8. PROJECT EVALUATION

8.1 General

In this chapter is described the evaluation of the Tenom Pangi Hydroelectric Power Development Project from the economic and financial viewpoints. The evaluation of the project is made also for the social and environmental aspects. In due consideration of the existing Tenom Pangi Project, which was completed and in commercial operation since 1984, the evaluation of the project is made first for its incremental part (Tenom Pangi, Phase III only) and then additionally the integral system of the project including whole the Tenom Pangi hydro system such as the existing Tenom Pangi power station, Sook reservoir and power station and the extending Tenom Pangi power station (Tenom Pangi, Phases I, II and III together). The economic and financial evaluations are made by comparing the project costs to implement, operate and maintain the project within the project life or evaluation period with the project benefits attributable to it. They are made on the capitalized cost and benefit basis.

The project cost consists of those for all the works planned and designed in the previous chapters, and the project benefit consists of the power benefit accrued from the direct power generation at the proposed Sook power station and that increased at the Tenom Pangi power station for the incremental part (Phase III only). To evaluate the integral system of the project (Phases I, II and III together), the power benefit accrued and the construction cost incurred from the existing Tenom Pangi power station are estimated and used. All the project costs and benefits are estimated in the 1985/86 price level.

8.2 Economic Evaluation

8.2.1 General

Economic evaluation is made so as to ascertain the contribution of the project toward the economic development of the nation. The project cost and benefit expressed in financial or market prices (1985/86 price) excluding price escalation and the interest during construction, are re-evaluated and converted into economic values or border prices by using the officially developed parameters or conversion factors for Malaysia, which were collected from the Federal Economic Planning Unit. Summary of the conversion factors is as shown in Table 8.1.

Table 8.1 NATIONAL ECONOMIC CONVERSION FACTORS

	Category	Factor
1)	General conversion factor	0.89
2)	Construction, general	0.84
3)	Construction materials	0.91
4)	Rent, fuel and power	0.95
5)	Private transport	0.56
6)	Transport equipment and parts	1.08
7)	Transport, general	0.79
8)	Diesel oil	0.88
9)	Crude oil	1.40
10)	Lubricating oil	0.80
11)	Telecommunications	0.78

8.2.2 Project Cost

The economic project cost comprises total implementation cost of the project less compensation cost plus an opportunity cost of production foregone in the area to be inundated by the Sook reservoir. Such a cost will be related to the productivity of the land in the reservoir area. No cost is associated with the wild and uncultivated areas. For the Sook reservoir area, most of the productive areas are used for upland paddy field, rubber plantation and grazing. Therefore, the opportunity cost is calculated from mainly the upland paddy and rubber production foregone. Grazing production foregone is estimated as same as that for upland paddy, and is included in that of the upland paddy since it is almost equivalent to or less than the upland paddy production foregone. Total production foregone is estimated to be US$282,000 (M$690,000) per annum.

The economic costs of the project are as shown in Table 8.2.

Table 8.2 (1) ECONOMIC PROJECT COST

(Unit: 10^3 US$)

Item	Conversion factor	Financial cost Foreign	Financial cost Local	Financial cost Total	Economic cost Foreign	Economic cost Local	Economic cost Total
I. Phase III only							
1 Sook dam and power station							
1) Civil work	0.84	26,768	28,062	54,830	26,768	23,572	50,340
2) Hydro-mechanical work	0.84	4,094	1,023	5,117	4,094	859	4,953
3) Generating equipment and transmission line	0.84	7,600	900	8,500	7,600	756	8,356
Subtotal:		38,462	29,985	68,447	38,462	25,187	63,649
4) Engineering and administration	0.89	4,381	1,095	5,476	4,281	975	5,356
5) Compensation	-	0	18,400	18,400	0	0	0
6) Production foregone	-	0	0	0	0	2,796 1/	2,796 1/
7) Physical contingency	-	4,284	4,948	9,232	4,284	2,896	7,180
Total		47,127	54,428	101,555	47,127	31,854	78,981
						(29,058) 2/	(76,185) 2/
2. Extension of Tenom Pangi power station							
1) Civil work	0.84	19,949	16,322	36,271	19,949	1 3,710	33,659
2) hydro-mech. work	0.84	5,461	1,365	6,826	5,461	1,147	6,608
3) Generating eq. and transmission line	0.84	15,300	2,700	18,000	15,300	2,268	17,586
Subtotal:		40,710	20,387	61,097	40,710	17,125	57,835
4) Engineering and administration	0.89	3,900	988	4,888	3,900	879	4,779
5) Physical contingency	-	4,461	2,138	6,599	4,461	1,800	6,261
Total		49,071	23,513	72,584	49,071	19,804	68,875
Grand-total (Phase III only):		96,198	77,941	174,139	96,198	51,658	147,856
						(48,862) 2/	(145,060) 2/

1/: Production foregone of US$282,000 per year, which is capitalized by 50 years project life and 10% discount rate

2/: Without production foregone

Table 8.2 (2) ECONOMIC PROJECT COST

(Unit: 10^3 US$)

Item	Conversion factor	Financial cost Foreign	Financial cost Local	Financial cost Total	Economic cost Foreign	Economic cost Local	Economic cost Total
II. Phases I, II and III							
1. Phase III only	-	96,198	77,941	174,139	96,198	51,658	147,856
2. Phases I and II							
1) Civil work	0.84	36,371	29,758	66,129	36,371	24,997	61,368
2) Electro-mechanical work	0.84	23,846	4,208	28,054	23,846	3,535	27,381
3) Other works	0.84	1,000	6,822	7,822	1,000	5,730	6,730
Subtotal		61,217	40,788	102,005	61,217	34,262	95,479
4) Engineering and administration	0.89	5,894	4,898	10,792	5,894	4,359	10,253
5) Contract price adjustment, etc.	0.84	25,162	0	25,162	25,162	0	25,162
6) Interest up to 1985		0	10,204	10,204	0	10,204	10,204
Total		92,273	55,890	148,163	92,273	48,825	141,098
						(38,621) 1/	(130,894) 1/
Grand total (Phases I, II and III)		188,471	133,831	322,302	188,471	100,483	288,954
				(312,098) 1/		(90,279) 1/	(278,750) 1/
						(87,483) 1/2/	(275,954) 1/2/

1/: Without interest up to 1985

2/: Without production foregone

The disbursement of the economic cost flow of the project for both incremental (Phase III only) and integral (Phases I, II and III) cases are summarized as shown in Table 8.3. Its details are as shown in Table A-8.1 to 8.3.

Table 8.3 DISBURSEMENT OF ECONOMIC COST

(UNIT: 10^3 US$)

No.	Year	Phase III only			Phases I, II and III		
		Foreign	Local	Total	Foreign	Local	Total
1	1979	-	-	-	92,273	38,621	130,894 1/
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
6	1984	-	-	-	-	-	
7	1985	-	-	-	-	(10,204) 2/	(10,204) 2/
8	1986	-	-	-	-	-	-
9	1987	-	-	-	-	-	-
10	1988	-	-	-	-	-	-
11	1989	4,601	2,704	7,305	4,601	2,705	7,305
12	1990	10,837	10,746	21,583	10,837	10,746	21,583
13	1991	15,367	9,692	25,059	15,367	9,692	25,059
14	1992	35,514	15,985	51,499	35,514	15,985	51,499
15	1993	29,879	9,735	39,614	29,879	9,734	39,614
16	1994	-	282	282	-	282	282
17	1995	-	282	282	-	282	282
18	1996	-	282	282	-	282	282
19	1997	-	282	282	-	282	282
20	1998	-	282	282	-	282	282
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
65	2043		282	282		282	282

1/: Total implementation cost finalized at end 1985

2/: Interest paid up to end 1985

The annual economic operation, maintenance and replacement (OMR) costs for the project are computed to be US$2,272,000 in total for incremental case and US$1,800,000 to 4,072,000 in total for integral case.

The capitalized economic cost of the project is calculated assuming the project commencement year is 1989, construction period, 5 years, project life, 50 years and discount rate is 10 per cent. It is summarized in Table 8.4.

Table 8.4 CAPITALIZED ECONOMIC COST

(Unit : 10^3 US$)

Item	Amount	
	Phase III only	Phases I,II,III
1. Project cost	145,060	275,954
2. Annual OMR costs	2,272	1,800 - 4,072
3. Annual production foregone	282	282
4. Capitalized to project commencement (1989)		
1) Project cost	113,382	301,183
2) OMR costs	13,986	40,115
3) Production foregone	1,736	1,736
5. Total capitalized economic cost	129,104	343,034

8.2.3 Project Benefit

The benefit for the Tenom Pangi Project is estimated by means of the least cost alternative method. In this study, a coal-fired thermal plant with 50 MW class unit is selected as an alternative power plant taking into account the scale of the project, economy of the alternative facilities and energy sources produced domestically.

The capacity (kW) value and energy (kWh) value for the alternative power plant are estimated as summarized below:

1) Alternative facility : Coal-fired thermal plant
2) Capacity : 50 MW class unit
3) Unit construction cost : 1,350 US$/kW (1985/86 price)
4) Service life : 25 years
5) Annual OMR costs : 3.0%
6) Adjustment factor :

	Thermal	Hydro
Forced outage :	0.03	0.005
Auxiliary power use :	0.07	0.005
Overhaul :	0.15	0.01
Transmission losses :	0.02	0.04

Capacity adjustment factor =

$$\frac{(1-0.005)(1-0.005)(1-0.01)(1-0.04)}{(1-0.03\ )(1-0.07\ )(1-0.15)(1-0.02)} = 1.252$$

Energy adjustment factor =

$$\frac{(1-0.005)(1-0.04)}{(1-0.07\ )(1-0.02)} = 1.048$$

7) Capacity value:
   Discount rate : 10%
   Capital recovery factor: 0.1102
   Capacity value = 1,350 x (0.1102 + 0.03) x 1.252
   = <u>237.0</u> (US$/kW)

8) Energy value:
   Price of coal : 0.055 US$/kg
   Fuel consumption rate : 0.45 kg/kWh
   Energy value = 0.055 x 0.45 x 1.048
   = <u>0.026</u> (US$/kWh)

The project benefit is estimated by using the unit power benefit mentioned above and the power demand allocated to the Tenom Pangi Project, taking into account the so-called build-up period corresponding to the increasing demand of power. The power benefit is calculated based on the simulation study on the month-to-month operation of the Sook-Tenom Pangi hydro system. To calculate the power generation and energy output for power benefit, 95 per cent dependable power and annual average energy output are used, respectively.

		Energy output (GWh)			Power
		Firm	Dump	Total	generation (MW)
1.	Sook dam and power station	45.5	6.3	51.8	9.9
2.	Tenom Pangi extention	283.8	-	283.8	61.1 1/
3.	Total (Phase III only)	329.3	6.3	335.6	71.0
4.	Tenom Pangi existing	331.6	184.6	516.2	45.0
	Total (Phases I, II, III)	660.9	190.9	851.8	116.0

Result of the project benefit calculation is expressed by the annual equivalent benefit capitalized to the year 1989 (project commencement year) using 10 per cent of annual discount rate and 50 years project life. It is summarized in Table 8.5. Detailed calculation is as shown in Tables A-8.4 and A-8.5.

1/: Including increase of power generation for existing Tenom Pangi.

Table 8.5 CAPITALIZED ECONOMIC BENEFIT

(Unit : 10^3 US$)

Item	Amount: Phase III only	Amount: Phase I, II, III
1. Annual power benefit		
1) Power benefit	9,700 - 16,800	1,400 - 27,500
2) Energy benefit	8,600	8,500 - 19,700
2. Capitalized to project commencement	163,000	432,200

8.2.4 Economic Cost-Benefit Comparison

The capitalized cost and benefit of the project at economic values (1985/86 price) are compared, and its benefit-cost ratio and economic internal rate of return (EIRR) are calculated as summarized in Table 8.6.

They are summarized as shown below:

Table 8.6 COST-BENEFIT COMPARISON (ECONOMIC)

Item	Index: Phase III only	Index: Phases I, II, III
1. Capitalized economic cost (C) (10^3 US$)	129,104	343,034
2. Capitalized economic benefit (B)(10^3 US$)	163,000	432,200
3. Net benefit (B-C) (10^3 US$)	33,896	89,166
4. Benefit-cost ratio (B/C)	1.26	1.26
5. EIRR (%)	12.6	13.9

8.2.5 Sensitivity Analysis

The sensitivity analysis indicates how a possible change in the assumptions and conditions of the project will affect the economic viability of the project. The analysis is made by varying the sensitive items of the project, and ascertaining their effects on EIRR.

The changes assumed for the sensitivity analysis are:

Case 1: Construction cost of the project is increased by 10%

Case 2: Construction cost of the project is increased by 20%

Case 3: Power benefit is decreased by 10%

Case 4: Power benefit is decreased by 20%

Case 5: Combination of Case 1 and Case 3

Case 6: Combination of Case 1 and Case 4

Case 7: Combination of Case 2 and Case 3

The results of the sensitivity analysis are summarized in Table 8.7.

Table 8.7 RESULTS OF ECONOMIC SENSITIVITY ANALYSIS

(Unit : %)

Case	EIRR	
	Phase III only	Phases I, II, III
Original	12.6	13.9
1	11.7	13.5
2	10.8	13.1
3	11.4	12.4
4	10.2	10.9
5	10.5	12.0
6	9.4	10.6
7	9.8	10.2

8.3 Financial Analysis

8.3.1 General

Financial analysis of the Tenom Pangi Project is made by examining the financial viability of the project from the viewpoint of the project entity for both incremental (Phase III only) and integral (Phases I, II and III) cases. All the expenditures and revenues are expressed in the form of financial or market prices. They are expressed in 1985/86 prices.

8.3.2 Financial Statement

In order to examine the financial viability of the project, the financial statement is prepared under the following conditions.

1) All the foreign currency portions of the project cost are to be financed by a loan from an international financing agency and all the local currency portions of the project cost are to be financed by the federal government fund of Malaysia. Their loan conditions are assumed as shown below:

	Local	Foreign
a) Annual interest rate (%):	8.5	4.0
b) Grace period:	5 years	7 years
c) Repayment period: (excluding grace period)	25 years	13 years

2) Revenue of the project is assumed as those obtained by selling the power1/ at the power station end. It is estimated based on the current power tariff (average) less transmission and distribution costs as well as administration expenses. As for the current power tariff, 1986 revised tariff is used. Calculation is as shown below:

1/: Same figures of the energy output in Tables A-8.4 and 8.5 are used.

$$\left[\text{1986 tariff} - \begin{matrix}\text{Transmission, distribution}\\ \text{and administration costs}\end{matrix}\right] \times \left[1 - \begin{matrix}\text{Transmission}\\ \text{loss ratio}\end{matrix}\right]$$

= (1985 tariff x 0.9[1/] - 5.0) (1 - 0.15)

= (28.99 x 0.9 - 5.0) x 0.85

= 17.93 (M¢) (= 7.32 US¢)

The financial statement for the Tenom Pangi Project is as shown in Table 8.8 for incremental case (Phase III only) and in Table 8.9 for integral case (Phase I, II and III). As seen in the tables debt of the project for incremental case turns to surplus in third year from the start of project operation, and that for integral case from the beginning year. Thus, the project is justified to be viable against usual loan repayability.

8.3.3 Financial Internal Rate of Return

The financial internal rate of return (FIRR) is calculated assuming the same conditions of the financial project cost and power sales as the financial statement and 50 years project life. It is 10.8 and 18.3 per cent, respectively.

1/: 1986 tariff (average) is reported to be 90% of 1985 tariff.

Table 8.8 FINANCIAL STATEMENT (SOOK DAM AND POWER STATION + TENOM PANGI EXTENSION - PHASE III ONLY)

(UNIT: 10^3 US$)

No.	Year	Expenditure		Project revenue	OMR costs	Net income	Repayment		Total repayment	Surplus or deficit	Accumulated Surplus or deficit
		Local c.	Foreign c.				Local c.	Foreign c.			
0	1985										
1	1986			0		0	0	0	0	0	0
2	1987			0		0	0	0	0	0	0
3	1988			0		0	0	0	0	0	0
4	1989	4,319	4,601	0		0	367	184	551	-551	-551
5	1990	13,934	10,947	0		0	1,551	621	2,172	-2,172	-2,723
6	1991	12,691	15,477	0		0	2,630	1,241	3,871	-3,871	-6,594
7	1992	27,359	35,514	0		0	4,955	2,661	7,616	-7,616	-14,210
8	1993	19,638	29,659	0		0	6,624	3,847	10,471	-10,471	-24,681
9	1994			24,335	2,610	21,725	7,615	3,847	11,462	10,263	-14,418
10	1995			24,335	2,610	21,725	7,615	3,847	11,462	10,263	-4,155
11	1996			24,335	2,610	21,725	7,615	9,634	17,249	4,476	321
12	1997			24,335	2,610	21,725	7,615	9,634	17,249	4,476	4,797
13	1998			24,335	2,610	21,725	7,615	9,634	17,249	4,476	9,273
14	1999			24,335	2,610	21,725	7,615	9,634	17,249	4,476	13,749
15	2000			24,335	2,610	21,725	7,615	9,634	17,249	4,476	18,225
16	2001			24,335	2,610	21,725	7,615	9,634	17,249	4,476	22,701
17	2002			24,335	2,610	21,725	7,615	9,634	17,249	4,476	27,177
18	2003			24,335	2,610	21,725	7,615	9,634	17,249	4,476	31,653
19	2004			24,335	2,610	21,725	7,615	9,634	17,249	4,476	36,129
20	2005			24,335	2,610	21,725	7,615	9,634	17,249	4,476	40,605
21	2006			24,335	2,610	21,725	7,615	9,634	17,249	4,476	45,081
22	2007			24,335	2,610	21,725	7,615	9,634	17,249	4,476	49,557
23	2008			24,335	2,610	21,725	7,615	9,634	17,249	4,476	54,033
24	2009			24,335	2,610	21,725	7,615		7,615	14,110	68,143
25	2010			24,335	2,610	21,725	7,615		7,615	14,110	82,253
26	2011			24,335	2,610	21,725	7,615		7,615	14,110	96,363
27	2012			24,335	2,610	21,725	7,615		7,615	14,110	110,473
28	2013			24,335	2,610	21,725	7,615		7,615	14,110	124,583
29	2014			24,335	2,610	21,725	7,615		7,615	14,110	138,693
30	2015			24,335	2,610	21,725	7,615		7,615	14,110	152,803
31	2016			24,335	2,610	21,725	7,615		7,615	14,110	166,913
32	2017			24,335	2,610	21,725	7,615		7,615	14,110	181,023
33	2018			24,335	2,610	21,725	7,615		7,615	14,110	195,133
Total:		77,941	96,198	608,375	65,250	543,125	206,502	141,490	347,992	195,133	-

Remarks : For loan conditions, refer to page 8-12.

Table 8. 9 FINANCIAL STATEMENT (SOOK DAM AND POWER STATION, TENOM PANGI EXTENSION + TENOM PANGI EXISTING - PHASES I, II, III)

(UNIT: 10^3 US$)

No.	Year	Expenditure		Project revenue	OMR costs	Net income	Repayment		Total repayment	Surplus or deficit	Accumulated Surplus or deficit
		Local c.	Foreign c.				Local c.	Foreign c.			
0	1985	55,090	92,273	23,856	2,070	21,786	5,461	3,691	9,152	12,634	12,634
1	1986			26,162	2,070	24,092	5,461	3,691	9,152	14,940	27,574
2	1987			29,624	2,070	27,554	5,461	9,240	14,701	12,853	40,427
3	1988			31,029	2,070	28,959	5,461	9,240	14,701	14,258	54,685
4	1989	4,319	4,601	31,029	2,070	28,959	5,828	9,424	15,252	13,707	68,392
5	1990	13,934	10,947	31,029	2,070	28,959	7,012	9,861	16,873	12,086	80,478
6	1991	12,691	15,477	31,029	2,070	28,959	8,091	10,481	18,572	10,387	90,865
7	1992	27,359	35,514	31,029	2,070	28,959	10,416	11,901	22,317	6,642	97,507
8	1993	19,638	29,659	31,029	2,070	28,959	12,085	13,087	25,172	3,787	101,294
9	1994			55,365	4,680	50,685	13,076	13,087	26,163	24,522	125,816
10	1995			55,365	4,680	50,685	13,076	13,087	26,163	24,522	150,338
11	1996			55,365	4,680	50,685	13,076	18,874	31,950	18,735	169,073
12	1997			55,365	4,680	50,685	13,076	18,874	31,950	18,735	187,808
13	1998			55,365	4,680	50,685	13,076	18,874	31,950	18,735	206,543
14	1999			55,365	4,680	50,685	13,076	18,874	31,950	18,735	225,278
15	2000			55,365	4,680	50,685	13,076	9,634	22,710	27,975	253,253
16	2001			55,365	4,680	50,685	13,076	9,634	22,710	27,975	281,228
17	2002			55,365	4,680	50,685	13,076	9,634	22,710	27,975	309,203
18	2003			55,365	4,680	50,685	13,076	9,634	22,710	27,975	337,178
19	2004			55,365	4,680	50,685	13,076	9,634	22,710	27,975	365,153
20	2005			55,365	4,680	50,685	13,076	9,634	22,710	27,975	393,128
21	2006			55,365	4,680	50,685	13,076	9,634	22,710	27,975	421,103
22	2007			55,365	4,680	50,685	13,076	9,634	22,710	27,975	449,078
23	2008			55,365	4,680	50,685	13,076	9,634	22,710	27,975	477,053
24	2009			55,365	4,680	50,685	13,076		13,076	37,609	514,662
25	2010			55,365	4,680	50,685	7,615		7,615	43,070	557,732
26	2011			55,365	4,680	50,685	7,615		7,615	43,070	600,802
27	2012			55,365	4,680	50,685	7,615		7,615	43,070	643,872
28	2013			55,365	4,680	50,685	7,615		7,615	43,070	686,942
29	2014			55,365	4,680	50,685	7,615		7,615	43,070	730,012
30	2015			55,365	4,680	50,685	7,615		7,615	43,070	773,082
31	2016			55,365	4,680	50,685	7,615		7,615	43,070	816,152
32	2017			55,365	4,680	50,685	7,615		7,615	43,070	859,222
33	2018			55,365	4,680	50,685	7,615		7,615	43,070	902,292
Total:		133,831	188,471	1,649,941	135,630	1,514,311	343,027	268,992	612,019	902,292	-

Remarks : For loan conditions, refer to page 8-12.

8.3.4 Sensitivity Analysis

The sensitivity analysis at financial values is conducted with the same approach as that for the economic aspect. Conditions applied to the analysis are:

The changes assumed for the sensitivity analysis are:

Case 1: Price contingency for the project cost is increased by 10%.

Case 2: Price contingency for the project cost is increased by 40%.

Case 3: Power sales is decreased by 10%

Case 4: Power sales is decreased by 20%

Case 5: Combination of Case 1 and Case 3

Case 6: Combination of Case 1 and Case 4

Case 7: Combination of Case 2 and Case 3

The results of the sensitivity analysis are summarized in Table 8.10.

Table 8.10 RESULTS OF FINANCIAL SENSITIVITY ANALYSIS

(Unit : %)

Case	FIRR	
	Phase III only	Phases I, II, III
Original	10.8	18.3
1	9.9	17.7
2	7.8	15.9
3	9.7	15.9
4	8.5	13.7
5	8.8	15.3
6	7.8	13.1
7	7.0	13.7

8.4 Socio-envinronmental Assessment

8.4.1 General

The environmental strategy in the Fifth Malaysia Plan, states that environmental impact assessments will be taken into account in the development planning, project implementation, and operation and maintenance. Countermeasure and/or the costs of the required environmental measures will furthermore be incorporated in the said planning and implementation.

Accordingly the socio-environmental assessment for the Tenom Pangi Project, Phase III, is based on significant social and environmental impacts. The impacts will be beneficial or detrimental, depending upon the locations of the social units affected. Households, for example, that will be displaced by creation of the Sook reservoir will be subject to great detrimenal impacts, whereas social units in areas which will receive the electric power supply or improved traffic facilities and which will suffer less flood damage will receive beneficial effects.

8.4.2 Social Aspects

1) Sociological Transformation

The households having the land within the reservoir area will be displaced and compensated, as will any possible tenants who are occupying land that is within the reservoir boundaries. Additional households will be displaced, if their holdings or leased lands are fragmented by the reservoir, reducing their unit of holdings below an economic unit.

Households and communities within the remainder of or around the Phase III Project areas will receive beneficial impacts from the Project. Electricity supply, relocated road system, new roads constructed as access roads or construction roods during the construction stage, and new public facilities such as schools, clinics, hospitals, churches and public halls will be provided for such households and communities.

Flood control resulting from attenuation by the Sook reservoir will be beneficial impacts to households in the flood-prone areas along the rivers below the Sook damsite.

It is rather difficult to assess the value of future fisheries because the 25m annual fluctuation of reservoir water level is not conducive to fish breeding. Some fishes that migrate upstream for spawning may then come back to the reservoir and provide some possibilities of fishing in the reservoir.

2) Displacement and Resettlement

As described before, the Sook dam is planned to be built on the Sook River, and therefore, about 35 km^2 of the flat land will be inandated. As may be seen in Table 8.11, almost one half of the proposed Sook reservoir area is covered by the bushes (42%) and forests (9%) of mostly secondary growth. The remaining area is used for rubber plantation (13%), cattle grazing (12%), agricultural land (3%) and so on.

Table 8.11 LAND USE AND COMPENSATION ITEMS IN THE RESERVOIR AREA

	Item	Unit	Quantities
1.	Population		
	Households (families)	Nos	416
	Inhabitants	Nos	2,225
2.	Land use		
	Forest	km2	3.2
	Bush	"	14.7
	Rubber plantation	"	4.4
	Agricultural land	"	1.2
	Cattle grazing	"	4.3
	Housing lot	"	0.7
	Others	"	6.5
	(Total)	"	(35.0)
3.	Houses and buildings		
	Houses	Nos	334
	Public buildings	"	8
	Schools	"	20
	Churches	"	5
	Clinics	"	3
	Saw mills	"	3
	Rice mills	"	2
	Cemeteries	"	304
4.	Roads		
	District roads	km	8.7
	Timber transportation roads	"	6.3
	Village roads	"	20.2
	(Total)		(35.2 km)

An estimated 420 households will be displaced from the Sook reservoir area. Resettlement of the households will have great impact on the families, neighborhoods and communities which will be disrupted.

According to the interview survey of inhabitants in the reservoir area, almost 80 per cent of the people will agree to the project implementation if they are allowed to resettle on nearby land and to continue their present livelihoods though they generally show reluctance for resettlement. Potential areas for resettlement around the reservoir area are suggested as shown on Figure A-8.1 in Annex.

It is concluded, therefore, that detrimental impacts from displacement and resettlement should be relatively small if the administrative arrangements by the Project for resettlement in neighboring areas can be considerately conducted.

3) Land and Water Surface Utilizatioon

a) Reservoir

Realization of the Sook dam and its reservoir with a water surface area of about 35 km^2, may be expected to utilize the riparian land and water surface of the reservoir. It is most conceivable to develop recreational resources for them. The Sook damsite is located only 5 km from Keningau town and about 100 km from Kota Kinabalu. There is a high probability therefore that suitable facilities would attract tourists from Kota Kinabalu through Mt. Kinabalu - which is the most famous focus for tourism in Sabah. It would thus be appropriate to consider developing recreation facilities at one or more selected sites around the reservoir.

Favorable impacts from the recreation developments could include more intensive utilization of selected areas, and could provide employment or business opportunities especially to some of those who will be displaced by the reservoir. Such recreation development must be done with consideration of an annual reservoir water fluctuation of about 25 m in the Sook reservoir. The following are promising recreation facilities near the damsite and/or around the reservoir:

a. Observatories for the dam and reservoir

b. Public garden/rest-house

c. Hotel and restaurant

d. Pleasure boats and wind-surfing

e. Camping facilities (Places and accommodation)

f. Fishing facilities (fish ponds, fishing boats, rest house)

b) <u>Sook Catchment</u>

The catchment area above the proposed Sook damsite is 1,705 km^2. Based on topographical maps of 1 to 50,000 scale and cadastral maps, present situation of land use in the catchment area above the Sook dam is identified as shown in Figure 8.1 and summarized below:

Present Land use in Sook Dam Catchment

Category	Area (km^2)
Forest land	1,286.6
FELDA Development area, etc.	103.4
Grass land (Sook plain)	60.0
Paddy field (mostly upland)	60.0
Rubber plantation	4.4
Cattle grazing land	4.3
Other agricultural land	0.3
Bush land	15.0
Housing lot	1.0
Others	170.0
Total	1,705.0

Most of the catchment area is forest land. It has been opened by deforestation of logging activity. Because of sparsely distributed population in the area, such forest land may not be developed so much, but better be restored again by reforestation or secondary generation of natural forest, and will be reserved for future logging work as well as for conservation of water resources. In this forest land some of the area may be utilized for plantation of tree crops such as oil palm, rubber, spices, coffee, etc., as FELDA do. Total area for development now being planned is about 250 km^2 (25,000 ha).

Flat sook plain can be utilized for cattle raising or pasture land. Its area is about 60 km^2 (6,000 ha).

Paddy fields sporadically distributed in the catchment are mostly on shifting cultivation. Some of the field can be changed to permanent paddy field with irrigation facility which leads water from the nearby rivers. Such land is about 30 km^2 (3,000 ha) in total.

After completion of the Sook reservoir which will inundate 35 km^2 in the catchment, rubber plantation, cattle grazing land and housing lot will be relocated from the reservoir area.

Thus, future land use which is forecasted taking into consideration the present situation and future prospect will be as summarized below:

Future Land use in Sook Dam Catchment

Category	Area (km^2)
Forest land	1,122
FELDA Development area, etc.	250
Cattle raising land/ Pasture land	60
Irrigated paddy field	30
Upland paddy field	30
Rubber plantation	5
Cattle grazing land	5
Agricultural land	1
Bush land	-
Housing lot	2
Sook reservoir area	35
Others	165
Total	1,705

4) Water Utilization

a) Irrigation water

At present, there is very limited direct water use for irrigation from the mainstream of the Sook, Pegalan and Padas rivers between the proposed Sook damsite and the

Tenom Pangi diversion weir site. Most of the water from agriculture in this area is drawn from tributaries for paddy fields or is derived from rainfall for upland crops. As this area is situated between the Keningau and Tenom plains, flat land is restricted in the area along the main stream and its tributaries. Such flat land in this area has been already cultivated for paddy, upland crops, cocoa and rubber. Therefore, there is little opportunity to directly utilize the river water from the mainstream for irrigation in future. Moreover, potential land for irrigation below the Sook Dam is only about 1,000 ha which is found in Tenom Plain and required water is 0.7 cubic meter/s on average and 1.1 cubic meter/s at peak. Compared with total water requirement of 212 cubic meter/s at the Pangi Power Station, such water use is negligibly small. This leads to the conclusion that the project will not affect water use for irrigation in the area between the Sook damsite and Tenom Pangi weir site since no direct use of river water from the mainstream for irrigation will be expected now or in future.

b) Domestic water supply

River water of the Pegalan and Padas Rivers is utilized for domestic water supply to Keningau and Tenom towns. As the intake site for water supply to Keningau town is located upstream of the confluence of the Pegalan and Sook Rivers, the project have no effect on the domestic water supply for Keningau town. On the other hand, the intake site for water supply to Tenom town is located just downstream of the confluence of the Pegalan and Padas Rivers. The amount of intake water for Tenom town is 1,530 m^3/day or 0.02 m^3/sec at present.

Compared with the 210 m^3/sec average discharge at Tenom Lama gauging station located at about 1 km downstream of the above intake site, the amount of water required for Tenom town will be negligibly small even if it increases to 10 times of the existing amount in future. As the catchment area at the Sook damsite is only 22 per cent of that at Tenom Lama, it is concluded that the project will not affect the domestic water supply for Tenom town.

At Kg. Ansip located at about 2 km downstream of the Sook damsite, people use river water of the Sook River for washing clothes and taking baths in daily life. When the project is implemented, the river flow of the Sook downstream of the dam will fluctuate artificially depending on reservoir operation for power generation. It is considered that the project will somewhat affect the daily water use of the Sook River by people of Kg. Ansip and should therefore, include provision of some suitable facility to supply water for Kg. Ansip such as wells or a piped water supply system.

5) Employment Opportunities

Employment of the men of displaced households to the fullest extent possible during construction of the project could reduce some of the adverse impacts of resettlement. The majority of the unskilled and semiskilled labor force for construction could be preferentially available from displaced households. If these households could develop reserves of capital that could improve their status upon resettlement and alleviate the detrimental effects of relocation.

6) Public Health

The most common disease in the project area is malaria which may be increased if the inhabitants or laboures are concentrated at the project construction site without sufficient medical countermeasures. Therefore, special attention would be paid to preventing malaria during and after construction of the project.

8.4.3 Environmental Aspects

1) Ecosystem Change

An ecosystem is an environmental-biological system which operates as a system, not as independent factors and/or components. When the unit of concern is man, individually or collectively, then the system is a physical-biological system.

The implementation and operation of the Tenom Pangi Project, Phase III, will result in environmental changes in the Sook river ecosystem.

The Sook river ecosystem is at present operating with extremes of low water and floods with variations characteristic of the system. The inland fisheries are in a degree of adjustment to those conditions. Considering the present river regimes as "natural", there will be significant changes when the project is completed. There will be a regulated release that will be greater than the natural low flows and greater than the average low flows. Therefore, the unfavorable impacts of the extreme lows will be eliminated. Flood control will provide reduction in the extremes of high water velocities and depths. The river system will be manipulated so that it will be operating in a "non-natural" manner which will permit the development of a whole new river ecosystem, beneficial to fisheries downstream from the Sook damsite.

However, no assessment can be made of the ecosystem in the reservoir area and upstream from the damsite after project completion as there is no data available on seasonal movements of fish, aquatic insects and weeds in the Sook River. Therefore, monitorings of ecological and socio-cultural effects of Project are recommended.

2) Water Quality

There is the high possibility of increased sediment load concentration and organic materials in the river water of the Sook River during construction of the Sook dam and power plant. Accordingly, special care will be paid to the aggregates production/washing system and waste water (sewer system) from the project site by providing settling ponds and septic tanks.

In consideration of tendency of aquatic weeds and contamination of the reservoir water which increase under tropical weather condition, vegetations including all trees will be taken out from the reservoir area before commencement of the reservoir water storage.

3) Vegetation

Vegetation in the most of the catchment area has been altered from the original tropical evergreen forests to secondary forests due mainly to logging activities and partly to shifting cultivation. In the reservoir area to be submerged, forests remain along the Sook River and occupy about 10 per cent of the reservoir area. These are mostly secondary forests which have little commercial potential due to poor quality.

The Tenom Pangi Project, Phase III, should have no direct beneficial or detrimental environmental impact on the reservoir area.

In order to prevent erosion of mountain area due to intensive logging activities and to recover the commercial value of the forests, re-afforestation in the catchment area is recommended.

4) Mineral Resources

It is reported by the Geological Survey Department of Malaysia that according to existing geological reports (Collenette 1965), the proposed reservoir area has no mineral resources of commercial value.

5) Wildlife Resources

The wildlife resources of the catchment area are primarily restricted to bird life, animals such as wild pigs, deer and rodents and reptiles such as lizards, pythons and snakes. Wild pigs and deer are hunted and trapped by the local people.

Almost all of these wildlife resources are living in the mountain area outside the reservoir area to be submerged. Therefore, the project will not have any serious effects on present wildlife resources.

8.5 Conclusion and Recommendation

Based on the above findings of the feasibility study, the Tenom Pangi Hydroelectric Power Development Project, Phase III, is now proven to be technically feasible, financially and economically viable and socio-environmentally acceptable.

Therefore, early realization of the project is hereby recommended. Implementation of the project is recommended to be carried out in the following manners:

1) Engineering design including additional field investigation, detailed design, preparation of tender documents, etc., should be started at the beginning of 1987 so that the project can be commissioned by the end of 1993 to meet expected power demand.

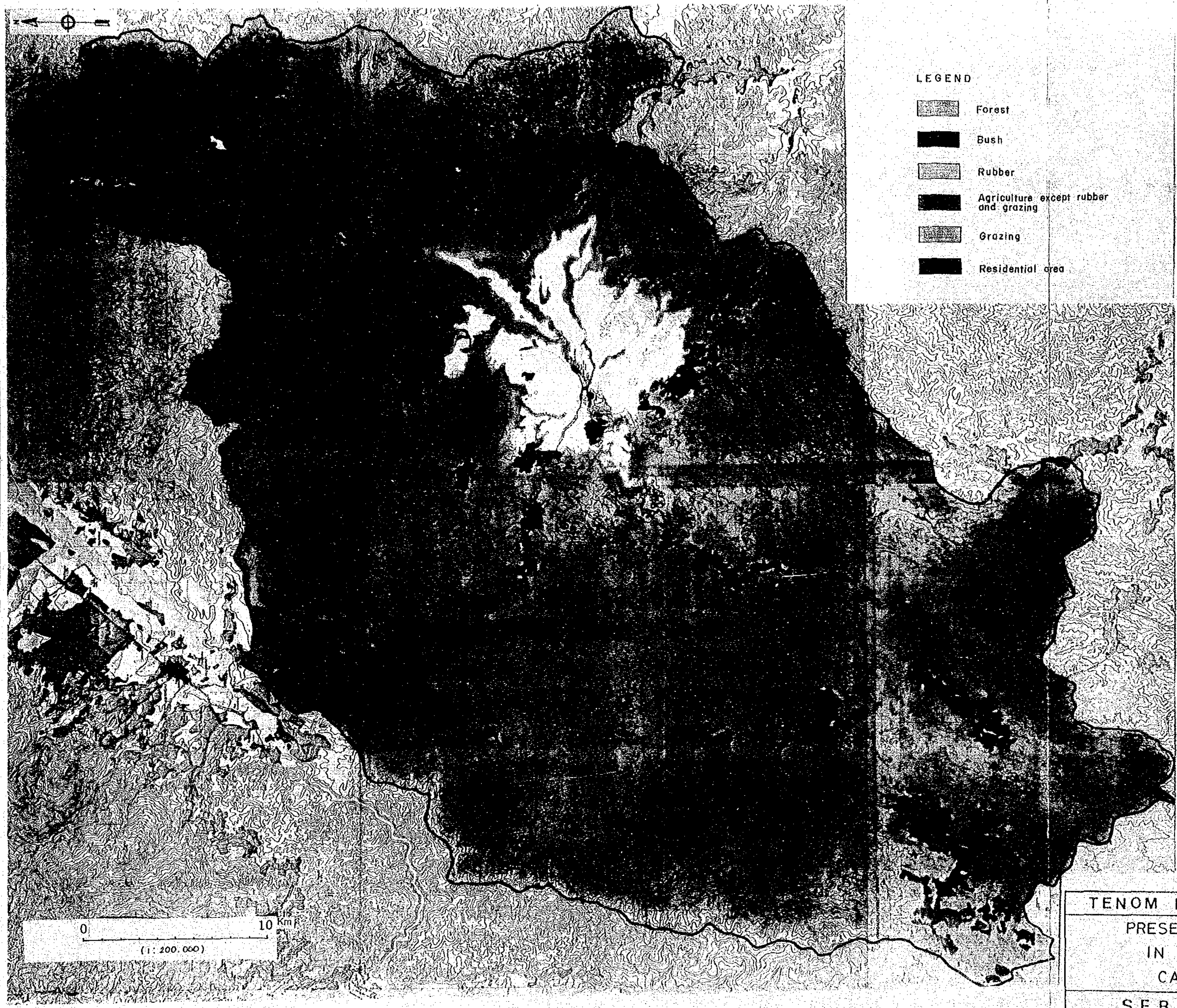
2) Proper procedures for gazetting the reservoir area should be taken now so that new development in the areas can be minimized.

3) Plan for Resettlement of the families affected by the proposed project should be undertaken by a committee during the Engineering Study.

4) Preparatory works such as construction of access roads, offices and quarters should be started at the beginning of 1989.

5) Main civil works which require five years to be completed, should be commenced in the middle of 1989.

FIGURE NO. 8.1



TENOM PANGI PHASE III

PRESENT LAND USE IN SOOK DAM CATCHMENT

SEB / JICA

9. FURTHER INVESTIGATIONS

9.1 General

Following the feasibility study for the Tenom Pangi Project, Phase III, detailed design works are required prior to commencement of the construction works. The following works will be required as the scope of the works to be conducted in the detailed design stage:

1) Detailed field investigation

2) Detailed design

3) Preparation of tender documents.

9.2 Further Field Investigations

1) Ground Survey

As the results of aerial and ground surveying works carried out in the feasibility study stage, the following topographical maps are available for detailed design:

(1) Maps of 1:500 scale with 1 m contour for Sook main damsite

(2) Maps of 1:500 scale with 1 m contour for Sook saddle damsite

(3) Maps of 1:10,000 scale with 10 m contour for Sook reservoir area

The new bench marks have been established at 4 points for the main damsite and 3 points for saddle damsite. These bench marks are available for further surveying and construction.

In the next stage, ground survey should be carried out for design of access roads, relocation roads and transmission line including route selection. The items to be surveyed are as below:

(1) Access roads to the crest of the Sook dam and to the power station site

(2) Relocation roads to be shifted outside of the reservoir area for the Sook dam

(3) Access road to the surge tank for extension in the Tenom Pangi power station site

(4) Transmission line to Keningau substation

In addition to the survey for access and relocation roads and transmission line, survey for compensation and resettlement will be required, which will be carried out by the land acquisition department of the state government or SEB.

2) Geological Survey

(1) Main dam

The dam foundation rock is remarkably permeable under high static water pressure. It is, therefore, recommendable to execute 80 m deep core drilling with Lugeon test and 50 m deep test grouting. Standard penetration test (SPT) is required at upper 5 to 7 m thick zone in the core-drilled holes in order to confirm the appropriate depth for foundation of the dam shell zone.

On both the left and right abutments, 10 to 15 m thick subsurface zones are deemed to be loosened along the bedding planes and slopes. It is recommendable to excavate test adits for in-situ confirmation of the conditions of the foundation for the dam core zone.

The conceived geological investigations for the main dam is as follows:

(a) Core drilling along the dam axis

- Core drilling
- Lugeon test in drillhole
- Standard penetration test

(b) Test grouting

(c) Test adit

(2) Appurtenant structures

The following appurtenant structures will require the core drilling with Lugeon test and SPT in order to confirm tightness of bedrocks and depth of competent foundation;

- Spillway; gate, chuteway, stilling basin and those cutslopes
- Diversion tunnel; inlet and outlet
- Intake; intake tower, inlet and outlet
- Powerhouse; powerhouse yard and its cutslope and tailrace

(3) Saddle Dam

The saddle consists of thick terrace deposits. Thickness of the deposits and continuity of layers in the deposits shall be revealed. Besides, liquefaction and piping problems shall be made more clear. For the said purpose, the following investigations will be required;

(a) Core drilling and drillhole test

- Core drilling
- Open-end pipe test
- Standard penetration test

(b) Laboratory test by using samples obtained by SPT; specific gravity, natural water content and grain size distribution

(4) Quarry Site

The quarry site is proposed to be selected around the drilling hole Q85-3 for the source of the rock material. Weathering condition, proportion of sandstone, shale and mudstone, and direction of strata in the quarry site shall be made clear. Core drilling and test aditting as follows will be required for this purpose;

- Core drilling
- Test aditting

(The test aditting may be eliminated depending on the results of core drilling.)

3) <u>Materials Survey and Laboratory Test</u>

Adding to the material survey and laboratory test conducted in the feasibility study stage, further investigation is recommended to be executed in the next stage as below;

(1) Impervious core materials for main dam

As shown in Figure 2.7, the borrow area A was selected for the detailed investigation. As the results of the survey and laboratory test, it is confirmed that the terrace deposits in the borrow area A are available for impervious core materials of the main dam. However suitable impervious core materials were unexpectedly found at the nearer place to the main damsite. It is shown as "TEMPORARY ROAD" in Figure 2.7. Therefore it is recommended to conduct additional material survey and laboratory test for the new promising borrow area.

(2) Rock materials for main dam

To select a quarry site, core drilling was carried out at 3 locations. As the results of core drilling, the quarry site is selected around the drilling hole No. Q85-3 in this stage. However some more core drilling should be carried out to clarify the geological condition of the selected quarry site and available quantity of rock materials.

(3) Embankment materials for saddle dam

The borrow area for the saddle dam embankment materials was selected at the area which is just near the damsite and located inside of reservoir area. As the results of core drilling carried out later, it was found that thick sand and gravel layer exists beneath the top soil. Therefore, it is judged that the borrow area for the saddle dam should be selected outside of the reservoir area or, if in the reservoir area, far from the saddle dam site. As the geological conditions are not different in the area around the saddle damsite, it is not difficult to select an alternative borrow area. However, additional material survey and laboratory test are required for confirmation.

(4) <u>Hydrological Survey</u>

To supplement and update the hydrological data collected during the feasibility study stage, additional data collection and hydrological survey will be made for the following items:

(a) Collection of supplemental streamflow record

(b) Collection of supplemental rainfall record

(c) Collection of supplemental meteorological data

(d) Supplemental rainfall data

(e) Additional streamflow measurement

(f) Additional water sampling for sediment load

(g) Additional water sampling for water quality test

Using the updated hydrological data, review of hydrological analysis will be made in the next stage.

5) <u>Environmental Investigations</u>

A preliminary investigation for the environmental aspects of the proposed project was conducted during October 1985 in the feasibility study stage. In addition to the preliminary investigation, further investigation will be required to collect detailed data and information before any resettlement policy and program can be formulated.

It is recommended that further environment investigation should be approached on a sub-study base separated from the detailed design works. The general objectives of these sub-studies should include :

(1) Completion of environmental data specific to the project area

(2) Confirmation and expansion of preliminary assessments on the environmental impacts of the project

(3) Advising action required in respect of :

(a) Mitigating unfavourable effect, if any

(b) Resolving resettlement problems

(c) Monitoring of ecological and socio-cultural effects of the project and resettlement

The obligation of SEB with respect to preparation of an "Environmental Impact Statement" have not been determined in this stage. According to information, guidelines for such a procedure have been prepared by the Division of Environment (DOE) of the Malaysian Ministry of Science, Technology and Environment. It is probable that authorities such as the major lending agencies will require such a statement to apprise the financing for the project.

The recommendation for specific sub-studies is based on the following concepts :

(1) Government authorities in Sabah will need to be intimately involved in specific aspects such as resettlement policy, planning and program.

(2) Government authorities have local or technical expertise which should be utilized (Sabah Museum and Institute for Medical Research).

(3) Academic bodies could be utilized to certain aspects, particularly those relating to ecology.

To rationalize the basic approach to resettlement including the selection of possible resettlement sites and preliminary assessment of agricultural potentials of the sites, investigations should be made to review compensation and resettlement policy of other development projects in Sabah and Malaysia.

To formulate a rational resettlement policy and plan, the following matters should also be investigated :

(1) Socio-cultural background of the project are including community structure and ethnological structure of individual communities

(2) Location, population, the leaders of communities in the reservoir area and attitudes of relocates towards resettlement

(3) Presence or absence of potential health hazards associated with the proposed reservoir development and resettlement schemes

ANNEX

A-1.1 MEMBER LIST OF SURVEY TEAM

	JICA Team		SEB Counterpart	
	Name	Assignment	Name	Assignment
1.	S. Omura	Team leader	1. N.F. Pang	Chief Engineer/Hydro Civil
2.	M. Ogawa	Deputy team leader	2. Amat Aji	Co-team leader
3.	K. Watanabe	Civil engineer (dam)	3. Sahril Jaraei	Civil engineer
4.	A. Katayama	Hydrogist	4. Chu Pui An	Civil engineer
5.	H. Kashiwagi	Sr. Geologist	5. Jokolin Jomini	Mechanical engineer
6.	K. Choshi	Geologist		
7.	M. Kikuchi	Geophysicist		
8.	H. Yoshida	Material engineer	(1) JURUKUR PERUNDING SERVICE SDN. BHD.	Local Contractor for ground surveying
9.	T. Masuda	Aerial surveying engineer		
10.	K. Yamashita	Ground surveying engineer	(2) GROUND ENGINEERING SDN. BHD.	Local Contractor for geological and material investigations and laboratory test
11.	S. Tsukahara	Electrical engineer		
12.	S. Hakoshima	Construction planner		
13.	M. Nishimura	Environmental engineer		
14.	M. Ohashi	Project economist		
15.	T. Ito	Civil engineer		
16.	I. Shimohara	Civil engineer		
17.	Y. Ataka	Electrical engineer		
18.	A. Odatai	Mechanical engineer		
19.	S. Osumi	Architectural engineer		

A.2-1 Water Quality of Padas River and Its Tributaries

Water sampling and analysis were conducted by the Department of Environment in 1984 at 8 spots on the Padas River and its tributaries as depicted in Figure A-2.1.

The results of water quality analysis are shown in Table A-2.1 and depicted in Figure A-2.2.

In addition to the above water quality data of the Padas River and its tributaries, water sampling and analysis were carried out by JICA survey team in 1985 at 4 spots on the Sook River as depicted in Figure A-2.3.

The results of water quality analysis are summarized in Table A-2.2.

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (1/8)

Station: Beringun (St. 1) Year: 1984

Date		18/1	7/2	9/3	11/5	22/6	17/7	7/8	7/9	N	Av	Rg	SD
Time		15:10	15:40	14:25	16:00	12:40	12:50	13:15	14:00				
pH*		7.05	6.20	6.71	-	-	-	-	6.34	4	6.58	6.20-7.05	0.38
Temperature*	°C	26	25	27.5	26	25	27	-	28	7	26.4	25-28	1.18
DO*	mg/ℓ	7.4	7.5	6.7	7.7	5.4	6.5	-	5.9	"	6.6	5.4-7.7	0.98
Conductivity*	micromho /cm	60	60	80	40	50	65	-	50	"	58	40-80	12.8
pH		6.4	7.2	6.5	6.6	6.7	6.8	7.2	6.9	8	6.8	6.5-7.2	0.3
Suspended Solids	mg/ℓ	129	151	30	131	333	88	26	74	"	115	26-333	102.2
Total Solids	"	239	237	68	176	421	155	102	77	"	184	68-239	116.2
BOD at 30°C	"	4.8	3.9	3.0	1.3	4.5	0	0	1.5	"	2.4	0-4.8	1.57
COD	"	9.1	8.4	3.0	6.0	27.0	0	3.1	9.1	"	8.2	0-27.0	7.68
Phosphones	"	0	0	0	0	0.01	0	0	0	"	0.00	0-0.01	0.00
Colour		50	120	15	80	20	50	15	70	"	46	15-120	37.7
Conductivity	micromho /cm	70	70	90	50	60	70	90	60	"	70	50-90	14.1
Turbidity		140	260	51	100	150	92	25	49	"	108	25-260	75.4
Silica	mg/ℓ	3.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	"	2.2	2.1-3.1	0.35
Sulphate	"	1.5	1.0	1.0	1.0	1.0	1.6	1.7	1.3	"	1.3	1.0-1.7	0.3
Ammonia (as N)	"	0.01	0.02	0.02	0	0.02	0.01	0.02	0.01	"	0.01	0-0.02	0.007
Nitrite (as N)	"	0.13	0.04	0	0	0.10	0.38	0	0.06	"	0.09	0-0.38	0.12
DO	"	6.5	5.7	6.3	6.7	5.8	6.1	7.0	5.6	"	6.2	5.6-7.0	0.5
Chloride	"	3	3	6	12	7	5	5	2	"	5	2-12	3.2
Hardness		23	23	30	18	21	28	33	23	"	25	18-30	5.0
Heavy Metal													
Cu	mg/ℓ	0.01	0.02	0	0.01	0.06	0.01	0.01	0	"	0.02	0-0.06	0.018
Zn	"	0.39	0.28	0.03	0.06	0.31	0.04	0.04	0.08	"	0.15	0.03-0.39	0.14
Fe	"	2.72	2.22	0.25	2.21	12.7	4.40	2.19	3.37	"	3.75	0.25-12.7	3.56
Mn	"	0.14	0.13	0.05	0.25	0.39	0.15	0.11	0.14	"	0.17	0.05-0.39	0.10
K	"	1.5	1.2	3.4	1.8	3.2	2.1	1.8	1.3	"	2.0	1.2-3.4	0.78
Na	"	4.1	4.2	8.0	2.8	7.9	6.2	5.2	3.9	"	5.6	2.8-8.0	1.79
Pb	"	0	0.01	0.01	0.02	0.02	0.01	0.01	0.01	"	0.01	0-0.02	0.006
Co	"	0.01	0	0	0.01	0.02	0	0	0	"	0.01	0-0.02	0.007
Cd	"	0	0	0	0	0	0	0	0	"	0	0	0
Cr	"	0	0	0	0.01	0.01	0.01	0	0	"	0.00	0-0.01	0.005

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (2/8)

Station: Beaufort (St. 2) Year: 1984

Date		18/1	7/2	9/3	11/5	22/6	17/7	7/8	7/9	N	Av	Rg	SD
Time		14:20	16:38	15:15	14:00	13:15	13:25	14:00	15:00				
pH*		6.74	6.20	6.43	-	-	-	-	6.66	4	6.51	6.20-6.74	0.24
Temperature*	°C	26	25	27	26	26	27	-	27	7	26.3	25-27	0.76
DO*	mg/ℓ	7.6	7.5	6.5	7.6	6.0	6.0	-	8.0	"	7.0	6.0-8.0	0.84
Conductivity*	micromho /cm	60	60	80	40	50	65	-	70	"	61	40-80	13.1
pH		6.5	7.0	6.5	6.8	6.8	6.8	7.2	7.1	8	6.8	6.5-7.2	0.26
Suspended Solids	mg/ℓ	102	132	81	146	386	118	20	17	"	125	17-386	115.8
Total Solids	"	222	194	127	156	478	189	102	65	"	192	65-478	126.0
BOD at 30°C	"	4.8	1.5	2.5	3.0	0	0	2.0	2.4	"	2.0	0-4.8	1.58
COD	"	12.2	8.4	3.0	15.1	0	0	8.1	3.0	"	5.6	0-15.1	5.66
Phosphones	"	0	0	0	0	0.01	0	0	0	"	0.00	0-0.01	0.00
Colour		30	50	20	90	20	40	5	20	"	34	20-90	26.4
Conductivity	micromho /cm	70	70	80	60	60	70	90	70	"	71	60-90	9.9
Turbidity		130	160	175	200	100	100	27	47	"	117	27-200	60.8
Silica	mg/ℓ	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	"	2.1	2.1	0
Sulphate	"	1.5	2.0	1.4	0.8	1.6	1.0	1.6	1.8	"	1.5	0.8-2.0	0.39
Ammonia (as N)	"	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	"	0.02	0.02	0
Nitrite (as N)	"	0.13	0.05	0	0	0.05	0.33	0	0.05	"	0.08	0-0.33	0.11
DO	"	6.9	6.4	6.6	6.6	6.2	6.1	6.6	5.5	"	6.4	5.5-6.9	0.43
Chloride	"	3	2	5	14	7	5	5	3	"	6	2-14	3.8
Hardness		24	24	28	20	22	28	34	28	"	26	20-34	4.2
Heavy Metal													
Cu	mg/ℓ	0.01	0.01	0	0.01	0.02	0.01	0	0	"	0.01	0-0.02	0.007
Zm	"	0.23	0.09	0.02	0.04	0.08	0.04	0.06	0.15	"	0.09	0.02-0.23	0.07
Fe	"	2.35	2.01	0.22	2.04	12.10	4.11	1.84	4.03	"	3.59	0.22- 12.1	3.66
Mn	"	0.11	0.16	0.05	0.23	0.34	0.16	0.09	0.18	"	0.17	0.05-0.34	0.09
K	"	1.8	1.1	1.4	2.3	2.1	1.5	1.3	1.5	"	1.6	1.1-2.3	0.41
Na	"	4.9	3.6	5.0	3.0	4.9	4.1	5.0	4.0	"	4.3	3.0-5.0	0.76
Pb	"	0.02	0.01	0	0.02	0.02	0.01	0.01	0.01	"	0.01	0-0.02	0.007
Co	"	0.00	0	0	0.02	0.01	0	0	0	"	0.00	0-0.02	0.007
Cd	"	0.02	0.01	0	0.02	0.02	0	0.01	0	"	0.01	0-0.02	0.009
Cr	"	0.00	0	0	0.02	0.01	0.01	0	0	"	0.01	0-0.02	0.007

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (3/8)

Station: Amboi (Sta. 3) Year: 1984

Date		18/1	7/2	9/3	7/8	13/9	N	Av	Rg	SD
Time		9:00	8:15	16:25	14:40	15:30				
pH*		5.20	6.77	6.05	6.71	6.49	5	6.24	5.20-6.77	0.45
Temperature*	°C	24	25	28	29	24	"	26.0	24-29	2.35
DO*	mg/ℓ	7.5	6.2	6.0	5.3	6.9	"	6.4	5.3-7.5	0.81
Conductivity*	micromho /cm	40	70	50	102	35	"	59	35-102	27.3
pH		8.3	7.4	7.4	7.2	6.9	"	7.4	6.9-83	0.52
Suspended Solids	mg/ℓ	100	63	70	4	178	"	83	4-178	63.5
Total Solids	"	389	178	117	99	262	"	209	99-389	119.1
BOD at 30°C	"	4.8	2.4	1.0	2.7	1.5	"	2.5	1.0-4.8	1.47
COD	"	20.0	8.2	11.7	3.0	15.0	"	11.6	3.0-20.0	6.47
Phosphones	"	0	0	0	0	0.01	"	0.00	0-0.01	0.004
Colour		90	30	30	5	20	"	35	5-90	32.4
Conductivity	micromho /cm	50	80	50	110	40	"	66	40-110	28.8
Turbidity		200	44	36	21	100	"	80	21-200	73.3
Silica	mg/ℓ	2.1	2.1	2.1	2.1	2.1	"	2.1	2.1	0
Sulphate	"	1.0	1.6	0.8	2.3	1.5	"	1.4	1.0-23	0.59
Ammonia (as N)	"	0.02	0.01	0.02	0.01	0.02	"	0.02	0.01-0.02	0.006
Nitrite (as N)	"	0.04	0	0.04	0.07	0.02	"	0.03	0-0.07	0.03
DO	"	4.6	7.1	6.0	6.7	6.4	"	6.2	4.6-7.1	0.96
Chloride	"	4	3	6	6	3	"	4	3-6	1.5
Hardness		18	30	18	39	17	"	24	17-39	9.8
Heavy Metal										
Cu	mg/ℓ	0.01	0.01	0.01	0.01	0.01	"	0.01	0.01	0
Zm	"	0.33	0.27	0.28	0.19	0.09	"	0.23	0.09-0.33	0.09
Fe	"	2.18	2.17	1.98	2.24	5.82	"	2.88	1.98-5.82	1.05
Mn	"	0.27	0.13	0.23	0.22	0.28	"	0.23	0.13-0.28	0.06
K	"	1.5	1.6	1.7	1.3	1.3	"	1.5	1.3-1.7	0.18
Na	"	2.9	5.0	4.5	5.6	3.0	"	4.2	2.9-5.6	1.21
Pb	"	0.01	0.02	0.02	0.01	0.01	"	0.01	0.01-0.02	0.006
Co	"	0	0	0	0	0.01	"	0.00	0-0.10	0.005
Cd	"	0	0	0	0	0	"	0	0	0
Cr	"	0.01	0.01	0.01	0	0.01	"	0.01	0-0.01	0.005

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (4/8)

Station: Kouran (St. 4) Year: 1984

Date		18/1	7/2	9/3	N	Av	Rg	SD
Time		16:40	16:30	8:57				
pH*		6.04	6.40	6.20	3	6.21	6.04-6.40	0.18
Temperature*	oC	24	25	25	"	24.7	24-25	0.58
DO*	mg/ℓ	9.2	8.3	6.7	"	8.1	6.7-9.2	1.26
Conductivity*	micromho /cm	35	40	30	"	35	30-40	5.0
pH		8.1	7.5	7.1	"	7.6	7.1-8.1	0.50
Suspended Solids	mg/ℓ	98	1	115	"	71	1-115	61.5
Total Solids	"	99	111	162	"	124	99-162	33.5
BOD at 30oC	"	3.4	1.9	0.5	"	1.9	0.5-3.4	1.45
COD	"	14.3	13.7	21.0	"	16.3	13.7-21.0	4.05
Phosphones	"	0	0	0	"	0	0	0
Colour		20	30	20	"	23	20-30	5.8
Conductivity	micromho /cm	40	50	40	"	43	40-50	5.8
Turbidity		20	9	38	"	22	9-38	14.6
Silica	mg/ℓ	2.1	2.1	2.1	"	2.1	2.1	0
Sulphate	"	1.5	1.6	1.0	"	1.4	1.0-1.6	0.32
Ammonia (as N)	"	0.02	0.01	0.02	"	0.02	0.01-0.02	0.006
Nitrite (as N)	"	0.05	0	0.04	"	0.03	0-0.05	0.016
DO	"	7.1	6.7	6.3	"	6.7	6.3-7.1	0.04
Chloride	"	3	3	6	"	4	3-6	1.7
Hardness		13	20	13	"	15	13-20	4.0
Heavy Metal								
Cu	mg/ℓ	0.01	0.01	0.01	"	0.01	0.01	0
Zm	"	0.24	0.27	0.07	"	0.19	0.07-0.27	0.11
Fe	"	1.09	0.73	2.94	"	1.59	0.73-2.94	1.28
Mn	"	0.08	0.05	0.11	"	0.08	0.05-0.11	0.03
K	"	1.0	0.9	0.9	"	0.9	0.9-1.0	0.06
Na	"	3.0	3.9	2.7	"	3.2	2.7-3.9	0.62
Pb	"	0.01	0.01	0.01	"	0.01	0.01	0
Co	"	0	0	0	"	0	0	0
Cd	"	0	0	0	"	0	0	0
Cr	"	0	0.01	0.02	"	0.01	0-0.02	0.01

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (5/8)

Station: Keningau (St. 5) Year: 1984

Date		18/1	7/2	9/3	11/5	14/8	13/9	N	Av	Rg	SD
Time		10:40	14:10	14:12	14:55	16:15	16:50				
pH*		6.37	7.40	6.20	-	7.38	6.45	5	6.76	2.60-7.40	0.58
Temperature*	^{o}C	21	26	26	25	29	25	6	25.3	21-29	2.58
DO*	mg/ℓ	7.5	7.4	7.0	-	7.2	6.8	"	7.2	6.8-7.5	0.26
Conductivity*	micromho /cm	60	80	80	40	110	60	"	71	40-110	24.0
pH		8.2	7.1	7.1	7.3	7.5	7.0	"	7.4	7.0-8.2	0.45
Suspended Solids	mg/ℓ	92	67	23	218	-	58	5	92	23-218	74.9
Total Solids	"	264	135	78	260	102	125	6	161	78-264	81.0
BOD at 30°C	"	4.3	1.0	0	2.0	4.4	2.0	"	2.3	0-4.4	1.76
COD	"	17.1	5.5	5.9	10.0	12.0	8.9	"	9.9	5.5-17.1	4.30
Phosphones	"	0	0	0	0.01	-	0	5	0.00	0-0.01	0.005
Colour		40	5	5	120	5	5	6	30	5-120	46.3
conductivity	micromho /cm	70	90	50	60	120	70	"	77	50-120	25.0
Turbidity		220	11	4.5	330	5.5	50	"	104	5-330	138.4
Silica	mg/ℓ	2.1	2.1	2.1	2.1	2.1	2.1	"	2.1	2.1	0
Sulphate	"	1.0	1.0	1.0	0.8	-	1.5	5	1.1	0.8-1.5	0.26
Ammonia (as N)	"	0.02	0.01	0.02	0.04	-	0.02	"	0.02	0.01-0.04	0.01
Nitrite (as N)	"	0.08	0.05	0.04	0	0.05	0	6	0.04	0-0.08	0.03
DO	"	6.7	6.5	6.0	6.5	6.8	6.7	"	6.5	6.0-6.8	0.29
Chloride	"	4	2	5	13	-	2	5	5	2-13	4.6
Hardness		25	34	30	23	-	27	"	28	23-34	4.3
Heavy Metal											
Cu	mg/ℓ	0.01	0.01	0.02	0.03	0.01	0.01	6	0.02	0.01-0.03	0.008
Zm	"	0.25	0.48	0.27	0.08	0.16	0.08	"	0.22	0.08-0.48	0.15
Fe	"	1.91	1.02	0.94	2.34	0.76	3.32	"	1.72	0.76-3.32	1.00
Mn	"	0.14	0.09	0.07	0.63	0.08	0.17	"	0.19	0.07-0.63	0.22
K	"	1.3	1.1	1.0	1.6	1.1	1.0	"	1.2	1.0-1.6	0.23
Na	"	3.4	4.1	4.9	3.7	5.4	3.1	"	4.1	3.1-5.4	0.89
Pb	"	0.09	0.01	0.02	0.03	0.01	0.01	"	0.03	0.01-0.09	0.03
Co	"	0	0	0	0.02	0	0	"	0.00	0-0.02	0.008
Cd	"	0	0	0	0	0	0	"	0	0	0
Cr	"	0	0.01	0.01	0	0	0.01	"	0.01	0-0.01	0.006

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (6/8)

Station: Apin-Apin (St. 6) Year: 1984

Date		18/1	7/2	9/3	11/5	14/8	13/9	N	Av	Rg	SD
Time		9:30	12:00	11:18	13:25	11:20	13:22				
pH*		7.76	6.95	7.66	-	7.92	7.47	5	7.60	6.95-7.92	0.37
Temperature*	°C	21	23	26	25	25	23	6	23.8	21-26	1.83
DO*	mg/ℓ	8.2	8.0	8.0	-	7.0	9.1	"	8.1	7.0-9.1	0.67
Conductivity*	micromho /cm	57	100	70	50	100	70	"	75	50-100	21.2
pH		8.0	7.6	7.2	7.4	7.4	7.4	"	7.5	7.2-8.0	0.28
Suspended Solids	mg/ℓ	105	2	0	14	8	13	"	24	0-105	40.2
Total Solids	"	107	113	82	98	90	95	"	97	82-113	11.3
BOD at 30°C	"	4.3	1.9	0	1.5	0	0	"	1.3	0-4.3	1.70
COD	"	11.4	2.7	2.9	9.1	0	0	"	4.4	0-11.4	4.79
Phosphones	"	0	0	0	0	0	-	5	0	0	0
Colour		5	5	5	10	5	10	6	7	5-10	2.6
Conductivity	micromho /cm	80	110	50	80	120	90	"	88	50-120	24.8
Turbidity		13	5.5	5.5	25	6.0	4.0	"	10	4.0-25	8.0
Silica	mg/ℓ	2.1	2.1	2.1	2.1	2.1	2.1	"	2.1	2.1	0
Sulphate	"	1.0	1.0	0.8	0.5	1.6	1.2	"	1.0	0.5-1.6	0.37
Ammonia (as N)	"	0.01	0.01	0.03	0	0	0.02	"	0.01	0-0.03	0.01
Nitrite (as N)	"	0.05	0.01	0	0	0.05	0	"	0.02	0-0.05	0.02
DO	"	7.0	6.9	7.2	6.5	7.1	7.1	"	7.0	6.5-7.2	0.25
Chloride	"	4	3	4	12	5	2	"	5	2-12	3.6
Hardness		33	45	42	31	48	37	"	39	31-48	6.8
Heavy Metal											
Cu	mg/ℓ	0.01	0.01	0	0	0.01	0	"	0.01	0-0.01	0.006
Zm	"	0.25	0.51	0.16	0.06	0.14	0.08	"	0.20	0.06-0.51	0.17
Fe	"	0.38	0.38	0.48	0.94	0.34	0.42	"	0.49	0.34-0.94	0.23
Mn	"	0.03	0.05	0.08	0.07	0.04	0.03	"	0.05	0.03-0.08	0.02
K	"	0.6	0.9	0.8	1.0	1.0	0.9	"	0.9	0.7-1.0	0.12
Na	"	3.4	4.2	4.9	3.2	5.0	3.4	"	4.0	3.2-5.0	0.80
Pb	"	0.01	0.02	0.02	0.02	0.01	0.01	"	0.02	0.01-0.02	0.006
Co	"	0	0	0	0	0	0	"	0	0	0
Cd	"	0	0	0	0	0	0	"	0	0	0
Cr	"	0	0.01	0.01	0	0	0.01	"	0.01	0-0.01	0.006

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (7/8)

Station: Tambunan (St. 7) Year: 1984

Date		18/1	7/2	9/3	11/5	14/8	13/9	N	Av	Rg	SD
Time		8:15	14:15	13:42	12:10	10:25	11:05				
pH*		5.53	6.96	6.78	-	7.10	5.84	5	6.44	5.53-7.10	0.71
Temperature*	°C	20	26	32	29	25	23	6	25.9	20-32	4.26
DO*	mg/ℓ	7.5	7.2	7.0	-	9.4	7.1	"	7.6	7.0-9.4	0.90
Conductivity*	micromho /cm	55	60	60	39	80	50	"	57	39-80	13.6
pH		8.0	7.6	7.1	7.1	7.4	7.2	"	7.4	7.1-8.0	0.35
Suspended Solids	mg/ℓ	82	7	8	117	8	9	"	39	7-117	48.9
Total Solids	"	96	85	63	187	70	69	"	95	63-187	46.7
BOD at 30°C	"	3.4	2.4	1.0	1.0	0	1.0	"	1.5	0-3.4	1.22
COD	"	14.3	2.7	8.8	24.0	0	3.0	"	8.8	0-24.0	9.65
Phosphones	"	0	0	0	0.01	0	0	"	0.00	0-0.01	0.004
Colour		5	5	5	60	5	5	"	14	5-60	22.5
Conductivity	micromho /cm	60	70	30	50	100	60	"	62	30-100	23.2
Turbidity		8.5	7.0	5.5	130	5.5	10	"	28	5.5-130	50.1
Silica	mg/ℓ	2.1	2.5	2.1	2.1	2.1	1.0	"	2.0	1.0-2.5	0.51
Sulphate	"	1.0	0.5	0.5	0.5	0.4	0.7	"	0.6	0.4-1.0	0.20
Ammonia (as N)	"	0.01	0.02	0.01	0	0	0.04	"	0.02	0-0.04	0.02
Nitrite (as N)	"	0	0	0.04	0	0.04	0	"	0.01	0-0.04	0.02
DO	"	6.7	7.0	6.9	7.0	7.1	7.0	"	7.0	6.7-7.1	0.14
Chloride	"	3	2	6	11	3	3	"	5	2-11	3.4
Hardness		27	26	26	21	40	26	"	28	21-40	6.4
Heavy Metal											
Cu	mg/ℓ	0.02	0.01	0	0.01	0.01	0	"	0.01	0-0.02	0.008
Zm	"	0.25	0.35	0.10	0.12	0.13	0.06	"	0.17	0.06-0.35	0.11
Fe	"	0.77	0.53	0.88	2.02	0.61	0.74	"	0.93	0.53-2.02	0.55
Mn	"	0.12	0.07	0.07	0.31	0.04	0.05	"	0.11	0.04-0.31	0.10
K	"	1.5	0.8	1.3	1.3	0.8	0.8	"	1.1	0.8-13	0.32
Na	"	3.4	7.5	4.0	2.9	4.4	2.9	"	4.2	2.9-7.5	1.73
Pb	"	0.01	0.02	0.02	0.02	0.01	0	"	0.01	0-0.02	0.008
Co	"	0	0	0	0.01	0	0	"	0.00	0-0.01	0.004
Cd	"	0	0	0	0	0	0	"	0	0	0
Cr	"	0	0.01	0.02	0	0	0.01	"	0.01	0-0.02	0.00

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.1 WATER QUALITY ANALYSIS OF THE PADAS RIVER BASIN (8/8)

Station: Biah (St. 8) Year: 1984

Date		18/1	7/2	9/3	N	Av	Rg	SD
Time		11:20	13:25	13:41				
pH*		6.17	6.53	6.73	3	6.48	6.17-6.73	0.28
Temperature*	°C	21	24	28	"	24.3	21-28	3.51
DO*	mg/ℓ	8.4	7.1	5.0	"	6.7	5.0-8.0	1.54
Conductivity*	micromho /cm	110	115	150	"	125	110-150	21.8
pH		8.0	7.5	7.0	"	7.5	7.0-8.0	0.50
Suspended Solids	mg/ℓ	149	62	48	"	86	48-149	143.5
Total Solids	"	249	193	139	"	194	139-249	55.0
BOD at 30°C	"	3.4	3.9	3.0	"	3.4	3.0-3.9	0.45
COD	"	11.4	10.9	8.8	"	10.4	8.8-11.4	1.38
Phosphones	"	0	0	0	"	0	0	0
Colour		40	30	5	"	25	5-40	26.5
Conductivity	micromho /cm	110	120	160	"	130	110-160	26.5
Turbidity		140	44	60	"	65	44-140	47.4
Silica	mg/ℓ	3.1	5.1	3.1	"	2.1	2.1	0
Sulphate	"	3.9	2.7	2.7	"	3.1	2.7-3.9	0.69
Ammonia (as N)	"	0.02	0.01	0.02	"	0.02	0.01-0.02	0.006
Nitrite (as N)	"	0.04	0	0.18	"	0.07	0-0.18	0.08
DO	"	6.1	2.0	6.2	"	4.8	2.0-6.2	3.87
Chloride	"	3	-	6	2	5	3-6	1.5
Hardness		43	47	57	3	49	43-57	7.2
Heavy Metal								
Cu	mg/ℓ	0.01	0.01	0.01	"	0.01	0.01	0
Zn	"	0.23	0.53	0.18	"	0.29	0.18-0.53	0.10
Fe	"	1.90	2.23	0.12	"	1.42	0.12-2.23	1.17
Mn	"	0.27	0.21	0.14	"	0.21	0.14-0.27	0.07
K	"	2.3	3.1	3.3	"	2.9	2.3-3.3	0.53
Na	"	5.8	7.6	8.3	"	7.2	5.8-8.3	1.35
Pb	"	0.01	0.02	0.02	"	0.02	0.01-0.02	0.006
Co	"	0	0.01	0	"	0.00	0-0.01	0.006
Cd	"	0	0	0	"	0	0	0
Cr	"	0	0.01	0.01	"	0.01	0-0.01	0.006

*: Field test

Source: Department of Environment

N: No. of data Av: Average Rg: Range SD: Standard deviation

Table A-2.2 WATER QUALITY ANALYSIS OF THE SOOK RIVER BASIN (1/4)

Station: Kg. Ansip Lant (St.9) River: Sook

Date Time		19/9 1730	27/9 1430	10/10 1440	Average
Temperature*	°C	29.0	28.0	26.0	27.7
Odour		Earthy	Earthy	Earthy	
pH		7.5	6.9	6.5	7.0
Colour		200	1,350	1,375	975
Turbidity		42	620	700	454
Conductivity	micromho /cm	100	60	38	66
Iron (Fe)	mg/ℓ	2.25	6.2	4.3	4.3
Manganese (Mn)	"	0.10	0.50	0.35	0.32
Chloride (Cl)	"	3	2	3	3
Free Carbon Dioxide	"	3.6	6.4	6.8	5.6
Alkalinity	"	33	28	11	24
Total Hardness	"	34	24	13	24
Total Organic Nitrogen	"	–	1.1	0	0.6
Ammonia (as N)	"	0.15	0.10	0.70	0.32
Nitrate (as N)	"	0.75	0.15	0	0.30
Nitrite (as N)	"	0	0	0	0
Oil and Grease	"	–	12	14	13
Oxygen Absorbed in 4 hrs	"	3.60	7.75	12.90	8.08
DO	"	5.45	8.0	4.85	6.1
Total Solids	"	90	358	424	291
Dissolved Solids	"	84	216	162	154
Suspended Solids	"	6	142	262	137
Sulphate (SO_4)	"	3.0	15.0	13.0	10.3
Cadmium (Cd)	"	–	0	0	0
Arsenic (As)	"	ND	ND	ND	ND
BOD	"	–	2.10	0	1.1
COD	"	–	9.2	76	42.6
Fluoride (F)	"	0.05	0	0.05	0.03
Phosphate (PO_4)	"	0	0	0	0
Potasium (K)	"	–	4.0	6.0	5.0
Calcium (Ca)	"	8.8	6.8	3.2	6.3
Sodium (Na)	"	–	3.6	1.2	2.4
Magnesium (Mg)	"	2.9	1.7	1.2	1.9

* : Field Test

Table A-2.2 WATER QUALITY ANALYSIS OF THE SOOK RIVER BASIN (2/4)

Station: Kg. Kuala Tigasa (St.10) River: Punteh

Date Time		19/9 1800	27/9 1500	10/10 1510	Average
Temperature*	°C	26.0	26.5	25.5	26.0
Odour		Earthy	Earthy	Earthy	
pH		7.7	7.5	6.5	7.2
Colour		250	250	1,375	625
Turbidity		69	80	760	303
Conductivity	micromho /cm	175	115	46	112
Iron (Fe)	mg/ℓ	1.30	1.60	5.20	2.7
Manganese (Mn)	"	0.10	0.15	0.40	0.22
Chloride (Cl)	"	3	2	3	3
Free Carbon Dioxide	"	4.0	4.0	5.6	4.5
Alkalinity	"	77	61	21	53
Total Hardness	"	66	51	26	48
Total Organic Nitrogen	"	–	2.3	0.74	1.52
Ammonia (as N)	"	0.15	0.18	0.40	0.36
Nitrate (as N)	"	0.40	0.05	0.05	0.17
Nitrite (as N)	"	0	0	0	0
Oil and Grease	"	–	25	15	20
Oxygen Absorbed in 4 hrs	"	4.05	4.55	13.70	7.43
DO	"	4.75	5.50	4.65	4.97
Total Solids	"	160	184	486	277
Dissolved Solids	"	144	152	170	155
Suspended Solids	"	16	32	316	121
Sulphate (SO_4)	"	12.0	13.5	14.0	13.2
Cadmium (Cd)	"	–	0	0	0
Arsenic (As)	"	ND	ND	ND	ND
BOD	"	–	0.30	0.50	0.40
COD	"	–	22.0	98	60.0
Fluoride (F)	"	0.10	0.05	0.20	0.12
Phosphate (PO_4)	"	0	0	0	0
Potasium (K)	"	–	8.9	7	8.0
Calcium (Ca)	"	18.0	14.0	7.2	13.1
Sodium (Na)	"	–	15.0	2.1	8.6
Magnesium (Mg)	"	5.1	3.8	1.9	3.6

* : Field Test

Table A-2.2 WATER QUALITY ANALYSIS OF THE SOOK RIVER BASIN (3/4)

Station: Kg. Kuala Aging (St.11)

Date Time		19/9 1600	27/9 1130	10/10 1145	Average
Temperature*	°C	27.5	26.0	25.5	26.3
Odour		Earthy	Earthy	Earthy	
pH		7.3	6.7	6.1	6.7
Colour		200	1,000	1,100	767
Turbidity		41	440	410	297
Conductivity	micromho /cm	92	50	38	60
Iron (Fe)	mg/ℓ	2.60	4.50	4.20	3.77
Manganese (Mn)	"	0.10	0.20	0.15	0.15
Chloride (Cl)	"	3	2	3	3
Free Carbon Dioxide	"	4.0	7.4	11.6	7.7
Alkalinity	"	42	29	13	28
Total Hardness	"	32	18	14	21
Total Organic Nitrogen	"	-	0.85	0.74	0.80
Ammonia (as N)	"	0.20	0.23	0.90	0.44
Nitrate (as N)	"	0.75	0.40	0.25	0.47
Nitrite (as N)	"	0	0	0	0
Oil and Grease	"	-	17	7	12
Oxygen Absorbed in 4 hrs	"	3.55	10.20	13.70	9.15
DO	"	4.75	6.75	1.80	4.43
Total Solids	"	128	290	292	237
Dissolved Solids	"	112	162	122	132
Suspended Solids	"	16	128	170	105
Sulphate (SO_4)	"	1.0	4.0	6.0	3.7
Cadmium (Cd)	"	-	0	0	0
Arsenic (As)	"	ND	ND	ND	ND
BOD	"	-	2.20	0	1.10
COD	"	-	12.0	33	22.5
Fluoride (F)	"	0.10	0.05	0.10	0.08
Phosphate (PO_4)	"	0	0	0	0
Potasium (K)	"	-	2.6	2.9	2.8
Calcium (Ca)	"	8.8	4.8	3.2	5.6
Sodium (Na)	"	-	4.6	1.2	2.9
Magnesium (Mg)	"	2.4	1.4	1.4	1.7

* : Field Test

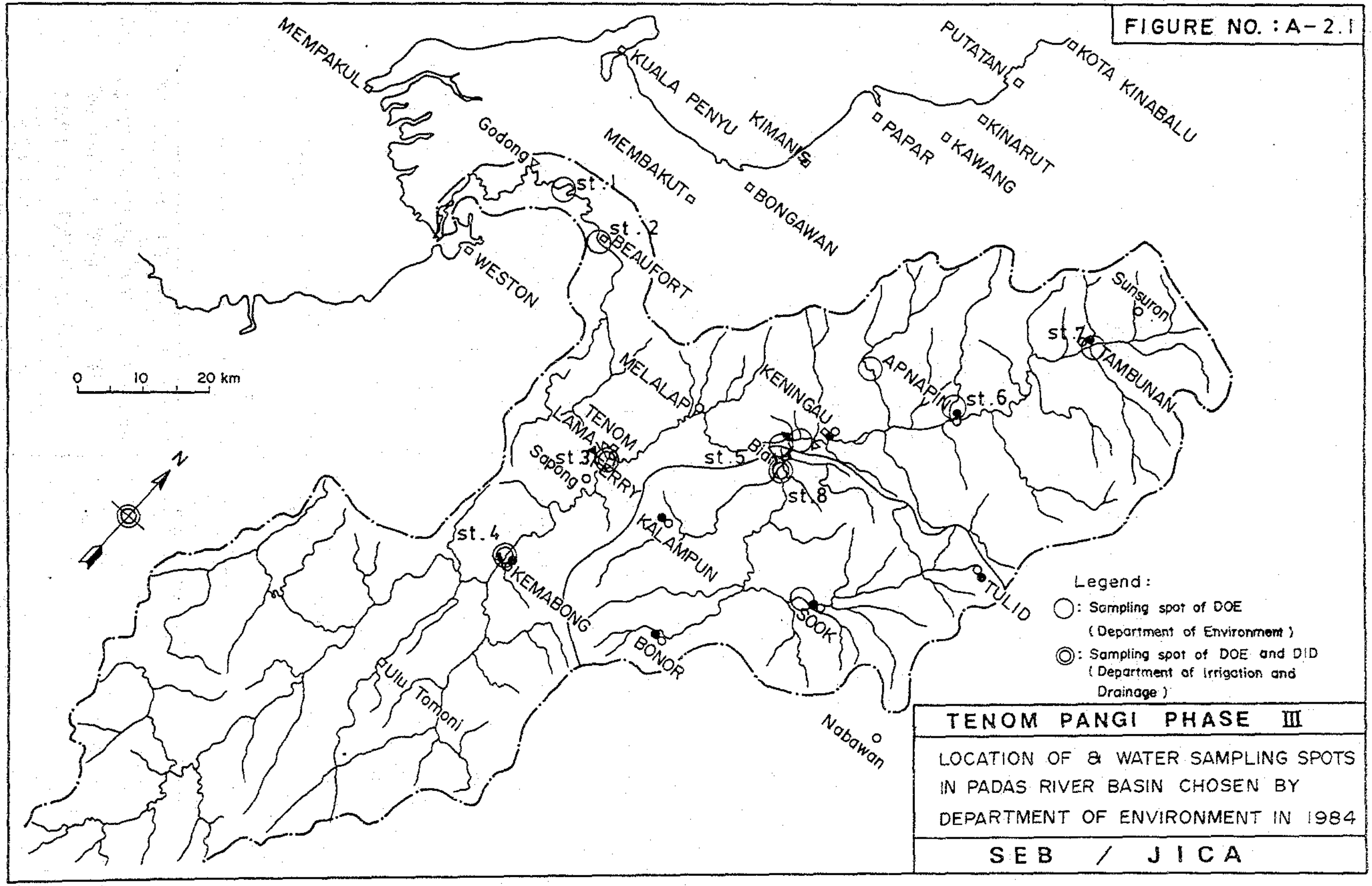
Table A-2.2 WATER QUALITY ANALYSIS OF THE SOOK RIVER BASIN (4/4)

Station: Kg. Karamatoi Tengah (St.12) River: Karamatoi

Date Time		19/9 1620	27/9 1150	10/10 1215	Average
Temperature*	°C	26.5	25.0	25.5	25.7
Odour		Earthy	Earthy	Earthy	
pH		7.3	6.6	6.5	6.8
Colour		1,350	1,500	400	1,083
Turbidity		510	780	185	492
Conductivity	micromho /cm	87	42	48	59
Iron (Fe)	mg/ℓ	3.35	5.20	2.20	3.58
Manganese (Mn)	"	0.20	0.55	0.15	0.30
Chloride (Cl)	"	2	3	3	3
Free Carbon Dioxide	"	4.4	7.0	6.4	5.9
Alkalinity	"	37	12	19	23
Total Hardness	"	29	16	12	19
Total Organic Nitrogen	"	-	0.99	0.53	0.76
Ammonia (as N)	"	0.06	0.25	0.25	0.19
Nitrate (as N)	"	1.30	0.15	0.15	0.53
Nitrite (as N)	"	0	0	0	0
Oil and Grease	"	-	13	13	13
Oxygen Absorbed in 4 hrs	"	3.70	10.85	4.75	6.43
DO	"	4.85	7.0	5.60	5.82
Total Solids	"	290	414	186	297
Dissolved Solids	"	148	230	68	149
Suspended Solids	"	142	184	118	148
Sulphate (SO_4)	"	17.0	6.0	10.0	11.0
Cadmium (Cd)	"	-	0	0	0
Arsenic (As)	"	ND	ND	ND	ND
BOD	"	-	3.05	0	1.5
COD	"	-	9.2	7.2	8.2
Fluoride (F)	"	0	0	0	0
Phosphate (PO_4)	"	0	0	0	0
Potasium (K)	"	-	5.4	3.3	4.4
Calcium (Ca)	"	7.6	2.8	2.8	4.4
Sodium (Na)	"	-	4.4	2.0	3.2
Magnesium (Mg)	"	2.4	2.2	1.9	2.2

* : Field Test

FIGURE NO. : A-2.1

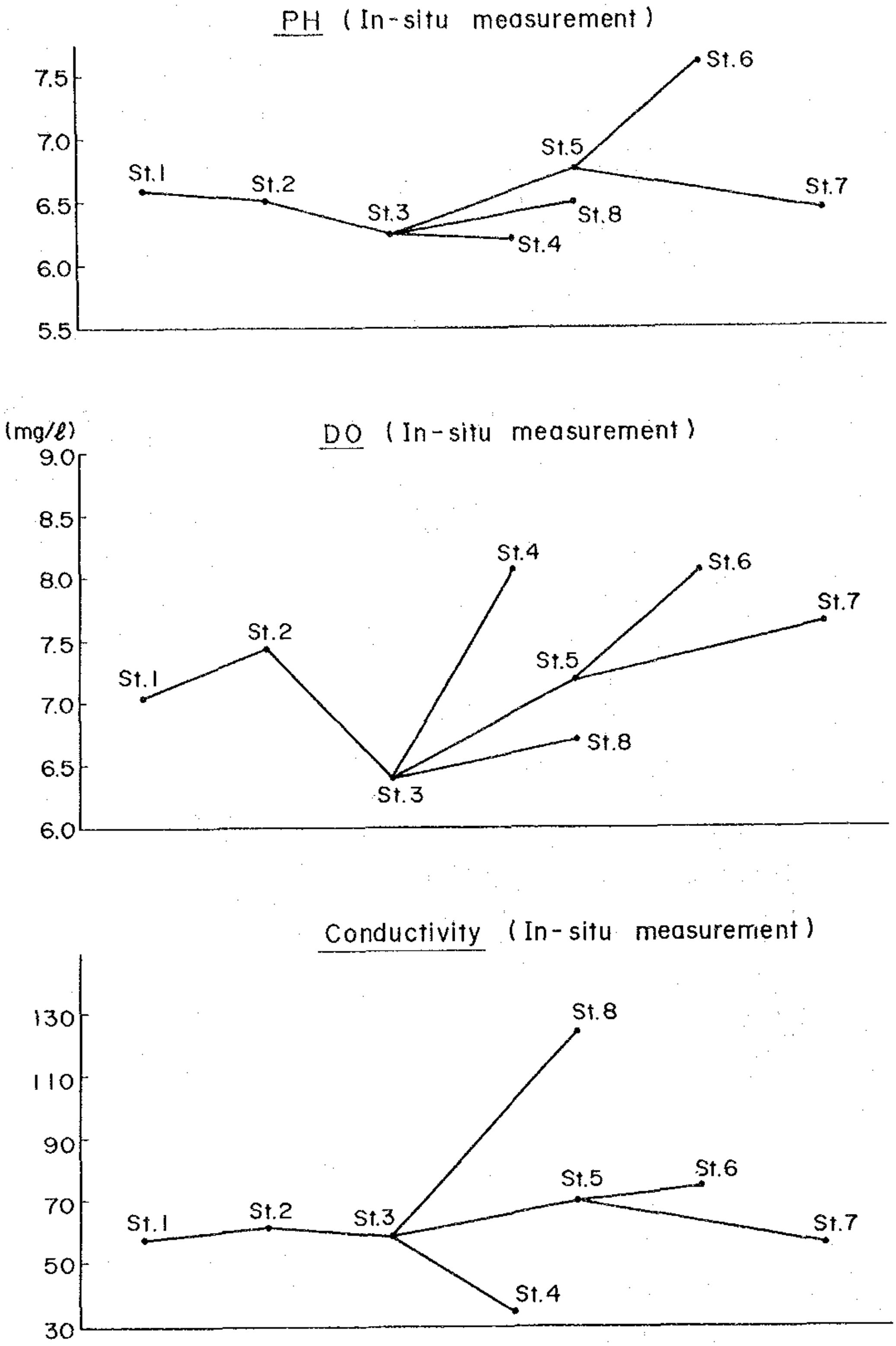


TENOM PANGI PHASE III

LOCATION OF 8 WATER SAMPLING SPOTS IN PADAS RIVER BASIN CHOSEN BY DEPARTMENT OF ENVIRONMENT IN 1984

SEB / JICA

FIGURE NO. :A-2.2(1/3)



Station No.	No. of Samples
1, 2, 5~7	6
3	5
4, 8	3

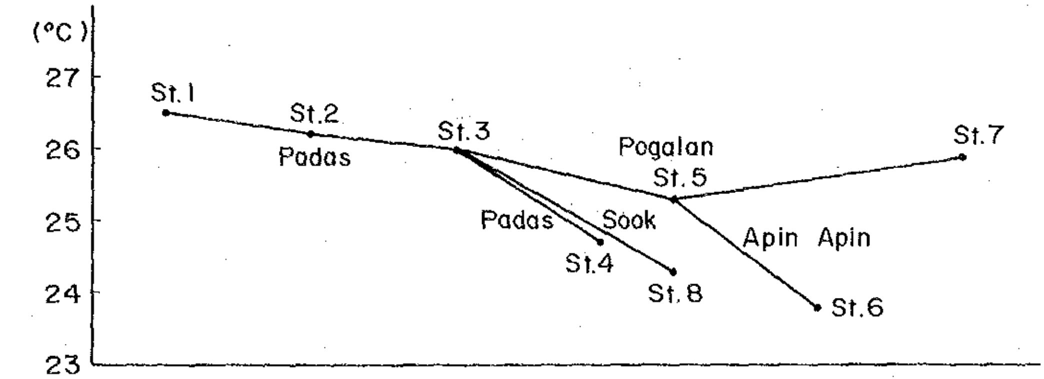
TENOM PANGI PHASE III

WATER QUALITY ANALYSES CONDUCTED BY THE DEPARTMENT OF ENVIRONMENT IN 1984

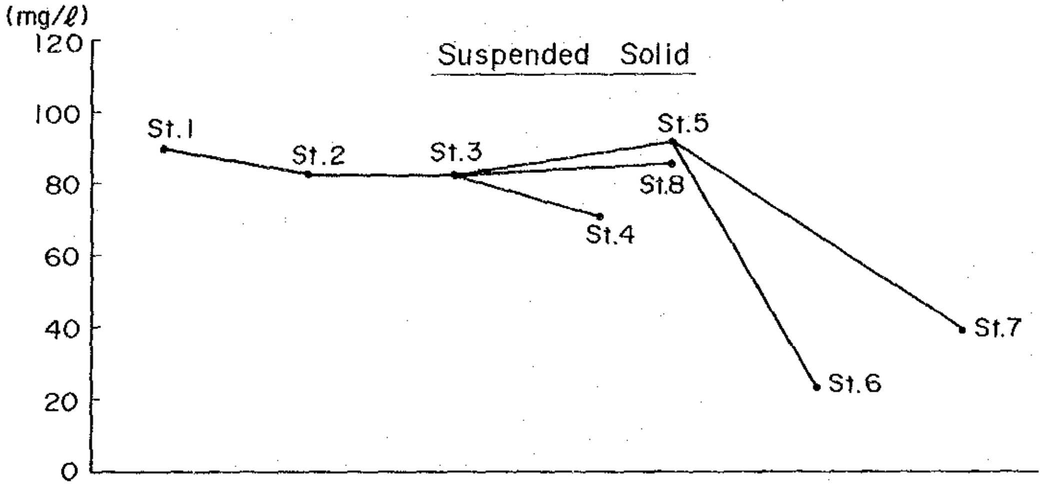
SEB / JICA

FIGURE NO. :A-2.2(2/3)

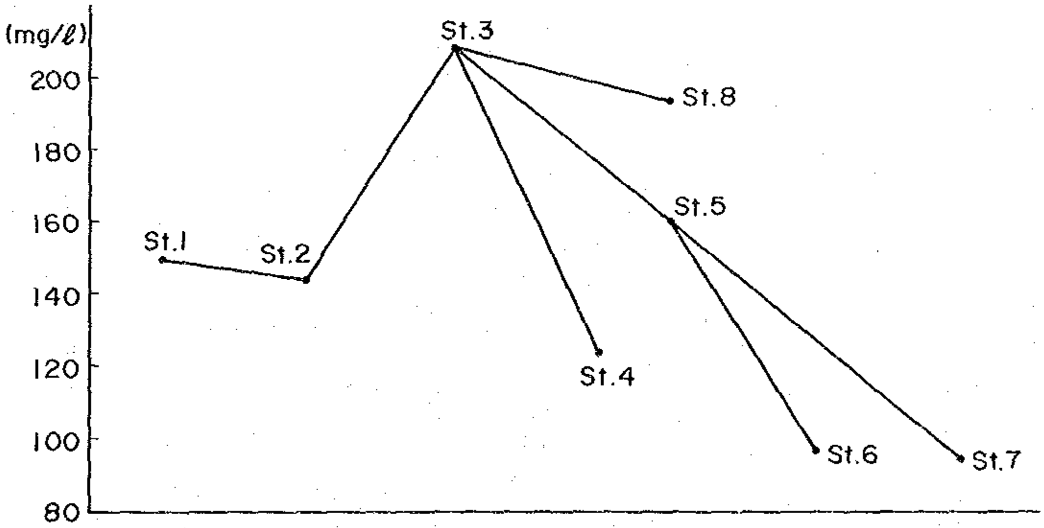
Temperature (In-situ measurement)



Suspended Solid



Total Solid



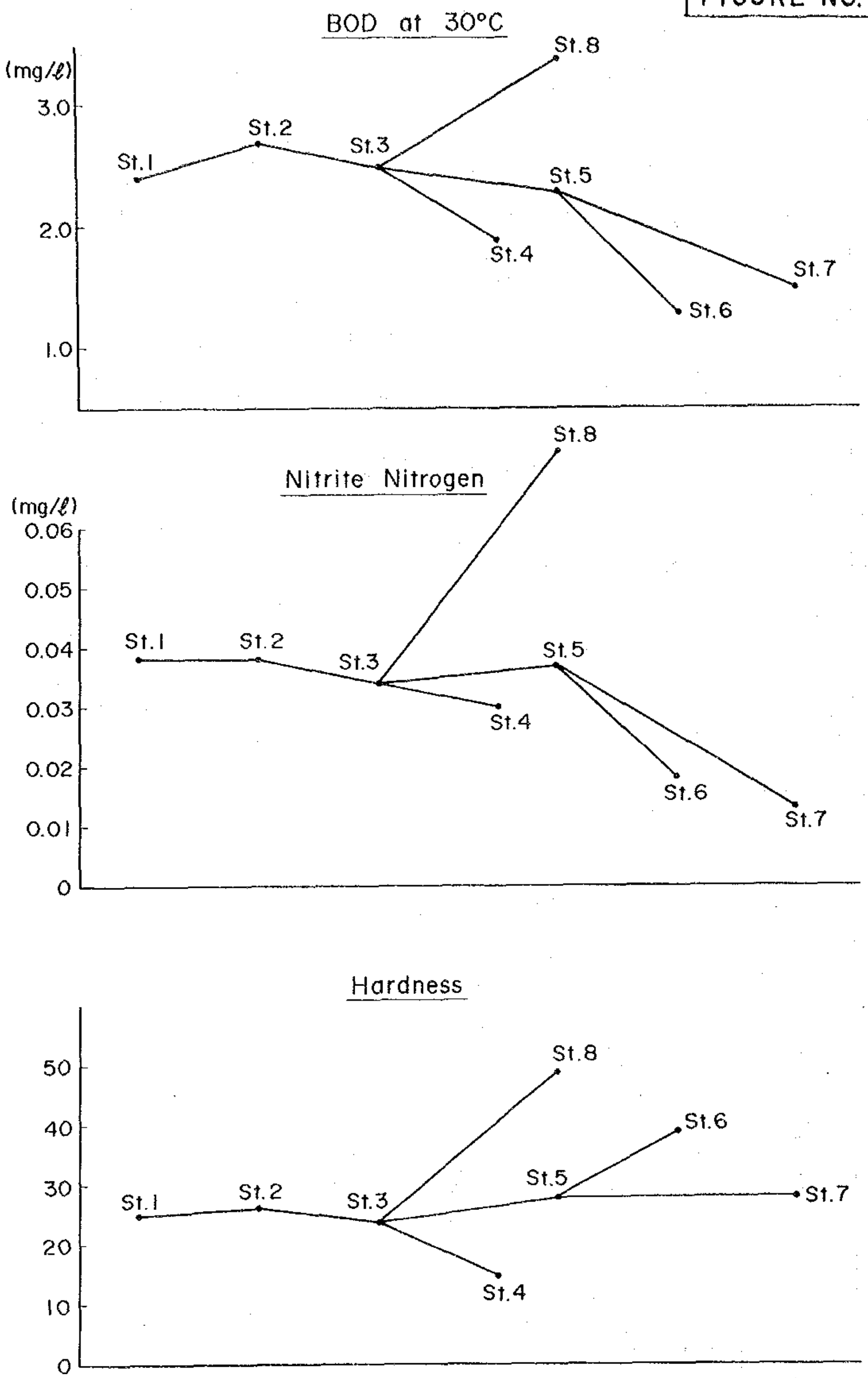
Station No.	No. of Samples
1,2,5~7	6
3	5
4,8	3

TENOM PANGI PHASE III

WATER QUALITY ANALYSES CONDUCTED BY THE DEPARTMENT OF ENVIRONMENT IN 1984

SEB / JICA

FIGURE NO. :A-2.2(3/3)



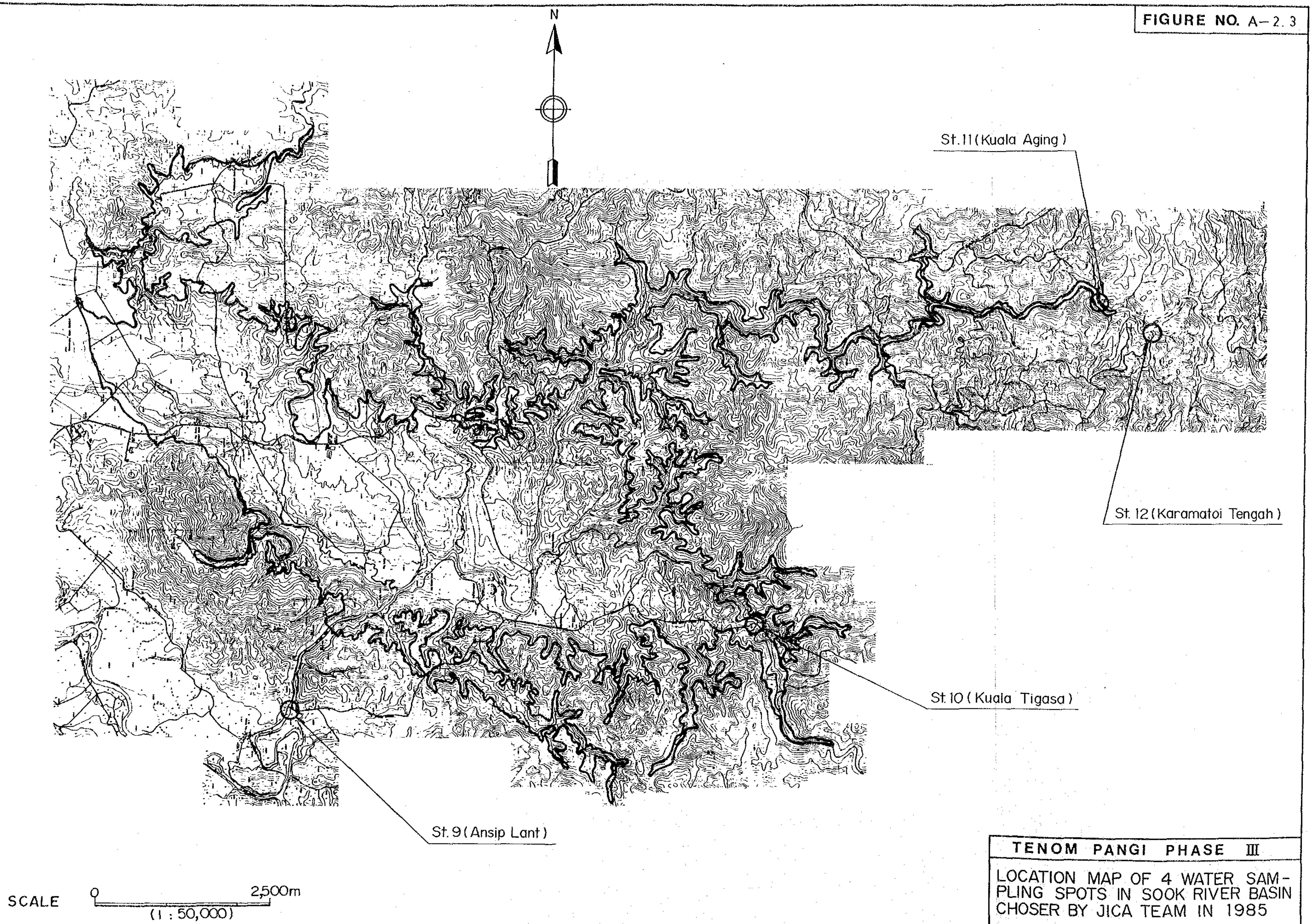
Station No.	No. of Samples
1, 2, 5~7	6
3	5
4, 8	3

TENOM PANGI PHASE III

WATER QUALITY ANALYSES CONDUCTED BY THE DEPARTMENT OF ENVIRONMENT IN 1984

SEB / JICA

FIGURE NO. A-2.3



TENOM PANGI PHASE III

LOCATION MAP OF 4 WATER SAMPLING SPOTS IN SOOK RIVER BASIN CHOSER BY JICA TEAM IN 1985

SEB / JICA

A-3.1 Study on Generation by Combined Cycle Plant

1) General

In Labuan island, about 8 million cu-feet per day of natural gas (NG) is reported to be available from SGI. So the study was made to operate the gas-fired combined cycle plant, and the cost comparison was made. The results are as summarized below.

2) Conditions and Assumptions

(1) The unit construction costs of combined cycle plant, based on constant 1985 price, are assumed as below:

(a) 60MW (20MW x 3 units)	US$1,200/kW
(b) 90MW (30MW x 3 units)	US$1,050/kW
(c) 180MW (60MW x 3 units)	US$ 850/kW

(2) Economic life of the plant is assumed to be 20 years.

(3) Operation, maintenance and replacement costs are estimated to be 2.5% of the construction cost for fixed portion and US¢0.25/kWh for variable portion.

(4) Life time of natural gas resource is not certain yet. If life time of natural gas resource is shorter than that of combined cycle plant, the cost of power generation will naturally become higher. In order to clarify this point, power generating cost of gas-fired combine cycle will be calculated for the cases of 20, 15 and 10 years of life time of natural gas resource.

(5) The price of natural gas is assumed to be M$ 5.00/1,000 cft. However calculation of power generating cost will be made for the cases of M$ 10.00/1,000 cft and M$ 15.00/1,000 cft of natural gas price to check its sensitivity.

(6) Installed capacity of gas-fired combined cycle plant is assumed to be 60MW (3 x 20MW) or 90MW (3 x 30MW) since available quantity of natural gas from SGI is estimated at 8 million cft per day. In this case, plant factor of the gas-fired combined cycle plant is calculated as below:

(a) Annual energy output of combined cycle plant:

$$\frac{8{,}000{,}000 \text{ cft/day} \times 365 \text{ days}}{8.5 \text{ cft/kWh}} \doteqdot 344 \times 10^6 \text{ kWh}$$

(b) Plant factor for 60 MW plant (20MW x 3 units):

$$\frac{344{,}000{,}000 \text{ kWh}}{60{,}000 \text{ kW} \times 24 \text{ hrs/day} \times 365 \text{ days}} = 0.654$$

(c) Plant factor for 90 MW Plant (30MW x 3 units):

$$\frac{344{,}000{,}000 \text{ kWh}}{90{,}000 \text{ kW} \times 24 \text{ hrs/day} \times 365 \text{ days}} = 0.436$$

Thus, plant factor of the combined cycle plant is assumed to be 0.6 and 0.7 for 60 MW plant and 0.4 and 0.5 for 90 MW plant to calculate the power generating cost.

(7) The power generating cost is calculated by the following equation:

$$C = \frac{P \times U \times (i+r) + P \times 24 \times 365 \times PF \times (f+v)}{P \times 24 \times 365 \times PF}$$

where, C : power generating cost (US$/kWh)

P : installed capacity (kW)

U : construction cost per kW (US$/kW)

i : capital recovery factor

r : rate of operation, maintenance and replacement costs for fixed portion

PF: plant factor

f : fuel price per kWh (US$/kWh)

[f = gas price x gas consumption rate
Gas consumption rate = 8.5 cft/kWh]

v : variable portion of operation, maintenance and replacement costs (US¢0.25/kWh)

(8) Discount rate is assumed to be 10 per cent.

Thus, capital recovery factors are given as below:

Period(year)	Capital recovery factor
10	0.1627
15	0.1315
20	0.1175

3) Power Generating Cost

Calculation results of power generating cost are tabulated as below:

(1) Installed capacity = 60 MW, Plant factor = 0.6

(Unit: US$/kWh)

Price of natural gas (M$/1,000 cft)	Life time of natural gas resource (years)		
	20	15	10
5.0	0.052	0.056	0.063
10.0	0.070	0.073	0.080
15.0	0.087	0.090	0.097

(2) Installed capacity = 60 MW, plant factor = 0.7

(Unit: US$/kWh)

Price of natural gas (M$/1,000 cft)	Life time of natural gas resource (years)		
	20	15	10
5.0	0.048	0.050	0.057
10.0	0.065	0.068	0.074
15.0	0.082	0.085	0.091

(3) Installed capacity = 90 MW, plant factor = 0.4

(Unit: US$/kWh)

Price of natural gas (M$/1,000 cft)	Life time of natural gas resource (years)		
	20	15	10
5.0	0.062	0.067	0.076
10.0	0.080	0.084	0.093
15.0	0.097	0.0101	0.111

(4) Installed capacity = 90 MW, plant factor = 0.5

(Unit: US$/kWh)

Price of natural gas (M$/1,000 cft)	Life time of natural gas resource (years)		
	20	15	10
5.0	0.054	0.057	0.065
10.0	0.072	0.075	0.082
15.0	0.089	0.092	0.100

The above results are also depicted in Figure A-3.1.

4) Study Results

(1) The power generating cost of gas-fired combined cycle plant is US$0.048/kWh under the most favorable conditions that life time of natural gas resource is longer than the economic life time of the plant and price of natural gas is M$ 5.00/1,000 cft.

(2) Increase of the power generating cost is 3 to 7 per cent for 15 years of life time of natural gas resource against 20 years of the assumed plant life time and 11 to 20 per cent for 10 years of life time of natural gas resource.

(3) The power generating cost of gas-fired combine cycle plant increases in proportion to increase of natural gas price. When the natural gas price becomes double, it increases by 33 per cent on an average.

(4) In order to compare with the power generating cost of hydro power, the above power cost of combined cycle plant will be adjusted by the factor;

	Hydro	Combined cycle plant
Auxiliary power use:	0.5%	4.0%
Transmission loss:	4.0%	4.0%

$$\text{Energy adjustment factor} = \frac{(1-0.005)\ (1-0.004)}{(1-0.04)\ (1-0.04)} = 1.036$$

Therefore US$ 0.048/kWh of the lowest power generation cost of combined cycle plant is adjusted to be US$0.050/kWh (=0.048 x 1.036).

(5) The power generating cost of Tenom Pangi Project is estimated at US$0.053/kWh. Therefore, it is concluded that the combined cycle plant can not be economically superior to the Tenom Pangi Project, unless the following most preferable conditions are wholly provided for it:

a) The price of natural gas is cheaper than M$5.0/1,000 cft.

b) Life of natural gas resource is longer than 15 years.

c) Plant factor is bigger than 65 per cent.

Fig. A-3.1 Power Generating Cost of Combined Cycle Plant (1/2)

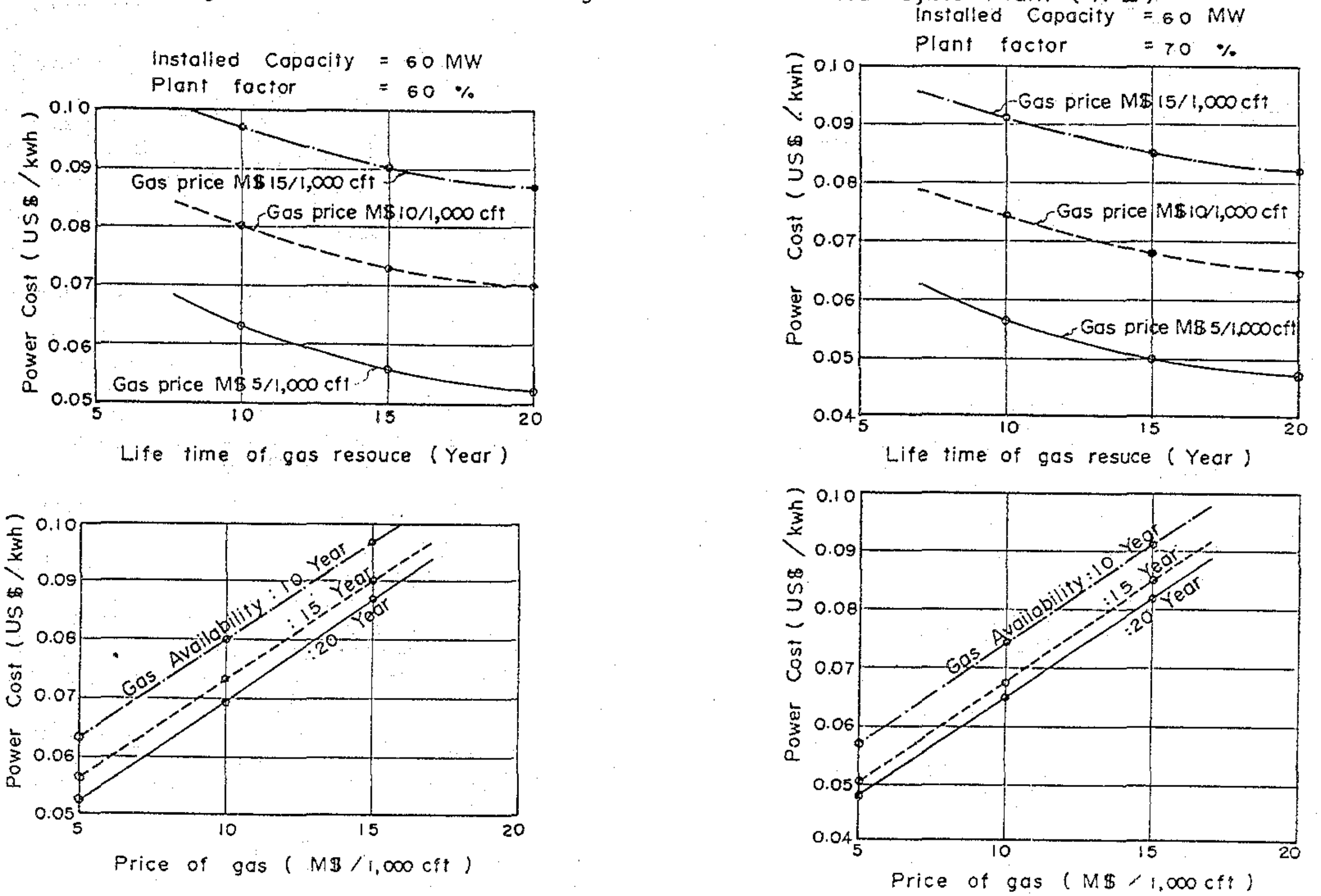


Fig. A - 3. 1 Power Generating Cost of Combined Cycle Plant (2/2)

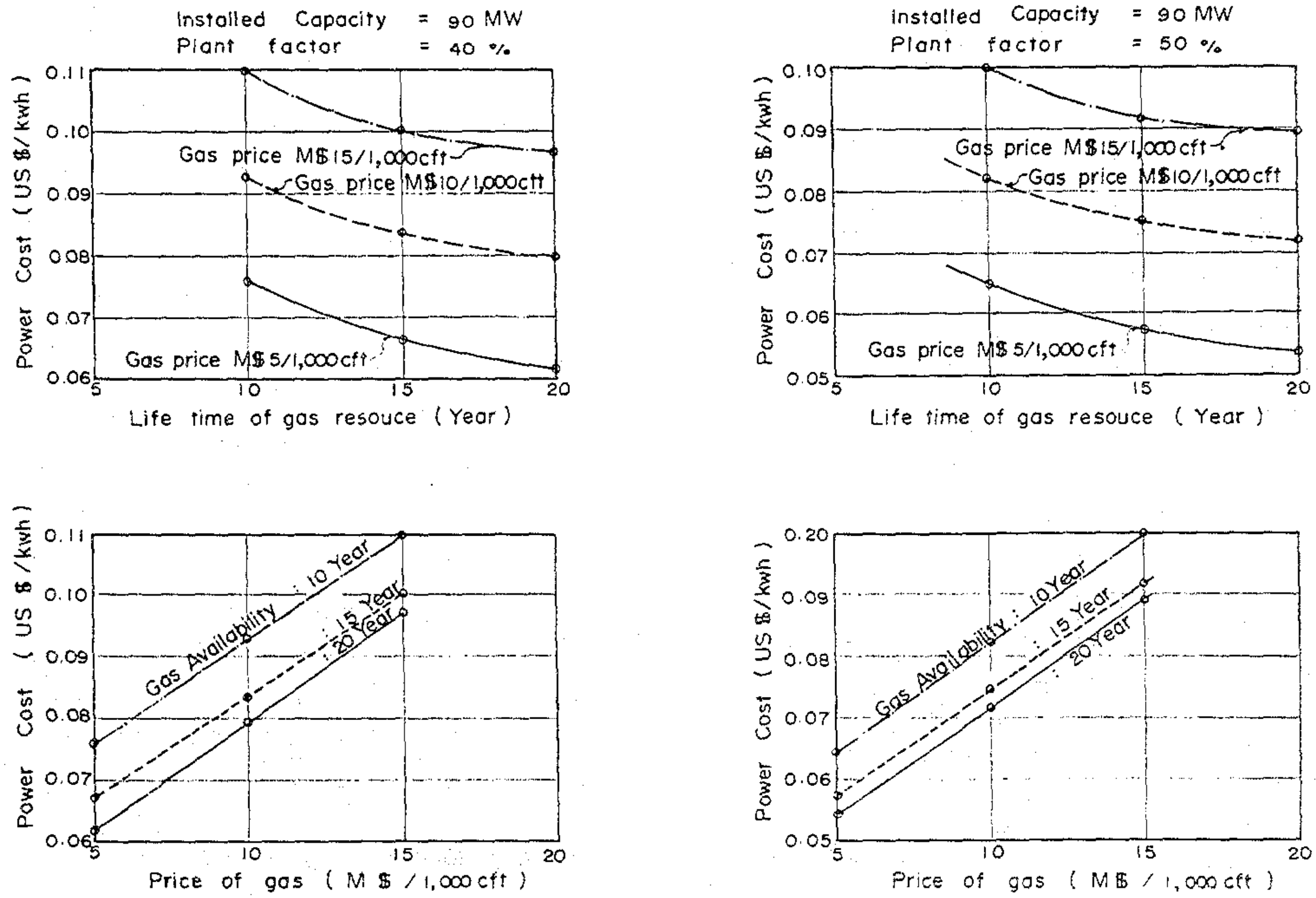


Table A-3.1 EXISTING GENERATING SETS (1)
(Kota Kinabalu Power Station)

Unit Number	Manufacturer	Type	Speed (r.p.m)	Commissioning Date	Estimated Retirement	Name Plate Rating (MW)	Derated Output (MW)	Projected after Rehabilitation (MW)
1.	English Electric	16SV	600	1961	1985	1.00	0.75	0.80
2./1	"	16CSV	750	1963	1987	1.50	0	0
3.	"	16SCV	750	1964	1987	1.60	1.00	1.30
4.	"	16CS	750	1965	1988	1.60	1.00	1.30
5./1	"	16V	600	1962	1983	1.00	0	0
6.	Ruston	18ATC	500	1979	1994	3.1	2.5	2.75
7.	"	18ATC	500	1968	1989	3.1	1.5	2.75
8.	Niigata	16V40X	428	1971	1989	5.0	4.0	4.3
9.	"	16V40X	428	1972	1986	5.3	3.8	4.0
10.	"	16V40X	428	1975	1989	5.3	4.0	4.4
11.	SEMT Pielstick	12PA0	1,000	1976	1990	2.75	2.0	2.5
12.	Pielstick	18PC2.5	500	1977	1994	8.1	6.5	7.4
13.	"	18PC2.5	500	1977	1994	8.1	6.5	7.4
14.	Niigata Pielstick	18PC2.5	500	1978	1995	8.22	6.5	7.4
15.	"	18PC2.5	500	1979	1995	8.22	6.5	7.4
16./2	Westinghouse	Gasturbine	1,500	1982	1998	14.75	14.75	14.75
17./2	"	Gasturbine	1,500	1982	1998	14.75	14.75	14.75

Note: /1. Not operational and parts are used for the running sets.
/2. Existing non-diesel generating sets.

Table A-3.2 EXISTING GENERATING SETS (2)
(Labuan Power Station)

Unit Number	Manufacturer	Type	Speed (r.p.m)	Commissioning Date	Estimated Retirement	Name Plate Rating (MW)	Derated Output (MW)	Projected after Rehabilitation (MW)
1.	English Electric	12SVA	750	1964	1988	1.00	0.8	0.85
2./1	"	6E 8CSV	750	-	1988	1.00	-	-
3.	SEMT Pielstick	12PC2.5	500	1977	1995	5.4	3.5	5.1
4.	"	12PC2.5	500	1978	1995	5.4	4.3	5.1
5.	N.K.K. Pielstick	12PC2.5	500	1981	1999	5.5	5.2	5.3
6.	Niigata Pielstick	18PC2.5	500	1984	2002	8.0	7.5	-

Note: /1. *Under installation.*

Table A-3.3 EXISTING GENERATING SETS (3)
(Keningan Power Station)

Unit Number	Manufacturer	Type	Speed (r.p.m)	Commissioning Date	Estimated Retirement	Name Plate Rating (MW)	Derated Output (MW)	Projected after Rehabilitation (MW)
1.	Dorman	12STK	1,500	1982	1994	0.5	0.45	0.45
2.	Caterpillar	3412DI	1,500	1979	1992	0.3	0.18	0.25
3.	Dorman	80TCA	1,500	1976	1990	0.3	0.21	0.25
4.	Caterpillar	3412DI	1,500	1979	1992	0.3	0.21	0.25
5.	Dorman	12STK	1,500	1976	1989	0.5	0.45	0.45
6.	Cummins	VT-635, GS	1,500	1976	1989	0.3	0.18	0.25
7.	Caterpillar	3412DI	1,500	1979	1992	0.3	0.24	0.25
8.	Ruston	6AP230	750	1982	1998	0.75	0.71	0.71
9.	"	"	750	1982	1998	0.75	0.71	0.71
10.	Caterpillar	3508CAT	1,500	1983	1999	0.5	0.45	0.45
11./1	Stark	-	-	1985		1.0		
12./1	"	-	-	1985		1.0		

Note: /1. Construction of foundations is going on as of July 1985 and the generating sets are expected to be commissioned toward the end of 1985.

Table A-3.4 EXISTING GENERATING SETS (4)
(Kudat Power Station)

Unit Number	Manufacturer	Type	Speed (r.p.m)	Commissioning Date	Estimated Retirement	Name Plate Rating (MW)	Derated Output (MW)	Projected after Rehabilitation (MW)
1.	Ruston	6AP230	750	1981	1997	0.75	0.6	0.66
2.	"	6AP230	750	1983	1998	0.75	-	0.66
3.	"	16PK3C	750	1976	1994	2.08	-	1.9
4.	"	16PK3C	750	1976	1994	2.08	-	1.9

Table A-3.5 EXISTING GENERATING SETS (5)
(Tenom Power Station)

Unit Number	Manufacturer	Type	Speed (r.p.m)	Commissioning Date	Estimated Retirement	Name Plate Rating (MW)	Derated Output (MW)	Projected after Rehabilitation (MW)
1.	Blackstone	EV5	600	1965	1985	0.15	0.1	0.1
2.	"	"	600	1965	1985	0.15	0.1	0.1
3.	Caterpillar	3412DI	1,500	1980	1993	0.3	0.21	0.25
4.	"	"	1,500	1978	1991	0.3	0.21	0.25
5.	"	"	1,500	1978	1991	0.3	0.25	0.25
6.	Dorman	12STK	1,500	1982	1995	0.5	0.45	0.45
7.	"	"	1,500	1982	1995	0.5	0.45	0.45

Table A-3.6 EXISTING GENERATING SETS (6)
(Kota Belud Power Station)

Unit Number	Manufacturer	Type	Speed (r.p.m)	Commissioning Date	Estimated Retirement	Name Plate Rating (MW)	Derated Output (MW)	Projected after Rehabilitation (MW)
1.	Dorman	12STK	1,500	1982/81	1995	0.5	0.42	0.45
2.	"	12QTCA	1,500	1976	1991	0.5	0.4	0.45
3.	"	12QTCA	1,500	-	-	0.5	0.4	0.45
4.	"	8QTCA	1,500	1975/71	1989	0.3	0.2	0.25
5.	"	6QT	1,500	1962	1987	0.18	0.1	0.15
6.	"	8QTCA	1,500	-	-	0.3	0.2	0.25
7.	Caterpillar	3508	1,500	1985	2006	0.5	0.45	-
8.	"	3508	1,500	1985	2000	0.5	0.45	-