Table 8-12 Stduy of Optimum Water Discharge of Manuel Jorge No.4

Item	Unit	Maximum Power Discharge						Remarks
		0.277m3/sec	0.292m3/sec	0.300m3/sec	0.306m3/sec	0.320m3/sec	0.335m3/sec	
1.Major Feature								
Catchment Area	km2	8.32	8.32	8.32	8.32	8.32	8.32	
Intake Water Level	EL.m	507.00	507.00	507.00	507.00	507.00	507.00	
Head Tank Water Level	EL.m	503.96	503.96	503.96	503.96	503.96	503.96	
Outlet Water Level	EL.m	388.40	388.40	388.40	388.40	388.40	388.40	
Gross Head	m	115.56	115.56	115.56	115.56	115.56	115.56	
Effective Head	m	111.634	111.767	111.870	111.881	112.000	112.102	
Maximum Discharge	m3/sec	0.277	0.292	0.300	0.306	0.320	0.335	
Maximum Output	kW	208.9	220.5	226.7	231.3	242.3	253.7	
Firm Peak Output	kW	76.4	76.5	76.5	76.5	76.5	76.6	12hrs peak genaration
Firm Output	kW	36.3	36.3	36.4	36.4	36.4	36.4	97%(355days) Firm Output
Annual Energy Production	MWh	1,274.8	1,287.5	1,292.4	1,295.9	1,301.5	1,308.0	
Construction Cost (A)	US$	4,399,907	4,407,404	4,410,253	4,412,283	4,416,604	4,422,694	excl. Interest during Construction
2.Economical Index								
a) Construction Cost per kW	US$/kW	21,062	19,988	19,454	19,076	18,228	17,433	
b) Construction Cost per kWh	US$/kWh	3.45	3.42	3.41	3.40	3.39	3.38	
c) Benefit								
Loss Factor of Effective Output	%	2.9	2.9	2.9	2.9	2.9	2.9	
Loss Factor of Effective Energy	%	4.9	4.9	4.9	4.9	4.9	4.9	
Effective Output	kW	74.2	74.3	74.3	74.3	74.3	74.4	
Effective Energy	MWh	1,212.3	1,224.4	1,229.1	1,232.4	1,237.7	1,243.9	
kW Value	US$/kW	146.4	146.4	146.4	146.4	146.4	146.4	
kWh Value	US$/kWh	0.062	0.062	0.062	0.062	0.062	0.062	
Benefit of kW	US$	10,861	10,875	10,875	10,875	10,875	10,889	
Benefit of kWh	US$	75,163	75,911	76,203	76,408	76,739	77,125	
Total Annual Benefit (B)	US$	86,023	86,786	87,077	87,283	87,614	88,014	
d) Cost								
Capital Recovery Factor: CRF	%	8.174	8.174	8.174	8.174	8.174	8.174	CRF=0.08(1+0.08)^50/ {(1+0.08)^50-1}= 0.08174
O & M Cost	%	1.000	1.000	1.000	1.000	1.000	1.000	
Total Annual Cost (C-1)	US$	403,647	404,335	404,597	404,783	405,179	405,738	incl. Capital recovery cost
Total Annual Cost (C-2)	US$	43,999	44,074	44,103	44,123	44,166	44,227	excl. Capital recovery cost
e) Benefit Cost Ratio :(B)/(C-1)		0.2131	0.2146	0.2152	0.2156	0.2162	0.2169	
Benefit Cost Ratio :(B)/(C-2)		1.955	1.969	1.974	1.978	1.984	1.990	
d) Benefit - Cost : (B)-(C-1)	US$	-317,624	-317,549	-317,519	-317,500	-317,565	-317,724	
Benefit - Cost : (B)-(C-2)	US$	42,024	42,712	42,975	43,160	43,448	43,787	
e) Justifiable Investment Cost	US$	937,684	946,001	949,177	951,420	955,023	959,380	(B)/(0.08174+0.01)
f) Necessary Aid Fund	US$	3,462,223	3,461,403	3,461,076	3,460,863	3,461,581	3,463,314	(A)-{(B)/(0.08174+0.01)}

Table 8-13 Estimated Construction Cost of Munuel Jorge No. 4

Unit:US$

Item	Maximum Power Discharge						Remarks
	0.277m3/sec	0.292m3/sec	0.300m3/sec	0.306m3/sec	0.320m3/sec	0.335m3/sec	
A. Preparation Works	116,504	116,504	116,504	116,504	116,504	116,504	P/H access road
B. Civil Works							
1. Intake Dame	112,079	112,079	112,079	112,079	112,079	112,079	
2. Sedimentation Basin	57,944	60,138	61,328	62,219	64,242	66,305	
3. Headrace Channel	570,108	578,061	582,331	585,275	592,282	599,697	
4. Head Tank	657,919	657,919	657,919	657,919	657,919	657,919	
5. Penstock and Spillway	84,719	85,864	86,372	86,899	87,891	88,938	
6. Powerhouse	214,592	224,797	230,217	234,293	243,774	253,900	
7. Intake & Channel for Local	60,336	60,336	60,336	60,336	60,336	60,336	
Sub-total	1,757,698	1,779,194	1,790,582	1,799,019	1,818,522	1,839,173	
C. Hydraulic Equipment							
1. Trashraks	4,770	4,860	4,950	5,040	5,130	5,265	
2. Gates	31,947	32,211	32,349	32,470	32,683	6,028	
3. Penstock	98,800	101,400	102,700	103,675	105,950	108,550	
Sub-total	135,517	138,471	139,999	141,185	143,763	146,749	
D. Electromechanical Equipment							
1. Turbine and Generator	958,200	938,600	927,200	918,600	898,600	878,500	
2. Transmission Line	258,000	258,000	258,000	258,000	258,000	258,000	
Sub-total	1,216,200	1,196,600	1,185,200	1,176,600	1,156,600	1,136,500	
E. Project Controlling							
1. Engineering Fee	720,000	720,000	720,000	720,000	720,000	720,000	
2. Administration Cost	60,000	60,000	60,000	60,000	60,000	60,000	
Sub-total	780,000	780,000	780,000	780,000	780,000	780,000	
F. Physical Contingency							
1. Preparation Works	11,650	11,650	11,650	11,650	11,650	11,650	
2. Civil Works	175,770	177,919	179,058	179,902	181,852	183,917	
3. Hydraulic Equipment	67,758	69,235	69,999	70,592	71,881	73,375	
4. Electromechanical Equipment	60,810	59,830	59,260	58,830	57,830	56,825	
5. Project Controlling	78,000	78,000	78,000	78,000	78,000	78,000	
Sub-total	393,988	396,635	397,968	398,975	401,214	403,767	
Total (Project Cost)	4,399,907	4,407,404	4,410,253	4,412,283	4,416,604	4,422,694	

Table 8-14 Calculation Sheet of Energy Production for Oputimamzation on Maximum Discharge (Case-B, With Strage Capacity)

Item		15days Qmax	25days Qmax	(Qmax=0.30)	35days Qmax	45days Qmax	55days Qmax	65days Qmax	75days Qmax	85days Qmax	95days Qmax
Maximum Discharge:Qmax	(m3/s)	0.335	0.306	0.300	0.292	0.282	0.277	0.272	0.264	0.257	0.253
Firm Discharge:Qf-345	(m3/s)	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Firm Discharge:Qf-355	(m3/s)	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
1.Energy Production											
Annual Power Discharge	(m3/s-d)	72.505	71.925	71.736	71.505	71.105	70.855	70.555	69.995	69.435	69.075
Penstock Diameter:D	(m)	0.462	0.441	0.440	0.431	0.424	0.420	0.416	0.410	0.404	0.401
D^1.33333		0.35715	0.33567	0.33466	0.32556	0.31853	0.31453	0.31054	0.30459	0.29866	0.29571
Ratio of (0.33466/D^1.3333)	(A)	0.93702	0.99698	1.00000	1.02794	1.05063	1.06399	1.07765	1.09873	1.12054	1.13173
Gross Head (115.56-113.112)*A	(m)	115.560	115.560	115.560	115.560	115.560	115.560	115.560	115.560	115.560	115.560
Loss Head (m)		2.294	2.441	2.448	2.516	2.572	2.605	2.638	2.690	2.743	2.770
Heffective Head	(m)	113.266	113.119	113.112	113.044	112.988	112.955	112.922	112.870	112.817	112.790
Efficiency of kWh	(ηtg)	0.6771967	0.6771967	0.6771967	0.6771967	0.6771967	0.6771967	0.6771967	0.6771967	0.6771967	0.6771967
Energy Production	(kWh)	1,308,038	1,295,893	1,292,403	1,287,462	1,279,631	1,274,763	1,268,990	1,258,342	1,247,684	1,240,914
2.Power Output											
1).Maximum Output (ηtg=0.6894)											
He=115.560-(A)*3.690	(m)	112.102	111.881	111.870	111.767	111.683	111.634	111.583	111.506	111.425	111.384
Pmax	(kW)	253.7	231.3	226.7	220.5	212.8	208.9	205.1	198.9	193.5	190.4
2).Pf-345 (ηtg=0.62142)											
He=115.56-(A)*1.362	(m)	114.284	114.202	114.198	114.160	114.129	114.111	114.092	114.064	114.034	114.019
Pf-345	(kW)	76.6	76.5	76.5	76.5	76.5	76.4	76.4	76.4	76.4	76.4
3)Pf-355 (ηtg=0.59373)											
He=115.56-(A)*1.932	(m)	113.750	113.634	113.628	113.574	113.530	113.504	113.478	113.437	113.395	113.373
Pf-355	(kW)	36.4	36.4	36.4	36.3	36.3	36.3	36.3	36.3	36.3	36.3

Table 8-15 Study of Optimum Inner Diameter of Penstock Pipe (1/2)

Item	Unit	Inner Diameter : D (m)														
		0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.44	0.45
Rated Generating Discharge :Qg	m3/sec	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310
Annual Power Discharge	m3/s-day	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03	72.03
Average Power Discharge (72.03/365)	m3/sec	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734	0.19734
Efficiency of T/G : ηtg (Avg. per Annum)		0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677
Generating Hour per Annum :Tg	hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Manning's Roughness Coefficient of Penstock Steel Lining : n		0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120
Fraction Loss Head at Generating hfg=(124.5*n^2/D^1.333)*v^2/(2g)	m	0.02980	0.02516	0.02135	0.01821	0.01560	0.01343	0.01160	0.01006	0.00876	0.00765	0.00671	0.00590	0.00520	0.00460	0.00408
Loss Power/Energy due to Friction																
Loss Power: Pg=9.8*hfg*Qg*ηtg	kW	0.039	0.033	0.028	0.024	0.020	0.018	0.015	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.005
Eg=Pg*Tg	kWh	342	288	245	209	179	154	133	115	100	88	77	68	60	53	47
(Quantities of Penstock per Meter)																
Thickness of Penstock Pipe t=0.006m	m	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Weight of Penstock, W=(D+0.006)π*0.06*7.85*1.0665	t	0.050	0.051	0.053	0.055	0.056	0.058	0.059	0.061	0.062	0.064	0.066	0.067	0.069	0.070	0.072
Common Excavation of Penstock Line Vec={(D+1.35+0.5)+(D+1.35+1.0+0.5)}1/2*1.0*0.5	m3	2.660	2.670	2.680	2.690	2.700	2.710	2.720	2.730	2.740	2.750	2.760	2.770	2.780	2.790	2.800
Rock Excavation of Penstock Line Ver={(D+1.35+0.5)+(D+1.35+1.0+0.5)}1/2*1.0*0.5	m3	2.660	2.670	2.680	2.690	2.700	2.710	2.720	2.730	2.740	2.750	2.760	2.770	2.780	2.790	2.800
Saddle Concrete Vcs=(D+0.15)*0.56*0.4+{(d+0.35)+(d+0.53)}0.5*0.6*1/12	m3	0.046	0.047	0.047	0.048	0.049	0.050	0.050	0.051	0.052	0.052	0.053	0.054	0.054	0.055	0.056
Anchor Block Concrete Vca=(D/0.43702)^0.5*90/224	m3	0.338	0.344	0.349	0.354	0.360	0.365	0.370	0.375	0.380	0.384	0.389	0.394	0.399	0.403	0.408
Gutter Conrete Vcg=0.053	m3	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
Masonry Wall Amw=1.789	m3	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789	1.789
Form Works Af=(D/0.43702)^0.5*340/224	m2	1.278	1.299	1.319	1.339	1.358	1.378	1.397	1.415	1.434	1.452	1.470	1.488	1.506	1.523	1.540
Weight of reinforcement steel bar Wr=Vcs*0.04+Vca*0.03	t	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.014	0.014	0.014

Table 8-15 Study of Optimum Inner Diameter of Penstock Pipe (2/2)

Item	Unit	Unit Cost (US$)	D=9.31m Q't	D=9.31m Amount (US$)	D=9.32m Q't	D=9.32m Amount (US$)	D=9.33m Q't	D=9.33m Amount (US$)	D=9.34m Q't	D=9.34m Amount (US$)	D=9.35m Q't	D=9.35m Amount (US$)	D=9.36m Q't	D=9.36m Amount (US$)	D=9.37m Q't	D=9.37m Amount (US$)	D=9.38m Q't	D=9.38m Amount (US$)	D=9.39m Q't	D=9.39m Amount (US$)	D=9.40m Q't	D=9.40m Amount (US$)	D=9.41m Q't	D=9.41m Amount (US$)	D=9.42m Q't	D=9.42m Amount (US$)	D=9.43m Q't	D=9.43m Amount (US$)	D=9.44m Q't	D=9.44m Amount (US$)	D=9.45m Q't	D=9.45m Amount (US$)	Remarks
1.Construction Cost																																	
(1)Direct Cost																																	
Common Excavation	m3	8	2,660	21	2,670	21	2,680	21	2,690	22	2,700	22	2,710	22	2,720	22	2,730	22	2,740	22	2,750	22	2,760	22	2,770	22	2,780	22	2,790	22	2,800	22	
Rock Excavation	m3	55	2,646	146	2,670	147	2,680	147	2,690	148	2,700	148	2,710	149	2,720	150	2,730	150	2,740	151	2,750	151	2,760	152	2,770	153	2,780	153	2,790	153	2,800	154	
Saddle Concrete	m3	315	0.046	15	0.047	15	0.047	15	0.048	15	0.049	15	0.049	15	0.050	16	0.050	16	0.051	16	0.052	16	0.052	16	0.053	17	0.053	17	0.054	17	0.054	17	0.054	17	
Anchor Block Concrete	m3	300	0.338	101	0.344	103	0.349	105	0.354	106	0.360	108	0.365	109	0.370	111	0.375	112	0.380	114	0.386	115	0.390	117	0.396	118	0.399	120	0.402	121	0.402	120	
Gutter Concrete	m3	315	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	0.053	17	
Masonry Concrete	m3	27	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	1.700	46	
Form Works	m2	40	1.278	51	1.296	52	1.319	53	1.335	54	1.358	54	1.378	55	1.397	56	1.415	57	1.434	57	1.452	58	1.470	59	1.488	60	1.506	60	1.525	61	1.540	62	
Reinforcement Bar	t	930	0.012	11	0.012	11	0.012	12	0.013	12	0.013	12	0.013	12	0.013	12	0.013	12	0.013	12	0.013	12	0.013	13	0.014	13	0.014	13	0.014	13	0.014	13	0.014	13	
Miscellaneous Works	LS		1	41	1	41	1	42	1	42	1	43	1	43	1	43	1	43	1	44		44		44		45		45		45		45	10% of above
Sub-total of (1)			10	452	10	456	10	460	10	463	10	467	10	471	10	474	10	478	10	481		485		488		492		495		499		502	
(2)Penstock Pipe	t	4,500	0.0698	324	0.0614	334	0.0630	345	0.0645	355	0.0661	365	******	375	******	386	0.0689	396	0.0625	406	0.0641	416	0.0656	427	0.0673	437	0.0688	447	0.0704	457	0.0720	468	
(3)Administration Cost	LS	1,170	1	148	1	142	2	146	2	147	2	158	2	152	2	155	2	157	2	160		162		164		167		170		172		175	30% of (1)+(2)
(4)Physical Contingency	LS	32%	1	76	1	77	1	78	1	79	1	80	1	81	1	82	1	83	1	84	0	84	0	87	0	88	0	89	0	90	0	91	
(5) Total of (1)+(2)+(3)+(4)				991		1,009		1,027		1,044		1,062		1,079		1,097		1,114		1,132		1,149		1,166		1,186		1,201		1,218		1,235	
2.Capital Recovery Factor to the Construction Cost																																	
C.R.F=r(1+r)^n/{(1+r)^n-1}		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174		0.08174	*Given
3.O & M Ratio		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000		0.01000	*Assumed
4.Annual Cost Ratio (2.+3.)		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174		0.09174	
5.Annual Cost (1.* 4.)	LS			90.96		92.57		94.19		95.81		97.47		99.03		100.62		102.25		103.83		105.42		107.01		108.59		110.17		111.76		113.35	
6.Annual Bonus Benefit (Cost)																																	
(1)Loss Power of Output	kW		0.030		0.030		0.029		0.029		0.029		0.028		0.028		0.028		0.027		0.027		0.026		0.026		0.026		0.026		0.025		
(2)Loss Rate of kW	h	2.5																															
(3)Loss Power and Benefit	kW	145	0.038	5.545	0.032	4.660	0.027	3.971	0.023	3.387	0.020	2.902	0.017	2.497	0.015	2.157	0.013	1.871	0.011	1.629	0.010	1.424	0.009	1.245	0.007	1.097	0.007	0.968	0.006	0.856	0.005	0.760	
(4)Loss Energy of Output	kWh		341.59		288.58		244.73		206.71		174.82		******		******		115.32		100.61		87.72		76.98		67.97		59.59		52.77		46.81		
(5)Loss Rate of kWh	¥	6.9																															
(6)Loss Energy and Benefit	kWh	0.062	321.85	20.111	270.24	17.004	232.74	14.439	198.48	12.306	170.05	10.543	******	9.072	******	7.829	105.67	6.888	95.49	5.928	83.42	5.172	73.13	4.534	64.31	3.987	56.73	3.517	50.18	3.111	44.51	2.760	
Total Cost (1.+2.+3.)+6.+(4)+(5)	US$			316,521		314,249		312,599		311,589		310,965		310,398		310,629		310,904		311,378		312,817		313,791		313,626		314,869		315,750		316,947	

Table 8-16 Optimum Development Plan of Manuel Jorg No.4 Project

Item \ Case	Unit	Description	Remarks
1. Catchment Area	km2	8.32	
2. Intake Water Level	EL.m	507.00	
3. Head Tank Water Level	EL.m	503.96	
4. Outlet Water Level	EL.m	388.4	Minus 2m of F.W.L
5. Gross Head	m	115.56	Hg=H.T.W.L-T.W.L
6. Effective Head	m	109.17	
7. Power Discharge			
Maximum Discharge	m3/s	0.310	
Peak Firm Discharge	m3/s	0.110	Qf×24/12hrs
Firm Discharge	m3/s	0.055	Qf: 97% Firm(355days)
8. Power Output			
Maximum Output	kW	230	
Firm Peak Output	kW	73.1	
Firm Output	kW	35.9	
9. Annual Energy Production	MWh	1,252.6	
10. Power structure			
Intake Dam (L×H)	m	11.0×2.0	
Headrace Channel (L×B)	m	1,150×0.57	
Slop of Headrace Channel		1/500	
Head Tank Storage Capacity	m3	2,400	12hrs×Qf×3,600sec
Penstock (Φ×L)	m	0.394×225.6	Maximum v= 2.54m/s
11. Electromechanical Equipment			
Type of Turbine		Cross flow	
Installed Capacity of Turbine	kW	253	
Type of Generator		3-phase synchronous	
Installed Capacity of Generator	kVA	290	
Transmission Line (kV×km)	km	30kV×5.5	1cct
12. Construction Period	year	1	

Table 8-17 Calculation Sheet of Energy Production of Manuel Jorge No.4

C.A=8.32km2, Qmax=0.310m3/sec, Qf=0.055(355days Run-off)

Run-off No.	Natu. Q Pian^2 CA=10.00km2 (X) (m3/sec)	MJ No.4, 8.32km2 Discharge Qin=(X*8.32/10-0.127) (m3/sec)	Effective Head He=115.56-(56.1225Q^2 +1.000) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax 9.8*Qin*He*ηt/Ptmax	Efficiency of Generator (%)	Power Output (kW)	Energy Production (kWh)	Remarks
1	1.204	0.875	109.167	1.000	76.50	1.0	90.00	228.638	-	Pmax=228.6kW
15	0.555	0.335	109.167	1.000	76.60	1.0	90.00	228.638	82,309.8	
25	0.520	0.306	109.167	0.986	76.93	99.0	90.00	226.381	54,602.3	
35	0.504	0.292	109.167	0.943	77.40	95.3	89.97	217.784	53,299.8	
45	0.491	0.282	109.167	0.908	77.65	92.8	89.95	210.356	51,376.8	
55	0.485	0.277	109.167	0.892	77.75	91.3	89.92	206.823	50,061.5	
65	0.479	0.272	109.167	0.876	77.80	89.7	89.90	203.175	49,199.8	
75	0.470	0.264	109.167	0.852	77.80	87.2	89.86	197.484	48,079.0	
85	0.461	0.257	109.167	0.828	77.70	84.6	89.82	191.551	46,686.2	
95	0.457	0.253	109.167	0.817	77.65	83.5	89.80	188.903	45,654.5	
105	0.452	0.249	109.167	0.803	77.55	82.0	89.77	185.498	44,928.1	
115	0.447	0.245	109.167	0.790	77.35	80.4	89.74	181.869	44,084.1	
125	0.439	0.238	109.167	0.769	77.01	77.9	89.69	176.057	42,951.1	
135	0.431	0.232	109.167	0.747	76.80	75.5	89.67	170.627	41,602.1	
145	0.421	0.223	109.167	0.720	76.35	72.4	89.54	163.296	40,070.8	
155	0.419	0.222	109.167	0.715	76.25	71.8	89.52	161.831	39,015.3	
165	0.411	0.215	109.167	0.693	75.75	69.1	89.42	155.767	38,111.7	
175	0.400	0.206	109.167	0.664	74.95	65.5	89.27	147.312	36,369.5	
185	0.395	0.202	109.167	0.650	74.55	63.8	89.17	143.403	34,885.8	
195	0.389	0.197	109.167	0.634	73.95	61.8	89.07	138.572	33,837.0	
205	0.385	0.193	109.167	0.624	74.15	60.9	89.01	136.503	33,009.0	
215	0.378	0.187	109.167	0.605	74.55	59.4	88.92	132.970	32,336.8	
225	0.367	0.178	109.167	0.575	74.80	56.6	88.74	126.647	31,154.1	
235	0.364	0.176	109.167	0.567	74.80	55.9	88.89	125.086	30,208.0	
245	0.356	0.169	109.167	0.546	74.70	53.7	88.71	119.947	29,403.9	
255	0.346	0.161	109.167	0.519	74.25	50.7	88.30	112.838	27,934.1	
265	0.338	0.154	109.167	0.497	73.75	48.3	88.08	107.173	26,401.2	
275	0.331	0.148	109.167	0.479	73.38	46.2	87.87	102.363	25,144.4	
285	0.324	0.143	109.167	0.460	72.85	44.1	87.58	97.313	23,961.2	
295	0.308	0.129	109.167	0.417	71.45	39.2	86.78	85.741	21,966.5	
305	0.291	0.115	109.167	0.371	69.25	33.9	85.73	73.112	19,062.4	Firm peak 73.1 kW
315	0.275	0.102	112.647	0.506	73.95	65.4	89.42	74.313	17,691.0	
325	0.248	0.079	113.104	0.433	72.05	49.9	88.23	55.901	15,625.7	
335	0.241	0.074	113.203	0.415	71.35	45.8	87.80	51.090	12,838.9	
345	0.236	0.069	113.270	0.401	70.75	42.9	87.42	47.614	11,844.5	95%Firm 47.6kW
355	0.219	0.055	113.468	0.356	68.35	33.0	85.48	35.868	10,017.8	97%Firm 35.9kW
365	0.192	0.033	113.690	0.283	70.80	20.3	81.92	21.159	6,843.2	
Total		80.917 m3/sec-day							1,252,566	

Table 8-18 Respective Case of Abade River Development Schemes

Case / Item	Unit	Case-A	Case-B				Case-C				Remark
			B-1	B-2	B-2'	Total	C-1	C-2	C-2'	Total	
1.Catchment Area	km2	9.10	9.10	9.10	13.06	-	9.19	9.19	13.15	-	
Main Stream	km2	9.10	9.10	9.10	9.10	-	9.19	9.19	9.19	-	
Tributary	km2	-	-	-	3.96	-	-	-	3.96	-	
2.Intake Water Level	EL.m	551.50	551.50	430.00	430.00	-	511.50	428.60	428.60	-	
3.Head Tank Water Level	EL.m	548.00	548.00	428.50	428.60	-	508.90	428.60	428.60	-	
4.Outlet Water Level	EL.m	375.00	430.00	318.00	318.00	-	428.60	318.00	318.00	-	
						228.60				190.90	
5.Gross Head (H.T.W.L-T.W.L)	m	173.00	118.00	110.60	110.60	228.60	80.30	110.60	110.60	190.90	
6.Effective Head	m	167.60	113.70	107.30	106.00	221.00	74.60	107.30	106.00	181.90	
						219.70				180.60	
7.Power Discharge											
Maximum Discharge	m3/s	0.78	0.78	0.78	1.12	-	0.78	0.78	1.12	-	Qmax=Qf×3≒40days Q
Farm Discharge	m3/s	0.259	0.259	0.259	0.372	-	0.261	0.261	0.374	-	95%ff(m(≒345days)
8.Power Output						1,240				990	
Maximum Output	kW	940	640	600	850	1,490	290	600	850	1,240	
Farm Output	kW	298.6	203.2	190.8	273.5	394.0	118.3	192.5	276.0	310.8	
						476.7				394.3	
9.Annual Energy Production	MWh	4,850	3,300	3,100	4,400	6,400.0	2,020	3,130	4,450	5,150.0	
						7,700.0				6,470.0	
10.Power structure											
Intake Dam (L×H)	m	20×2.25	20×2.25	-	20×2.25		20×2.25	-	20×2.25		
Headrace Channel (L×B)	m	1,020×0.8	1,020×0.8	670×0.8	670×0.9		520×0.8	-	-		
Inlet Channel (L×B)	m	-	-	-	1,000×0.6		-	-	1,750×0.6		
Head Tank (L×B)	m	39.72×4.0	39.72×4.0	12.0×25.0	12.0×25.0		30.0×4.0	12.0×25.0	12.0×25.0		
Penstock (Φ×L)	m	0.7×557.0	0.7×385.0	0.7×220.0	0.85×220.0		0.7×670.0	0.7×220.0	0.85×220.0		
Tailrace (L×B)	m	0.7×5.0	-	0.7×10.0	0.85×10.0		-	0.7×10.0	0.85×10.0		
11.Electromechanical Equipment											
Type of Turbine		Pelton	Pelton	Pelton	Pelton		Cross flow	Pelton	Pelton		
Installed Capacity of Turbine	kW	1,044	711	667	944		433	667	944		
Type of Generator											
Installed Capacity of Generator	kVA	1,106	753	706	1,000		459	706	1,000		
Transmission Line (kVA×cct)	km	16.5	16.3	0.9	0.9		16.3	0.3	0.3		
12.Construction Cost	US$	7,888,764	5,826,569	4,490,220	6,175,358	10,316,789	3,694,720	4,068,458	5,989,585	7,763,178	
13.Construction Period	year	1	1	1	1		1	1	1		
14.Economical Index											
Costruction Cost per kW	US$/kW	8,392				8,320				7,842	
						8,055				7,810	
Costruction Cost per kWh	US$/kWh	1.63				1.61				1.51	
						1.56				1.59	
Benefit Cost Ratio (B)/(C.1)		0.450				0.454				0.484	
						0.469				0.488	
Benefit Cost Ratio (B)/(C.2)		4.124				4.161				4.427	
						4.306				4.475	
Benefit-Cost(C.1)	US$	-398,394				-517,176				-367,627	
						-584,199				-455,018	
Benefit-Cost(C.2)	US$	246,434				326,118				266,936	
						396,839				336,577	
Justifiable Investment Cost	US$	3,546,122				4,679,375				3,755,911	(B)/(0.08174+0.01)
						5,633,941				4,724,443	(B)/(0.01)
Necessary Aid Fund	US$	4,342,642				5,637,414				4,007,267	(A)-((B)/(0.08174+0.01))
						6,967,986				4,959,862	(A)-(B)/0.01

Table 8-19 Economical Comparision of Combined Abade River Development Schemes

Item	Unit	Case A	Case B		Case C		Remarks
			(B-1)+(B-3)	(B-1)+(B-2')	(C-1)+(C-3)	(C-1)+(C-2')	
1. Major Feature							
Catchment Area	km2	9.10	9.10	13.06	9.13	13.15	
Intake Water Level (No.1 P/S)	EL.m	551.50	551.50	551.50	511.50	511.50	
Intake Water Level (No.2 P/S)	EL.m	-	430.00	430.00	428.60	428.60	
Head Tank Water Level (No.1 P/S)	EL.m	508.00	508.00	508.00	506.80	508.80	
Head Tank Water Level (No.2 P/S)	EL.m	-	428.60	428.60	426.60	426.60	
Tailrace Water Level (No.1 P/S)	EL.m	395.00	430.00	430.00	428.60	428.60	
Tailrace Water Level (No.2 P/S)	EL.m	-	318.00	318.00	318.00	318.00	
Total Gross Head	m	193.00	230.00	230.00	180.10	180.80	H.W.L-T.W.L
Total Effective Head	m	167.60	221.00	218.70	161.80	180.60	
Maximum Discharge (No.1)	m3/sec	0.780	0.780	0.780	0.780	0.780	
Maximum Discharge (No.2)	m3/sec	0.780	0.780	1.120	0.780	1.120	
Firm Discharge (No.1)	m3/sec	0.358	0.358	0.358	0.288	0.288	
Firm Discharge (No.2)	m3/sec	-	0.358	0.372	0.288	0.374	
Maximum Output (No.1)	kW	840	640	640	380	380	
Maximum Output (No.2)	kW	-	600	850	800	850	
Total Maximum Output	kW	840	1,240	1,490	880	1,240	
Firm Output (No.1)	kW	388.6	303.8	303.8	118.3	118.3	97%(355days) Firm Output
Firm Output (No.2)	kW	-	380.8	393.5	192.5	296.0	
Total Firm Output	kW	388.6	384	471.7	310.8	384.3	
Total Annual Energy Production	MWh	4,850	6,400	7,700	5,250	6,670	
Construction Cost (A)	US$	7,888,744	10,316,780	12,001,927	7,765,178	9,684,305	excl. Interest during Construction
2. Economical Index							
a) Construction Cost per kW	US$/kW	8,388	8,330	8,055	7,662	7,810	
b) Construction Cost per kWh	US$/kWh	1.83	1.61	1.56	1.51	1.50	
c) Benefit							
Loss Factor of Effective Output	%	3.7	3.7	3.7	3.7	3.7	
Loss Factor of Effective Energy	%	5.7	5.7	5.7	5.7	5.7	
Effective Output	kW	387.6	378.4	458.1	298.3	378.7	
Effective Energy	MWh	4,573.6	6,035.2	7,261.1	4,858.5	6,101.2	
kW Value	US$/kW	145.23	145.23	145.23	145.23	145.23	
kWh Value	US$/kWh	0.082	0.082	0.082	0.082	0.082	
Benefit of kW	US$	41,783	55,103	66,520	43,467	55,145	
Benefit of kWh	US$	383,560	374,102	450,188	301,100	378,275	
Total Annual Benefit (B)	US$	335,331	429,208	518,858	344,567	433,420	
d) Cost							CRF=0.08(1+0.08)^50/
Capital Recovery Factor: CRF	%	8.174	8.174	8.174	8.174	8.174	{(1+0.08)^50-1}=0.08174
O & M Cost	%	1.000	1.000	1.000	1.000	1.000	
Total Annual Cost (C-1)	US$	123,715	846,682	1,101,059	712,191	888,638	incl. Capital recovery cost
Total Annual Cost (C-2)	US$	78,888	103,388	320,019	92,832	98,843	excl. Capital recovery cost
e) Benefit Cost Ratio : (B)/(C-1)		0.458	0.458	0.488	0.484	0.488	
Benefit Cost Ratio : (B)/(C-1)		4.124	4.861	4.306	4.438	4.495	
d) Benefit - Cost : (B)-(C-1)	US$	-388,384	-537,174	-586,199	-387,627	-455,018	
Benefit - Cost : (B)-(C-2)	US$	848,834	326,188	386,839	286,838	334,577	
e) Justifiable Investment Cost	US$	3,566,128	4,838,395	5,833,841	3,155,838	4,324,643	(2)/(0.0817440.01)
f) Necessary Aid Fund	US$	4,342,643	5,837,814	6,367,886	4,809,267	4,958,862	(A)-{(B)/(0.0817440.01)}

Table 8-20 POWER VALUE OF ALTERNATIVE THERMAL POWER PLANT FOR ABADE RIVER DEVELOPMENT SCHEME

Item	Unit	Description
1. Plant Type		Diesel Power Plant
2. Construction Cost		
Installed Capacity	kW	1,000 kW x 1 unit = 1,000 kW
Annual Plant Factor	%	81%
Service Life	year	15
Generator Terminal Energy	MWh	1,000 kW x 8,760 hrs x 0.97 x 0.81 = 7,096 MWh
Auxiliary Power Use	%	2.5
Annual Energy Production	MWh	7,096 MWh x (1 - 0.025) = 6,919 MWh
Construction Cost	US$	980 US$ x 1,000 kW = 980,000 US$
3. Power Value		
(A) kW Value		
a) Capital Recovery Factor		C.R.F=0.08 (1+0.08)^15/{(1+0.08) ^15-1}= 0.11683
b) Capital Recovery Cost	US$	Discount Rate = 8%
c) O&M and Administration Cost	US$	980,000 x 0.11683 = 114,493
d) Total Fixed Cost (b)+c))	US$	980,000 x 0.03 = 29,400 (Ratio 3%)
e) Unit Fixed Cost per kW	US$/kW	143,893
f) kW Value	US$/kW	143,893 ÷ 1,000 kW = 143.89
		143,89 x 1.0093 = 145.23 (Adjustment factor for kW value α = 1.0093)
(B) kWh Value		
a) Diesel Oil Calorific Value	Kcal/kg	10,170, Gas oil
b) Fuel Consumption Rate	kg/kWh	0.255 (Specific gravity of Fuel : 0.848)
c) Fuel Cost	US$/kWh	0.255 kg/kWh ÷ 0.848 x 0.206$/l = 0.062
d) kWh Value	US$/kWh	0.062 ÷ (1-0.025) x 0.97675 = 0.062 (Adjustment factor for kWh value β = 0.9689)

Adjustment Factor for kW and kWh

Item		Loss of kW		Loss of kWh	
		Hydro	Thermal	Hydro	Thermal
Transmission Loss Rate	%	0.9	0.1	0.9	0.1
Forced Outage	%	0.5	2.0	0.5	-
Auxiliary Power Use	%	0.3	2.5	0.3	2.5
Scheduled Outage Rate	%	2.0	-	4.0	-
Total		3.7	4.6	5.7	2.6

kW Adjustment Factor $\alpha = (1-0.009)(1-0.005)(1-0.003)(1-0.02)/\{(1-0.001)(1-0.02)(1-0.025)\} = 1.0093$

kWh Adjustment factor $\beta = (1-0.009)(1-0.005)(1-0.003)(1-0.04)/\{(1-0.001)(1-0.025)\} = 0.9689$

Table 8-21 Estimated Cost of Small Hydropower Projects in Abede River

Item	Case-A	Case B					Case C					Remarks
		B-1	B-2	B-2'	(B-1)+(B-2)	(B-1)+(B-2')	C-1	C-2	C-2'	(C-1)+(C-2)	(C-1)+(C-2')	
	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	Amount (US$)	
1. Preparation Works(access Road)	66,990	11,121	88,726	88,726	99,847	99,847	21,835	88,726	88,726	110,561	110,561	Access Road of P/H
2. Civil Works												
(1) Intake Dam	92,494	92,494	0	92,494	92,494	184,987	92,494	0	92,494	92,494	184,987	
(2) Sedimentation Basin	93,104	93,104	0	71,360	93,104	164,464	93,104	0	71,360	93,104	164,464	
(3) Headrace	549,461	549,461	368,063	735,816	917,524	1,285,277	272,913	0	584,983	272,913	857,897	
(4) Head Tank	155,265	155,265	155,265	179,988	310,530	335,253	157,685	157,685	179,988	315,370	337,673	
(5) Penstock and Spillway	201,916	172,029	80,422	84,827	252,451	256,856	151,828	82,347	85,477	234,175	238,304	
(6) Powerhouse	116,143	94,846	92,808	126,959	187,654	221,805	75,043	92,808	126,959	167,851	202,002	
(7) Tailrace	2431	2465.1	2431	3558.5	4,896	6,024	2157.1	2431	3558.5	4,588	5,716	
Sub-total	1,210,813	1,159,663	698,990	1,295,001	1,858,653	2,454,665	845,224	335,271	1,145,818	1,180,495	1,991,042	
3. Hydraulic Equipment												
(1) Trashracks & Gates	9,800	9,800	6,650	8,000	16,450	17,800	9,800	6,650	8,000	16,450	17,800	
(2) Penstock	403,000	279,500	162,500	175,500	442,000	455,000	481,000	162,500	175,500	643,500	656,500	
Sub-total	412,800	289,300	169,150	183,500	458,450	472,800	490,800	169,150	183,500	659,950	674,300	
4. Electromechanical Equipment												
(1) Turbine and Generator	4,200,000	2,940,000	2,770,000	3,730,000	5,710,000	6,670,000	940,000	2,770,000	3,730,000	3,710,000	4,670,000	
(2) Transmission Line	567,600	560,720	30,960	30,960	591,680	591,680	560,720	10,320	10,320	571,040	571,040	
Sub-total	4,767,600	3,500,720	2,800,960	3,760,960	6,301,680	7,261,680	1,500,720	2,780,320	3,740,320	4,281,040	5,241,040	
5. Project Controlling												
(1) Engineering Fee	720,000	360,000	360,000	360,000	720,000	720,000	360,000	360,000	360,000	720,000	720,000	
(2) Administration Cost	60,000	30,000	30,000	30,000	60,000	60,000	30,000	30,000	30,000	60,000	60,000	
Sub-total	780,000	390,000	390,000	390,000	780,000	780,000	390,000	390,000	390,000	780,000	780,000	
6. Physical Contingency												
(1) Preparation Works	6,099	1,112	8,873	8,873	9,985	9,985	2,184	8,873	8,873	11,056	11,056	10% of the Works
(2) Civil Works	121,081	115,966	69,899	129,500	185,865	245,466	84,522	33,527	114,582	118,049	199,104	10% of Civil Works
(3) Hydraulic Equipment	206,400	144,650	84,575	91,750	229,225	236,400	245,400	84,575	91,750	329,975	337,150	10% of H.E
(4) Electromecanical Equipment	238,380	175,036	140,048	188,048	315,084	363,084	75,036	139,016	187,016	214,052	262,052	10% of E.E
(5) Project Controlling	78,000	39,000	39,000	39,000	78,000	78,000	39,000	39,000	39,000	78,000	78,000	10% of P.C
Sub-total	650,560	475,764	342,395	457,171	818,159	932,935	446,142	304,991	441,220	751,133	887,362	
Total (project Cost)	7,888,764	5,826,569	4,490,220	6,175,358	10,316,789	12,001,927	3,694,720	4,068,458	5,989,585	7,763,178	9,684,305	
7. Interest during Construction	252,440	186,450	143,687	197,611	330,137	384,062	118,231	130,191	191,667	248,422	309,808	0.4KT=0.4×0.08×1
Groud Total (Investment Cost)	8,141,204	6,013,019	4,633,907	6,372,970	10,646,926	12,385,989	3,812,951	4,198,649	6,181,251	8,011,600	9,994,203	K=0.08, T=1 year

Table 8-22 Calculation Sheet of Power Energy of Abade River Development Cheme (Case A)

Qmax=0.78m3/s, Qf=0.26m3/s (Pelton turbine)

Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 9.1km2 Discharge (m3/s)	Effective Head He=173-(8.93439673Q^2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	3.787	167.564	1.000	81.50	1.000	90.00	939.5	-
15	1.329	1.209	167.564	1.000	81.50	1.000	90.00	939.5	338,224.3
25	1.019	0.927	167.564	1.000	81.50	1.000	90.00	939.5	225,482.9
35	0.910	0.828	167.564	1.000	81.50	1.000	90.00	939.5	225,482.9
45	0.822	0.748	168.001	0.959	82.00	0.967	89.97	908.6	221,770.9
55	0.756	0.688	168.771	0.882	82.80	0.903	89.89	846.9	210,656.9
65	0.694	0.632	169.437	0.810	83.00	0.834	89.77	781.3	195,389.0
75	0.659	0.600	169.787	0.769	83.00	0.793	89.70	742.9	182,909.0
85	0.628	0.571	170.082	0.733	82.85	0.756	89.60	707.1	174,000.5
95	0.605	0.551	170.292	0.706	82.80	0.729	89.52	681.0	166,576.9
105	0.579	0.527	170.520	0.676	82.70	0.698	89.42	651.1	159,858.2
115	0.564	0.513	170.647	0.658	82.65	0.680	89.35	633.8	154,195.5
125	0.552	0.502	170.746	0.644	82.60	0.665	89.28	619.9	150,443.8
135	0.533	0.485	170.898	0.622	82.50	0.642	89.17	597.6	146,093.7
145	0.506	0.460	171.106	0.590	82.35	0.609	88.97	565.7	139,595.6
155	0.495	0.450	171.187	0.578	82.30	0.596	88.91	553.0	134,239.8
165	0.476	0.433	171.324	0.555	82.15	0.572	88.77	530.4	129,997.7
175	0.464	0.422	171.407	0.541	82.05	0.557	88.67	516.0	125,565.3
185	0.455	0.414	171.468	0.531	82.00	0.547	88.61	505.5	122,588.2
195	0.443	0.403	171.548	0.517	81.85	0.531	88.51	491.0	119,583.5
205	0.432	0.393	171.619	0.504	81.80	0.518	88.42	478.2	116,303.7
215	0.415	0.378	171.726	0.484	81.60	0.497	88.23	457.6	112,293.9
225	0.415	0.378	171.726	0.484	81.60	0.497	88.23	457.6	109,816.8
235	0.399	0.363	171.822	0.466	81.45	0.477	88.03	438.4	107,512.8
245	0.388	0.353	171.886	0.453	81.30	0.463	87.92	425.1	103,619.7
255	0.375	0.341	171.960	0.438	81.20	0.447	87.72	409.6	100,169.4
265	0.357	0.325	172.057	0.417	81.00	0.425	87.43	387.9	95,705.9
275	0.344	0.313	172.124	0.401	80.80	0.409	87.22	372.1	91,207.4
285	0.332	0.302	172.184	0.387	80.60	0.394	86.93	357.2	87,519.0
295	0.322	0.293	172.233	0.376	80.45	0.381	86.73	345.1	84,274.3
305	0.312	0.284	172.280	0.364	80.20	0.368	86.48	332.5	81,306.9
315	0.304	0.277	172.316	0.355	80.00	0.358	86.32	322.6	78,608.2
325	0.299	0.272	172.339	0.349	79.90	0.352	86.17	316.4	76,679.3
335	0.285	0.259	172.399	0.333	79.55	0.334	85.80	299.1	73,855.5
345	0.285	0.259	172.399	0.333	79.55	0.334	85.80	299.1	71,777.1
355	0.276	0.251	172.436	0.322	79.25	0.322	85.55	287.8	70,419.3
365	0.260	0.237	172.500	0.303	78.70	0.302	85.10	267.9	66,675.9
Total									4,850,399.5

Table 8-23 Calculation Sheet of Power Energy of Abade River Development Cheme (Case B-1)

Qmax=0.78m3/s, Qf=0.26m3/s (Pelton turbine)

Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 9.1km2 Discharge (m3/s)	Effective Head He=118-(7.12890730^2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	3.787	113.663	1.000	81.50	1.000	90.00	637.3	-
15	1.329	1.209	113.663	1.000	81.50	1.000	90.00	637.3	229,425.4
25	1.019	0.927	113.663	1.000	81.50	1.000	90.00	637.3	152,950.3
35	0.910	0.828	113.663	1.000	81.50	1.000	90.00	637.3	152,950.3
45	0.822	0.748	114.011	0.959	82.10	0.969	89.98	617.4	150,564.7
55	0.756	0.688	114.626	0.882	82.75	0.903	89.90	574.9	143,078.8
65	0.694	0.632	115.157	0.810	83.00	0.835	89.80	531.2	132,735.0
75	0.659	0.600	115.436	0.769	83.00	0.795	89.72	505.2	124,369.7
85	0.628	0.571	115.672	0.733	82.90	0.758	89.65	481.5	118,399.0
95	0.605	0.551	115.839	0.706	82.80	0.731	89.56	463.5	113,391.6
105	0.579	0.527	116.021	0.676	82.70	0.700	89.45	443.2	108,796.7
115	0.564	0.513	116.122	0.658	82.65	0.682	89.38	431.5	104,955.8
125	0.552	0.502	116.201	0.644	82.60	0.667	89.32	422.0	102,419.6
135	0.533	0.485	116.323	0.622	82.50	0.644	89.22	407.0	99,481.8
145	0.506	0.460	116.489	0.590	82.35	0.611	89.02	385.3	95,079.6
155	0.495	0.450	116.554	0.578	82.30	0.598	88.94	376.6	91,435.2
165	0.476	0.433	116.662	0.555	82.15	0.575	88.80	361.3	88,545.3
175	0.464	0.422	116.729	0.541	82.05	0.560	88.71	351.6	85,540.6
185	0.455	0.414	116.778	0.531	82.00	0.549	88.63	344.4	83,514.0
195	0.443	0.403	116.841	0.517	81.85	0.534	88.53	334.5	81,463.5
205	0.432	0.393	116.898	0.504	81.80	0.520	88.42	325.7	79,226.3
215	0.415	0.378	116.983	0.484	81.60	0.499	88.24	311.7	76,497.1
225	0.415	0.378	116.983	0.484	81.60	0.499	88.24	311.7	74,818.0
235	0.399	0.363	117.060	0.466	81.45	0.479	88.05	298.7	73,255.9
245	0.388	0.353	117.111	0.453	81.30	0.465	87.92	289.7	70,605.1
255	0.375	0.341	117.170	0.438	81.20	0.449	87.71	279.1	68,247.1
265	0.357	0.325	117.248	0.417	81.00	0.427	87.42	264.3	65,207.7
275	0.344	0.313	117.301	0.401	80.80	0.411	87.15	253.4	62,126.9
285	0.332	0.302	117.349	0.387	80.60	0.395	86.89	243.3	59,607.4
295	0.322	0.293	117.388	0.376	80.45	0.383	86.65	235.0	57,397.6
305	0.312	0.284	117.425	0.364	80.20	0.370	86.37	226.3	55,356.6
315	0.304	0.277	117.454	0.355	80.00	0.360	86.17	219.5	53,499.6
325	0.299	0.272	117.472	0.349	79.90	0.353	86.05	215.4	52,184.9
335	0.285	0.259	117.520	0.333	79.55	0.336	85.65	203.5	50,265.2
345	0.285	0.259	117.520	0.333	79.55	0.336	85.65	203.5	48,843.3
355	0.276	0.251	117.550	0.322	79.25	0.324	85.37	195.8	47,911.8
365	0.260	0.237	117.601	0.303	78.70	0.303	84.80	182.0	45,327.7
Total									3,290,475.0

Table 8-24 Calculation Sheet of Power Energy of Abade River Development Chewe (Case B-2)

Qmax=0.78m3/s, Qf=0.259m3/s (Pelton Turbine)

Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 9.1km2 Discharge (m3/s)	Effective Head He=110.6-(5.4165746Q^2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	3.787	107.305	1.000	81.50	1.000	90.00	601.6	-
15	1.329	1.209	107.305	1.000	81.50	1.000	90.00	601.6	216,591.5
25	1.019	0.927	107.305	1.000	81.50	1.000	90.00	601.6	144,394.4
35	0.910	0.828	107.305	1.000	81.50	1.000	90.00	601.6	144,394.4
45	0.822	0.748	107.569	0.959	82.00	0.967	89.98	581.8	142,015.3
55	0.756	0.688	108.036	0.882	82.80	0.902	89.90	542.2	134,880.7
65	0.694	0.632	108.440	0.810	83.00	0.833	89.79	500.2	125,083.4
75	0.659	0.600	108.652	0.769	83.00	0.793	89.71	475.5	117,075.5
85	0.628	0.571	108.831	0.733	82.85	0.755	89.64	452.7	111,374.1
95	0.605	0.551	108.958	0.706	82.80	0.728	89.55	435.9	106,626.5
105	0.579	0.527	109.096	0.676	82.70	0.697	89.44	416.7	102,307.5
115	0.564	0.513	109.173	0.658	82.65	0.679	89.36	405.6	98,667.0
125	0.552	0.502	109.233	0.644	82.60	0.664	89.30	396.6	96,262.9
135	0.533	0.485	109.326	0.622	82.50	0.641	89.18	382.3	93,476.0
145	0.506	0.460	109.452	0.590	82.35	0.608	88.98	361.9	89,308.3
155	0.495	0.450	109.501	0.578	82.30	0.595	88.90	353.7	85,868.5
165	0.476	0.433	109.584	0.555	82.15	0.572	88.76	339.2	83,142.8
175	0.464	0.422	109.634	0.541	82.05	0.557	88.67	330.1	80,309.7
185	0.455	0.414	109.671	0.531	82.00	0.546	88.58	323.2	78,395.2
195	0.443	0.403	109.720	0.517	81.85	0.531	88.48	313.9	76,459.0
205	0.432	0.393	109.763	0.504	81.80	0.517	88.36	305.6	74,347.7
215	0.415	0.378	109.827	0.484	81.60	0.496	88.18	292.5	71,774.1
225	0.415	0.378	109.827	0.484	81.60	0.496	88.18	292.5	70,193.7
235	0.399	0.363	109.886	0.466	81.45	0.476	87.99	280.2	68,723.8
245	0.388	0.353	109.925	0.453	81.30	0.463	87.82	271.6	66,215.2
255	0.375	0.341	109.969	0.438	81.20	0.447	87.63	261.7	63,990.4
265	0.357	0.325	110.028	0.417	81.00	0.424	87.33	247.8	61,137.3
275	0.344	0.313	110.069	0.401	80.80	0.408	87.02	237.4	58,225.9
285	0.332	0.302	110.106	0.387	80.60	0.393	86.77	228.0	55,849.8
295	0.322	0.293	110.135	0.376	80.45	0.381	86.55	220.2	53,784.5
305	0.312	0.284	110.163	0.364	80.20	0.368	86.27	212.1	51,874.7
315	0.304	0.277	110.185	0.355	80.00	0.357	86.07	205.7	50,131.7
325	0.299	0.272	110.199	0.349	79.90	0.351	85.95	201.8	48,897.8
335	0.285	0.259	110.236	0.333	79.55	0.333	85.55	190.7	47,096.4
345	0.285	0.259	110.236	0.333	79.55	0.333	85.55	190.7	45,762.1
355	0.276	0.251	110.258	0.322	79.25	0.322	85.23	183.3	44,877.9
365	0.260	0.237	110.297	0.303	78.70	0.301	84.70	170.5	42,453.9
Total									3,101,969.5

Table 8-25 Calculation Sheet of Power Energy of Abade River Development Cheme (Case B-2')

Qmax=1.12m3/s, Qf=0.372m3/s (Pelton Turbine)

Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 13.06km2 Discharge (m3/s)	Effective Head He=110.6-(3.6719087Q^2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	5.434	105.994	1.000	81.50	1.000	90.00	853.3	-
15	1.329	1.736	105.994	1.000	81.50	1.000	90.00	853.3	307,204.7
25	1.019	1.331	105.994	1.000	81.50	1.000	90.00	853.3	204,803.1
35	0.910	1.188	105.994	1.000	81.50	1.000	90.00	853.3	204,803.1
45	0.822	1.074	106.368	0.959	82.00	0.968	89.98	825.7	201,483.4
55	0.756	0.987	107.021	0.882	82.80	0.904	89.89	770.7	191,568.9
65	0.694	0.906	107.584	0.809	83.00	0.837	89.79	712.2	177,946.9
75	0.659	0.861	107.880	0.768	83.00	0.797	89.71	677.5	166,760.9
85	0.628	0.820	108.130	0.732	82.90	0.760	89.67	646.1	158,829.0
95	0.605	0.790	108.308	0.705	82.80	0.732	89.55	621.8	152,148.9
105	0.579	0.756	108.500	0.675	82.70	0.701	89.41	594.5	145,964.1
115	0.564	0.737	108.608	0.658	82.65	0.683	89.36	579.0	140,825.8
125	0.552	0.721	108.692	0.644	82.60	0.669	89.28	566.3	137,437.5
135	0.533	0.696	108.821	0.622	82.50	0.646	89.17	546.1	133,488.1
145	0.506	0.661	108.996	0.590	82.35	0.613	88.98	517.2	127,601.6
155	0.495	0.646	109.065	0.577	82.30	0.600	88.88	505.4	122,720.5
165	0.476	0.622	109.181	0.555	82.15	0.576	88.74	484.9	118,839.9
175	0.464	0.606	109.252	0.541	82.05	0.561	88.64	471.9	114,812.3
185	0.455	0.594	109.303	0.531	82.00	0.550	88.56	462.2	112,093.1
195	0.443	0.579	109.371	0.517	81.85	0.535	88.45	448.9	109,341.8
205	0.432	0.564	109.431	0.504	81.80	0.522	88.35	437.3	106,346.1
215	0.415	0.542	109.521	0.484	81.60	0.501	88.17	418.5	102,696.6
225	0.415	0.542	109.521	0.484	81.60	0.501	88.17	418.5	100,447.3
235	0.399	0.521	109.603	0.465	81.45	0.481	87.96	401.0	98,343.3
245	0.388	0.507	109.657	0.452	81.30	0.467	87.82	388.8	94,775.1
255	0.375	0.490	109.719	0.437	81.20	0.451	87.62	374.7	91,615.3
265	0.357	0.466	109.802	0.416	80.95	0.428	87.28	354.5	87,496.1
275	0.344	0.449	109.859	0.401	80.80	0.412	87.00	340.0	83,337.7
285	0.332	0.434	109.910	0.387	80.60	0.397	86.75	326.5	79,987.2
295	0.322	0.421	109.951	0.375	80.40	0.384	86.48	315.1	76,993.1
305	0.312	0.407	109.990	0.364	80.20	0.372	86.26	303.9	74,269.6
315	0.304	0.397	110.021	0.354	80.00	0.361	86.04	294.7	71,820.5
325	0.299	0.390	110.040	0.349	79.90	0.355	85.91	289.1	70,045.9
335	0.285	0.372	110.091	0.332	79.50	0.337	85.48	272.9	67,434.3
345	0.285	0.372	110.091	0.332	79.50	0.337	85.48	272.9	65,495.3
355	0.276	0.360	110.123	0.322	79.25	0.325	85.19	262.6	64,263.2
365	0.260	0.340	110.177	0.303	78.70	0.304	84.65	244.2	60,825.5
Total									4,424,864.5

Table 8-26 Calculation Sheet of Power Energy of Abade River Development Cheme (Case C-1)

Qmax=0.78m3/s, Qf=0.261m3/s (Cross Flow Turbine)

Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 9.19km2 Discharge (m3/s)	Effective Head He=80.3-(9.38408971Q^2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	3.824	74.591	1.000	76.60	1.000	90.00	393.1	-
15	1.329	1.221	74.591	1.000	76.60	1.000	90.00	393.1	141,507.4
25	1.019	0.936	74.591	1.000	76.60	1.000	90.00	393.1	94,338.3
35	0.910	0.836	74.591	1.000	76.60	1.000	90.00	393.1	94,338.3
45	0.822	0.755	74.945	0.968	77.10	0.979	89.94	384.7	93,337.5
55	0.756	0.695	75.770	0.891	77.75	0.918	89.87	360.5	89,425.6
65	0.694	0.638	76.483	0.818	77.65	0.850	89.76	333.2	83,239.8
75	0.659	0.606	76.858	0.776	77.20	0.806	89.68	315.8	77,880.1
85	0.628	0.577	77.174	0.740	76.65	0.766	89.57	299.7	73,858.4
95	0.605	0.556	77.399	0.713	76.20	0.736	89.48	287.6	70,466.9
105	0.579	0.532	77.643	0.682	75.45	0.699	89.35	272.9	67,259.5
115	0.564	0.518	77.779	0.665	74.95	0.678	89.37	264.6	64,509.6
125	0.552	0.507	77.885	0.650	74.50	0.660	89.16	257.2	62,619.4
135	0.533	0.490	78.048	0.628	74.05	0.635	89.03	247.0	60,503.2
145	0.506	0.465	78.271	0.596	74.65	0.610	88.88	236.7	58,039.1
155	0.495	0.455	78.358	0.583	74.80	0.598	88.82	232.1	56,249.2
165	0.476	0.437	78.504	0.561	74.80	0.576	88.68	223.2	54,638.6
175	0.464	0.426	78.594	0.547	74.65	0.561	88.58	217.2	52,849.8
185	0.455	0.418	78.659	0.536	74.50	0.550	88.50	212.5	51,563.7
195	0.443	0.407	78.745	0.522	74.25	0.534	88.38	206.2	50,242.4
205	0.432	0.397	78.821	0.509	74.00	0.520	88.28	200.3	48,780.3
215	0.415	0.381	78.935	0.489	73.60	0.497	88.07	191.2	46,988.5
225	0.415	0.381	78.935	0.489	73.60	0.497	88.07	191.2	45,896.2
235	0.399	0.367	79.038	0.470	73.10	0.475	87.83	182.4	44,830.4
245	0.388	0.357	79.107	0.457	72.75	0.460	87.63	176.2	43,029.6
255	0.375	0.345	79.185	0.442	72.30	0.443	87.43	169.1	41,433.4
265	0.357	0.328	79.290	0.421	71.60	0.418	87.03	158.9	39,349.1
275	0.344	0.316	79.362	0.405	70.90	0.399	86.68	151.1	37,195.6
285	0.332	0.305	79.426	0.391	70.25	0.382	86.38	144.1	35,426.2
295	0.322	0.296	79.478	0.379	69.70	0.368	86.10	138.3	33,891.9
305	0.312	0.287	79.529	0.368	69.05	0.353	85.82	132.4	32,489.3
315	0.304	0.279	79.568	0.358	68.50	0.342	85.52	127.6	31,205.1
325	0.299	0.275	79.591	0.352	68.10	0.334	85.35	124.6	30,263.0
335	0.285	0.262	79.656	0.336	68.50	0.321	85.02	119.1	29,237.9
345	0.285	0.262	79.656	0.336	68.50	0.321	85.02	119.1	28,577.8
355	0.276	0.254	79.696	0.325	69.45	0.315	84.85	116.7	28,297.5
365	0.260	0.239	79.764	0.306	70.35	0.301	84.47	111.0	27,327.6
Total									2,021,086.2

Table 8-27 Calculation Sheet of Power Energy of Abade River Development Cheme (Case C-2)

Qmax=0.78m3/s, Qf=0.261m3/s (Pelton Turbine)

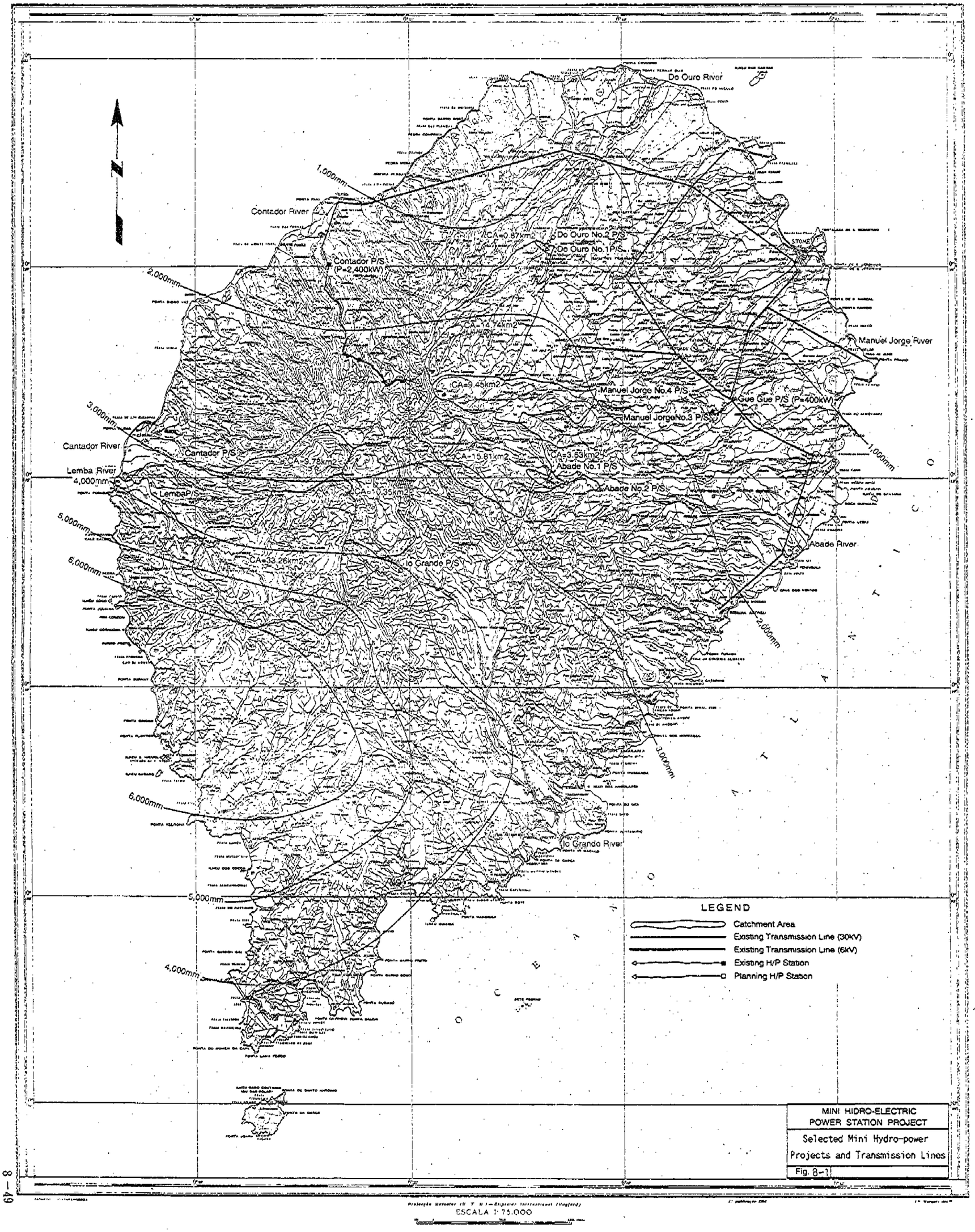
Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 9.19km2 Discharge (m3/s)	Effective Head He=110.6-(5.416574Q2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	3.824	107.305	1.000	81.50	1.000	90.00	601.6	-
15	1.329	1.221	107.305	1.000	81.50	1.000	90.00	601.6	216,591.5
25	1.019	0.936	107.305	1.000	81.50	1.000	90.00	601.6	144,394.4
35	0.910	0.836	107.305	1.000	81.50	1.000	90.00	601.6	144,394.4
45	0.822	0.755	107.509	0.968	81.85	0.974	89.98	586.2	142,537.5
55	0.756	0.695	107.985	0.891	82.65	0.909	89.91	546.4	135,903.6
65	0.694	0.638	108.397	0.818	83.00	0.841	89.61	503.9	126,032.3
75	0.659	0.606	108.613	0.776	83.00	0.800	89.72	480.0	118,073.8
85	0.628	0.577	108.796	0.740	82.95	0.764	89.65	457.6	112,516.1
95	0.605	0.556	108.926	0.713	82.80	0.735	89.57	440.2	107,731.6
105	0.579	0.532	109.066	0.682	82.75	0.704	89.47	421.1	103,349.0
115	0.564	0.518	109.145	0.665	82.65	0.685	89.39	409.6	99,680.2
125	0.552	0.507	109.206	0.650	82.60	0.671	89.33	400.6	97,222.8
135	0.533	0.490	109.300	0.628	82.55	0.648	89.22	386.4	94,442.8
145	0.506	0.465	109.429	0.596	82.40	0.615	89.03	365.8	90,271.9
155	0.495	0.455	109.479	0.583	82.80	0.605	88.96	359.5	87,040.8
165	0.476	0.437	109.563	0.561	82.50	0.580	88.82	344.2	84,441.4
175	0.464	0.426	109.615	0.547	82.10	0.563	88.71	333.6	81,334.8
185	0.455	0.418	109.653	0.536	82.00	0.551	88.63	326.6	79,221.5
195	0.443	0.407	109.702	0.522	81.90	0.536	88.52	317.3	77,265.0
205	0.432	0.397	109.746	0.509	81.80	0.522	88.41	308.8	75,132.8
215	0.415	0.381	109.812	0.489	81.65	0.501	88.23	295.7	72,536.2
225	0.415	0.381	109.812	0.489	81.65	0.501	88.23	295.7	70,961.7
235	0.399	0.367	109.872	0.470	81.50	0.481	88.04	283.3	69,476.2
245	0.388	0.357	109.911	0.457	81.35	0.467	87.88	274.6	66,944.5
255	0.375	0.345	109.957	0.442	81.25	0.451	87.72	264.7	64,710.4
265	0.357	0.328	110.017	0.421	81.00	0.429	87.40	250.4	61,811.4
275	0.344	0.316	110.059	0.405	80.80	0.412	87.12	240.0	58,853.0
285	0.332	0.305	110.096	0.391	80.60	0.397	86.87	230.5	56,461.8
295	0.322	0.296	110.126	0.379	80.45	0.384	86.62	222.6	54,365.2
305	0.312	0.287	110.155	0.368	80.25	0.372	86.35	214.5	52,444.9
315	0.304	0.279	110.177	0.358	80.10	0.361	86.15	208.2	50,717.8
325	0.299	0.275	110.191	0.352	79.95	0.355	86.03	204.1	49,470.2
335	0.285	0.262	110.228	0.336	79.65	0.337	85.64	193.0	47,650.3
345	0.285	0.262	110.228	0.336	79.65	0.337	85.64	193.0	46,318.4
355	0.276	0.254	110.252	0.325	79.35	0.325	85.35	185.6	45,431.6
365	0.260	0.239	110.291	0.306	78.80	0.304	84.80	172.6	42,981.3
Total									3,128,712.9

Table 8-28 Calculation Sheet of Power Energy of Abade River Development Cheme (Case C-2')

Qmax=1.12m3/s, Qf=0.374m3/s (Pelton Turbine)

Run-off No.	Abade 10km2 Discharge (m3/s)	Abade 13.15km2 Discharge (m3/s)	Effective Head He=110.6-(3.671Q87Q2) (m)	Ratio of Quse/Qmax	Efficiency of Turbine (%)	Ratio of Pt/Ptmax	Efficiency of Generator (%)	Power Energy (kW)	Energy Production (kWh)
1	4.161	5.472	105.994	1.000	81.50	1.000	90.00	853.3	-
15	1.329	1.748	105.994	1.000	81.50	1.000	90.00	853.3	307,204.7
25	1.019	1.340	105.994	1.000	81.50	1.000	90.00	853.3	204,803.1
35	0.910	1.197	105.994	1.000	81.50	1.000	90.00	853.3	204,803.1
45	0.822	1.081	106.310	0.965	81.90	0.973	89.98	829.9	201,989.7
55	0.756	0.994	106.971	0.888	82.70	0.909	89.90	774.8	192,567.4
65	0.694	0.913	107.542	0.815	83.00	0.842	89.80	716.9	179,004.2
75	0.659	0.867	107.843	0.774	83.00	0.802	89.69	681.8	167,839.5
85	0.628	0.826	108.096	0.737	82.90	0.765	89.65	650.2	159,834.7
95	0.605	0.796	108.276	0.710	82.80	0.737	89.55	625.9	153,133.3
105	0.579	0.761	108.471	0.680	82.75	0.706	89.44	599.0	146,996.2
115	0.564	0.742	108.580	0.662	82.65	0.688	89.37	582.9	141,834.6
125	0.552	0.726	108.665	0.648	82.60	0.673	89.31	570.2	138,381.0
135	0.533	0.701	108.796	0.626	82.50	0.650	89.19	549.9	134,414.3
145	0.506	0.665	108.974	0.594	82.40	0.618	89.00	521.1	128,520.1
155	0.495	0.651	109.044	0.581	82.30	0.604	88.91	509.0	123,614.2
165	0.476	0.626	109.161	0.559	82.20	0.581	88.77	488.6	119,712.6
175	0.464	0.610	109.233	0.545	82.05	0.565	88.67	475.2	115,658.0
185	0.455	0.598	109.285	0.534	82.00	0.554	88.59	465.5	112,884.9
195	0.443	0.583	109.354	0.520	81.90	0.539	88.49	452.4	110,154.3
205	0.432	0.568	109.415	0.507	81.80	0.526	88.37	440.3	107,132.3
215	0.415	0.546	109.506	0.487	81.60	0.504	88.20	421.5	103,418.8
225	0.415	0.546	109.506	0.487	81.60	0.504	88.20	421.5	101,160.2
235	0.399	0.525	109.589	0.468	81.45	0.484	88.00	403.9	99,047.2
245	0.388	0.510	109.644	0.456	81.35	0.470	87.87	391.9	95,494.2
255	0.375	0.493	109.707	0.440	81.25	0.454	87.66	377.6	92,340.2
265	0.357	0.469	109.791	0.419	81.00	0.432	87.32	357.3	88,184.3
275	0.344	0.452	109.849	0.404	80.85	0.415	87.07	342.8	84,008.4
285	0.332	0.437	109.900	0.390	80.65	0.400	86.80	329.2	80,636.9
295	0.322	0.423	109.942	0.378	80.40	0.387	86.55	317.5	77,595.2
305	0.312	0.410	109.982	0.366	80.25	0.374	86.30	306.3	74,846.2
315	0.304	0.400	110.013	0.357	80.05	0.364	86.10	297.1	72,397.0
325	0.299	0.393	110.032	0.351	79.90	0.357	85.93	291.1	70,577.8
335	0.285	0.375	110.084	0.335	79.65	0.340	85.57	275.6	67,999.6
345	0.285	0.375	110.084	0.335	79.65	0.340	85.57	275.6	66,136.4
355	0.276	0.363	110.116	0.324	79.30	0.328	85.25	264.8	64,841.4
365	0.260	0.342	110.171	0.305	78.85	0.307	84.72	246.6	61,364.3
Total									4,450,530.4

CARTA DA ILHA DE S. TOMÉ



MINI HIDRO-ELECTRIC POWER STATION PROJECT

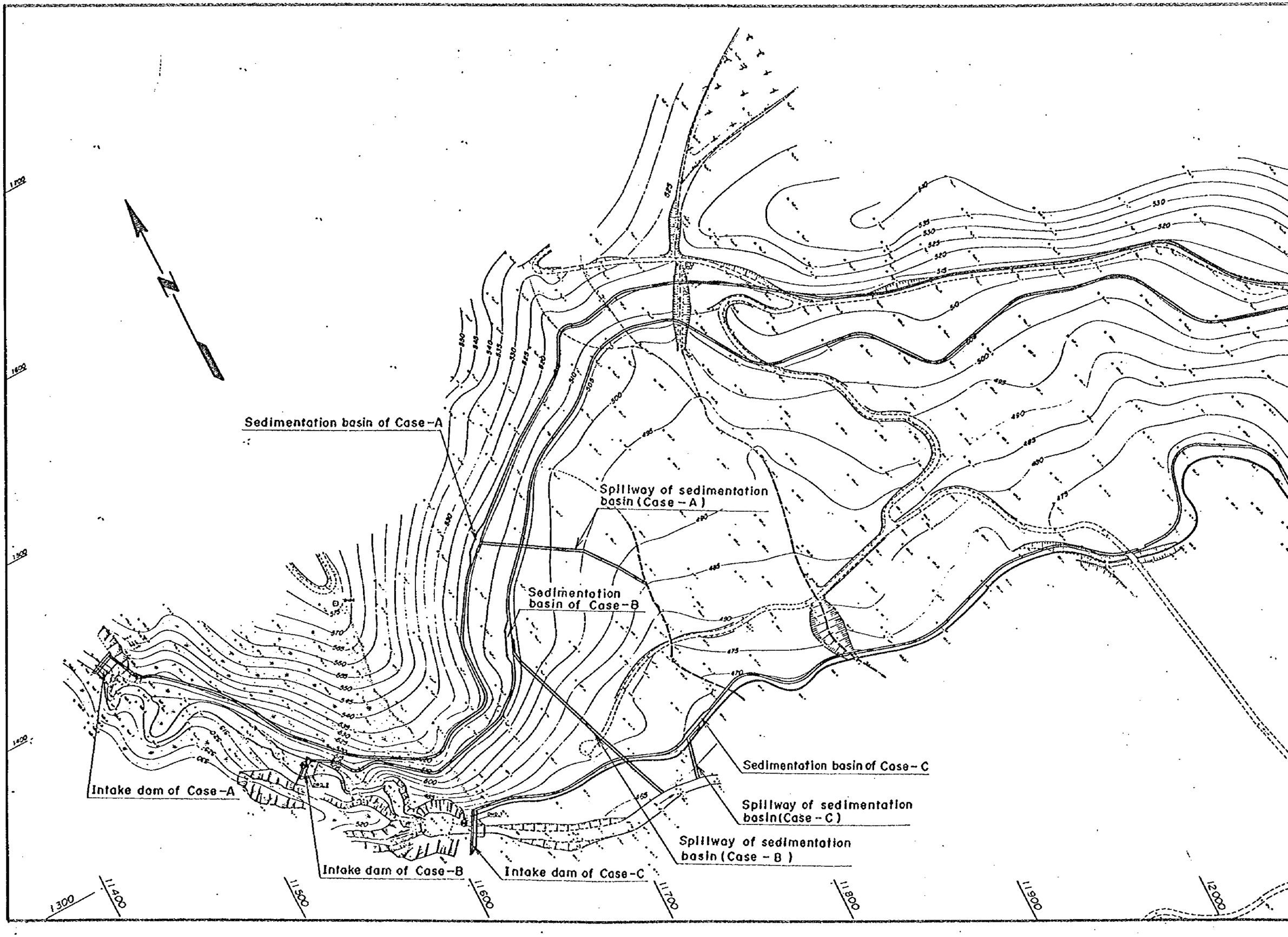
Selected Mini Hydro-power Projects and Transmission Lines

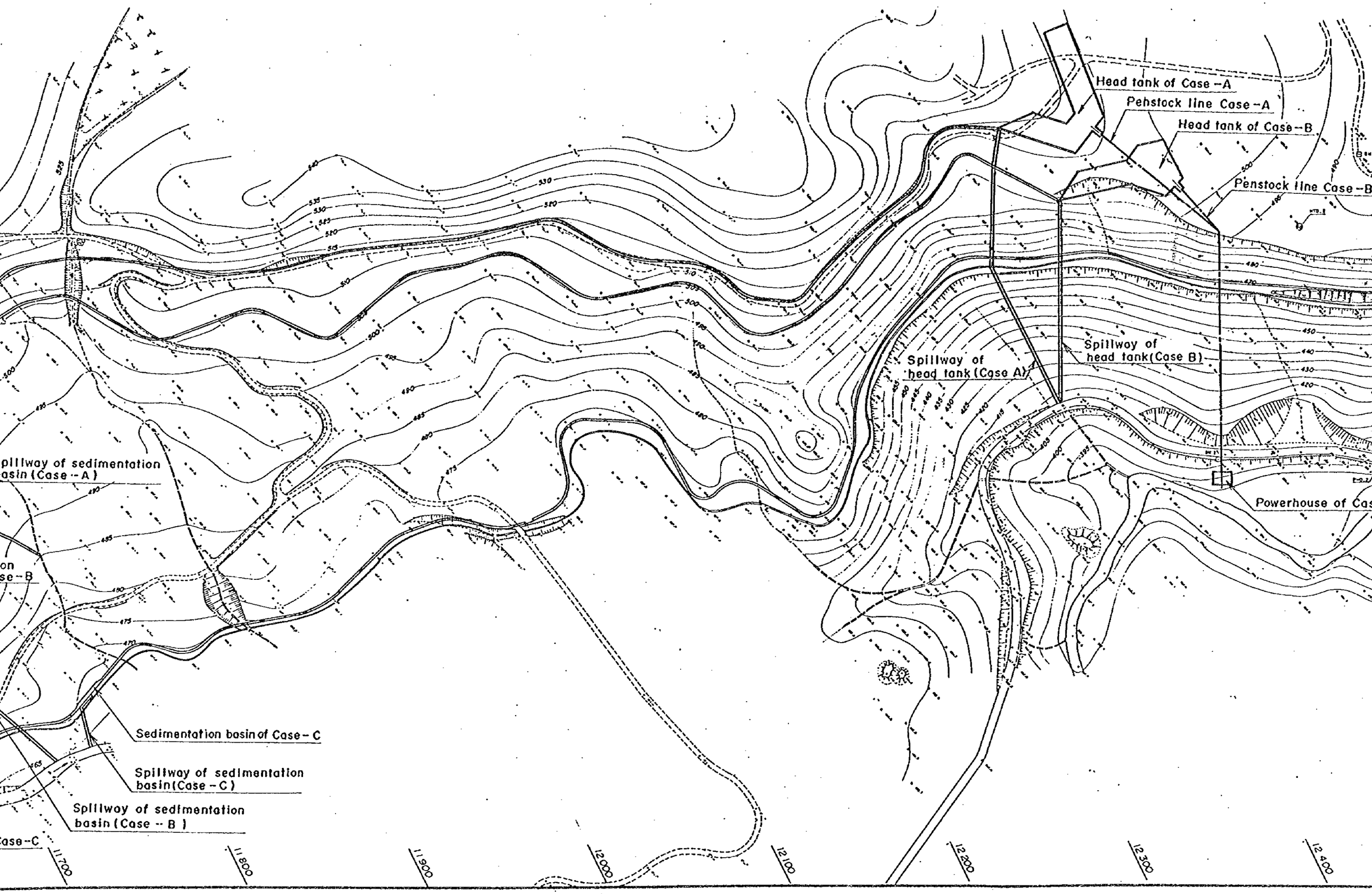
Fig. 8-1

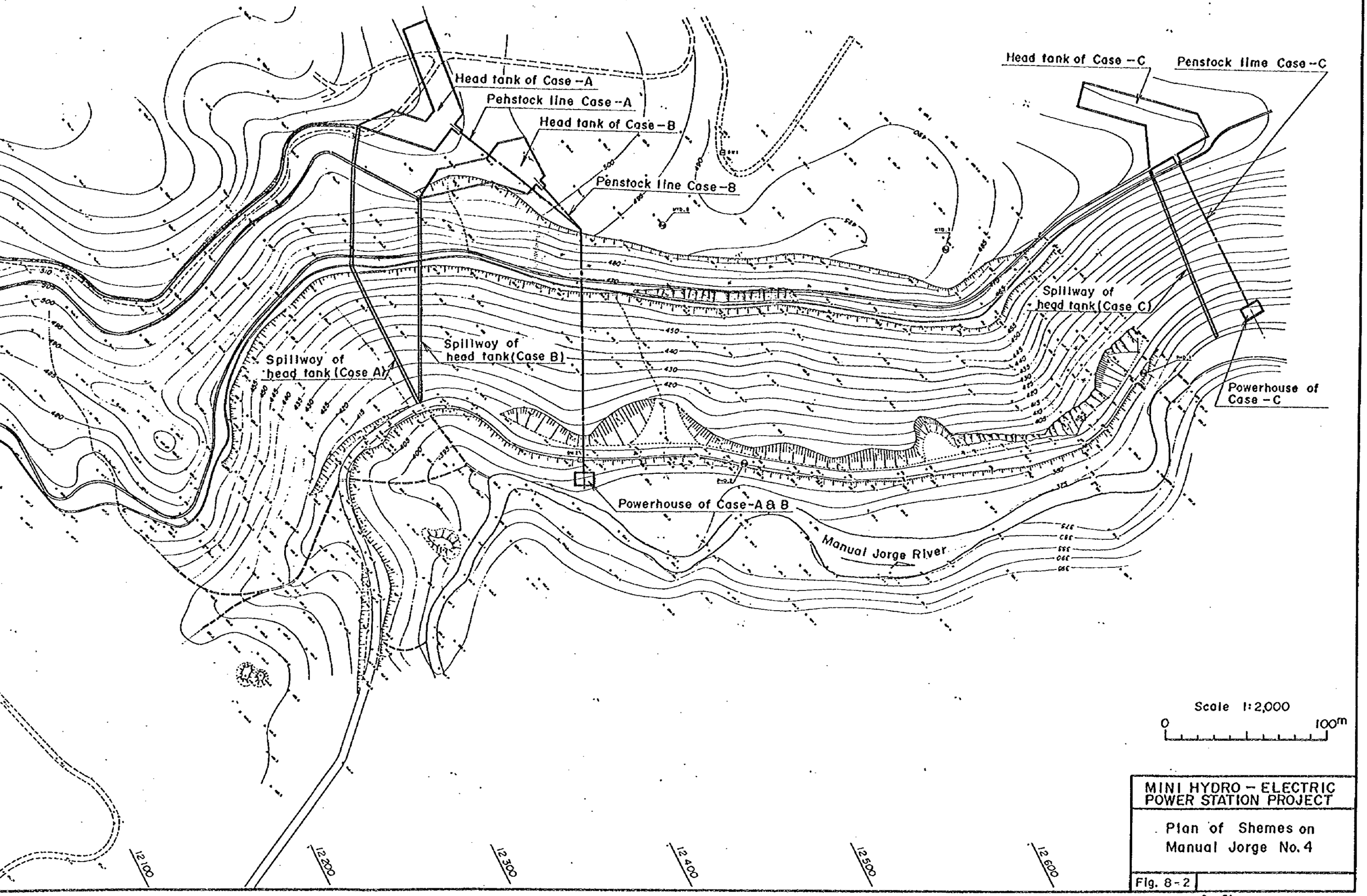
Projeção Mercator (U. T. M.)—Elipsóide Internacional (Hayford)

ESCALA 1: 75.000

CONVENÇÕES


Sedimentation basin of Case-A
Spillway of sedimentation basin (Case - A)
Sedimentation basin of Case-B
Intake dam of Case-A
Intake dam of Case-B
Intake dam of Case-C
Sedimentation basin of Case - C
Spillway of sedimentation basin (Case - C)
Spillway of sedimentation basin (Case - B)
1700
1600
1500
1400
1300
11400
11500
11600
11700
11800
11900
12000


Head tank of Case-A
Penstock line Case-A
Head tank of Case-B
Penstock line Case-B
Spillway of head tank(Case A)
Spillway of head tank(Case B)
Powerhouse of Cas
Spillway of sedimentation basin (Case-A)
Sedimentation basin of Case-C
Spillway of sedimentation basin(Case-C)
Spillway of sedimentation basin (Case-B)
11700
11800
11900
12000
12100
12200
12300
12400



Scale 1:2,000

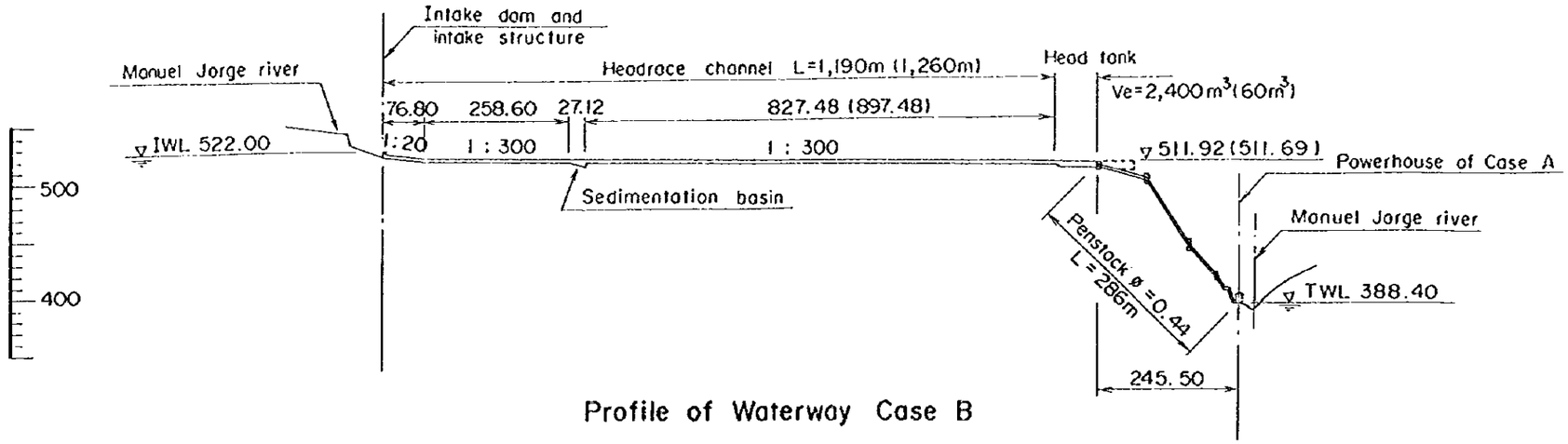
0 100m

MINI HYDRO - ELECTRIC POWER STATION PROJECT

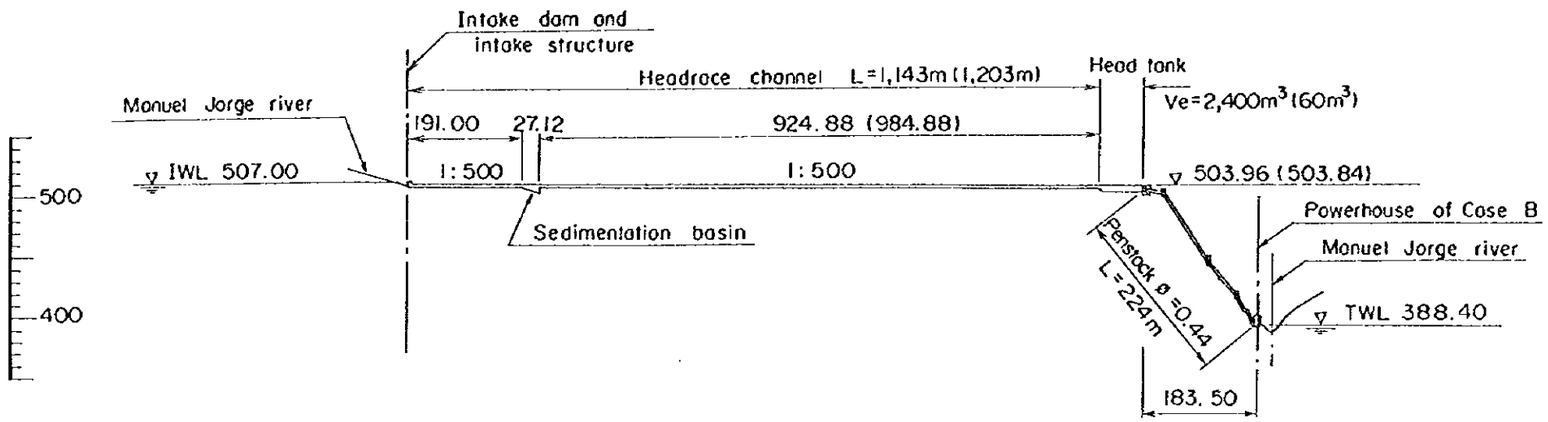
Plan of Shemes on Manual Jorge No. 4

Fig. 8-2

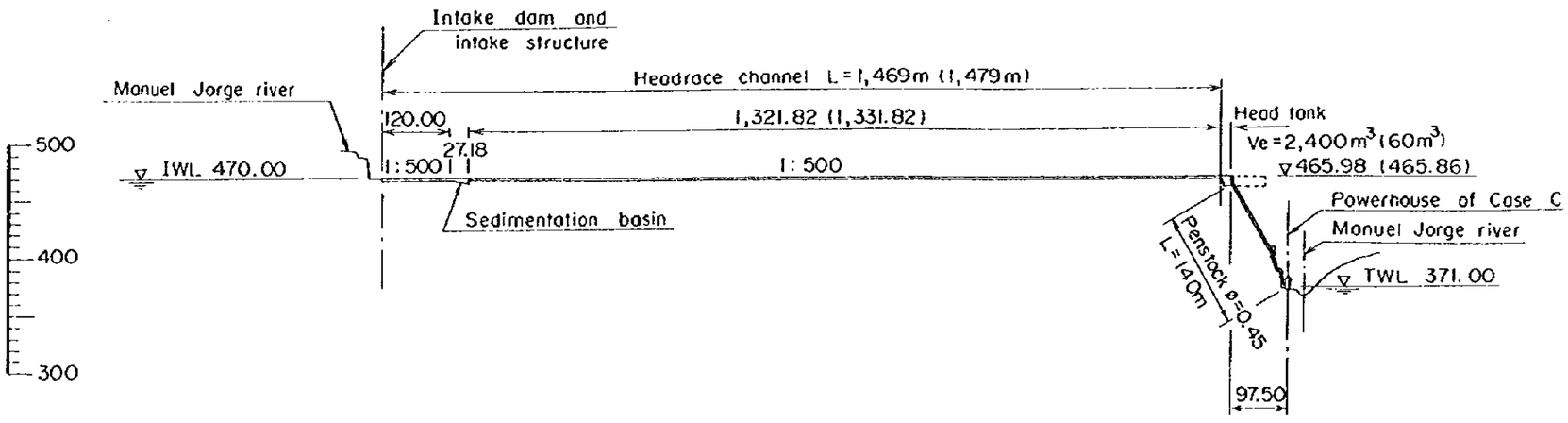
Profile of Waterway Case A



Profile of Waterway Case B



Profile of Waterway Case C



Note: Figure in parenthesis are shown in case of without storage capacity.

Vertical Scale 1/5,000

0 100 200 300m

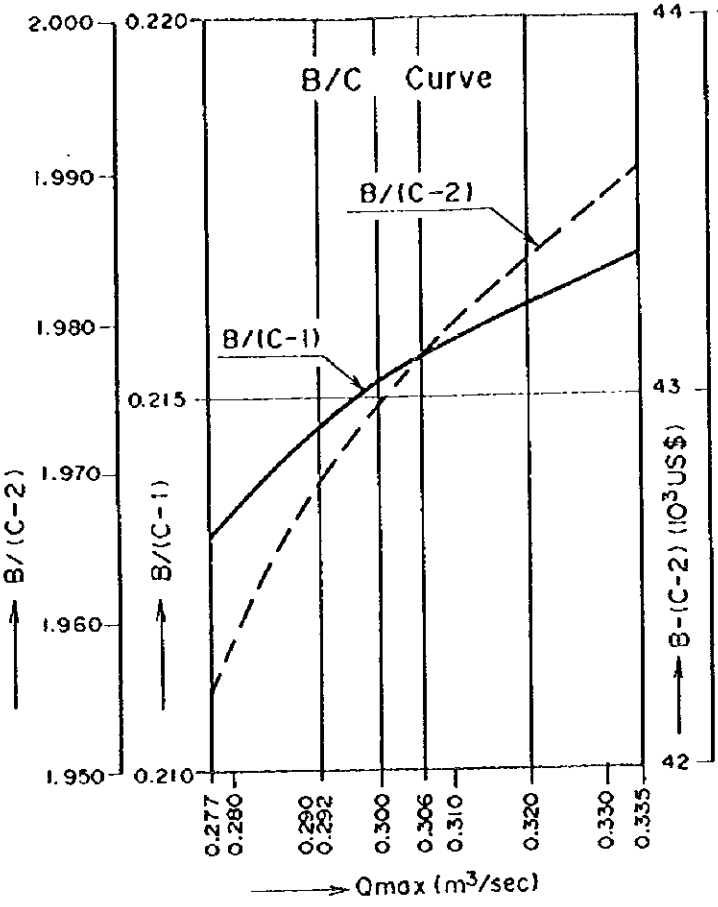
Horizontal Scale 1/10,000

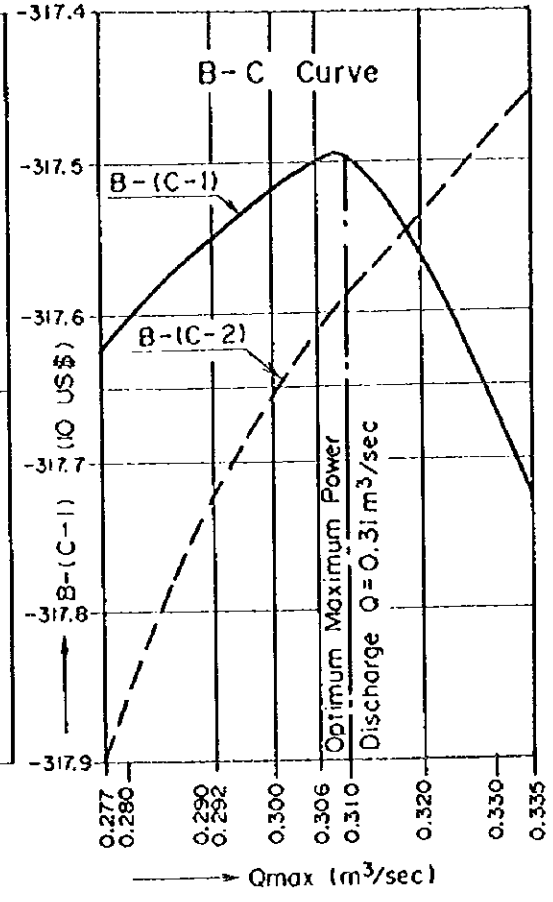
0 500m

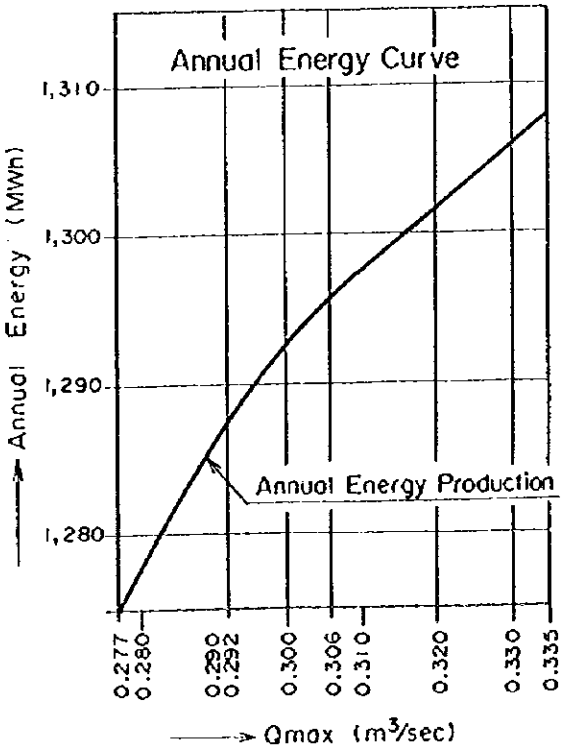
MINI HYDRO-ELECTRIC POWER STATION PROJECT

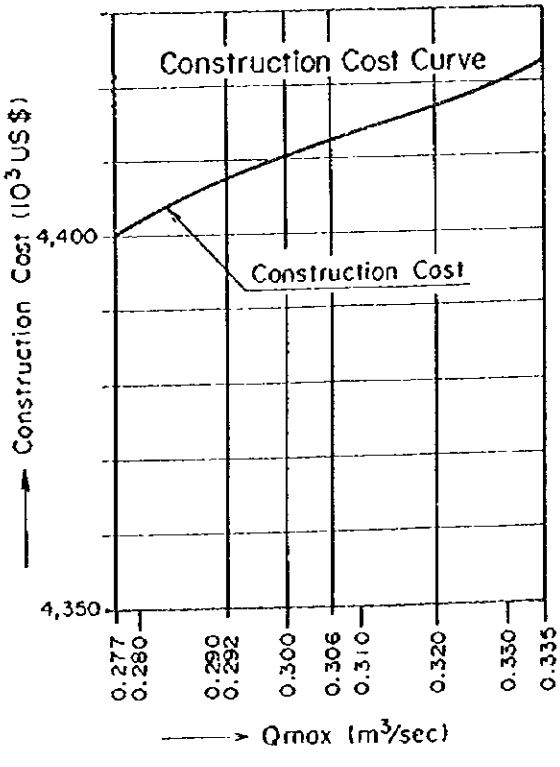
Profile of Alternative Scheme Manuel Jorge No.4 Project

Fig. 8-3





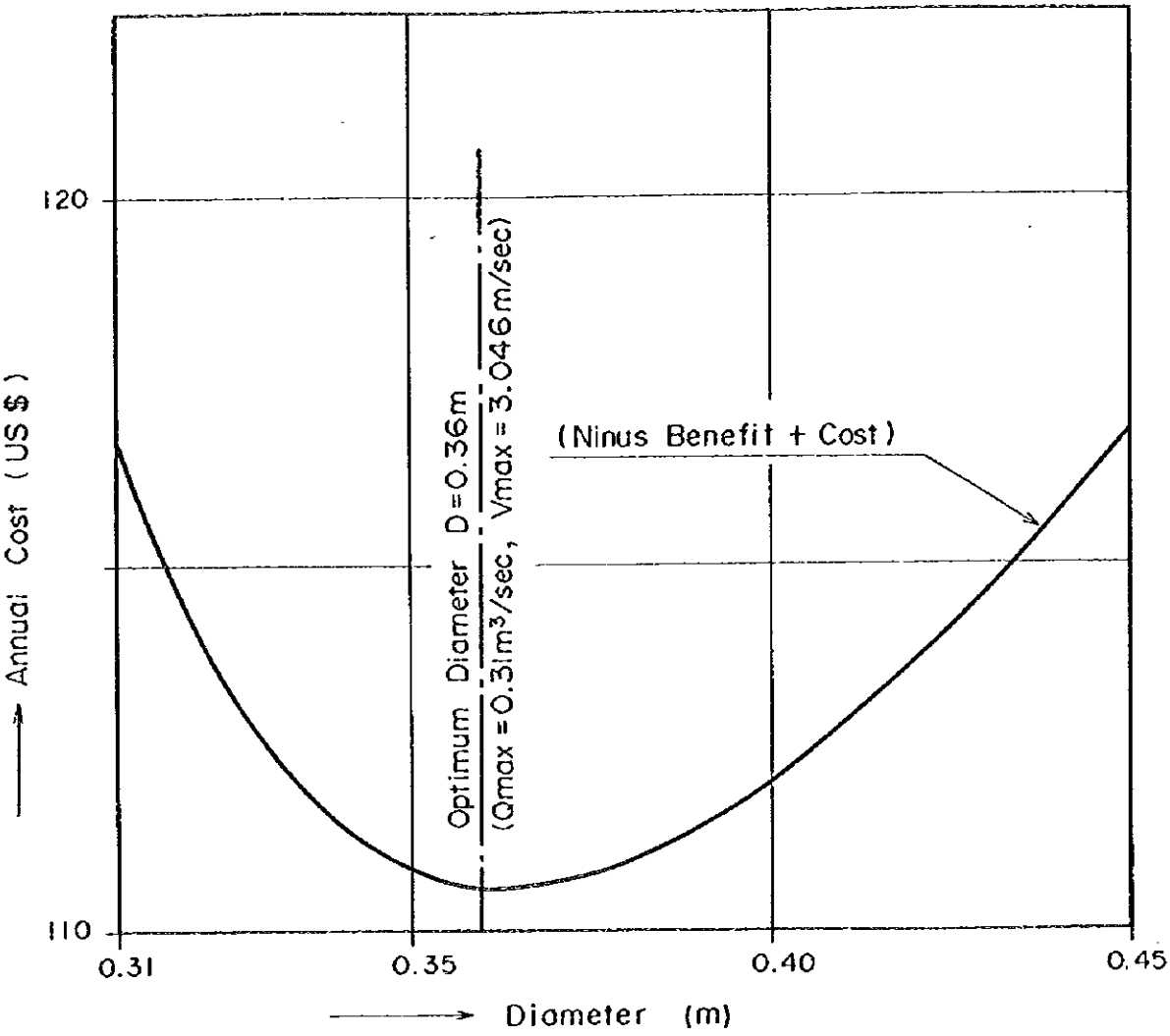




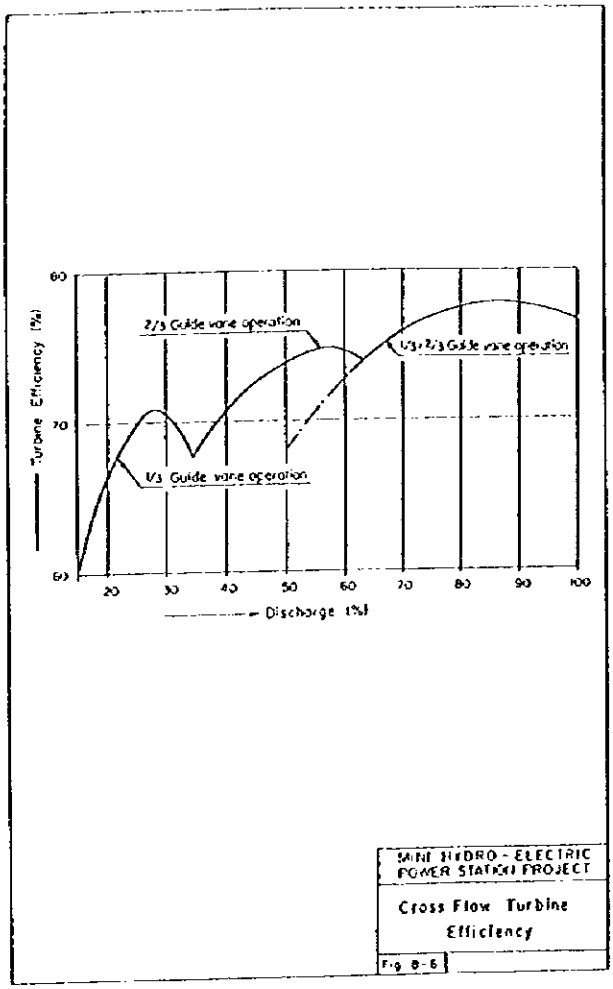
MINI HYDRO - ELECTRIC POWER STATION PROJECT

Relation Curve of Maximum Power Discharge to Economical Index

Fig. 8-4



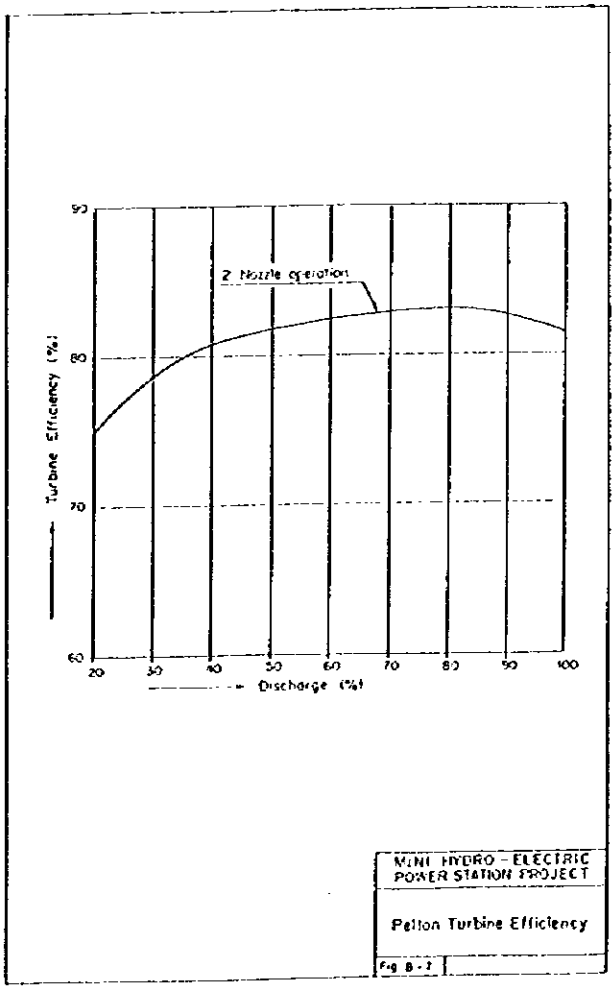
MINI HYDRO - ELECTRIC POWER STATION PROJECT
Study of Optimum Diameter of Penstock Pipe
Fig. 8 - 5



MINI HYDRO - ELECTRIC POWER STATION PROJECT

Cross Flow Turbine Efficiency

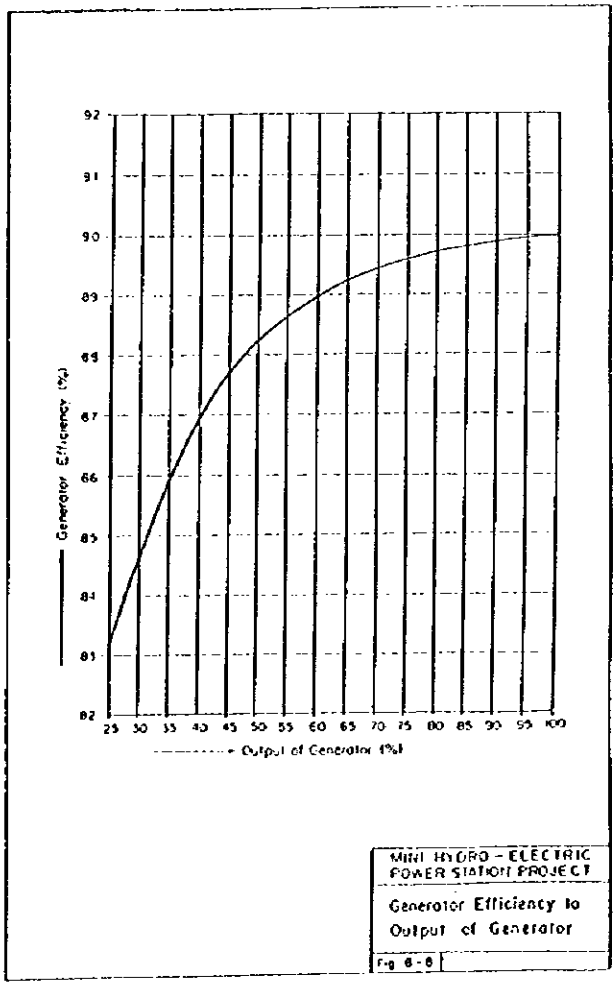
Fig 8-6



MINI HYDRO - ELECTRIC POWER STATION PROJECT

Pelton Turbine Efficiency

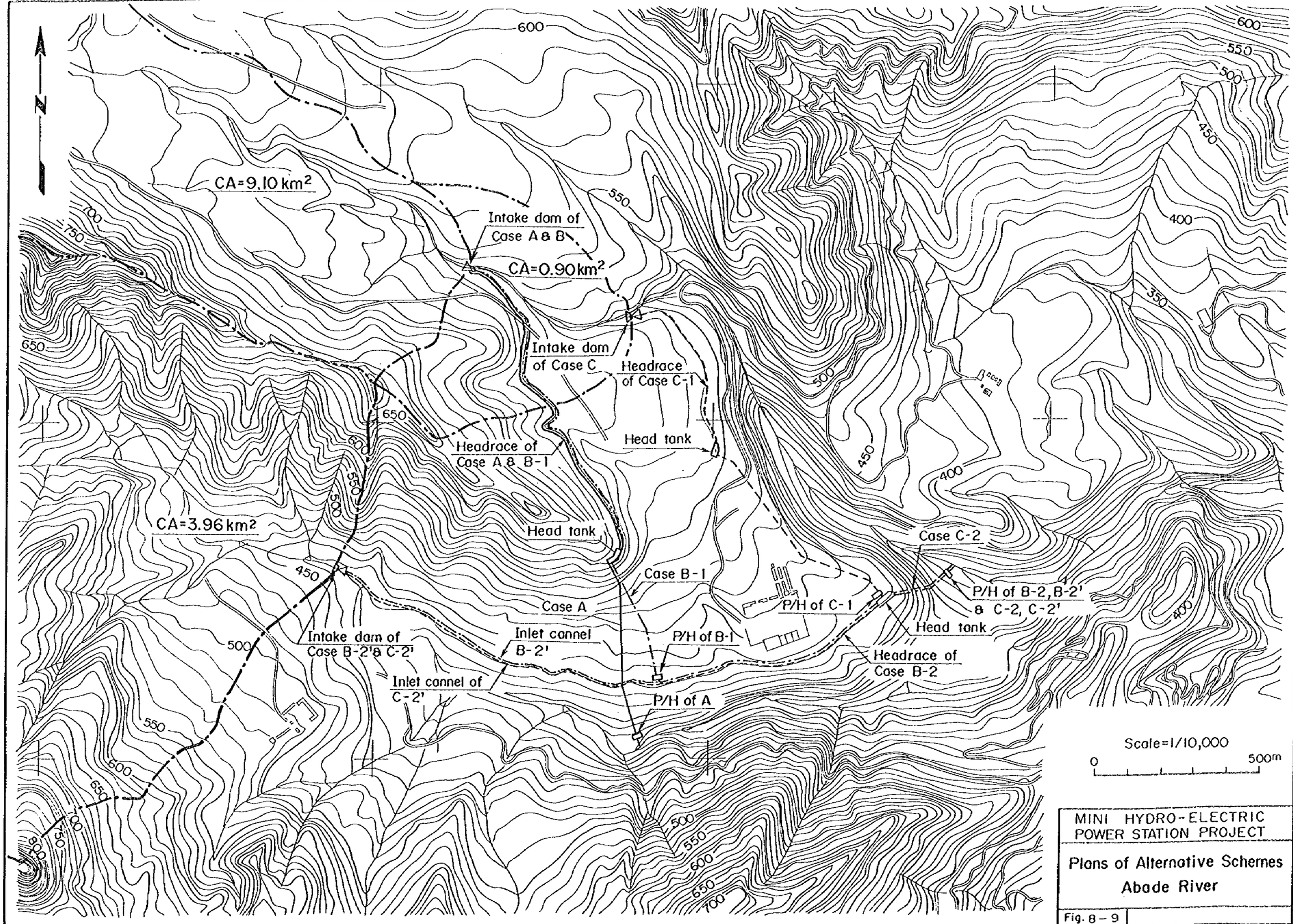
Fig 8-7



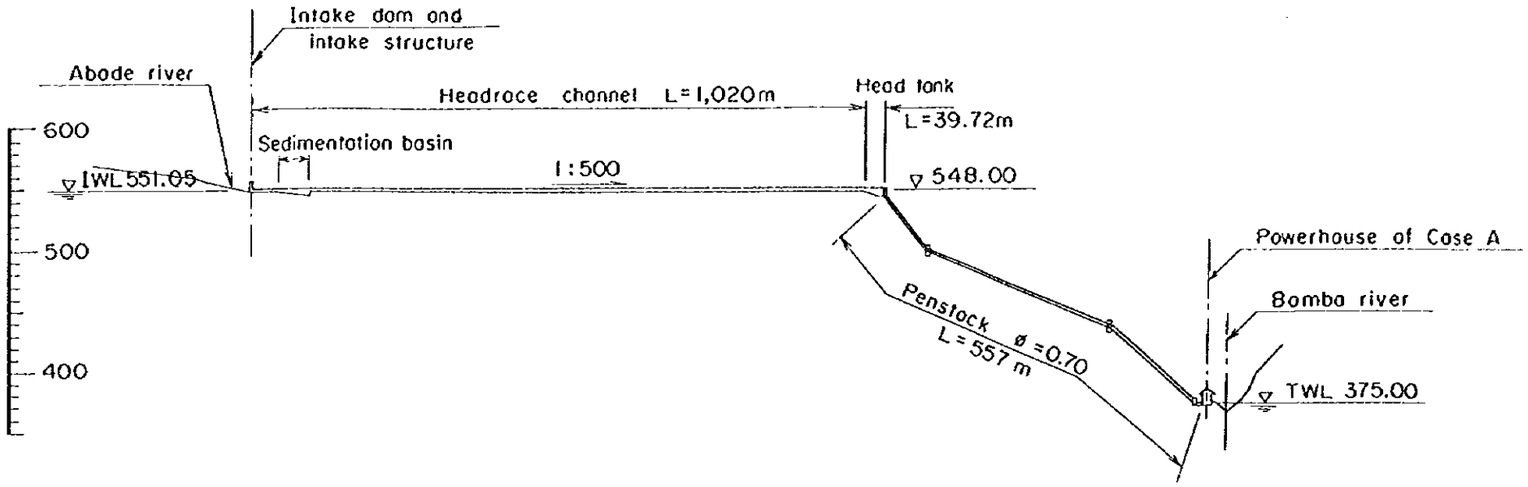
MINI HYDRO - ELECTRIC POWER STATION PROJECT

Generator Efficiency to Output of Generator

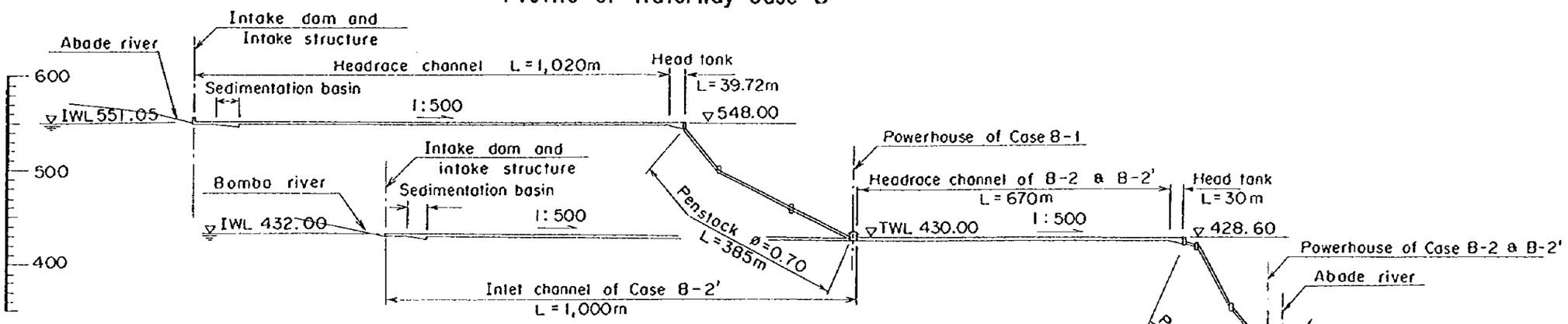
Fig 8-8


N
CA=9.10 km²
Intake dam of
Case A & B
CA=0.90 km²
Intake dam
of Case C
Headrace
of Case C-1
Head tank
Headrace of
Case A & B-1
CA=3.96 km²
Head tank
Case B-1
Case A
Intake dam of
Case B-2' & C-2'
Inlet cannel
B-2'
Inlet cannel of
C-2'
P/H of B-1
P/H of A
P/H of C-1
Case C-2
P/H of B-2, B-2'
& C-2, C-2'
Head tank
Headrace of
Case B-2
Scale=1/10,000
0
500m
MINI HYDRO-ELECTRIC
POWER STATION PROJECT
Plans of Alternative Schemes
Abade River
Fig. 8 – 9

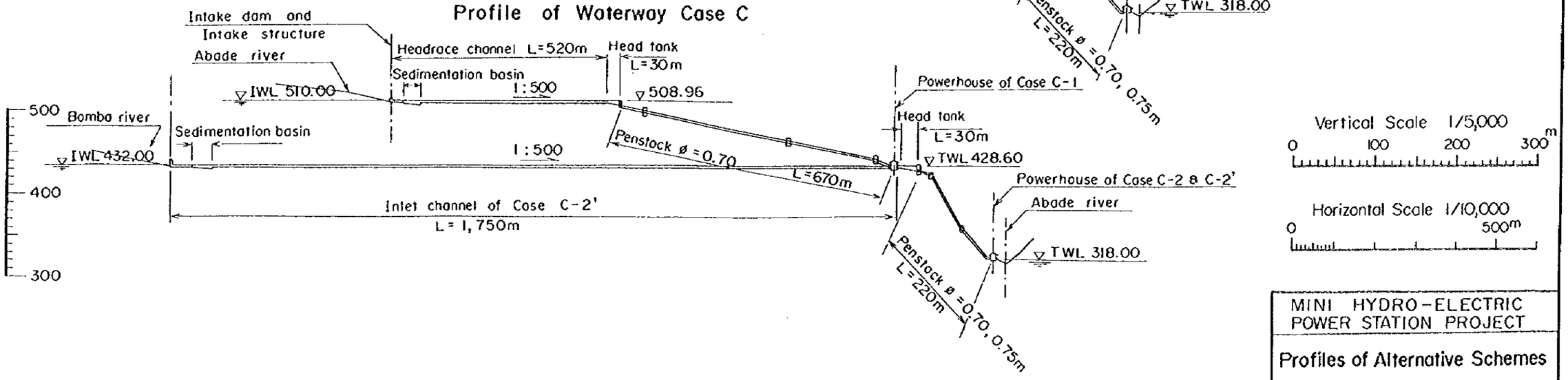
Profile of Waterway Case A



Profile of Waterway Case B



Profile of Waterway Case C



Vertical Scale 1/5,000

0 100 200 300 m

Horizontal Scale 1/10,000

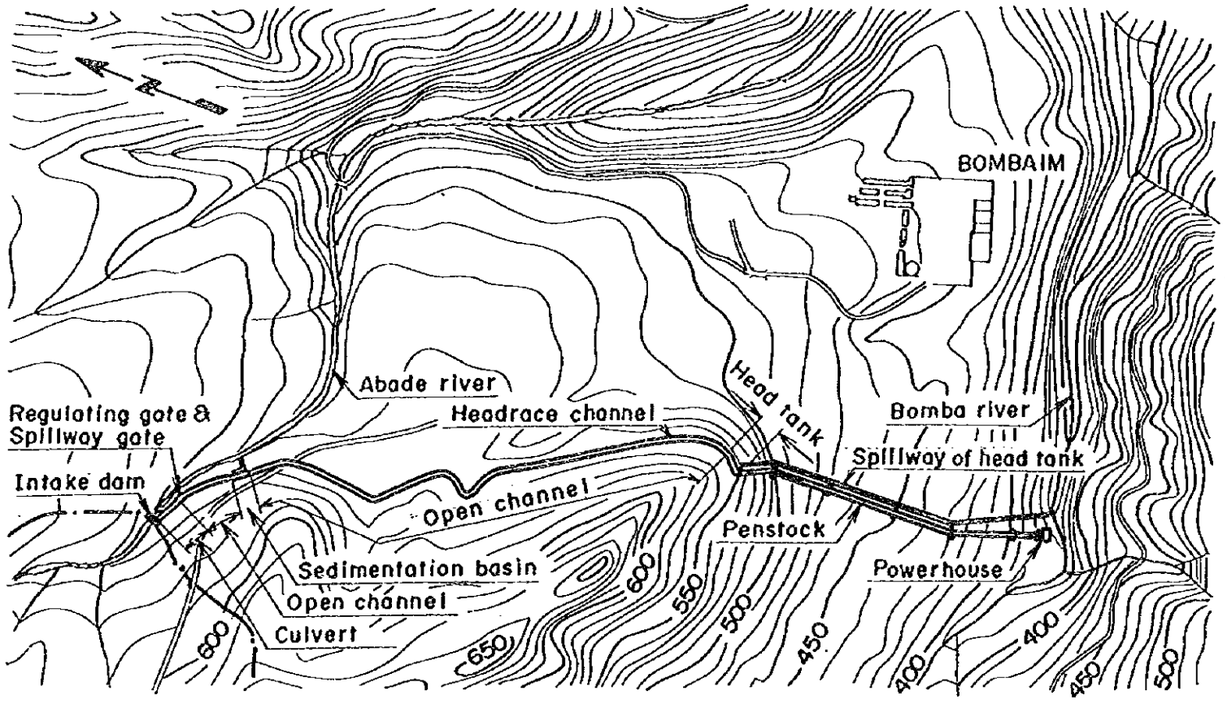
0 500 m

MINI HYDRO-ELECTRIC POWER STATION PROJECT

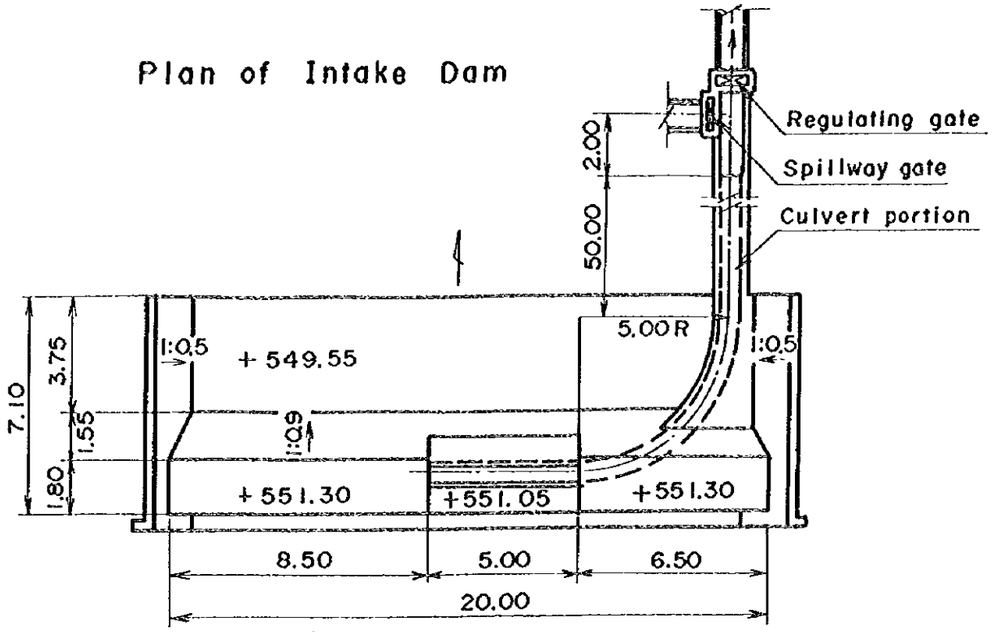
Profiles of Alternative Schemes
Abade River

Fig. 8-10

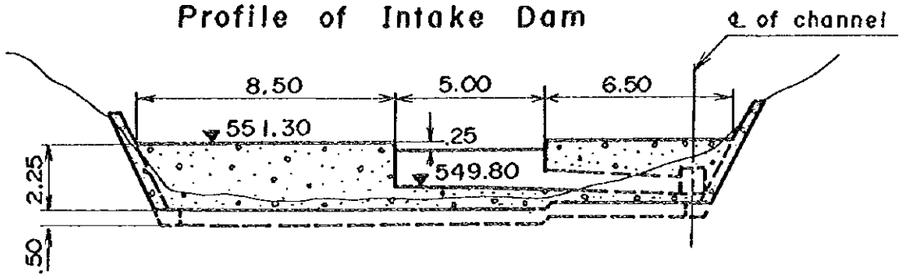
Plan of Water Way (Scale=1: 10.000)



Plan of Intake Dam

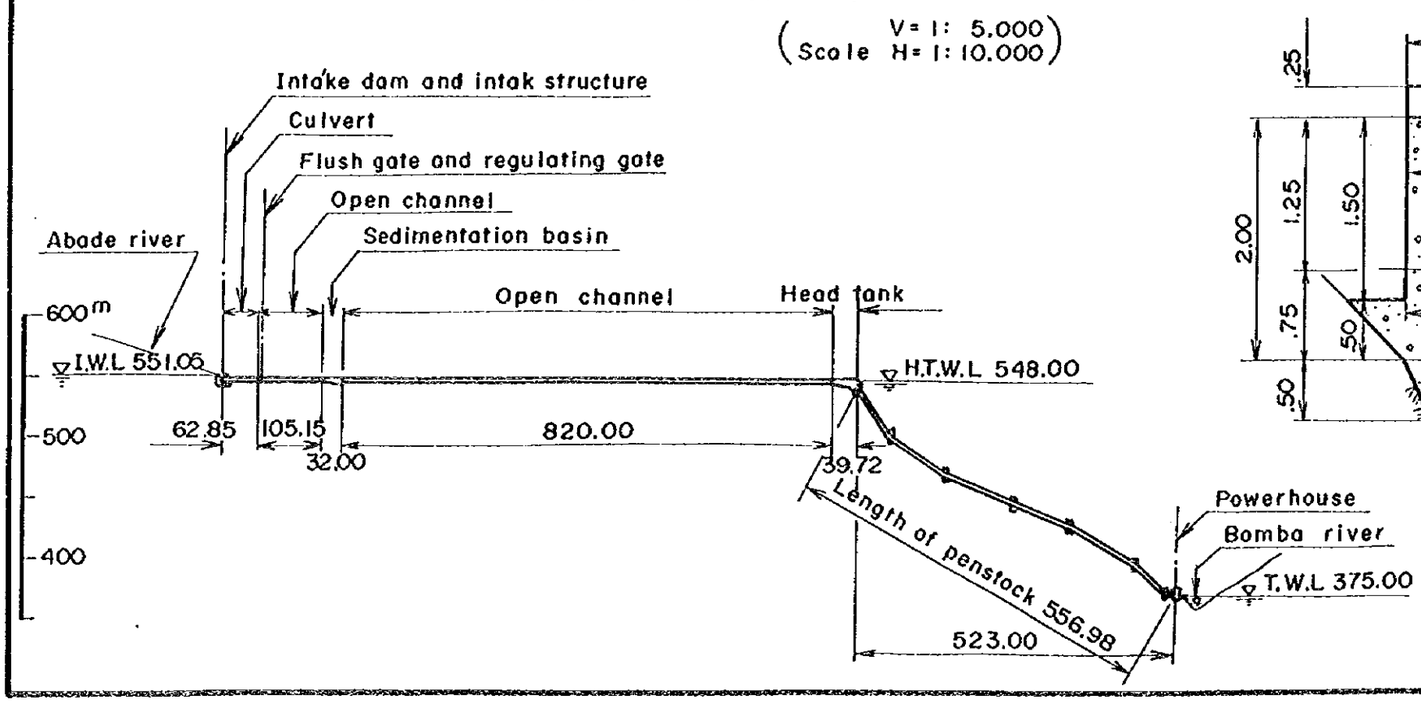


Profile of Intake Dam

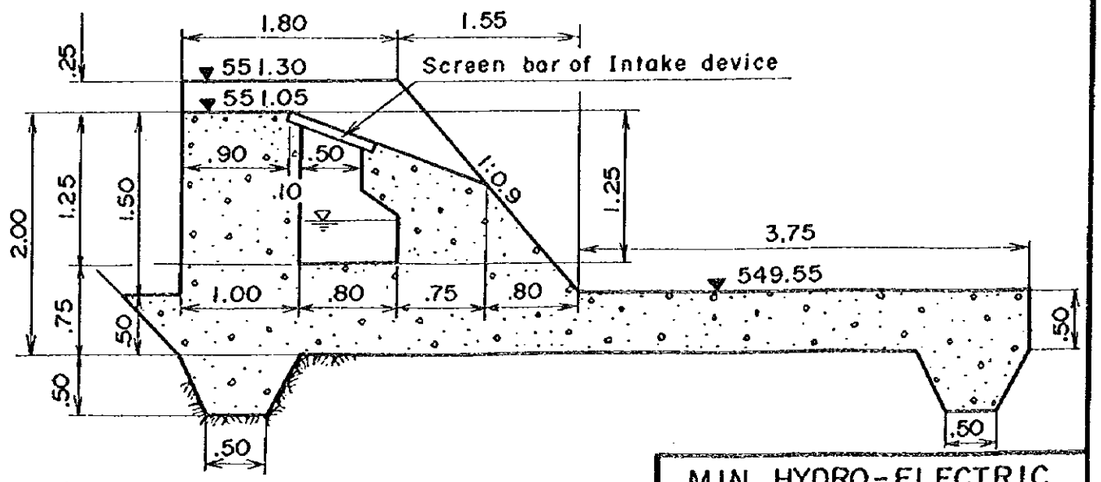


Profile of Water Way

(Scale V= 1: 5.000, H= 1: 10.000)



Typical Cross Section of Intake Dam

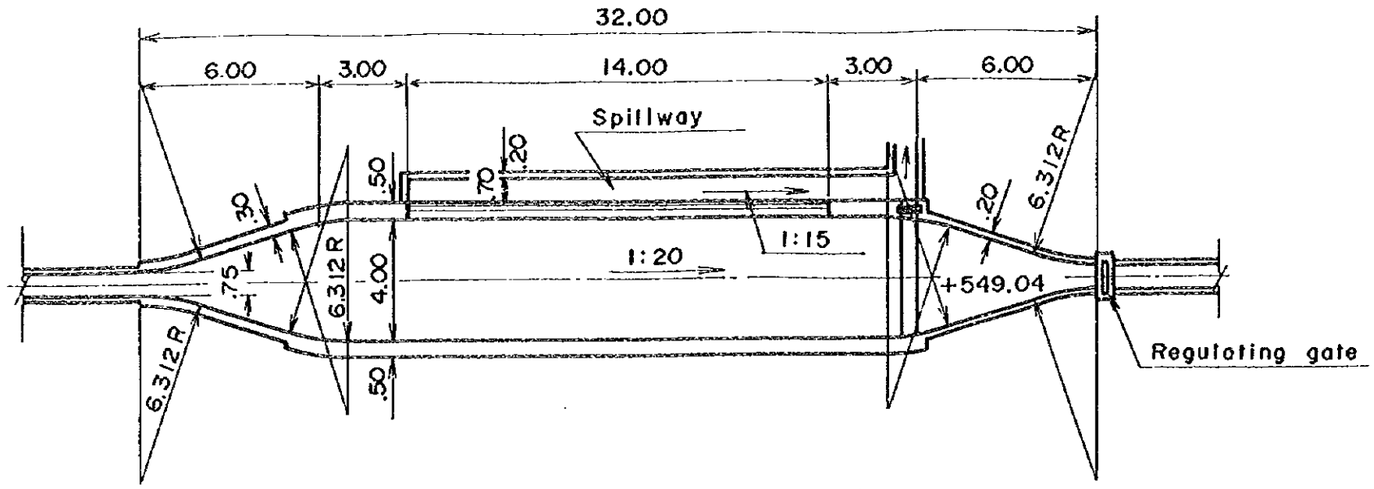


MIN HYDRO-ELECTRIC POWER STATION PROJECT

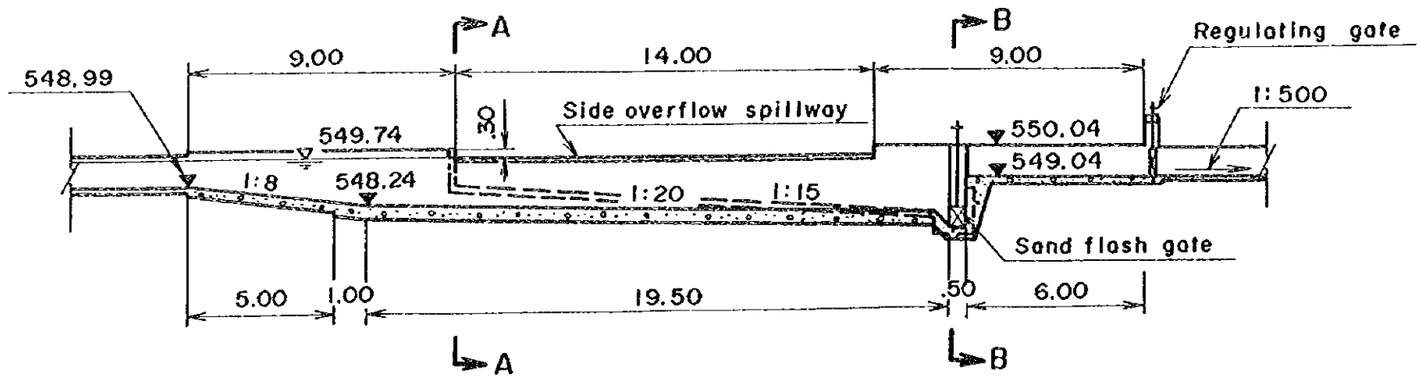
Plan & Profile of Water Way and Intake Dam Details Case A, Abade River Scheme

Fig. 8-11

Plan of Sedimentation Basin

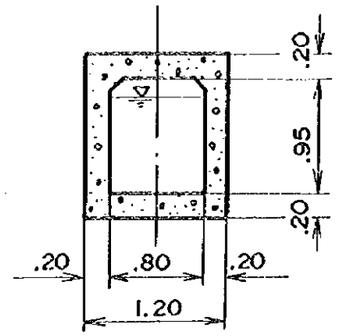


Profile of Sedimentation Basin

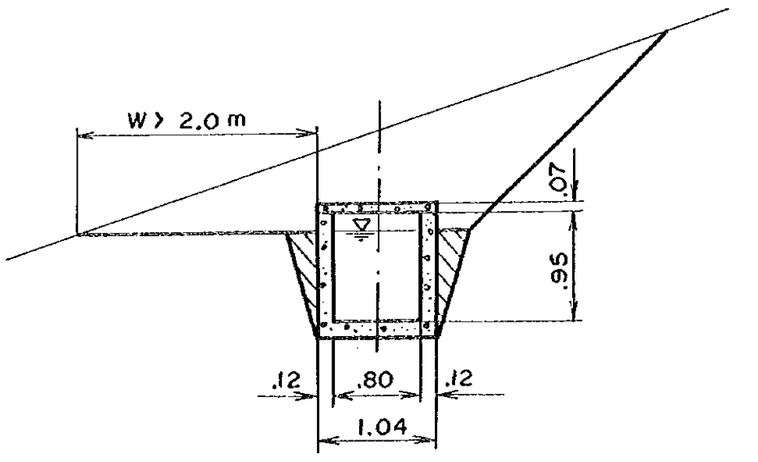


Typecal Cross Section of Headrace

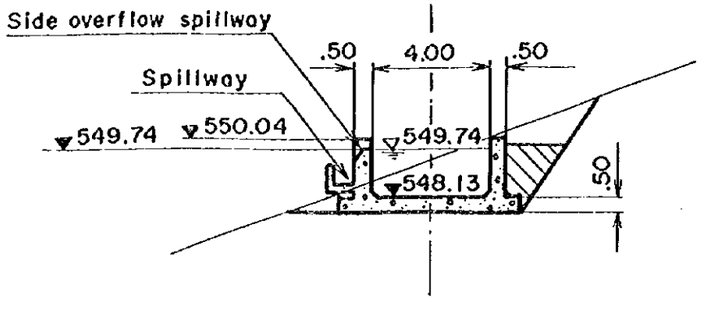
Culvert Portion



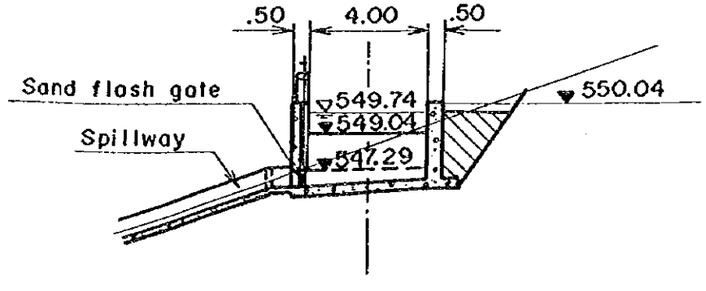
Open Channel Portion



Section A – A



Section B – B

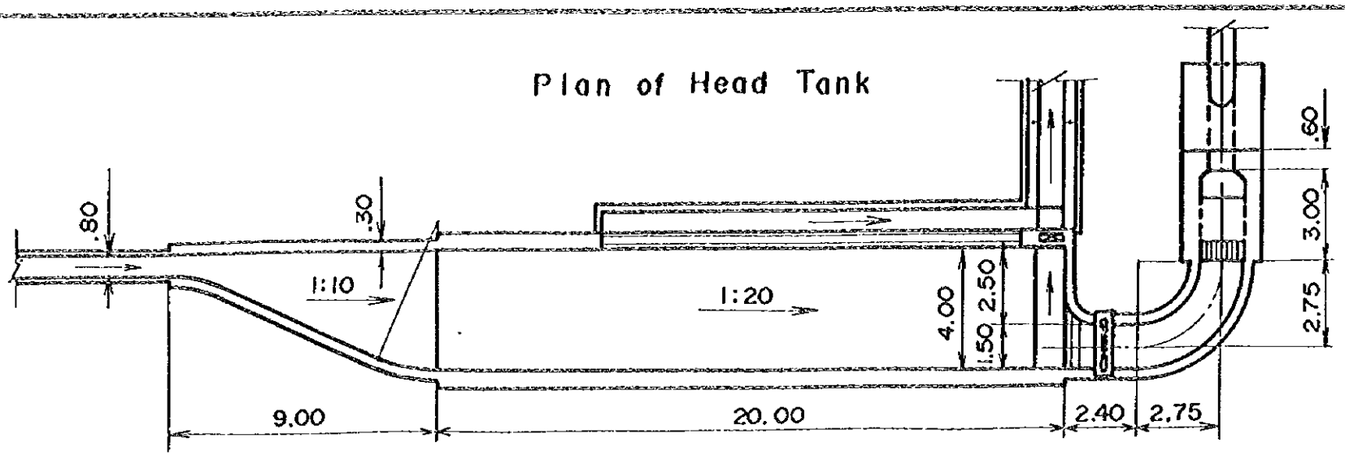


MIN HYDRO-ELECTRIC POWER STATION PROJECT

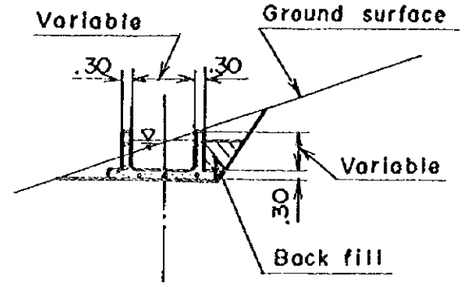
Details of Sedimentation Basin and Headrace Channel Case A, Abade River Scheme

Fig. 8-12

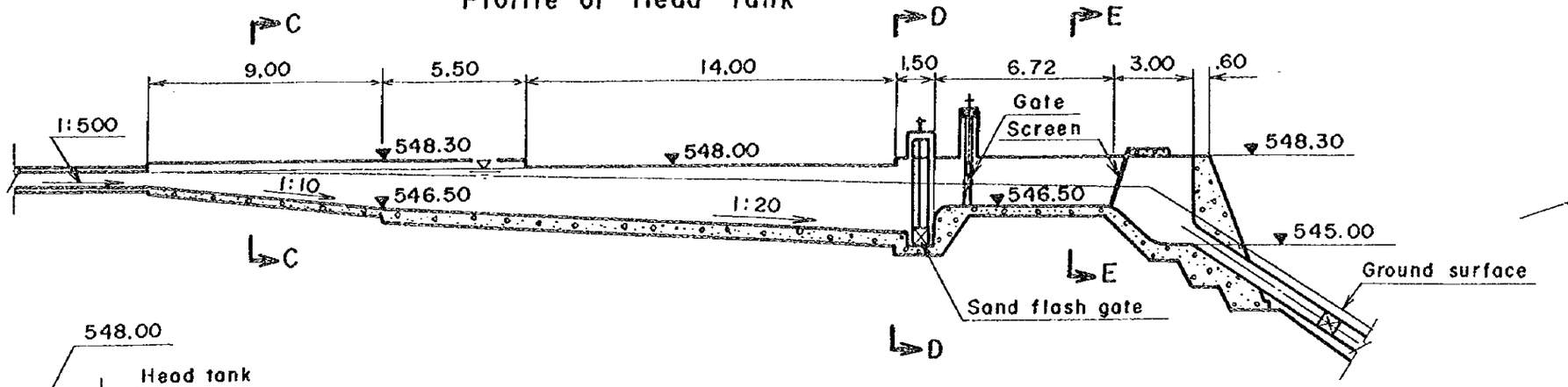
Plan of Head Tank



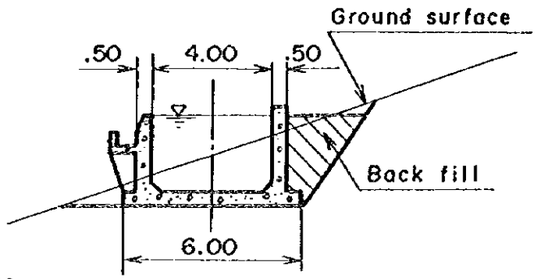
Section C–C



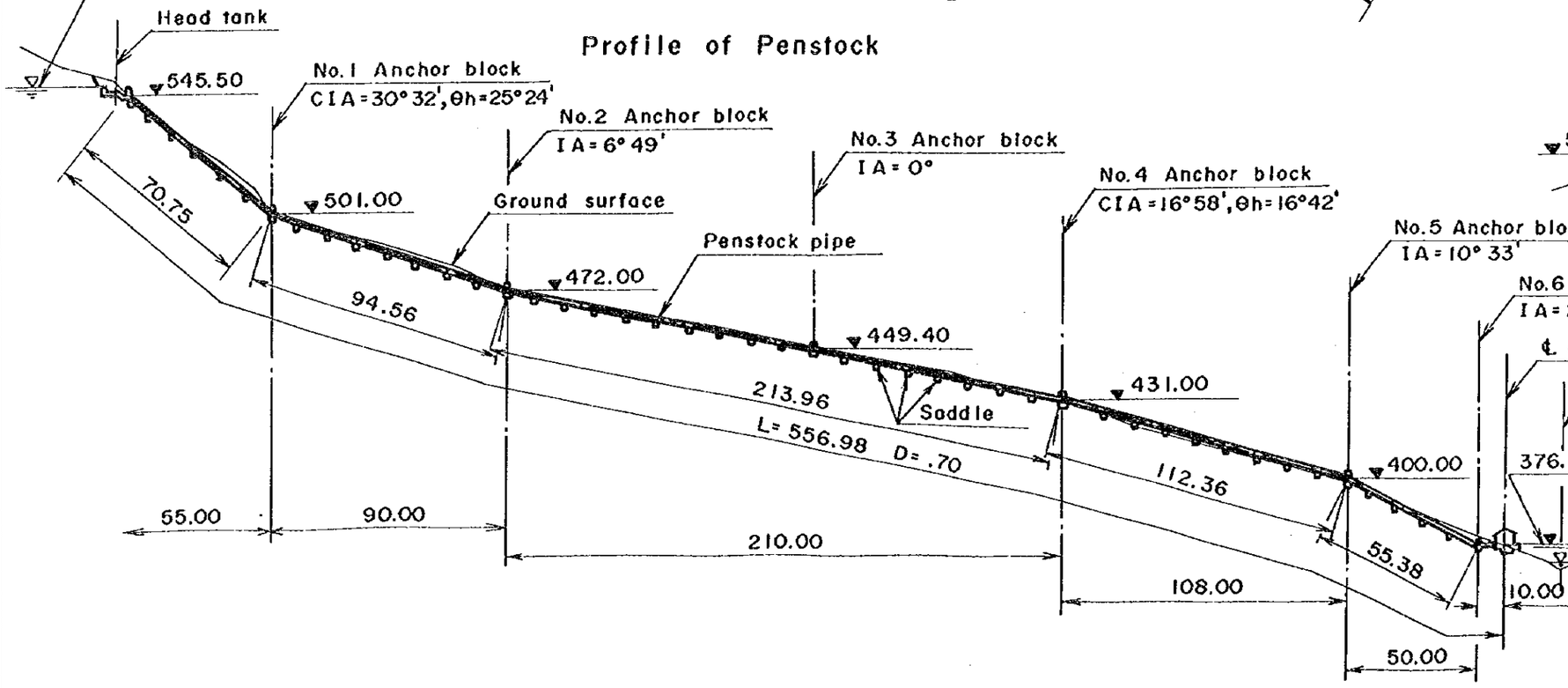
Profile of Head Tank



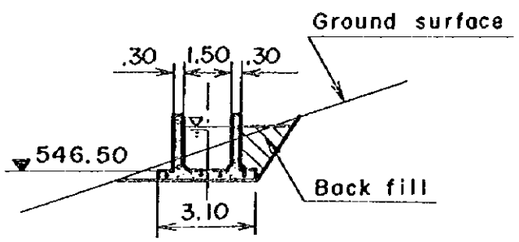
Section D–D



Profile of Penstock



Section E–E



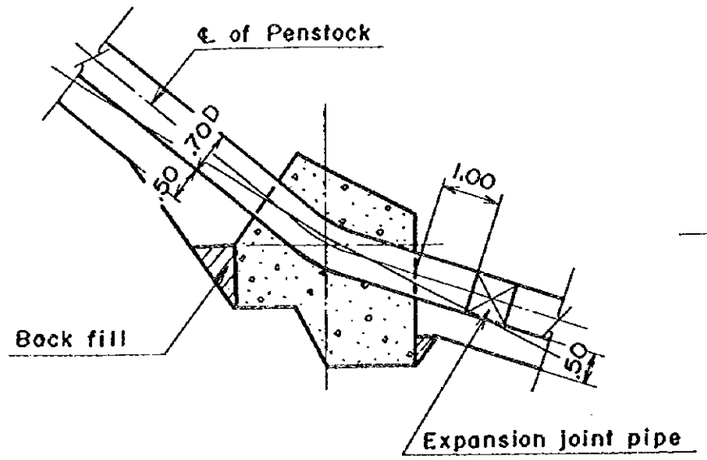
MIN HYDRO-ELECTRIC POWER STATION PROJECT

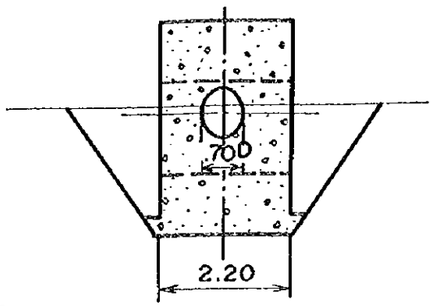
Details of Head Tank and Profile of Penstock Case A, Abade River Scheme

Fig. 8-13

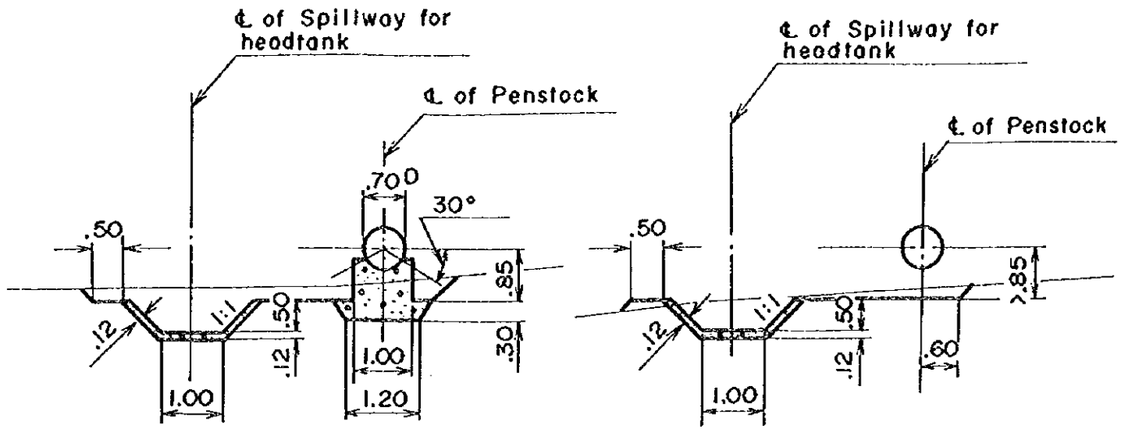
Typecal Cross Section of Penstock and Spillway of Head Tank

Anchor Block

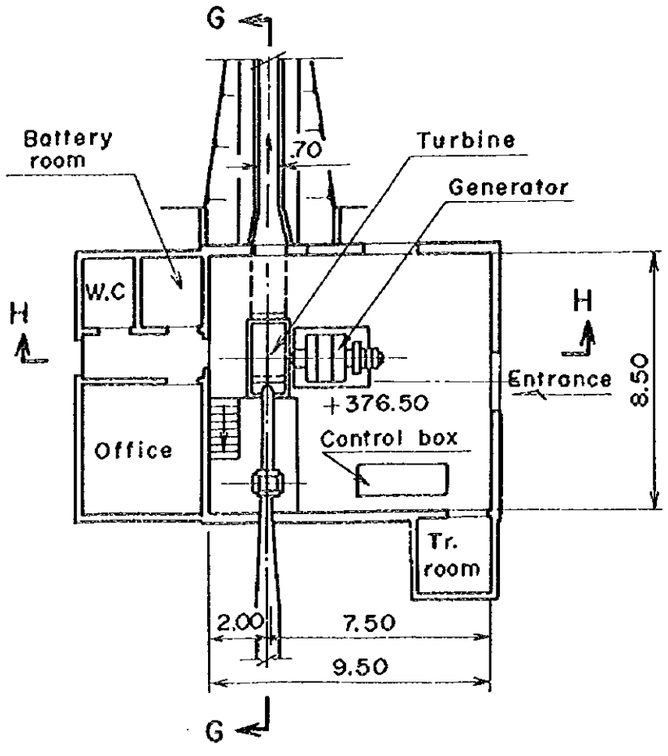




Saddle and Spillway



Section F – F



Section G – G

Section H – H

MINI HYDRO-ELECTRIC POWER STATION PROJECT

Anchor Block and Saddle of Penstock and Powerhouse
Case A, Abade River Scheme

Fig. 8-14

Chapter 9

GROUND SURVEY AND GEOLOGICAL INVESTIGATION

9. GRAND SURVEY AND GEOLOGICAL INVESTIGATION

9.1 Existing Topographical Maps and Geological Data

The existing topographical maps below related to this mini-hydropower project investigation were collected:

(1) S = 1/75,000 map: entire Sao Tome Island, 1sheet (original, prepared 1961)

(2) S = 1/25,000 map: entire Sao Tome Island, 5 sheets (original, prepared 1958)

(3) S = 1/10,000 map: Manuel Jorge River Basin, 3 sheets (blueprint, prepared 1966)
Abade River Basin, 3 sheets (blueprint, prepared 1966)

Regarding 1/10,000 scale maps, they were collected placing emphasis on the Manuel Jorge and Abade river basins. Geological data are enumerated in 9.3.2.

9.2 Ground Survey

As indicated in 9.1 above, the largest scale of existing topographical maps is 1/10,000, and since the scale was too small for a feasibility study to be carried out on the Manuel Jorge No. 4 site based on the results of the studies described in Chapter 8, and since the year of preparation was old and changes had occurred in structures such as buildings and in roads with subsequent elapse of time, ground survey is was done for the purpose of preparing 1/1,000 scale topographical maps with which study of the power generation project and feasibility design can be achieved. Together with this, cross-sectional surveying was done for studies to avoid damage from floods to power generation structures at the intake dam and powerhouse sites.

As a result of field reconnaissance, it was learned that no bench mark (BM) to be the basis for elevation existed in the vicinity of the project site (although there had been some in the past) and, therefore, the elevation of the point appearing to coincide the most according to the existing 1/10,000 scale topographical map and local topography was taken as the datum point of EL. 390.90 (= EL. 396.50 m + 0.40 m).
And with this as the basis, bench marks at 4 locations were provided in the Manuel Jorge No. 4 project area for ground survey and future implementation of the project.

Further, since triangulation points having plane coordinates to indicate plane positions do not exist in the neighborhood similarly to the case of bench marks, topographical maps with the coordinate values of points read on 1/10,000 scale topographical maps, which are considered the most appropriate to be based on as bench marks are prepared.

For the scope of survey, since there are 5 or 6 waterfalls from 2 m to around 18 m in the vicinity of the intake site, it was considered that a place of stable topography and geology which moreover would be economical must be selected from EL. 500 m of this location to around 470 m. The headrace and head tank areas would require an elevation range roughly the same as the intake site, but especially, in order to make it possible for the head tank to assume a reservoir-like role, consideration was given so that there would not be insufficiency of its capacity. The area of the powerhouse and outlet would be related to the topographies at the head tank and penstock, and asking into consideration the relationship between power station space and outlet water level and flood water level, a range long in the upstream-downstream direction from river bed elevation 410 m to 370 m was selected.

The scope of survey and items and quantities are given in Fig. 9-1 and Table 9-1.

Table 9-1 Quantities Planned in Ground Survey

Item	Unit	Quantity	Remark
Benchmark installation	Point	4	
Topographical surveying (scale 1/1,000)	m^2	285,000	
Stream cross-sectional surveying (50 m traverse)	Traverse	6	Intake dam site (3 sites)
Stream cross-sectional surveying (100 m traverse)	Traverse	8	Powerhouse site (2 sites)

9.3 Geological Investigations

9.3.1 Selection of Investigation Work

Examinations were made of the contents of various geological investigations such as geophysical prospecting and boring scheduled to be carried out hereafter based on the results of field topographical and geological investigations in the First Field Survey. As a result, of geophysical prospecting (refraction method seismic prospecting), 8 traverses, 600 m, and boring, total 70 m,

seismic prospecting was called off due to the conditions below, and it was decided to ascertain the geology of the project site by boring and surface geological exploration.

(1) Geological Conditions

The plan is for intake facilities to be provided downstream or upstream of water falls located approximately 1 km west of the Santa Luzia hamlet at the midstream section of the Manuel Jorge River, with headrace, head tank, penstock, and powerhouse provided along the left bank.

According to the results of field investigations, there are parting layers of basalt and agglomerate at the slopes on both banks upstream and downstream of the waterfalls at the intake dam site, while at the river bed, there are very small distributions of river deposits.

Consequently, it is thought unnecessary for underground geological distributions and geological structures of the projected dam site to be estimated by velocity Layer classifications which are analysis results of seismic prospecting. Likewise, outcrops are seen along drag roads with regard to the headrace, penstock, and powerhouse sites, and the necessity for investigations by seismic prospecting is not seen for these sites also.

(2) Land Use at Investigation Site

Cacao is widely cultivated in the left-bank area in general of the Manuel Jorge River midstream, and there is a possibility of various difficulties being encountered when setting out seismic prospecting traverses.

(3) Vibration Source in Seismic Prospecting

In most cases, explosives are generally used as the vibration sources in seismic prospecting, but on investigating the conditions for using explosives at the site, it was found that explosives are not available in Sao Tome and Principe, and importing would need to be done. And to use explosives, it may be expected that considerable time would be consumed in making applications and receiving permits and approvals.

Alternatives would be hammering and weight dropping, but vibration energies would be small with these methods, and there is a possibility that obtaining the results of investigation aimed for such as layer thicknesses of deposits will not be achieved.

(4) Investigation Firm

There is no firm is Sao Tome and Principe capable of performing seismic prospecting (including boring), and it would be necessary to look to Gabon, from which there are scheduled airplane flights, or other countries. Even then, it would be necessary to bring in seismic prospecting equipment and specialists from Europe.

9.3.2 Geological Investigation

Literature and geological maps obtained as geological data concerning the mini hydro power development project survey are as follows:

1) Sao Tome Island Geological Map
   Scale: 1/75,000
   Year published, publisher unknown

2) Sao Tome Island Land Use Map
   Scale: 1/50,000
   1974, Sao Tome and Principe National Geographical Institute

3) Sao Tome Island Soil Map
   Scale: 1/50,000
   1960, Overseas Survey Committee, Foreign Ministry, Portugal

4) Proposal for Hydro Power Resources Development in the Democratic Republic of Sao Tome and Principe, Civil Engineering and Geology Volume, May 1981 Planning and Survey Research Institute, GUIDOPROEKT, U.S.S.R.

5) Ditto: Drawings

In the present survey, boring investigations were carried out at the midstream stretch of the Manuel Jorge River as a mini hydro power development site. Boring consisted of 6 drillholes

totaling 90 m, with 2 holes each of 10 to 20 m drilled at the intake dam, head tank, and powerhouse sites. In selection of boring investigation locations, since suitable topographical maps were not available, existing 1/10,000 topographical maps were used. Consequently, there are places where the boring investigation locations are deviated from the projected locations of structures.

Details of boring investigation locations and results of investigations are given in Fig. 10-6 ~10, and, regarding these investigation works, geological profiles were prepared based on 1/1,000 scale topographical maps newly made, and these are given as Figs. 10-6 to 10-10.

9.4 Execution

Ground survey and geological investigation works were executed by Gabon-based GERI-LOISON S.A.R.L., the contractor, during a period of about 3 months from end-July to mid-October, 1996. The Contractor had been selected by competitive bids based on the tender documents which included technical specifications of the works concerned.