The virtual B/C ratio of Nam Mae Ngao project is higher than 1.22 as estimated previously.

9.6 Equalizing Discount Rate (EDR)

In order to determine a priority or development order among various projects proposed and to obtain optimum development scales of these projects, comparison study has been carried out by using annual cost method in the previous sections.

Furthermore, in this section, the equalizing discount rates (EDR) have been calculated on Nam Mae Ngao individual development and Nam Mae Ngao + Lower Yuam integrated development.

The results are shown in Table 9-12 and 9-13.

The results will make it possible to evaluate the economical efficiency of these projects through comparison with other national projects. In calculation of EDR, the same criteria and data as those used in the calculation of B/C were employed, and actual disbursement schedules of construction cost, which were ignored in the calculation of B/C, have been taken into account.

9.7 Sensitivity Analysis

(1) First, the sensitivity analysis to the variation of the fuel prices for the alternative thermal power plant is performed. All together 4 cases of the variation were tested of which Case 0 was adopted as the base case as already described in the preceding section.

The results are plotted on Fig. 9-8. It is seen from these results that the B/C ratio of Nam Mae Ngao No.2 increases from 1.22 for the base case to 1.34 for the case 3 as the fuel price goes up.

At the same time, the B/C ratio of Nam Mae Ngao No.2 + Lower Yuam integrated project remains at the same level of 1.35.

(2) The second sensitivity analysis concerns with a variation of a discount rate

In this test, a discount rate of 12% is adopted for the base case. Assuming that all other conditions are equal, the procedures and results are shown on Table 9-14 through 9-24.

It is seen that the B/C ratio of 1.06 and 1.20 are obtained for Nam Mae Ngao individual development and Nam Mae Ngao + Lower Yuam integrated development respectively.

The result shows that even in the case of discount rate at 12% the projects are economically feasible, and in particular, the B/C ratio of the integrated development exceeds 1.20.

(3) The third sensitivity analysis is concerned with the transmission line of Nam Mae Ngao Project.

In this case, the 2 circuits 230 KV transmission line is constructed directly from the project to Lamphun 2 substation (the length of the line: 197 km) as against the original plan where the transmission line only from the project to Lower Yuam was considered.

The results of analysis are contained in Table 9-26-1 and 9-26-2.

It is seen that the B/C ratios of Nam Mae Ngao Project vary from 1.08 for base case of fuel price to 1.18 for case 3 of fuel price indicating still the economic superiority of the project.

Table 9–1 Economic Criteria and Basic Cost of Thermal Power Plants Case 0 (Base Case)

3rd stage study

		Unit	Hydro power plant	Gas turbine		Thermal		Lignite (50 years)	
				Natural gas (1st 25 years)	Diesel Oil (2nd 25 years)	Natural gas (1st 25 years)	Imported coal (2nd 25 years)		
	Installed capacity	MW	H	G	G	T	T	L	
a	Standard unit capacity	MW		25	25	600	600	600	EGAT data given on Oct.7,1985
b	Standard capacity factor	%		$Xg \leqq 5$	$Xg \leqq 5$	$40 \leqq X_t \leqq 85$	$40 \leqq X_t \leqq 85$	$40 \leqq X_t \leqq 85$	- ditto -
c	Economic life length adopted	years	50	10	10	20	25	25	
d	Station service rate	%	1	2	2	7	7	7	
e	Scheduled outage rate	%		2	2	13	13	13	
f	Forced outage rate	%		4	4	4	4	4	
g	Annual fixed O&M rate	%	1	3	3	2.5	2.5	2.5	
h	Unit construction cost								
	w/o IDC	$/KW		320	320	580	957	957	
	ditto	฿/KW		8640	8640	15660	25839	25839	1 US$ = 27 ฿
	(Fuel)								
i	Fuel calorific value			Natural gas 1000Btu/cu.ft	Diesel oil 8959.6Kcal/Lit = 35558Btu/Lit	Natural gas 1000Btu/Cu.ft	Imported coal 5796Kcal/kg	Lignite 2648.8Kcal/kg	EGAT data given on July 3,1986
j									
k	Thermal efficiency	%		25	25	36	36	36	
l	Energy equivalence	Kcal/KWH		3440Kcal/KWH	3440Kcal/KWH		2388.9Kcal/KWH	2388.9Kcal/KWH	- ditto -
m	= Plant heat value	Btu/KWH		13650.8Btu/KWH		9479.7Btu/KWH			
n	Fuel consumption			13.6508cu.ft/KW	0.3839Lit/KWH	9.4797cu.ft/KWH	0.4122kg/KWH	0.9019kg/KWH	- ditto -
o	Unit fuel price			71.0947฿/MBtu	3.68฿/Lit	71.0947฿/MBtu	1.484฿/kg	0.5332฿/kg	- ditto -
p	Unit fuel cost	฿/KWH		0.9705	1.4128	0.6740	0.6117	0.4809	- ditto - (Base case)
q	Effective capacity	MW		0.94G	0.94G	0.83T	0.83T	0.83L	(1-(e+f)/100)xInstalled capa.
r	Send-out capacity	MW	0.99H	0.92G	0.92G	0.77T	0.77T	0.77L	q x (1-a/100)
s	Energy production	MWH		$GXgH_r$	$GXgH_r$	TX_tH_r	TX_tH_r	LX_LH_r	
t	Send-out energy	MWH		$0.98GXgH_r$	$0.98GXgH_r$	$0.93TX_tH_r$	$0.93TX_tH_r$	$0.93LX_LH_r$	
u	Capital investment cost	฿		8640G	8640G	15660T	25839T	25839L	h x installed capacity
v	Annual O&M cost	฿		259.2G	259.2G	391.5T	646.0T	646.0L	u x g
w	Daily O&M cost	฿		0.7101G	0.7101G	1.0726T	1.7698T	2.1238L	v/365
x	Fuel cost	฿		$0.9705GXgH_r$	$1.4128GXgH_r$	$0.6740TX_tH_r$	$0.6117TX_tH_r$	$0.4809LX_LH_r$	s x p

Table 9–2 Cost Stream of Alternative Gas Turbine (Natural Gas – Diesel Oil)
Case 0 (Base Case)

3rd stage study

Year	Single payment worth factor [1]	Capital investment cost						O&M	Fuel Cost		
		Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Total		for the 1st 25 years	for the 2nd 25 years	Total
n	i = 10%										
0	1.000	8640G									
1								259.2G	$0.9705GXgH_r$		
10	0.385543		8640G								
20	0.148644			8640G							
25										$1.4128GXgH_r$	
30	0.057308				8640G						
40	0.022095					8640G					
50	0.008519										
Present value factor		1.000	0.385543	0.148644	0.057308	0.022095			9.077040 [3]	0.837774 [4]	
Present value		8640G	3331.1G	1284.3G	495.1G	190.9G	13941.4G		$8.8093GXgH_r$	$1.1836GXgH_r$	$9.9929GXgH_r$
Capital recovery factor		0.100859175)									
Annuitized cost							1406.1G	259.2G			$1.0079GXgH_r$

Cost	Unit	Fixed	Variable
Capital investment	฿	1406.1G	
O&M	฿	259.2G	
Fuel	฿		$1.0079GXgH_r$
Total	฿	1665.3G	$1.0079GXgH_r$

	Unit	Cost	
KW-benefit	฿/KW	1810.1	1665.3G/0.92G
KWH-benefit	฿/KWH	1.0285	$1.0079GXgH_r/0.98GXgH_r$

Total annuitized fixed & variable cost in ฿/KW: Annual cost ..... Yg = 1810.1 + 1.0285 x 8760 Xg

Daily cost ..... Yg = 1810.1/365 + 1.0285 x 24 Xg = 4.9592 + 24.6840Xg

Table 9–3 Cost Stream of Alternative Steam Thermal (Natural Gas – Imported Coal)
Case 0 (Base Case)

3rd stage study

Year	Single payment worth factor [1]	Capital investment cost				O&M cost			Fuel cost		
		Plant 1 Natural gas	Plant 2 Natural gas	Plant 3 Imported coal	Total	Plant 1 & Plant 2	Plant 3	Total	for the 1st 25 years	for the 2nd 25 years	Total
n	i = 10%	T MW	T MW	T MW							
0	1.000	15660T									
1						391.5T			$0.674TX_tH_r$		
20	0.148644		15660T								
25	0.092296		$-\frac{15}{20}$ 15660T	25839T			646.0T			$0.6117TX_tH_r$	
50	0.008519										
Present value factor i = 10%		1.000	0.148644 0.092296	0.092296		9.07704[3]	0.83777[4]		9.07704[3]	0.83777[4]	
Present value		15660T	2327.8T	2384.8T		3553.7T	541.2T		$6.118TX_tH_r$	$0.512TX_tH_r$	
			-1084.0T		19288.6T			4094.9T			$6.630TX_tH_r$
Capital recovery factor		0.100859175									
Annuitized cost					1945.4T			413.0T			$0.6687TX_tH_r$

Cost	Unit	Fixed	Variable
Capital investment	฿	1945.4T	
O&M	฿	413.0T	
Fuel	฿		$0.6687TX_tH_r$
Total	฿	2358.4T	$0.6687TX_tH_r$

	Unit	Cost	
KW-benefit	฿/KW	3062.9	2358.4T/0.77T
KWH-benefit	฿/KW	0.7190	$0.6687TX_tH_r/0.93TX_tH_r$

Total annuitized fixed & variable cost in ฿/KW: Annual cost ..... $Y_t = 3062.9 + 0.7190 \times 8760X_t = 3062.9 + 6298.4X_t$

Daily cost ..... $Y_t = 3062.9/365 + 0.7190 \times 24X_t = 8.392 + 17.256X_t$

Table 9–4 Cost Stream of Alternative Steam Thermal (Lignite)
Case 0 (Base Case)

3rd stage study

Year	Single payment worth factor 1)	Capital investment cost			O&M cost			Fuel cost		
		Plant 1	Plant 2	Total	Plant 1	Plant 2	Total	for the 1st 25 years	for the 2nd 25 years	Total
n	i = 10%	L MW	L MW					Lignite	Lignite	
0	1.0	25839L								
1 ↓ 25 ↓ 50	0.092296		25839L		646.0L ↓	646.0L ↓	646.0L ↓	0.4809LX$_1$H$_r$ ↓	0.4809LX$_1$H$_r$ ↓	0.4809LX$_1$H$_r$ ↓
Present value factor i = 10%		1.0	0.092296					9.077043)	0.837774)	
Present value		25839L	2384.8L	28223.8L						
Capital recovery factor		← 0.100859175) →								
Annuitized cost				2846.6L			646.0L			0.4809LX$_1$H$_r$

Cost	Unit	Fixed	Variable
Capital investment	฿	2846.6L	
O&M	฿	646.0L	
Fuel	฿		0.4809LX$_1$H$_r$
Total	฿	3492.6L	0.4809LX$_1$H$_r$

	Unit	Cost	
KW-benefit	฿/KW	4535.8	3492.6L/0.77L
KWH-benefit	฿/KW	0.5171	0.4809LX$_1$H$_r$/0.93LX$_1$H$_r$

Total annuitized fixed & variable cost in ฿/KW: Annual cost ..... $Y_1 = 4535.8 + 0.5171 \times 8760Y_1 = 4535.8 + 4529.8X_1$

Daily cost ..... $Y_1 = 4535.8/365 + 0.5171 \times 24X_1 = 12.4268 + 12.4104X_1$

Table 9–7 Additional Study, Variations of Fuel Cost, Capacity Factors and Economic Life Lengths of Alternative Thermals

Daily plant factor of hydro power plant at max. demand day = 0.15, discount rate = 10%

Additional study

	Unit	Case 0 Base Case	Case 1	Case 2	Case 3
[1] Alternative thermal plants					
a) Unit fuel cost					
Gas turbine (natural gas)	฿/KWH	0.9705 1)	1.0560	1.1415	1.2270
Gas turbine (diesel oil)	฿/KWH	1.4128 1)	1.6638	1.9149	2.1659
Gas turbine (natural gas - diesel oil)	฿/KWH	1.0092			
Thermal (natural gas)	฿/KWH	0.6740 1)	0.6974	0.7208	0.7442
Thermal (imported coal)	฿/KWH	0.6117 1)	0.6254	0.6392	0.6529
Thermal (natural gas - imported coal)	฿/KWH	0.6687			
Lignite(lignite)	฿/KWH	0.4809 1)	0.4843	0.4877	0.4912
b) Estimated ranges of capacity factors					
Gas turbine, X_g	%	0 - 37.5			
Thermal, X_t	%	37.5 - 83.3			
Lignite, X_l	%	83.3 - 100			
c) Standard ranges of capacity factors					
Gas turbine, X_{go}	%	$X_{go} \leq 5$ 2)			
Thermal, X_{to}	%	$40 \leq X_{to} \leq 85$ 2)			
Lignite, X_{lo}	%				
d) Estimated economic life length					
Gas turbine	year	10	12	14	16
Thermal (natural gas)	year	20	21	22	23
Thermal (imported coal,lignite)	year	25	25	25	25

1) Given by EGAT on July 3, 1986.

2) Given by EGAT on Oct. 7, 1985.

Table 9–11

3rd Stage Study, Incremental Benefit of Lower Yuam due to Effect of Nam Mae Ngao Development (Lower Nam Yuam: Dam is fixed at F/S, installed capacity is optimized)

3rd stage study

Base Case

		Individual development			Integrated development Nam Mae Ngao & Lower Yuam	Increase
		Nam Mae Ngao	Lower Yuam	Total (1) + (2)		
Simulation Case No.		3 NO2A260.25b	1 YOV170.20o		Case VI	(4) - (3)
	Unit	(1)	(2)	(3)	(4)	(5)
Installed capacity	MW	116.9	162.0	278.9	374.0	95.1
Firm capacity	MW	97.9	139.9	237.8	320.5	82.7
Annual energy product						
Firm energy	GWH	128.6	181.6	310.2	421.1	110.9
Secondary energy	GWH	116.5	357.3	473.8	383.3	-90.5
Total	GWH	245.1	538.9	784.0	804.4	20.4
Construction cost						
Generating f.	M฿	3081.3	4352	7433.3	8250.1	816.8
Transmission f.	M฿	89.5	550	639.5	660.0	20.5
Total	M฿	3170.8	4902	8072.8	8910.1	837.3
Annual cost						
for generating f.	M฿	342.0	483.1	825.1	915.8	90.7
for transmission f.	M฿	10.1	62.2	72.3	74.6	2.3
for transmission loss	M฿	0.7	8.3	9.0	21.7	12.7
Total	M฿	352.8	553.6	906.4	1012.1	105.7
Annual benefit						
for firm capacity	M฿	177.2	253.2	430.4	580.1	149.7
for firm energy	M฿	132.3	186.8	319.1	433.2	114.1
for secondary energy	M฿	119.8	334.0	453.8	353.7	-100.1
Total	M฿	429.3	774.0	1203.3	1367.0	163.7
B - C	M฿	76.5	220.4	296.9	354.9	58.0
B/C		1.22	1.40	-	1.35	-
Energy cost	฿/KWH	1.439	1.027			
Incremental benefit	M฿					58.0
EDR	%	10.64			11.68	

Table 9–12 Cost and Benefit Stream of Nam Mae Ngao Individual Development

Equalizing discount rate 10.64(%)
(without shadow price factor)

Case: 0
unit: Mill Bahts

Serial Number	Number After Completion	Costs				Benefits				
		Investment Cost	O & M Cost	Total	Discounted Cost Flow	Investment Cost	O & M Cost	Fuel Cost	Total	Discounted Benefit Flow
1		0.00		0.00	0.00				0.00	0.00
2		329.70		329.70	269.33				0.00	0.00
3		704.30		704.30	520.02				0.00	0.00
4		903.70		903.70	603.08	362.50			362.50	241.91
5		986.70		986.70	595.14	453.20			453.20	273.35
6		246.40		246.40	134.32	90.60			90.60	49.39
7	1		31.70	31.70	15.61		27.20	240.20	267.40	131.73
8	2		31.70	31.70	14.11		27.20	240.20	267.40	119.08
9	3		31.70	31.70	12.75		27.20	240.20	267.40	107.63
10	4		31.70	31.70	11.53		27.20	240.20	267.40	97.28
11	5		31.70	31.70	10.42		27.20	240.20	267.40	87.92
12	6		31.70	31.70	9.42		27.20	240.20	267.40	79.47
13	7		31.70	31.70	8.51		27.20	240.20	267.40	71.82
14	8		31.70	31.70	7.69	362.50	27.20	240.20	629.90	152.93
15	9		31.70	31.70	6.95	453.20	27.20	240.20	720.60	158.12
16	10		31.70	31.70	6.28	90.60	27.20	240.20	358.00	71.00
17	11		31.70	31.70	5.68		27.20	240.20	267.40	47.93
18	12		31.70	31.70	5.13		27.20	240.20	267.40	43.32
19	13		31.70	31.70	4.64		27.20	240.20	267.40	39.15
20	14		31.70	31.70	4.19		27.20	240.20	267.40	35.39
21	15		31.70	31.70	3.79		27.20	240.20	267.40	31.98
22	16		31.70	31.70	3.42		27.20	240.20	267.40	28.91
23	17		31.70	31.70	3.09		27.20	240.20	267.40	26.13
24	18		31.70	31.70	2.80	362.50	27.20	240.20	629.90	55.63
25	19		31.70	31.70	2.53	453.20	27.20	240.20	720.60	57.52
26	20		31.70	31.70	2.28	90.60	27.20	240.20	358.00	25.83
27	21		31.70	31.70	2.06		27.20	240.20	267.40	17.43
28	22		31.70	31.70	1.86		27.20	240.20	267.40	15.76
29	23		31.70	31.70	1.68		27.20	240.20	267.40	14.24
30	24		31.70	31.70	1.52		27.20	240.20	267.40	12.87
31	25		31.70	31.70	1.37		27.20	240.20	267.40	11.63
32	26		31.70	31.70	1.24		27.20	349.70	376.90	14.82
33	27		31.70	31.70	1.12		27.20	349.70	376.90	13.40
34	28		31.70	31.70	1.01	362.50	27.20	349.70	739.40	23.76
35	29		31.70	31.70	0.92	453.20	27.20	349.70	830.10	24.11
36	30		31.70	31.70	0.83	90.60	27.20	349.70	467.50	12.27
37	31		31.70	31.70	0.75		27.20	349.70	376.90	8.94
38	32		31.70	31.70	0.67		27.20	349.70	376.90	8.08
39	33		31.70	31.70	0.61		27.20	349.70	376.90	7.30
40	34		31.70	31.70	0.55		27.20	349.70	376.90	6.60
41	35		31.70	31.70	0.50		27.20	349.70	376.90	5.96
42	36		31.70	31.70	0.45		27.20	349.70	376.90	5.39
43	37		31.70	31.70	0.41		27.20	349.70	376.90	4.87
44	38		31.70	31.70	0.37	362.50	27.20	349.70	739.40	8.54
45	39		31.70	31.70	0.33	453.20	27.20	349.70	830.10	8.77
46	40	22.40	31.70	54.10	0.51	90.60	27.20	349.70	467.50	4.46
47	41		31.70	31.70	0.27		27.20	349.70	376.90	3.25
48	42		31.70	31.70	0.24		27.20	349.70	376.90	2.94
49	43		31.70	31.70	0.22		27.20	349.70	376.90	2.65
50	44		31.70	31.70	0.20		27.20	349.70	376.90	2.40
51	45		31.70	31.70	0.18		27.20	349.70	376.90	2.17
52	46		31.70	31.70	0.16		27.20	349.70	376.90	1.96
53	47		31.70	31.70	0.14		27.20	349.70	376.90	1.77
54	48		31.70	31.70	0.13		27.20	349.70	376.90	1.60
55	49		31.70	31.70	0.12		27.20	349.70	376.90	1.44
56	50		31.70	31.70	0.11		27.20	349.70	376.90	1.30
		3193.20	1585.00	4778.20	2283.51	4531.50	1360.00	14747.50	20639.00	2284.47

Table 9–13 Cost and Benefit Stream of Nam Mae Ngao + Lower Yuam

Integrated Development

Equalizing discount rate 11.68(%)
(without shadow price factor)

Case: 0
unit: Mill Bahts

Serial Number	Number After Completion	Costs				Benefits				
		Investment Cost	O & M Cost	Total	Discounted Cost Flow	Investment Cost	O & M Cost	Fuel Cost	Total	Discounted Benefit Flow
1		610.60		610.60	546.74				0.00	0.00
2		826.80		826.80	662.90				0.00	0.00
3		1743.60		1743.60	1251.75				0.00	0.00
4		2874.10		2874.10	1847.56	1156.40			1156.40	743.37
5		2363.90		2363.90	1360.66	1445.40			1445.40	831.97
6		491.10		491.10	253.11	289.10			289.10	149.00
7	1		89.10	89.10	41.11		86.70	749.50	836.20	385.90
8	2		89.10	89.10	36.81		86.70	749.50	836.20	345.54
9	3		89.10	89.10	32.96		86.70	749.50	836.20	309.40
10	4		89.10	89.10	29.52		86.70	749.50	836.20	277.04
11	5		89.10	89.10	26.43		86.70	749.50	836.20	248.07
12	6		89.10	89.10	23.66		86.70	749.50	836.20	222.12
13	7		89.10	89.10	21.19		86.70	749.50	836.20	198.89
14	8		89.10	89.10	18.97	1156.40	86.70	749.50	1992.60	424.38
15	9		89.10	89.10	16.99	1445.40	86.70	749.50	2281.60	435.11
16	10		89.10	89.10	15.21	289.10	86.70	749.50	1125.30	192.15
17	11		89.10	89.10	13.62		86.70	749.50	836.20	127.85
18	12		89.10	89.10	12.19		86.70	749.50	836.20	114.48
19	13		89.10	89.10	10.92		86.70	749.50	836.20	102.51
20	14		89.10	89.10	9.78		86.70	749.50	836.20	91.79
21	15		89.10	89.10	8.75		86.70	749.50	836.20	82.19
22	16		89.10	89.10	7.84		86.70	749.50	836.20	73.59
23	17		89.10	89.10	7.02		86.70	749.50	836.20	65.89
24	18		89.10	89.10	6.28	1156.40	86.70	749.50	1992.60	140.60
25	19		89.10	89.10	5.62	1445.40	86.70	749.50	2281.60	144.16
26	20		89.10	89.10	5.04	289.10	86.70	749.50	1125.30	63.66
27	21		89.10	89.10	4.51		86.70	749.50	836.20	42.36
28	22		89.10	89.10	4.04		86.70	749.50	836.20	37.93
29	23		89.10	89.10	3.61		86.70	749.50	836.20	33.96
30	24		89.10	89.10	3.24		86.70	749.50	836.20	30.41
31	25		89.10	89.10	2.90		86.70	749.50	836.20	27.23
32	26		89.10	89.10	2.59		86.70	1039.90	1126.60	32.85
33	27		89.10	89.10	2.32		86.70	1039.90	1126.60	29.41
34	28		89.10	89.10	2.08	1156.40	86.70	1039.90	2283.00	53.37
35	29		89.10	89.10	1.86	1445.40	86.70	1039.90	2572.00	53.84
36	30		89.10	89.10	1.67	289.10	86.70	1039.90	1415.70	26.53
37	31		89.10	89.10	1.49		86.70	1039.90	1126.60	18.90
38	32		89.10	89.10	1.33		86.70	1039.90	1126.60	16.93
39	33		89.10	89.10	1.19		86.70	1039.90	1126.60	15.16
40	34		89.10	89.10	1.07		86.70	1039.90	1126.60	13.51
41	35		89.10	89.10	0.96		86.70	1039.90	1126.60	12.15
42	36		89.10	89.10	0.86		86.70	1039.90	1126.60	10.88
43	37		89.10	89.10	0.77		86.70	1039.90	1126.60	9.74
44	38		89.10	89.10	0.69	1156.40	86.70	1039.90	2283.00	17.68
45	39		89.10	89.10	0.61	1445.40	86.70	1039.90	2572.00	17.85
46	40	165.00	89.10	254.10	1.57	289.10	86.70	1039.90	1415.70	8.79
47	41		89.10	89.10	0.49		86.70	1039.90	1126.60	6.26
48	42		89.10	89.10	0.44		86.70	1039.90	1126.60	5.60
49	43		89.10	89.10	0.39		86.70	1039.90	1126.60	5.02
50	44		89.10	89.10	0.35		86.70	1039.90	1126.60	4.49
51	45		89.10	89.10	0.31		86.70	1039.90	1126.60	4.02
52	46		89.10	89.10	0.28		86.70	1039.90	1126.60	3.60
53	47		89.10	89.10	0.25		86.70	1039.90	1126.60	3.22
54	48		89.10	89.10	0.22		86.70	1039.90	1126.60	2.89
55	49		89.10	89.10	0.20		86.70	1039.90	1126.60	2.58
56	50		89.10	89.10	0.18		86.70	1039.90	1126.60	2.31
		9075.10	4455.00	13530.10	6315.37	14454.50	4335.00	44735.00	63524.50	6319.46

Table 9–14 Additional Study, Economic Criteria and Basic Costs of Thermal Power Plants Case 0 (Base Case)

Additional study

		Unit	Hydro power plant	Gas turbine		Thermal		Lignite (50 years)	
				Natural gas (1st 25 years)	Diesel Oil (2nd 25 years)	Natural gas (1st 25 years)	Imported coal (2nd 25 years)		
	Installed capacity	MW	H	G	G	T	T	L	
a	Standard unit capacity	MW		25	25	600	600	600	EGAT data given on Oct.7,1985
b	Standard capacity factor	%		$Xg \leqq 5$	$Xg \leqq 5$	$40 \leqq X_t \leqq 85$	$40 \leqq X_t \leqq 85$	$40 \leqq X_t \leqq 85$	- ditto -
c	Economic life length adopted	years	50	10	10	20	25	25	
d	Station service rate	%	1	2	2	7	7	7	
e	Scheduled outage rate	%		2	2	13	13	13	
f	Forced outage rate	%		4	4	4	4	4	
g	Anual fixed O&M rate	%	1	3	3	2.5	2.5	2.5	
h	Unit construction cost w/o IDC	$/KW		320	320	580	957	957	
	ditto	฿/KW		8640	8640	15660	25839	25839	1 US$ = 27 ฿
	(Fuel)								
i	Fuel calorific value			Natural gas 1000Btu/cu.ft	Diesel oil 8959.6Kcal/Lit = 35558Btu/Lit	Natural gas 1000Btu/Cu.ft	Imported coal 5796Kcal/kg	Lignite 2648.8Kcal/kg	EGAT data given on July 3,1986
j									
k	Thermal efficiency	%		25	25	36	36	36	
l	Energy equivalence	Kcal/KWH		3440Kcal/KWH	3440Kcal/KWH		2388.9Kcal/KWH	2388.9Kcal/KWH	- ditto -
m	= Plant heat value	Btu/KWH		13650.8Btu/KWH		9479.7Btu/KWH			
n	Fuel consumption			13.6508cu.ft/KWH	0.3839Lit/KWH	9.4797cu.ft/KWH	0.4122kg/KWH	0.9019kg/KWH	- ditto -
o	Unit fuel price			71.0947฿/MBtu	3.68฿/Lit	71.0947฿/MBtu	1.484฿/kg	0.5332฿/kg	- ditto -
p	Unit fuel cost	฿/KWH		0.9705	1.4128	0.6740	0.6117	0.4809	- ditto - (Base case)
q	Effective capacity	MW		0.94G	0.94G	0.83T	0.83T	0.83L	(1-(e+f)/100fxInstalled capa.
r	Send-out capacity	MW	0.99H	0.92G	0.92G	0.77T	0.77T	0.77L	q x (1-a/100)
s	Energy production	MWH		$GXgH_r$	$GXgH_r$	TX_tH_r	TX_tH_r	LX_LH_r	
t	Send-out energy	MWH		$0.98GXgH_r$	$0.98GXgH_r$	$0.93TX_tH_r$	$0.93TX_tH_r$	$0.93LX_LH_r$	
u	Capital investment cost	฿		8640G	8640G	15660T	25839T	25839L	h x installed capacity
v	Annual O&M cost	฿		259.2G	259.2G	391.5T	646.0T	646.0L	u x g
w	Daily O&M cost	฿		0.7101G	0.7101G	1.0726T	1.7698T	2.1238L	v/365
x	Fuel cost	฿		$0.9705GXgH_r$	$1.4128GXgH_r$	$0.6740TX_tH_r$	$0.6117TX_tH_r$	$0.4809LX_LH_r$	s x p

Table 9–15 Additional Study, Sensitivity Analysis for Discount Rate = 12%
Cost Stream of Alternative Gas Turbine (Natural Gas - Diesel Oil)

Case 0 (Base Case)

Additional study

Year	Single payment worth factor 1)	Capital investment cost						O&M	Fuel Cost		
		Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Total		for the 1st 25 years	for the 2nd 25 years	Total
n	i = 12%										
0	1,000	8640G									
1								259.2G	$0.9705GXgH_r$		
10	0.321973		8640G								
20	0.103667			8640G							
25										$1.4128GXgH_r$	
30	0.033378				8640G						
40	0.010747					8640G					
50	0.003460										
Present value factor		1.000	0.321973	0.103667	0.033378	0.010747			7.843139 3)	0.461359 4)	
Present value		8640G	2781.8G	895.7G	288.4G	92.9G	12698.8G		$7.6117664GXgH_r$	$0.651808GXgH_r$	$8.263574GXgH_r$
Capital recovery factor		0.1204167									
Annuitized cost							1529.1G	259.2G			$0.9951GXgH_r$

Cost	Unit	Fixed	Variable
Capital investment	฿	1529.1G	
O&M	฿	259.2G	
Fuel	฿		$0.9951GXgH_r$
Total	฿	1788.3G	$0.9951GXgH_r$

	Unit	Cost	
KW-benefit	฿/KW	1943.8	1788.3G/0.92G
KWH-benefit	฿/KW	1.0154	$0.9951GXgH_r/0.98GXgH_r$

Total annuitized fixed & variable cost in ฿/KW: Annual cost ..... $Yg = 1943.8 + 1.0154 \times 8760\ Xg$

Daily cost ..... $Yg = 1943.8/365 + 1.0154 \times 24\ Xg$
$= 5.3255 + 24.3696Xg$

1) Present worth factor $1/(1+i)^n$

3) Annuity cost factor $= \frac{(1+i)^n-1}{i(1+i)^n}$

$i = 0.12 \quad n = 25 \quad 7.843139$

4) $\frac{(1+i)^{50}-1}{i(1+i)^{50}} - \frac{(1+i)^{25}-1}{i(1+i)^{25}}$

$= 8.304498 - 7.843139 = 0.461359$

5) Annuity factor $\frac{i(1+i)^n}{(1+i)^n-1}$

Table 9–16 Additional Study, Sensitivity Analysis for Discount Rate = 12%
Cost Stream of Alternative Steam Thermal (Natural Gas - Imported Coal)

Case 0 (Base Case)

Additional study

Year	Single payment worth factor [1]	Capital investment cost				O&M cost			Fuel cost		
		Plant 1 Natural gas	Plant 2 Natural gas	Plant 3 Imported coal	Total	Plant 1 & Plant 2	Plant 3	Total	for the 1st 25 years	for the 2nd 25 years	Total
n	i = 12%	T MW	T MW	T MW							
0	1.000	15660T									
1						391.5T			$0.674TX^{c}H^{c}$		
20	0.103667		15660T								
25	0.058823		$-\frac{15}{20}$ 15660T	25839T							
							646.0T			$0.6117TX_{t}H_{r}$	
50	0.003460										
Present value factor i = 12%		1.000	0.103667 0.058823	0.058823		7.843139[3]	0.4613594[4]		7.843139[3]	0.4613594[4]	
Present value		15660T	1623.4T	1519.9T		3070.6T	298.0T		$5.286TX_{t}H_{r}$	$0.282TX_{t}H_{r}$	
			-690.9T		18112.4T			3368.6T			$5.568TX_{t}H_{r}$
Capital recovery factor		0.12041675[5]									
Annuitized cost					2181.0T			405.6T			$0.6705TX_{t}H_{r}$

Cost	Unit	Fixed	Variable
Capital investment	¥	2181.0T	
O&M	¥	405.6T	
Fuel	¥		$0.6705TX_{t}H_{r}$
Total	¥	2586.6T	$0.6705TX_{t}H_{r}$

	Unit	Cost	
KW-benefic	¥/KW	3359.2	2586.6T/0.77T
KWH-benefic	¥/KW	0.7210	$0.6705TX_{t}H_{r}/0.93TX_{t}H_{r}$

Total annuitized fixed & variable cost in ¥/KW: Annual cost ..... $Y_{t} = 3359.2 + 0.7210 \times 8760X_{t} = 3359.2 + 6316.0X_{t}$

Daily cost ..... $Y_{t} = 3359.2/365 + 0.7210 \times 24X_{t} = 9.203 + 17.304X_{t}$

Table 9–17 Additional Study, Sensitivity Analysis for Discount Rate = 12%
Cost Stream of Alternative Steam Thermal (Lignite)

Case 0 (Base Case)

Additional study

Year	Single payment worth factor [1]	Capital investment cost			O&M cost			Fuel cost		
		Plant 1	Plant 2	Total	Plant 1	Plant 2	Total	for the 1st 25 years	for the 2nd 25 years	Total
n	i = 12%	L MW	L MW					Lignite	Lignite	
0	1.0	25839L								
1					646.0L		646.0L	$0.4809LX_1H_r$		$0.4809LX_1H_r$
25	0.058823		25839L			646.0L			$0.4809LX_1H_r$	
50	0.003460									
Present value factor i = 12%		1.0	0.058823					7.8431393 [3]	0.4613594 [4]	
Present value		25839L	1519.9L	27358.9L						
Capital recovery factor		0.1204167 [5]								
Annuitized cost				3294.5L			646.0L			$0.4809LX_1H_r$

Cost	Unit	Fixed	Variable
Capital investment	฿	3294.5L	
O&M	฿	646.0L	
Fuel	฿		$0.4809LX_1H_r$
Total	฿	3940.5L	$0.4809LX_1H_r$

	Unit	Cost	
KW-benefit	฿/KW	5117.5	3940.5L/0.77L
KWH-benefit	฿/KWH	0.5171	$0.4809LX_1H_r/0.93LX_1H_r$

Total annuitized fixed & variable cost in ฿/KW: Annual cost ..... $Y_1 = 5117.5 + 0.5171 \times 8760Y_1$

Daily cost ..... $Y_1 = 5117.5/365 + 0.5171 \times 24X_1 = 14.0205 + 12.4104X_1$

Table 9–18 Sensitivity Test for Discount Rate
Nam Mae Ngao Individual Development

Nam Mae Ngao individual development

	Unit	Case B1 Discount rate = 12%	
Simulation Case No.		N02A260.25b	
a) Project features			
Catchment area	km^2	835	
Annual flow	MCM	1272	
HWL	m	260	
NIWL	m	248.4	
LWL	m	235	
TWL	m	163	
Effective head	m	82.5	
Daily plant factor at max. demand day	%	15	
Capacity factor	%	23.9	
Firm discharge (95% probability)	cms	24.9	
Max. turbine discharge	cms	166.2	
Installed capacity	MW	116.9	
Firm capacity	MW	97.9	
Annual energy production	GWH	245.2	
Annual firm energy	GWH	128.6	
Annual secondary energy (97%)	GWH	116.5	
b) Project economy			
Construction cost			
for generating facilities	M฿	3081.3	
for transmission facilities	M฿	89.5	
Annual cost			
for generating facilities	M฿	401.8	0.1304
for transmission facilities	M฿	11.8	0.1313
for transmission loss	M฿	0.8	
Total annual cost, C	M฿	414.4	
Annual benefit			
for firm capacity	M฿	@1943.8 190.3	
for firm energy	M฿	@1.0154 130.6	
for secondary energy	M฿	@1.0154 118.3	
Total annual benefit, B	M฿	439.2	
c) B - C	M฿	24.8	
B/C		1.06	
Annual energy cost	฿/KWH	1.690	

Table 9–19 Sensitivity Test for Discount Rate
Transmission Loss for Nam Mae Ngao Individual Development

Transmission loss for Nam Mae Ngao individual development

		Unit	Case B1 Discount rate = 12%
Capacity loss	(A)	MW	0.311
Average capacity cost	(B)	฿/KW	1943.8
(A) x (B)		M฿	0.605
Annual energy loss	(C)	MWH	165.6
Average energy cost	(D)	฿/KWH	1.0154
(C) x (D)		M฿	0.168
Total transmission loss		M฿	0.773 ≒ 0.8

Table 9–20 Sensitivity Test for Discount Rate
Lower Yuam Individual Development

Lower Nam Yuam individual development

	Unit	Case B2 Discount rate = 12%	
Simulation Case No.		YOV170.20o	
a) Project features			
Catchment area	km^2	5920	
Annual flow	MCM	2818	
HWL	m	170	
NIWL	m	161.7	
LWL	m	150	
TWL	m	73.2	
Effective head	m	85.6	
Daily plant factor at max. demand day	%	14.8	
Capacity factor	%	38.0	
Firm discharge (95% probability)	cms	32.5	
Max. turbine discharge	cms	219.5	
Installed capacity	MW	162.0	
Firm capacity	MW	139.9	
Annual energy production	GWH	538.9	
Annual firm energy	GWH	181.6	
Annual secondary energy (97%)	GWH	357.3	
b) Project economy			
Construction cost			
for generating facilities	M฿	4352	
for transmission facilities	M฿	550	
Annual cost			
for generating facilities	M฿	567.5	0.1304
for transmission facilities	M฿	72.2	0.1313
for transmission loss	M฿	8.8	
Total annual cost, C	M฿	648.5	
Annual benefit			
for firm capacity	M฿	@1943.8 271.9	
for firm energy	M฿	@1.0154 184.4	
for secondary energy	M฿	@0.9666 345.3	
Total annual benefit, B	M฿	801.6	
c) B – C	M฿	153.1	
B/C		1.24	
Annual energy cost	฿/KWH	1.203	

Table 9–21 Sensitivity Test for Discount Rate
Transmission Loss for Lower Yuam Individual Development

Transmission loss for Lower Nam Yuam Individual development

		Unit	Case B2 Discount rate = 12%
Capacity loss	(A)	MW	3.55
Average capacity cost	(B)	฿/KW	1943.8
(A) x (B)		M฿	6.900
Annual energy loss	(C)	MWH	1888
Average energy cost	(D)	฿/KWH	0.9829
(C) x (D)		M฿	1.856
Total transmission loss		M฿	8.756 ≒ 8.8

Table 9–22 Sensitivity Test for Discount Rate
Nam Mae Ngao + Lower Yuam Integrated Development

Nam Mae Ngao + Lower Nam Yuam integrated development

	Unit	Case B3 Discount rate = 12%	
Simulation Case No.		NO2A260.25b+YOA170.20C	
a) Project features			
Catchment area	km^2	5920	
Annual flow	MCM	2825	
HWL	m	260 & 170	
NIWL	m	248.4 & 161.4	
LWL	m	235 & 150	
TWL	m	163 & 73.2	
Effective head	m	82.5 & 85.3	
Daily plant factor at max. demand day	%	15	
Capacity factor	%	23.9 & 24.8	
Firm discharge (95% probability)	cms	24.9 & 52.4	
Max. turbine discharge	cms	166.2 & 349.3	
Installed capacity	MW	116.9+257.1 = 374.0	
Firm capacity	MW	97.9+222.6 = 320.5	
Annual energy production	GWH	245.1+559.3 = 804.4	
Annual firm energy	GWH	128.6+292.5 = 421.1	
Annual secondary energy (97%)	GWH	116.5+266.8 = 383.3	
b) Project economy			
Construction cost			
for generating facilities	M฿	8250.1	
for transmission facilities	M฿	660	
Annual cost			
for generating facilities	M฿	1075.8	0.1304
for transmission facilities	M฿	86.7	0.1313
for transmission loss	M฿	23.0	
Total annual cost, C	M฿	1185.5	
Annual benefit			
for firm capacity	M฿	@1943.8 623.0	
for firm energy	M฿	@1.0154 427.7	
for secondary energy	M฿	@0.9712 372.2	
Total annual benefit, B	M฿	1422.9	
c) B – C	M฿	237.4	
B/C		1.20	
Annual energy cost	฿/KWH	1.474	

Table 9–23 Sensitivity Test for Discount Rate
Transmission Loss for Nam Mae Ngao + Lower Yuam Integrated Development

Transmission loss for Nam Mae Ngao + Lower Nam Yuam integrated development

		Unit	Case B3 Discount rate = 12%
Capacity loss	(A)	MW	9.3
Average capacity cost	(B)	฿/KW	1943.8
(A) x (B)		M฿	18.077
Annual energy loss	(C)	MWH	4924
Average energy cost	(D)	฿/KWH	0.9944
(C) x (D)		M฿	4.896
Total transmission loss		M฿	22.973 ≒ 23.0

Table 9–24 Sensitivity Test for Discount Rate (= 12%) Incremental Benefit of Lower Yuam

fuel price: base case

		Individual development			Integrated development Nam Mae Ngao & Lower Yuam	Increase
		Nam Mae Ngao	Lower Yuam	Total (1) + (2)		
Simulation Case No.		3 NO2A260.25b	1 YOV170.20o		Case VI	(4) - (3)
	Unit	(1)	(2)	(3)	(4)	(5)
Installed capacity	MW	116.9	162.0	278.9	374.0	95.1
Firm capacity	MW	97.9	139.9	237.8	320.5	82.7
Annual energy product						
Firm energy	GWH	128.6	181.6	310.2	421.1	110.9
Secondary energy	GWH	116.5	357.3	473.8	383.3	-90.5
Total	GWH	245.1	538.9	784.0	804.4	20.4
Construction cost						
Generating f.	MB	3081.3	4352	7433.3	8250.1	816.8
Transmission f.	MB	89.5	550	639.5	660.0	20.5
Total	MB	3170.8	4902	8072.8	8910.1	837.3
Annual cost						
for generating f.	MB	401.8	567.5	969.3	1075.8	106.5
for transmission f.	MB	11.8	72.2	84.0	86.7	2.7
for transmission loss	MB	0.8	8.8	9.6	23.0	13.4
Total	MB	414.4	648.5	1062.9	1185.5	122.6
Annual benefit						
for firm capacity	MB	190.3	271.9	462.2	623.0	160.8
for firm energy	MB	130.6	184.4	315.0	427.7	112.7
for secondary energy	MB	118.3	345.3	463.6	372.2	-91.4
Total	MB	439.2	801.6	1240.8	1422.9	182.1
B - C	MB	24.8	153.1	177.9	237.4	59.5
B/C		1.06	1.24	-	1.20	-
Energy cost	B/KWH	1.690	1.203		1.474	
Incremental benefit	MB					59.5

Table 9–26–1 Economic Evaluation of Nam Mae Ngao Individual Development for Various Cases of Fuel Costs Sensitivity Test
(Transmission Line from Nam Mae Ngao to Lamphun 2 included)

Discount rate = 10%

	Unit	Case 0	Case 1	Case 2	Case 3
Simulation Case No.		NO2A260.25b			
a) Project features					
Catchment area	km^2	835			
Annual flow	MCM	1272			
HWL	m	260			
NIWL	m	248.4			
LWL	m	235			
TWL	m	163			
Effective head	m	82.5			
Daily plant factor at max. demand day	%	15			
Capacity factor	%	23.9			
Firm discharge (95% probability)	cms	24.9			
Max. turbine discharge	cms	166.2			
Installed capacity	MW	116.9			
Firm capacity	MW	97.9			
Annual energy production	GWH	245.2			
Annual firm energy	GWH	128.6			
Annual secondary energy (97%)	GWH	116.5			
b) Project economy					
Construction Cost					
for generating facilities	M฿	3081.3	3081.3	3081.3	3081.3
for transmission facilities	M฿	476.0	476.0	476.0	476.0
Annual cost					
for generating facilities, n=50, O&M 1%	M฿	342.0	342.0	342.0	342.0
for transmission facilities, n=40,O&M1%	M฿	53.3	53.3	53.3	53.3
for transmission loss, see next page	M฿	3.4	3.3	3.2	3.2
Total annual cost, C	M฿	398.7	398.6	398.5	398.5
Annual benefit					
for firm capacity	M฿	@1810.1 177.2	@1660.7 162.6	@1557.9 152.5	@1482.6 145.1
for firm energy	M฿	@1.0285 132.3	@1.1300 145.4	@1.2315 158.4	@1.333 171.5
for secondary energy	M฿	@1.0285 119.8	@1.1300 131.6	@1.2315 143.5	@1.331 155.0
Total annual benefit, B	M฿	429.3	439.6	454.4	471.6
c) B-C	M฿	30.6	41.0	55.9	73.1
B/C		1.08	1.10	1.14	1.18
Annual energy cost	฿/KWH	1.626	1.626	1.625	1.625

Table 9–26–2 Transmission Loss for Nam Mae Ngao Individual Development (116.9 MW) Sensitivity Test (Transmission Line from Nam Mae Ngao to Lamphun 2 included)

		Unit	Case 0	Case 1	Case 2	Case 3
Capacity loss	(A)	MW	1.45	1.45	1.45	1.45
Average capacity cost	(B)	฿/KW	1810.1	1660.7	1557.9	1482.2
(A) x (B)		M฿	2.62	2.41	2.26	2.15
Annual energy loss	(C)	MWH	772	772	772	772
Average energy cost	(D)	฿/KWH	1.0285	1.1300	1.2315	1.332
(C) x (D)		M฿	0.79	0.87	0.95	1.03
Total transmission loss		M฿	3.41 ≒ 3.4	3.28 ≒ 3.3	3.21 ≒ 3.2	3.18 ≒ 3.2

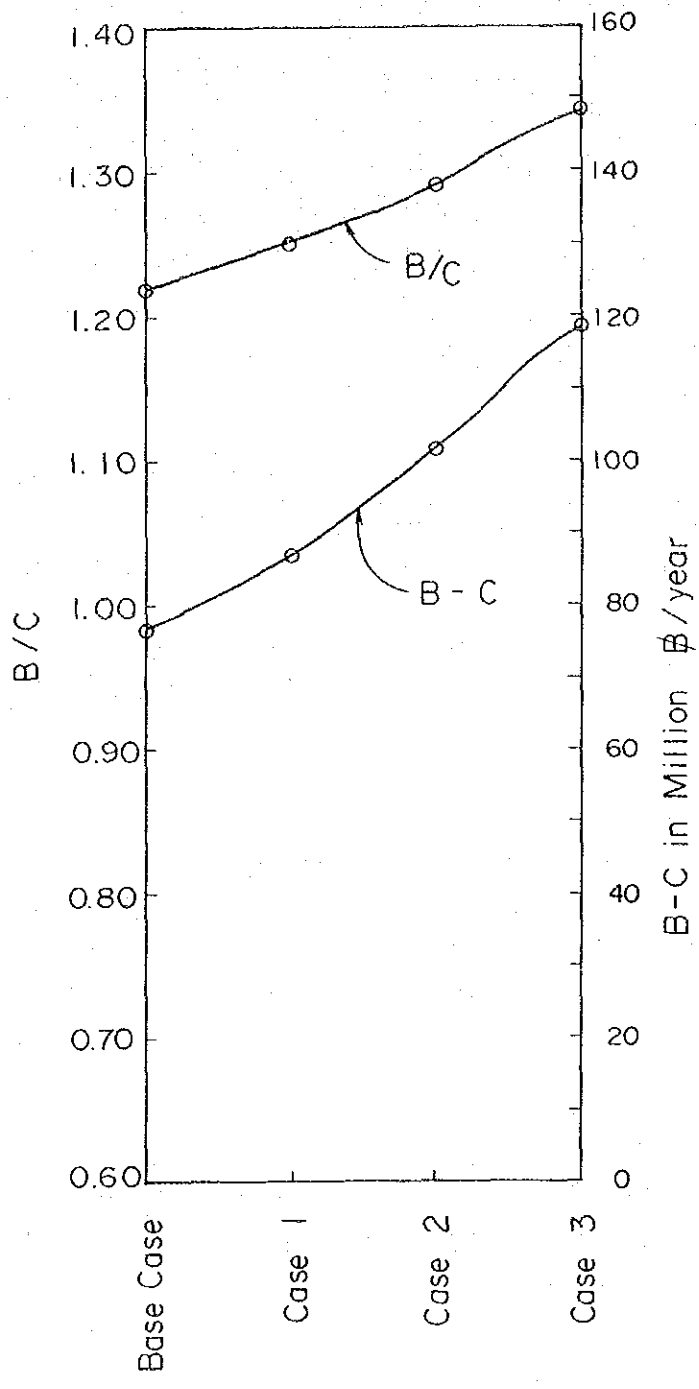


Fig. 9–8 Variation of B - C & B/C for
Nam Mae Ngao Individual Development

10. IMPACT ON IRRIGATION PROJECTS

10.1 Purpose of Field Investigation

Upper Mae Yuam 1 Project is located in the upstream reach of the Yuam river basin and the project site is situated in the upstream of Lower Yuam Project, the feasibility study of which was completed in March 1984 by JICA. There are several irrigation projects using the water resource of the main and tributaries of the Yuam river in the investigation area extending between No.1 dam site of the Upper Mae Yuam Hydro Power Project and the upstream end of Lower Yuam reservoir.

It will be necessary for Upper Mae Yuam Project to study its power scheme by taking into consideration the impact on the existing and future irrigation projects in the said investigation area.

The purpose of field investigation is to examine the impact on the downstream irrigation projects which will be caused by Upper Mae Yuam Project. Major study items of the field investigation are summarized below.

(1) Existing condition and operation works of the irrigation projects which have been constructed by Royal Irrigation Department (referred to as RID) and Rural Acceleration Development by the Ministry of Interior (referred to as RAD).

(2) Possibility of future irrigation projects in the Mae Sariang Plain.

(3) Various agriculture information on cropping schedule, yield and price etc. in the existing RID Irrigation Project in the Mae Sariang Plain.

10.2 Result of Field Investigation

JICA-Team collected the data and/or information of agriculture and irrigation by means of interview to villagers, RID office and Agriculture office etc., as well as observation of topographic feature and agricultural condition in the investigation area. The results of investigation are summarized as follows.

(1) The right bank area of the Yuam river in the Mae Sariang plain (Approximately 12,500 rai) has been brought into irrigation by Large-medium Scale Irrigation Project of RID and used the river water of the Yuam river through the year.

(2) There is little possibility of land to economically develop new irrigation areas by the Yuam river because of topographical constraint within the investigation area.

(3) Irrigation requirement at the RID diversion weir is maximum 2.94 cu.m/sec for the existing RID irrigation project at present and in future.

(4) In case that the river run-off in the dry season would be improved by Upper Mae Yuam Project, cropping intensity in the dry season will increase within the existing RID Irrigation Project area. Incremental net benefit thereby is estimated to be 5.4 million Baht per year.

(5) There is no impact on the existing small irrigation projects constructed by RID and RAD after completion of Upper Mae Yuam Project to be built on the main river because those projects use the tributary water for irrigation purpose.

10.3 RID Nam Yuam Irrigation Project (existing)

Nam Yuam Irrigation Project was completed in 1976 by RID and the operation of the project has been also undertaken by RID. Irrigation water is diverted at the RID diversion weir which is located at approximately 25 km downstream of Upper Mae Yuam 1 Project.

The project description is as follows:

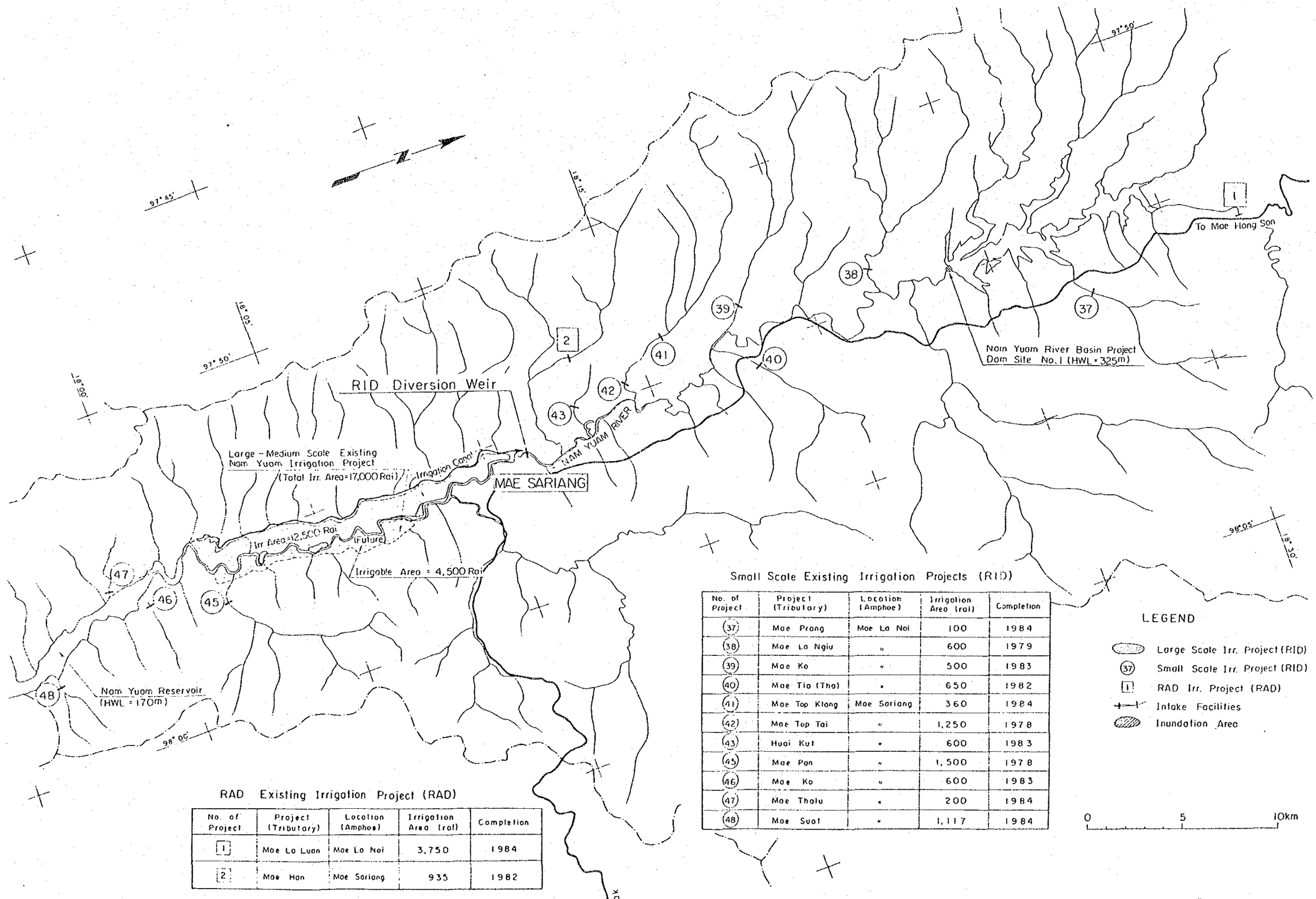
Irrigation Area	:	12,500 Rai in the right bank, 4,500 Rai in the left bank (not completed as of the end of 1985)
Water Requirement at Diversion Site	:	Maximum 2.94 cu.m/sec
Diversion Weir	:	Height 2.5 m Length 110 m in concrete 870 m in embankment
Main Canal	:	22.58 km of concrete lining canal
Household	:	Approximately 5,000
Major Crop	:	Paddy in wet season (approximately 100%) Soybean in dry season (approximately 60%)

10.4 Incremental Benefit

Impact and/or benefit can be expected to increase by intensifying the land-use in the dry season from 60% (7,500 Rai) to 100% (12,500 Rai) within the RID irrigation area. Because the minimum discharge to be released at Upper Mae Yuam 1 Project is estimated to be more than 12 cu.m/sec, which results in improvement of run-off condition of the Yuam river in the dry season.

Incremental benefit due to the said increasing cropping intensity in the dry season can be evaluated in terms of increased production of soybean which is major dry season crop and estimated to be 5.4 million Baht per annum in the value of net profit.

Yield of Soybean	:	300 kg/rai
Farm-gate Price	:	6 Baht/kg
Gross Value	:	1,800 Baht/rai
Net Profit	:	1,080 Baht/rai
Incremental Area	:	5,000 rai
Incremental Benefit	:	5.4 million Baht per annum



RAD Existing Irrigation Project (RAD)

No. of Project	Project (Tributary)	Location (Amphoe)	Irrigation Area (rai)	Completion
1	Mae Lo Luan	Mae Lo Noi	3,750	1984
2	Mae Han	Mae Sariang	935	1982

Small Scale Existing Irrigation Projects (RID)

No. of Project	Project (Tributary)	Location (Amphoe)	Irrigation Area (rai)	Completion
(37)	Mae Prang	Mae Lo Noi	100	1984
(38)	Mae Lo Ngiu	〃	600	1979
(39)	Mae Ko	〃	500	1983
(40)	Mae Tio (Tha)	〃	650	1982
(41)	Mae Top Klong	Mae Sariang	360	1984
(42)	Mae Top Tai	〃	1,250	1978
(43)	Huai Kut	〃	600	1983
(45)	Mae Pan	〃	1,500	1978
(46)	Mae Ko	〃	600	1983
(47)	Mae Thalu	〃	200	1984
(48)	Mae Suat	〃	1,117	1984

LEGEND

- Large Scale Irr. Project (RID)
- (37) Small Scale Irr. Project (RID)
- 1 RAD Irr. Project (RAD)
- Intake Facilities
- Inundation Area

0 5 10km

Fig. 10–1 Location Map of Existing Irrigation Projects

11. ENVIRONMENTAL PROBLEM

11.1 Environmental Background

11.1.1 Physical Resource

1) Meteorology

The average annual rainfall at Amphoe Mae Sariang in 30 years period is 1,245.3 mm. The average maximum monthly rainfall in August of 253.4 mm and the average minimum monthly rainfall in February of 5.1 mm were also recorded. The average annual relative humidity in 30 years period at Amphoe Mae Sariang is 74%. The record showed an annual mean temperature of 26.2°C.

2) Surface Water Hydrology

Hydrological stations in the Yuam river comprise 2 stations, Ban Tha Rua station and Sop Han station. The prediction of average annual flow at many located sub-projects are shown as follows; 2,816 MCM at lower Yuam sub-project, 395 MCM at Nam Mae Rit sub-project; 1,292 MCM at Nam Mae Ngao sub-project and 570 MCM at Upper Mae Yuam 1 sub-project.

3) Water Quality

The analytical results show that physical and chemical water quality characteristics of the Yuam, the Rit, the Ngao river are suitable for aquatic esosystem. The concentration of dissolved oxygen ranges from 5.5 to 8.8 mg/ℓ. The pH values varies from 7.0 to 7.7. The alkalinity of the water at Ban Nam Rit are considered high in value of 142 mg/ℓ, at other points have the value from 74 to 100 mg/ℓ. The vlaue of hardness of the water is in values ranging from 76 to 108 mg/ℓ, varies from 115 to 292.5 mg/ℓ.

4) Geology

The geologic structure of the Lower Yuam consists of pre-cambrian to quaternary about 600 million years to recent age.

11.1.2 Ecological Resource

1) Forestry and Wildlife

The proposed reservoir area of hydroelectric development in Nam Yuam basin project consists of 3 forest types, namely, mixed deciduous forest, tropical evergreen forest and dry dipterocarpus forest. Many wild animal species live in the project area, for examples: Common Barking Deer, Sambar deer, Common Wild Pig, Hog Deer, Elephant, etc. including many species of birds, reptiles. Presently the hunting for food is the reason of wildlife's destruction.

2) Fisheries

Generally species of fish existing in the Yuam river are striped snake-head fish (Pla Chon), climbing fish (Pla Mor), walking catfish (Pla Duk Dan), common silver barb (Pla Ta Pien).

11.1.3 Human Uses Value

1) Soil and Land Uses

The study of soil characteristic and land potential in the project area are shown that the proper area for agriculture covers a small size and is limited at the riverbank plain in Amphoe Mae Sariang and Amphoe Mae La Noi. The regions which can be used for cultivation are the area at Tambon Mae La Luang, Tambon Mae Yuam and Tambon Mae Na Tuan from the area of 70,529 rai, 32,593 rai and 25,695 rai serially.

2) Water Utilization

Water utilizations from the Yuam river in the project area are classified as follows:

a. For agriculture and irrigation
b. For water supply at Amphoe Mae Sariang and Amphoe Mae La Noi

3) Mineral Resource

In Amphoe Mae Sariang and Amphoe Mae La Noi area, there are several economic mineral occurrences. Tungsten, tin, fluorite, barite, lead zinc, iron and manganese are found in this area. The important mineral resources in Amphoe Mae Sarieng are in the south of amphoe near the domain with Amphoe Tha Song Yang and in the east of amphoe at Amphoe Mae La Noi, there are 9 mineral resources.

11.1.4 Quality of Life

1) Socio-economic

There are many differences in ethnic composition of the people in Amphoe Mae Sariang and Amphoe Mae La Noi, for examples the local northern people, Thai Yai and the hill-tribe of 65%. The average density of population from size of household of 5.5 persons per household is 16.24 persons per sq.km.

The majority of pupulation who are in Amphoe Mae Sariang and Amphoe Mae La Noi obtained education level of Prathom. Urban residents finished higher education.

Main occupation of people is agriculture, they cultivate rice, soybean, peanut, garlic and tobacco. Many of them considered wage earning as their occupation.

Land holding document occur with the few at the riverside of the Yuam river. About less than 10,000 cases have the legal document with the average plot size of 5 rai per household.

Important existing land transportation to the project area consists of Highway No.108 from Chiangmai to Mae Hong Son, highway No. 1085 from Amphoe Mae Sariang to Amphoe Mae Sod.

2) Compensation

From preliminary study, hydroelectric development in Nam Yuam basin project, resettling of 3,962 persons in 846 households will be required.

3) Public Health

For health care service in the project area, a number of health centers are enough for the demand of people. But the ratio of physician and population is not sufficient. Contagious disease in the project area are gastro-intestinal tract disease, respiratory tract disease and malaria. The disease in this area is generally, can be controlled.

4) Archaeology

From the preliminary study, the proposed reservoir area is unlikely to have any archaeological or historical significants. But there are 2 monasteries in this area. Wat Mae Su in Ban Mae Su, Amphoe Mae La Noi may be effected from Upper Mae Yuam 1 subproject and Wat Ban Maei in Ban Maie, Amphoe Mae Sariang may be effected from Lower Yuam sub-project.

5) Tourism

In general, no important tourist attractions will be lost because the implementation of hydroelectric development in the Yuam river basin project. But the important benefit of tourism development caused by the proposed reservoir will be increased.

11.2 Environmental Implication

11.2.1 Land Features and Uses

Hydropower sources in the Yuam river basin may be considered as a system or a package to develop consecutively providing maximized benefit obtained from indigenous resources. But the implementation of Lower Yuam sub-project and Upper Mae Yuam 1 sub-project may be significant caused of the effect upon the Yuam riverbank plain. This area which is rich agricultural land will be the proposed reservoir area. Land uses in the project area will change from agricultural uses for people in Amphoe Mae Sariang to the inundated area. For the effect from the Nam Mae Rit sub-project and Nam Mae Ngao sub-project will be trivial impacts because the most of the area is the mountain and the steep area.

11.2.2 Air Environment

The hydroelectric development in the Yuam river basin is the hydropower project. Air Quality of the proposed power plant and the proposed area project will not change. The total proposed project area is about 70.6 sq.km. which is considered as the small size area. So the construction and the operation of the project will effect to the meteorological characteristics insignificantly.

11.2.3 Water Environment

The construction of the Upper Mae Yuam 1 sub-project may be the cause of changing in flow of the downstream region significantly. Because the people in Amphoe Mae La Noi and Amphoe Mae Sariang use the water for irrigation, agriculture and other water supply. The water quality may be changed during the construction period.

11.2.4 Species and Ecosystem

Local forests will be disturbed by logging, cleaning and filling the reservoir. The changes to the environment caused by the project are likely to result in the reducing number of local nature flora and fauna in forest ecosystem and fresh-water ecosystem. The species diversity and the density of flora and fauna in the project area will change because of the construction.

11.2.5 Social and Economic Environment

The Lower Yuam project will have impacts upon the socio-economics of the Yuam river basin including the resettlement in the proposed reservoir area. The loss of the rich agricultural land beside the Yuam river will occur because of the reservoir of the Lower Yuam sub-project and Upper Mae Yuam 1 sub-project. Highway No. 1085 at Tambon Sop Moie and Tambon Mae Ta Cuan in Amphoe Mae Sariang will be inundated.