towns as shown in Figures 8.1.4 and 8.1.5. The construction costs required for the extension of transmission lines to those towns are estimated at US$ 1.4 million.

Power demand of Baldanda, Gajara and Jayagadh is projected to reach 459 kW (refer to Table 8.1.1) in year 2013 by SHMP, resulting in 864 kW together with the demand of Mangalsen including Bisiakot. The installed capacity of the Achham small hydropower scheme, which is 600 kW even with the second stage development, will require to add another small hydropower scheme by year 2013. The site lying further upstream of the Achham scheme on the Kailash Khola will be promising for the development of another small hydropower scheme.

8.6 Binayak Area

Binayak, which is another densely populated town in Achham district, lies 15 km southeast of the Achham small hydropower plant, which is referred to the preceding Section 8.5. Power demand of the town is estimated to reach 200 kW (refer to Table 8.1.1) in year 2013 by SHMP.

In case of planning the electric power supply to Binayak lying in the Karnali River basin by the extension of the transmission line from the Achham small hydropower plant situated in the Seti River basin, the transmission line to be constructed will require to carry electricity for the

distance of longer than 15 km by passing the high hill, which divides the two river basins. Furthermore, the installed capacity of the Achham small hydropower scheme, 600 kW, including the second stage development will not allow the inclusion of Binayak in the system due to the saturated demand. A new small hydropower scheme with an installed capacity of 300 kW (refer to Table 8.1.2) was identified in the Tala Gad as shown in Figure 8.1.6. The cost required for the construction of the plant is estimated at US$ 1.47 million including US$ 0.25 million required for the erection of the transmission line by SHMP.

List of References

Ref. IV-1 Nepal Electricity Authority. (1988). Kalikot Small Hydro Project, Vol. I, Design Report.

Ref. IV-2 Nepal Electricity Authority. (1990). Dolpa Small Hydro Project, Design Report Vol. I.

Ref. IV-3 Nepal Electricity Authority. (1988). Dailekh Small Hydro Project, Vol. II, Design Report.

Ref. IV-4 Himalayan Power Consultants. (1989). Karnali Multipurpose Project Feasibility Study Report, Annex I, Main Dam.

Ref. IV-5 Sogreah. (1987). West Seti Hydroelectric Project, Feasibility Study.

Ref. IV-6 Pancheshwar Consortium. (1991). Pancheshwar Multipurpose Project Report, Field Investigation Report.

Ref. IV-7 Electric de France International. (1990). LRMC & Tariff Study.

TABLES

Table 2.2.1 EXISTING AND UNDER-CONSTRUCTION POWER PLANTS IN THE NATIONAL GRID

Name	Type	In-service Date	Installed Capacity (MW)	Effective Capacity (MW)	Potential Annual Energy Output, (GWh)
Existing					
Trisuli	ROR ^1	1962	21.0	14.0	115
Sunkosi	ROR ^1	1973	10.1	5.8	57
Gandaki	ROR ^1	1979	15.0	9.4	44
Kulekhani I	RES ^2	1982	60.0	60.0	163
Devighat	ROR ^1	1983	14.1	14.1	92
Kulekhani II	ROR ^3	1986	32.0	32.0	95
Marsyangdi	ROR ^1	1990	69.0	64.0	462
Andhi Khola	ROR ^1	1990	5.1	5.1	27 ^4
Small Hydro			6.0	6.0	15
Hetauda	Diesel		10.0	10.0	53
Other Diesel			15.0	7.0	37 ^4
Duhabi	Multi-fuel	1991	26.0	26.0	137 ^4
Sub-total			283.3	253.4	1,297
Under-construction					
Jhimruk Piuthan	ROR ^1	1994	12.5	12.5	66 ^4
Sub-total			12.5	12.5	66
Total			295.8	265.9	1,363

Notes :
^1 Hydro plant of the run-of-river type
^2 Hydro plant of thr reservoir type
^3 Cascade development with Kulekhani I
^4 The plant factor is assumed at 0.6.

Table 2.3.1 PRESENT CONDITION OF RURAL ELECTRIFICATION IN THE STUDY AREA (1/2)

Mid Western Development Region

Name of Towns	Name of District	Name of Plant	Installed Capacity, kW	Type of Plant	Installation Status	Remarks
Karnali Zone						
Simikot	Humla	Simikot	50	Solar	Existing	Maintenance problem
Gamgadhi	Mugu	Gamgadhi	50	Solar	Existing	Maintenance problem
Manma	Kalikot	Manma	500	Hydro	Planned	Feasibility study has been done. ^1
Jumla	Jumla	Jumla	200	Hydro	Existing	
Dunai	Dolpa	Dolpa	160	Hydro	Planned	Feasibility study has been done. ^2
Rapti Zone						
Jumlikhaanga	Rukum	Syarpudaha	200	Hydro	Existing	
Bheri Zone						
Dailekh	Dailekh	Dailekh	360	Hydro	Planned	Feasibility study has been done. ^3
Jajarkot	Jajarkot	Chaurjhari	150	Hydro	Existing	
Birendranagar	Surkhet	Surkhet	345	Hydro	Existing	

Table 2.3.1 PRESENT CONDITION OF RURAL ELECTRIFICATION IN THE STUDY AREA (2/2)

Far Western Development Region

Name of Town	Name of District	Name of Plant	Installed Capacity, kW	Type of Plant	Installation Status	Remarks
Mahakali Zone						
Darchula	Darchula	Darchula I	50	Hydro	Existing	
		Darchula II	250	Hydro	Under-construction	Completion in 1992
Baitadi	Baitadi	Surnaiya Gad	200	Hydro	Existing	Service in 1991
Dadeldhura	Dadeldhura	Rupal Gad	100	Hydro	Existing	
		Dadeldhura	112	Diesel	Existing	Irregular Service
Mahendranagar	Kanchanpur		500	Imported		
Seti Zone						
Chainpur	Bajhang	Bajhang	200	Hydro	Existing	Worn out
Martadi	Bajura	Bajura	200	Hydro	Existing	
Dipayal and Silgadhi	Doti	Doti	200	Hydro	Existing	Power deficit
Mangalsen	Achham	Achham	400	Hydro	Under-construction	Completion in 1994

Notes : ^1 Kalikot Small Hydel Project, NEA , June 1990
^2 Dolpa Small Hydel Project, NEA, June 1990
^3 Dailekh Small Hydel Project, NEA, October 1988

Table 2.3.2 PROPOSED TOWNS FOR RURAL ELECTRIFICATION

Name of Towns ^1	Name of District	Name of Zone Development Region	Remarks
1. Baldanda	Achham	Seti, Far Western	
2. Binayak	Achham	Seti, Far Western	
3. Gajara	Achham	Seti, Far Western	
4. Jayagadh	Achham	Seti, Far Western	
5. Lake Rara ^2	Mugu	Karnali, Mid Western	Extension from Gamgadhi
6. Khaptad National Park ^2	Doti	Seti, Far Western	Extension from Dipayal

Note : ^1 Towns with population more than 300 person/km ^{2}

^2 Lake Rara and the Khaptad National Park will be developed as tourisum centres.

TABLE 4.1.1 HYDROPOWER POTENTIAL SCHEMES IDENTIFIED IN THE PAST STUDIES

Name of Scheme	Tributary	Type of Scheme	Catchment Area km2	Remarks
Karnali River Basin				
Karnali/Chisapani ^1	Karnali	Reservoir	43,679	Feasibility
KR 7^2	Karnali	Run-of-river	21,314	Reservoir type alternative
KR 3/Lakharpata ^2	Karnali	Run-of-river	21,291	
Karnali Bend/KR 1A^3	Karnali	Run-of-river	20,120	Pre-feasibility
KR 2^2	Karnali	Run-of-river	15,739	
KR 4^2	Karnali	Run-of-river	13,238	
TR 1^2	Tila	Run-of-river	3,326	
TR 2^2	Tila	Run-of-river	2,840	
MKR 1^2	Mugu	Run-of-river	6,008	
HKR 1^2	Humla	Run-of-river	5,964	
BR1/Bheri/Babai ^2	Bheri	Run-of-river	11,815	Reservoir type alternative
BR3/Surkhet ^2	Bheri	Reservoir	11,554	
BR5/Thapna ^2	Bheri	Reservoir	10,757	
BR 4^2	Bheri	Reservoir	10,305	
BR 6^2	Bheri	Run-of-river	1,367	
SR 6^2	Seti	Reservoir	7,213	
West Seti/SR 1^4	Seti	Reservoir	4,250	Feasibility
SR 3^2	Seti	Run-of-river	2,421	
THR 1^2	Thuli Gad	Run-of-river	626	
Mahakali River Basin				
Pancheshwar ^5	Mahakali	Reservoir	12,600	F/S level field investigation
Rupali Regulating dam ^6	Mahakali	Reservoir		
Poornagiri ^5	Mahakali	Reservoir	15,000	
Chamliya ^6	Chamliya	Reservoir	1,570	Plant factor of 0.2

Sources : ^1 Karnali (Chisapani) Multipurpose Project, Himalayan Power Consultants, December 1989
^2 The Upper Karnali Hydroelectric Projet, Himalayan Power Consultants, December 1987.
^3 The Upper Karnali Hydroelectric Project, Prefeasibility Study of the Karnali Bend Site KRIA, Himalayan Consultants, December 1989.
^4 West Seti Hydroelectric Project, Sogreah, March 1987.
^5 Pancheshwar Project, Water Power Consultancy Service, India, November 1971.
^6 Pancheshwar Multipurpose Project, Field Investigations whthin Nepal Territory, Pancheshwar Consortium, February 1991.

TABLE 4.1.2 NEWLY PROPOSED HYDROPOWER POTENTIAL SCHEMES

Name of Scheme	Tributary	Type of Scheme	Catchment Area km2	Remarks
Karnali River Basin				
TR3	Tila	Run-of-river	3,105	SG240*
TR4	Tila	Run-of-river	513	SG240
MKR2	Mugu	Run-of-river	5,773	SG240
MKR3	Mugu	Run-of-river	4,251	SG240
HKR2	Humla	Run-of-river	5,654	SG240
HKR3	Humla	Run-of-river	4,144	SG240
HKR4	Humla	Run-of-river	3,807	SG240
BR3B	Bheri	Reservoir	10,910	SG270
BR7	Bheri	Run-of-river	628	SG270
BR8	Bheri	Run-of-river	2,438	SG270
LR1	Lohore	Reservoir	733	SG240
BS1	Buriganga	Run-of-river	853	SG260
SR7	Seti	Run-of-river	978	SG260
Mahakali River Basin				
CR1	Chamliya	Run-of-river	280	SG120
CR2	Chamliya	Run-of-river	785	SG120

Notes: * Stream gauge number used for the calculation of power output and annual energy output.

Table 4.3.1 **PORWER AND ENERGY GENERATION OF THE RESERVOIR TYPE SCHEMES**

Scheme	Draft Rate	Plant Discharge (m3/sec)	FSL (EL m)	MOL (EL m)	RWL (EL m)	TWL (EL m)	Installed Capacity (MW)	Firm Energy (GWh/yr)	Sec. Energy (GWh/yr)	Total Energy (GWh/yr)
BR3A	0.6	648	556	519	544	415	660	1,874	796	2,670
	0.7	756	563	519	548	415	797	2,274	754	3,028
	0.8	864	574	519	556	415	961	2,747	686	3,433
BR3B	0.6	590	682	615	660	488	801	2,243	988	3,231
	0.7	688	701	615	672	488	1,003	2,775	1,006	3,781
	0.8	786	712	615	680	488	1,192	3,407	911	4,318
BR4	0.6	527	794	752	780	620	667	1,900	800	2,700
	0.7	615	802	752	785	620	804	2,245	779	3,024
	0.8	703	814	752	793	620	964	2,757	679	3,436
BR5	0.6	570	726	681	711	516	880	2,512	1,047	3,559
	0.7	665	732	681	715	516	1,048	2,939	968	3,907
	0.8	760	750	681	727	516	1,269	3,624	888	4,512
SR6	0.6	434	603	557	588	401	642	1,841	799	2,640
	0.7	507	613	557	594	401	776	2,240	752	2,992
	0.8	579	639	557	612	401	966	2,809	690	3,499
LR1	0.6	62	800	766	789	693	47	135	71	206
	0.7	72	808	766	794	693	58	166	70	236
	0.8	83	824	766	805	693	73	210	66	276

Table 4.3.2 POWER AND ENERGY GENERATION OF THE RUN-OF-RIVER TYPE SCEMES

Scheme	Firm Discharge (m3/sec)	Plant Discharge (m3/sec)			FSL	TWL	Firm Power (MW)	Power (MW)			Firm Energy (GWh/yr)	Secondary Energy (GWh/yr)			Total Energy (GWh/yr)		
		8-hr	12-hr	16-hr				8-hr	12-hr	16-hr		8-hr	12-hr	16-hr	8-hr	12-hr	16-hr
Karnali River Basin																	
KR2	60.4	181.1	120.7	90.6	1,050	762	137.6	412.8	275.2	206.4	1,198	1,695	909	487	2,893	2,107	1,685
KR3/Lakharpata	98.3	294.9	196.6	147.5	586	400	144.7	434.1	289.4	217.0	1,260	1,782	956	512	3,042	2,215	1,772
KR4	45.0	134.9	89.9	67.4	1,240	1,158	29.2	87.5	58.3	43.8	254	359	193	103	613	447	357
KR7	98.4	295.2	196.8	147.6	525	421	81.0	243.0	162.0	121.5	705	998	535	287	1,703	1,240	992
TR1	19.3	57.8	38.5	28.9	1,110	712	60.7	182.1	121.4	91.1	529	748	401	215	1,276	929	743
TR2	15.6	46.8	31.2	23.4	1,830	1,330	61.8	185.3	123.5	92.7	538	761	408	219	1,299	946	757
TR3	17.6	52.7	35.1	26.4	1,330	1,079	34.9	104.7	69.8	52.3	304	430	230	124	734	534	427
TR4	2.4	7.2	4.8	3.6	2,530	2,345	3.5	10.5	7.0	5.2	30	43	23	12	73	53	43
MKR1	17.6	52.9	35.3	26.5	1,451	1,235	30.2	90.5	60.3	45.3	263	372	199	107	634	462	369
MKR2	15.6	46.8	31.2	23.4	1,855	1,705	18.5	55.6	37.1	27.8	161	228	122	66	390	284	227
MKR3	9.0	27.1	18.1	13.6	2,865	2,285	41.5	124.4	82.9	62.2	361	511	274	147	872	635	508
HKR1	23.3	69.9	46.6	34.9	1,643	1,320	59.5	178.6	119.0	89.3	518	733	393	211	1,251	911	729
HKR2	21.8	65.5	43.7	32.7	1,855	1,705	25.9	77.7	51.8	38.9	226	319	171	92	545	397	317
HKR3	17.1	51.4	34.3	25.7	2,066	1,890	23.9	71.6	47.7	35.8	208	294	158	84	502	365	292
HKR4	15.8	47.4	31.6	23.7	2,362	2,066	37.0	111.1	74.1	55.5	322	456	245	131	778	567	453
BR1/Bheri/Babai	19.4	58.2	38.8	29.1	437	259	27.3	82.0	54.7	41.0	233	361	195	103	595	428	337
BR6	7.6	22.7	15.2	11.4	1,919	1,646	16.4	49.1	32.8	24.6	142	187	100	54	329	242	196
BR7	1.7	5.1	3.4	2.5	2,620	1,890	9.7	29.2	19.5	14.6	85	111	60	32	196	144	117
BR8	4.1	12.4	8.3	6.2	2,590	2,285	10.0	30.0	20.0	15.0	87	114	61	33	201	148	120
SR3	13.2	39.6	26.4	19.8	1,307	1,067	25.1	75.2	50.1	37.6	217	280	152	91	497	369	308
SR7	4.9	14.7	9.8	7.3	1,975	1,524	17.5	52.4	34.9	26.2	151	195	106	63	347	257	215
THR 1	1.1	3.3	2.2	1.7	729	401	2.9	8.6	5.7	4.3	25	40	21	11	65	46	36
BS1	6.0	18.2	12.1	9.1	850	760	4.3	12.9	8.6	6.5	37	48	26	16	86	63	53
Mahakali River Basin																	
CR1	2.1	6.4	4.3	3.2	1,860	1,675	3.1	9.4	6.3	4.7	27	35	19	11	62	46	38
CR2	7.2	21.7	14.5	10.9	882	765	6.7	20.1	13.4	10.1	58	75	41	23	134	99	81

Table 4.4.1 CASH FLOW DIAGRAM OF THE BHERI-BABAI DIVERSION SCHEME CONSIDERING THE NEGATIVE BENEFITS OF THE KARNALI PROJECT (1/3)

Unit: US$1,000

Case 1 : 16-hour Operation
EIRR 10.0%
Net Benefit 287

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-5	11,232				-11,232
-4	28,081				-28,081
-3	33,697				-33,697
-2	28,081				-28,081
-1	11,232				-11,232
0		555	16,442		15,887
1		555	16,442		15,887
2		555	16,442		15,887
3		555	16,442		15,887
4		555	16,442		15,887
5		555	16,442		15,887
6		555	16,442		15,887
7		555	16,442		15,887
8		555	16,442		15,887
9		555	16,442		15,887
10		555	16,442		15,887
11		555	16,442		15,887
12		555	16,442		15,887
13		555	16,442		15,887
14		555	16,442		15,887
15		555	16,442		15,887
16		555	16,442		15,887
17		555	16,442		15,887
18		555	16,442		15,887
19		555	16,442		15,887
20		555	16,442		15,887
21		555	16,442		15,887
22		555	16,442		15,887
23		555	16,442		15,887
24		555	16,442		15,887
25		555	16,442	-24,201	-8,314
26		555	16,442	-24,201	-8,314
27		555	16,442	-24,201	-8,314
28		555	16,442	-24,201	-8,314
29		555	16,442	-24,201	-8,314
30		555	16,442	-24,201	-8,314
31		555	16,442	-24,201	-8,314
32		555	16,442	-24,201	-8,314
33		555	16,442	-24,201	-8,314
34		555	16,442	-24,201	-8,314
35		555	16,442	-24,201	-8,314
36		555	16,442	-24,201	-8,314
37		555	16,442	-24,201	-8,314
38		555	16,442	-24,201	-8,314
39		555	16,442	-24,201	-8,314
40		555	16,442	-24,201	-8,314
41		555	16,442	-24,201	-8,314
42		555	16,442	-24,201	-8,314
43		555	16,442	-24,201	-8,314
44		555	16,442	-24,201	-8,314
45		555	16,442	-24,201	-8,314
46		555	16,442	-24,201	-8,314
47		555	16,442	-24,201	-8,314
48		555	16,442	-24,201	-8,314
49		555	16,442	-24,201	-8,314
50		555	16,442	-24,201	-8,314

Table 4.4.1 CASH FLOW DIAGRAM OF THE BHERI-BABAI DIVERSION SCHEME CONSIDERING THE NEGATIVE BENEFITS OF THE KARNALI PROJECT (2/3)

Unit: US$1,000

Case 2 : 12-hour Operation
EIRR 11.3%
Net Benefit 10,612

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-5	12,453				-12,453
-4	31,133				-31,133
-3	37,359				-37,359
-2	31,133				-31,133
-1	12,453				-12,453
0		616	20,270		19,654
1		616	20,270		19,654
2		616	20,270		19,654
3		616	20,270		19,654
4		616	20,270		19,654
5		616	20,270		19,654
6		616	20,270		19,654
7		616	20,270		19,654
8		616	20,270		19,654
9		616	20,270		19,654
10		616	20,270		19,654
11		616	20,270		19,654
12		616	20,270		19,654
13		616	20,270		19,654
14		616	20,270		19,654
15		616	20,270		19,654
16		616	20,270		19,654
17		616	20,270		19,654
18		616	20,270		19,654
19		616	20,270		19,654
20		616	20,270		19,654
21		616	20,270		19,654
22		616	20,270		19,654
23		616	20,270		19,654
24		616	20,270		19,654
25		616	20,270	-31,169	-11,515
26		616	20,270	-31,169	-11,515
27		616	20,270	-31,169	-11,515
28		616	20,270	-31,169	-11,515
29		616	20,270	-31,169	-11,515
30		616	20,270	-31,169	-11,515
31		616	20,270	-31,169	-11,515
32		616	20,270	-31,169	-11,515
33		616	20,270	-31,169	-11,515
34		616	20,270	-31,169	-11,515
35		616	20,270	-31,169	-11,515
36		616	20,270	-31,169	-11,515
37		616	20,270	-31,169	-11,515
38		616	20,270	-31,169	-11,515
39		616	20,270	-31,169	-11,515
40		616	20,270	-31,169	-11,515
41		616	20,270	-31,169	-11,515
42		616	20,270	-31,169	-11,515
43		616	20,270	-31,169	-11,515
44		616	20,270	-31,169	-11,515
45		616	20,270	-31,169	-11,515
46		616	20,270	-31,169	-11,515
47		616	20,270	-31,169	-11,515
48		616	20,270	-31,169	-11,515
49		616	20,270	-31,169	-11,515
50		616	20,270	-31,169	-11,515

Table 4.4.1 CASH FLOW DIAGRAM OF THE BHERI-BABAI DIVERSION SCHEME CONSIDERING THE NEGATIVE BENEFITS OF THE KARNALI PROJECT (3/3)

Unit: US$1,000

Case 3 : 8-hour Operation
EIRR 12.1%
Net Benefit 21,538

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-5	15,671				-15,671
-4	39,178				-39,178
-3	47,014				-47,014
-2	39,178				-39,178
-1	15,671				-15,671
0		775	27,175		26,401
1		775	27,175		26,401
2		775	27,175		26,401
3		775	27,175		26,401
4		775	27,175		26,401
5		775	27,175		26,401
6		775	27,175		26,401
7		775	27,175		26,401
8		775	27,175		26,401
9		775	27,175		26,401
10		775	27,175		26,401
11		775	27,175		26,401
12		775	27,175		26,401
13		775	27,175		26,401
14		775	27,175		26,401
15		775	27,175		26,401
16		775	27,175		26,401
17		775	27,175		26,401
18		775	27,175		26,401
19		775	27,175		26,401
20		775	27,175		26,401
21		775	27,175		26,401
22		775	27,175		26,401
23		775	27,175		26,401
24		775	27,175		26,401
25		775	27,175	-43,202	-16,801
26		775	27,175	-43,202	-16,801
27		775	27,175	-43,202	-16,801
28		775	27,175	-43,202	-16,801
29		775	27,175	-43,202	-16,801
30		775	27,175	-43,202	-16,801
31		775	27,175	-43,202	-16,801
32		775	27,175	-43,202	-16,801
33		775	27,175	-43,202	-16,801
34		775	27,175	-43,202	-16,801
35		775	27,175	-43,202	-16,801
36		775	27,175	-43,202	-16,801
37		775	27,175	-43,202	-16,801
38		775	27,175	-43,202	-16,801
39		775	27,175	-43,202	-16,801
40		775	27,175	-43,202	-16,801
41		775	27,175	-43,202	-16,801
42		775	27,175	-43,202	-16,801
43		775	27,175	-43,202	-16,801
44		775	27,175	-43,202	-16,801
45		775	27,175	-43,202	-16,801
46		775	27,175	-43,202	-16,801
47		775	27,175	-43,202	-16,801
48		775	27,175	-43,202	-16,801
49		775	27,175	-43,202	-16,801
50		775	27,175	-43,202	-16,801

Table 5.1.1 PRELIMINARY FINDINGS FOR THE HYDROPOWER POTENTIAL SCHEMES IDENTIFIED IN THE PAST STUDIES

Name Of Scheme	Tributary	Type of Scheme	Name of Rock	Geological Conditions	Type of Dam	Length of Waterway m	Type of Powerhouse	Road to be improved km	Road to be newly constructed km	Transmission line to be constructed km	Remarks
Karnali River Basin											
Karnali/Chisapani ^1	Karnali	Reservoir	Sandstone/Mudstone	Poor	Rockfill	880 --1550	Underground				Quoted from F/S Report
KR 7^2	Karnali	Run-of-river	Sandstone/Shale	Pair	Conc. Weir	600	Open	79	55	41	Reservoir type alternative
KR 3/Lakharpata ^2	Karnali	Run-of-river	Siwaliks	Poor	Conc. Weir	6,200	Underground	79	41	15	Pre-feasibility
Karnali Bend/KR 1A^3	Karnali	Run-of-river	Quartzite	Good	Conc. Weir	2,100	Open	79	70	26	
KR 2^2	Karnali	Reservoir	Schist/Phyllite	Fair to Good	Rockfill	2,900	Open	79	99	79	
KR 4^2	Karnali	Run-of-river	Schist/Phyllite	Fair to Good	Conc. Weir	3,700	Open	79	167	154	
TR 1^2	Tila	Run-of-river	Schist/Phyllite	Fair to Good	Conc. Weir	7,800	Open	79	108	81	
TR 2^2	Tila	Run-of-river	Schist/Phyllite	Fair to Good	Conc. Weir	6,600	Open	79	131	100	
MKR 1^2	Mugu	Run-of-river	Quartzite	Good	Conc. Weir	5,200	Open	79	177	156	
HKR 1^2	Humla	Run-of-river	Schist/Phyllite	Good	Conc. Weir	11,400	Open	79	192	162	
BR1/Bheri/Babai ^2	Bheri	Run-of-river	Sandstone/Mudstone/ /Conglomerate	Poor	Conc. Weir	9,200	Open	69	15	15	Reservoir type alternative
BR3A/Surkhet ^2	Bheri	Reservoir	Sandstone/Mudstone/ /Conglomerate	Poor	Rockfill	1,100	Open	69	0	15	
BR5/Thapna ^2	Bheri	Reservoir	Schist/Phyllite	Fair to Good	Rockfill	1,000	Open	69	0	45	
BR 4^2	Bheri	Reservoir	Schist/Phyllite	Fair to Good	Rockfill	600	Open	69	0	65	
BR 6^2	Bheri	Run-of-river	Gneiss	Good	Conc. Weir	7,200	Open	69	80	152	
SR 6^2	Seti	Reservoir	Metasediment	Fair to Good	Rockfill	1,300	Open	263	17	29	
West Seti/SR 1^4	Seti	Reservoir	Schist	Good	Concrete-facing	8,475	Underground	263	12	10	Quoted from F/S Report
SR 3^2	Seti	Run-of-river	Metasediment	Fair to Good	Conc. Weir	8,600	Open	263	5	59	
THR 1^2	Thuli Gad	Run-of-river	Siwaliks	Poor	Conc. Weir	7,800	Open	9	9	43	
Mahakali River Basin											
Pancheshwar ^5	Mahakali	Reservoir	Metasediment	Fair to Good	Not decided	500	Underground	-	54	-	F/S level field investigation
Rupali Regulating dam ^6	Mahakali	Reservoir	Sandstone/Shale	Pair	-	-	-	-	-	-	
Poornagiri ^5	Mahakali	Reservoir	Sandstone/Mudstone	Poor	-	-	-	-	-	-	
Chamliya ^6	Chamliya	Reservoir	Metasediment	Fair							Plant factor of 0.2

Sources : ^1 Karnali (Chisapani) Multipurpose Project, Himalayan Power Consultants, December 1989
^2 The Upper Karnali Hydroelectric Projet, Himalayan Power Consultants, December 1987.
^3 The Upper Karnali Hydroelectric Project, Prefeasibility Study of the Karnali Bend Site KR1A, Himalayan Consultants, December 1989.
^4 West Seti Hydroelectric Project, Sogreah, March 1987.
^5 Pancheshwar Project, Water Power Consultancy Service, India, November 1971.
^6 Pancheshwar Multipurpose Project, Field Investigations whthin Nepal Territory, Pancheshwar Consortium, February 1991.

Table 5.1.2 PRELIMINARY FINDINGS FOR NEWLY PROPOSED HYDROPOWER POTENTIAL SCHEMES

Name of Scheme	Tributary	Type of Scheme	Name of Rock	Geological Conditions	Type of Dam	Length of Waterway m	Type of Powerhouse	Road to be improved km	Road to be newly constructed km	Transmission line to be constructed km	Remarks
Karnali River Basin											
TR3	Tila	Run-of-river	Schist/Phyllite	Fair	Conc. Weir	3,600	Open	79	116	88	
TR4	Tila	Run-of-river	Schist	Fair	Conc. Weir	5,800	Open	79	183	148	
MKR2	Mugu	Run-of-river	Gneiss	Good	Conc. Weir	4,300	Open	79	199	176	
MKR3	Mugu	Run-of-river	Granite	Good	Conc. Weir	6,800	Open	79	256	219	
HKR2	Humla	Run-of-river	Gneiss	Good	Conc. Weir	4,300	Open	79	212	191	
HKR3	Humla	Run-of-river	Gneiss	Good	Conc. Weir	4,600	Open	79	230	210	
HKR4	Humla	Run-of-river	Gneiss	Good	Conc. Weir	6,400	Open	79	242	221	
BR3B	Bheri	Reservoir	Schist/Phyllite	Fair to Good	Rockfill	1,000	Open	69	0	35	Alternative of BR3
BR7	Bheri	Run-of-river	Schist	Fair	Conc. Weir	6,600	Underground	69	96	167	
BR8	Bheri	Run-of-river	Gneiss	Good	Conc. Weir	4,400	Open	69	120	193	
BS1	Buriganga	Run-of-river	Gneiss	Good	Conc. Weir	4,500	Open	263	26	40	
SR7	Seti	Run-of-river	Gneiss	Good	Conc. Weir	6,800	Open	298	35	87	
LR1	Lahare	Reservoir	Mica schist	Fair	Rockfill	5,300	Open	79	0	2	
Mahakali River Basin											
CR1	Chamliya	Run-of-river	Quartzite	Good	Conc. Weir	5,600	Open	0	43	101	
CR2	Chamliya	Run-of-river	Dolomitic limestone	Fair	Conc. Weir	4,200	Open	0	10	74	

Table 5.1.3 APPLICABLE UNIT PRICES

Description	Unit	Unit Price ($)
1. Excavation works		
Common	cum	3.50
Weathered rock	cum	6.00
Hard rock	cum	10.00
Tunnel	cum	55.00
Shaft	cum	125.00
2. Embankment works		
Core	cum	5.00
Filter	cum	10.00
Rock	cum	6.00
Riprap	cum	9.00
Common	cum	4.00
3. Concrete works (including form works)		
Mass/dam	cum	90.00
Structure	cum	140.00
Superstructure	cum	250.00
Tunnel	cum	160.00
Shaft	cum	200.00
4. Reinforcement steel bar	ton	1,500.00
5. Grouting		
Consolidation	m	90.00
Curtain	m	70.00
Backfill	cum	200.00
6. Access road		
New construction	km	600,000.00
Upgraded	km	50,000.00
7. Transmission line		
132 kV S.C	km	59,000.00
66 kV S.C	km	46,000.00

Table 5.1.4 ESTIMATED UNIT PRICES FOR CONSTRUCTION

(Unit : US $)

Description	Unit	Karnali Estimated in year 1988	West Seti Estimated in year 1990	Pancheswar Road Estimated in year 1990
1. Excavation				
Common, open	cum	2.97	3.50	3.00
Weathered rock, open	cum	5.17	6.00	6.00
Hard rock, open	cum	9.48	8.00	10.00
Tunnel	cum	28.50	55.00	-
Shaft	cum	125.00	100.00	-
2. Embankment				
Core	cum	9.50	2.50	-
Filter	cum	10.90	3.75	-
Rock	cum	5.20	6.00	-
Riprap	cum	9.00	8.00	-
Common	cum	3.43	2.50	6.00
3. Concrete				
Concrete dam/Mass	cum	80.00	90.00	58.00
Structure	cum	124.00	137.50	120.00
Superstructure	cum	220.00	-	-
Tunnel	cum	137.00	153.00	-
Shaft	cum	250.00	190.00	-
4. Reinforcement steel far	t	1,190.00	1,500.00	-
5. Grouting				
Consolidation	m	56.36	98.00	-
Curtain	m	49.41	72.00	-
6. Access road				
New construction	km	555,000.00	600,000.00	600,000.00
Upgraded	km	-	-	450,000.00

Table 5.1.5 COST OF ELECTRIC POWER TRANSMISSION LINE

Description	Unit cost per km (X 10 3 $)
(1) 132 kV	
S. C. 200 sq. mm ACSR	59.0
D. C. 200 sq. mm ACSR	96.0
First circuit of a D. C. line	77.0
(2) 66 kV	
S. C. 160 sq. mm ACSR	46.0
D. C. 160 sq. mm ACSR	74.0
Fisrt circuit of D.C. line	59.0
(3) 33 kV	
Rural Area	
S. C. 0.1 sq. mm ACSR	16.0
D. C. 0.1 sq. inch ACSR	24.0
S. C. 0.125 sq. inch ACSR	18.5
S. C. 0.125 sq. inch ACSR	21.0
Suburban area	
S. C. 0.1 sq. inch ACSR	25.0
D. C. 0.1 sq. inch ACSR	37.5
(4) 11 kV	
Rural area	
S. C. 0.1 ACSR	13.0
D.C. 0.1 ACSR	20.0
Subarban area	
S. C. 0.1 ACSR	20.0
D. C. 0.1 ACSR	30.0

Table 5.2.1 ECONOMIC EVALUATION OF POTENTIAL SCHEMES (RESERVOIR TYPE)

Scheme	Draft Rate	Installed Capacity (MW)	Firm Energy (GWh/y)	Secondary Energy (GWh/y)	Construction Cost (US$1,000)	Net Benefit (US$1,000)	EIRR (%)	(US¢/KWh)
LR1	0.6	47.0	135	71	105,078	-11,899	8.5%	5.10
	0.7	58.0	166	70	118,259	-7,807	9.1%	5.01
	0.8	73.0	210	66	144,540	-12,277	8.8%	5.24
BR3A	0.6	660.0	1,874	796	820,923	256,488	13.9%	3.07
	0.7	797.0	2,274	754	914,306	311,548	14.2%	3.02
	0.8	961.0	2,747	686	1,060,168	348,304	14.1%	3.09
BR3B	0.6	801.0	2,243	988	816,255	427,034	16.2%	2.53
	0.7	1,003.0	2,775	1,006	911,115	538,775	16.9%	2.41
	0.8	1,192.0	3,407	911	1,005,558	653,871	17.6%	2.33
BR4	0.6	667.0	1,900	800	1,046,339	115,391	11.4%	3.88
	0.7	804.0	2,245	779	1,216,106	107,230	11.2%	4.02
	0.8	964.0	2,757	679	1,373,534	140,560	11.3%	4.00
BR5	0.6	880.0	2,512	1,047	1,028,160	386,903	14.6%	2.89
	0.7	1,048.0	2,939	968	1,123,183	440,035	14.8%	2.87
	0.8	1,269.0	3,624	888	1,311,537	513,275	14.8%	2.91
SR6	0.6	642.0	1,841	799	926,363	176,302	12.4%	3.51
	0.7	776.0	2,240	752	997,620	244,535	13.1%	3.33
	0.8	966.0	2,809	690	1,175,156	292,445	13.1%	3.36

Note: US¢ means US cents.

TABLE 5.2.2 ECONOMIC EVALUATION OF POTENTIAL SCHEMES (RUN-OF-RIVER TYPE) (1/2)

Scheme	Operation (Hours)	Installed Capacity (MW)	Firm Energy (GWh/y)	Secondary Energy (GWh/y)	Construction Cost (US$1,000)	Net Benefit (US$1,000)	EIRR (%)	(US¢/KWh)
KR2	8	412.8	1,198	1,695	810,044	277,590	14.2%	2.80
	12	275.2	1,198	909	666,503	171,941	13.2%	3.16
	16	206.4	1,198	487	594,236	112,015	12.4%	3.53
KR3	8	434.1	1,260	1,782	689,299	399,762	16.8%	2.27
	12	289.4	1,260	955	515,387	304,022	16.9%	2.33
	16	217.0	1,260	512	404,524	264,567	17.6%	2.28
KR4	8	87.5	254	359	332,577	-83,372	6.3%	5.43
	12	58.3	254	193	278,825	-74,041	6.1%	6.24
	16	43.8	254	103	254,471	-72,183	5.8%	7.13
KR7	8	243.0	705	998	386,925	223,407	16.8%	2.27
	12	162.0	705	535	325,049	146,038	15.4%	2.62
	16	121.5	705	287	288,747	106,704	14.5%	2.91
TR1	8	120.3	349	494	340,586	10,818	10.4%	4.04
	12	80.2	349	265	289,082	-13,456	9.4%	4.71
	16	60.2	349	142	255,233	-22,361	8.8%	5.20
TR2	8	52.6	153	216	314,818	-106,008	4.8%	8.53
	12	35.1	153	116	273,169	-103,805	4.0%	10.15
	16	26.3	153	62	251,963	-103,474	3.4%	11.72
TR3	8	104.7	304	430	290,474	13,486	10.6%	3.96
	12	69.8	304	230	248,230	-9,543	9.5%	4.65
	16	52.3	304	123	229,182	-24,238	8.5%	5.37
TR4	8	10.5	30	43	64,683	-24,573	4.5%	8.86
	12	7.0	30	23	58,522	-25,393	3.4%	11.04
	16	5.2	30	13	53,916	-24,737	2.9%	12.54
MKR1	8	90.5	263	371	282,801	-9,643	9.5%	4.46
	12	60.3	263	199	250,871	-32,389	8.2%	5.43
	16	45.3	263	106	231,977	-43,599	7.3%	6.29
MKR2	8	55.6	161	229	272,091	-71,560	6.1%	6.98
	12	37.1	161	123	244,489	-80,282	5.0%	8.61
	16	27.8	161	66	229,646	-84,972	4.2%	10.12
MKR3	8	124.4	361	511	331,076	25,375	11.0%	3.80
	12	82.9	361	274	300,594	-14,998	9.3%	4.73
	16	62.2	361	147	282,426	-49,536	7.5%	5.56
IIKR1	8	178.6	518	733	411,916	78,549	12.4%	3.29
	12	119.0	518	393	354,395	29,847	11.1%	3.89
	16	89.3	518	211	325,096	2,780	10.1%	4.46
IIKR2	8	77.7	226	319	354,653	-82,843	6.6%	6.51
	12	51.8	226	171	319,855	-97,520	5.4%	8.06
	16	38.9	226	91	298,353	-103,655	4.6%	9.41

TABLE 5.2.2 ECONOMIC EVALUATION OF POTENTIAL SCHEMES (RUN-OF-RIVER TYPE) (2/2)

Scheme	Operation (Hours)	Installed Capacity (MW)	Firm Energy (GWh/y)	Secondary Energy (GWh/y)	Construction Cost (US$1,000)	Net Benefit (US$1,000)	EIRR (%)	(US¢/KWh)
HKR3	8	71.6	208	294	360,684	-99,047	5.9%	7.18
	12	47.7	208	157	331,128	-114,409	4.7%	9.07
	16	35.8	208	84	313,184	-121,128	3.9%	10.73
HKR4	8	111.1	322	456	415,744	-57,799	8.0%	5.34
	12	74.1	322	245	367,532	-79,659	6.9%	6.48
	16	55.5	322	131	341,503	-91,483	6.0%	7.54
BR1	8	82.0	233	362	184,369	44,219	13.0%	3.10
	12	54.7	233	196	146,507	26,975	12.4%	3.42
	16	41.0	233	104	132,146	12,993	11.3%	3.92
BR6	8	49.1	142	187	154,001	-9,494	9.2%	4.68
	12	32.8	142	100	137,381	-20,685	7.9%	5.68
	16	24.6	142	54	125,515	-24,553	7.2%	6.40
BR7	8	29.2	85	111	138,552	-36,910	6.1%	7.07
	12	19.5	85	59	129,270	-44,035	4.8%	8.98
	16	14.6	85	32	123,693	-47,228	4.0%	10.57
BR8	8	30.0	87	114	189,910	-69,822	4.2%	9.45
	12	20.0	87	61	170,743	-70,597	3.3%	11.54
	16	15.0	87	33	161,353	-71,499	2.7%	13.45
SR3	8	75.2	217	280	166,124	30,269	12.3%	3.34
	12	50.1	217	152	137,463	16,616	11.6%	3.73
	16	37.6	217	91	118,304	13,785	11.5%	3.84
SR7	8	52.4	151	196	152,659	-3,407	9.7%	4.40
	12	34.9	151	106	115,410	-1,572	9.8%	4.49
	16	26.2	151	64	103,891	-4,648	9.4%	4.83
THR1	8	8.6	25	40	48,762	-14,117	5.8%	7.50
	12	5.7	25	21	43,730	-15,944	4.5%	9.51
	16	4.3	25	11	40,372	-16,408	3.7%	11.21
BS1	8	8.6	37	49	98,866	-42,497	3.2%	11.50
	12	6.5	37	26	86,278	-40,151	2.5%	13.69
	16	4.3	37	16	79,047	-37,898	2.2%	14.91
CR1	8	9.4	27	35	79,859	-36,635	2.6%	12.88
	12	6.3	27	19	74,089	-37,099	1.7%	16.11
	16	4.7	27	11	70,303	-36,698	1.1%	18.50
CR2	8	23.5	68	88	68,258	894	10.2%	4.38
	12	15.7	68	48	57,931	-3,139	9.3%	4.99
	16	11.8	68	27	51,317	-4,421	8.8%	5.40

Note: US¢ means US cents.

Table 6.1.1 COMPARISON OF DEVELOPMENT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II	Alternative-III
PROJECT FEATURES				
	Operation Hours	8 hours	12 hours	16 hours
	Full Supply Level (EL.)	420.00	420.00	420.00
	Tailwater Level (EL.)	240.00	240.00	240.00
	Plant Discharge (m3/sec)	58.2	38.8	29.1
	Installed Capacity (MW)	82.9	55.3	41.5
COST ESTIMATE				
1.00	Preparatory Works	10,612,026	8,477,030	7,339,507
2.00	Civil Works			
2.10	Intake dam	11,085,780	10,977,540	10,868,400
2.21	Desanding Basin	9,328,825	5,413,925	3,198,800
2.22	Flushing Tunnels	860,895	610,575	538,808
2.31	Intake	293,480	253,143	208,175
2.32	Penstock Line	1,503,390	1,258,950	1,023,435
2.33	Tailrace Tunnel	39,938,430	28,209,437	22,762,950
2.34	Work Adits	1,914,990	1,714,545	1,513,785
2.35	Outlet Channel	936,650	798,050	635,140
2.41	Access Tunnel	9,500,085	8,349,075	7,269,964
2.42	Underground Powerhouse	4,794,460	3,968,800	3,498,000
2.43	Gate Chamber	109,305	81,438	71,757
2.44	Tailrace Surge Tank	2,250,360	1,729,245	1,560,720
2.45	Outdoor Switchyard	635,800	488,675	417,340
2.50	Architectural Buildings	550,000	440,000	385,000
2.60	Access Road	12,450,000	12,450,000	12,450,000
2.70	Check Dam	320,513	320,513	320,513
	Civil Works total	96,472,963	77,063,911	66,722,787
3.00	Metal Works	4,340,000	3,451,000	2,860,000
4.00	Generating Equipment	28,181,500	21,439,200	17,385,400
5.00	Transmission Lines and Substations	690,000	690,000	690,000
	Total of Direct Cost	140,296,489	111,121,141	94,997,694
6.00	Land Aquisition and Compensation	1,402,965	1,111,211	949,977
7.00	Administration Expenses	1,402,965	1,111,211	949,977
8.00	Engineering Servives	9,820,754	7,778,480	6,649,839
9.00	Physical Contingency	21,044,473	16,668,171	14,249,654
	Total of Construction Cost	173,967,646	137,790,215	117,797,140
ECONOMIC EVALUATION				
	Annual Firm Energy (GWh/yr)	236	236	236
	Annual Secondary Energy (GWh/yr)	365	197	105
	EIRR (%)	13.4	12.5	11.6

Table 6.1.2 BREAKDOWN OF CONSTRUCTION COST FOR BR-1 (1/3)

Item No.	Work Item	Unit	Quantities	Unit price F.C.(US$)	Amount F.C.(US$)
1.00	GENERAL ITEMS & PREPARATORY WORKS (11 % of Civil Works)	L.S.			10,612,026
2.00	CIVIL WORKS				
2.10	INTAKE DAM				
	Open Excavation				
	Open excavation,common	m3	41,700	3.50	145,950
	Open excavation,weathered rock	m3	41,700	6.00	250,200
	Open excavation,hard rock	m3	56,000	9.00	504,000
	Concrete				
	Mass concrete	m3	31,950	90.00	2,875,500
	Reinforced concrete	m3	29,000	140.00	4,060,000
	Reinforcement bar	ton	870	1,500.00	1,305,000
	Curtain grouting	m	750	70.00	52,500
	Consolidation grouting	m	500	90.00	45,000
	Others (10%)	L.S.			923,815
	River diversion (10% of 2.10)	L.S.			923,815
	Subtotal				11,085,780
2.20	DESANDING BASIN				
2.21	BASIN				
	Excavation				
	Excavation,common	m3	73,500	3.50	257,250
	Excavation,weathered rock	m3	122,500	6.00	735,000
	Excavation,hard rock	m3	45,500	9.00	409,500
	Concrete	m3	38,100	140.00	5,334,000
	Reinforcement bars	tom	1,140	1,500.00	1,710,000
	Curtain grouting	m	500	70.00	35,000
	Others (10%)	L.S.			848,075
	Subtotal				9,328,825
2.22	FLUSHING TUNNELS				
	Excavation				
	Excavation,common	m3	2,200	3.50	7,700
	Excavation,weathered rock	m3	3,200	6.00	19,200
	Excavation,hard rock	m3	1,600	9.00	14,400
	Excavation,tunnel	m3	4,500	48.00	216,000
	Concrete, open structure	m3	800	140.00	112,000
	Concrete, tunnel	m3	2,400	144.00	345,600
	Reinforcement bars	tom	70	1,500.00	105,000
	Others (5%)	L.S.			40,995
	Subtotal				860,895
2.30	WATERWAY				
2.31	INTAKE				
	Excavation				
	Excavation,common	m3	3,200	3.50	11,200
	Excavation,weathered rock	m3	5,400	6.00	32,400
	Excavation,hard rock	m3	2,200	9.00	19,800
	Concrete,open structure	m3	1,100	144.00	158,400
	Reinforcement	ton	30	1,500.00	45,000
	Others (10%)	L.S.			26,680
	Subtotal				293,480
2.32	PENSTOCK LINE				
	Excavation,tunnel	m3	3,400	53.00	180,200
	Excavation,shaft	m3	3,700	123.00	455,100
	Concrete,tunnel	m3	1,800	160.00	288,000
	Concrete,shaft	m3	1,800	200.00	360,000
	Reinforcement	ton	75	1,500.00	112,500
	Curtain grout	m	400	70.00	28,000
	Backfill grout	m3	40	200.00	8,000
	Others (5%)	L.S.			71,590
	Subtotal				1,503,390

Table 6.1.2 BREAKDOWN OF CONSTRUCTION COST FOR BR-1 (2/3)

Item No.	Work Item	Unit	Quantities	Unit price F.C.(US$)	Amount F.C.(US$)
2.33	TAILRACE TUNNEL				
	Excavation, tunnel	m3	314,200	53.00	16,652,600
	Concrete,tunnel	m3	100,400	160.00	16,064,000
	Reinforcement	ton	1,500	1,500.00	2,250,000
	Consolidation grout	m	37,000	70.00	2,590,000
	Backfill grout	m3	2,400	200.00	480,000
	Others (5%)	L.S.			1,901,830
	Subtotal				39,938,430
2.34	WORK ADITS				
	Excavation				
	Excavation,common	m3	4,800	3.50	16,800
	Excavation,weathered rock	m3	12,000	6.00	72,000
	Excavation,hard rock	m3	7,200	9.00	64,800
	Excavation, tunnel	m3	30,100	48.00	1,444,800
	Concrete,open structure	m3	350	140.00	49,000
	Concrete,tunnel	m3	700	144.00	100,800
	Reinforcement	ton	20	1,500.00	30,000
	Curtain grout	m	480	70.00	33,600
	Backfill grout	m3	60	200.00	12,000
	Others (5%)	L.S.			91,190
	Subtotal				1,914,990
2.35	OUTLET CHANNEL				
	Excavation				
	Excavation,common	m3	24,000	3.50	84,000
	Excavation,weathered rock	m3	60,000	6.00	360,000
	Excavation,hard rock	m3	35,000	9.00	315,000
	Concrete,open structure	m3	500	140.00	70,000
	Reinforcement	ton	15	1,500.00	22,500
	Others (10%)	L.S.			85,150
	Subtotal				936,650
2.40	POWER STATION				
2.41	ACCESS TUNNEL				
	Excavation				
	Excavation,common	m3	1,000	3.50	3,500
	Excavation,weathered rock	m3	2,700	6.00	16,200
	Excavation,hard rock	m3	1,500	9.00	13,500
	Excavation,tunnel	m3	78,000	53.00	4,134,000
	Concrete,open structure	m3	400	140.00	56,000
	Concrete,tunnel	m3	25,000	160.00	4,000,000
	Reinforcement	ton	500	1,500.00	750,000
	Consolidation grout	m	350	70.00	24,500
	Backfill grout	m3	250	200.00	50,000
	Others (5%)	L.S.			452,385
	Subtotal				9,500,085
2.42	UNDERGROUND POWERHOUSE				
	Excavation, underground	m3	31,200	53.00	1,653,600
	PC anchor	m	6,200	60.00	372,000
	Concrete,underground	m3	9,100	160.00	1,456,000
	Second stage concrete	m3	2,200	160.00	352,000
	Reinforcement	ton	350	1,500.00	525,000
	Others (10%)	L.S.			435,860
	Subtotal				4,794,460
2.43	GATE CHAMBER				
	Excavation, tunnel	m3	250	53.00	13,250
	Excavation, shaft	m3	150	123.00	18,450
	Concrete,tunnel	m3	90	160.00	14,400
	Concrete,shaft	m3	80	200.00	16,000
	Reinforcement	ton	10	1,500.00	15,000
	Consolidation grout	m	300	70.00	21,000
	Backfill grout	m3	30	200.00	6,000
	Others (5%)	L.S.			5,205
	Subtotal				109,305

Table 6.1.2 BREAKDOWN OF CONSTRUCTION COST FOR BR-1 (3/3)

Item No.	Work Item	Unit	Quantities	Unit price F.C.(US$)	Amount F.C.(US$)
2.44	TAILRACE SURGE TANK				
	Excavation, shaft	m3	13,400	123.00	1,648,200
	Concrete,shaft	m3	2,100	200.00	420,000
	Reinforcement	ton	50	1,500.00	75,000
	Others (5%)	L.S.			107,160
	Subtotal				2,250,360
2.45	OUTDOOR SWITCHYARD				
	Excavation				
	Excavation,common	m3	9,000	3.50	31,500
	Excavation,weathered rock	m3	20,000	6.00	120,000
	Excavation,hard rock	m3	7,500	9.00	67,500
	Embankment	m3	3,200	10.00	32,000
	Concrete,open structure	m3	1,800	140.00	252,000
	Reinforcement	ton	50	1,500.00	75,000
	Others (10%)	L.S.			57,800
	Subtotal				635,800
2.50	ARCHITECTURAL BUILDINGS	m2	500	1,100.00	550,000
2.60	ACCESS ROAD				
	New construction	km	15	600,000.00	9,000,000
	Upgraded	km	69	50,000.00	3,450,000
	Subtotal				12,450,000
2.70	CHECH DAM				
	Excavation				
	Excavation,common	m3	7,500	3.50	26,250
	Excavation,weathered rock	m3	16,500	6.00	99,000
	Excavation,hard rock	m3	6,000	9.00	54,000
	Concrete, mass concrete	m3	1,400	90.00	126,000
	Others (5%)	L.S.			15,263
	Subtotal				320,513
3.00	METAL WORKS				
	Penstock steel pipes	ton	700	5,000.00	3,500,000
	Gates	ton	120	7,000.00	840,000
	Subtotal				4,340,000
4.00	GENERATING EQUIPMENT				
	Turbines	ton	520	18,700.00	9,724,000
	Generators	ton	890	20,400.00	18,156,000
	Transformers	MVA	90	3,350.00	301,500
	Subtotal				28,181,500
5.00	TRANSMISSION LINES AND SUBSTATIONS	km	15	46,000.00	690,000
	Total of Direct Cost				140,296,488
6.00	LAND AQUISITION AND COMPENSATION	LS			1,402,965
7.00	ADMINISTRATION EXPENSES	LS			1,402,965
8.00	ENGINEERING SERVICES	LS			9,820,754
9.00	PHYSICAL CONTINGENCY (15 % of direct co	LS			21,044,473
	GRAND TOTAL				173,967,646

Table 6.1.3 CASH FLOW DIAGRAM OF BR-1 SCHEME

Unit: US$1,000

Case 1 : 8-hour Operation
EIRR 13.4%
Net Benefit 40,473

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-5	14,787				-14,787
-4	36,968				-36,968
-3	44,362				-44,362
-2	36,968				-36,968
-1	14,787				-14,787
0		701	27,472		26,770
1		701	27,472		26,770
2		701	27,472		26,770
3		701	27,472		26,770
4		701	27,472		26,770
5		701	27,472		26,770
6		701	27,472		26,770
7		701	27,472		26,770
8		701	27,472		26,770
9		701	27,472		26,770
10		701	27,472		26,770
11		701	27,472		26,770
12		701	27,472		26,770
13		701	27,472		26,770
14		701	27,472		26,770
15		701	27,472		26,770
16		701	27,472		26,770
17		701	27,472		26,770
18		701	27,472		26,770
19		701	27,472		26,770
20		701	27,472		26,770
21		701	27,472		26,770
22		701	27,472		26,770
23		701	27,472		26,770
24		701	27,472		26,770
25		701	27,472	-24,201	2,569
26		701	27,472	-24,201	2,569
27		701	27,472	-24,201	2,569
28		701	27,472	-24,201	2,569
29		701	27,472	-24,201	2,569
30		701	27,472	-24,201	2,569
31		701	27,472	-24,201	2,569
32		701	27,472	-24,201	2,569
33		701	27,472	-24,201	2,569
34		701	27,472	-24,201	2,569
35		701	27,472	-24,201	2,569
36		701	27,472	-24,201	2,569
37		701	27,472	-24,201	2,569
38		701	27,472	-24,201	2,569
39		701	27,472	-24,201	2,569
40		701	27,472	-24,201	2,569
41		701	27,472	-24,201	2,569
42		701	27,472	-24,201	2,569
43		701	27,472	-24,201	2,569
44		701	27,472	-24,201	2,569
45		701	27,472	-24,201	2,569
46		701	27,472	-24,201	2,569
47		701	27,472	-24,201	2,569
48		701	27,472	-24,201	2,569
49		701	27,472	-24,201	2,569
50		701	27,472	-24,201	2,569

Table 6.2.1 COMPARISON OF LAYOUT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II	Alternative-III	Alternative-IV
PROJECT FEATURES					
	Dam Crest (EL.)	803.00	803.00	793.00	793.00
	Full Supply Level (EL.)	798.00	798.00	788.00	788.00
	Tailwater Level (EL.)	680.00	630.00	670.00	630.00
	Waterway Length (m)	750	5,150	650	4,300
	Installed Capacity (MW)	59.0	84.0	61.0	81.0
COST ESTIMATE					
1.00	Preparatory Works	7,928,038	10,121,110	6,977,775	8,847,617
2.00	Civil Works				
2.10	Diversion Tunnel	5,309,010	5,309,010	4,420,448	4,420,448
2.20	Coffer Dam	4,737,920	4,737,920	4,737,920	4,737,920
2.30	Main Dam	46,304,895	46,304,895	38,598,735	38,598,735
2.40	Spillway	10,458,250	10,458,250	10,246,170	10,246,170
2.50	Waterway				
2.51	Intake	1,018,710	1,018,710	1,018,710	1,018,710
2.52	Headrace Tunnel	1,790,775	20,609,925	1,266,825	16,977,975
	Surge Tank		3,111,570		2,815,395
2.53	Penstock	874,775	874,775	702,900	874,775
2.60	Open Powerhouse	3,515,600	3,515,600	3,515,600	3,515,600
2.70	Tailrace	220,440	220,440	220,440	220,440
2.80	Architectural Buildings	1,100,000	1,100,000	1,100,000	1,100,000
2.90	Access Road	3,950,000	3,950,000	3,950,000	3,950,000
	Civil Works total	79,280,375	101,211,095	69,777,748	88,476,168
3.00	Metal Works	1,780,000	2,050,000	1,780,000	2,050,000
4.00	Generating Equipment	10,521,000	11,926,000	10,521,000	11,926,000
5.00	Transmission Lines and Substations	92,000	368,000	92,000	368,000
	Total of Direct Cost	99,601,413	125,676,205	89,148,523	111,667,785
6.00	Land Aquisition and Compensation	4,980,071	6,283,810	4,457,426	5,583,389
7.00	Administration Expenses	996,014	1,256,762	891,485	1,116,678
8.00	Engineering Servives	6,972,099	8,797,334	6,240,397	7,816,745
9.00	Physical Contingency	14,940,212	18,851,431	13,372,278	16,750,168
	Total of Construction Cost (US$)	127,489,808	160,865,542	114,110,109	142,934,765
ECONOMIC EVALUATION					
	Annual Firm Energy(GWh/yr)	167	239	173	231
	Annual Secondary Energy (GWh/yr)	73	97	72	92
	EIRR (%)	8.6	9.5	9.7	10.2

Table 6.2.2 COMPARISON OF DEVELOPMENT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II	Alternative-III
DRAFT RATE		0.6	0.7	0.8
PROJECT FEATURES				
	Dam Crest (EL.)	785.00	793.00	808.00
	Full Supply Level (EL.)	780.00	788.00	803.00
	Min. Operating Level (EL.)	751.50	751.50	751.50
	Tailwater Level (EL.)	630.00	630.00	630.00
	Installed Capacity (MW)	67.0	81.0	98.0
COST ESTIMATE				
1.00	Preparatory Works	8,222,926	8,847,617	11,998,231
2.00	Civil Works			
2.10	Diversion Tunnel	4,239,848	4,420,448	4,833,518
2.20	Coffer Dam	4,737,920	4,737,920	4,987,400
2.30	Main Dam	34,922,475	38,598,735	58,412,550
2.40	Spillway	9,748,200	10,246,170	11,873,950
2.50	Waterway			
2.51	Intake	932,030	1,018,710	1,329,350
2.52	Headrace Tunnel	15,858,675	16,977,975	22,613,850
2.53	Surge Tank	2,423,575	2,815,395	3,977,160
2.54	Penstock	826,650	874,775	1,217,975
2.60	Open Powerhouse	3,342,020	3,515,600	4,953,740
2.70	Tailrace	202,868	220,440	292,820
2.80	Architectural Buildings	1,045,000	1,100,000	1,540,000
2.90	Access Road	3,950,000	3,950,000	3,950,000
	Civil Works total	82,229,261	88,476,168	119,982,313
3.00	Metal Works	2,000,000	2,050,000	2,890,000
4.00	Generating Equipment	11,331,000	11,926,000	17,711,000
5.00	Transmission Lines and Substations	368,000	368,000	368,000
	Total of Direct Cost	104,151,187	111,667,785	152,949,544
6.00	Land Aquisition and Compensation	5,207,559	5,583,389	7,647,477
7.00	Administration Expenses	1,041,512	1,116,678	1,529,495
8.00	Engineering Servives	7,290,583	7,816,745	10,706,468
9.00	Physical Contingency	15,622,678	16,750,168	22,942,432
	Total of Construction Cost (US$)	133,313,519	142,934,765	195,775,417
ECONOMIC EVALUATION				
	Annual Firm Energy(GWh/yr)	193	231	281
	Annual Secondary Energy (GWh/yr)	98	92	79
	EIRR (%)	9.8	10.2	9.3

Table 6.2.3 BREAKDOWN OF CONSTRUCTION COST FOR LR-1 (1/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
1.00	GENERAL ITEMS & PREPARATORY WORKS (10 % of Civil Works)	L.S.			8,847,617
2.00	CIVIL WORKS				
2.10	DIVERSION TUNNEL				
	Open Excavation of Inlet &Outlet				
	Open excavation,common	m3	2,100	3.50	7,350
	Open excavation,weathered rock	m3	2,100	6.00	12,600
	Open excavation,hard rock	m3	3,500	10.00	35,000
	Concrete of Inlet &Outlet	m3	1,500	140.00	210,000
	Tunnel Excavation	m3	33,500	50.00	1,675,000
	Tunnel Concrete	m3	10,500	144.00	1,512,000
	Reinforcement bar	m3	260	1,500.00	390,000
	Plug Concrete	m3	2,300	160.00	368,000
	Others (5%)	L.S.			210,498
	Subtotal				4,420,448
2.20	COFFER DAM				
	Excavation				
	Excavation,common	m3	151,000	3.50	528,500
	Embankment				
	Embankment,core	m3	105,300	5.00	526,500
	Embankment,filter	m3	26,600	10.00	266,000
	Embankment,rock	m3	497,700	6.00	2,986,200
	Others (10%)	L.S.			430,720
	Subtotal				4,737,920
2.30	MAIN DAM				
	Excavation				
	Excavation,common	m3	327,000	3.50	1,144,500
	Excavation,weathered rock	m3	174,700	6.00	1,048,200
	Excavation,hard	m3	47,000	10.00	470,000
	Embankment				
	Embankment,core	m3	941,000	5.00	4,705,000
	Embankment,filter	m3	21,900	10.00	219,000
	Embankment,rock	m3	3,890,000	7.00	27,230,000
	Curtain Grouting	m	21,600	70.00	1,512,000
	Consolidation Grouting	m	4,800	90.00	432,000
	Others (5%)	L.S.			1,838,035
	Subtotal				38,598,735
2.40	SPILLWAY				
	Excavation				
	Excavation,common	m3	90,200	3.50	315,700
	Excavation,weathered rock	m3	289,000	6.00	1,734,000
	Excavation,hard rock	m3	244,000	10.00	2,440,000
	Concrete	m3	26,000	140.00	3,640,000
	Reinforcement bars	tom	790	1,500.00	1,185,000
	Others (10%)	L.S.			931,470
	Subtotal				10,246,170

Table 6.2.3 BREAKDOWN OF CONSTRUCTION COST FOR LR-1 (2/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
2.50	WATERWAY				
2.51	INTAKE				
	Excavation				
	Excavation,common	m3	3,800	3.50	13,300
	Excavation,weathered rock	m3	3,800	6.00	22,800
	Excavation,hard rock	m3	5,000	10.00	50,000
	Concrete,open structure	m3	4,500	140.00	630,000
	Reinforcement	ton	140	1,500.00	210,000
	Others (10%)	L.S.			92,610
	Subtotal				1,018,710
2.52	HEADRACE TUNNEL				
	Excavation,tunnel	m3	135,000	55.00	7,425,000
	Concrete, tunnel	m3	43,000	160.00	6,880,000
	Reinforcement	ton	400	1,500.00	600,000
	Consolidation grout	m	12,000	90.00	1,080,000
	Curtain grout	m	350	70.00	24,500
	Backfill grout	m3	800	200.00	160,000
	Others (5%)	L.S.			808,475
	Subtotal				16,977,975
2.54	SURGE TANK				
	Excavation				
	Excavation,common	m3	4,900	3.50	17,150
	Excavation,weathered rock	m3	5,300	6.00	31,800
	Excavation,hard rock	m3	3,800	10.00	38,000
	Excavation, shaft	m3	19,000	55.00	1,045,000
	Concrete, open structure	m3	550	140.00	77,000
	Concrete, shaft	m3	5,600	160.00	896,000
	Reinforcement	ton	270	1,500.00	405,000
	Consolidation grout	m	550	90.00	49,500
	Others (10%)	L.S.			255,945
	Subtotal				2,815,395
2.53	PENSTOCK				
	Excavation,tunnel	m3	6,250	55.00	343,750
	Concrete,tunnel	m3	2,300	160.00	368,000
	Reinforcement	ton	45	1,500.00	67,500
	Backfill grout	m3	80	200.00	16,000
	Others (10%)	L.S.			79,525
	Subtotal				874,775
2.60	OPEN POWERHOUSE				
	Excavation				
	Excavation,common	m3	8,000	3.50	28,000
	Excavation,weathered rock	m3	8,000	6.00	48,000
	Excavation,hard rock	m3	11,000	10.00	110,000
	Concrete, substructure	m3	7,800	250.00	1,950,000
	Concrete, second stage	m3	2,000	140.00	280,000
	Reinforcement	ton	520	1,500.00	780,000
	Others (10%)	L.S.			319,600
	Subtotal				3,515,600

Table 6.2.3 BREAKDOWN OF CONSTRUCTION COST FOR LR-1 (3/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
2.70	TAILRACE				
	Excavation				
	Excavation,common	m3	1,200	3.50	4,200
	Excavation,weathered rock	m3	1,200	6.00	7,200
	Excavation,hard rock	m3	1,800	10.00	18,000
	Concrete, structure	m3	900	140.00	126,000
	Reinforcement	ton	30	1,500.00	45,000
	Others (10%)	L.S.			20,040
	Subtotal				220,440
2.80	ARCHITECTURAL BUILDINGS	m2	1,000	1,100.00	1,100,000
2.90	ACCESS ROAD				
	New construction	km	0	600,000.00	0
	Upgraded	km	79	50,000.00	3,950,000
	Subtotal				3,950,000
	Total of Civil Works				88,476,168
3.00	METAL WORKS				
	Penstock steel pipes	ton	340	5,000.00	1,700,000
	Gates	ton	50	7,000.00	350,000
	Subtotal				2,050,000
4.00	GENERATING EQUIPMENT				
	Turbines	ton	250	18,700.00	4,675,000
	Generators	ton	340	20,400.00	6,936,000
	Transformers	MVA	70	4,500.00	315,000
	Subtotal				11,926,000
5.00	TRANSMISSION LINES AND SUBSTATIONS	km	8	46,000.00	368,000
	Total of Direct Cost				111,667,784
6.00	LAND AQUISITION AND COMPENSATION	LS			5,583,389
7.00	ADMINISTRATION EXPENSES	LS			1,116,678
8.00	ENGINEERING SERVICES	LS			7,816,745
9.00	PHYSICAL CONTINGENCY (15 %)	LS			16,750,168
	GRAND TOTAL				142,934,764

Table 6.2.4 CASH FLOW DIAGRAM OF LR-1 SCHEME

Unit: US$1,000

Case 1 : 8-hour Operation
EIRR 10.2%
Net Benefit 2,327

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-5	12,149				-12,149
-4	30,374				-30,374
-3	36,448				-36,448
-2	30,374				-30,374
-1	12,149				-12,149
0		558	15,839		15,281
1		558	15,839		15,281
2		558	15,839		15,281
3		558	15,839		15,281
4		558	15,839		15,281
5		558	15,839		15,281
6		558	15,839		15,281
7		558	15,839		15,281
8		558	15,839		15,281
9		558	15,839		15,281
10		558	15,839		15,281
11		558	15,839		15,281
12		558	15,839		15,281
13		558	15,839		15,281
14		558	15,839		15,281
15		558	15,839		15,281
16		558	15,839		15,281
17		558	15,839		15,281
18		558	15,839		15,281
19		558	15,839		15,281
20		558	15,839		15,281
21		558	15,839		15,281
22		558	15,839		15,281
23		558	15,839		15,281
24		558	15,839		15,281
25		558	15,839		15,281
26		558	15,839		15,281
27		558	15,839		15,281
28		558	15,839		15,281
29		558	15,839		15,281
30		558	15,839		15,281
31		558	15,839		15,281
32		558	15,839		15,281
33		558	15,839		15,281
34		558	15,839		15,281
35		558	15,839		15,281
36		558	15,839		15,281
37		558	15,839		15,281
38		558	15,839		15,281
39		558	15,839		15,281
40		558	15,839		15,281
41		558	15,839		15,281
42		558	15,839		15,281
43		558	15,839		15,281
44		558	15,839		15,281
45		558	15,839		15,281
46		558	15,839		15,281
47		558	15,839		15,281
48		558	15,839		15,281
49		558	15,839		15,281
50		558	15,839		15,281

Table 6.3.1 COMPARISON OF LAYOUT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II
PROJECT FEATURES			
	Operation Hours	8 hours	8 hours
	Full Supply Level (EL.)	1250.00	1250.00
	Tailwater Level (EL.)	1070.00	1125.00
	Plant Discharge (m3/sec)	39.6	39.6
	Installed Capacity (MW)	56.4	39.2
COST ESTIMATE			
1.00	Preparatory Works	9,089,546	7,804,113
2.00	Civil Works		
2.10	Intake dam	18,398,400	18,398,400
2.21	Desanding Basin	5,074,960	5,074,960
2.22	Flushing Tunnels	1,761,480	1,761,480
2.31	Intake	248,490	248,490
2.32	Headrace Tunnel	24,733,275	15,354,675
2.33	Work Adits	1,620,360	1,145,235
2.34	Surge Tank	2,049,245	1,670,350
2.35	Penstock	943,635	1,018,710
2.40	Open Powerhouse	3,049,475	2,605,460
2.50	Tailrace	396,900	341,513
2.60	Architectural Buildings	1,320,000	1,265,000
2.70	Access Road	16,150,000	16,150,000
	Civil Works total	75,746,220	65,034,273
3.00	Metal Works	4,590,000	4,120,000
4.00	Generating Equipment	22,366,000	18,500,000
5.00	Transmission Lines and Substations	2,714,000	2,990,000
	Total of Direct Cost	114,505,766	98,448,386
6.00	Land Aquisition and Compensation	1,145,058	984,484
7.00	Administration Expenses	1,145,058	984,484
8.00	Engineering Servives	8,015,404	6,891,387
9.00	Physical Contingency	17,175,865	14,767,258
	Total of Construction Cost (US$)	141,987,150	122,075,998
ECONOMIC EVALUATION			
	Annual Firm Energy (GWh/yr)	163	113
	Annual Secondary Energy (GWh/yr)	210	146
	EIRR (%)	11.0	9.1

Table 6.3.2 COMPARISON OF DEVELOPMENT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II	Alternative-III
PROJECT FEATURES				
	Operation Hours	8 hours	12 hours	16 hours
	Full Supply Level (EL.)	1250.00	1250.00	1250.00
	Tailwater Level (EL.)	1070.00	1070.00	1070.00
	Plant Discharge (m3/sec)	39.6	26.4	19.8
	Installed Capacity (MW)	56.4	37.6	28.2
COST ESTIMATE				
1.00	Preparatory Works	9,089,546	7,862,621	6,937,752
2.00	Civil Works			
2.10	Intake dam	18,398,400	17,165,160	15,968,400
2.21	Desanding Basin	5,074,960	3,918,750	3,376,285
2.22	Flushing Tunnels	1,761,480	1,137,780	941,063
2.31	Intake	248,490	205,480	183,920
2.32	Headrace Tunnel	24,733,275	19,856,235	15,162,000
2.33	Work Adits	1,620,360	1,485,750	1,306,830
2.34	Surge Tank	2,049,245	1,425,875	1,158,575
2.35	Penstock	943,635	736,785	643,860
2.40	Open Powerhouse	3,049,475	2,023,450	1,647,910
2.50	Tailrace	396,900	316,575	285,758
2.60	Architectural Buildings	1,320,000	1,100,000	990,000
2.70	Access Road	16,150,000	16,150,000	16,150,000
	Civil Works total	75,746,220	65,521,840	57,814,601
3.00	Metal Works	4,590,000	3,210,000	2,605,000
4.00	Generating Equipment	22,366,000	17,094,000	13,886,000
5.00	Transmission Lines and Substations	2,714,000	2,714,000	2,714,000
	Total of Direct Cost	114,505,766	96,402,461	83,957,353
6.00	Land Aquisition and Compensation	1,145,058	964,025	839,574
7.00	Administration Expenses	1,145,058	964,025	839,574
8.00	Engineering Servives	8,015,404	6,748,172	5,877,015
9.00	Physical Contingency	17,175,865	14,460,369	12,593,603
	Total of Construction Cost (US$)	141,987,150	119,539,051	104,107,118
ECONOMIC EVALUATION				
	Annual Firm Energy (GWh/yr)	163	163	163
	Annual Secondary Energy (GWh/yr)	210	114	68
	EIRR (%)	*11.0*	*10.2*	*10.0*

Table 6.3.3 BREAKDOWN OF CONSTRUCTION COST FOR SR-3 (1/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
1.00	GENERAL ITEMS & PREPARATORY WORKS (12 % of Civil Works)	L.S.			9,089,546
2.00	CIVIL WORKS				
2.10	INTAKE DAM				
	Open Excavation				
	Open excavation,common	m3	107,000	3.50	374,500
	Open excavation,weathered rock	m3	107,000	6.00	642,000
	Open excavation,hard rock	m3	53,500	10.00	535,000
	Concrete				
	Mass concrete	m3	86,600	90.00	7,794,000
	Reinforced concrete	m3	34,000	140.00	4,760,000
	Reinforcement bar	ton	700	1,500.00	1,050,000
	Curtain grouting	m	1,300	70.00	91,000
	Consolidation grouting	m	950	90.00	85,500
	Others (10%)	L.S.			1,533,200
	River diversion (10% of 2.10)	L.S.			1,533,200
	Subtotal				18,398,400
2.40	DESANDING BASIN				
2.41	BASIN				
	Excavation				
	Excavation,common	m3	54,600	3.50	191,100
	Excavation,weathered rock	m3	91,000	6.00	546,000
	Excavation,hard rock	m3	36,400	10.00	364,000
	Concrete	m3	18,700	140.00	2,618,000
	Reinforcement bars	tom	580	1,500.00	870,000
	Curtain grouting	m	350	70.00	24,500
	Others (10%)	L.S.			461,360
	Subtotal				5,074,960
2.42	FLUSHING CHANNELS				
	Excavation				
	Excavation,common	m3	8,800	3.50	30,800
	Excavation,weathered rock	m3	8,800	6.00	52,800
	Excavation,hard rock	m3	30,000	10.00	300,000
	Concrete	m3	7,100	140.00	994,000
	Reinforcement bars	tom	200	1,500.00	300,000
	Others (5%)	L.S.			83,880
	Subtotal				1,761,480
2.50	WATERWAY				
2.51	INTAKE				
	Excavation				
	Excavation,common	m3	2,600	3.50	9,100
	Excavation,weathered rock	m3	4,400	6.00	26,400
	Excavation,hard rock	m3	1,800	10.00	18,000
	Concrete,open structure	m3	910	140.00	127,400
	Reinforcement	ton	30	1,500.00	45,000
	Others (10%)	L.S.			22,590
	Subtotal				248,490

Table 6.3.3 BREAKDOWN OF CONSTRUCTION COST FOR SR-3 (2/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
2.52	HEADRACE TUNNEL				
	Excavation,tunnel	m3	166,300	55.00	9,146,500
	Concrete, tunnel	m3	55,600	160.00	8,896,000
	Reinforcement	ton	1,100	1,500.00	1,650,000
	Consolidation grout	m	35,500	90.00	3,195,000
	Curtain grout	m	400	70.00	28,000
	Backfill grout	m3	3,200	200.00	640,000
	Others (5%)	L.S.			1,177,775
	Subtotal				24,733,275
2.53	WORK ADITS				
	Excavation				
	Excavation,common	m3	2,400	3.50	8,400
	Excavation,weathered rock	m3	3,900	6.00	23,400
	Excavation,hard rock	m3	1,700	10.00	17,000
	Excavation,tunnel	m3	9,500	50.00	475,000
	Concrete,open structure	m3	480	140.00	67,200
	Concrete,tunnel	m3	6,300	144.00	907,200
	Reinforcement	ton	30	1,500.00	45,000
	Others (5%)	L.S.			77,160
	Subtotal				1,620,360
2.54	SURGE TANK				
	Excavation				
	Excavation,common	m3	2,500	3.50	8,750
	Excavation,weathered rock	m3	4,200	6.00	25,200
	Excavation,hard rock	m3	3,000	10.00	30,000
	Excavation, shaft	m3	14,000	55.00	770,000
	Concrete, open structure	m3	900	140.00	126,000
	Concrete, shaft	m3	4,200	160.00	672,000
	Reinforcement	ton	130	1,500.00	195,000
	Consolidation grout	m	400	90.00	36,000
	Others (10%)	L.S.			186,295
	Subtotal				2,049,245
2.55	PENSTOCK				
	Excavation,tunnel	m3	5,300	55.00	291,500
	Concrete,tunnel	m3	3,000	160.00	480,000
	Reinforcement	ton	60	1,500.00	90,000
	Curtain grout	m	360	70.00	25,200
	Backfill grout	m3	60	200.00	12,000
	Others (5%)	L.S.			44,935
	Subtotal				943,635
2.60	OPEN POWERHOUSE				
	Excavation				
	Excavation,common	m3	7,500	3.50	26,250
	Excavation,weathered rock	m3	7,500	6.00	45,000
	Excavation,hard rock	m3	9,800	10.00	98,000
	Concrete, substructure	m3	6,200	250.00	1,550,000
	Concrete, second stage	m3	2,700	140.00	378,000
	Reinforcement	ton	450	1,500.00	675,000
	Others (10%)	L.S.			277,225
	Subtotal				3,049,475

Table 6.3.3 BREAKDOWN OF CONSTRUCTION COST FOR SR-3 (3/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
2.70	TAILRACE				
	Excavation				
	Excavation,common	m3	4,000	3.50	14,000
	Excavation,weathered rock	m3	4,000	6.00	24,000
	Excavation,hard rock	m3	5,500	10.00	55,000
	Concrete, structure	m3	1,500	140.00	210,000
	Reinforcement	ton	50	1,500.00	75,000
	Others (5%)	L.S.			18,900
	Subtotal				396,900
2.80	ARCHITECTURAL BUILDINGS	m2	1,200	1,100.00	1,320,000
2.90	ACCESS ROAD				
	New construction	km	5	600,000.00	3,000,000
	Upgraded	km	263	50,000.00	13,150,000
	Subtotal				16,150,000
	Total of Civil Works				75,746,220
3.00	METAL WORKS				
	Penstock steel pipes	ton	750	5,000.00	3,750,000
	Gates	ton	120	7,000.00	840,000
	Subtotal				4,590,000
4.00	GENERATING EQUIPMENT				
	Turbines	ton	380	18,700.00	7,106,000
	Generators	ton	730	20,400.00	14,892,000
	Transformers	MVA	80	4,600.00	368,000
	Subtotal				22,366,000
5.00	TRANSMISSION LINES AND SUBSTATIONS	km	59	46,000.00	2,714,000
	Total of Direct Cost				114,505,766
6.00	LAND AQUISITION AND COMPENSATION	LS			1,145,058
7.00	ADMINISTRATION EXPENSES	LS			1,145,058
8.00	ENGINEERING SERVICES	LS			8,015,404
9.00	PHYSICAL CONTINGENCY	LS			17,175,865
	GRAND TOTAL				141,987,150

Table 6.3.4 CASH FLOW DIAGRAM OF SR-3 SCHEME

Case 1 : 8-hour Operation

Unit: US$1,000

EIRR 11.0%

Net Benefit 11,327

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-5	12,069				-12,069
-4	30,172				-30,172
-3	36,207				-36,207
-2	30,172				-30,172
-1	12,069				-12,069
0		573	17,215		16,643
1		573	17,215		16,643
2		573	17,215		16,643
3		573	17,215		16,643
4		573	17,215		16,643
5		573	17,215		16,643
6		573	17,215		16,643
7		573	17,215		16,643
8		573	17,215		16,643
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44		573	17,215		16,643
45		573	17,215		16,643
46		573	17,215		16,643
47		573	17,215		16,643
48		573	17,215		16,643
49		573	17,215		16,643
50		573	17,215		16,643

Table 6.4.1 COMPARISON OF LAYOUT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II
PROJECT FEATURES			
	Operation Hours	8 hours	8 hours
	Full Supply Level (EL.)	930.00	880.00
	Tailwater Level (EL.)	790.00	790.00
	Plant Discharge (m3/sec)	21.7	21.7
	Installed Capacity (MW)	24.1	15.5
COST ESTIMATE			
1.00	Preparatory Works	4,116,871	2,868,109
2.00	Civil Works		
2.10	Diversion Tunnel	3,754,275	0
2.20	Cofferdam	1,211,650	0
2.30	Intake dam	10,683,200	6,144,050
2.40	Desanding Basin	4,263,215	3,932,500
2.51	Intake	254,760	240,300
2.52	Headrace Tunnel	6,747,405	5,949,930
2.53	Work Adits	410,340	178,185
2.54	Surge Tank	857,300	697,590
2.55	Penstock	764,558	697,725
2.60	Open Powerhouse	1,254,550	1,086,965
2.70	Tailrace	344,850	321,475
2.80	Architectural Buildings	880,000	825,000
2.90	Access Road	6,000,000	6,000,000
	Civil Works total	37,426,103	26,073,720
3.00	Metal Works	2,240,000	2,020,000
4.00	Generating Equipment	8,621,750	7,717,550
5.00	Transmission Lines and Substations	1,850,000	1,850,000
	Total of Direct Cost	54,254,724	40,529,379
6.00	Land Aquisition and Compensation	2,712,736	2,026,469
7.00	Administration Expenses	542,547	405,294
8.00	Engineering Servives	3,797,831	2,837,057
9.00	Physical Contingency	8,138,209	6,079,407
	Total of Construction Cost (US$)	69,446,047	51,877,605
ECONOMIC EVALUATION			
	Annual Firm Energy (GWh/yr)	70	45
	Annual Secondary Energy (GWh/yr)	90	58
	EIRR (%)	10.3	8.9

Table 6.4.2 COMPARISON OF DEVELOPMENT ALTERNATIVES

	Items	Alternatives Alternative-I	Alternative-II	Alternative-III
PROJECT FEATURES				
	Operation Hours	8 hours	12 hours	16 hours
	Full Supply Level (EL.)	930.00	930.00	930.00
	Tailwater Level (EL.)	790.00	790.00	790.00
	Plant Discharge (m3/sec)	21.7	14.5	10.9
	Installed Capacity (MW)	24.1	16.0	12.0
COST ESTIMATE				
1.00	Preparatory Works	4,116,871	3,660,174	3,362,733
2.00	Civil Works			
2.10	Diversion Tunnel	3,754,275	3,754,275	3,754,275
2.20	Cofferdam	1,211,650	1,211,650	1,211,650
2.30	Intake dam	10,683,200	10,683,200	10,683,200
2.40	Desanding Basin	4,263,215	2,812,810	2,157,100
2.51	Intake	254,760	181,080	150,300
2.52	Headrace Tunnel	6,747,405	5,175,975	3,734,010
2.53	Work Adits	410,340	410,340	325,710
2.54	Surge Tank	857,300	659,630	497,610
2.55	Penstock	764,558	591,360	521,063
2.60	Open Powerhouse	1,254,550	873,290	773,960
2.70	Tailrace	344,850	260,700	211,420
2.80	Architectural Buildings	880,000	660,000	550,000
2.90	Access Road	6,000,000	6,000,000	6,000,000
	Civil Works total	37,426,103	33,274,310	30,570,298
3.00	Metal Works	2,240,000	1,800,000	1,430,000
4.00	Generating Equipment	8,621,750	7,215,500	5,838,500
5.00	Transmission Lines and Substations	1,850,000	1,850,000	1,850,000
	Total of Direct Cost	54,254,724	47,799,984	43,051,531
6.00	Land Aquisition and Compensation	2,712,736	2,389,999	2,152,577
7.00	Administration Expenses	542,547	478,000	430,515
8.00	Engineering Servives	3,797,831	3,345,999	3,013,607
9.00	Physical Contingency	8,138,209	7,169,998	6,457,730
	Total of Construction Cost (US$)	69,446,047	61,183,980	55,105,959
ECONOMIC EVALUATION				
	Annual Firm Energy (GWh/yr)	70	70	70
	Annual Secondary Energy (GWh/yr)	90	49	27
	EIRR (%)	10.3	9.0	8.4

Table 6.4.3 BREAKDOWN OF CONSTRUCTION COST FOR CR-2 (1/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
1.00	GENERAL ITEMS & PREPARATORY WORKS (11 % of Civil Works)	L.S.			4,116,871
2.00	CIVIL WORKS				
2.10	DIVERSION TUNNEL				
	Open Excavation of Inlet &Outlet				
	Open excavation,common	m3	1,000	3.50	3,500
	Open excavation,weathered rock	m3	1,000	6.00	6,000
	Open excavation,hard rock	m3	1,200	10.00	12,000
	Concrete of Inlet &Outlet	m3	600	140.00	84,000
	Tunnel Excavation	m3	24,000	55.00	1,320,000
	Tunnel Concrete	m3	11,000	160.00	1,760,000
	Reinforcement bar	m3	100	1,500.00	150,000
	Plug Concrete	m3	1,500	160.00	240,000
	Others (5%)	L.S.			178,775
	Subtotal				3,754,275
2.20	COFFER DAM				
	Excavation				
	Open excavation,common	m3	1,000	3.50	3,500
	Open excavation,weathered rock	m3	1,000	6.00	6,000
	Open excavation,hard rock	m3	1,200	10.00	12,000
	Concrete				
	Mass concrete	m3	12,000	90.00	1,080,000
	Others (10%)	L.S.			110,150
	Subtotal				1,211,650
2.30	INTAKE DAM				
	Open Excavation				
	Open excavation,common	m3	6,000	3.50	21,000
	Open excavation,weathered rock	m3	8,000	6.00	48,000
	Open excavation,hard rock	m3	5,000	11.00	55,000
	Concrete				
	Mass concrete	m3	66,000	90.00	5,940,000
	Reinforced concrete	m3	18,000	140.00	2,520,000
	Reinforcement bar	ton	600	1,500.00	900,000
	Curtain grouting	m	1,200	70.00	84,000
	Consolidation grouting	m	1,600	90.00	144,000
	Others (10%)	L.S.			971,200
	Subtotal				10,683,200
2.40	DESANDING BASIN				
	Excavation,common	m3	37,500	3.50	131,250
	Excavation,weathered rock	m3	53,400	6.00	320,400
	Excavation,hard rock	m3	39,000	11.00	429,000
	Concrete, open structure	m3	14,500	160.00	2,320,000
	Reinforcement bars	ton	450	1,500.00	675,000
	Others (10%)	L.S.			387,565
	Subtotal				4,263,215
2.50	WATERWAY				
2.51	INTAKE				
	Excavation				
	Excavation,common	m3	2,800	3.50	9,800
	Excavation,weathered rock	m3	4,800	6.00	28,800
	Excavation,hard rock	m3	2,200	11.00	24,200
	Concrete,open structure	m3	800	140.00	112,000
	Reinforcement	ton	25	1,500.00	37,500
	Others (10%)	L.S.			42,460
	Subtotal				254,760

Table 6.4.3 BREAKDOWN OF CONSTRUCTION COST FOR CR-2 (2/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
2.52	HEADRACE TUNNEL				
	Excavation,tunnel	m3	40,700	57.00	2,319,900
	Concrete, tunnel	m3	15,100	160.00	2,416,000
	Reinforcement	ton	150	1,500.00	225,000
	Consolidation grout	m	14,000	90.00	1,260,000
	Curtain grout	m	360	70.00	25,200
	Backfill grout	m3	900	200.00	180,000
	Others (5%)	L.S.			321,305
	Subtotal				6,747,405
2.53	WORK ADITS				
	Excavation				
	Excavation,common	m3	1,600	3.50	5,600
	Excavation,weathered rock	m3	2,800	6.00	16,800
	Excavation,hard rock	m3	1,200	11.00	13,200
	Excavation,tunnel	m3	3,300	51.00	168,300
	Concrete,tunnel	m3	1,100	144.00	158,400
	Concrete,open structure	m3	150	140.00	21,000
	Reinforcement	ton	5	1,500.00	7,500
	Others (5%)	L.S.			19,540
	Subtotal				410,340
2.54	SURGE TANK				
	Excavation				
	Excavation,common	m3	2,100	3.50	7,350
	Excavation,weathered rock	m3	3,700	6.00	22,200
	Excavation,hard rock	m3	1,500	11.00	16,500
	Excavation, shaft	m3	5,900	57.00	336,300
	Concrete, open structure	m3	130	140.00	18,200
	Concrete, shaft	m3	1,700	160.00	272,000
	Reinforcement	ton	50	1,500.00	75,000
	Consolidation grout	m	400	90.00	36,000
	Others (10%)	L.S.			73,750
	Subtotal				857,300
2.55	PENSTOCK				
	Excavation				
	Excavation,common	m3	7,700	3.50	26,950
	Excavation,weathered rock	m3	7,700	6.00	46,200
	Excavation,hard rock	m3	10,300	10.00	103,000
	Excavation,tunnel	m3	3,300	55.00	181,500
	Concrete,open structure	m3	500	140.00	70,000
	Concrete,tunnel	m3	1,200	160.00	192,000
	Reinforcement	ton	55	1,500.00	82,500
	Curtain grout	m	200	70.00	14,000
	Backfill grout	m3	60	200.00	12,000
	Others (5%)	L.S.			36,408
	Subtotal				764,558
2.60	OPEN POWERHOUSE				
	Excavation				
	Excavation,common	m3	3,000	3.50	10,500
	Excavation,weathered rock	m3	3,000	6.00	18,000
	Excavation,hard rock	m3	4,000	11.00	44,000
	Concrete, substructure	m3	2,800	250.00	700,000
	Concrete, second stage	m3	700	140.00	98,000
	Reinforcement	ton	180	1,500.00	270,000
	Others (10%)	L.S.			114,050
	Subtotal				1,254,550

Table 6.4.3 BREAKDOWN OF CONSTRUCTION COST FOR CR-2 (3/3)

Item No.	Work Item	Unit	Quantity	Unit price F.C.(US$)	Amount F.C.(US$)
2.70	TAILRACE				
	Excavation				
	Excavation,common	m3	3,000	3.50	10,500
	Excavation,weathered rock	m3	3,000	6.00	18,000
	Excavation,hard rock	m3	4,000	11.00	44,000
	Concrete, structure	m3	1,400	140.00	196,000
	Reinforcement	ton	30	1,500.00	45,000
	Others (10%)	L.S.			31,350
	Subtotal				344,850
2.80	ARCHITECTURAL BUILDINGS	m2	800	1,100.00	880,000
2.90	ACCESS ROAD				
	New construction	km	10	600,000.00	6,000,000
	Upgraded	km	0	50,000.00	0
	Subtotal				6,000,000
	Total of Civil Works				37,426,103
3.00	METAL WORKS				
	Penstock steel pipes	ton	350	5,000.00	1,750,000
	Gates	ton	70	7,000.00	490,000
	Subtotal				2,240,000
4.00	GENERATING EQUIPMENT				
	Turbines	ton	140	18,700.00	2,618,000
	Generators	ton	290	20,400.00	5,916,000
	Transformers	MVA	15	5,850.00	87,750
	Subtotal				8,621,750
5.00	TRANSMISSION LINES AND SUBSTATIONS	km	74	25,000.00	1,850,000
	Total of Direct Cost				54,254,724
6.00	LAND AQUISITION AND COMPENSATION	LS			2,712,736
7.00	ADMINISTRATION EXPENSES	LS			542,547
8.00	ENGINEERING SERVICES	LS			3,797,831
9.00	PHYSICAL CONTINGENCY (15 % of direct cost	LS			8,138,209
	GRAND TOTAL				69,446,046

Table 6.4.4 CASH FLOW DIAGRAM OF CR-2 SCHEME

Unit: US$1,000

Case 1 : 8-hour Operation
EIRR 10.3%
Net Benefit 1,378

Year	Capital Cost	O&M Cost	Benefit	Negative Benefit	B-C
-4	11,806				-11,806
-3	17,709				-17,709
-2	17,709				-17,709
-1	11,806				-11,806
0		271	7,371		7,099
1		271	7,371		7,099
2		271	7,371		7,099
3		271	7,371		7,099
4		271	7,371		7,099
5		271	7,371		7,099
6		271	7,371		7,099
7		271	7,371		7,099
8		271	7,371		7,099
9		271	7,371		7,099
10		271	7,371		7,099
11		271	7,371		7,099
12		271	7,371		7,099
13		271	7,371		7,099
14		271	7,371		7,099
15		271	7,371		7,099
16		271	7,371		7,099
17		271	7,371		7,099
18		271	7,371		7,099
19		271	7,371		7,099
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43		271	7,371		7,099
44		271	7,371		7,099
45		271	7,371		7,099
46		271	7,371		7,099
47		271	7,371		7,099
48		271	7,371		7,099
49		271	7,371		7,099
50		271	7,371		7,099

Table 8.1.1 LOAD DEMAND FORECAST IN THE PROPOSED RURAL ELECTRIFICATION AREAS

Unit : kW

Name of Town	Name of District	Year				
		1995	2000	2005	2010	2013
Simikot	Humla	52	105	122	138	148
Gamgadhi	Mugu	101	201	224	242	253
Rara Lake	Mugu	35	79	86	92	96
Jumla	Jumla	388	432	478	530	562
Binayak	Achham	83	147	171	190	200
Mangalsen	Achham	125	205	244	275	289
Bisiakot	Achham	44	92	102	111	116
Baldanda	Achham	69	128	147	162	170
Jayagadh	Achham	69	126	145	160	168
Gajara	Achham	46	95	105	115	121

Table 8.1.2 PROPOSED RURAL ELECTRIFICATION BY SMALL HYDROPOWER PROJECT

Name of Town	Name of District	Name of Zone	Name of River/Khola	Catchment area (km2)	Disharge (m3/sec)	Potential (kW)	Construction Cost, Million US$	Remarks
Simikot	Humla	Mid Western	Hepkha Khola	153	0.63	914	5.36	Quoted from SHMP
Gamgadhi	Mugu	Mid Western	Gam Gad	105	0.64	599	2.45	Quoted from SHMP
Rara Lake (national park)	Mugu	Mid Western	Gam Gad	(105)	(0.64)	(599)	(2.45)	To be exended from Gamgadhi
Jumla	Jumla	Mid Western	Babila Khola	16	0.90	250	1.35	An open cannal for irrigation can be used for hydropower
Binayak	Achham	Far Western	Tala Gad	72	0.43	300	1.47	
Baldanda	Achham	Far Western	Kailash Khola	-	-	-	1.40 ^1	To be extended from Mangalsen
Jayagadh	Achham	Far Western	Chipiya Khola	-	-	-	(1.40)	To be extended from Mangalsen
Gajara	Achham	Far Western	Chipiya Khola	-	-	-	(1.40)	To be extended from Mangalsen

Note : ^1 Costs required for the extension of transmission lines from the Achham hydropower plant to the demand centres

FIGURES

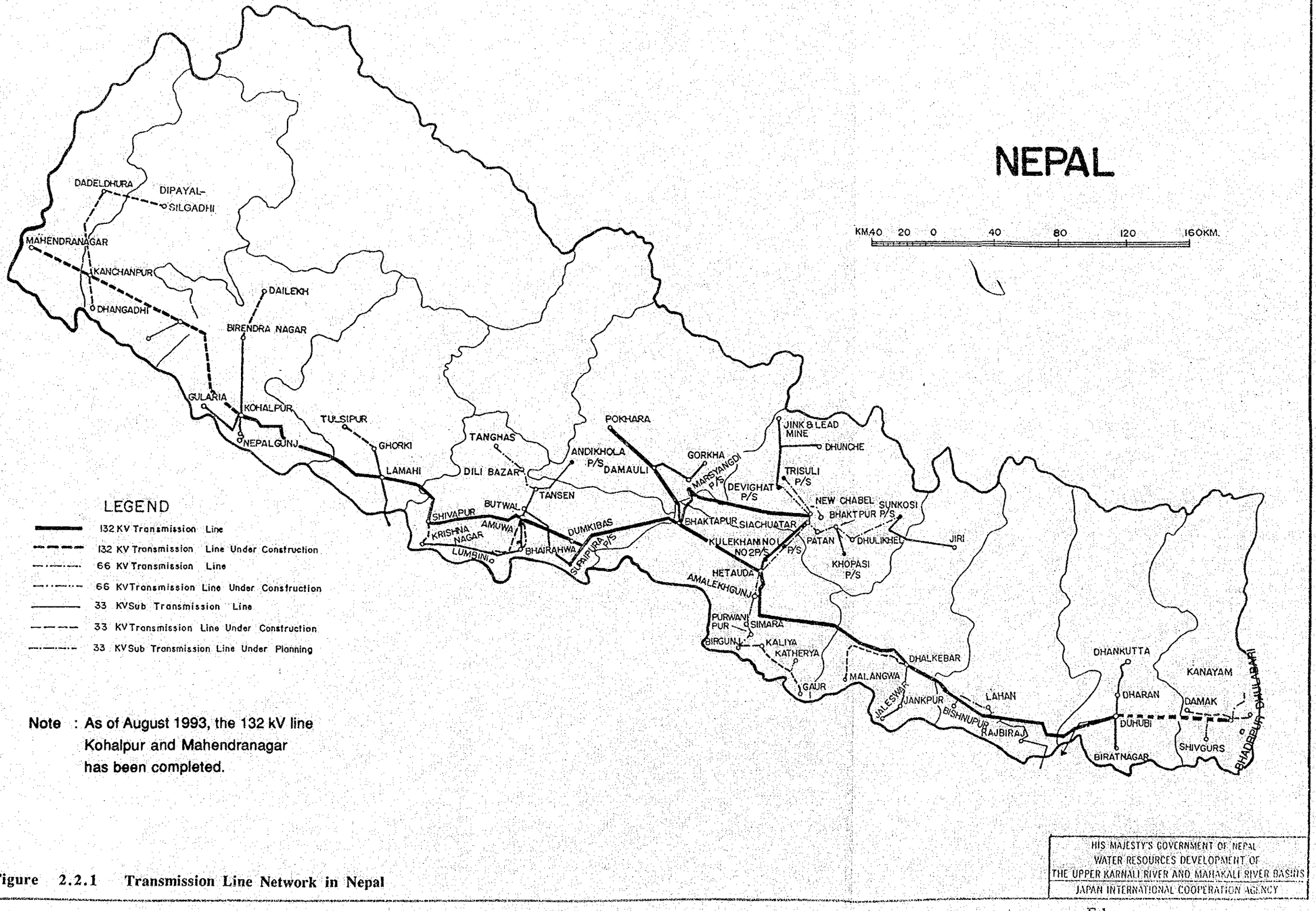


Figure 2.2.1 Transmission Line Network in Nepal

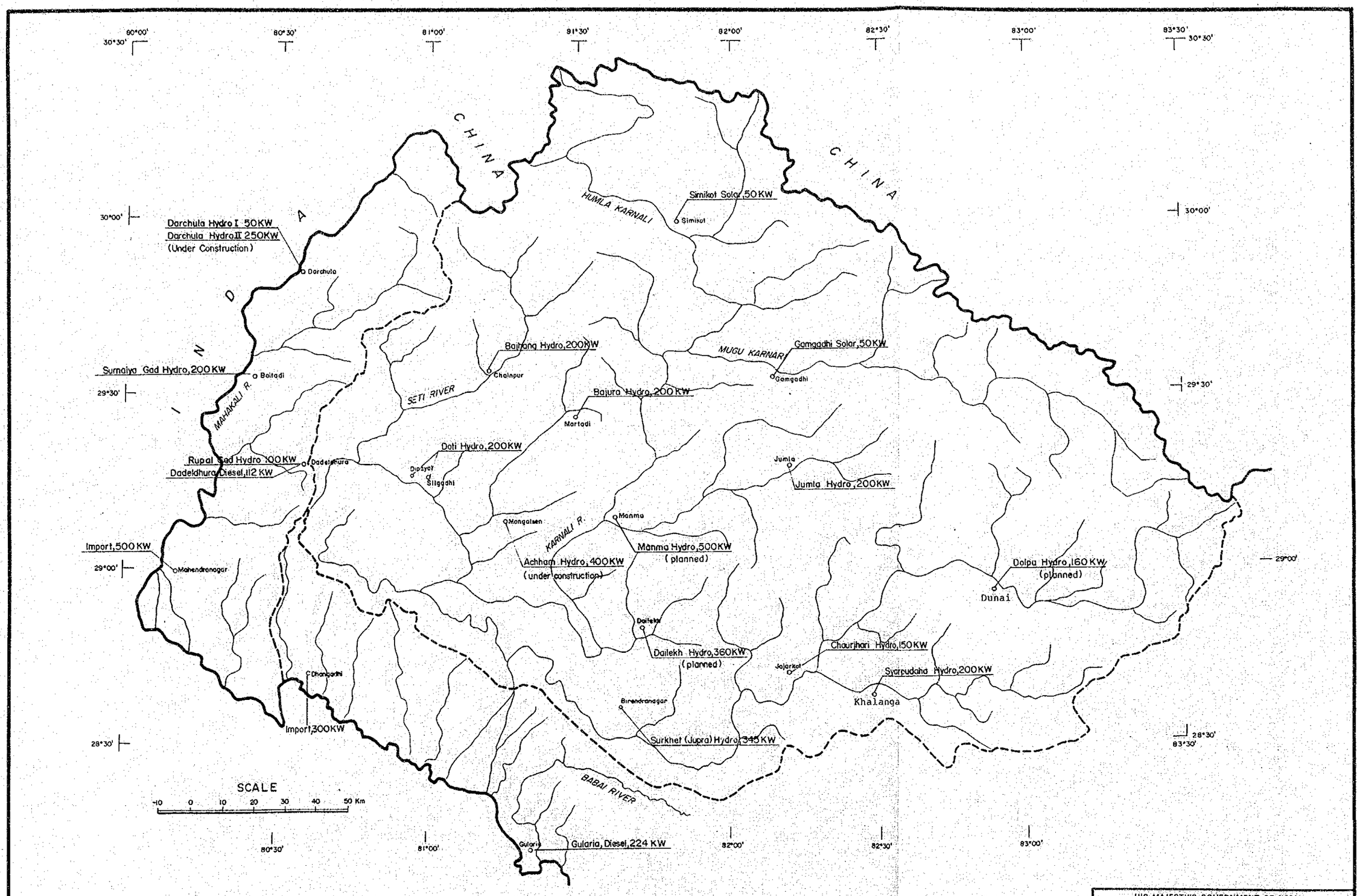


Figure 2.3.1 Rural Electrification in the Study Area

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

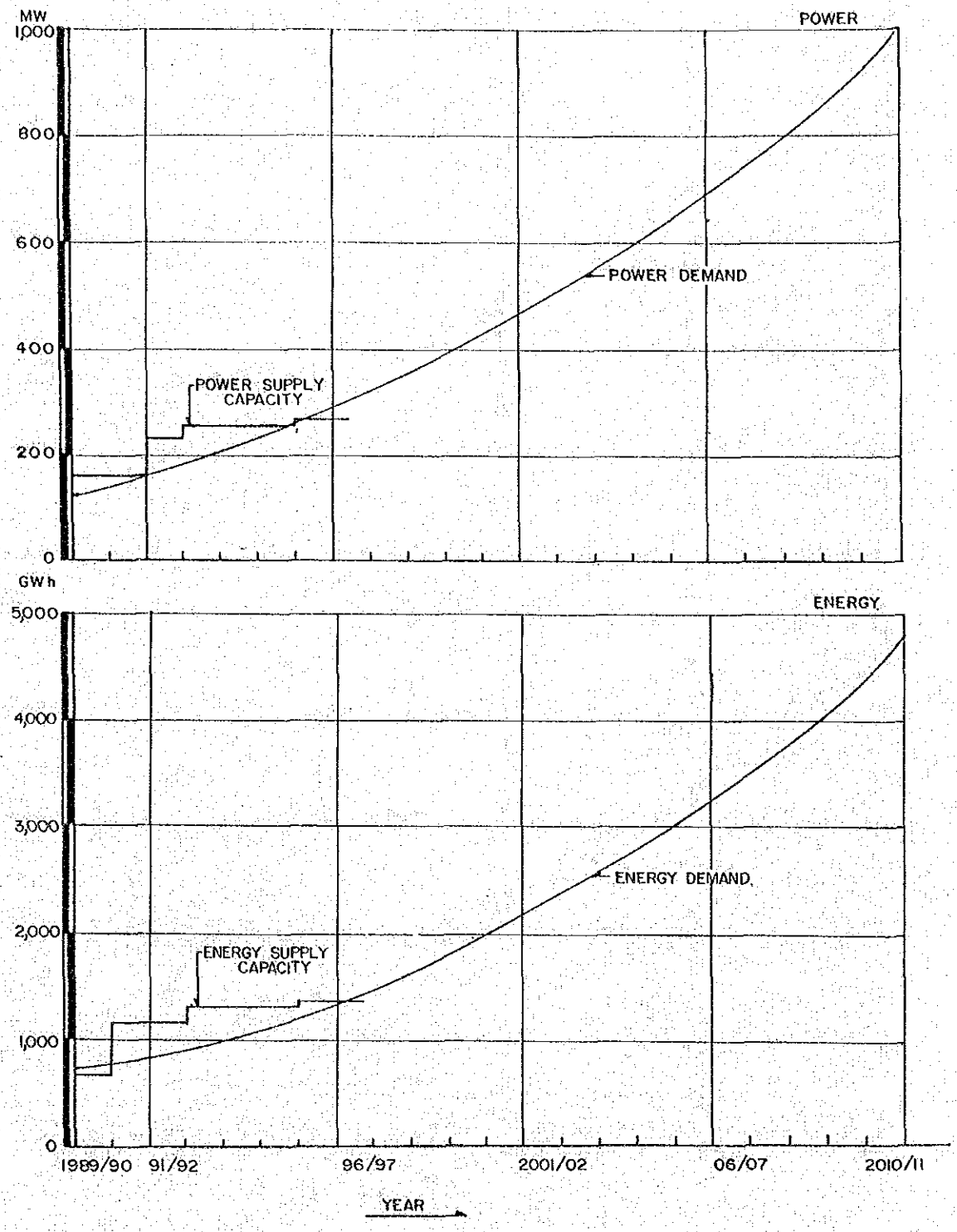


Figure 3.1.1 Relationship between Power Supply Capacity and Demand

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

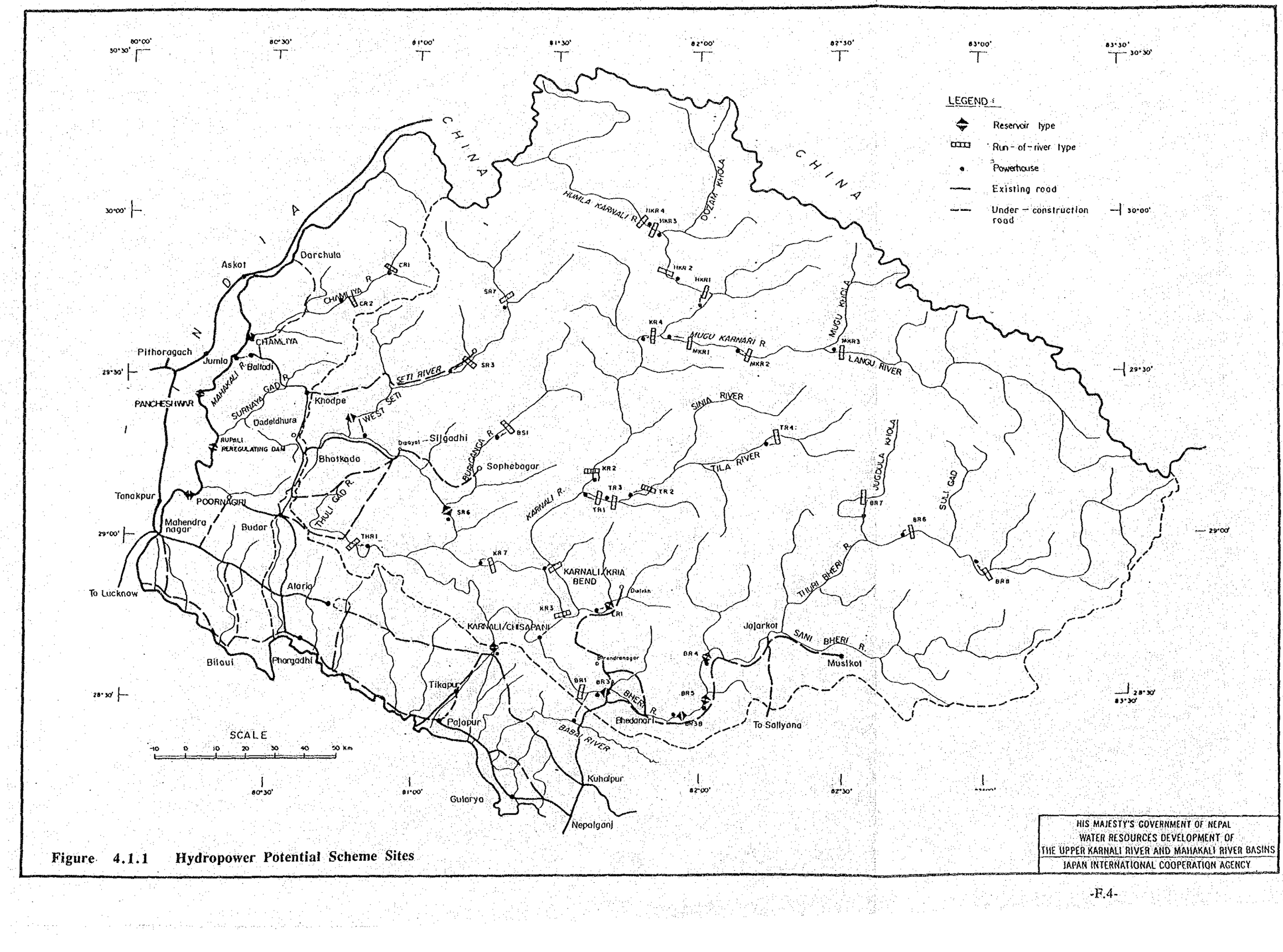


Figure 4.1.1 Hydropower Potential Scheme Sites

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

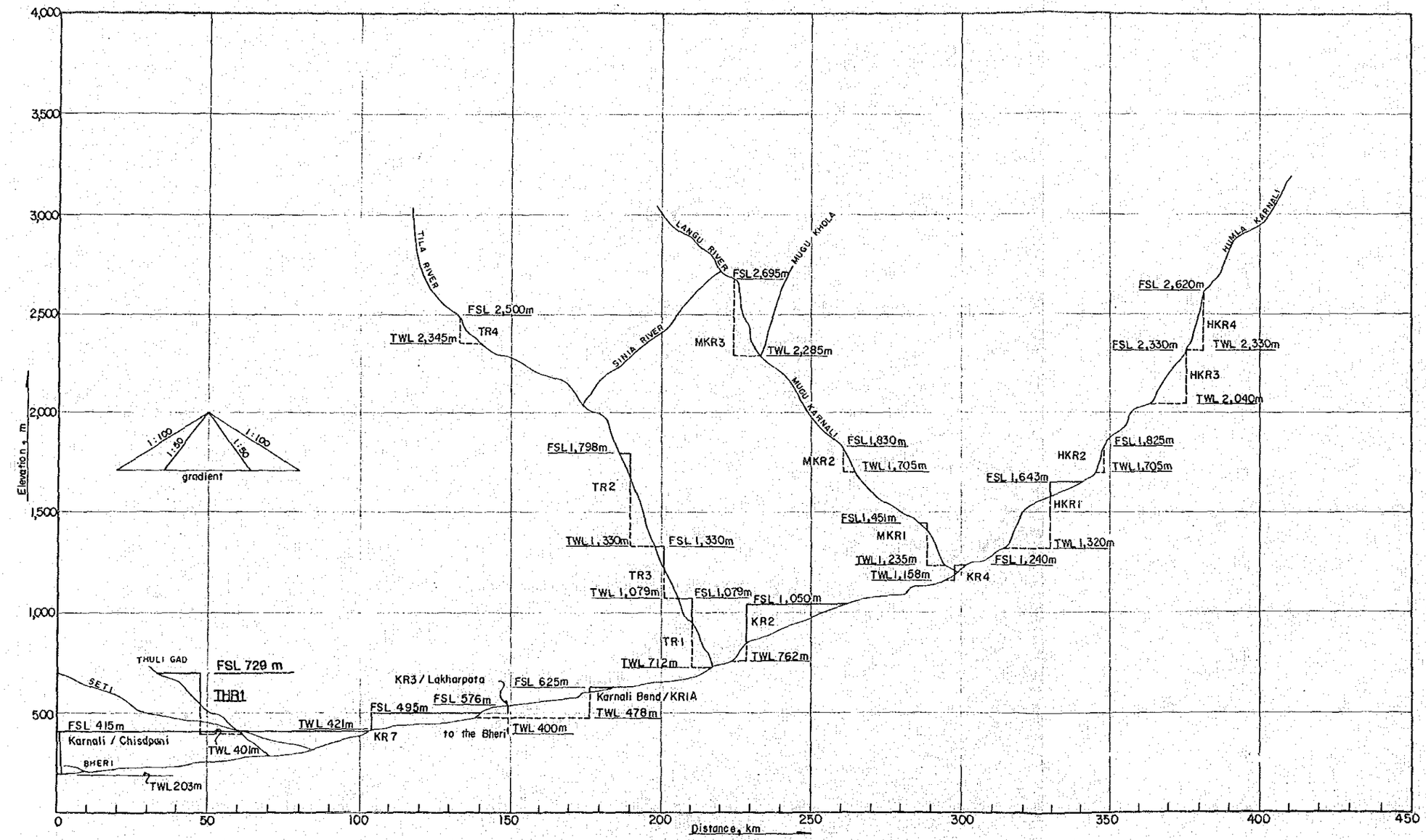


Figure 4.1.2 Longitudinal Profile for the Main Stem of the Karnali River and Potential Sites

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

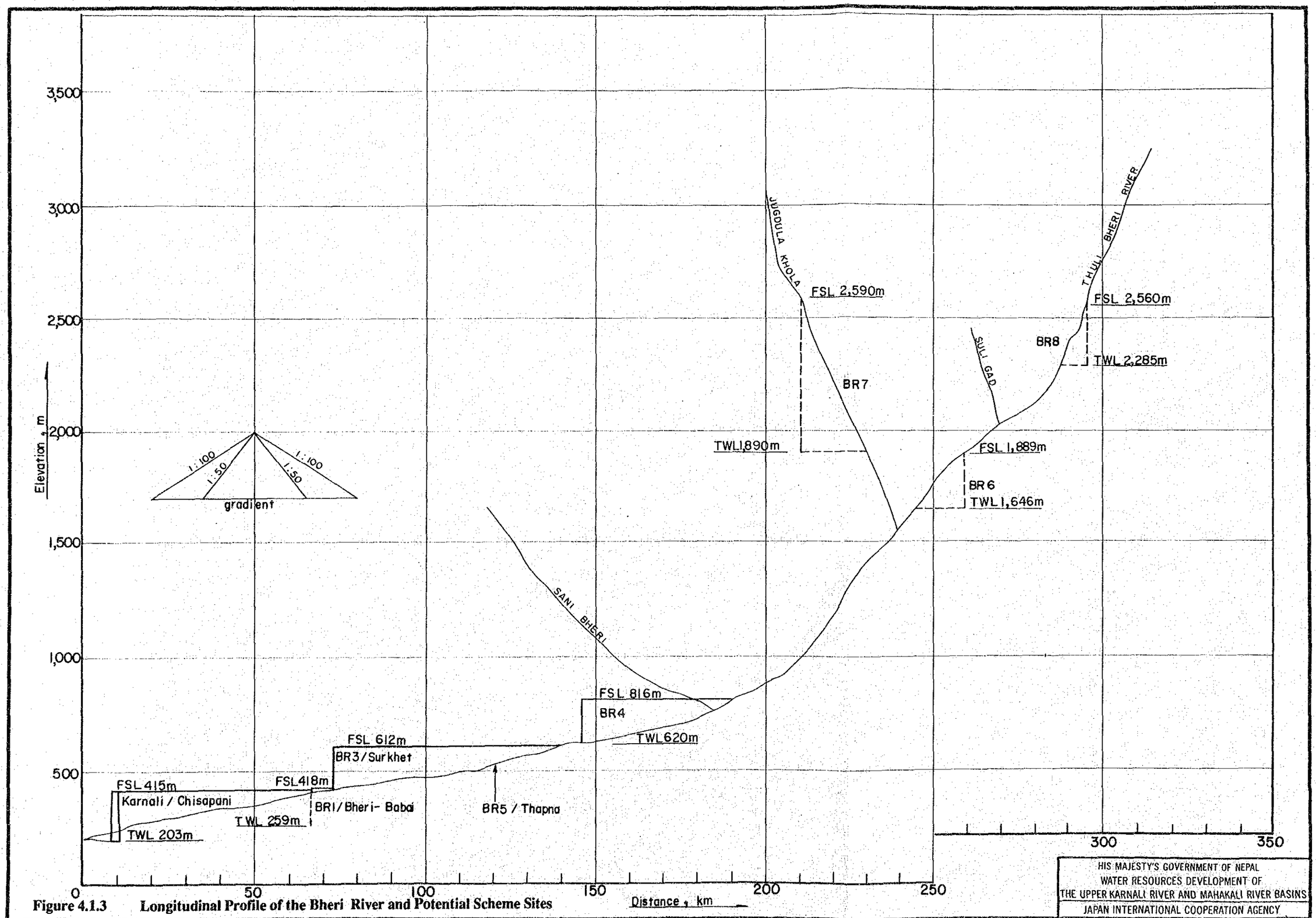


Figure 4.1.3 Longitudinal Profile of the Bheri River and Potential Scheme Sites

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

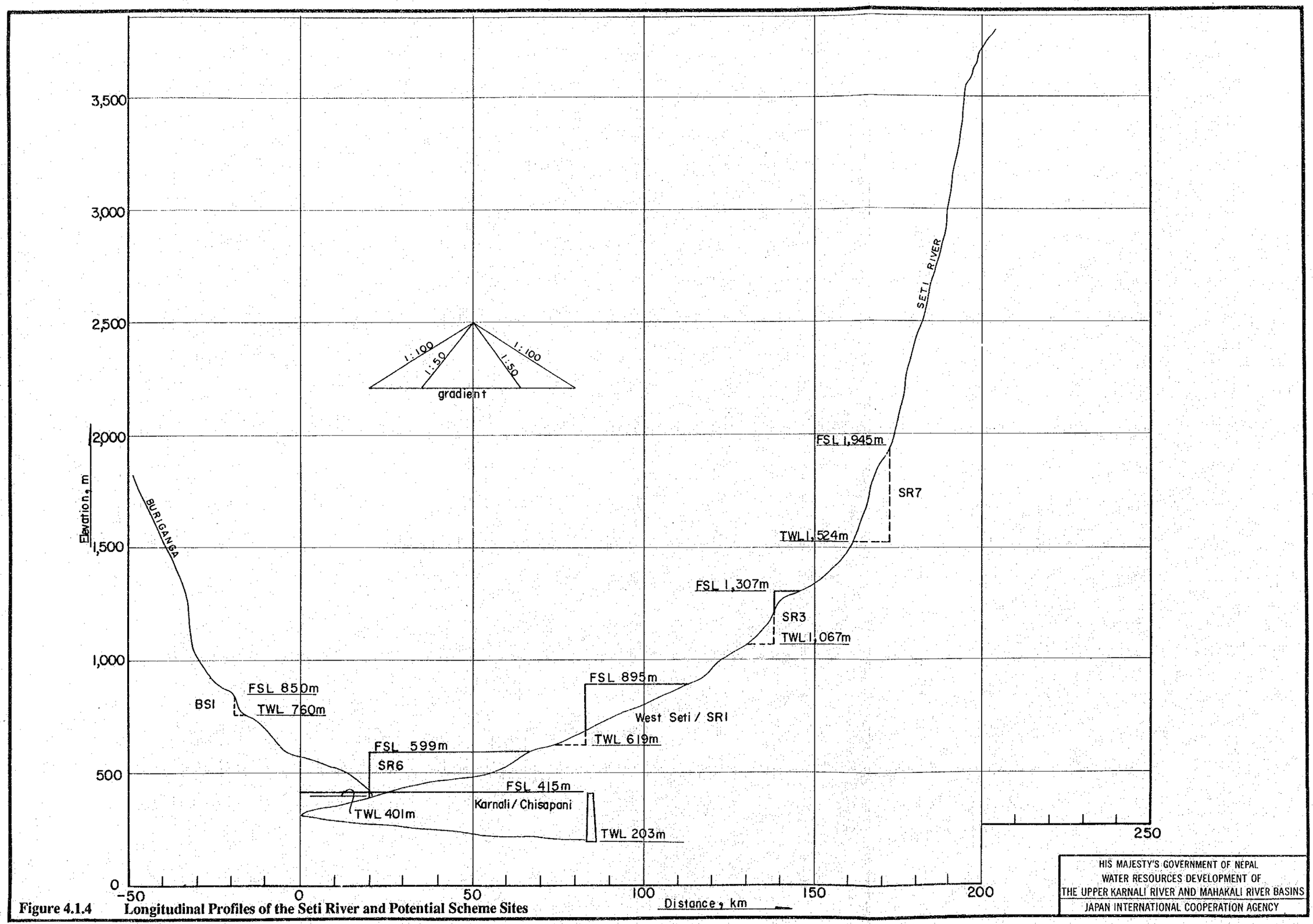


Figure 4.1.4 Longitudinal Profiles of the Seti River and Potential Scheme Sites

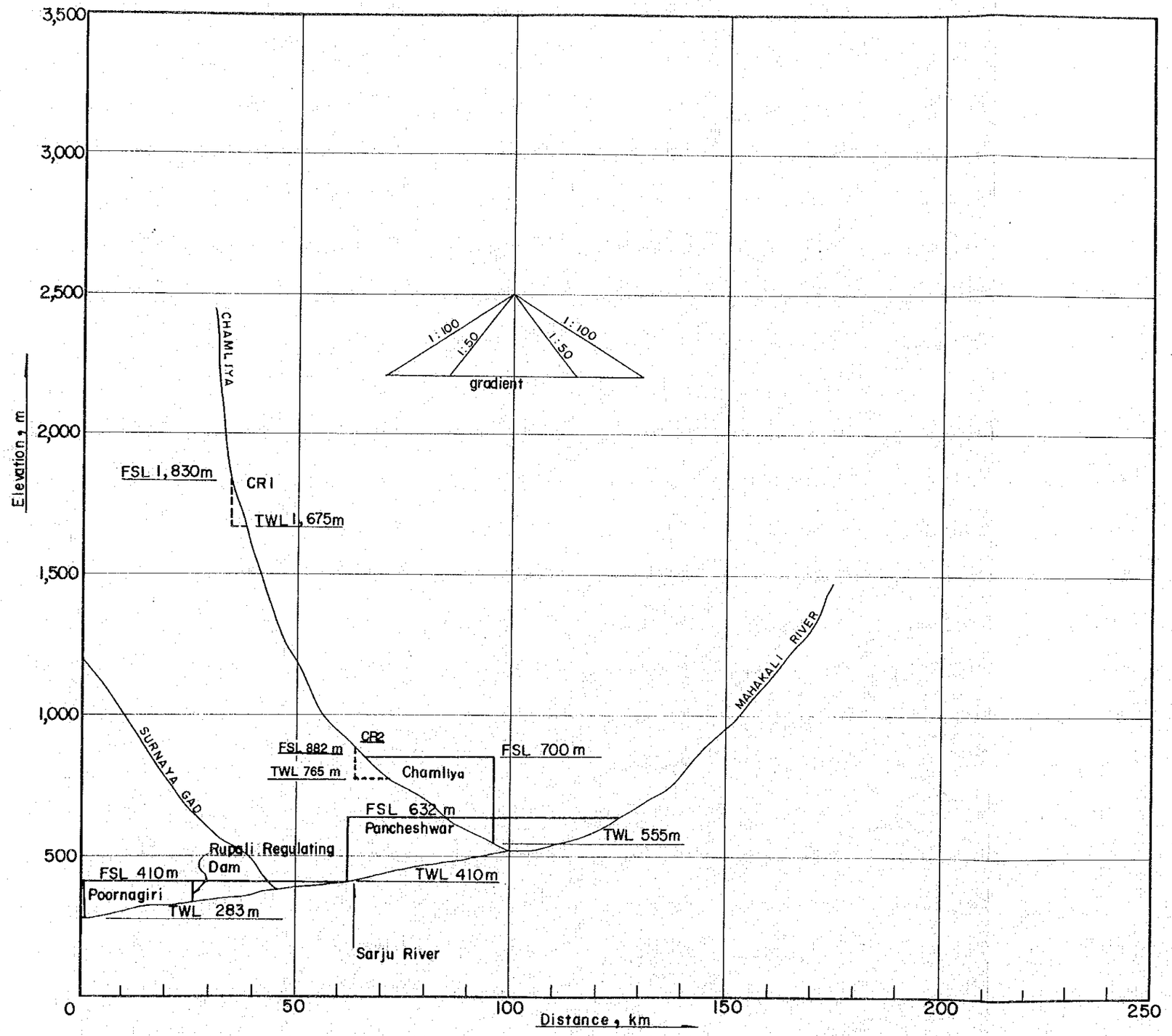


Figure 4.1.5 **Longitudinal Profiles of the Mahakali River and Potential Scheme Sites**

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

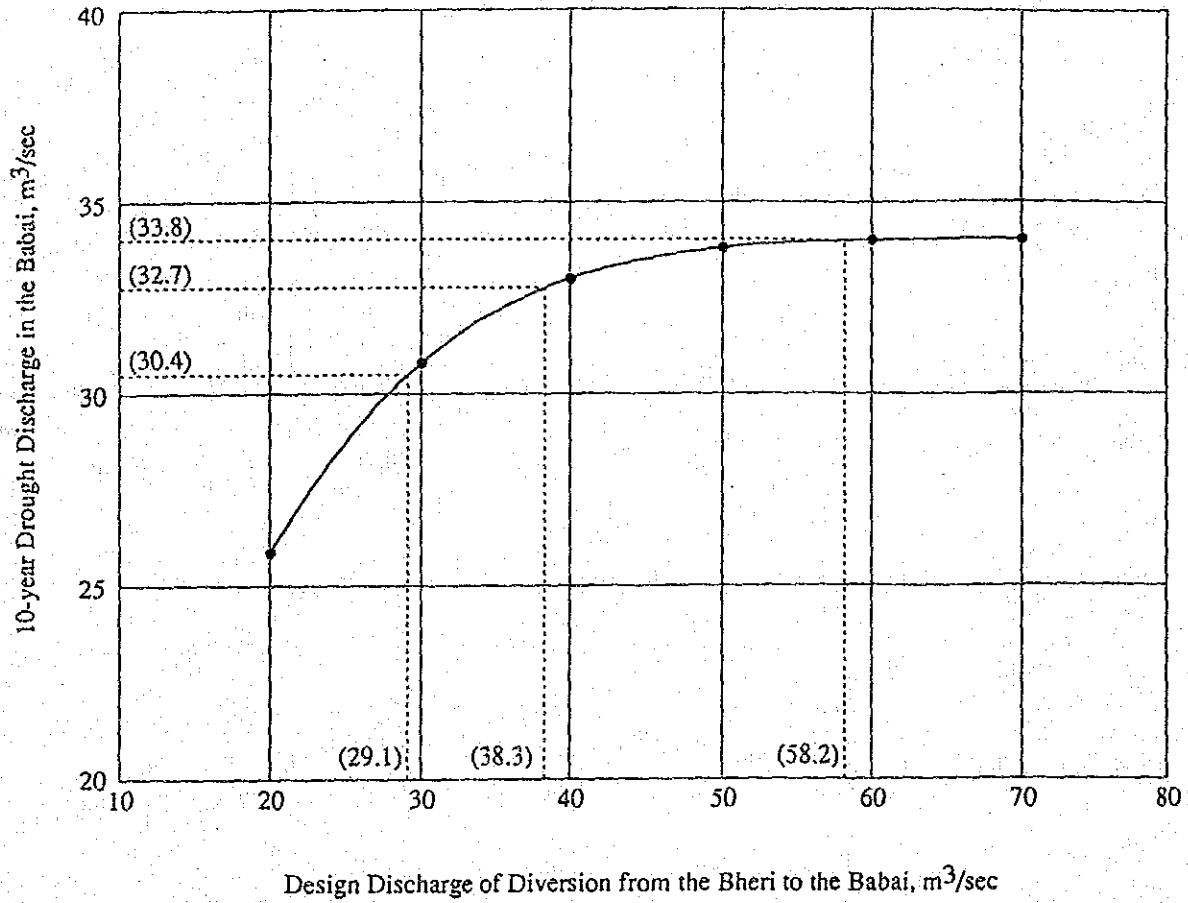


Figure 4.4.1
10-year Drought Discharge of the Babai with the Diversion from the Bheri

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

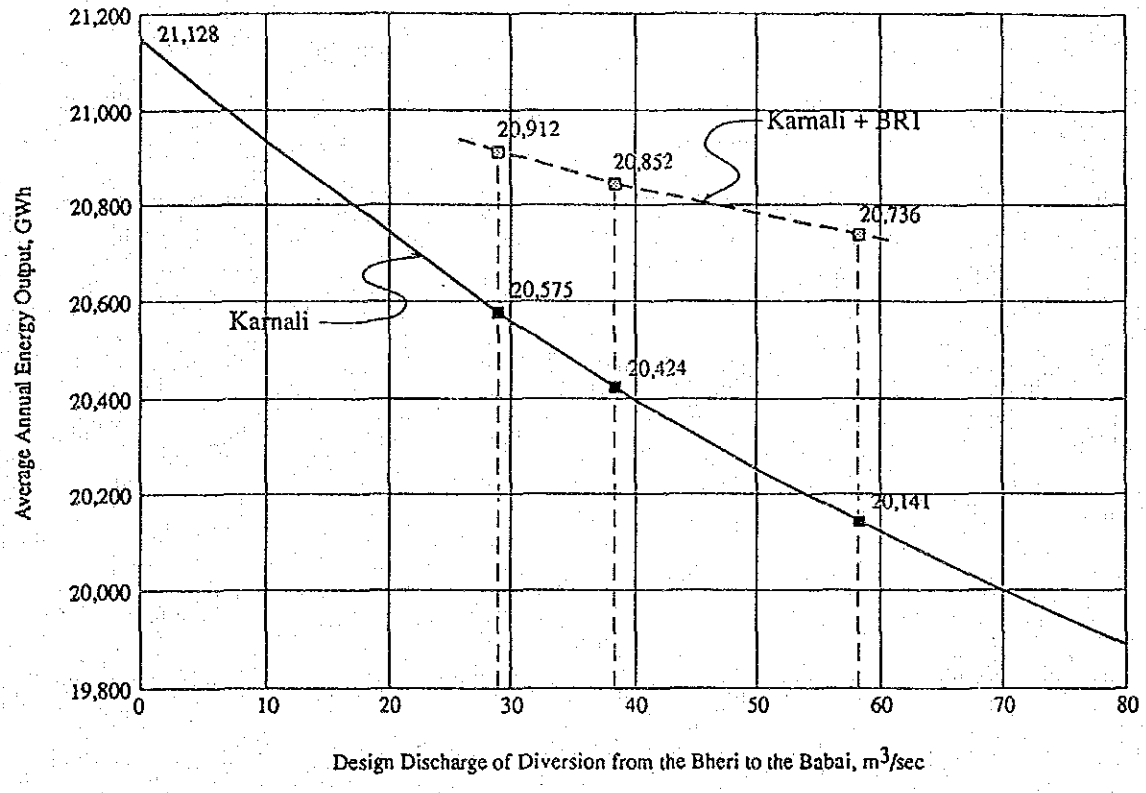


Figure 4.4.2
Energy Reduction of the Karnali Project with the Introduction of the Bheri/Babai Diversion Scheme

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

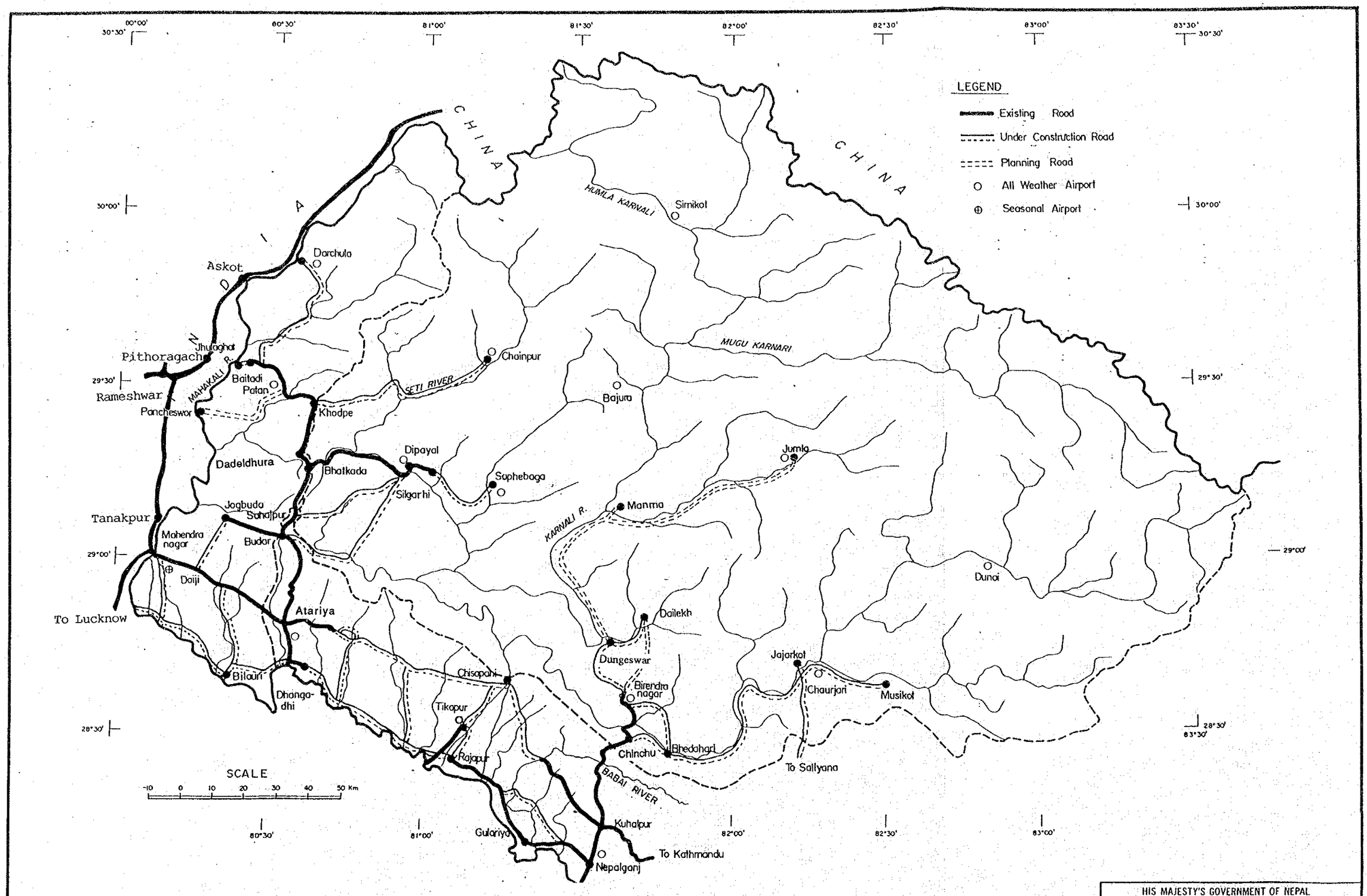
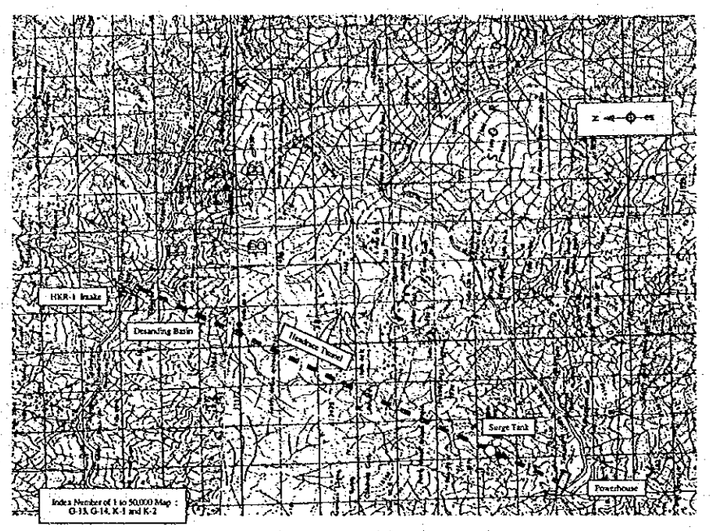
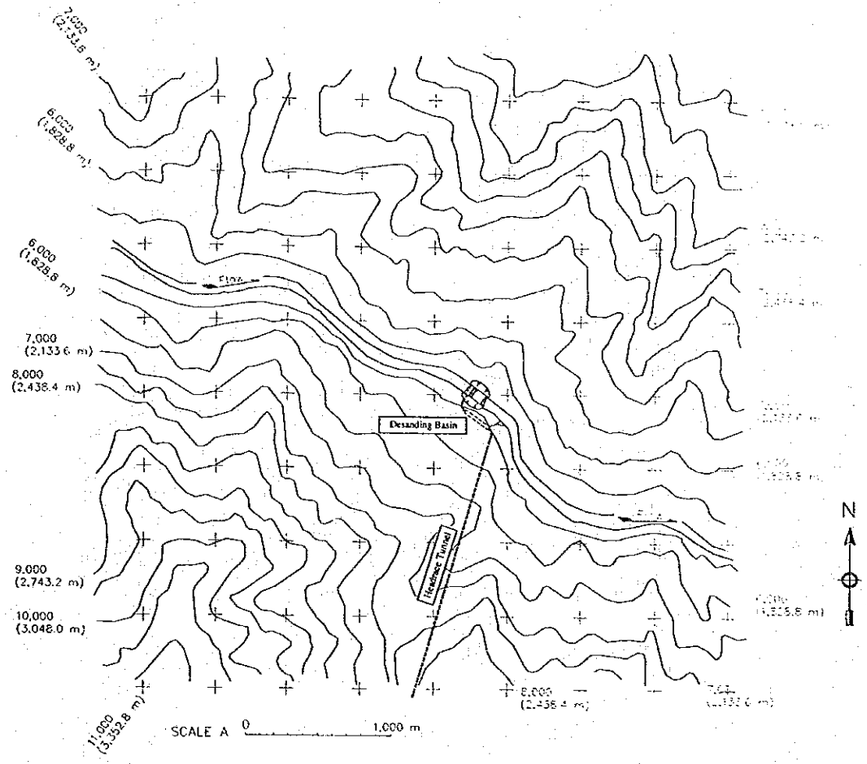


Figure 5.1.1 Road Networks and Airports in the Study Area

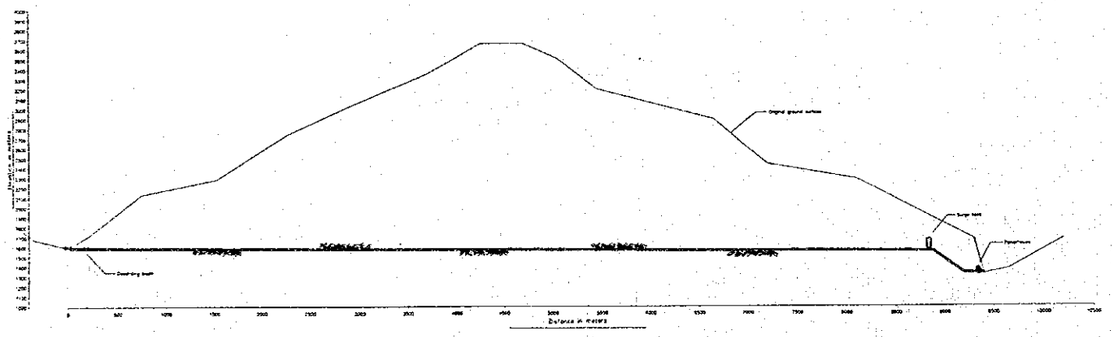
HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



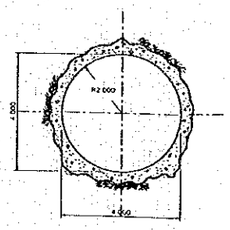
General Layout of HKR-1 Scheme



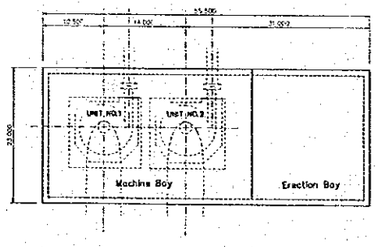
General Plan at Intake Damsite



Waterway Profile



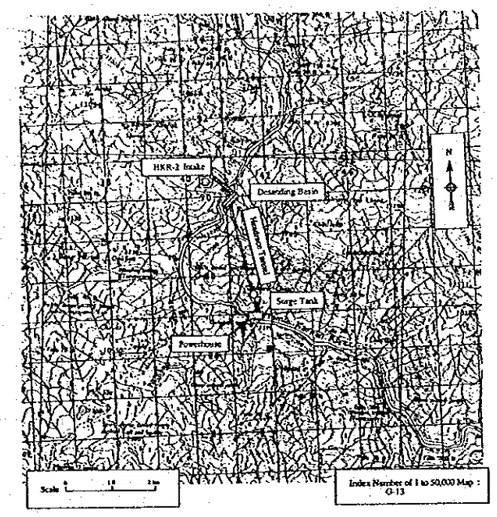
Typical Cross Section
of Headrace Tunnel



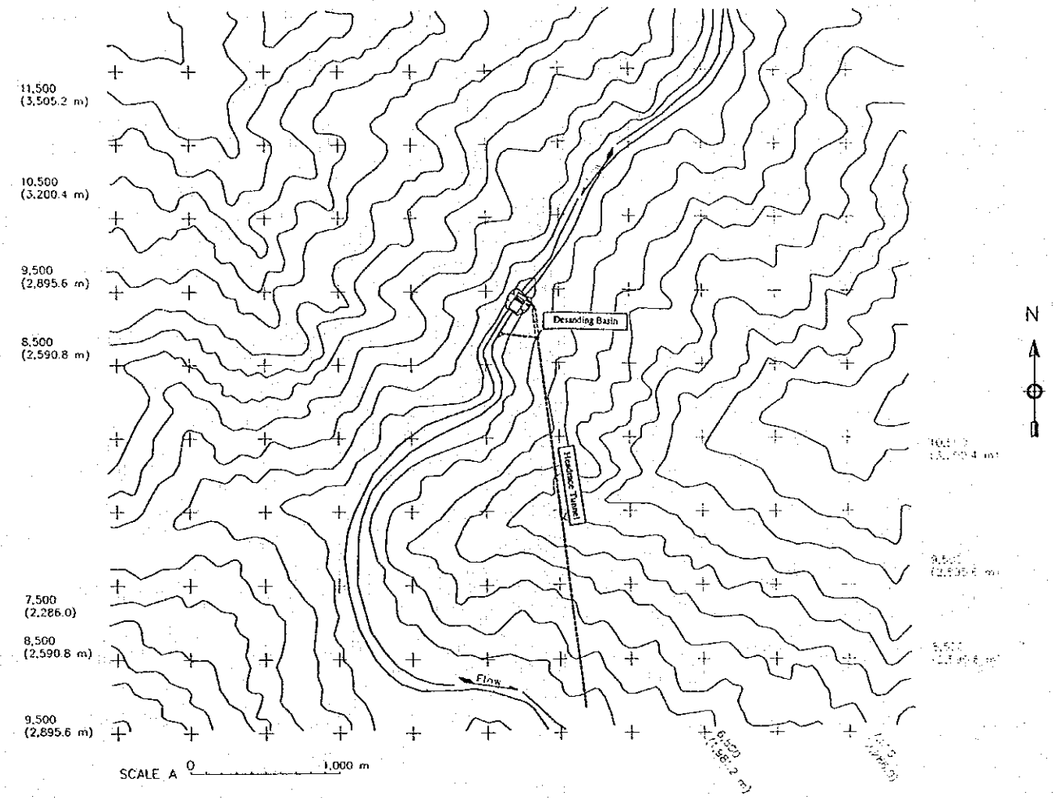
Plan of Powerhouse

Figure 5.1.2 Preliminary Plan of HKR-1 Scheme

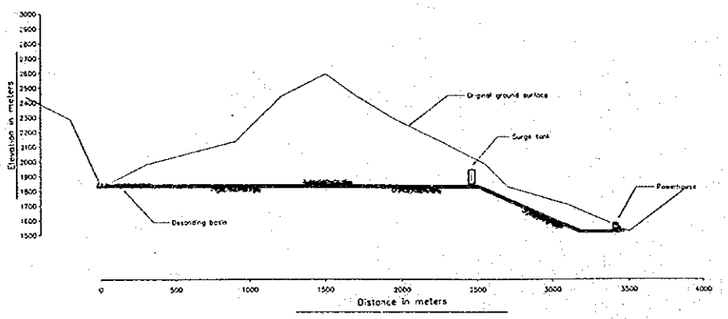
HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



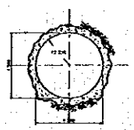
General Layout of HKR-2 Scheme



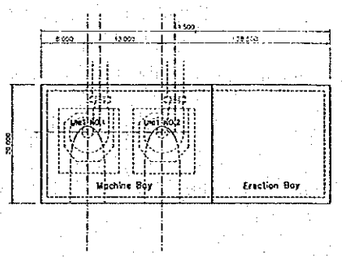
General Plan at Intake Damsite



Waterway Profile



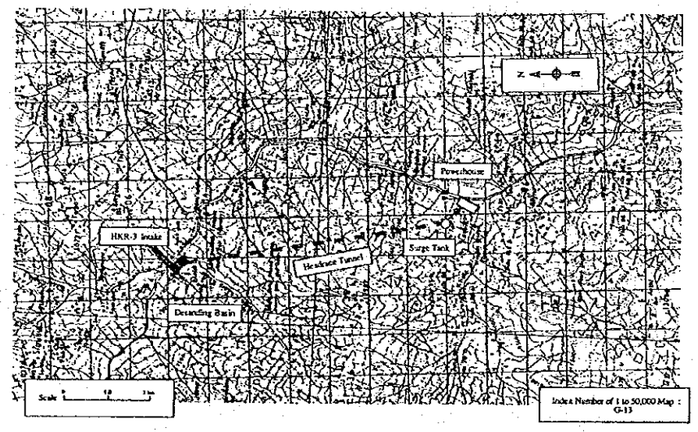
Typical Cross Section of Headrace Tunnel



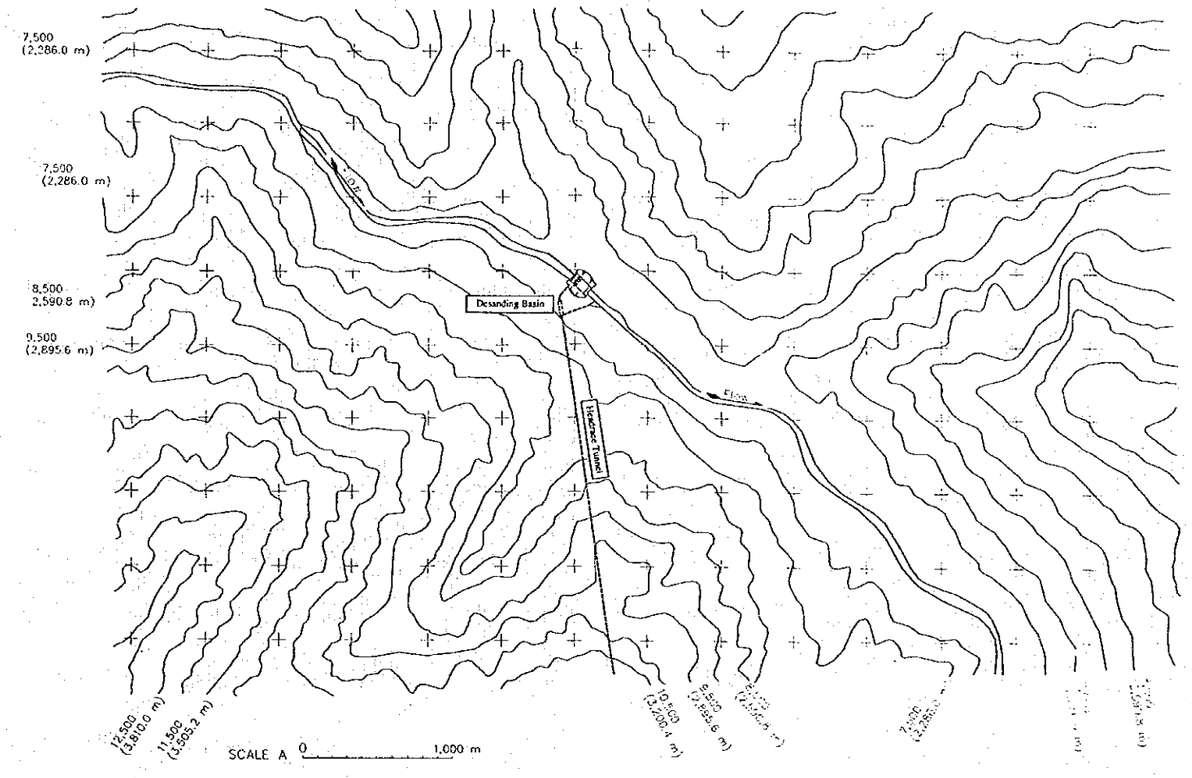
Plan of Powerhouse

Figure 5.1.3 Preliminary Plan of HKR-2 Scheme

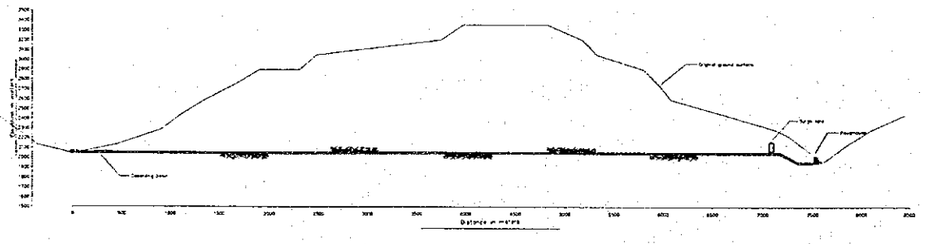
HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



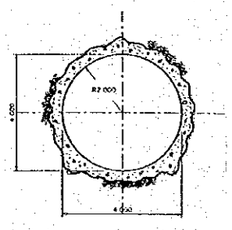
General Layout of HKR-3 Scheme



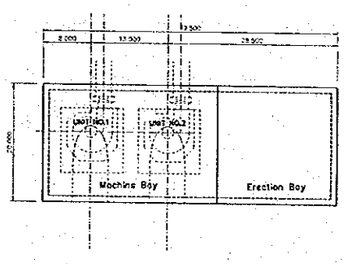
General Plan at Intake Damsite



Waterway Profile



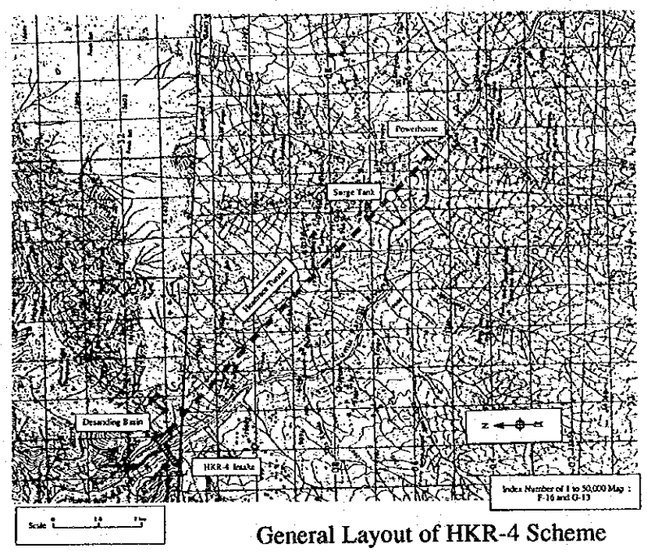
Typical Cross Section
of Headrace Tunnel



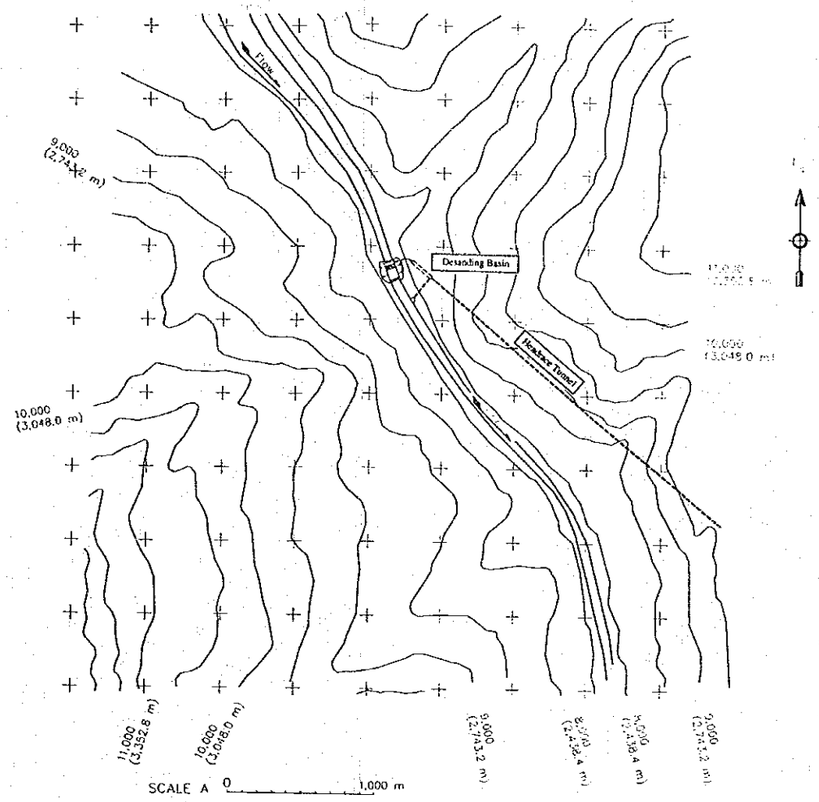
Plan of Powerhouse

Figure 5.1.4 Preliminary Plan of HKR-3 Scheme

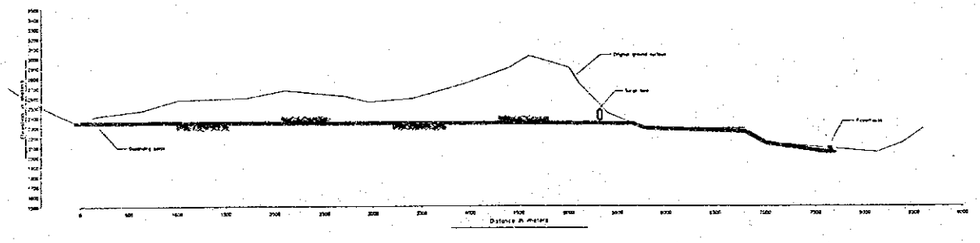
HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



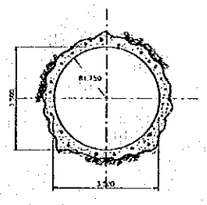
General Layout of HKR-4 Scheme



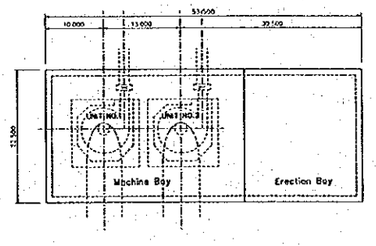
General Plan at Intake Damsite



Waterway Profile



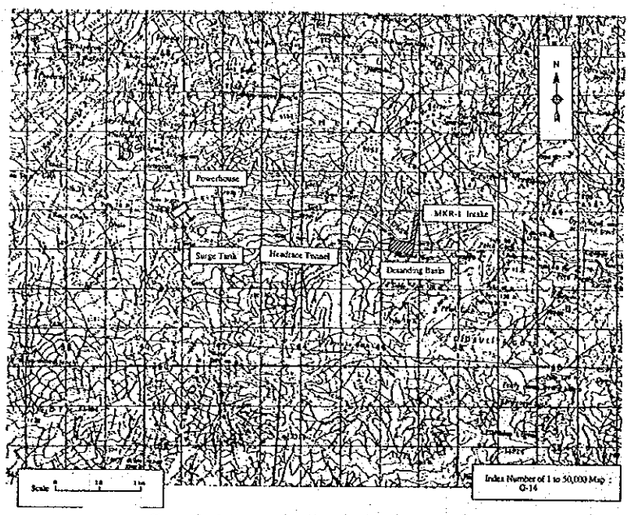
Typical Cross Section of Headrace Tunnel



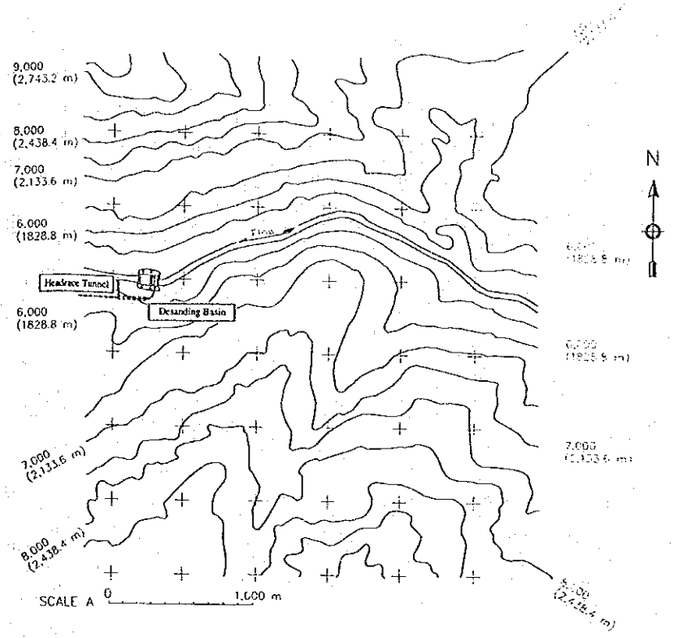
Plan of Powerhouse

Figure 5.1.5 Preliminary Plan of HKR-4 Scheme

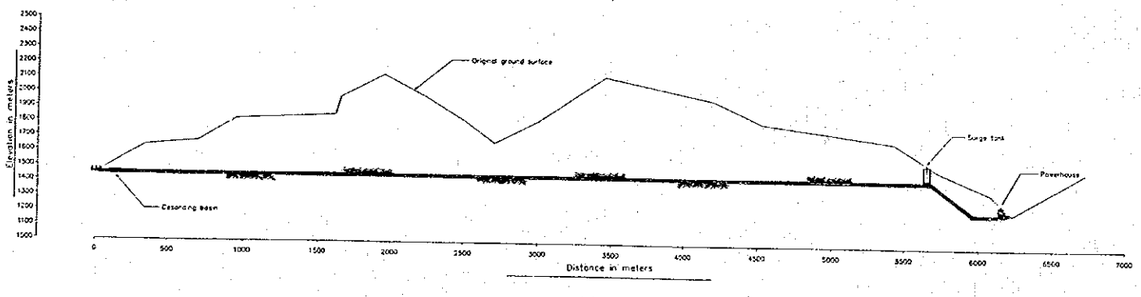
HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



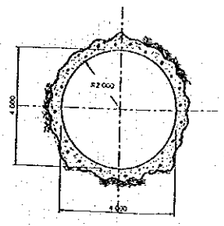
General Layout of MKR-1 Scheme



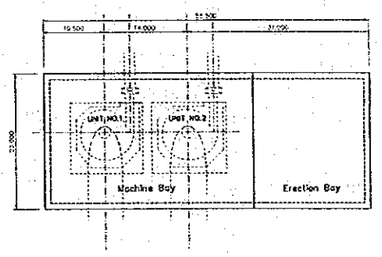
General Plan at Intake Damsite



Waterway Profile



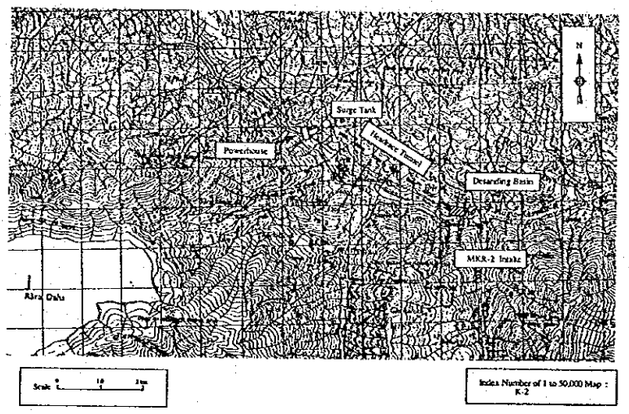
Typical Cross Section
of Headrace Tunnel



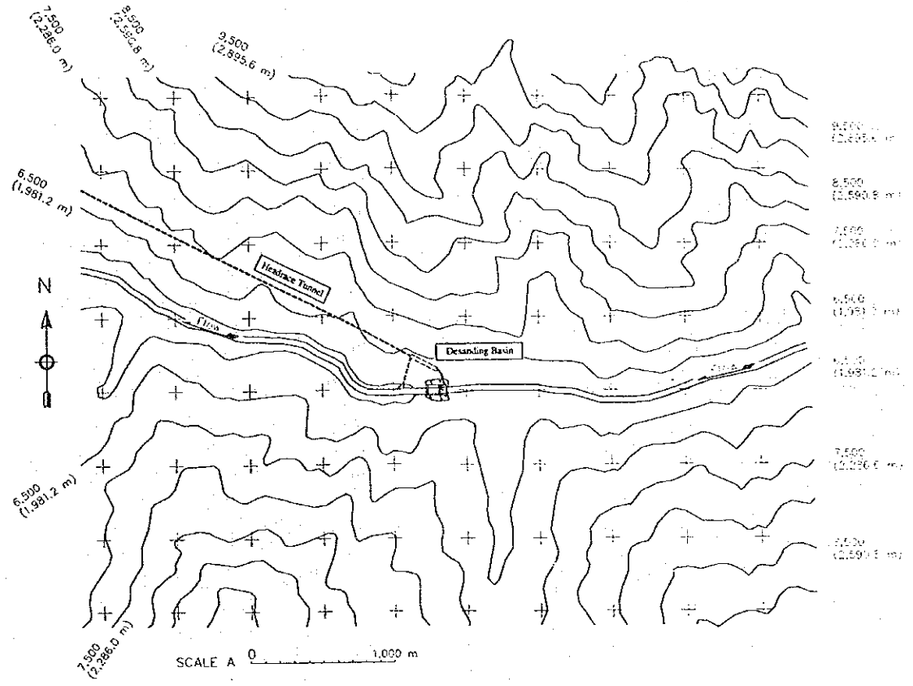
Plan of Powerhouse

Figure 5.1.6 Preliminary Plan of MKR-1 Scheme

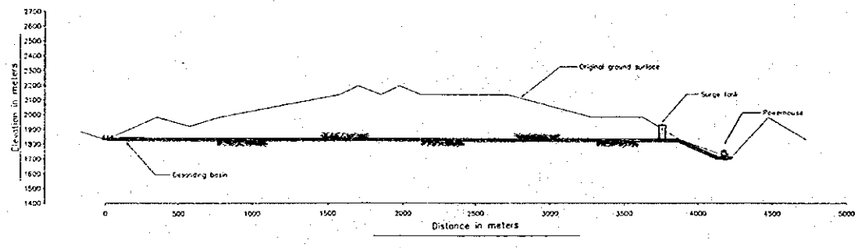
HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



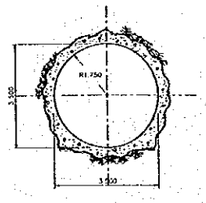
General Layout of MKR-2 Scheme



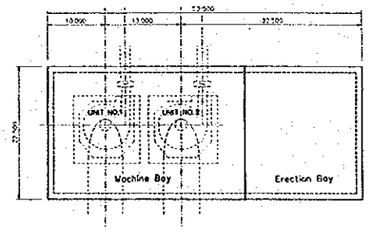
General Plan at Intake Damsite



Waterway Profile



Typical Cross Section of Headrace Tunnel



Plan of Powerhouse

Figure 5.1.7 Preliminary Plan of MKR-2 Scheme

HIS MAJESTY'S GOVERNMENT OF NEPAL
WATER RESOURCES DEVELOPMENT OF
THE UPPER KARNALI RIVER AND MAHAKALI RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY