Table 8.1-2 Diesel Power Plant Initial Capital Cost (Market Price)

(Unit : million Rs)

Item \ Year	Grand Total			1st Year	2nd Year
	Local	Foreign	Total		
1. Labour					
(1) Unskilled	6.2	—	6.2	—	6.2
(2) Skilled	14.0	3.9	17.9	—	17.9
2. Fuel Cost	3.3	11.9	15.2	—	15.2
3. Construction Equipment	11.2	32.8	44.0	—	44.0
4. Facilities	—	67.0	67.0	—	67.0
5. Materials					
(1) Cement	15.2	5.0	20.2	—	20.2
(2) Steel	3.6	8.1	11.7	—	11.7
(3) Others	8.9	8.8	17.7	—	17.7
6. Provisional Facilites	8.3	14.3	22.6	—	22.6
7. Land Compensation	—	—	—	—	—
8. Engineering fee	24.8	—	24.8	12.4	12.4
9. Contingency	9.3	16.1	25.4	—	25.4
Grand Total	104.8	167.9	272.7	12.4	260.3

(US$ 1 = Rs 48.25)

8.2 Financial Evaluation

(1) Method of Financial Analysis

As for the financial analysis, "total capital financial internal rate of return", in which total capital becomes the object of evaluation, is calculated.

① Cost

The cost consists of the initial capital cost and the O/M cost described in Section 8.1.1, which are quoted in the market price. These are calculated according to fixed prices at the commencement of Project, and price escalation is not included. The annual O/M cost is estimated at 1.5 % of the initial capital cost.

② Benefit

The benefit is revenue from sales of electricity. The revenue is calculated by multiplying average electricity tariff per unit (Rs 2.27/kWh) by electric power sold. The annual electric power sold is estimated at 42,020,000 kWh (45,771,000 kWh × 0.96), estimating rate of loss plus self-consumption in the power house at 4 % of the annual

generated power (43,771,000 kWh). Accordingly, the annual revenue from sales of electricity is calculated at Rs 95.39 million (42,020,000 kWh × Rs 2.27/kWh).

(2) Financial internal rate of return (FIRR)

The result calculated based on the above (1) is FIRR = 10.65 % (in base case). This percentage is somewhat low, and this is attributed to government policy aimed at maintaining low power rates. Comparison with the electricity tariff calculated based on LRMC (Rs 4.63/kWh) obtained from NEA bears this assumption out.

(3) Sensitivity analysis

The sensitivity analysis was carried out assuming the following factors:

		FIRR
①	One year delay of realization of the project benefit due to construction delay	10.06 %
②	10 % cost over-run for initial construction cost	9.38 %
③	20 % cost over-run for initial construction cost	8.94 %
④	The case of calculating FIRR in terms of equity, presuming that the executing agency borrows 85 % of initial capital cost over a 30 year term including 10 years grace period and annual interest of 10 %	10.01 %

Computation tables for the base case and the above ① through ④ are as shown in Table 8.2-1.

(4) Result of Financial Analysis

The value of the FIRR in which the present electricity tariff is applied as benefit, is 10.65 % in the base case, which shows a comparatively lower value than that of the FIRR mentioned in Section 8.3. Now, the electricity tariff has not been established for this Project, and as mentioned above, it is assumed that the lower value of the FIRR depends on the present electricity charge being maintained under government policy at a low level (Rs 2.27/kWh), which is borne out by comparing it with the electricity charge calculated based on LRMC (Rs 4.63/kWh). As the annual relending interest rate of ODA soft loan etc. to an executing agency through the Nepalese government is 10%, computation was carried out for case ④ in (3) Sensitivity Analysis resulting in FIRR of 10.01. In view of this result, when an executing agency tries to cover some percentage of the initial capital cost by loan, it is desirable that the agency strive to reduce the percentage of loan amount and keep the relending interest rate as low as possible, in order to maximize profit.

Table 8.2-1 (1)

FINANCIAL CALCULATION ANALYISIS — NEPAL : ILAM SMALL HYDRO-ELECTRIC POWER PROJECT — (UNIT : MILL. NRs)

BASE CASE: IRR = 10.65 %

CASE-1 : ONE YEAR DELAY CASE: IRR = 10.06 %

YEAR	BASE CASE INVEST. & REPLACE	BASE CASE O & M COST	BASE CASE TOTAL COST	BASE CASE TOTAL BENEFIT	BASE CASE NET CASH IN-FLOW	CASE-1 INVEST. & REPLACE	CASE-1 O & M COST	CASE-1 TOTAL COST	CASE-1 TOTAL BENEFIT	CASE-1 NET CASH IN-FLOW
1	252.10		252.10		-252.10	201.68		201.68		-201.68
2	249.70		249.70		-249.70	199.76		199.76		-199.76
3	204.60		204.60		-204.60	163.68		163.68		-163.68
4		10.60	10.60	95.39	84.79	141.28		141.28		-141.28
5		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
6		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
7		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
8		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
9		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
10		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
11		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
12		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
13		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
14		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
15		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
16		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
17		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
18		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
19		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
20		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
21		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
22		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
23		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
24		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
25		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
26		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
27		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
28		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
29		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
30		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
31		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
32		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
33		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
34		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
35		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
36		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
37		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
38		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
39		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
40		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
41		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
42		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
43		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
44		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
45		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
46		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
47		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
48		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
49		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
50		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
TOTAL	706.40	498.20	1,204.60	4,483.33	3,278.73	706.40	487.60	1,194.00	4,387.94	3,193.94

CASE-2 : 10% COST OVER-RUN CASE: IRR = 9.73 %

CASE-3 : 20% COST OVER-RUN CASE: IRR = 8.94 %

YEAR	CASE-2 INVEST. & REPLACE	CASE-2 O & M COST	CASE-2 TOTAL COST	CASE-2 TOTAL BENEFIT	CASE-2 NET CASH IN-FLOW	CASE-3 INVEST. & REPLACE	CASE-3 O & M COST	CASE-3 TOTAL COST	CASE-3 TOTAL BENEFIT	CASE-3 NET CASH IN-FLOW
1	277.31		277.31		-277.31	302.52		302.52		-302.52
2	274.67		274.67		-274.67	299.64		299.64		-299.64
3	225.06		225.06		-225.06	245.52		245.52		-245.52
4		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
5		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
6		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
7		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
8		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
9		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
10		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
11		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
12		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
13		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
14		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
15		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
16		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
17		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
18		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
19		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
20		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
21		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
22		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
23		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
24		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
25		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
26		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
27		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
28		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
29		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
30		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
31		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
32		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
33		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
34		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
35		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
36		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
37		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
38		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
39		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
40		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
41		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
42		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
43		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
44		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
45		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
46		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
47		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
48		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
49		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
50		10.60	10.60	95.39	84.79		10.60	10.60	95.39	84.79
TOTAL	777.04	498.20	1,275.24	4,483.33	3,208.09	847.68	498.20	1,345.88	4,483.33	3,137.45

Table 8.2-1 (2)

EQUITY BASE

IRR = 10.01 %

YEAR	INVEST. & REPLACE	REPAY P. & I.	O & M COST	TOTAL COST	LOAN AMOUNT	ELECTRIC TARIFF	TOTAL BENEFIT	NET CASH IN-FLOW
1	252.10	21.43		273.53	214.29		214.29	-59.24
2	249.70	42.65		292.35	212.25		212.25	-80.11
3	204.60	60.04		264.64	173.91		173.91	-90.73
4		60.04	10.60	70.64		95.39	95.39	24.75
5		60.04	10.60	70.64		95.39	95.39	24.75
6		60.04	10.60	70.64		95.39	95.39	24.75
7		60.04	10.60	70.64		95.39	95.39	24.75
8		60.04	10.60	70.64		95.39	95.39	24.75
9		60.04	10.60	70.64		95.39	95.39	24.75
10		60.04	10.60	70.64		95.39	95.39	24.75
11		87.06	10.60	97.66		95.39	95.39	-2.27
12		84.06	10.60	94.66		95.39	95.39	0.73
13		81.06	10.60	91.66		95.39	95.39	3.73
14		78.06	10.60	88.66		95.39	95.39	6.73
15		75.06	10.60	85.66		95.39	95.39	9.74
16		72.05	10.60	82.65		95.39	95.39	12.74
17		69.05	10.60	79.65		95.39	95.39	15.74
18		66.05	10.60	76.65		95.39	95.39	18.74
19		63.05	10.60	73.65		95.39	95.39	21.74
20		60.04	10.60	70.64		95.39	95.39	24.75
21		57.04	10.60	67.64		95.39	95.39	27.75
22		54.04	10.60	64.64		95.39	95.39	30.75
23		51.04	10.60	61.64		95.39	95.39	33.75
24		48.04	10.60	58.64		95.39	95.39	36.75
25		45.03	10.60	55.63		95.39	95.39	39.76
26		42.03	10.60	52.63		95.39	95.39	42.76
27		39.03	10.60	49.63		95.39	95.39	45.76
28		36.03	10.60	46.63		95.39	95.39	48.76
29		33.02	10.60	43.62		95.39	95.39	51.77
30		30.02	10.60	40.62		95.39	95.39	54.77
31			10.60	10.60		95.39	95.39	84.79
32			10.60	10.60		95.39	95.39	84.79
33			10.60	10.60		95.39	95.39	84.79
34			10.60	10.60		95.39	95.39	84.79
35			10.60	10.60		95.39	95.39	84.79
36			10.60	10.60		95.39	95.39	84.79
37			10.60	10.60		95.39	95.39	84.79
38			10.60	10.60		95.39	95.39	84.79
39			10.60	10.60		95.39	95.39	84.79
40			10.60	10.60		95.39	95.39	84.79
41			10.60	10.60		95.39	95.39	84.79
42			10.60	10.60		95.39	95.39	84.79
43			10.60	10.60		95.39	95.39	84.79
44			10.60	10.60		95.39	95.39	84.79
45			10.60	10.60		95.39	95.39	84.79
46			10.60	10.60		95.39	95.39	84.79
47			10.60	10.60		95.39	95.39	84.79
48			10.60	10.60		95.39	95.39	84.79
49			10.60	10.60		95.39	95.39	84.79
50			10.60	10.60		95.39	95.39	84.79
TOTAL	706.40	1,715.29	498.20	2,919.89	600.44	4,483.33	5,083.77	2,163.88

8.3 Economic Evaluation

(1) Method of Economic Analysis

① Cost

As for the cost of the Project, namely, prices of material and equipment put into the Project, "international prices", namely CIF price in the case of imported goods and FOB price in the case of exported goods are applied as approximate value of shadow price for traded goods. The domestic market prices of non-traded goods, domestic services, land, etc. are converted into international standard prices, namely, "accounting prices", which are then applied. As for conversion factors used to convert domestic market prices into accounting prices, standard conversion factor (SCF) = 0.90 and conversion factor (CF) for wages of unskilled labourers = 0.75 are applied.

Accordingly, the cost, namely, the initial cost and the O/M cost based on the accounting price (See Table 8.3-1) calculated by using the above conversion factors, is applied for calculating FIRR.

In addition, SCF can be calculated by using the following formula.

Formula for calculating SCF : $SCF = \dfrac{M + X}{M(1+t)+(1+S-tx)}$

M : Total amount of imported goods (CIF)
X : Total amount of exported goods (FOB)
t : Weighted average of import custom tariff
S : Weighted average of export subsidy rate
tx : Weighted average of export custom tariff

SCF was calculated based on five years total export and import amount, etc. in Nepal from 1985/1986 to 1989/1990 by using the above formula, the result of which was SCF $\cong$ 0.9. (Furthermore, as SCF value from 0.89 to 0.90 and CF value from 0.6 to 0.75 for wages of unskilled labourers are applied in economic analysis of projects in Nepal by international organizations such as the World Bank, 0.75 was adopted as CF for wages of unskilled labourers under the Project.)

Table 8.3-1 Small Hydropower Plant Initial Capital Cost (Accounting Price)

(Unit : Rs million)

Item \ Year	Grand Total			1st Year	2nd Year	3rd Year
	Local	Foreign	Total			
1. Labour						
(1) Unskilled	12.1	—	12.1	3.5	4.8	3.8
(2) Skilled	36.1	12.0	48.1	14.0	19.0	15.1
2. Fuel Cost	7.0	27.6	34.6	10.2	13.7	10.7
3. Construction Equipment	24.5	72.4	96.9	28.4	38.3	30.2
4. Facilities	15.5	137.0	152.5	44.6	60.3	47.6
5. Materials						
(1) Cement	37.3	12.2	49.5	14.5	19.6	15.4
(2) Steel	6.8	15.4	22.2	6.5	8.7	7.0
(3) Others	20.8	20.4	41.2	12.1	16.4	12.7
6. Provisional Facilities	16.5	30.0	46.5	41.9	—	4.6
7. Land Compensation	6.8	—	6.8	4.8	—	2.0
8. Engineering fee	57.8	—	57.8	29.2	14.3	14.3
9. Contingency	21.5	44.3	65.8	16.3	29.3	20.2
Grand Total	262.7	371.3	634.0	226.0	224.4	183.6

(US$ 1 = Rs 48.25)

② Alternative Benefit

As for alternative benefit, accounting prices (See Table 8.3-2) are applied to the initial capital cost of the diesel power plant (3,100 kW × 2 units, comprising the alternative facilities), replacement cost and the fuel cost.

Table 8.3-2 Diesel Power Plant Initial Capital Cost (Accounting Price)

(Unit : million Rs)

Ite \ Year	Grand Total			1st Year	2nd Year
	Local	Foreign	Total		
1. Labour					
(1) Unskilled	4.7	—	4.7	—	4.7
(2) Skilled	12.6	3.9	16.5	—	16.5
2. Fuel Cost	3.0	10.6	13.6	—	13.6
3. Construction Equipment	10.1	29.1	39.2	—	39.2
4. Facilities	—	59.4	59.4	—	59.4
5. Materials					
(1) Cement	13.7	4.4	18.1	—	18.1
(2) Steel	3.2	7.2	10.4	—	10.4
(3) Others	8.0	7.8	15.8	—	15.8
6. Provisional Facilites	7.5	12.7	20.2	—	20.2
7. Land Compensation	—	—		—	—
8. Engineering fee	22.3	—	22.3	11.1	11.2
9. Contingency	8.4	16.1	24.5	—	24.5
Grand Total	93.5	151.2	244.7	11.1	233.6

(US$ 1 = Rs 48.25)

(2) Economic Internal Rate of Return (EIRR)

As the result of the calculation based on the above ① and ②, EIRR = 19.70 % is obtained (in base case). Accordingly, it is recognized that the Project is economically feasible.

(3) Sensitivity Analysis

Presuming fluctuating factors affecting directly the economic feasibility of this Project as shown below, sensitivity analysis was carried out for the base case in which the diesel power plant is the alternative electric power energy source.

		FIRR
①	One year delay of realization of the project benefit due to construction delay	17.58 %
②	10 % cost over-run for initial construction cost	17.71 %
③	20 % cost over-run for initial construction cost	16.07 %
④	10 % rise in fuel cost (price of diesel oil) at the initiation year of operation	21.14 %

⑤ In the case of using the benefit calculated with the electricity tariff (4.63 Rs./kWh) based on LRMC 23.07 %

The computational tables of the base case and the above ① through ⑤ are as shown in Table 8.3-3.

(4) Result of Economic Analysis

This project is very feasible from the national economic viewpoint, in view of the fact that alternative EIRR shows a high value (19.70 % in base case). This means that this hydropower project should be implemented instead of the alternative diesel power project when undertaking new power source development. Also savings of fuel imports would be derived by the implementation of hydropower development. The economic feasibility of the Project remains unchanged under sensitivity analyses, even if some negative factors were to affect the Project.

Table 8.3-3 (1)

ECONOMIC ANALYISIS NEPAL : ILAM SMALL HYDRO-ELECTRIC POWER PROJECT

(UNIT : MILL. NRs)

BASE CASE

IRR = 19.70 %

YEAR	INVEST. & REPLACE	O & M COST	TOTAL COST	ALTANATIVE BENEFIT INVEST. & REPLACE	FUEL COST	O & M COST	TOTAL BENEFIT	NET CASH IN-FLOW
1	226.00		226.00	0.00			0.00	-226.00
2	224.40		224.40	11.10			11.10	-213.30
3	183.60		183.60	233.60			233.60	50.00
4		9.51	9.51		100.67	12.03	112.70	103.19
5		9.51	9.51		100.67	12.03	112.70	103.19
6		9.51	9.51		100.67	12.03	112.70	103.19
7		9.51	9.51		100.67	12.03	112.70	103.19
8		9.51	9.51		100.67	12.03	112.70	103.19
9		9.51	9.51		100.67	12.03	112.70	103.19
10		9.51	9.51		100.67	12.03	112.70	103.19
11		9.51	9.51		100.67	12.03	112.70	103.19
12		9.51	9.51		100.67	12.03	112.70	103.19
13		9.51	9.51		100.67	12.03	112.70	103.19
14		9.51	9.51		100.67	12.03	112.70	103.19
15		9.51	9.51		100.67	12.03	112.70	103.19
16		9.51	9.51		100.67	12.03	112.70	103.19
17		9.51	9.51		100.67	12.03	112.70	103.19
18		9.51	9.51		100.67	12.03	112.70	103.19
19		9.51	9.51		100.67	12.03	112.70	103.19
20		9.51	9.51		100.67	12.03	112.70	103.19
21		9.51	9.51		100.67	12.03	112.70	103.19
22		9.51	9.51		100.67	12.03	112.70	103.19
23		9.51	9.51	195.76	100.67	12.03	308.46	298.95
24		9.51	9.51		100.67	12.03	112.70	103.19
25		9.51	9.51		100.67	12.03	112.70	103.19
26		9.51	9.51		100.67	12.03	112.70	103.19
27		9.51	9.51		100.67	12.03	112.70	103.19
28		9.51	9.51		100.67	12.03	112.70	103.19
29		9.51	9.51		100.67	12.03	112.70	103.19
30		9.51	9.51		100.67	12.03	112.70	103.19
31		9.51	9.51		100.67	12.03	112.70	103.19
32		9.51	9.51		100.67	12.03	112.70	103.19
33		9.51	9.51		100.67	12.03	112.70	103.19
34		9.51	9.51		100.67	12.03	112.70	103.19
35		9.51	9.51		100.67	12.03	112.70	103.19
36		9.51	9.51		100.67	12.03	112.70	103.19
37		9.51	9.51		100.67	12.03	112.70	103.19
38		9.51	9.51		100.67	12.03	112.70	103.19
39		9.51	9.51		100.67	12.03	112.70	103.19
40		9.51	9.51		100.67	12.03	112.70	103.19
41		9.51	9.51		100.67	12.03	112.70	103.19
42		9.51	9.51		100.67	12.03	112.70	103.19
43		9.51	9.51	195.76	100.67	12.03	308.46	298.95
44		9.51	9.51		100.67	12.03	112.70	103.19
45		9.51	9.51		100.67	12.03	112.70	103.19
46		9.51	9.51		100.67	12.03	112.70	103.19
47		9.51	9.51		100.67	12.03	112.70	103.19
48		9.51	9.51		100.67	12.03	112.70	103.19
49		9.51	9.51		100.67	12.03	112.70	103.19
50		9.51	9.51		100.67	12.03	112.70	103.19
TOTAL	634.00	446.97	1,080.97	636.22	4,731.49	565.41	5,933.12	4,852.15

CASE-1 : ONE YEAR DELAY CASE

IRR = 17.58 %

YEAR	INVEST. & REPLACE	O & M COST	TOTAL COST	ALTANATIVE BENEFIT INVEST. & REPLACE	FUEL COST	O & M COST	TOTAL BENEFIT	NET CASH IN-FLOW
1	180.08		180.08	0.00			0.00	-180.08
2	179.52		179.52	0.00			0.00	-179.52
3	146.88		146.88	11.10			11.10	-135.78
4	127.52		127.52	233.60			233.60	106.08
5		9.51	9.51		100.67	12.03	112.70	103.19
6		9.51	9.51		100.67	12.03	112.70	103.19
7		9.51	9.51		100.67	12.03	112.70	103.19
8		9.51	9.51		100.67	12.03	112.70	103.19
9		9.51	9.51		100.67	12.03	112.70	103.19
10		9.51	9.51		100.67	12.03	112.70	103.19
11		9.51	9.51		100.67	12.03	112.70	103.19
12		9.51	9.51		100.67	12.03	112.70	103.19
13		9.51	9.51		100.67	12.03	112.70	103.19
14		9.51	9.51		100.67	12.03	112.70	103.19
15		9.51	9.51		100.67	12.03	112.70	103.19
16		9.51	9.51		100.67	12.03	112.70	103.19
17		9.51	9.51		100.67	12.03	112.70	103.19
18		9.51	9.51		100.67	12.03	112.70	103.19
19		9.51	9.51		100.67	12.03	112.70	103.19
20		9.51	9.51		100.67	12.03	112.70	103.19
21		9.51	9.51		100.67	12.03	112.70	103.19
22		9.51	9.51		100.67	12.03	112.70	103.19
23		9.51	9.51		100.67	12.03	112.70	103.19
24		9.51	9.51	195.76	100.67	12.03	308.46	298.95
25		9.51	9.51		100.67	12.03	112.70	103.19
26		9.51	9.51		100.67	12.03	112.70	103.19
27		9.51	9.51		100.67	12.03	112.70	103.19
28		9.51	9.51		100.67	12.03	112.70	103.19
29		9.51	9.51		100.67	12.03	112.70	103.19
30		9.51	9.51		100.67	12.03	112.70	103.19
31		9.51	9.51		100.67	12.03	112.70	103.19
32		9.51	9.51		100.67	12.03	112.70	103.19
33		9.51	9.51		100.67	12.03	112.70	103.19
34		9.51	9.51		100.67	12.03	112.70	103.19
35		9.51	9.51		100.67	12.03	112.70	103.19
36		9.51	9.51		100.67	12.03	112.70	103.19
37		9.51	9.51		100.67	12.03	112.70	103.19
38		9.51	9.51		100.67	12.03	112.70	103.19
39		9.51	9.51		100.67	12.03	112.70	103.19
40		9.51	9.51		100.67	12.03	112.70	103.19
41		9.51	9.51		100.67	12.03	112.70	103.19
42		9.51	9.51		100.67	12.03	112.70	103.19
43		9.51	9.51		100.67	12.03	112.70	103.19
44		9.51	9.51	195.76	100.67	12.03	308.46	298.95
45		9.51	9.51		100.67	12.03	112.70	103.19
46		9.51	9.51		100.67	12.03	112.70	103.19
47		9.51	9.51		100.67	12.03	112.70	103.19
48		9.51	9.51		100.67	12.03	112.70	103.19
49		9.51	9.51		100.67	12.03	112.70	103.19
50		9.51	9.51		100.67	12.03	112.70	103.19
TOTAL	634.00	437.46	1,071.46	636.22	4,630.82	553.38	5,820.42	4,748.96

CASE-2 : 10% COST OVER-RUN CASE

IRR = 17.71 %

YEAR	INVEST. & REPLACE	O & M COST	TOTAL COST	ALTANATIVE BENEFIT INVEST. & REPLACE	FUEL COST	O & M COST	TOTAL BENEFIT	NET CASH IN-FLOW
1	248.60		248.60	0.00			0.00	-248.60
2	246.84		246.84	11.10			11.10	-235.74
3	201.96		201.96	233.60			233.60	31.64
4		9.51	9.51		100.67	12.03	112.70	103.19
5		9.51	9.51		100.67	12.03	112.70	103.19
6		9.51	9.51		100.67	12.03	112.70	103.19
7		9.51	9.51		100.67	12.03	112.70	103.19
8		9.51	9.51		100.67	12.03	112.70	103.19
9		9.51	9.51		100.67	12.03	112.70	103.19
10		9.51	9.51		100.67	12.03	112.70	103.19
11		9.51	9.51		100.67	12.03	112.70	103.19
12		9.51	9.51		100.67	12.03	112.70	103.19
13		9.51	9.51		100.67	12.03	112.70	103.19
14		9.51	9.51		100.67	12.03	112.70	103.19
15		9.51	9.51		100.67	12.03	112.70	103.19
16		9.51	9.51		100.67	12.03	112.70	103.19
17		9.51	9.51		100.67	12.03	112.70	103.19
18		9.51	9.51		100.67	12.03	112.70	103.19
19		9.51	9.51		100.67	12.03	112.70	103.19
20		9.51	9.51		100.67	12.03	112.70	103.19
21		9.51	9.51		100.67	12.03	112.70	103.19
22		9.51	9.51		100.67	12.03	112.70	103.19
23		9.51	9.51	195.76	100.67	12.03	308.46	298.95
24		9.51	9.51		100.67	12.03	112.70	103.19
25		9.51	9.51		100.67	12.03	112.70	103.19
26		9.51	9.51		100.67	12.03	112.70	103.19
27		9.51	9.51		100.67	12.03	112.70	103.19
28		9.51	9.51		100.67	12.03	112.70	103.19
29		9.51	9.51		100.67	12.03	112.70	103.19
30		9.51	9.51		100.67	12.03	112.70	103.19
31		9.51	9.51		100.67	12.03	112.70	103.19
32		9.51	9.51		100.67	12.03	112.70	103.19
33		9.51	9.51		100.67	12.03	112.70	103.19
34		9.51	9.51		100.67	12.03	112.70	103.19
35		9.51	9.51		100.67	12.03	112.70	103.19
36		9.51	9.51		100.67	12.03	112.70	103.19
37		9.51	9.51		100.67	12.03	112.70	103.19
38		9.51	9.51		100.67	12.03	112.70	103.19
39		9.51	9.51		100.67	12.03	112.70	103.19
40		9.51	9.51		100.67	12.03	112.70	103.19
41		9.51	9.51		100.67	12.03	112.70	103.19
42		9.51	9.51		100.67	12.03	112.70	103.19
43		9.51	9.51	195.76	100.67	12.03	308.46	298.95
44		9.51	9.51		100.67	12.03	112.70	103.19
45		9.51	9.51		100.67	12.03	112.70	103.19
46		9.51	9.51		100.67	12.03	112.70	103.19
47		9.51	9.51		100.67	12.03	112.70	103.19
48		9.51	9.51		100.67	12.03	112.70	103.19
49		9.51	9.51		100.67	12.03	112.70	103.19
50		9.51	9.51		100.67	12.03	112.70	103.19
TOTAL	697.40	446.97	1,144.37	636.22	4,731.49	565.41	5,933.12	4,788.75

Table 8.3-3 (2)

CASE-3 : 20% COST OVER-RUN CASE

IRR = 16.07 %

YEAR	INVEST. & REPLACE	O & M COST	TOTAL COST	ALTANATIVE BENEFIT INVEST. & REPLACE	FUEL COST	O & M COST	TOTAL BENEFIT	NET CASH IN-FLOW
1	271.20		271.20	0.00			0.00	-271.20
2	269.28		269.28	11.10			11.10	-258.18
3	220.32		220.32	233.60			233.60	13.28
4		9.51	9.51		100.67	12.03	112.70	103.19
5		9.51	9.51		100.67	12.03	112.70	103.19
6		9.51	9.51		100.67	12.03	112.70	103.19
7		9.51	9.51		100.67	12.03	112.70	103.19
8		9.51	9.51		100.67	12.03	112.70	103.19
9		9.51	9.51		100.67	12.03	112.70	103.19
10		9.51	9.51		100.67	12.03	112.70	103.19
11		9.51	9.51		100.67	12.03	112.70	103.19
12		9.51	9.51		100.67	12.03	112.70	103.19
13		9.51	9.51		100.67	12.03	112.70	103.19
14		9.51	9.51		100.67	12.03	112.70	103.19
15		9.51	9.51		100.67	12.03	112.70	103.19
16		9.51	9.51		100.67	12.03	112.70	103.19
17		9.51	9.51		100.67	12.03	112.70	103.19
18		9.51	9.51		100.67	12.03	112.70	103.19
19		9.51	9.51		100.67	12.03	112.70	103.19
20		9.51	9.51		100.67	12.03	112.70	103.19
21		9.51	9.51		100.67	12.03	112.70	103.19
22		9.51	9.51		100.67	12.03	112.70	103.19
23		9.51	9.51	195.76	100.67	12.03	308.46	298.95
24		9.51	9.51		100.67	12.03	112.70	103.19
25		9.51	9.51		100.67	12.03	112.70	103.19
26		9.51	9.51		100.67	12.03	112.70	103.19
27		9.51	9.51		100.67	12.03	112.70	103.19
28		9.51	9.51		100.67	12.03	112.70	103.19
29		9.51	9.51		100.67	12.03	112.70	103.19
30		9.51	9.51		100.67	12.03	112.70	103.19
31		9.51	9.51		100.67	12.03	112.70	103.19
32		9.51	9.51		100.67	12.03	112.70	103.19
33		9.51	9.51		100.67	12.03	112.70	103.19
34		9.51	9.51		100.67	12.03	112.70	103.19
35		9.51	9.51		100.67	12.03	112.70	103.19
36		9.51	9.51		100.67	12.03	112.70	103.19
37		9.51	9.51		100.67	12.03	112.70	103.19
38		9.51	9.51		100.67	12.03	112.70	103.19
39		9.51	9.51		100.67	12.03	112.70	103.19
40		9.51	9.51		100.67	12.03	112.70	103.19
41		9.51	9.51		100.67	12.03	112.70	103.19
42		9.51	9.51		100.67	12.03	112.70	103.19
43		9.51	9.51	195.76	100.67	12.03	308.46	298.95
44		9.51	9.51		100.67	12.03	112.70	103.19
45		9.51	9.51		100.67	12.03	112.70	103.19
46		9.51	9.51		100.67	12.03	112.70	103.19
47		9.51	9.51		100.67	12.03	112.70	103.19
48		9.51	9.51		100.67	12.03	112.70	103.19
49		9.51	9.51		100.67	12.03	112.70	103.19
50		9.51	9.51		100.67	12.03	112.70	103.19
TOTAL	760.80	446.97	1,207.77	636.22	4,731.49	565.41	5,933.12	4,725.35

CASE-4 : 10 % RISE FUEL COST

IRR = 21.14 %

YEAR	INVEST. & REPLACE	O & M COST	TOTAL COST	ALTANATIVE BENEFIT INVEST. & REPLACE	FUEL COST	O & M COST	TOTAL BENEFIT	NET CASH IN-FLOW
1	226.00		226.00	0.00			0.00	-226.00
2	224.40		224.40	11.10			11.10	-213.30
3	183.60		183.60	233.60			233.60	50.00
4		9.51	9.51		110.74	12.03	122.77	113.26
5		9.51	9.51		110.74	12.03	122.77	113.26
6		9.51	9.51		110.74	12.03	122.77	113.26
7		9.51	9.51		110.74	12.03	122.77	113.26
8		9.51	9.51		110.74	12.03	122.77	113.26
9		9.51	9.51		110.74	12.03	122.77	113.26
10		9.51	9.51		110.74	12.03	122.77	113.26
11		9.51	9.51		110.74	12.03	122.77	113.26
12		9.51	9.51		110.74	12.03	122.77	113.26
13		9.51	9.51		110.74	12.03	122.77	113.26
14		9.51	9.51		110.74	12.03	122.77	113.26
15		9.51	9.51		110.74	12.03	122.77	113.26
16		9.51	9.51		110.74	12.03	122.77	113.26
17		9.51	9.51		110.74	12.03	122.77	113.26
18		9.51	9.51		110.74	12.03	122.77	113.26
19		9.51	9.51		110.74	12.03	122.77	113.26
20		9.51	9.51		110.74	12.03	122.77	113.26
21		9.51	9.51		110.74	12.03	122.77	113.26
22		9.51	9.51		110.74	12.03	122.77	113.26
23		9.51	9.51	195.76	110.74	12.03	318.53	309.02
24		9.51	9.51		110.74	12.03	122.77	113.26
25		9.51	9.51		110.74	12.03	122.77	113.26
26		9.51	9.51		110.74	12.03	122.77	113.26
27		9.51	9.51		110.74	12.03	122.77	113.26
28		9.51	9.51		110.74	12.03	122.77	113.26
29		9.51	9.51		110.74	12.03	122.77	113.26
30		9.51	9.51		110.74	12.03	122.77	113.26
31		9.51	9.51		110.74	12.03	122.77	113.26
32		9.51	9.51		110.74	12.03	122.77	113.26
33		9.51	9.51		110.74	12.03	122.77	113.26
34		9.51	9.51		110.74	12.03	122.77	113.26
35		9.51	9.51		110.74	12.03	122.77	113.26
36		9.51	9.51		110.74	12.03	122.77	113.26
37		9.51	9.51		110.74	12.03	122.77	113.26
38		9.51	9.51		110.74	12.03	122.77	113.26
39		9.51	9.51		110.74	12.03	122.77	113.26
40		9.51	9.51		110.74	12.03	122.77	113.26
41		9.51	9.51		110.74	12.03	122.77	113.26
42		9.51	9.51		110.74	12.03	122.77	113.26
43		9.51	9.51	195.76	110.74	12.03	318.53	309.02
44		9.51	9.51		110.74	12.03	122.77	113.26
45		9.51	9.51		110.74	12.03	122.77	113.26
46		9.51	9.51		110.74	12.03	122.77	113.26
47		9.51	9.51		110.74	12.03	122.77	113.26
48		9.51	9.51		110.74	12.03	122.77	113.26
49		9.51	9.51		110.74	12.03	122.77	113.26
50		9.51	9.51		110.74	12.03	122.77	113.26
TOTAL	634.00	446.97	1,080.97	636.22	5,204.64	565.41	6,406.27	5,325.30

CASE-5 : USE OF ELECTRIC TARIFF BASED ON LRMC

IRR = 23.07 %

YEAR	INVEST. & REPLACE	O & M COST	TOTAL COST	TOTAL BENEFIT	NET CASH IN-FLOW
1	226.00		226.00		-226.00
2	224.40		224.40		-224.40
3	183.60		183.60		-183.60
4		9.51	9.51	194.55	185.04
5		9.51	9.51	194.55	185.04
6		9.51	9.51	194.55	185.04
7		9.51	9.51	194.55	185.04
8		9.51	9.51	194.55	185.04
9		9.51	9.51	194.55	185.04
10		9.51	9.51	194.55	185.04
11		9.51	9.51	194.55	185.04
12		9.51	9.51	194.55	185.04
13		9.51	9.51	194.55	185.04
14		9.51	9.51	194.55	185.04
15		9.51	9.51	194.55	185.04
16		9.51	9.51	194.55	185.04
17		9.51	9.51	194.55	185.04
18		9.51	9.51	194.55	185.04
19		9.51	9.51	194.55	185.04
20		9.51	9.51	194.55	185.04
21		9.51	9.51	194.55	185.04
22		9.51	9.51	194.55	185.04
23		9.51	9.51	194.55	185.04
24		9.51	9.51	194.55	185.04
25		9.51	9.51	194.55	185.04
26		9.51	9.51	194.55	185.04
27		9.51	9.51	194.55	185.04
28		9.51	9.51	194.55	185.04
29		9.51	9.51	194.55	185.04
30		9.51	9.51	194.55	185.04
31		9.51	9.51	194.55	185.04
32		9.51	9.51	194.55	185.04
33		9.51	9.51	194.55	185.04
34		9.51	9.51	194.55	185.04
35		9.51	9.51	194.55	185.04
36		9.51	9.51	194.55	185.04
37		9.51	9.51	194.55	185.04
38		9.51	9.51	194.55	185.04
39		9.51	9.51	194.55	185.04
40		9.51	9.51	194.55	185.04
41		9.51	9.51	194.55	185.04
42		9.51	9.51	194.55	185.04
43		9.51	9.51	194.55	185.04
44		9.51	9.51	194.55	185.04
45		9.51	9.51	194.55	185.04
46		9.51	9.51	194.55	185.04
47		9.51	9.51	194.55	185.04
48		9.51	9.51	194.55	185.04
49		9.51	9.51	194.55	185.04
50		9.51	9.51	194.55	185.04
TOTAL	634.00	446.97	1,080.97	9,143.85	8,062.88

8.4 Environmental Impact Assessment

8.4.1 General

The Ilam Small Hydropower Development Project has as its aim the stable supply of inexpensive electric power to the eastern region of Nepal. Under the Study, the optimum plan for the Project was formulated in terms of technical, economical and environmental feasibility.

Major environmental problems in Nepal at present are known to be rapid increase of population, deforestation and land degradation. The environmental impact assessment (EIA) under the Study gives careful consideration to these environmental problems.

8.4.2 General Features of the Environment in Nepal

(1) Physiographical and Regional Zones

Nepal lies in South Asia, on the southern slope of the Himalayas, between the latitude of 26° 22' N and 30° 27' N and between the longitude of 80° 04' E and 88° 12' E. The country has a length of 885 km from east to west and an average width north to south of 193 km. The total area of the country is 147,181 km². The altitude varies from 60 m to 8,848 m. The Himalayas are the youngest mountain system in the world as they are considered to be only about 40 million years old, and still rising.

The country can be categorized into the following seven physiographical zones.

Lowland	1.	Terai
	2.	Churia (or Siwalik) hills
	3.	Mahabharat lekh
Midland	4.	Midlands (central hills)
Highland	5.	Himalayas
	6.	Inner Himalayas
	7.	Tibetan marginal mountains

(2) Climate

The climate of Nepal is most affected by topological altitude. On the basis of climate, the country represents the following zones south to north.

a. Tropical and subtropical
b. Warm temperate
c. Cool temperate
d. Alpine
e. Tundra

Nepal falls within the monsoonal system of the Indian subcontinent. Eighty percent of rain comes during the wet season from June to September, and the rest of rain comes in winter from December to March. Actual rainfall amount varies in different eco-climatic zones. Kathmandu receives 1,346 mm of average rain annually, while Ilam, a high precipitation area, receives over 1,700 mm..

(3) Population Characteristics

The population of Nepal is 19 million (1990), with 2.5 percent annual growth rate. Population density is 130 persons/ha. Regarding the distribution of the population in the geographic regions, 46.6 percent live in Terai, 45.6 percent in Hill, and 7.8 percent in Mountain. People have been migrating to the Terai from Hill and Mountain areas. The average age of the Nepalese citizen is 54.3 year.

Ethnically, the population of Nepal is a complex mixture of Indian, Tibetan and Mongolian ancestry. Spoken languages include Nepali (59%), Maithili (11%), Bhojpuri, Tamang, Tharu, Newari as well as other languages.

Population distribution by region is Eastern Region (24.09%), Central Region (33.44%), Western Region (20.32), Mid Western Region (13.02%), and Far Western Region (9.10%). The centralization of population is progressing in recent years with urban population reaching 9.11% in 1991 as opposed to only 4% in 1971. This centralization of population has caused new environmental problems, such as deforestation, alternation of land use, increase of domestic and industrial waste, etc.

(4) Land Use

The land area of the country is estimate to be 147,181 km^2. Major land uses are:

a.	Forest	55,334 km^2	(37.6%)
b.	Agriculture	26,533 km^2	(18.0%)
c.	Grazing	19,785 km^2	(13.4%)

Despite its low latitude, approximately 22,785 km^2 (15.3%) of the countries land area is covered by snow and ice.

(5) Energy Consumption Structure and Water Resources

Regarding energy resources, Nepal depends mostly on traditional fuel wood because coal and petro-products are lacking in this country. In 1988/89 the total consumption of energy was 5.96 million tons of coal equivalent. 68 % was from fuel wood, and 12.5 % from agricultural residues, 12.5% from animal waste, 3.3% from petro-products, 0.7% from coal and 0.7 % from electricity. Others account for 0.1%. This fact is a direct cause of deforestation of the country.

There are about 6,000 rivers and rivulets in the country. Out of these about 1,000 rivers are more than 100 km long. The rivers of Nepal are grouped into three major systems:

a. Kosi - Mechi - Kankai river system in the east
b. Gandaki - Bagmati river system in the center
c. Karnali - Mahakari - Babachi - Rapti river system in the west

Many of the rivers have not yet been utilized to generate electricity. Up to 1991 about 45 principal hydropower stations have been constructed.

(6) Vegetation and Forest Type

All forest and forest land is owned and managed by HMGN. Forest is one of the most important national resources and has been supplying fuel wood, timber, fodder for animals, herb and others. Forest provides more than 50 percent of total supply of animal feed in the Hill Region.

37.6% of the country is considered as forest area, including bush and shrubland. The upper limit of forest in altitude is about 4,400 m in Nepal. The distribution of forest according to geographic region is:

Mid Mountain Region	33 %
High Mountain Region	30 %
Churia Region	26 %

Distribution of forest according to the development regions is greatest in the Mid Western Region at 30%:

33 types of forest are found in the country as follows:

a.	Tropical and Subtropical Broadleaved	8 types
b.	Tropical and Subtropical Conifer	1 type
c.	Temperate and Alpine Broadleaved	10 types
d.	Temperate and Alpine Conifer	9 types
e.	Alpine Scrub	3 types

(7) Agriculture

Agricultural land area is estimated to be 26,533 km^2, which is about 18 percent of the total land area of the country. The major portion of agriculture land is in the Terai Region, especially for cereal production. The Hill Region has potential for horticultural development, while the Mountain Region is suitable for livestock farming. Although regional variations occur in relation to climate, major crops in the country are rice, maize, wheat, barley, millet, sugarcane, jute, oil seed, tobacco, and potato.
Livestock raising plays an important roll in the agriculture economy. Cattle, buffalo, goat, pig, poultry and water fowl are main livestock.

(8) National Parks, Wildlife Reserves, and Conservation Areas

Nepal is a signatory to the Ramsar Convention, the Washington Convention, and the Convention for the Protection of World Culture and Natural Heritage, and there is a keen interest within the country regarding preservation of natural and historical assets.

His Majesty's Government inaugurated the National Parks and Wildlife Conservation Act in 1973. The Royal Chitwan National Park was officially established in the same year. At present, national parks, wildlife reserves, and conservation areas have been established at 15 locations. Total area of these is 13,554 ha, equivalent to 9.2 percent of the nation's total land area.

a. National park:	Royal Chitwan National Park, etc.	8 locations
b. Wildlife reserve:	Shukla Phanta Reserve, etc.	5 locations
c. Conservation area:	Annapurna National Park, etc.	2 locations

(9) Endangered Species of Fauna and Flora

Nepal has a very wide range of natural habitats for wild animal and plant species. Considering the size of the country, Nepal has a rich and fascinating bio-diversity. Under fauna, there are over 200 species of mammals, 63 species of reptiles, 858 species of birds, and 129 species of fishes. Under flora, 7,000 species of higher plants, 375 species of pteridophyte, and 1,200 species of fungi are known. Under higher plants, 133 species are endemic in the country.

Many species of fauna and flora have experienced drastic reduction in their numbers in Nepal, because of degradation of wildlife habitats in recent years. The Department of National Parks and Wildlife Conservation, Ministry of Forest and Environment, has identified 40 endangered species for fauna (snow leopard, one-horned rhino, etc.), including 28 for mammals, 8 for birds, and 3 for reptiles, in the country. Out of these 40 species, 34 endangered and vulnerable species were listed in the 1988 IUCN Red List Book .

Under flora, although data is still lacking, the Department of Environment, Ministry of Forest and Environment, published a list of 41 endangered, threatened, and rare species of plants (high altitude primrose, orchid varieties, etc.). Since the Convention on Conservation of Biological Diversity agreed to at the Earth-Summit held in Brazil in 1992, it is anticipated that the protection of these endangered species of fauna and flora will be accelerated.

(10) Governmental and Institutional Organizations Dealing with the Environment

Governmental agencies engaged in the formulation and administration of environmental policy in the country include Ministry of Forest and Environment (name changed from Ministry of Forest and Watershed Management in 1991), Ministry of Water Resources, Ministry of Land Reform, Ministry of Agriculture, Ministry of Industries and Commerce, Ministry of Public Works and Transport, as well as KMTNC, MAB, ICMOID, LUCN, RONAST, etc.

(11) Environmental Protection Council

Environmental conservation is currently being given major emphasis at the international level, and in this light the Environment Protection Council was established on October 1, 1992 under the chairmanship of the Right Honorable Prime Minister with 20 representatives from concerned sectors including the ministers of the Ministry of Forest and

Environment, Ministry of Agriculture, Ministry of Tourism, Ministry of Industries, Ministry of Welfare, and Ministry of Education, as well as the directorship of the National Planning Committee and noted university professors, etc. The aims and the policies of the council are to efficiently manage natural and physical resources and to maintain balance and coordinate between developmental efforts and environmental conservation. The head of the Environmental Protection Department of the National Planning Committee serves as the office director for the Council.

(12) Environmental Protection Legislation

Important legislation currently in effect in Nepal with regards to environmental protection include Forest Protection (Special Arrangement) Act, National Parks and Wildlife Conservation Act, Aquatic Animal Protection Act, Mine Act, Soil and Watershed Protection Act, Archeological Building Protection Act, etc.

(13) National Environmental Impact Assessment Guidelines

National Planning Commission, HMGN, in collaboration with the International Union of Conservation of Nature, published the National Environmental Impact Assessment Guidelines on Sept. 27, 1992. Draft guidelines have also been prepared for such specific sectors as water use, energy development, etc.

(14) Nepal Environmental Policy and Action Plan

Recently, a national symposium was held on "Environment Law - Future Direction for Nepal". A need for an environment act at this stage was emphasized by all the participants at the symposium.

National Planning Commission, HMGN, in collaboration with International Union of Conservation of Nature, released the revised draft of Nepal Environmental Policy and Action Plan (NEPAP) in May, 1993. This draft aims to analyze the country's environmental issue in a multi-sectorial framework and to set forth a long term strategy for maintaining the country's natural environment, health and safety of its population, and its cultural heritage as economic development occurs. There are four key themes that run through the NEPAP. These are stable development, population control, decentralization and institutional development.

Though this NEPAP is still now under review, it should be noted that all development projects would follow the systematic process of environmental impact assessment before approval.

8.4.3 Natural Environmental Investigation and Analysis of the Project Area

(1) Climate

The Project area is located in Ilam district, Mechi zone, in the Eastern Development Region. The altitude of the district capital, Ilam Bazar, is about 1,300 m. Annual

precipitation is about 1,684 mm. The average temperature for the highest month, lowest month and annual average are 22.3 °C, 12.5 °C, and 19.0 °C, respectively. Annual rainfall is 1,684 mm. Ecologically, the area belongs to Hill zone.

(2) Land Use and Agriculture

Land use in Ilam District is mainly for seasonal crop (80.8 percent), seasonal fallow and meadow (3.3%), perennial crop (3.7%), perennial meadow and pasture (3.7%), wood and forest (9.3%) for a total land area of 59,986 ha according to 1981/82 statistics. Paddy rice, maize, wheat, and millet were the main crops among food crops, and potato was the most important cash crop under the 1981/82 statistics.

Regarding livestock production in Ilam district, main livestock were cattle (86,000 head, buffalo (23,000 head), goat (80,000 head), hogs (18,000 head) and poultry (131,000 birds) in the district according to 1989/90 statistics.

(3) National Parks, Wildlife Reserves and Conservation Areas

The Project area is not included in any of the 8 national parks, 5 wildlife reserves, or 2 conservation areas in Nepal.

(4) Endangered Species of Fauna and Flora

According to the interview survey of Ilam Bazar residents, none of the 40 endangered species of fauna listed by the Department of National Parks and Wildlife Conservation of the Ministry of Forest and Environment were found in the Project area.

Regarding endangered species of flora listed by the Department of Environment, Ministry of Forest and Environment, the two species *Malaxis tamurensis* (*Orohidaceae*) and *Jasmium amabile* (*Oleaceae*) were thought to be possibly found in the Project area because of the region and the altitude of their habitats. However, it was not possible to find these two species in the course of the forest and tree study in the area.

(5) Ecology and Use of Forest and Trees

Although farm land is privately owned, forest and forest land is owned and managed by HMGN throughout the country. In the Hill Region, fodder tree is an important resource for animal feed.

Under the present Study, the forest cover was carefully surveyed to identify local name and uses of trees (as well as scrub and major grasses). Photos were also taken. Study sites were as follows:

a. The ridge line from Ilam Bazar to the power station site on the Mai khola (altitude 750 - 450 m)

b. The ridge line from Ilam Bazaar to the intake site on the Puwa khola (altitude 1,300 - 560 m)

c. The area around the Puwa Khola Bridge at the upper reaches of the Puwa khola (altitude 1,000 m)

d. The mountain top area of Ilam Bazar (altitude 1,300 - 1,500 m)

The findings of the study are as follows:

1. The forests in the Project area mostly subtropical broadleaved forest. At higher elevations over 1,500 m, subtropical conifer forest is present.

2. The forest around the power house site on the Mai Khola is subtropical evergreen forest. Dominant tree specie is Sal (*Shorea robusta*). Forests along the Puwa khola are subtropical deciduous riverain forests or Shima - Castanopsis forest. Dominant tree species are Chilaune, Katus, and Utis.

3. Fifty-seven species for timber trees, 17 for fodder trees, 12 for fruit trees, 3 for fire and fuel wood trees, 1 for manure covering tree, 1 for miscellaneous tree, 4 for medicine shrubs and grasses, 8 for wild ornamental shrubs and grasses, and 4 for important grasses were identified (total: 107 species).

4. Planting fodder trees has been a very efficient traditional method for the use of terrace land under hill agriculture. The species of trees were chosen according to their characteristics, such as fast regrowth after logging, high production of forage, nutritive value, etc.

5. Despite the small land area of the Project area, ninety-five tree species were found in the study sites. This shows the wide diversity of forest trees in subtropical region.

(6) Fishes, Animals and Birds

Eight species of fishes were identified in the Puwa khola and Mai khola on the basis of field study and interview of local residents. As construction of the intake under the Project on the Puwa khola will affect the 125 km² river ecosystem of the catchment, it is necessary to ensure a minimum effective river flow as well as preserve fishing locations.

Ten species of animals (fox, monkey, squirrel, etc.) are common in Ilam according to interview survey of local residents. Eleven species of bird (pigeon, eagle, etc.) are also common in Ilam.

(7) Landscape

Although there are no unique landscape assets requiring special conservation measures in the Project area, it is desirable to construct facilities that blend well with the superior natural landscape in the surrounded area.

8.4.4 Socio-Environmental Assessment

(1) Population and Industry

According to the 1981 census, population of Ilam district is 178,356. Population of Ilam Bazar is about 13,000. The most important industries are agriculture, animal husbandry, commerce, and tea industry. With regards to religion, 94 percent of population is Hindu, followed by 5 percent Buddhist. Nepali speakers are 80 percent. Other language speakers include Rai Kirauti (7%), Limbu (6%), as well as others.

(2) Historical and Cultural Heritages

There exists a fort built during the Old Kingdom Era, and a small Hindu temple in the central area of Ilam Bazar. However, there will be no impact on these heritages as they are located far from the Project construction sites.

(3) Inhabitants and Agriculture

At the intake site of Puwa khola, a retarding basin and descending basin will be constructed at the river bed. Likewise, the power house will be constructed at the river bed of the Mai khola. Accordingly, there will be no inundation of dwellings under the Project.

The sites for head tank and penstock are on farm land where several farmers live. Accordingly, issues of purchase, compensation, removal, and resettlement need to be resolved.

According to the regional office, the process of transferring land is as follows. An application form including map, area, and price of the specific land will be sent from NEA to the CDO (Chief District Officer) of Ilam district. The CDO will give permission after the approval from the land reform committee. The price of irrigated farm land at present is estimated at Rs 80,000. and non-irrigated farm land at Rs 30,000. The compensation cost will include that for the farmer's house, fruit and fodder trees, and pen-house for animals.

(4) Irrigation Rights and Fishing Rights

There are two irrigation canals at the downstream of the intake site on the Puwa khola. The larger one was constructed by the regional irrigation office, and the smaller one by farmers. The irrigation rights for both canals must be guaranteed. There is a new plan for an irrigation program by the regional irrigation office of the Ministry of Water Resources, utilizing the water of the Puwa khola (design discharge: 1.1 m^3/s; canal length: 19 km; benefit area: 425 ha). As the benefit area for this project located on the south slope of Ilam ridge. Concerning their water use plan is discussed at clause 2.5 in this report.

Fishes in the Puwa khola and the Mai khola are caught by twelve farmers for sale in local markets and by eight farmers for self consumption. Anyone is allowed to catch fishes in rivers in the area, and fishing rights have not been formally established at present.

Furthermore, there are no large settlements nor diversion of domestic water downstream of the intake site under the Project to the confluence of the Puwa khola with Mai khola. As a result, water rights downstream of the intake weir are not an issue. Nevertheless, royalties must be paid to the Chief District Office for use of sand and gravel from the Puwa and Mai kholas during construction.

(5) Forest Timber Cutting

Forest is owned by HMGN. Forest timber cutting without permission is strictly prohibited by law. Permission in this regard must be sought from CDO at the survey phase and the Ministry of Forest and Environment at the construction phase of the Project. The royalty for timber varies depending upon tree species and trunk diameter.

The forest types at the intake site and power station site are rather common in the Eastern Development Region. However, deforestation during construction should be minimized to conserve forest in the area.

(6) Impact on Existing Road

The site for the construction of the penstock from the head tank to the power station will cross existing road at least once. Furthermore, the penstock alignment lies completely along the village road on the ridge line to the Mai khola. Thoughtful consideration on these existing road systems is important.

8.4.5 Environmental Impact Assessment of Construction Phase in the Project Area

The 3.3 km of canal construction under the Project will produce a volume of excavated waste materials. The outflow of these materials from the spoil bank during the rainy season would cause degradation of the environment, through serious destruction of forest and river ecosystems. Mitigation measures such as using these materials for road pavement should be considered.

8.4.6 Overall Evaluation

Overall evaluation is as shown in Table 8.4-1.

Table 8.4-1 Overall Evaluation

		Item	Grade	Remarks
Social Environment	1	Resettlement	A	Necessary to acquire land for facility sites (head tank, penstock, etc.)
	2	Economic activity	D	Benefits are great for agricultural and commercial activities in the area
	3	Transportation / other daily life infrastructure	C	Depending on conditions as a result of construction of the various facilities and access road under the Project
	4	Regional division	D	No impact under the Project in this regard
	5	Historical remains / cultural assets	D	No impact under the Project in this regard
	6	Water rights and membership in water use associations	A	Necessary to guarantee existing irrigation water use rights
	7	Health and sanitation	D	No impact under the Project in this regard
	8	Waste	C	Depending on quantity of excavated material and disposal method for the same under the Project
	9	Disaster (risk)	C	Need to adopt construction method which minimizes risk of slope collapse
Natural Environment	10	Topography/geology	D	No impact under the Project in this regard
	11	Soil erosion	C	Uncertain as to what conditions will be during construction
	12	Groundwater	D	No impact under the Project in this regard
	13	Status of water bodies (river, lake, etc.)	C	Change in discharge volume, discharge velocity and river bed will impact on fish species
	14	Coastal area	--	No impact under the Project in this regard
	15	Flora and fauna	D	No rare or endangered species in Project area
	16	Climate	D	No impact under the Project in this regard
	17	Scenic beauty	C	Actual condition as a result of construction is uncertain
Pollution	18	Air pollution	D	No impact under the Project in this regard
	19	Water pollution	D	No impact under the Project in this regard
	20	Soil pollution	D	No impact under the Project in this regard
	21	Noise/vibration	C	Actual condition as a result of construction is uncertain
	22	Ground subsidence	D	No impact under the Project in this regard
	23	Foul odor	D	No impact under the Project in this regard

Note:

A: Heavy impact is anticipated
B: Some impact is anticipated
C: Impact is uncertain (further study is necessary with countermeasures to be taken as conditions become clear in the course of the Project)
D: As negligible impact is anticipated, item does not need to be addressed under IEE or EIA

8.5 Secondary Development Effect

(1) Job Opportunity Effect and Development Effect on Related Industries

The total investment cost of this Project is estimated at Rs 706.4 million, in which local labour cost is Rs 56.2 million, cost of material and equipment procured locally is Rs 142.5 million, compensation cost is Rs 7.5 million, local engineering fee is Rs 64.2 million and local contingency cost is Rs 23.9 million. Local cost to be spent in Nepal totals up to Rs 294.3 million. During the construction period, local labour employed for the construction are estimated at 501,000 man·day of unskilled labor and 350,000 man·day of skilled labour. Increased labour opportunities are also expected related to procurement, transportation, storage, custody, etc. of the many materials and equipment to be transported to the site. At the same time, the implementation of this Project contributes to development of industries in such sectors as procurement, transportation and storage of the above materials and equipment.

(2) Development Effect on Local District

In case this Project is implemented, road infrastructure will not only be strengthened through repair of existing roads, construction of new access roads, etc. but also the economy of Ilam district will be invigorated by procurement of a portion of construction materials within the district, and by consumption expenditure by workers engaged in the construction who stay in the district during the implementation period.

CHAPTER 9

CHAPTER 9 ATTACHED DRAWINGS

Attached drawings are as indicated in Drawing List (1)~(8).

Drawing List (1): Fig. 2.2-1 ~ Fig. 2.2-3

Drawing List (2): Fig. 2.3-1 ~ Fig. 2.3-6

Drawing List (3): Fig. 2.4-1

Drawing List (4): Fig. 3.6-1 ~ Fig. 3.6-15

Drawing List (5): Fig. 3.7-1 ~ Fig. 3.7-9

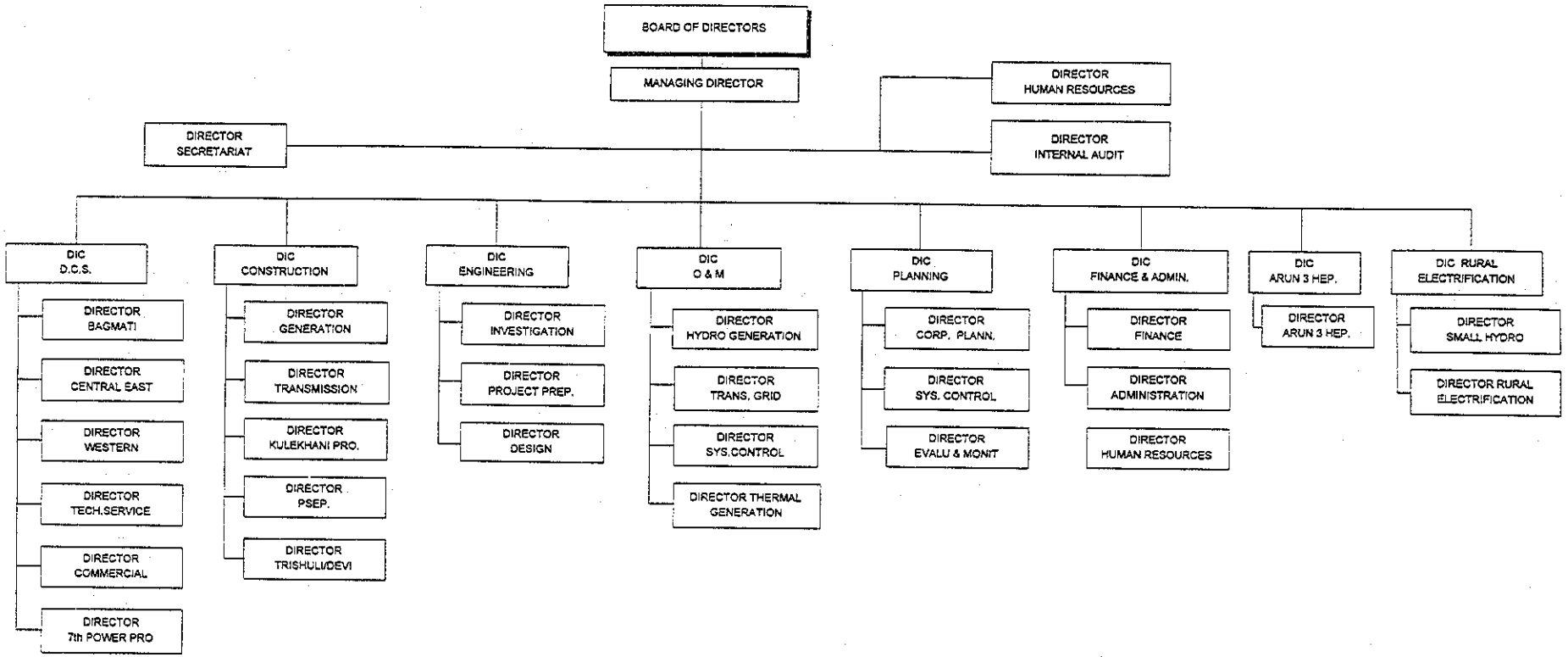
Drawing List (6): Fig. 4-1 ~ Fig. 4-2

Drawing List (7): DWG. No. ILAM-F/S001 ~ DWG. No. ILAM-F/S009

Drawing List (8): Fig. 5.5-1 ~ Fig. 5.5-6

DRAWING LIST (1)

Drawing No.	Title
Fig. 2.2-1	NEA Organization
Fig. 2.2-2	Transmission Line in Nepal
Fig. 2.2-3	Transmission Plan for the Ilam Area under 7th Power Project



DIC - DERECTOR-IN-CHIEF
D.C.S. - DISTRIBUTION & CONSUMER SERVICES
PSEP - POWER SECTOR EFFICIENCY PROJECT
O & M - OPERATION AND MAINTENANCE

Fig. 2.2.-1 NEA Organization

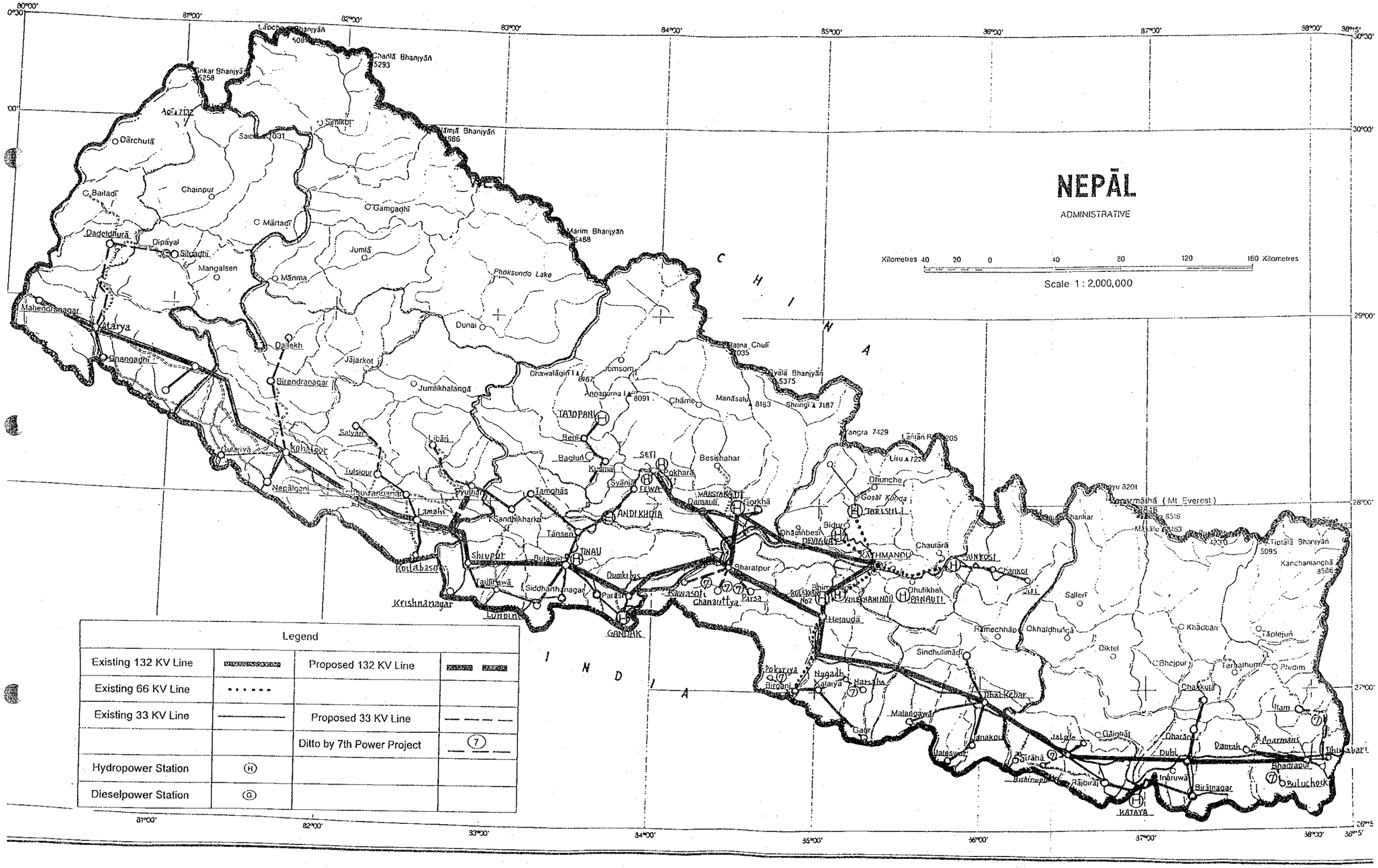


Fig. 2.2-2 Transmission Line in Nepal

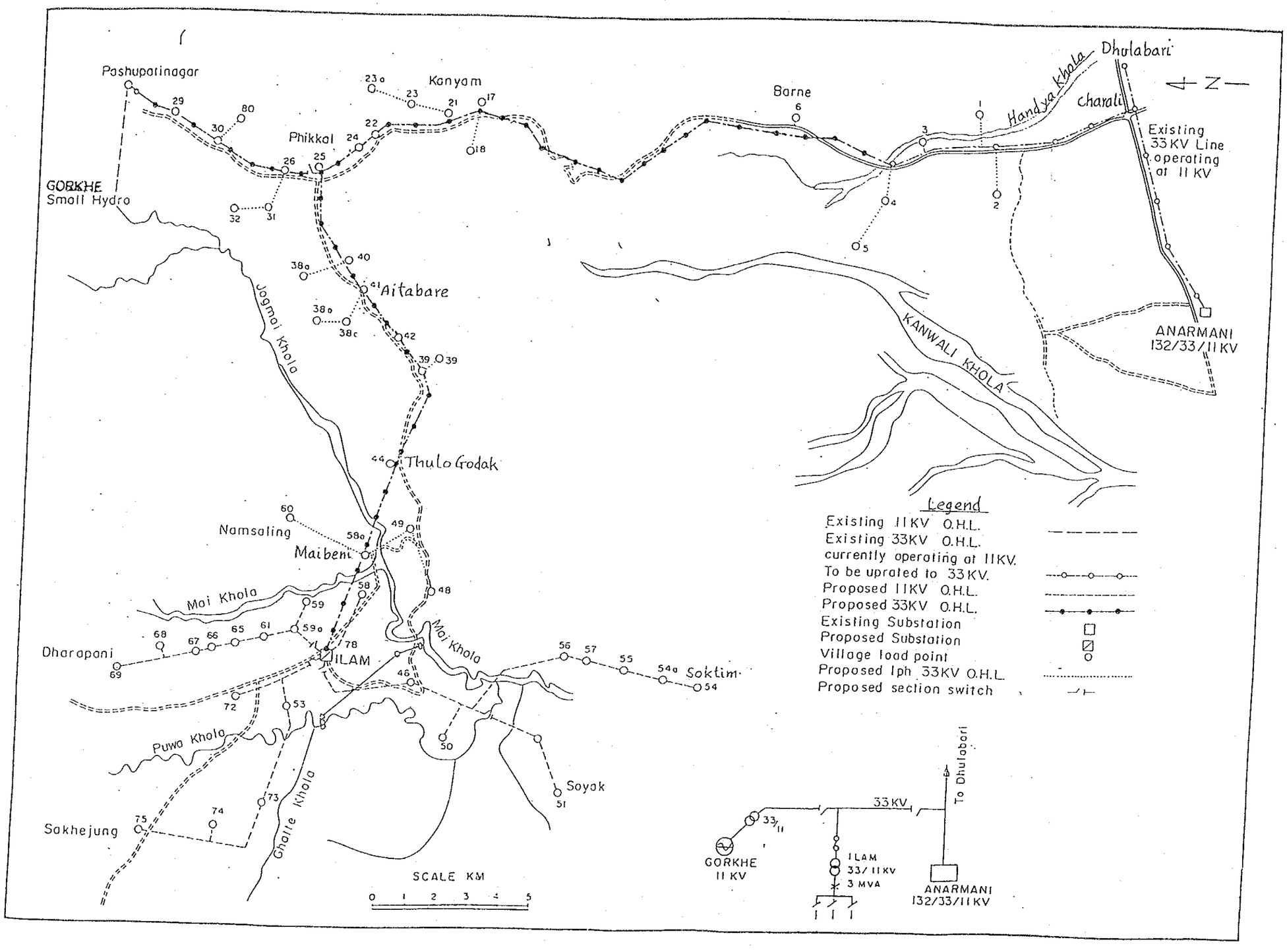
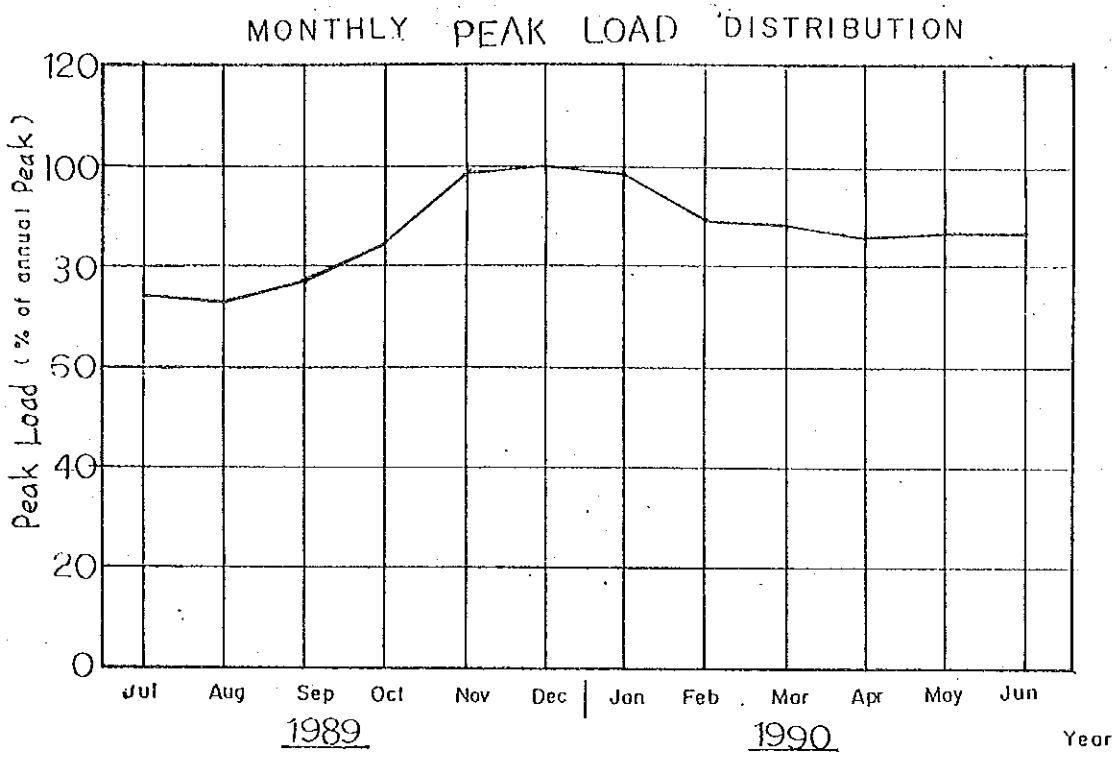


Fig. 2.2-3 Transmission Plan for the Ilam Area under 7th Power Project

DRAWING LIST (2)

Drawing No.	Title
Fig. 2.3-1	Monthly Peak Load Distribution
Fig. 2.3-2	Daily Load Curve in December 1992
Fig. 2.3-3	Daily Load Curve in January 1991
Fig. 2.3-4	Demand Forecast
Fig. 2.3-5	Electrification under the 7th Power Plan
Fig. 2.3-6	Electrification under Small Hydropower Master Plan



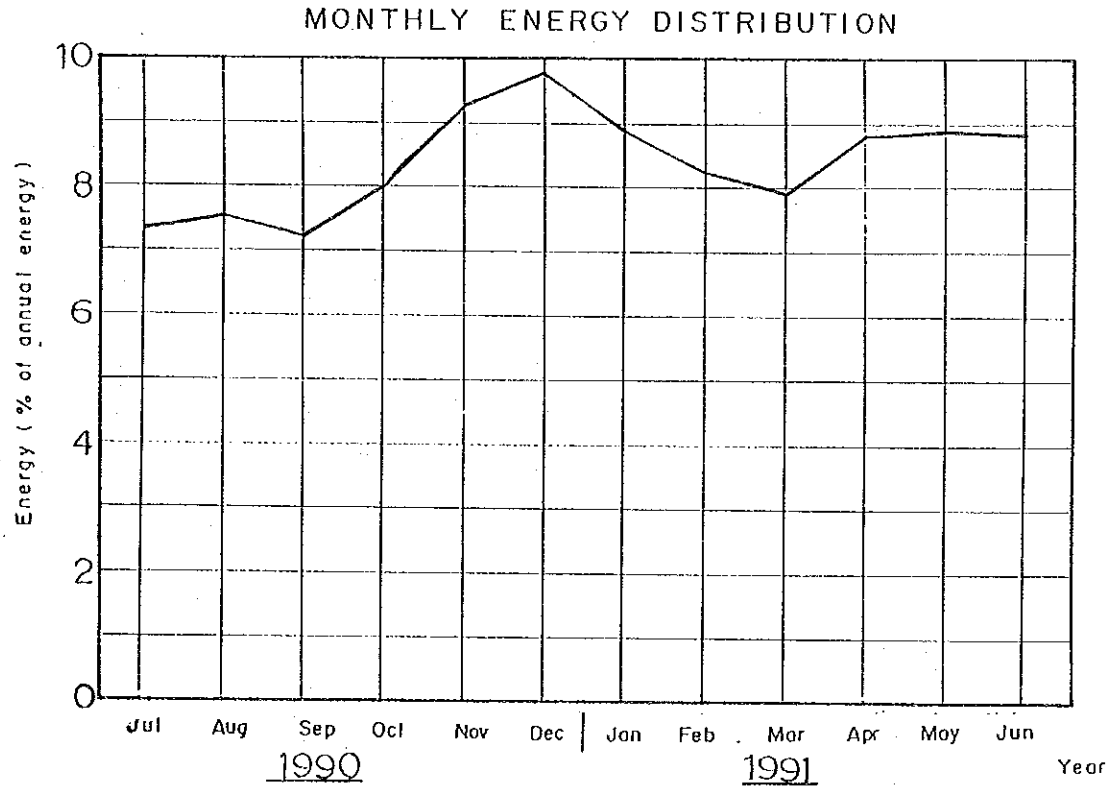


Fig. 2.3-1 Monthly Peak Load Distribution

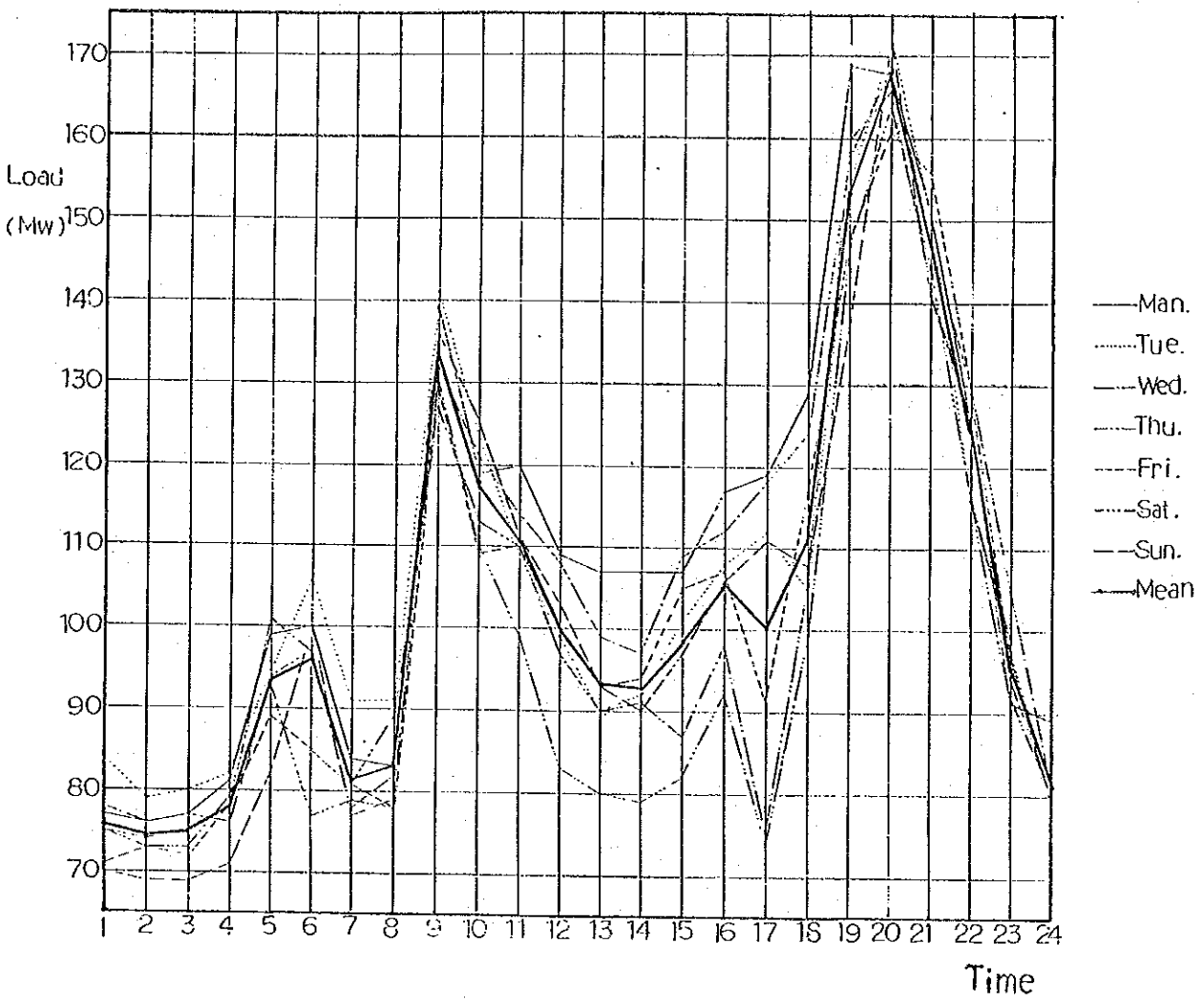


Fig. 2.3-2 Daily Load Curve in December 1992

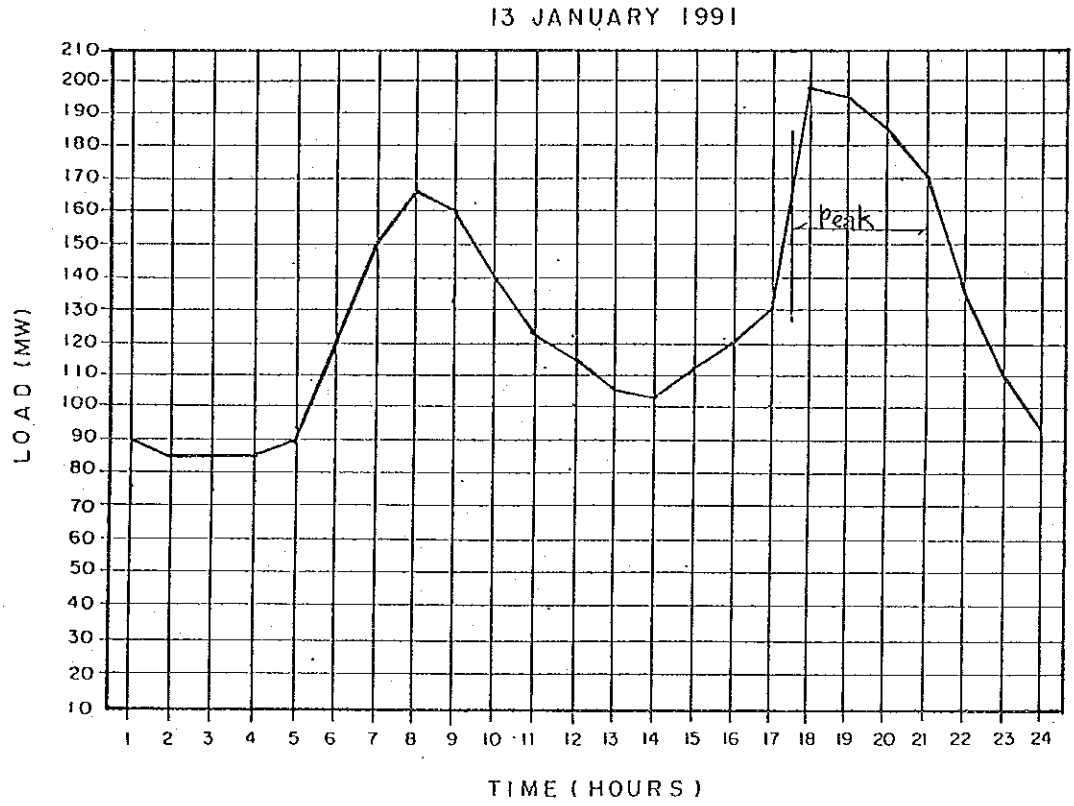


Fig. 2.3-3 Daily Load Curve in January 1991

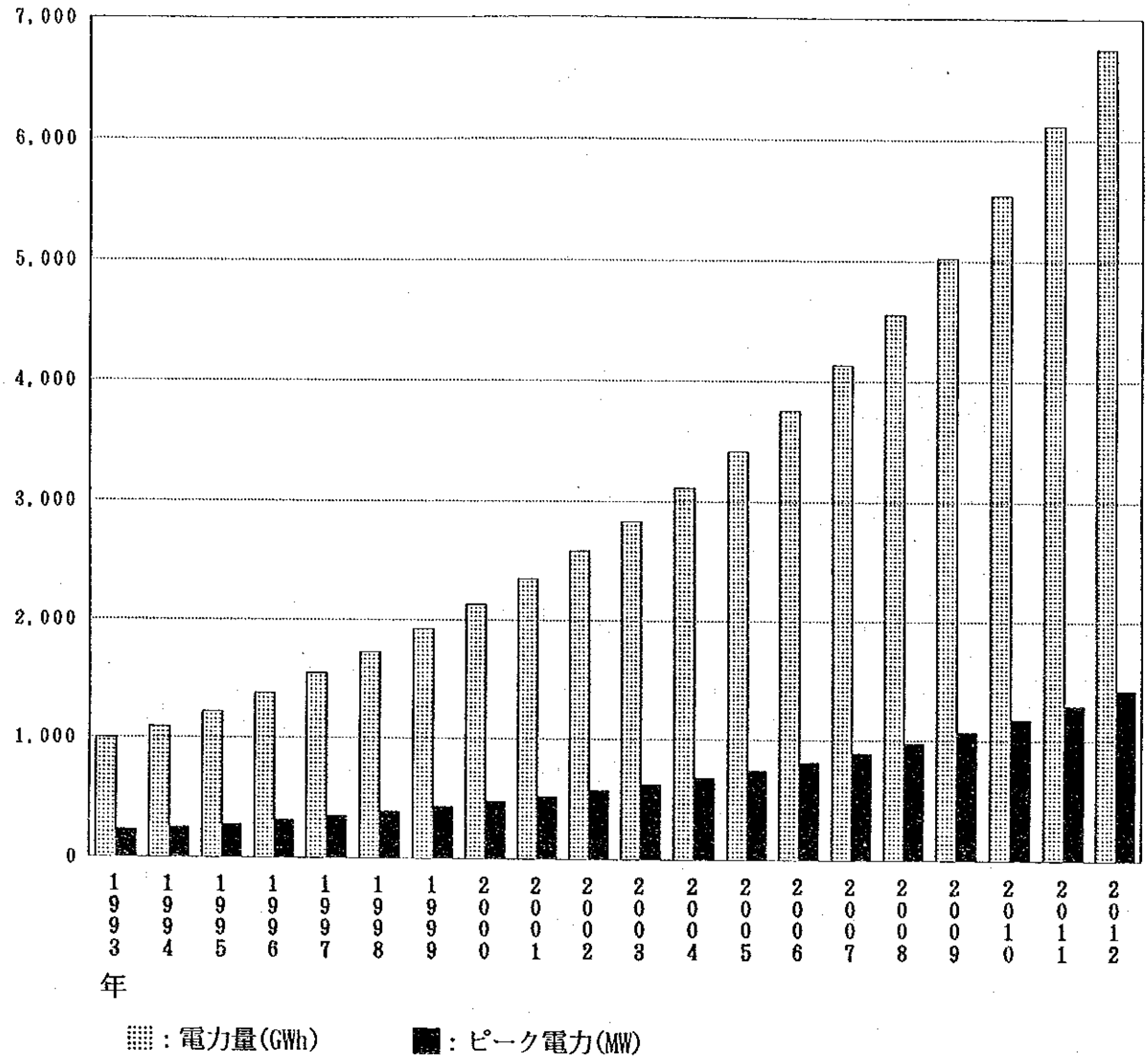


Fig. 2.3-4 Demand Forecast

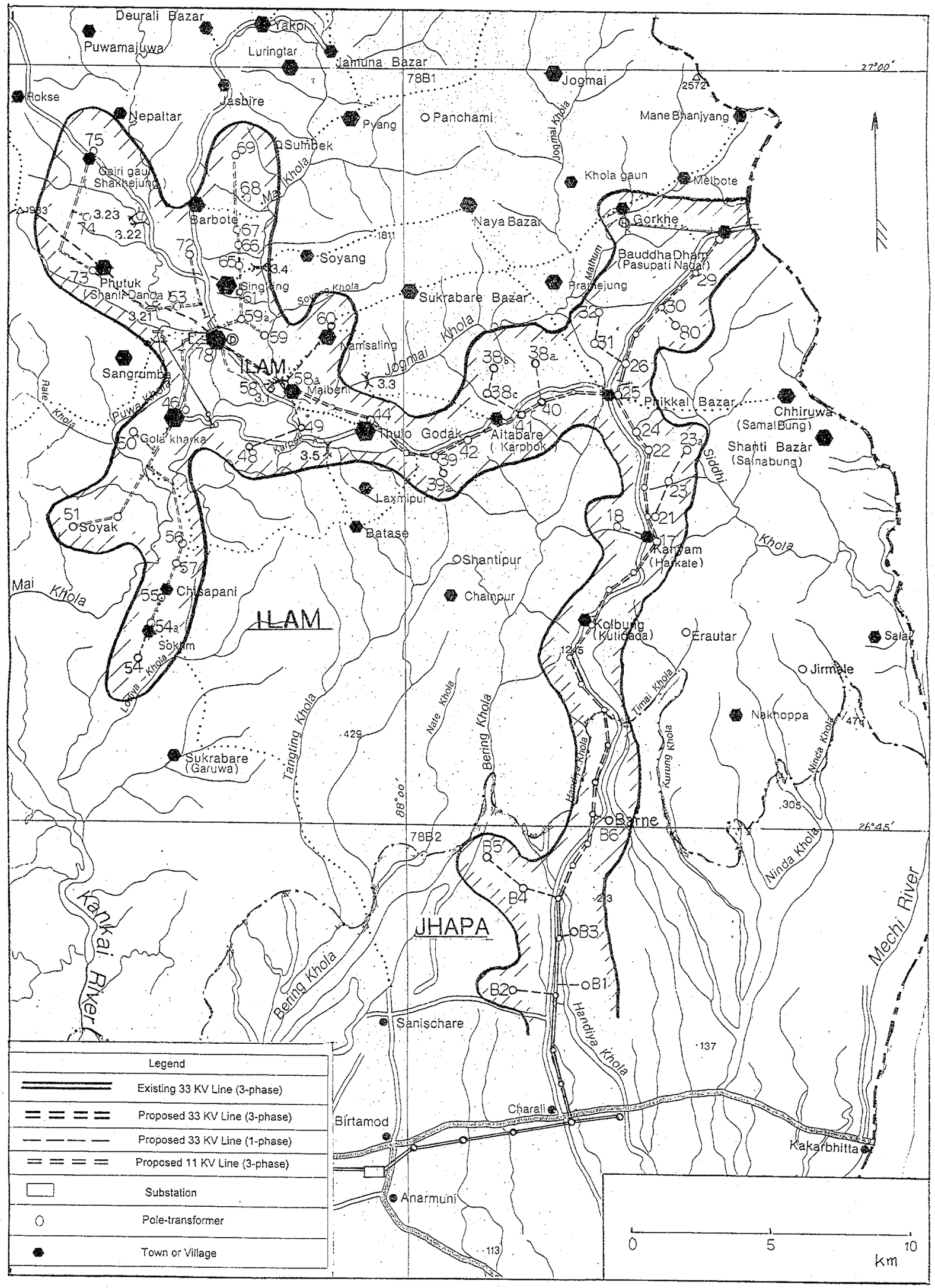


Fig. 2.3-5 Electrification under the 7th Power Plan

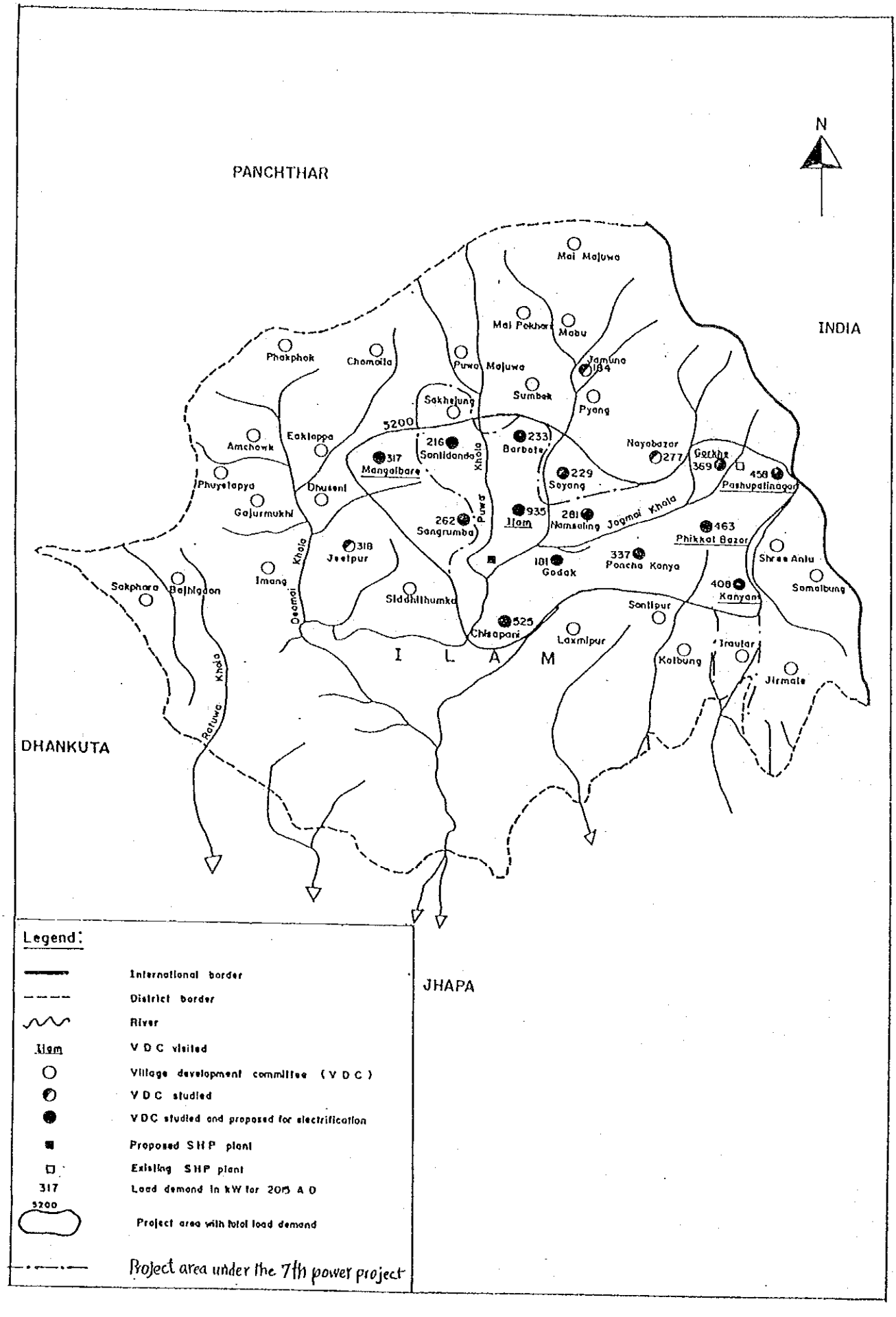


Fig. 2.3-6 Electrification under Small Hydropower Master Plan

DRAWING LIST (3)

Drawing No.	Tilte
Fig. 3.4-1	Location of Discharge Gauging and Precipitation Station

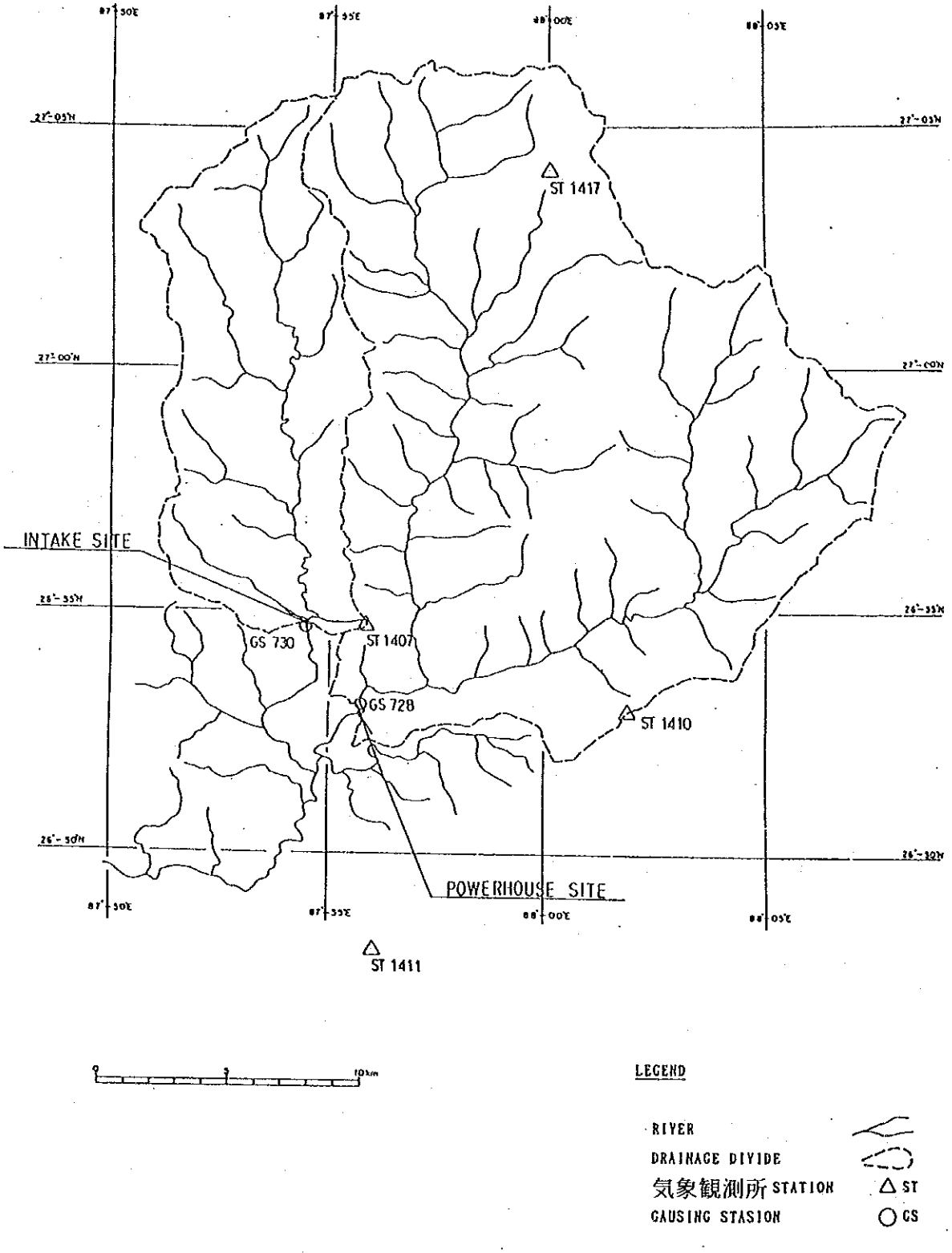


Fig. 3.4-1 Location of Discharge Gauging and Precipitation Station

DRAWING LIST (4)

Drawing No.	Title
Fig. 3.6-1	Geological Map
Fig. 3.6-2	Geological Map - Intake site
Fig. 3.6-3	Map (plan) - Penstock (1)
Fig. 3.6-4	Geological Section - Penstock (1)
Fig. 3.6-5	Map (Plan) - Penstock (2)
Fig. 3.6-6	Geological Section - Penstock (2)
Fig. 3.6-7	Map (Plan) - Penstock (3)
Fig. 3.6-8	Geological Section - Penstock (3)
Fig. 3.6-9	Geological Map - Power House Site
Fig. 3.6-10 (1)	Drilling Core Log. B-1 (1)
Fig. 3.6-10 (2)	- do - (2)
Fig. 3.6-10 (3)	- do - (3)
Fig. 3.6-11 (1)	Drilling Core Log. B-2 (1)
Fig. 3.6-11 (2)	- do - (2)
Fig. 3.6-12	Drilling Core Log. B-3
Fig. 3.6-13 (1)	Drilling Core Log. B-4 (1)
Fig. 3.6-13 (2)	- do - (2)
Fig. 3.6-14 (1)	Seismic Line Location Map (1)
Fig. 3.6-14 (2)	- do - (2)
Fig. 3.6-15	Distribution of Earthquake in Nepal

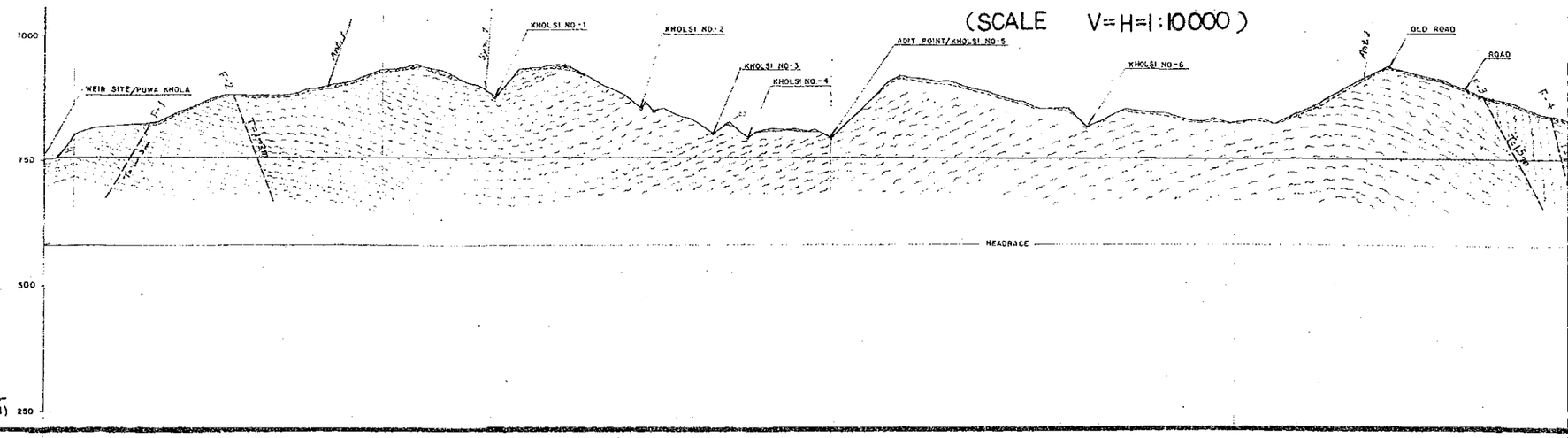
GEOLOGICAL MAP

S= 1:10,000

GEOLOGICAL SECTION

ALONG SEISMIC REFRACTION LINE

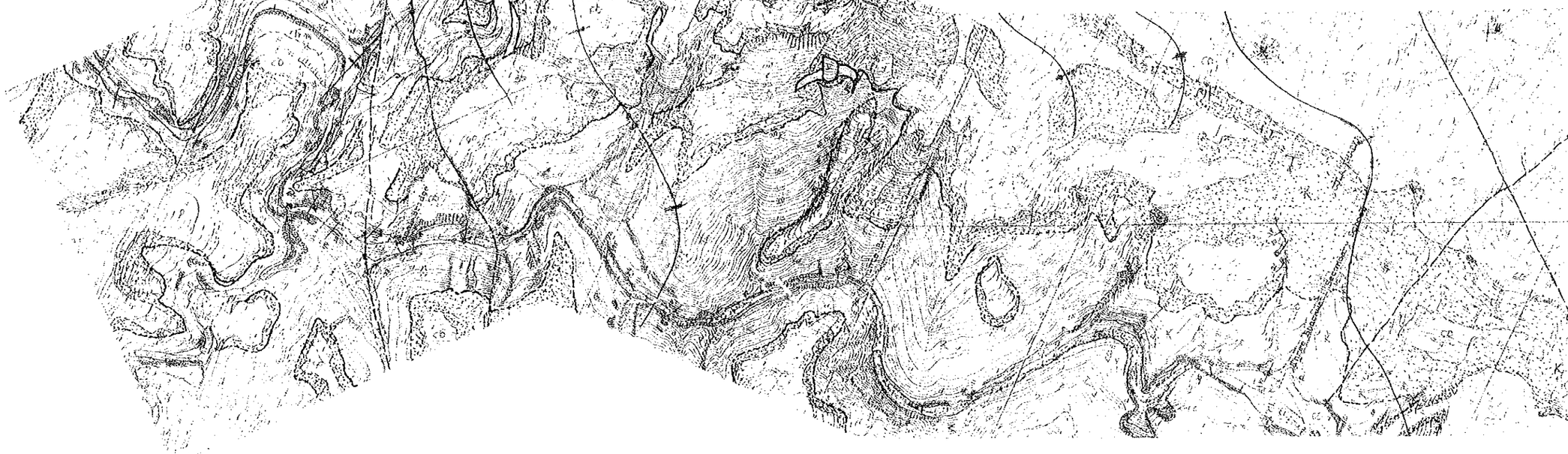
(SCALE V=H=1:10000)



GEOLOGICAL MAP

S= 1:10.000

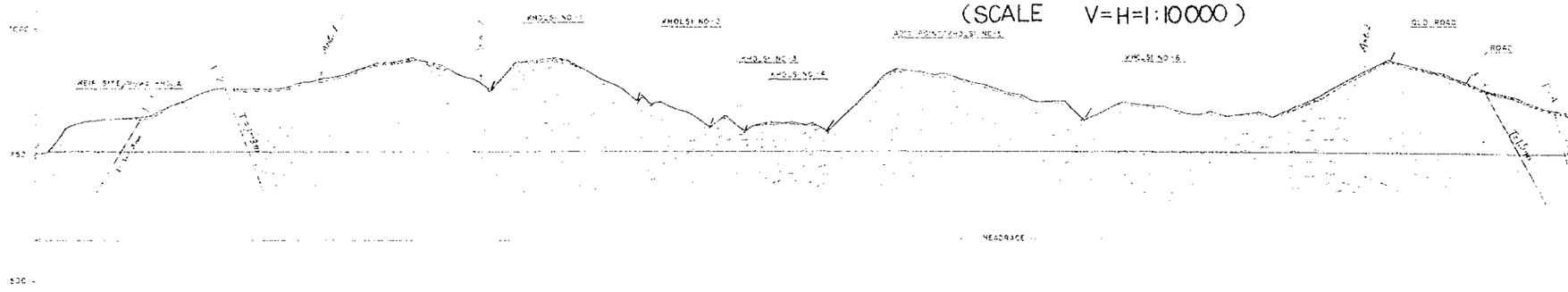
N



GEOLOGICAL SECTION

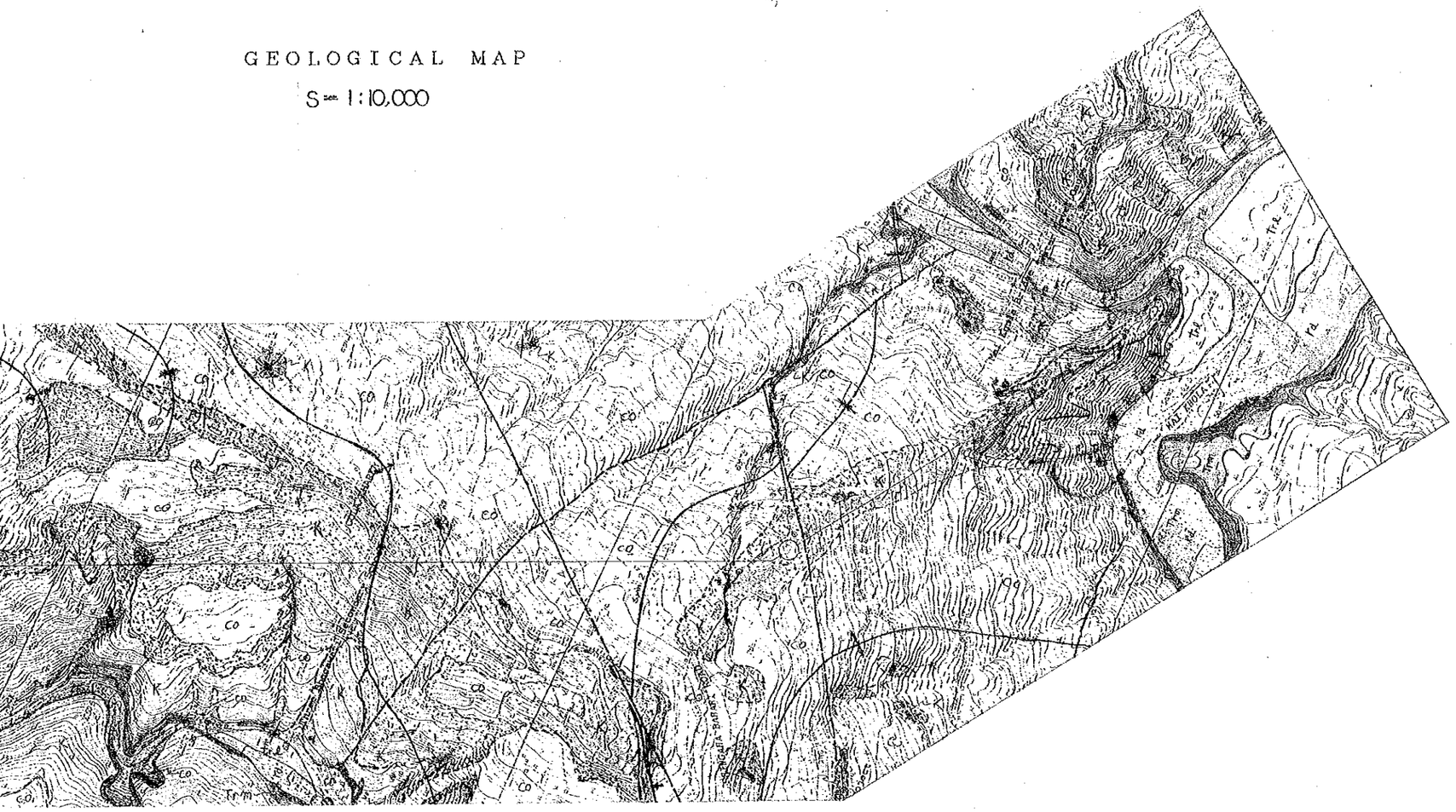
ALONG SEISMIC REFRACTION LINE

(SCALE V=H=1:10000)



GEOLOGICAL MAP

S= 1:10,000



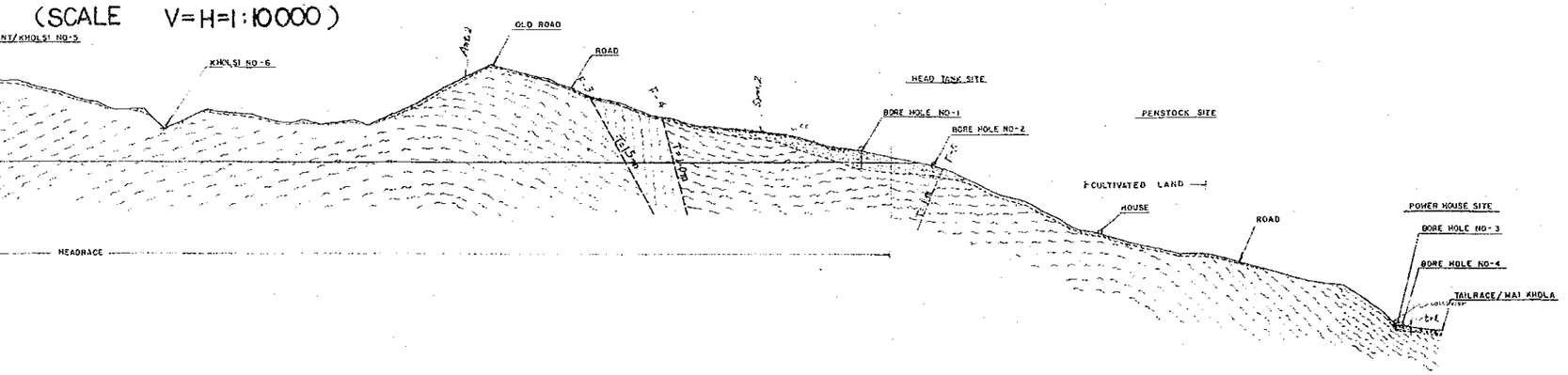
LEGEND

- RECENT RIVER DEPOSIT
- COLLUVIAL DEPOSIT AND ITS DEPTH
- LOWER TERRECE DEPOSIT
- MIDDLE TERRACE DEPOSIT
- KATHMANDU GROUP (ALTERNATION OF BIOTITE SCHIST, MUSCOBITE SCHIST, QUARTZITE AND GNEISSOSE SCHIST) WITH INTERBEDS OF THICK QUARTZITE (LENTICULAR SHAPED) AND THOSE RESIDUAL SOIL (DOTTED AREA)
- OUTCROPS OBSERVED
- LAND SLIDES OBSERVED
- FAULT AND ITS THICKNESS INFERRED
- ANTICLINAL AXIS INFERRED
- SYNCLINAL AXIS INFERRED
- STRIKE AND DIP AMOUNT OF FOLIATION OBSERVED
- STRIKE AND DIP AMOUNT OF FAULT OBSERVED
- GEOLOGICAL CONTACT INFERRED
- SEISMIC REFRACTION LINES

GEOLOGICAL SECTION

ALONG SEISMIC REFRACTION LINE

(SCALE V=H=1:10000)



LEGEND

- RECENT RIVER DEPSIT
- COLLUVIAL DEPOSIT
- LOWER TERRECE DEPOSIT
- KATHMANDU GROUP (ALTERNATION OF BIOTITE SCHIST, MUSCOBITE SCHIST, QUARTZITE AND GNEISSOSE SCHIST) WITH INTERBEDS OF THICK QUARTZITE (LENTICULAR SHAPED) AND THOSE RESIDUAL SOIL (DOTTED AREA)
- FAULT AND ITS THICKNESS INFERRED
- ANTICLINAL AXIS INFERRED
- SYNCLINAL AXIS INFERRED
- GEOLOGICAL CONTACT INFERRED

Fig. 3.6-1 Geological Map

GEOLOGICAL MAP

S= 1:10,000

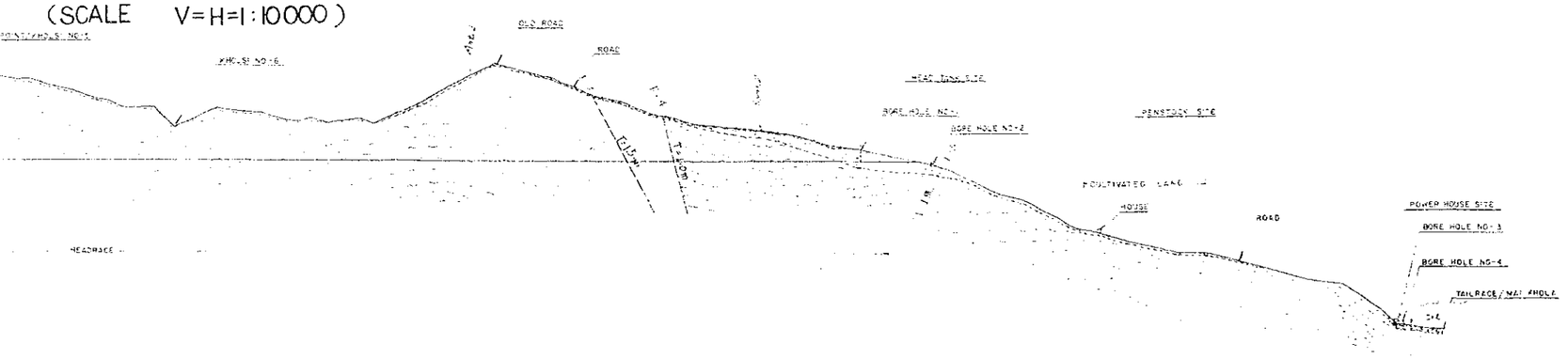
LEGEND

Qd	RECENT RIVER DEPOSIT
Qco	COLLUVIAL DEPOSIT AND ITS DEPTH
Tcl	LOWER TERRACE DEPOSIT
Tch	MIDDLE TERRACE DEPOSIT
K	KATHMANDU GROUP : ALTERNATION OF BIOTITE SCHIST, MUSCOVITE SCHIST, QUARTZITE AND GNEISSOSE SCHIST : WITH INTERBEDS OF THICK QUARTZITE : LENTICULAR SHAPED : AND THOSE RESIDUAL SOIL : DOTTED AREA :
	OUTCROPS OBSERVED
	LAND SLIDES OBSERVED
	FAULT AND ITS THICKNESS INFERRED
	ANTICLINAL AXIS INFERRED
	SYNCLINAL AXIS INFERRED
	STRIKE AND DIP AMOUNT OF FOLIATION OBSERVED
	STRIKE AND DIP AMOUNT OF FAULT OBSERVED
	GEOLOGICAL CONTACT INFERRED
	SEISMIC REFRACTION LINES

GEOLOGICAL SECTION

ALONG SEISMIC REFRACTION LINE

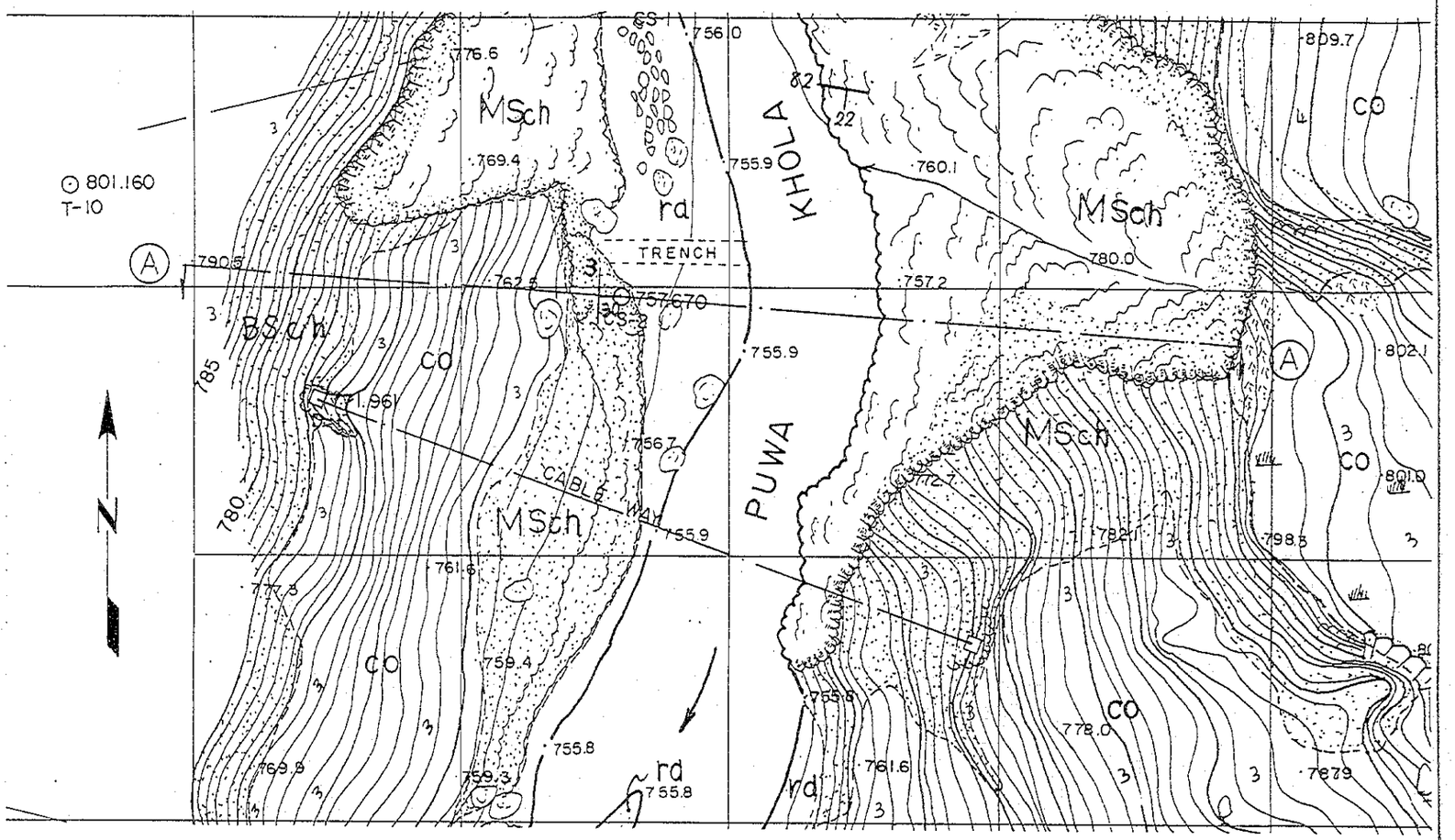
(SCALE V=H=1:10000)



LEGEND

	RECENT RIVER DEPOSIT
Co	COLLUVIAL DEPOSIT
Tcl	LOWER TERRACE DEPOSIT
K	KATHMANDU GROUP : ALTERNATION OF BIOTITE SCHIST, MUSCOVITE SCHIST, QUARTZITE AND GNEISSOSE SCHIST : WITH INTERBEDS OF THICK QUARTZITE : LENTICULAR SHAPED : AND THOSE RESIDUAL SOIL : DOTTED AREA :
	FAULT AND ITS THICKNESS INFERRED
	ANTICLINAL AXIS INFERRED
	SYNCLINAL AXIS INFERRED
	GEOLOGICAL CONTACT INFERRED

Fig. 3.6-1 Geological Map



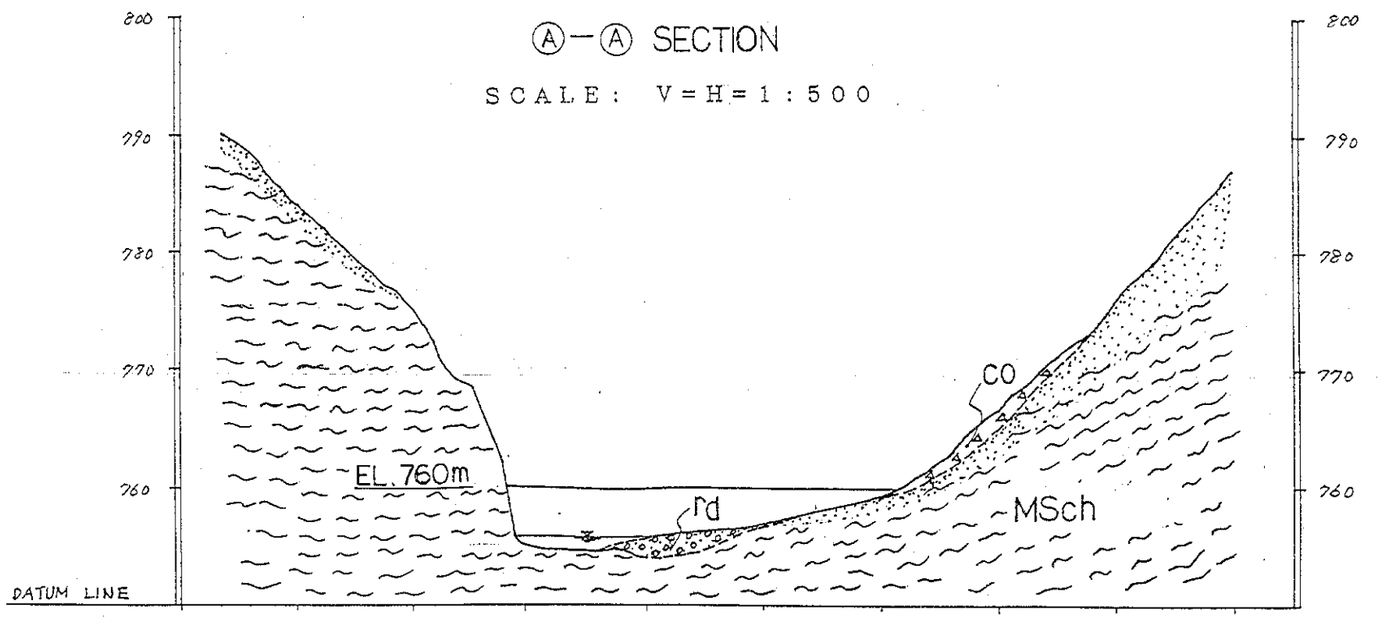


Fig. 3.6-2 Geological Map-Intake site

SHEET NO.-02

SURVEYED ON 1993, MAY 25th

TOPO MAP OF HEAD TANK AND PENSTOCK SITE
ILAM, NEPAL

N

LEGEND

PADDY FIELD	
UPLAND FIELD	
GRASS	
BAMBOO	
ISOLATED TREE	MANGO, D-12M
BUSHES/SCURB	
BROAD LEAF TREE	
ROCK OUT CROP	
ROCKY CLIFF	
SAND	
BOULDER	
BIG BOULDER	
SLOPE LAND SLIDE	
SPOT HEIGHT	726.4
CONTROL POINT	683.3 B-5
BENCH MARK	747.5 HT-1
HOUSE	
SHED	
TRAIL	
MAIN TRAIL	
ROAD	
FIELD LIMIT	

SCALE 1:500

INTERMEDIATE CONTOUR INTERVAL 1.0 M

MAIN CONTOUR INTERVAL 5.0 M

VERTICAL DATUM MEAN SEA LEVEL

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

INDEX

02 03 04

Fig. 3.6-3 Map (Plan) - Penstock (1)

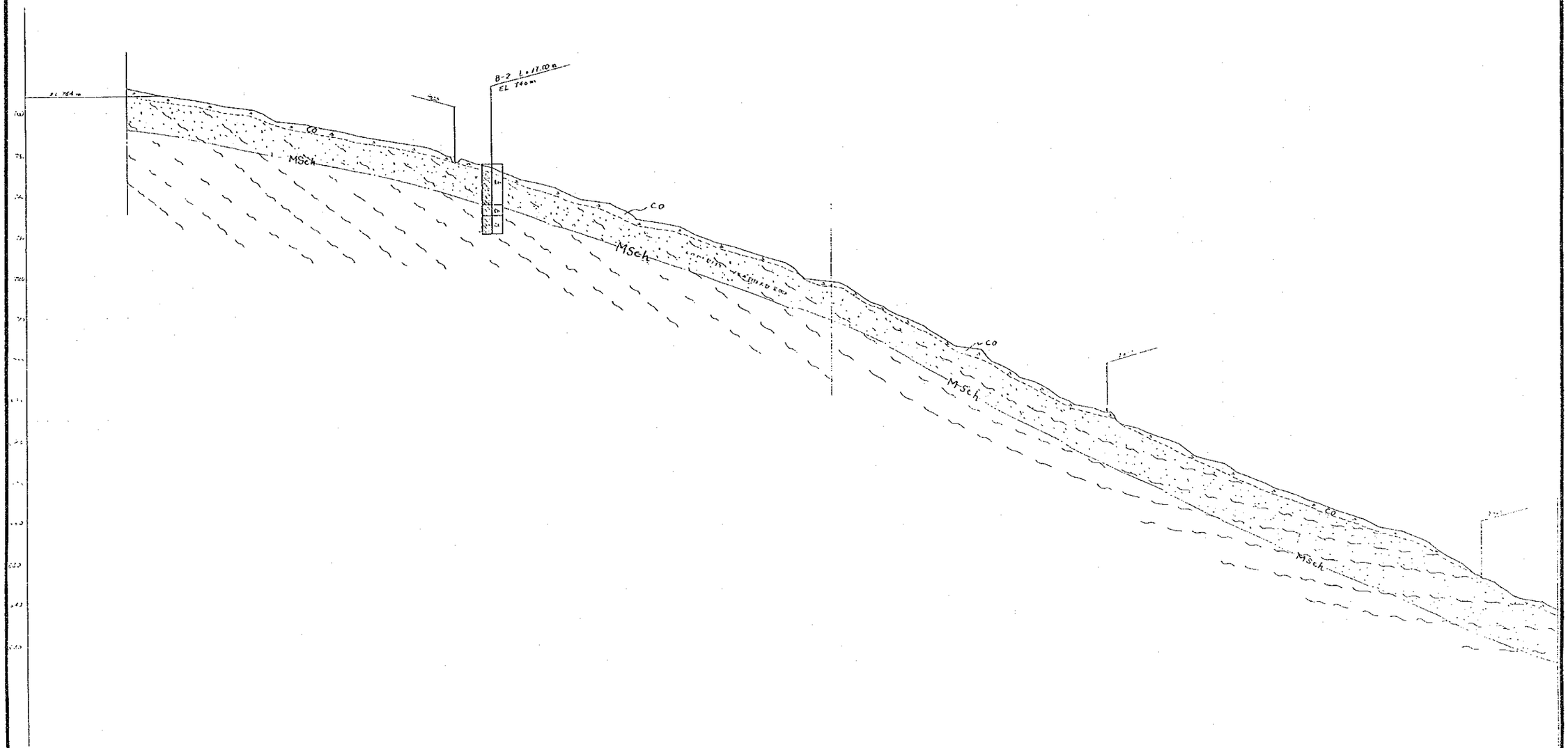


Fig. 3.6-4 Geological Section - Penstock (1)

SHEET NO.:03

SURVEYED ON: 1993, MAY 24TH

TOPO MAP OF PENSTOCK SITE
ILAM, NEPAL

N

LEGEND

PADDY FIELD	
UPLAND FIELD	
GRASS	
BAMBOO	
ISOLATED TRE	
BUSHES/SCURB	
BROAD LEAF TREE	
ROCK OUT CROP	
ROCKY CLIFF	
SAND	
BOULDER	
BIG BOULDER	
SLOPE LAND SLIDE	
SPOT HEIGHT	574.4
CONTROL POINT	581.5 N-1
BENCH MARK	568.9 HT-2
HOUSE	
SHED	
TRAIL	
MAIN TRAIL	
ROAD	
FIELD LIMIT	

SCALE 1:500

INTERMEDIATE CONTOUR INTERVAL 1.0 M

MAIN CONTOUR INTERVAL 5.0 M

VERTICAL DATUM MEAN SEA LEVEL

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

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02 03 04

Fig. 3.6-5 Map (Plan) - Penstock (2)

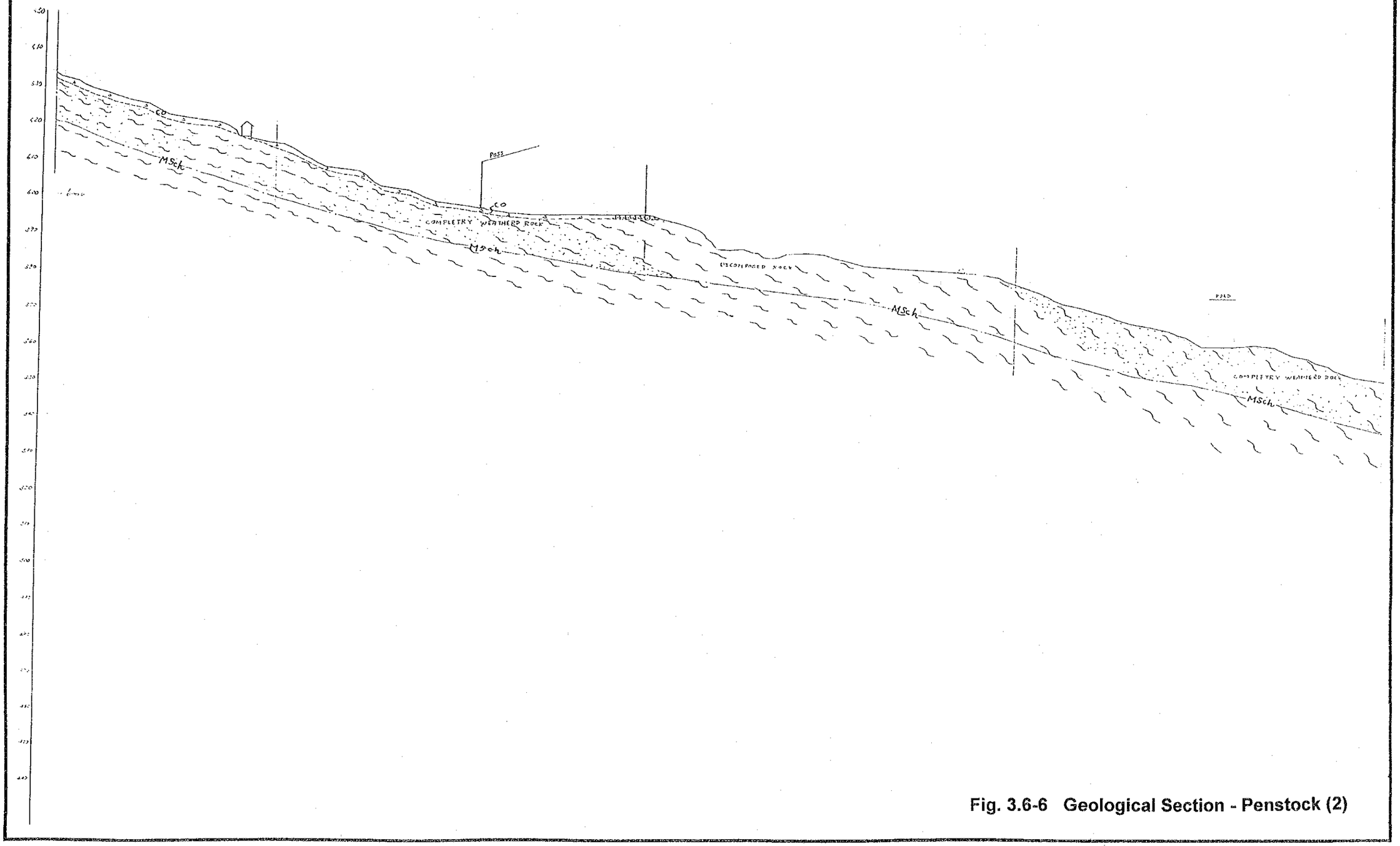


Fig. 3.6-6 Geological Section - Penstock (2)

SHEET NO.·04

SURVEYED ON 1993, MAY 20th

TOPO MAP OF POWER HOUSE SITE

MAI KHOLA, ILAM

NEPAL

N

LEGEND

PADDY FIELD	
UPLAND FIELD	V
GRASS	GL
BAMBOO	
ISOLATED TREE	MAINA, Ø 1.0M
BUSHES/SCURB	3
BROAD LEAF TREE	Q
ROCK OUT CROP	
ROCKY CLIFF	
SAND	
BOULDER	
BIG BOULDER	
SLOPE LAND SLIDE	
SPOT HEIGHT	·438.9
CONTROL POINT	⊙525.68 CS-5
BENCH MARK	□437.95 PH-1
HOUSE	
SHED	
TRAIL	
MAIN TRAIL	
ROAD	
FIELD LIMIT	

SCALE 1:500

0 5 10 15 20 25 30 35 40 45

INTERMEDIATE CONTOUR INTERVAL 10 M

MAIN CONTOUR INTERVAL 50 M

VERTICAL DATUM MEAN SEA LEVEL

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

INDEX

02 03 04

FOREST

MAI KHOLA

MAINA TREE Ø 1.50 M.

ROAD

CHILAUNE Ø 0.70M

N.2974250 2974225 2974200 2974175 2974150 2974125 2974100 2974075 2974050 2974025 2974000 2973975

E592150 592175 592200 592225 592250 592275 592300 592325 592350 592375 592400 592425 592450 592475 592500

Fig. 3.6-7 Map (Plan) - Penstock (3)

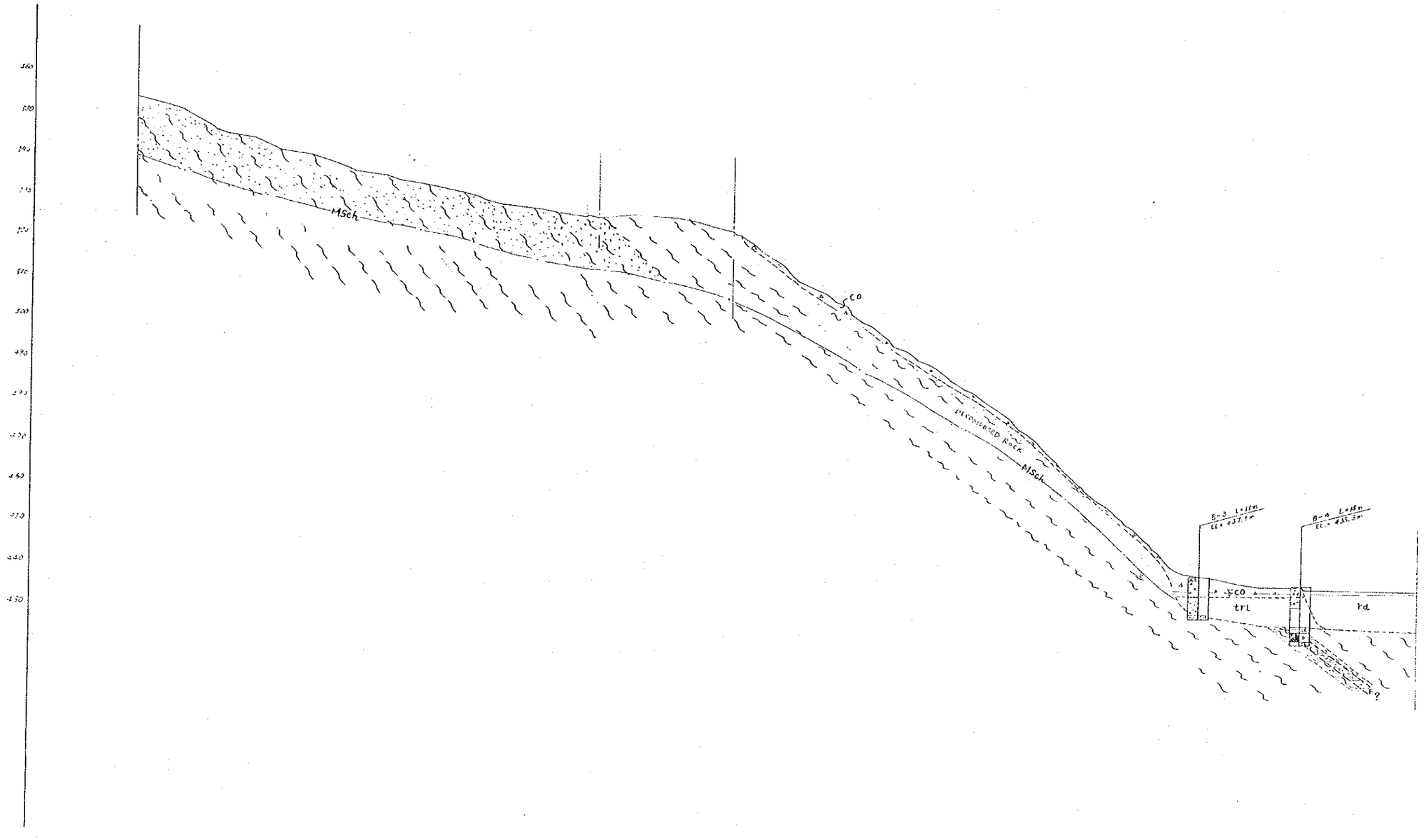
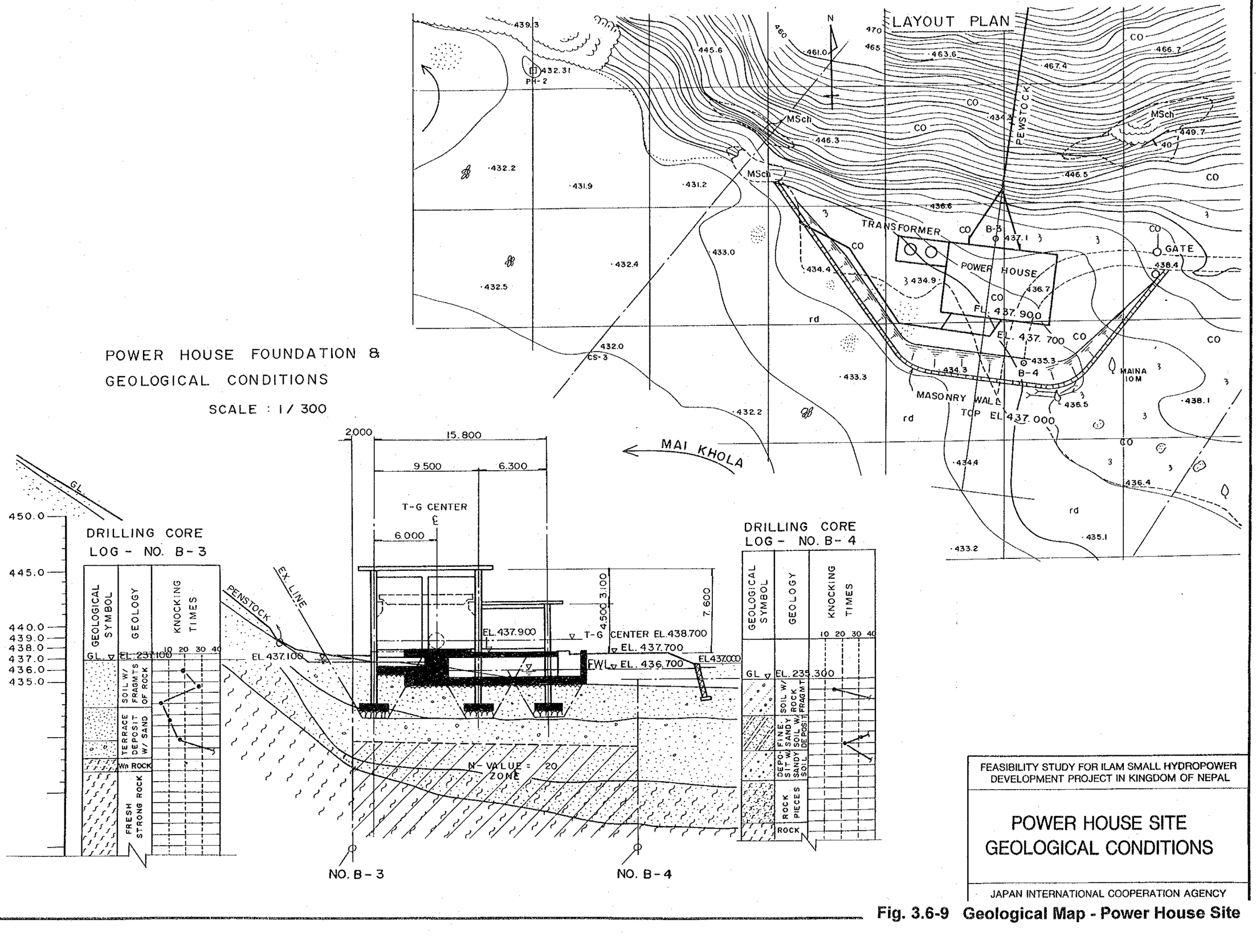


Fig. 3.6-8 Geological Section - Penstock (3)



POWER HOUSE FOUNDATION &
GEOLOGICAL CONDITIONS

SCALE : 1/ 300

FEASIBILITY STUDY FOR ILAM SMALL HYDROPOWER DEVELOPMENT PROJECT IN KINGDOM OF NEPAL

POWER HOUSE SITE
GEOLOGICAL CONDITIONS

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 3.6-9 Geological Map - Power House Site

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project — No. of Hole: B - 1

Location : Foreba — Depth of Bedrock: None — Bore Hole Dia.: 66 mm, Type of Drill — Depth of Hole : 33.0 m

Elevation :.... — Core Recovery: 86.47 % — Machine : TONE UD-5 — Operator : Nara Bahadur

Direction :.... — Underground — Engineer : R.G.Siwakoti

Inclination : Vertic — Water Table: 16.06-22.43 m — Date: 08061993 — Geologist: D.R.Pant

Casing Depth : 24.07/NW size.

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)						Sampling			Remarks
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times	Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10 20 30 40 50				
1.00			Fine to medium lateritic soil with quartz grains and muscovite.	Brownish Red	100	0	1.05	31	8	9	14		1	1.05		
2.00					100	0	2.05	50	23	16	11/5		2	2.05	R	
	2.30		Soil with rock fragments	Gray												
3.00	2.65		Residual soil derived from mica schist	Light gray	100	0	3.05	34	7	17	10		3	3.05	A	
	3.50															
4.00	3.80		Residual soil with quartz.	gray	100	0	4.05	50	32	18/5			4	4.05	Y	
5.00			Residual soil less sandy with gravelly bottom	Yellowish red	100	0	5.05	50	29	21/5			5	5.05	M	
	5.20															
6.00					100	0									O	
							6.45	50	12	20	18/3		6	6.45		
7.00					100	0	7.05	42	11	16	15		7	7.05	N	
			Sandy residual Soil	Yellowish Brown												7.6-8.0
8.00					100	0	8.05	35	12	13	10		8	8.05	D	Core lo
9.00					100	0										
							9.65	32	10	8	14		9	9.45		
10.00					100	0										
11.00					100	0	11.1	50	11	20	19		10	11.05		
	11.25		Residual soil with quartz	Brownish Yellow												
12.00	12.10				100	0										
			Residual soil with grain size decreasing below	Yellowish bro			12.2	22	6	7	9		11	12.2		
13.00					100	0										

Fig. 3.6-10 (1) Drilling Core Log. B-1 (1)

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project

No. of Hole: B - 1
(Sheet No. 2)

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)						Sampling			Remark
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times	Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10 20 30 40 50				
							13.6	31	12	9	10		12	13.55		
14.00					100	0										
			Residual soil with the grain size decreasing with depth.	Yellowish Brown			14.9	50	18	28	4/2		13	14.86	R	
15.00					100	0	15.70	30	10	10	10		14	15.70		
16.00					100	0									A	
																At 17 m
17.00					100	0									Y	SPT not
																possible
18.00					100	0	18.1	50	50/8				15	18.09	M	
	18.20		Core Loss													Core los
19.00	18.8				45	0									O	
			Coarse grained residual soil with quartz	Light Gray			19.5	50	30	20/5			16	19.53		
20.00					70	0									N	Core Lo
	20.40						20.7	44	9	13	22		17	20.72		19.7-20.
21.00	20.70		Resid. soil med grains	Yellow	75	0									D	
			Medium grained Residual soil.	Gray			21.8	50	45	5/1			18	21.79		
22.00					100	0										
							22.80	50	31	19			19	22.80		
23.00	23.10				100	0										
			Fine to medium grained residual soil with mica and quartz fragments.	Brownish Yellow												
24.00					90	0	24.1	50	50				20	24.05		
25.00					100	0	25.1	50	18	32/8			21	25.05		
26.00					100	0										

Fig. 3.6-10 (2) Drilling Core Log. B-1 (2)

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project

No. of Hole: B - 1
(Sheet No. 3)

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)										Sampling			Remark
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times					Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10	20	30	40	50				
	26.9						26.30	50	50/5								22	26.30		
27.00			Core Loss		83	0													R	Core los
	27.5																			26.9-27.
28.00					55	0													A	
				Yellowish																
29.00				Gray	100	0													Y	
			Mainly medium grains																	
30.00			residual soil with		100	0													M	
			increasing quartz																	
31.00			content with a pocket		100	0	31.1	50	50/8								23	31.05	O	
			od silt 20 cm thick																	
32.00			at 32.00 m depth.		100	0													N	
33.00	33.00			Yellowish	100	0													D	
				Gray																
34.00																				

Drill hole terminated at 33.00 m depth.

Fig. 3.6-10 (3) Drilling Core Log. B-1 (3)

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project — No. of Hole: B - 2

Location : Foreba — Depth of Bedrock: 12.7 m — Bore Hole Dia.: 66 mm — Depth of Hole : 17.00 m

Elevation :.... — Core Recovery: 86.47 % — Type of Drill Machine : TONE UD-5 — Operator : Nara Bahadur

Direction :... — Underground — Engineer : R.G.Siwakoti

Inclination : Vertic — Water Table: DRY — Date: 12061993 — Geologist: D.R.Pant

Casing Depth : 12.93 m/NW size.

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)					Sampling			Remarks
							Test Depth m	N Value	Knocking Times Per 10 cm.			Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10				
1.00			Fine to medium grained residual soil with highly weathered fragments of mica, quartz, feldspar, etc. with the percentage of clay varying from place to place.	Light gray to brownis Red.	100	0	1.05	11	3	4	4	1	1.05		
2.00					100	0	2.05	42	18	12	12	2	2.05	R	
3.00					100	0	3.05	38	21	10	7	3	3.05	A	
4.00					100	0	4.25	19	6	6	7	4	4.05	Y	
5.00					100	0	5.05	24	7	10	7	5	5.05	M	
6.00					100	0	6.05	15	4	5	6	6	6.05	O	
7.00					100	0	7.05	17	4	5	8	7	7.05	N	
8.00					100	0	8.05	14	4	5	8	8	8.05	D	7.6-8.0 Core los
9.00	8.78		Coarser soil than above	Gray	100	0	9.05	32	12	11	9	9	9.05		
10.00	9.50		Residual soil with smaller quartz grains than in the overlying soil.	Brownis Yellow	100	0	10.1	50	22	28		10	10.05		
11.00					100	0	11.1	50	22	28		11	11.05		
12.00	12.50		Weathered mica schist		100	0	12.1	50	50			12	12.05		
	12.70		Mica schist 56 deg.dip	Gray											
13.00					100	50									

Knocking Times: 10 20 30 40 50

Fig. 3.6-11 (1) Drilling Core Log. B-2 (1)

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project

No. of Hole: B - 2
(Sheet No. 2)

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)										Sampling			Remark
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times					Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10	20	30	40	50				
	13.2																			
14.00			Core Loss from		25	44														
	14.40		13.24 to 14.40 m																	
15.00	14.77		Mica Schist	Gray	35	0														
			Core loss from 14.77																	
16.00	15.90		to 15.90 m		10	0														
	16.4		Mica Schist, dip 78 de																	
17.00	17.00		Fine to medium graine		100	39														

completely decomposed

between 16.5-16.58 m depth.

Fig. 3.6-11 (2) Drilling Core Log. B-2 (2)

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Proje Location : Power House No. of Hole: B - 3

Depth of Bedrock: 8.90 m Bore Hole Dia.: 66 mm Depth of Hole : 11.06 m

Type of Drill

Elevation :.... Core Recovery: 89.42 % Machine : TONE UD-5 Operator : Nara Bahadur

Direction :... Underground Engineer : R.G.Siwakoti

Inclination : Vertic Water Table: 3.30 m Date: 02061993 Geologist: D.R.Pant

Casing Depth : 7.43 m/NW size.

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)						Sampling			Remar'
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times	Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10 20 30 40 50				
1.00	1.68		Colluvium with soil and fragments of schist	Grayish Brown	100	0	1.05	20	6	6	8		1	1.05		
2.00			Colluvium with soil and smaller fragments of Rock.	Grayish to Yellowis Brown	100	0	2.40	27	10	9	8		2	2.40	R A Y	
3.00					100	0	3.75	5	1	1	3		3	3.75		
4.00	4.30				100	0										
5.00			Terrace deposit compose of fine to medium grained sandy soil.	Gray	80	0	5.10	10	2	4	4		4	5.10	M	
6.00					100	0									O	
7.00					80	0	6.30	14	3	5	6		5	6.30		
8.00	7.35		Terrace deposit composed of quartzite an gneiss fragments and soil	Varyous shades gray & brown	70	0	7.05	15	2	5	8		6	7.05	N	
9.00	8.90		Slightly weathered thinly bedded mica schist.		71	0	8.50	50	13	21	16		7	8.50	D	Core lo 9.32-9.4 Limonit St. joint dip 57& Foliatio dip 37 d
10.00	10.10		Fresh and strong quartz rich mica schist.	Gray with lig & dark	88	0										
11.00					100	50										

Drill Hole Terminated at 11.06 m Layers

Fig. 3.6-12 Drilling Core Log. B-3

DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project

No. of Hole: B - 4
(Sheet No. 2)

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)											Sampling			Remarks
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times						Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10	20	30	40	50					
	9.30		Sand	Gray																	
10.00			Gray schistose rock piece obtained from 9.85-10.08		45	0															
11.00					13	0															
			10.95-11.08,& 11.59-11.76	Gray																	
12.00			In rest of the sections, cor		25	0															
			loss due to poor rock																		
13.00	13.1		condition.		0	0															
			Mica schist, blocky, strong	Banded																	R.'Dip 27
14.00			slightly weathered to fresh	gray	92	43															J.16&35

Rock dips at 27 and joints at 16 and 35 degrees.

Terminated at 14.00 m.

Fig. 3.6-13 (1) Drilling Core Log. B-4 (1)

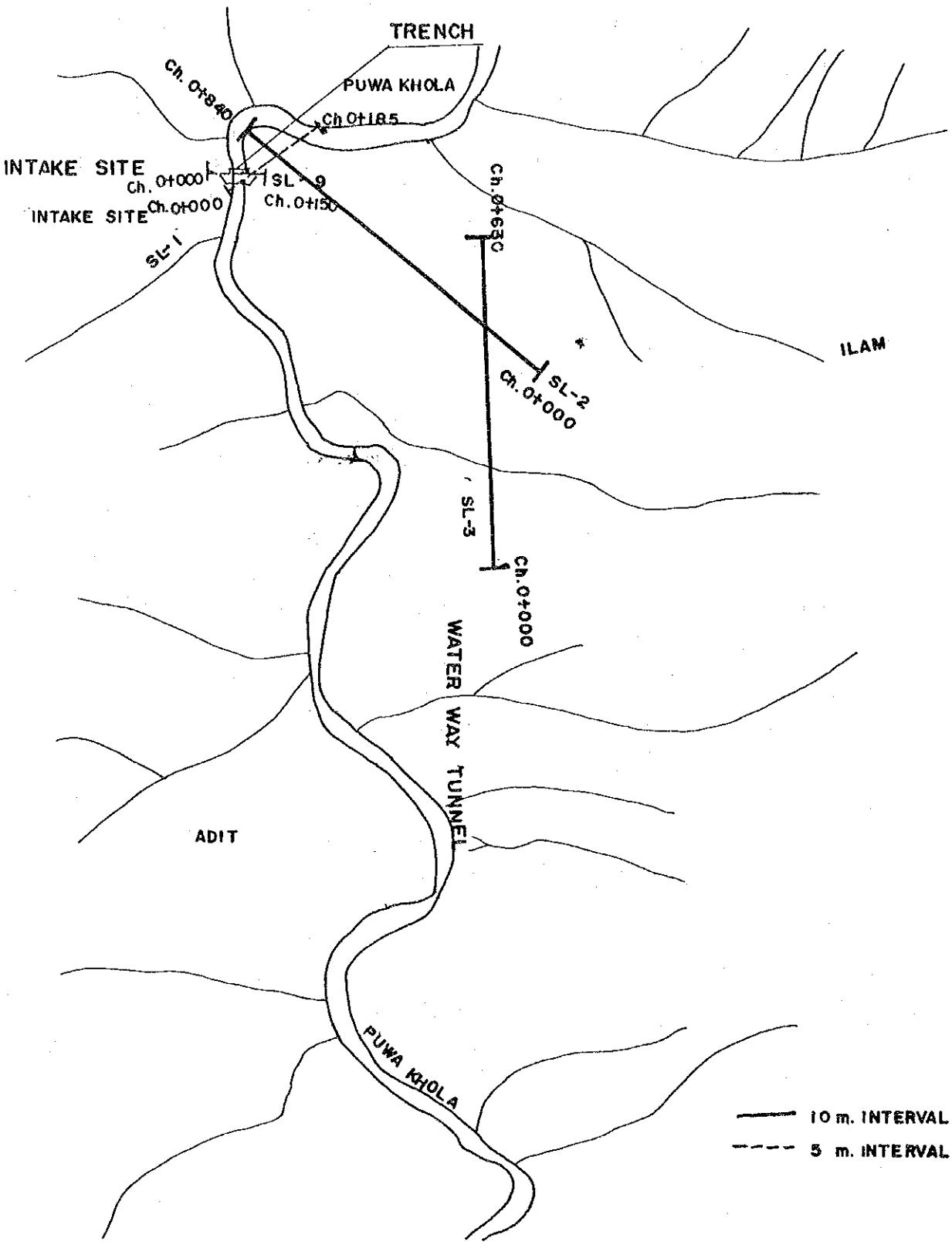
DRILLING CORE LOG

Project : Ilam Small Hydropower Development Project

No. of Hole: B - 4
(Sheet No. 2)

Scale m	Depth m	Geological Section	Geology	Color	Core Recovery, %	RQD %	Standard Penetration Test (SPT)										Sampling			Remarks
							Test Depth m	N Value	Knocking Times Per 10 cm.			Knocking Times					Sample No.	Sample Depth m	Sampler	
									cm 10	cm 10	cm 10	10	20	30	40	50				
	9.30		Sand	Gray																
10.00			Gray schistose rock piece obtained from 9.85-10.08		45	0														
11.00					13	0														
12.00			10.95-11.08,& 11.59-11.76 In rest of the sections, cor loss due to poor rock	Gray	25	0														
13.00	13.1		condition.		0	0														
14.00			Mica schist, blocky, strong slightly weathered to fresh	Banded gray	92	43														R.'Dip 27 J.16&35
			Rock dips at 27 and joints at 16 and 35 degrees.				Terminated at 14.00 m.													

Fig. 3.6-13 (2) Drilling Core Log. B-4 (2)



SEISMIC LINE LOCATION MAP, INTAKE SITE AND HEADRACE TUNNEL. SCALE, 1:10000

Fig. 3.6-14 (1) Seismic Line Location Map (1)

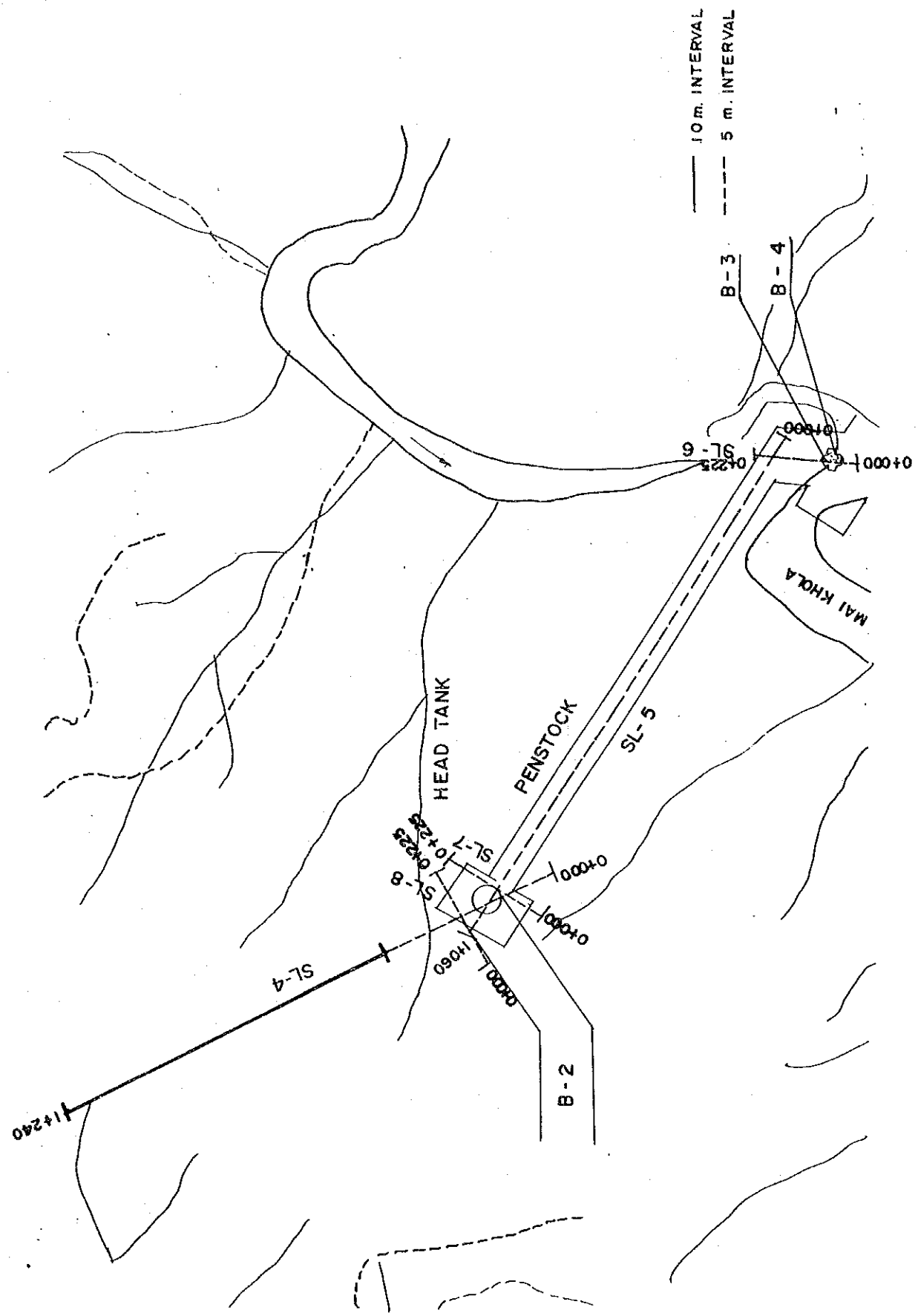


Fig. 3.6-14 (2) Seismic Line Location Map (2)

DISTRIBUTION OF EARTHQUAKE IN NEPAL

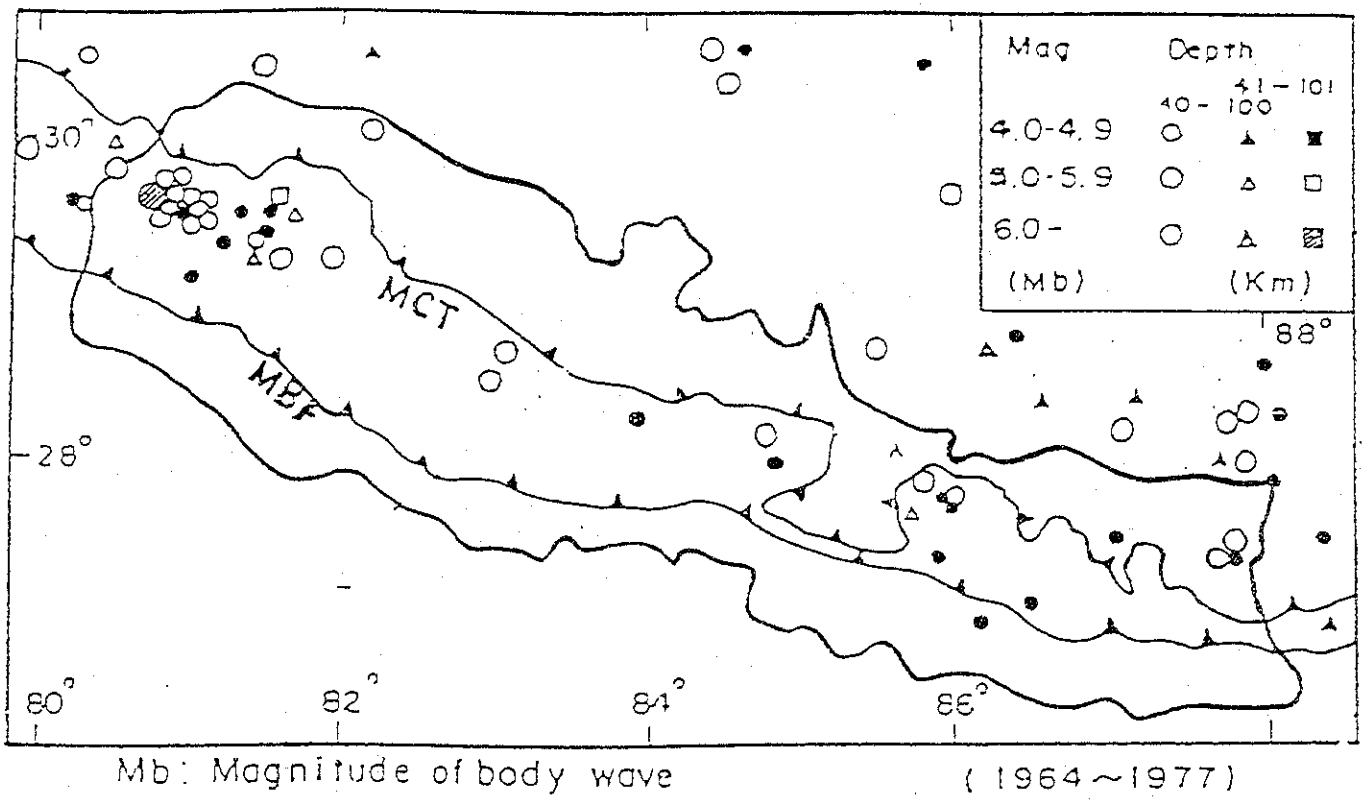


Fig. 3.6-15 Distribution of Earthquake in Nepal

DRAWING LIST (5)

Drawing No.	Title
Fig.3.7-1	Topography at the Upper Catchment of the Project Area
Fig.3.7-2	Longitudinal Profile of Mai Khola River System
Fig.3.7-3	Water Level Discharge Curve (1969 ~ 74)
Fig.3.7-4	Water Level Discharge Curve (1975 ~ 82)
Fig.3.7-5	Water Level Discharge Curve (1982 ~ 84)
Fig.3.7-6	Water Level Discharge Curve (1985 ~ 87)
Fig.3.7-7	Discharge Duration curve at Gauge Stand GS - 730
Fig.3.7-8	Water Level Discharge Curve for Puwa Khola Intake Site
Fig.3.7-9	Water Level Discharge Curve for Mai Khola Power House Site

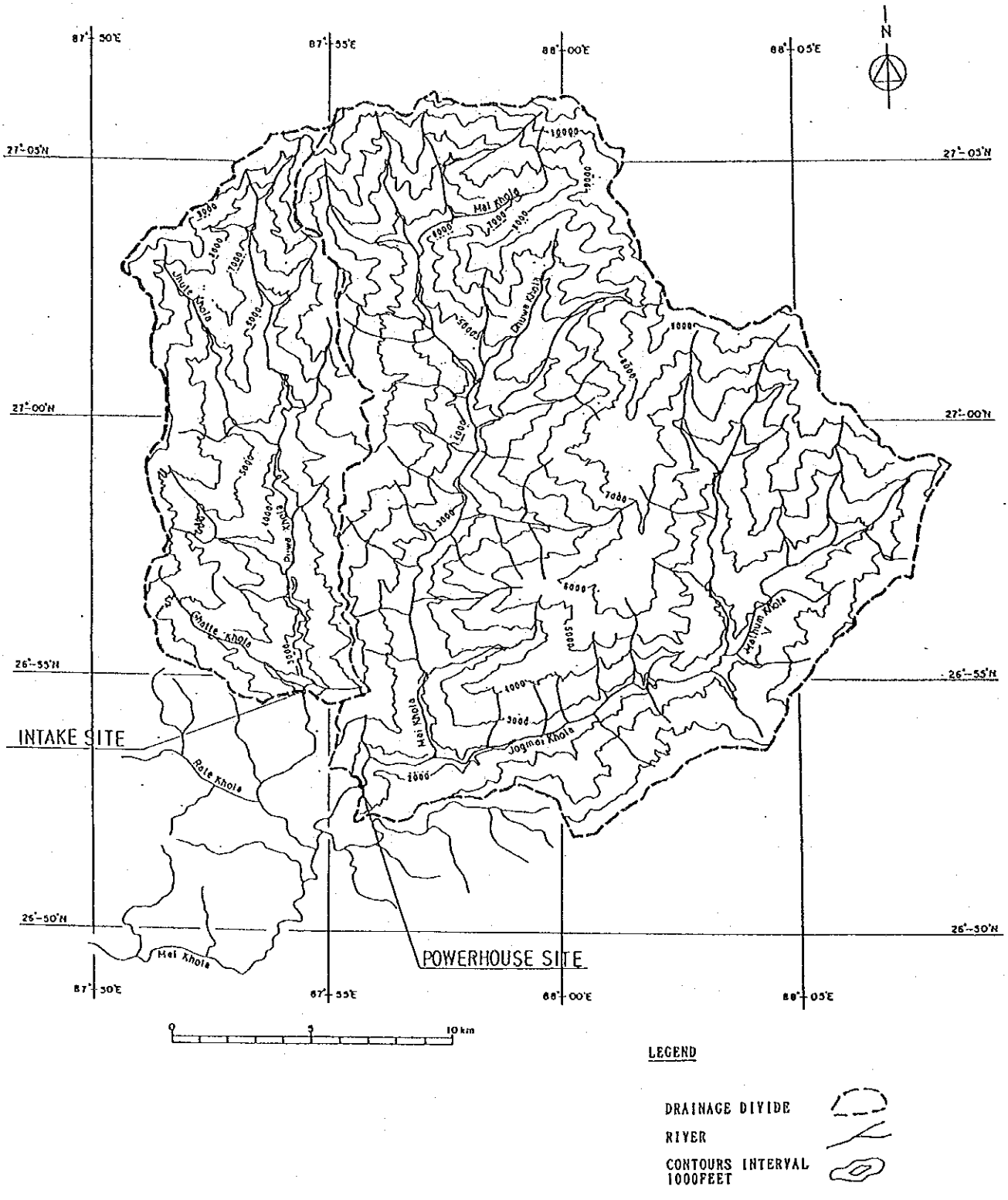


Fig. 3.7-1 Topography at the Upper Catchement of the Project Area

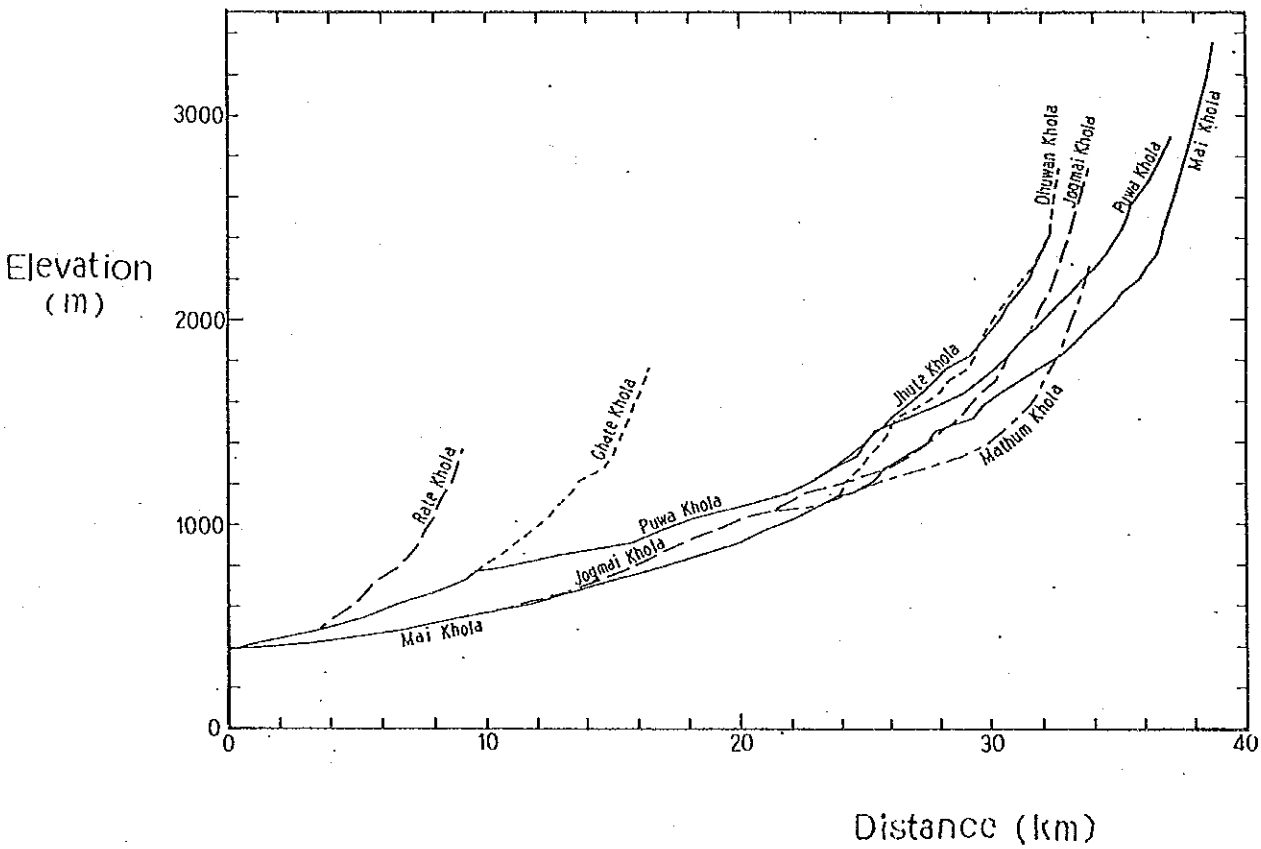


Fig. 3.7-2 Longitudinal Profile of Mai Khola River System

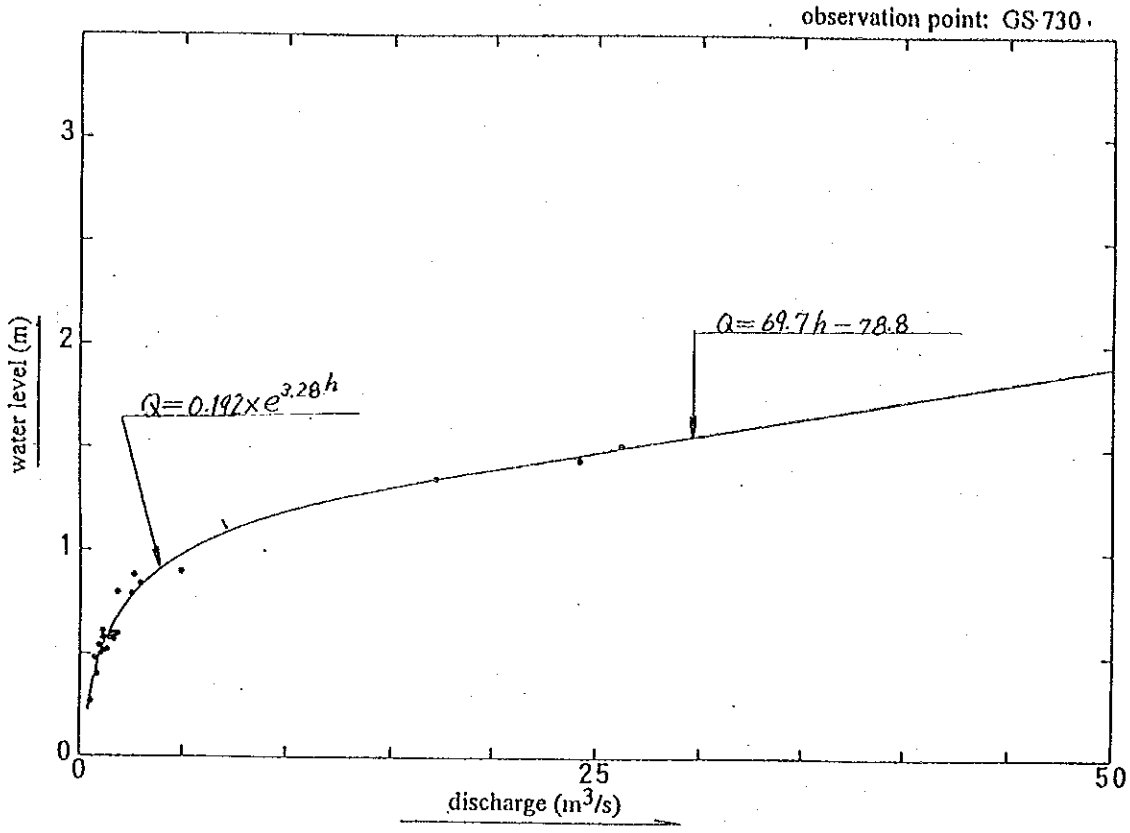


Fig. 3.7-3 Water Level Discharge Curve (1969 ~ 74)

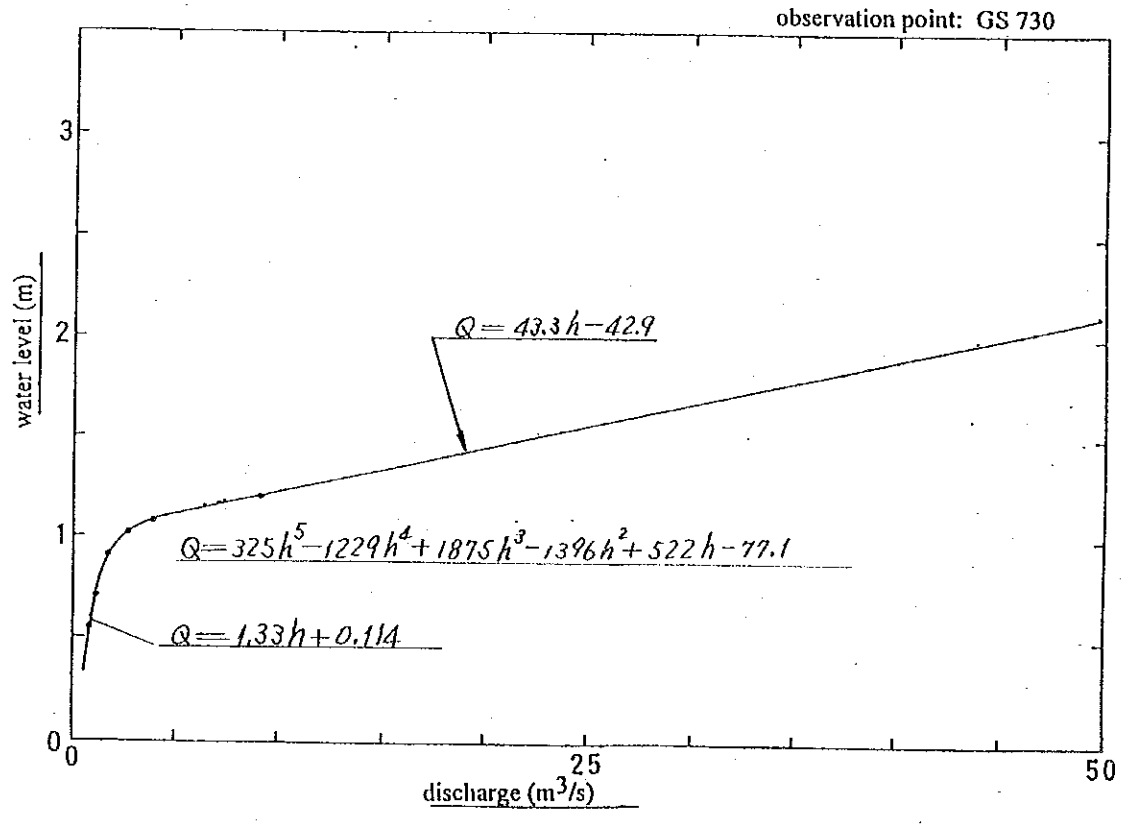


Fig. 3.7-4 Water Level Discharge Curve (1975 ~ 82)

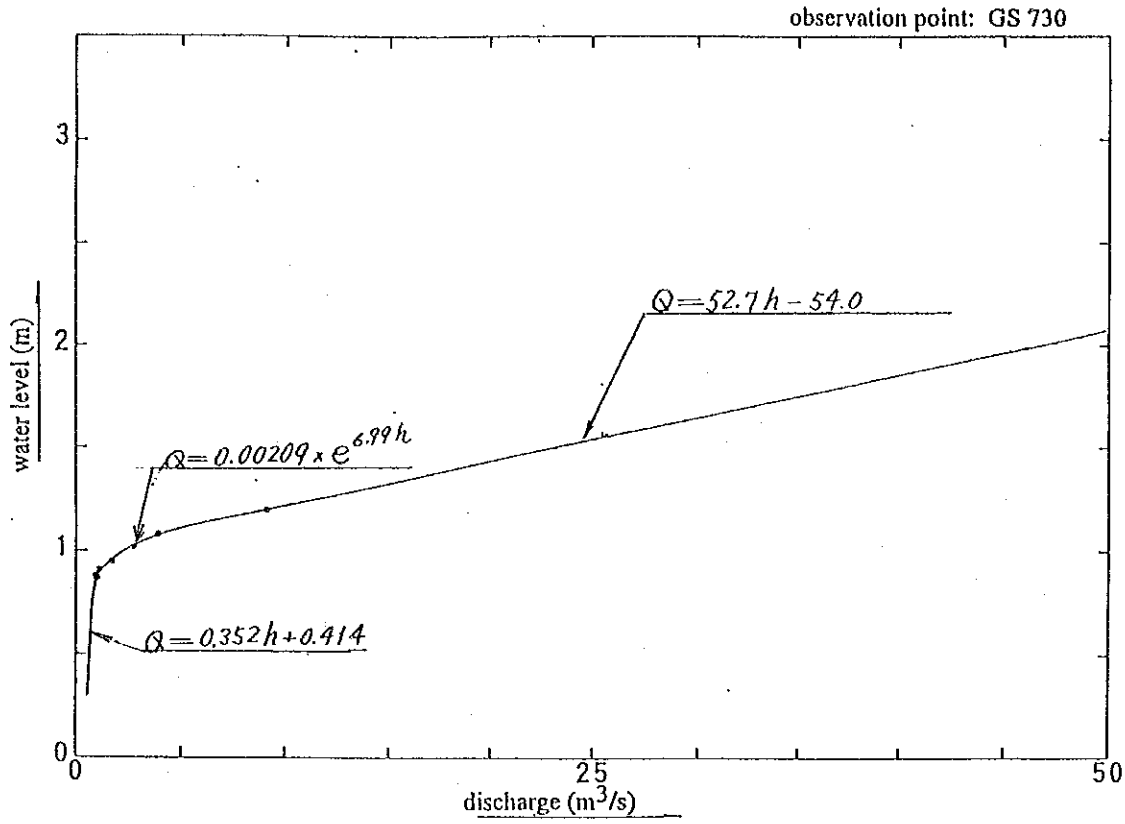


Fig. 3.7-5 Water Level Discharge Curve (1982 ~ 84)

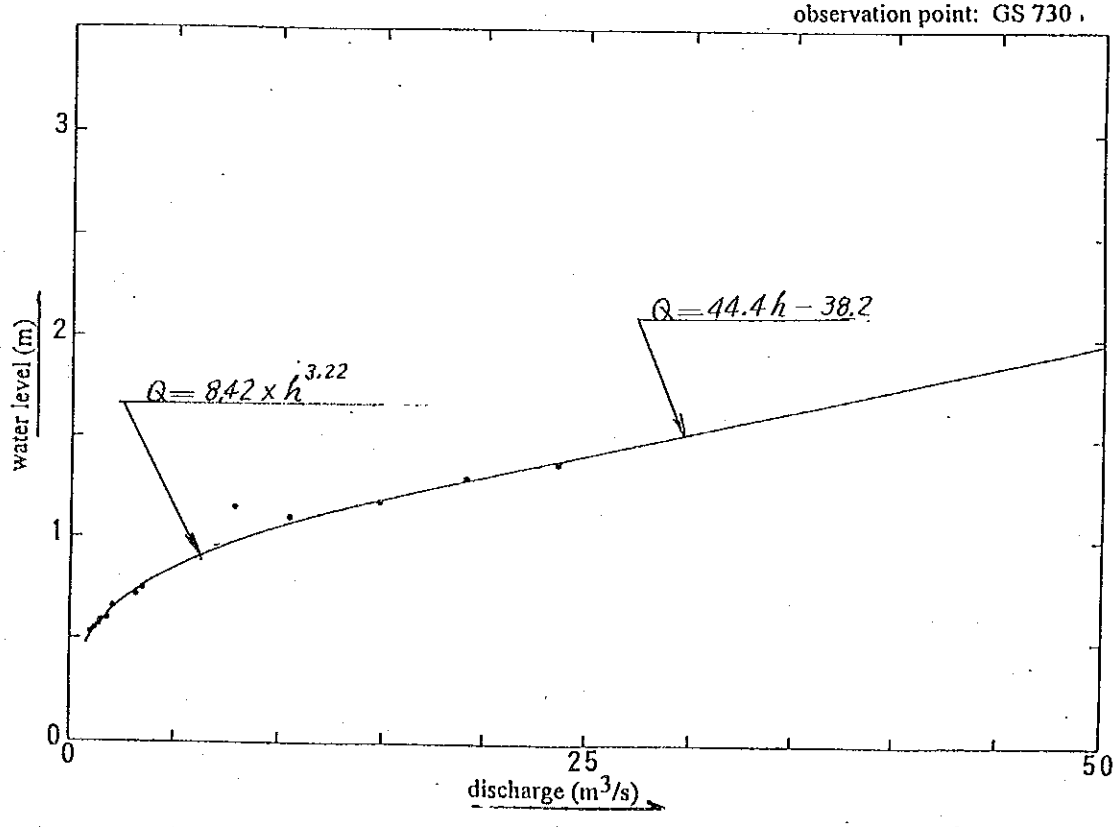
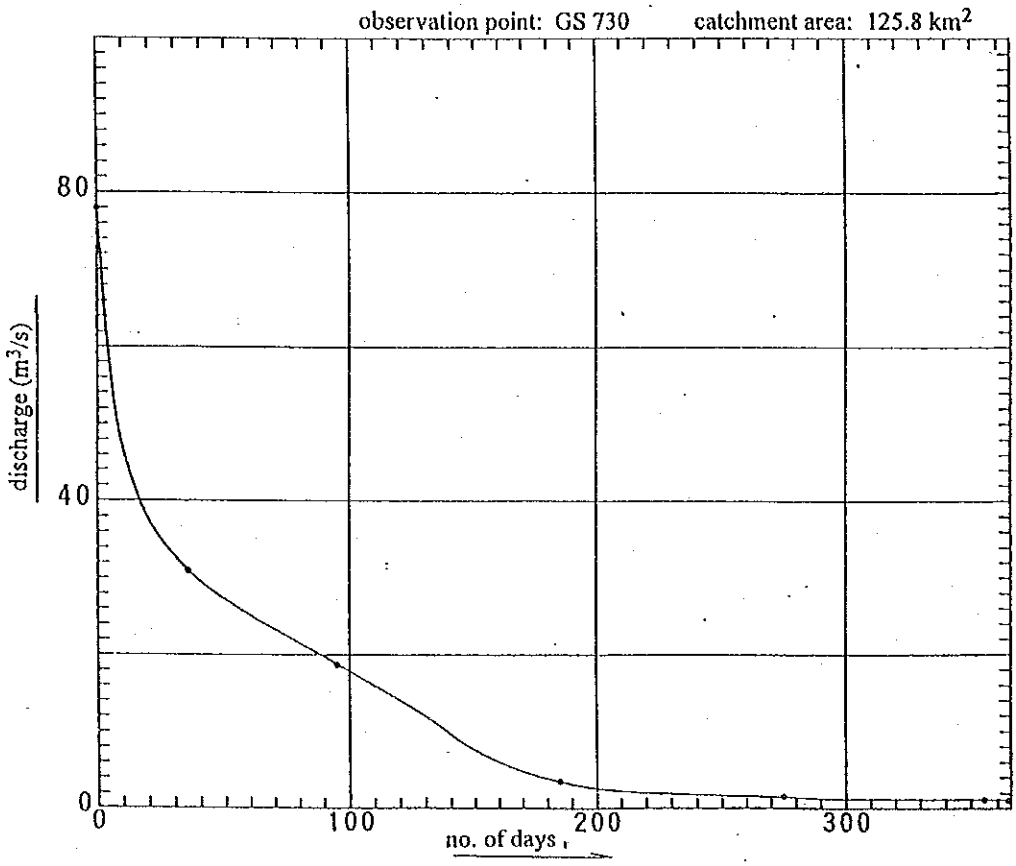


Fig. 3.7-6 Water Level Discharge Curve (1985 ~ 87)



maximum	78.0 m³/s
35 days	31.0 m³/s
high water (95 days)	18.7 m³/s
average (185 days)	3.6 m³/s
low water (275 days)	1.5 m³/s
drought (355 days)	1.1 m³/s
minimum	1.0 m³/s

Fig. 3.7-7 Discharge Duration Curve at Gauge Stand GS - 730

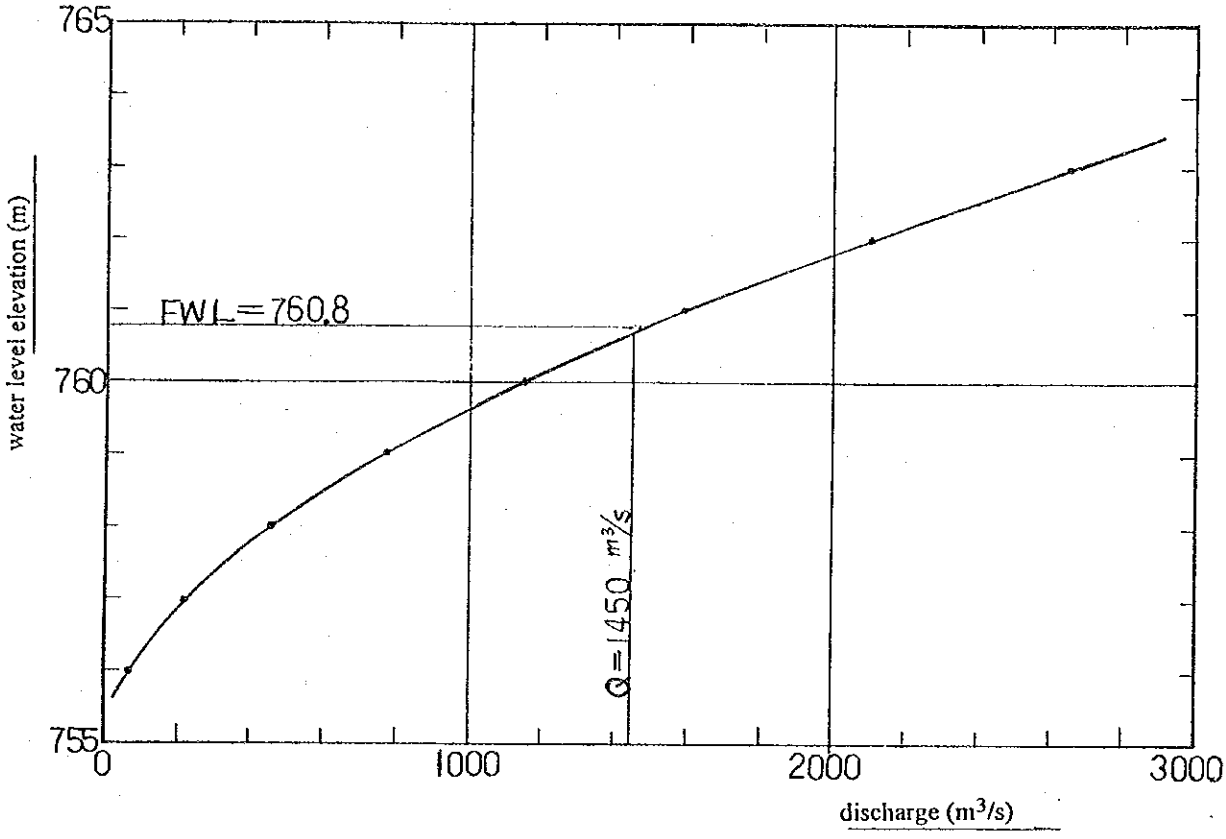


Fig. 3.7-8 Water Level Discharge Curve for Puwa Khola Intake Site

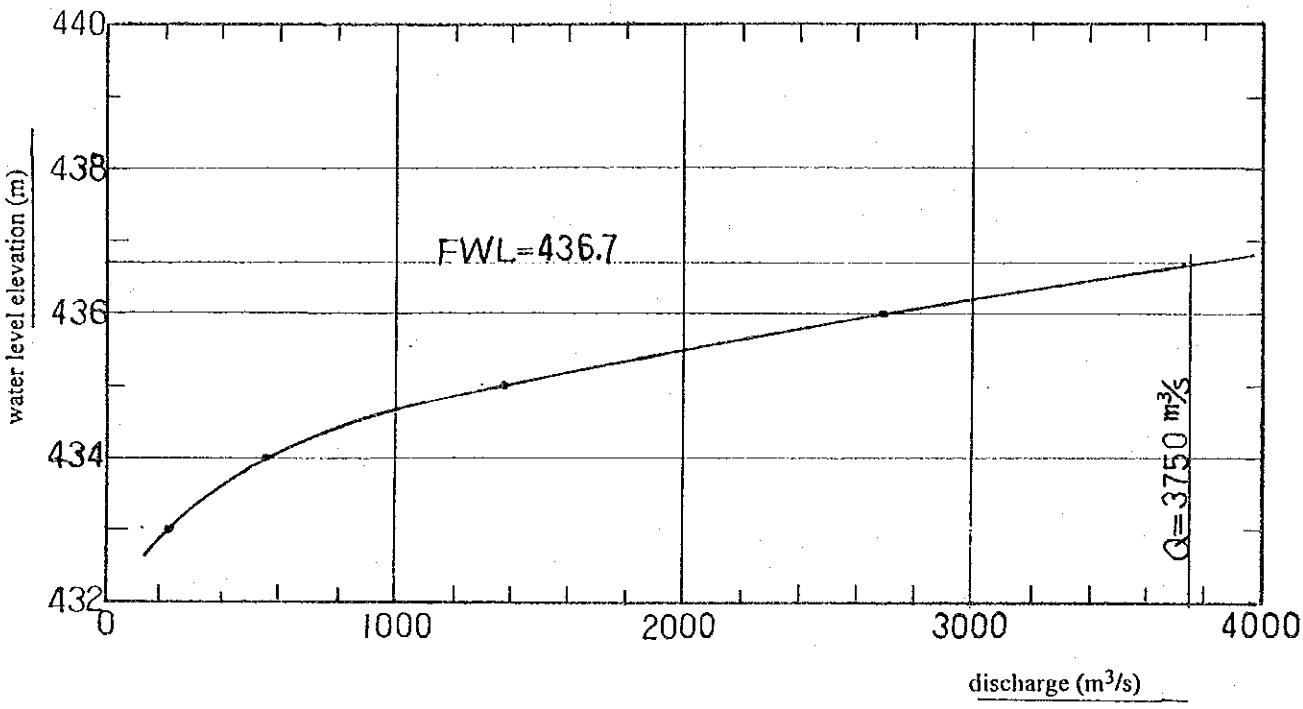


Fig. 3.7-9 Water Level Discharge Curve for Mai Khola Power House Site

DRAWING LIST (6)

Drawing No.	Title
Fig. 4 - 1	Alternative Plan
Fig. 4 - 2	Comparison of B/C

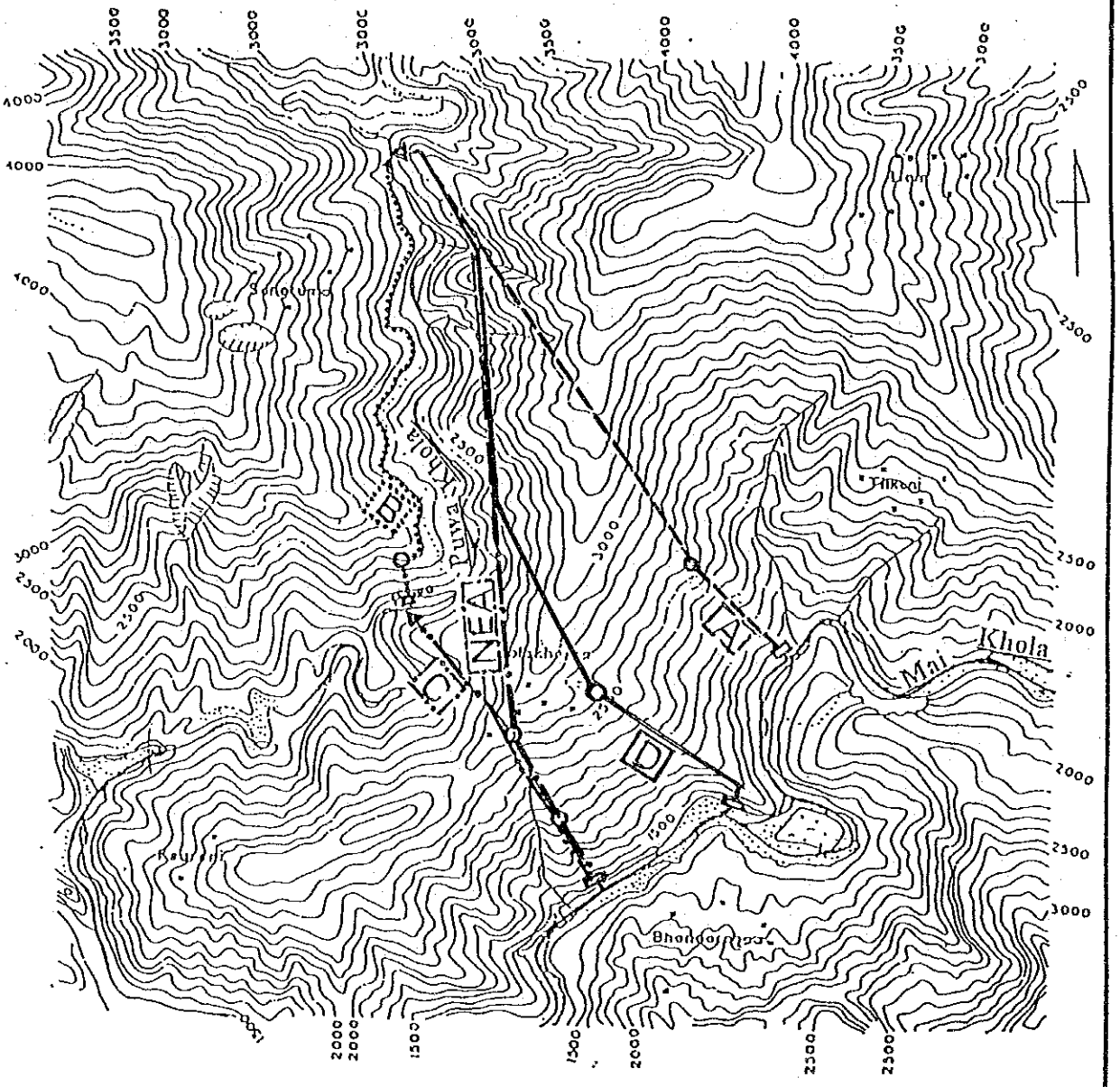


Fig. 4 - 1 Alternative Plan