12.2.4 Turbine Generator Facilities

The cost estimate is based on Japanese product and the local material. The Lub. oil tank, condenser, the compressed air pipes the pipe ruck, the Low voltage power supply cubicle and the cabling materials are supplied from the local materials. 10% of contingency is involved in the respective equipment.

The turbine generator facilities cost is shown in Table 12-4.

Table 12-4 Turbine Facilities Cost

Item	Cost (Million Baht)	Remarks
Steam Turbine and all Necessary Ancillary Plant	386.1	Steam Turbine, Valves, Lubricated Oil Equipment Turning Equipment, Grand Condensing Equipment and Supervisory Equipment
Condenser System Including CW Pumps	155.5	Condenser, CW Pump, Condenser Pump, Condenser Booster Pump
Feed Water System	88.2	Heaters (High No. 1, No. 2, Low No. 1, No. 2) Deareator
Boiler Feed Water Pump	74.8	BFP and Motor
Pipes	104.1	Main Steam Pipes and other pipes
Miscellaneous Plants Including Ceiling Crane	39.0	Auxiliary Cooling Water Pump, Cooler, Ceiling Crane
Generator and all Necessary Ancillary Plant	177.1	Generator, AVR, Exciter
I.P.B	25.3	
Electrical	101.0	6.6 kV C.B., 380 V C.B., D.C. Supply Cabling
Control and Instrument	207.9	Control Panel, CVCF, Instrumentation
Computer	153.7	
Transformer	90.2	Main Transformer, House Transformer, Stating Transformer
Spare Parts	20.8	
Total	1623.7	Foreign: Domestic = 1305:318.7

12.2.5 Miscellaneous Facilities

The cost estimate is based on Japanese product and the local material. The bag filter, the conveyor girder, the communication facilities and the fire fighting facilities apply largely the local material.

The miscellaneous facilities cost is shown in Table 12-5.

Table 12-5 Miscellaneous Facilities Cost

Item	Cost (Million Baht)	Remarks
Bag Filter	103.0	99% Dust Removed
Ash Handling System	100.5	Simplified Ash Handling System (Economical System) (Additional cost for the medium system in Chapter 11 is 700 million yen)
Lignite-Limestone Preparation System	209.7	Lignite Receiving & Dispatching System, Limestone Receiving & Dispatching System, Lignite-Limestone Crushing & Mixing System
Demineralized Water Treatment	39.0	Demineralized Water Treatment Facility
Waste Water Treatment	58.6	Waste Water Treatment Facility
Switchyard Switchgear	70.7	115 kV C.B., CT, PD, DS
Communication	49.7	Power Plant Communication Facility
Fire Fighting and Small Facility	106.7	Fire Fighting Facility, D.G.
Contingency (20%)	122	Contingency for Ash Handling System
Total	859.9	Foreign: Domestic = 547:312.9

12.2.6 Administration Cost

75 MW scale power plant is relatively scale in the grid system of EGAT and it is considered that the staffs in EGAT have an ample experience to implement the construction of this project.

The allocation of the local engineering fee is shown in Table 12-6. The existing facility such as office and resident are utilized during construction and those facility is not involved in the administration cost.

Table 12-6 Allocation of Staff and Cost

Man-year

Class of Staff (Salaries)	1993	1994	1995	1996	1997	Total
Class A (480,000 Baht/y)	2	3	3	3	1.5	13.5
Class B (Chief, Head) (360,000 Baht/y)	5	10	20	20	10	65
Class C (Engineer) (240,000 Baht/y)	30	40	80	80	20	250
Class D (Technician/Driver) (180,000 Baht/y)	20	30	80	80	20	230
Total Salaries (Million Baht)	13.56	20.04	40.24	40.24	12.72	126.8
Expense Rate	x 3.0	x 3.0	x 3.0	x 3.0	x 3.0	x 3.0
Total Administration Cost Round Value (Million Baht)	40	60	120	120	40	380

12.2.7 Import Duty

5% of FOB cost is added for the import duty.

12.2.8 Interest During Construction

Interest during construction (tentative) is to be

8% : All foreign currency portion
10% : All local currency portion

12.2.9 Total Construction Cost

The total construction cost is shown in Table 12-7.

Table 12-7 Total Construction Cost

(Million Baht)

	Foreign	Local	Total
Civil & Structure	145.8	910.2	1,056
Boiler	1,363	466.7	1,829.7
Turbine	1,305	318.7	1,623.7
Miscellaneous	547	312.9	859.9
Administration	0	380.0	380.0
Sub Total	3,360.8	2,388.5	5,749.3 (5,317.3)
Import Duty	0	183	183
Sub Total	3,360.8	2,758.5	6,119.3
IDC	515.3	454.7	970
TOTAL	3,876.1	3,026.2	6,902.3

Note: ( ) portion shows the subtotal without the contingency.

13. ECONOMIC AND FINANCIAL EVALUATION

CHAPTER 13 ECONOMIC AND FINANCIAL EVALUATION

List of Tables

List of Figures

13. Economic and Financial Evaluation

13.1 Economic Evaluation

13.1.1 Summary

(1) In this economic evaluation, "Alternative Facilities Approach" Method was adopted. The evaluation was carried out by comparison between economic cost of the Sin Pun A-FBC Project and economic cost of the alternative projects as benefit of the Project. Each economic cost includes construction cost, fuel cost, limestone cost (when necessary) and operation & maintenance cost. The alternative projects established for comparison are to provide same amount of electricity and have some environmental emission level.

(2) One of the alternative is a lignite fired plant that has some capacity and energy production of the Sin Pun A-FBC Project by burning the same fuel in an usual pulverized type boiler. The alternative plant has a Do-SOx facility and has same emission level of the Sin Pun Project.

Another alternative is an oil fired plant that has same capacity, energy production and emission level of the Sin Pun Project.

By comparing the cost of the Sin Pun A-FBC Project and that of alternative projects,

1) Benefit and Cost Ratio (B/C) and
2) Net Present Value (NPV, B-C)

were calculated.

(3) The result of the calculation was as follows

1) B/C: 1.10 with Lignite Fired Plant
0.96 with Oil Fired Plant
2) NPV: 885 Million Baht with Lignite Fired Plant
-380 Million Baht with Oil Fired Plant

The result shows that the Sin Pun A-FBC Project is economically feasible, as compared with Lignite Fired Plant.

13.1.2 Method of Evaluation

In this economic evaluation "Alternative Facilities Approach" Method was adopted and the cost of the Sin Pun A-FBC project and benefit by the Project were compared.

In general, economic evaluation of development project is designed to measure its socio-economic impacts on the country as a whole by comparing two cases; the project is implemented and the project is not implemented.

In this economic evaluation the benefit from the implementation of the Sin Pun A-FBC Project was evaluated by Alternative Facilities Approach Method. There, the cost of alternative project is put in the benefit side and verified that it is more expensive than the cost of the Sin Pun Project. In this way it is made clear that implementation of the Sin Pun Project saves the cost of alternative project. The calculated amount of cost side and benefit side are shown in Section 13.1.3.

To obtain economic cost and benefit of a project, market prices should be converted to real benefit and cost, because market prices are generally distorted due to taxes, government subsidies, import duties and other government intervention and monopolistic pricing.

In this economic evaluation, only import duty is considered for converting market prices to calculation prices after consultation with EGAT and amount equivalent to import duty was reduced from both cost side and benefit side.

13.1.3 Economic Cost and Economic Benefit for Evaluation

(1) Economic Cost

Economic cost of the Sin Pun A-FBC Project includes construction cost stated in Chapter 12, fuel cost, limestone cost and operation and maintenance cost necessary after construction,

(2) Economic Benefit and Alternative Project

After consultation with EGAT, the economic cost of alternative Project that provides same service of the Sin Pun Project including environmental aspects was adopted as Economic Benefit of the Project.

As an alternative project a lignite fired plant was selected based on the national energy policy of Thai government i.e., to utilize lignite as domestic energy source and to save foreign currency. This policy is also an important back ground of this Sin Pun A-FBC Project. The alternative lignite-fired plant burns the same lignite from Sin Pun and Krabi mine in an usual pulverized type boiler, has same energy production, and has same environmental emission level by a De-SOx facility.

Also as an another alternative plant, an oil fired plant that has same energy production and environmental emission level was established for comparison.

These alternative plants are to be constructed in the existing Krabi Power Station site, in the same way as the Sin Pun A-FBC Project.

(a) Basic Factors of Alternative Projects and the Sin Pun A-FBC Project

The Table 13-1 shows the Basic Factors of the Sin Pun A-FBC Project and alternative projects.

Table 13-1 Comparison of Basic Factors of the Project and Alternative Projects

Item	Sin-Pun FBC Project	Alternative Thermal Projects	
		Lignite Fired Plant + De-Sox Facility	Oil Fired Plant
Capacity	150 MW (75 MW x 2)	150 MW (75 MW x 2)	150 MW (75 MW x 2)
Emission Level	below 700 ppm	below 700 ppm	below 700 ppm
Site	KRABI	KRABI	KRABI
Thermal Efficiency	36.9% (LHV)	38.0% (LHV)	35.8% (HHV) 38.0% (LHV)
Annual Plant Factor	80%	81.8%	78.7%
Station Service Ratio	9.5%	11.5%	8%
Net Annual Production (Sending End)	951,336 Mwh*1	951,336 Mwh*1	951,336Mwh*1
Fuel Calorific Value (Lower Heat Value)	2,556 kcal/kg (Lignite from Sin Pun and Krabi)	2,556 kcal/kg (Lignite from Sin Pun and Krabi)	9,194 kcal/ℓ*2 (Fuel oil (1% Sulfur))
Fuel Consumption	958.5 x 10^3 ton/year*3	951.71 x 10^3 ton/year*4	254,554 x 10^3 ℓ/year*5
Fuel Cost (Unit) Economic Cost Financial Cost	Baht/ton*6 558.99 672.34	Baht/ton*6 558.99 672.34	 3.18 Baht/ℓ 3.73 Baht/ℓ
Fuel Cost (Gross) Economic Cost Financial Cost	million Baht/year*7 535.79 644.44	million Baht/year*8 532.00 639.87	million Baht/year*9 809.48 954.58
Lime Stone Cost (Unit)	160 Baht/ton	325 Baht/ton	-
Lime Stone Cost (Gross)	64.14 million Baht/year*10	63.27 million Baht/year*11	-
Annual Operation and Maintenance Cost	Calculated on Japanese Example*12	Calculated on Japanese Example*12	40.71 million Baht/year*13 (1st year)
Book Life	25 years	25 years	25 years

Exchange Rate : 1 US$ = 26 Baht

Discount Rate for Evaluation : 10%

*1 $150\ MW \times 80\% \times (24\ H \times 365) \times (1-0.095)$
$\fallingdotseq 150\ MW \times 81.8\% \times (24\ H \times 365) \times (1-0.115)$
$\fallingdotseq 150\ MW \times 78.7\% \times (24\ H \times 365) \times (1-0.08)$
$\fallingdotseq 951,336\ MWh$

*2 HHV : 9,746 kcal/ℓ (by EGAT) → LHV : 9,746 x 1/1.06 = 9,194 kcal/ℓ

*3 $$150\ MW \times 80\% \times (24\ H \times 365) \times \frac{860\ kcal/kWh}{2,556\ kcal/kg \times 36.9\%} = 958.5 \times 10^3\ ton/year$$

*4 $$150\ MW \times 81.8\% \times (24\ H \times 365) \times \frac{860\ kcal/kWh}{2,556\ kcal/kg \times 38\%} = 951.71 \times 10^3\ ton/year$$

*5 $$150\ MW \times 78.7\% \times (24\ H \times 365) \times \frac{860\ kcal/kWh}{9,194\ kcal/\ell \times 38\%} = 254,554 \times 10^3\ \ell/year$$

*6 Economic: Sin Pun [474.24 B/t (18.24 US$/t) + 132 B/t] x 80% + Krabi 370 B/t x 20% = 558.99 B/t

Financial: Sin Pun [592.80 B/t (22.8 US$/t) + 132 B/t] x 80% + Krabi 462.5 B/t x 20% = 672.34 B/t

132 B/t: Transportation, Sin Pun ---> Krabi 22.8 US$/t: 18.24 US$/t x 1.25

*7 Economic: (958.5×10^3) t/y x 558.99 B/t x 10^{-6} = 535.79 million Baht/year

Financial: (958.5×10^3) t/y x 672.34 B/t x 10^{-6} = 644.44 million Baht/year

*8 Economic: (951.71×10^3) t/y x 558.99 B/t x 10^{-6} = 532.00 million Baht/year

Financial: (951.71×10^3) t/y x 672.34 B/t x 10^{-6} = 639.87 million Baht/year

*9 Economic: 254,554 ℓ/y x 10^3 x 3.18 = 809.48 million Baht/year

Financial: 254,554 ℓ/y x 10^3 x 3.75 = 954.58 million Baht/year

*10 160 B/t x 28.6 t/H x 2 x (24 Hx 365) x 80% = 64.14 million Baht/year

*11 325 B/t x (28.6 t/H x 1/2 x 0.95) x 2 x (24 H x 365) x 81.8% = 63.27 million Baht/year

*12*13 Operation and Maintenance Cost

Year of Operation	*12 ↓	*13 ↓
1st :	Investment x 0.015	40.71 million Baht/year
2nd :	0.0171	40.71 x 0.0171/0.015
3rd :	0.0193	40.71 x 0.0193/0.015
4th :	0.0214	40.71 x 0.0214/0.015
5th :	0.0236	40.71 x 0.0236/0.015
6th :	0.0257	40.71 x 0.0257/0.015
7th :	0.0279	40.71 x 0.0279/0.015
8th :	0.0300	40.71 x 0.0300/0.015
9th :	0.0321	40.71 x 0.0321/0.015
10th :	0.0343	40.71 x 0.0343/0.015
11th :	0.0364	40.71 x 0.0364/0.015
12th :	0.0386	40.71 x 0.0386/0.015
13th :	0.0407	40.71 x 0.0407/0.015
14th :	0.0429	40.71 x 0.0429/0.015
15th ~ 20th :	0.0450	40.71 x 0.045/0.015

(b) Alternate plan for DeSOx facilities

There are two desulfurization facilities which have practice record for handling the high SOx flue gas such as 8,000 ppm over with 95% DeSOx efficiency. The one is the limestone-gypsum method (Jet Bubble Type) and the other is the magnesium water method ($Mg-MgSO_4$).

Both of them do not have a practice record on the coal fired power plant with the high SO_x such as 8,000 ppm over but on the chemical plant or the oil shale plant. Since there is no practice record of the high sulfur coal fired plant over 10,000 ppm SO_x flue gas in the world, the alternate plan is just tentative plan for the study.

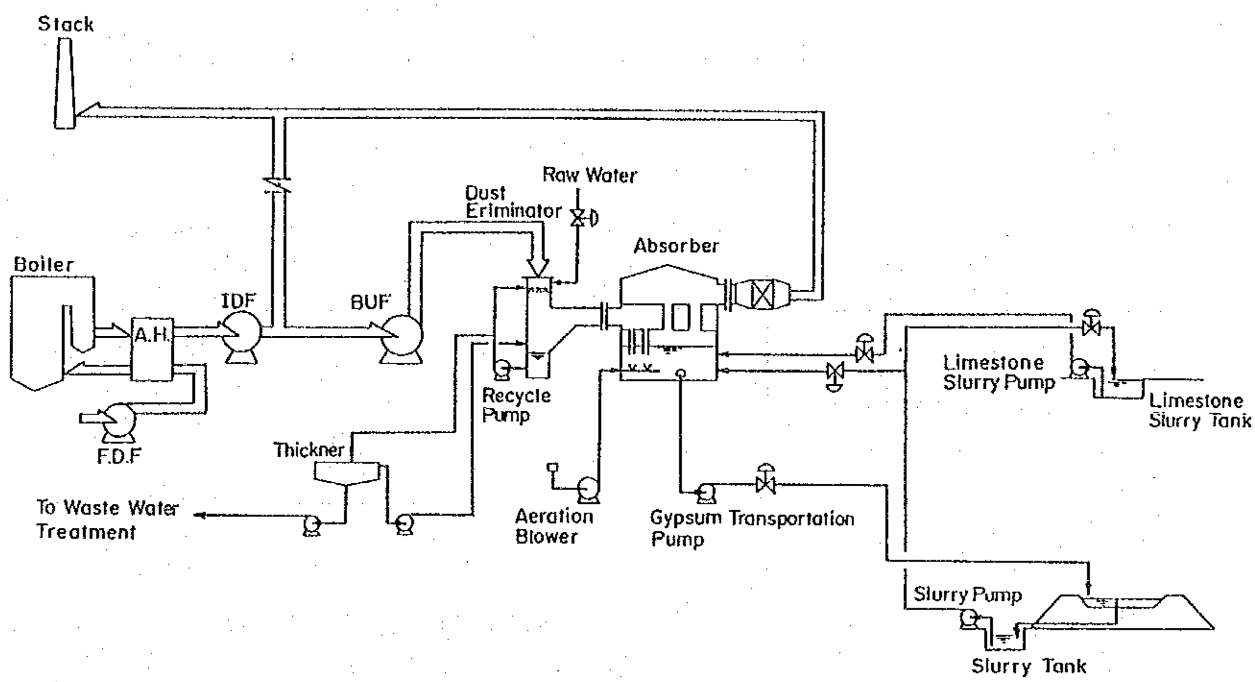
Fig. 13-1 shows the flow sheet of the alternate plan of the above desulfurization facility.

In Japanese market, the $Mg-MgSO_x$ method has a economical merit under the capacity of 100 MW with 1 ~ 2% sulfur content because of the lowest investment cost, and the limestone-gypsum method has a economical merit over 200 MW because of the economical absorbent cost. However, in Thai market, the $Mg-MgSO_x$ method does not have a economical merit for the high sulfur fuel because of much higher product cost of the magnesium than the limestone in Thailand. Table 13-2 shows the comparison of the above two method for Sin Pun Project.

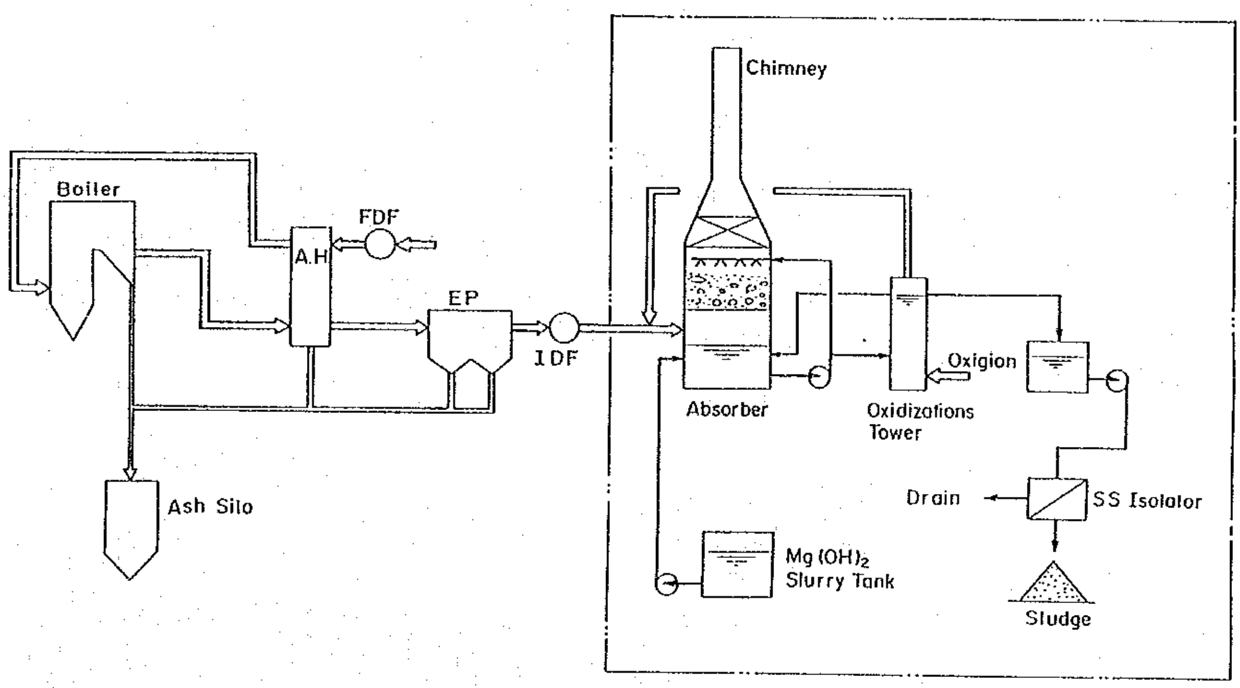
From the Table, it is very clear that the limestone-gypsum method has a fine economical performance for Sin Pun project. Therefore, the limestone-gypsum method is applied for the alternate desulfurized method in the study.

As for an oil fired alternative plant, De-Sox facility was not considered, because it is to use low sulfur oil.

Fig. 13-1 Flow Sheet of De-Sox



Flow Sheet of Limestone - Gypsum Method



Flow Sheet of Mg - $MgSO_4$ Method

Table 13-2 Comparison of Wet FGD (2x75MW) for Sin Pun Project

	Limestone gypsum	Mg-$MgSO_4$
Investment Million Yen (Million Baht)	 6,200 (1,240)	 2,730 (546)
Absorbent Unit Cost (Baht/t) Required Amount (t/year) Annual Cost (Million Baht)	 325 ($CaCO_3$ 90% 325 mesh) 80,800 x 2 52.5	 *(1)9,884 ($Mg(OH)_2$ 100%) 48,750 x 2 963.6
Electricity Unit Cost (Baht/kwh) Required Amount (Gwh/year) Annual cost (Million Baht)	 1.2 14.8 x 2 35.5	 1.2 13.5 32.4
Required water	34 t/h	250 t/h
Total Evaluation	O	

*(1) $MgCo_3$ 910 Baht/t $\xrightarrow{\text{Decarbonization}}$ MgO 910 x $\frac{84}{40}$ x 5 times

(Magnetite 910 Baht/t 1988)

$$MgO + H_2O \longrightarrow Mg(OH)_2 \quad (910 \times \frac{84}{40} \times 5 \text{ times}) \times \frac{40}{58} \times 1.5 \text{ times}$$

$$= 9,884 \text{ Baht/t}$$

(c) Construction Cost of Alternative Projects and the Sin Pun A-FBC Project

The Table 13-3-1 shows construction cost (economic cost for economic evaluation) of alternative projects and Sin Pun A-FBC project.

(d) Operation and Maintenance Cost of Alternative Projects and Sin Pun A-FBC Project

As for operation and maintenance cost of lignite fired alternative plant and Sin Pun A-FBC Project, amount obtained by calculation - construction cost multiplied by rate fixed for each year - was adopted based on example of coal-fired plant in Japan. (Table 13-1, Note *12)

As for oil fired alternative plant, the operation and maintenance cost for the first year of operation was calculated based on the actual levelized cost of EGAT (0.077 Baht/kwh). Then, amount get by calculation - construction cost multiplied by rate fixed for each year - was adopted so that the levelized cost for 25 years would be the same with the fixed amount method based on example of coal-fired plant in Japan. (Table 13-1, Note *13)

(e) Fuel Cost of Alternative Projects and the Sin Pun A-FBC Project

The following fuel cost was adopted for this economic and financial evaluation.

As for Sin Pun lignite, 18.24 US$/t (= 474.23 Baht/t) as provided by EGAT and 132 Baht/t was added to the price as transportation cost from Sin Pun to Krabi.

As for Krabi lignite, 370 Baht/t were adopted.

Table 13-3-1 Construction Cost (Economic Cost) of the Project and Alternative Projects
(FC: Foreign Currency, DC: Domestic Currency)

Sin Pun A-FBC Project (unit: Million Baht)

Year		1	2	3	4	5	Total
Civil and Architectural Works	FC		29	102	15		146
	DC		137	636	137		910
Electro-Mechanical Works	FC		418	2058	482	257	3215
	DC		55	439	439	165	1098
Engineering & Administration Cost	FC						
	DC	40	60	120	120	40	380
TOTAL	FC		447	2,160	497	257	3,361
	DC	40	252	1,195	696	205	2,388
FC + DC		40	699	3,355	1,193	462	5,749

Alternative Project I (PCF Plant) (unit: Million Baht)

Year		1	2	3	4	5	Total
Civil and Architectural Works	FC		34	119	17		170
	DC		140	650	140		930
Electro-Mechanical Works	FC		484	2381	558	298	3721
	DC		78	620	620	232	1550
Engineering & Administration Cost	FC						
	DC	40	60	120	120	40	380
TOTAL	FC		518	2,500	575	298	3,891
	DC	40	278	1,390	880	272	2,860
FC + DC		40	796	3,890	1,455	570	6,751

Alternative Project II (Oil Fired Plant) (unit: Million Baht)

Year		1	2	3	4	5	Total
Civil and Architectural Works	FC		23	80	11		114
	DC		107	498	107		712
Electro-Mechanical Works	FC		302	1485	348	185	2320
	DC		39	310	310	117	776
Engineering & Administration Cost	FC						
	DC	25	37	74	74	25	235
TOTAL	FC		325	1,565	359	185	2,434
	DC	25	183	882	491	142	1,723
FC + DC		25	508	2,447	850	327	4,157

The ratio of mixture of Sin Pun lignite and Krabi lignite is 80% for Sin Pun lignite and 20% for Krabi lignite (See Table 13-1 Note *6)

As for fuel of oil fired plant, 3.18 Baht/ℓ (without import duty) provided by EGAT was adopted.

f) Limestone Cost for Alternative Project and Sin Pun A-FBC Project

325 Baht/t for alternative project (lignite fired plant) and 160 Baht/t for Sin Pun A-FBC Project were adopted as limestone cost.

Table 13-4 shows the study result of De-SOx material price for the alternative lignite fired project and the Sin Pun A-FBC project. As the table shows, the limestone unit price is 49% ~ 54% of that of alternative project, because the De-SOx material for Sin Pun A-FBC Project is larger in particle size of the desulfurizer than alternative lignite project. Escalation was not considered for economic evaluation.

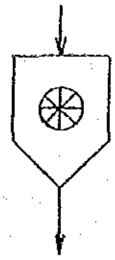
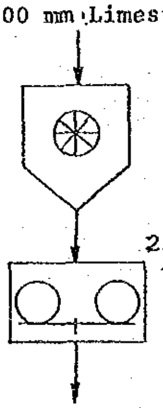
13.1.4 Indicator and Standard Evaluation

(1) Indicator of Evaluation

Cost and Benefit Ratio and Net Present Value were adopted as indicator of this economic evaluation.

These were obtained from comparison between cost necessary for the Sin Pun A-FBC Project and Benefit produced by the Project after conversion to the present value.

Table 13-4 Comparison of Limestone Crushing

	3 mm under for FBC	325 mesh for FGD
System Diagram	250 x 450 mm Limestone 	250 x 400 mm Limestone 
Limestone Raw Material Cost (Including Transportation Cost) 4% Escalation	145 B/T	145 B/T
Crusher Equipment 3.6% Escalation	60 Million Yen	30 Million Yen (Crusher) 840 Million Yen (Mill)
Construction & Erection Cost (Including Transportation Cost) 4% Escalation	18 Million Yen (30% of Equipment Cost)	135 Million Yen (30% of Crusher Cost + 15% of Mill Cost)
Electricity 3% Escalation	800 kW	Crusher Mill 300 kW + 1,350 kW
Maintenance Cost/year 3.6% Escalation	1.8 Million Yen 3% of Crusher Cost	84.9 Million Yen 3% of Crusher Cost + 10% of Mill Cost
Operation Cost 7% Escalation	2,818 KB/year	2,818 KB/year
Levelized Cost 10% Discount Rate — With Escalation	282 B/t	531 B/t
Levelized Cost 10% Discount Rate — Without Escalation	160 B/t	325 B/t

Note: Electricity 1.2 B/kWh, 5 Yen = 1 Baht

Benefit and Cost Ratio (B/C)

This indicator is a ratio obtained from comparison between cost necessary for the project and benefit produced by the project during the project life (from the initial time of construction to the end of service).

The comparison is carried out after conversion of cost and benefit to the present value by discounting each price using fixed discount rate (usually Social Discount Rate which shows Opportunity Cost of the Country). The project is regarded as economically feasible if the ratio is over 1.

Net Present Value (NPV) [or Difference between Cost and Benefit (B-C)]

This indicator shows the difference between cost necessary for the project and benefit produced by the project during the project life, after conversion to the present value by fixed discount rate. The project is regarded as economically feasible if the difference is over 0.

(2) Standard of Evaluation

The standard of the evaluation is the discount rate for present value calculation. That is the Social Discount Rate which reflects the opportunity cost of Thailand. Here 10% was adopted after consultation with EGAT.

13.1.5 Result of Evaluation

Table 13-5 shows the result of Economic Evaluation.

In consequence B/C with lignite fired plant is 1.10 and B/C with oil fired plant is 0.96.

NPV (B-C) with lignite fired plant is 885.4 Million Baht, and NPV (B-C) with oil fired plant is -379.7 Million Baht.

Table 13-5 (1) Econmic Evaluation (1) Lignite Fired Plant

(Unit:Million Baht)

	Sin Pun FBC Project						Lignite Fired Plant + De-Sox						B − C	N.P.V. (DCR=10%)		B-C
	Investment	O & M	Fuel Cost	Limestone	Total	Generation	Investment	O & M	Fuel Cost	Limestone	Total	Generation		Cost	Benefit	
1	40.00				40.00		40.00				40.00		0.00	36.36	36.36	0.00
2	699.00				699.00		796.00				796.00		97.00	577.69	657.85	80.17
3	3355.00				3355.00		3890.00				3890.00		535.00	2520.66	2922.61	401.95
4	1193.00				1193.00		1455.00				1455.00		262.00	814.84	993.78	178.95
5	462.00	64.68	401.84	48.11	976.62	713502	570.00	75.95	399.00	47.45	1092.40	713502	115.78	606.41	678.30	71.89
6		86.24	535.79	64.14	686.17	951336		101.27	532.00	63.27	696.54	951336	10.37	387.32	393.18	5.85
7		98.31	535.79	64.14	698.24	951336		115.44	532.00	63.27	710.71	951336	12.47	358.31	364.71	6.40
8		110.96	535.79	64.14	710.89	951336		130.29	532.00	63.27	725.56	951336	14.68	331.63	338.48	6.85
9		123.03	535.79	64.14	722.96	951336		144.47	532.00	63.27	739.74	951336	16.78	306.61	313.72	7.12
10		135.68	535.79	64.14	735.61	951336		159.32	532.00	63.27	754.59	951336	18.99	283.61	290.93	7.32
11		147.75	535.79	64.14	747.68	951336		173.50	532.00	63.27	768.77	951336	21.09	262.06	269.45	7.39
12		160.40	535.79	64.14	760.33	951336		188.35	532.00	63.27	783.62	951336	23.30	242.26	249.69	7.42
13		172.47	535.79	64.14	772.40	951336		202.53	532.00	63.27	797.80	951336	25.40	223.74	231.09	7.36
14		184.54	535.79	64.14	784.47	951336		216.71	532.00	63.27	811.98	951336	27.50	206.58	213.82	7.24
15		197.19	535.79	64.14	797.12	951336		231.56	532.00	63.27	826.83	951336	29.71	190.82	197.94	7.11
16		209.26	535.79	64.14	809.19	951336		245.74	532.00	63.27	841.01	951336	31.81	176.10	183.03	6.92
17		221.91	535.79	64.14	821.84	951336		260.59	532.00	63.27	855.86	951336	34.02	162.60	169.33	6.73
18		233.98	535.79	64.14	833.91	951336		274.77	532.00	63.27	870.04	951336	36.12	149.99	156.48	6.50
19		246.63	535.79	64.14	846.56	951336		289.62	532.00	63.27	884.89	951336	38.33	138.42	144.69	6.27
20		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	127.63	133.64	6.01
21		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	116.03	121.49	5.46
22		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	105.48	110.45	4.97
23		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	95.89	100.41	4.52
24		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	87.17	91.28	4.10
25		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	79.25	82.98	3.73
26		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	72.04	75.44	3.39
27		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	65.49	68.58	3.08
28		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	59.54	62.34	2.80
29		258.71	535.79	64.14	858.64	951336		303.80	532.00	63.27	899.07	951336	40.43	54.13	56.68	2.55
30		64.68	133.95	16.04	214.66	237834		75.95	133.00	15.82	482.79	237834	268.13	12.30	27.67	15.37
Total	5749.00	5044.75	13394.75	1603.50	25792.00	23783400.00	6751.00	5924.00	13300.00	1581.75	27814.78	23783400.00	2022.78	8850.95	9736.38	885.43
					8850.9533	5763990.017					9736.3805		885.43	B-C=	885.43	
														B/C=	1.100	

Generation: Net Annual Production, Sending End
'150 x 0.8 x 24 x 365 x(1-0.095)= 951336
N.P.V. (DCR=10%)of Total Generation 5763990.0
N.P.V. (DCR=10%)of Total Cost 8850.9533
Production Cost(Baht/Kwh) 1.5355601

Generation: Net Annual Production, Sending End
'150 x 0.818 x 24 x 365 x(1-0.115)= 951336
N.P.V. (DCR=10%)of Total Generation 5763990.0
N.P.V. (DCR=10%)of Total Cost 9736.3805
Production Cost(Baht/Kwh) 1.6891737

-1.994620

Table 13-5 (2) Economic Evaluation (2) Oil fired Plant

	Sin Pun FBC Project						Oil Fired Plant						B - C	N.P.V. (DCR=10%)		
	Investment	O & M	Fuel Cost	Limestone	Total	Generation	Investment	O & M	Fuel Cost	Limestone	Total	Generation		Cost	Benefit	B-C
1	40.00				40.00		25.00				25.00		-15.00	36.36	22.73	-13.64
2	699.00				699.00		508.00				508.00		-191.00	577.69	419.83	-157.85
3	3355.00				3355.00		2447.00				2447.00		-908.00	2520.66	1838.47	-682.19
4	1193.00				1193.00		850.00				850.00		-343.00	814.84	580.56	-234.27
5	462.00	64.68	401.84	48.11	976.62	713502	327.00	30.53	607.11	0.00	964.64	713502	-11.98	606.41	598.97	-7.44
6		86.24	535.79	64.14	386.17	951336		40.71	809.48	0.00	850.19	951336	164.03	387.32	479.91	92.59
7		98.31	535.79	64.14	698.24	951336		46.41	809.48	0.00	855.89	951336	157.65	358.31	439.21	80.90
8		110.96	535.79	64.14	710.89	951336		52.38	812.03	0.00	864.41	951336	153.52	331.63	403.25	71.62
9		123.03	535.79	64.14	722.96	951336		58.08	812.03	0.00	870.11	951336	147.15	306.61	369.01	62.41
10		135.68	535.79	64.14	735.61	951336		64.05	812.03	0.00	876.08	951336	140.47	283.61	337.77	54.16
11		147.75	535.79	64.14	747.68	951336		69.75	817.77	0.00	887.52	951336	139.84	262.06	311.07	49.01
12		160.40	535.79	64.14	760.33	951336		75.72	817.77	0.00	893.49	951336	133.17	242.26	284.69	42.43
13		172.47	535.79	64.14	772.40	951336		81.42	817.12	0.00	898.54	951336	126.14	223.74	260.27	36.54
14		184.54	535.79	64.14	784.47	951336		87.12	817.12	0.00	904.24	951336	119.76	206.58	238.11	31.54
15		197.19	535.79	64.14	797.12	951336		93.09	819.66	0.00	912.75	951336	115.63	190.82	218.51	27.68
16		209.26	535.79	64.14	809.19	951336		98.79	819.66	0.00	918.45	951336	109.26	176.10	199.88	23.78
17		221.91	535.79	64.14	821.84	951336		104.76	819.66	0.00	924.42	951336	102.58	162.60	182.89	20.30
18		233.98	535.79	64.14	833.91	951336		110.46	822.21	0.00	932.67	951336	98.75	149.99	167.75	17.76
19		246.63	535.79	64.14	846.56	951336		116.43	822.21	0.00	938.64	951336	92.08	138.42	153.48	15.06
20		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	127.63	140.75	13.12
21		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	116.03	127.95	11.93
22		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	105.48	116.32	10.84
23		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	95.89	105.75	9.86
24		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	87.17	96.13	8.96
25		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	79.25	87.39	8.15
26		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	72.04	79.45	7.40
27		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	65.49	72.23	6.73
28		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	59.54	65.66	6.12
29		258.71	535.79	64.14	858.64	951336		122.13	824.75	0.00	946.88	951336	88.25	54.13	59.69	5.56
30		64.68	133.95	16.04	214.66	237834		30.53	206.19	0.00	236.72	237834	22.06	12.30	13.57	1.26
Total	5749.00	5044.75	13394.75	1603.50	25792.00	23783400.00	4157.00	2381.54	20489.09	0.00	27027.62	23783400.00	1235.62	8850.95	8471.25	-379.70
					8850.9533	5763990.017					8471.2519		-379.70	B-C=	-379.70	
														B/C=	0.957	

Generation: Net Annual Production, Sending End
150 x 0.8 x 24 x 365 x(1-0.095)= 951336
N.P.V. (DCR=10%)of Total Generation 5763990.0
N.P.V. (DCR=10%)of Total Cost 8850.9533
Production Cost(Baht/Kwh) 1.5355601

Generation: Net Annual Production, Sending End
150 x 0.787 x 24 x 365 x(1-0.08)= 951336
N.P.V. (DCR=10%)of Total Generation 5763990.0
N.P.V. (DCR=10%)of Total Cost 8471.2519
Production Cost(Baht/Kwh) 1.4696853

0.0532145

The figure of indicator shows that construction and operation of Sin Pun A-FBC Project is, economically more profitable than the alternative project of Lignite Fired Plant.

(Note) Generally Economic Internal Rate of Return (EIRR) is adopted as indicator of economic evaluation in the most of the projects. EIRR is discount rate that equalizes the net present value of the cost side (cost of the project) and the benefit side (cost of alternative). If the EIRR is larger than the Social Discount Rate which reflects the opportunity cost of that country, the project is judged to be feasible.

In usual projects, the initial investment is collected by benefit after starting operation. In this case the net present value of the project becomes larger if the discount rate that discounts future benefit to the present value becomes smaller. Since the Social Discount Rate is used for the discount, it is necessary for the materialization of the project that the Social Discount Rate becomes smaller than the EIRR of the project. That is to say it is necessary that the EIRR becomes larger than the Social Discount Rate.

However, in the Sin Pun A-FBC Project, comparatively large cost is necessary after operation though initial investment is smaller than the alternative lignite fired plant of pulverized type. Namely benefit of the project appears as the saving of the initial investment during the construction period, but the large cost is required after operation.

Therefore when the discount rate for the future cost becomes larger the project becomes more advantageous and EIRR does not show the feasibility of the project. In this case it is necessary for the project that the apparent EIRR becomes smaller than the Social Discount Rate.

Consequently, EIRR was decided to be not adequate for evaluation of the Sin Pun A-FBC Project, and B/C and NPV (B-C) were adopted for the evaluation.

The result shows that B/C >1 and B-C>0, which means that the present value of the benefit by the saving of the initial cost is larger than the present value of the cost after operation, and the Project is economically feasible.

13.2 Financial Evaluation

13.2.1 Summary

The financial evaluation of this study was carried out by means of obtaining the Financial Internal Rate of Return (FIRR) by comparing financial cost necessary for the Sin Pun A-FBC Project and financial benefit from sales revenue of the Project.

13.2.2 Financial Internal Rate of Return (FIRR)

The financial evaluation of this study was carried out by means of obtaining the Financial Internal Rate of Return (FIRR) by comparing financial cost and the financial benefit of the Project. As the financial cost, the cost necessary for the Project during the project life was adopted. The cost includes construction cost, fuel cost, limestone cost and operation and maintenance cost each at a market price.

The financial benefit is revenue from the sales of the electricity produced by the Project.

FIRR was obtained by discounting both cost side and benefit side using the discount rate of 10%.

(1) The financial cost was calculated at the market price by adding the import duty on the cost which was used for the economic

evaluation. Table 13-3-2 shows the financial construction cost. As the cost for the fuel, limestone and operation and maintenance the same cost for the economic evaluation was used.

(2) The financial benefit is revenue from the sales of the electricity produced by the Project during the project life. The point of evaluation is the sending end of the power station. The amount of the electricity possible to be sold was calculated based on the capable annual generation in this project. And the actual average electricity tariff of EGAT (1.21 B/kwh) was applied as unit price.

(3) For the indicator of the financial evaluation, Financial Internal Rate of Return was obtained as the discount rate that equalizes the present value of the above financial cost and financial benefit.

(4) Result of study

Table 13-6 shows the calculation of FIRR based on 1.21 Bht/kWh, the actual average tariff of EGAT. The result was 0% for FIRR.

The reason for the low figures of FIRR would be that the current selling unit price does not involve the environmental mitigation cost.

13.2.3 Money Supply and Repayment Plan

In general construction of a power plant requires, a huge amount of investment during the construction period, while the income as returns from the investment starts only after the construction is completed. The time required to recover the investment is considerably long compared to ordinary consumer durables. Consequently, it is quite usual to obtain loans with such financing conditions as a low interest rate, long grace period and long repayment period. The major part of the funds required for the Project shall be supplied by international financing institutions, and the rest by domestic

Table 13-3-2 Construction Cost (Financial Cost) of the Project and Alternative Projects (FC: Foreign Currency, DC: Domestic Currency)

Sin Pun A-FBC Project (unit: Million Baht)

Year		1	2	3	4	5	Total
Civil and Architectural Works	FC		29	102	15		146
	DC		137	636	137		910
Electro-Mechanical Works	FC		418	2058	482	257	3215
	DC		55	439	439	165	1098
Import Duty	FC						
	DC		21	108	25	29	183
Engineering & Administration Cost	FC						
	DC	40	60	120	120	40	380
TOTAL	FC		447	2,160	497	257	3,361
	DC	40	273	1,303	721	234	2,571
FC + DC		40	720	3,463	1,218	491	5,932

Alternative Project I (PCF Plant) (unit: Million Baht)

Year		1	2	3	4	5	Total
Civil and Architectural Works	FC		34	119	17		170
	DC		140	650	140		930
Electro-Mechanical Works	FC		484	2381	558	298	3721
	DC		78	620	620	232	1550
Import Duty	FC						
	DC		26	125	28	31	210
Engineering & Administration Cost	FC						
	DC	40	60	120	120	40	380
TOTAL	FC		518	2,500	575	298	3,891
	DC	40	304	1,515	908	303	3,070
FC + DC		40	822	4,015	1,483	601	6,961

Alternative Project II (Oil Fired Plant) (unit: Million Baht)

Year		1	2	3	4	5	Total
Civil and Architectural Works	FC		23	80	11		114
	DC		107	498	107		712
Electro-Mechanical Works	FC		302	1485	348	185	2320
	DC		39	310	310	117	776
Import Duty	FC						
	DC		16	78	18	25	137
Engineering & Administration Cost	FC						
	DC	25	37	74	74	25	235
TOTAL	FC		325	1,565	359	185	2,434
	DC	25	199	960	509	167	1,860
FC + DC		25	524	2,525	868	352	4,294

Table 13-6 Financial Evaluation

(Unit:Million Baht)

	Benefit	Cost					B - C	N.P.V. (DCR=10%)		
		Investment	O & M	Fuel Cost	Limestone	Total		Benefit	Cost	B-C
1		40.00				40.00	-40.00	0.00	36.36	-36.36
2		720.00				720.00	-720.00	0.00	595.04	-595.04
3		3463.00				3463.00	-3463.00	0.00	2601.80	-2601.80
4		1218.00				1218.00	-1218.00	0.00	831.91	-831.91
5	863.34	491.00	64.68	483.33	48.11	1087.11	-223.77	536.06	675.01	-138.95
6	1151.12		86.24	644.44	64.14	794.82	356.30	649.78	448.65	201.12
7	1151.12		98.31	644.44	64.14	806.89	344.23	590.70	414.06	176.64
8	1151.12		110.96	644.44	64.14	819.54	331.58	537.00	382.32	154.68
9	1151.12		123.03	644.44	64.14	831.61	319.51	488.19	352.68	135.50
10	1151.12		135.68	644.44	64.14	844.26	306.86	443.81	325.50	118.31
11	1151.12		147.75	644.44	64.14	856.33	294.79	403.46	300.14	103.32
12	1151.12		160.40	644.44	64.14	868.98	282.14	366.78	276.88	89.90
13	1151.12		172.47	644.44	64.14	881.05	270.07	333.44	255.21	78.23
14	1151.12		184.54	644.44	64.14	893.12	257.99	303.12	235.19	67.94
15	1151.12		197.19	644.44	64.14	905.77	245.35	275.57	216.83	58.73
16	1151.12		209.26	644.44	64.14	917.84	233.27	250.52	199.75	50.77
17	1151.12		221.91	644.44	64.14	930.49	220.63	227.74	184.09	43.65
18	1151.12		233.98	644.44	64.14	942.56	208.55	207.04	169.53	37.51
19	1151.12		246.63	644.44	64.14	955.21	195.90	188.22	156.18	32.03
20	1151.12		258.71	644.44	64.14	967.29	183.83	171.11	143.78	27.33
21	1151.12		258.71	644.44	64.14	967.29	183.83	155.55	130.71	24.84
22	1151.12		258.71	644.44	64.14	967.29	183.83	141.41	118.83	22.58
23	1151.12		258.71	644.44	64.14	967.29	183.83	128.55	108.02	20.53
24	1151.12		258.71	644.44	64.14	967.29	183.83	116.87	98.20	18.66
25	1151.12		258.71	644.44	64.14	967.29	183.83	106.24	89.28	16.97
26	1151.12		258.71	644.44	64.14	967.29	183.83	96.58	81.16	15.42
27	1151.12		258.71	644.44	64.14	967.29	183.83	87.80	73.78	14.02
28	1151.12		258.71	644.44	64.14	967.29	183.83	79.82	67.07	12.75
29	1151.12		258.71	644.44	64.14	967.29	183.83	72.57	60.98	11.59
30	287.78		64.68	161.11	16.04	241.82	45.96	16.49	13.86	2.63
Total	28777.91	5932.00	5044.75	16111.00	1603.50	28691.25	86.67	6974.43	9642.83	-2668.40
		5749.00								

Net Annual Production Energy , Sending End

150 x 0.8 x 24 x 365 x (1-0.095) = 951336

Tariff

1.21(Baht/KWh)

FIRR 0.0011863

Benefit

951.336 x 1.21 = 1151.1165 Million Baht

financing bodies. To realize the project, the appropriate financing condition was studied to prepare a schedule for the loans.

- Interest: 8% for foreign currency portion
  10% for domestic currency portion

- Repayment Method: The grace period for repayment is given during the construction period. However, no commitment charge is considered.

  Repayment of principal in equal amounts in 25 years.

- Depreciation : The service life is 25 years, straight-line method is adopted with zero salvage value.

On the above conditions, the repayment schedule, the Profit and Loss Statement and the Cash Flow Sheet were prepared and studied. (Table 13-7)

From the above study it is clear that some raising of the sales unit cost is necessary to materialize the Project from the financial standpoint of view.

13.3 Overall Evaluation

13.3.1 Unit Generation Cost

As a part of the Economic and Financial Evaluation, Unit Generation Cost of the electricity to be produced by the Sin Pun A-FBC Project and alternative projects were calculated and compared, after consultation with EGAT.

As total cost necessary during the project life for the calculation, the same cost for financial evaluation was adopted. Unit Generation Cost was obtained dividing total cost by total generation after converting both cost and generation to present value using 10% of discount rate.

Table 13-7 (1) Fund Requirement and Repayment Schedule

(Unit:Million Baht)

No.	CONSTRUCTION COST			REPAYMENT SCHEDULE							
				Foreign Currency				Domestic Currency			
	Foreign	Domestic	Total	Interest*1	Principal	Total	Balance	Interest*2	Principal	Total	Balance
1	0	40	40	(0)				(2)			
2	447	273	720	(18)				(18)			
3	2,160	1,303	3,463	(122)				(96)			
4	497	721	1,218	(228)				(198)			
5	257	234	491	(55)			3,361	(43)			2,571
				202	101	302	3,260	193	77	270	2,494
6				261	134	395	3,126	249	103	352	2,391
7				250	134	384	2,991	239	103	342	2,288
8				239	134	374	2,857	229	103	332	2,185
9				229	134	363	2,722	219	103	321	2,083
10				218	134	352	2,588	208	103	311	1,980
11				207	134	341	2,454	198	103	301	1,877
12				196	134	331	2,319	188	103	291	1,774
13				186	134	320	2,185	177	103	280	1,671
14				175	134	309	2,050	167	103	270	1,568
15				164	134	298	1,916	157	103	260	1,465
16				153	134	288	1,781	147	103	249	1,363
17				143	134	277	1,647	136	103	239	1,260
18				132	134	266	1,512	126	103	229	1,157
19				121	134	255	1,378	116	103	219	1,054
20				110	134	245	1,244	105	103	208	951
21				99	134	234	1,109	95	103	198	848
22				89	134	223	975	85	103	188	746
23				78	134	212	840	75	103	177	643
24				67	134	202	706	64	103	167	540
25				56	134	191	571	54	103	157	437
26				46	134	180	437	44	103	147	334
27				35	134	169	302	33	103	136	231
28				24	134	159	168	23	103	126	129
29				13	134	148	34	13	103	116	26
30				3	34	36	-0	3	26	28	0
Total	3,361	2,571	5,932	3,919	3,361	6,554		3,699	2,494	5,643	

Note: Figures in parentheses are I.D.C.
Interest*1 8 % for foreign currency
Interest*2 10 % for local currency
Only 3 month I.D.C. is considered for the 5th year.

Table 13-7 (2) Profit and Loss Statement

(Unit:Million Baht)

No.	Operating Revenue (A)	Operating Expenses OM, Fuel, L. Stone	Operating Expenses Depreciation	Total (B)	Operating Income (C)=A-B	Financial Expenses F.C.	Financial Expenses D.C.	Total (D)	Net Income (E)=C-D
1						0	2	2	
2						18	18	36	
3						122	96	219	
4						228	198	426	
5						55	43	98	
	863	569	201	771	93	202	193	394	-302
6	1,151	759	268	1,027	124	261	249	510	-386
7	1,151	772	268	1,040	111	250	239	489	-378
8	1,151	785	268	1,054	98	239	229	468	-371
9	1,151	798	268	1,066	85	229	219	447	-362
10	1,151	811	268	1,080	71	218	208	426	-355
11	1,151	824	268	1,093	58	207	198	405	-347
12	1,151	838	268	1,106	45	196	188	384	-339
13	1,151	850	268	1,119	32	186	177	363	-331
14	1,151	863	268	1,132	19	175	167	342	-323
15	1,151	877	268	1,145	6	164	157	321	-315
16	1,151	890	268	1,158	-7	153	147	300	-307
17	1,151	903	268	1,172	-20	143	136	279	-299
18	1,151	916	268	1,184	-33	132	126	258	-291
19	1,151	929	268	1,198	-47	121	116	237	-283
20	1,151	942	268	1,211	-60	110	105	216	-275
21	1,151	942	268	1,211	-60	99	95	195	-254
22	1,151	942	268	1,211	-60	89	85	174	-233
23	1,151	942	268	1,211	-60	78	75	153	-212
24	1,151	942	268	1,211	-60	67	64	131	-191
25	1,151	942	268	1,211	-60	56	54	110	-170
26	1,151	942	268	1,211	-60	46	44	89	-149
27	1,151	942	268	1,211	-60	35	33	68	-128
28	1,151	942	268	1,211	-60	24	23	47	-107
29	1,151	942	268	1,211	-60	13	13	26	-86
30	288	236	67	303	-15	3	3	5	-20
31									
32									
33									
34									
35									
Total	28,778	22,043	6,712	28,755	23	3,919	3,699	7,618	-6,815

Table 13-7 (3) Cash Flow Sheet

(Unit:Million Baht)

No.	Cash Inflow				Cash Outflow						Balance	
	Fund Requirement	Net Income	Depreciation	Total	Construction cost	Principal Repayment F.C.	Principal Repayment D.C.	Principal Repayment Subtotal	I.D.C.	Total	Yearly	Accummulation
1	40	0	0	40	40	0	0	0	2	42	-2	-2
2	720	0	0	720	720	0	0	0	36	756	-36	-38
3	3,463	0	0	3,463	3,463	0	0	0	219	3,682	-219	-256
4	1,218	0	0	1,218	1,218	0	0	0	426	1,644	-426	-682
5	491	0	0	491	491	0	0	0	98	589	-98	-354
	0	-302	201	-100	0	101	77	178	0	178	-278	-961
6	0	-386	268	-118	0	134	103	237	0	237	-355	-1,316
7	0	-378	268	-110	0	134	103	237	0	237	-347	-1,663
8	0	-371	268	-102	0	134	103	237	0	237	-339	-2,002
9	0	-362	268	-94	0	134	103	237	0	237	-331	-2,333
10	0	-355	268	-86	0	134	103	237	0	237	-324	-2,656
11	0	-347	268	-78	0	134	103	237	0	237	-315	-2,972
12	0	-339	268	-70	0	134	103	237	0	237	-308	-3,280
13	0	-331	268	-62	0	134	103	237	0	237	-300	-3,579
14	0	-323	268	-54	0	134	103	237	0	237	-291	-3,871
15	0	-315	268	-47	0	134	103	237	0	237	-284	-4,154
16	0	-307	268	-38	0	134	103	237	0	237	-276	-4,430
17	0	-299	268	-31	0	134	103	237	0	237	-268	-4,698
18	0	-291	268	-23	0	134	103	237	0	237	-260	-4,958
19	0	-283	268	-15	0	134	103	237	0	237	-252	-5,210
20	0	-275	268	-7	0	134	103	237	0	237	-244	-5,454
21	0	-254	268	14	0	134	103	237	0	237	-223	-5,677
22	0	-233	268	35	0	134	103	237	0	237	-202	-5,879
23	0	-212	268	56	0	134	103	237	0	237	-181	-6,060
24	0	-191	268	77	0	134	103	237	0	237	-160	-6,220
25	0	-170	268	98	0	134	103	237	0	237	-139	-6,359
26	0	-149	268	119	0	134	103	237	0	237	-118	-6,477
27	0	-128	268	140	0	134	103	237	0	237	-97	-6,574
28	0	-107	268	161	0	134	103	237	0	237	-76	-6,650
29	0	-86	268	183	0	134	103	237	0	237	-55	-6,704
30	0	-20	67	47	0	34	26	59	0	59	-12	-6,717
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
Total	5,932	-6,815	6,712	5,829	5,932	3,361	2,571	5,932	780	12,644	-6,815	

Table 13-8 shows the result of the calculation, 1.67 Baht/kWh for the Sin Pun Project, 1.83 Baht/kWh for alternative lignite fired plant and 1.61 Baht/kWh for alternative oil fired plant.

Consequently it became clear that Sin Pun A-FBC Project is more advantageous than lignite fired plant from the standpoint of Unit Generation Cost.

13.3.2 Indirect Effect of the Sin Pun A-FBC Project

In addition, there are several indirect benefits derived from the Sin Pun A-FBC project, which are not considered in the evaluation due to difficulty in qualification. Incidentally, indirect effects currently conceivable are as follows.

(1) The Project will promote the development of new energy sources to replace oil.

The Sin Pun A-FBC Project was planned and started in accordance with the national energy policy of Thai Government i.e. to utilize lignite as domestic energy source and to save foreign currency.

In Thailand, construction of thermal power station using domestic lignite is promoted recently in line with the energy policy of the Thai Government to answer the need from rapid increase of power demand. To utilize lignite, it is necessary to attach effective De-Sox facility to the power plant for environmental protection, because lignite contains a high rate of sulfur. For this purpose Fludized Bed Combustion (FBC) Boiler was selected as most useful measure. The reason is that FBC boiler features many excellent properties; various kinds of coal can be burned efficiently using limestone in the fludizing medium; dessulfurization takes place during combustion without attaching special De-Sox facility; and the formation of NO_x can be effectively suppressed because of low burning temperatures.

Table 13-8 (1) Production Cost

(Unit:Million Baht)

	Sin Pun FBC Project						Lignite Fired Plant + De-Sox							N.P.V. (DCR=10%)		
	Investment	O & M	Fuel Cost	Limestone	Total	Generation	Investment	O & M	Fuel Cost	Limestone	Total	Generation	B - C	Cost	Benefit	B-C
1	40.00				40.00		40.00				40.00		0.00	36.36	36.36	0.00
2	720.00				720.00		822.00				822.00		102.00	595.04	679.34	84.30
3	3463.00				3463.00		4015.00				4015.00		552.00	2601.80	3016.53	414.73
4	1218.00				1218.00		1483.00				1483.00		265.00	831.91	1012.91	181.00
5	491.00	64.68	483.33	48.11	1087.11	713502	601.00	75.95	479.90	47.45	1204.30	713502	117.19	675.01	747.78	72.77
6		86.24	644.44	64.14	794.82	951336		101.27	639.87	63.27	804.41	951336	9.59	448.65	454.07	5.41
7		98.31	644.44	64.14	806.89	951336		115.44	639.87	63.27	818.58	951336	11.69	414.06	420.06	6.00
8		110.96	644.44	64.14	819.54	951336		130.29	639.87	63.27	833.43	951336	13.90	382.32	388.80	6.48
9		123.03	644.44	64.14	831.61	951336		144.47	639.87	63.27	847.61	951336	16.00	352.68	359.47	6.79
10		135.68	644.44	64.14	844.26	951336		159.32	639.87	63.27	862.46	951336	18.21	325.50	332.52	7.02
11		147.75	644.44	64.14	856.33	951336		173.50	639.87	63.27	876.64	951336	20.31	300.14	307.26	7.12
12		160.40	644.44	64.14	868.98	951336		188.35	639.87	63.27	891.49	951336	22.52	276.88	284.06	7.17
13		172.47	644.44	64.14	881.05	951336		202.53	639.87	63.27	905.67	951336	24.62	255.21	262.34	7.13
14		184.54	644.44	64.14	893.12	951336		216.71	639.87	63.27	919.85	951336	26.72	235.19	242.22	7.04
15		197.19	644.44	64.14	905.77	951336		231.56	639.87	63.27	934.70	951336	28.93	216.83	223.76	6.93
16		209.26	644.44	64.14	917.84	951336		245.74	639.87	63.27	948.88	951336	31.03	199.75	206.50	6.75
17		221.91	644.44	64.14	930.49	951336		260.59	639.87	63.27	963.73	951336	33.24	184.09	190.67	6.58
18		233.98	644.44	64.14	942.56	951336		274.77	639.87	63.27	977.91	951336	35.34	169.53	175.88	6.36
19		246.63	644.44	64.14	955.21	951336		289.62	639.87	63.27	992.76	951336	37.55	156.18	162.32	6.14
20		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	143.78	149.67	5.89
21		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	130.71	136.07	5.36
22		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	118.83	123.70	4.87
23		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	108.02	112.45	4.43
24		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	98.20	102.23	4.03
25		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	89.28	92.94	3.66
26		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	81.16	84.49	3.33
27		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	73.78	76.81	3.02
28		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	67.07	69.82	2.75
29		258.71	644.44	64.14	967.29	951336		303.80	639.87	63.27	1006.94	951336	39.65	60.98	63.48	2.50
30		64.68	161.11	16.04	241.82	237834		75.95	159.97	15.82	251.73	237834	9.91	13.86	14.43	0.57
Total	5932.00	5044.75	16111.00	1603.50	28691.25	23783400.00	6961.00	5924.00	15996.75	1581.75	30463.50	23783400.00	1772.25	9642.83	10528.94	886.11
	5749						6751									
					9642.8254	5763990.017					10528.935		886.11	B-C=	886.11	
														B/C=	1.092	
													-1.333333			

Generation: Net Annual Production, Sending End
'150 x 0.8 x 24 x 365 x(1-0.095)= 951336
N.P.V. (DCR=10%)of Total Generation 5763990.0
N.P.V. (DCR=10%)of Total Cost 9642.8254
Production Cost(Baht/Kwh) 1.6729427

Generation: Net Annual Production, Sending End
'150 x 0.818 x 24 x 365 x(1-0.115)= 951336
N.P.V. (DCR=10%)of Total Generation 5763990.0
N.P.V. (DCR=10%)of Total Cost 10528.935
Production Cost(Baht/Kwh) 1.8266747

Table 13-8 (2) Production Cost

(Unit: Million Baht)

	Sin Pun FBC Project: Investment	O & M	Fuel Cost	Limestone	Total	Generation	Oil Fired Plant: Investment	O & M	Fuel Cost	Limestone	Total	Generation	B - C	N.P.V. (DCR=10%): Cost	Benefit	B-C
1	40.00				40.00		25.00				25.00		-15.00	36.36	22.73	-13.64
2	720.00				720.00		524.00				524.00		-196.00	595.04	433.06	-161.98
3	3463.00				3463.00		2525.00				2525.00		-938.00	2601.80	1897.07	-704.73
4	1218.00				1218.00		868.00				868.00		-350.00	831.91	592.86	-239.05
5	491.00	64.68	483.33	48.11	1087.11	713502	352.00	30.53	715.93	0.00	1098.47	725328	11.35	675.01	682.06	7.05
6		86.24	644.44	64.14	794.82	951336		40.71	954.58	0.00	995.29	967104	200.47	448.65	561.81	113.16
7		98.31	644.44	64.14	806.89	951336		46.41	954.58	0.00	1000.99	967104	194.10	414.06	513.66	99.60
8		110.96	644.44	64.14	819.54	951336		52.38	954.58	0.00	1006.96	967104	187.42	382.32	469.75	87.43
9		123.03	644.44	64.14	831.61	951336		58.08	954.58	0.00	1012.66	967104	181.05	352.68	429.47	76.78
10		135.68	644.44	64.14	844.26	951336		64.05	954.58	0.00	1018.63	967104	174.37	325.50	392.72	67.23
11		147.75	644.44	64.14	856.33	951336		69.75	954.58	0.00	1024.33	967104	168.00	300.14	359.02	58.88
12		160.40	644.44	64.14	868.98	951336		75.72	954.58	0.00	1030.30	967104	161.32	276.88	328.28	51.40
13		172.47	644.44	64.14	881.05	951336		81.42	954.58	0.00	1036.00	967104	154.95	255.21	300.09	44.88
14		184.54	644.44	64.14	893.12	951336		87.12	954.58	0.00	1041.70	967104	148.57	235.19	274.31	39.12
15		197.19	644.44	64.14	905.77	951336		93.09	954.58	0.00	1047.67	967104	141.90	216.83	250.80	33.97
16		209.26	644.44	64.14	917.84	951336		98.79	954.58	0.00	1053.37	967104	135.52	199.75	229.24	29.49
17		221.91	644.44	64.14	930.49	951336		104.76	954.58	0.00	1059.34	967104	128.85	184.09	209.58	25.49
18		233.98	644.44	64.14	942.56	951336		110.46	954.58	0.00	1065.04	967104	122.47	169.53	191.56	22.03
19		246.63	644.44	64.14	955.21	951336		116.43	954.58	0.00	1071.01	967104	115.80	156.18	175.12	18.93
20		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	143.78	160.05	15.26
21		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	130.71	145.50	14.79
22		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	118.83	132.27	13.44
23		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	108.02	120.24	12.22
24		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	98.20	109.31	11.11
25		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	89.28	99.38	10.10
26		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	81.16	90.34	9.18
27		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	73.78	82.13	8.35
28		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	67.07	74.66	7.59
29		258.71	644.44	64.14	967.29	951336		122.13	954.58	0.00	1076.71	967104	109.42	60.98	67.88	6.90
30		64.68	161.11	16.04	241.82	237834		30.53	238.64	0.00	269.17	241776	27.35	13.86	15.43	1.57
Total	5932.00	5044.75	16111.00	1603.50	28691.25	23783400.00	4294.00	2381.53	23864.44	0.00	30539.97	24177600.00	1848.72	9642.83	9410.39	-232.44
	5749.00															
					9642.8254	5763990.017					9410.3864		-232.44	B-C=	-232.44	
														B/C=	0.976	

Generation: Net Annual Production, Sending End
150 x 0.8 x 24 x 365 x(1-0.095)= 951336
N.P.V. (DCR=10%) of Total Generation 5763990.0
N.P.V. (DCR=10%) of Total Cost 9642.8254
Production Cost (Baht/kWh) 1.6729427

Generation: Net Annual Production, Sending End
150 x 0.8 x 24 x 365 x(1-0.08)= 967104
N.P.V. (DCR=10%) of Total Generation 5859525.7
N.P.V. (DCR=10%) of Total Cost 9410.3864
Production Cost (Baht/kWh) 1.6059979

0.0732005

In consequence Thai government requested Japanese government for feasibility study of Sin Pun A-FBC Project.

(2) As this is the first FBC thermal power station in Southeast Asia region, the learning and acquisition of FBC thermal power generation technology will be made possible through the construction, operation and maintenance of the Sin Pun A-FBC Plant. Implementation of the Project will also make it possible to popularize and propagate technology in other countries of the region to say nothing of Kingdom of Thailand.

(3) Implementation of the Project will contribute to the development of the project area (Region III) which is one of less developed areas of Thailand.

(4) It will contribute much in increasing quality and reliability of energy supply for Region III.

(5) Construction of the Plant will make it possible to utilize of the land and a part of facilities of existing Krabi Thermal Power Station which is to be closed in 1995. Constructing FBC power station in Krabi site will also make it possible to inaugurate new power station earlier than other projects, because no land acquisition problem is expected.

(6) Furthermore, implementation of the Sin Pun A-FBC project will save the cost related to employment, because it can utilize man-power of employees in Krabi Power Station continuously and can avoid labor problem caused by lay-off etc.

(7) Since there are sightseeing resort near the Krabi site, new power station of EGAT with new environmental facility will make the image of the resort area better all the more. And it will also become a good show-window of EGAT's environmental policy, because the new power station adopts new environmental technology.

Taking these benefits into consideration, it is concluded that the Project is worth developing from economic and social stand point of view.

APPENDIX

Appendix

CONTENTS

List of Figures

List of Tables

APPENDIX I

STUDY ON CAPACITY OF BANG KAM PRAT WATER SUPPLY FACILITIES

1. General

There are water supply facilities constructed by RID in the upper stream of Khlong Bang Kam Prat. They consist of an intake weir, a dam and a reservoir. The outline of them is as follows;

(1) Bang Kam Prat Weir

Catchment Area	42 km^2
High Water Level	+45.569 m (above mean sea level)
Low Water Level	+43.369 m (ditto)
Design Flood Discharge	150 m^3/sec

(2) Bang Kam Prat Dam

Catchment Area	24 km^2
Elevation of Dam Crest	+79.00 m (above mean sea level)
High Water Level	+76.00 m (ditto)
Dead Storage Level	+62.00 m (ditto)
Effective Capacity	15.8 x 10^6 m^3
Total Capacity	16.0 x 10^6 m^3

Storage capacity and surface area of Bang Kam Prat Reservoir is shown in Fig. 1.

The existing facilities have been constructed for the purpose of supplying water to irrigation projects in the lower basin. According to the information from RID's engineers, the second stage of Khlong Bang Kam Prat Water Development Project has been cancelled. Accordingly, the existing water supply facilities seem to be able to provide the power plant with necessary water.

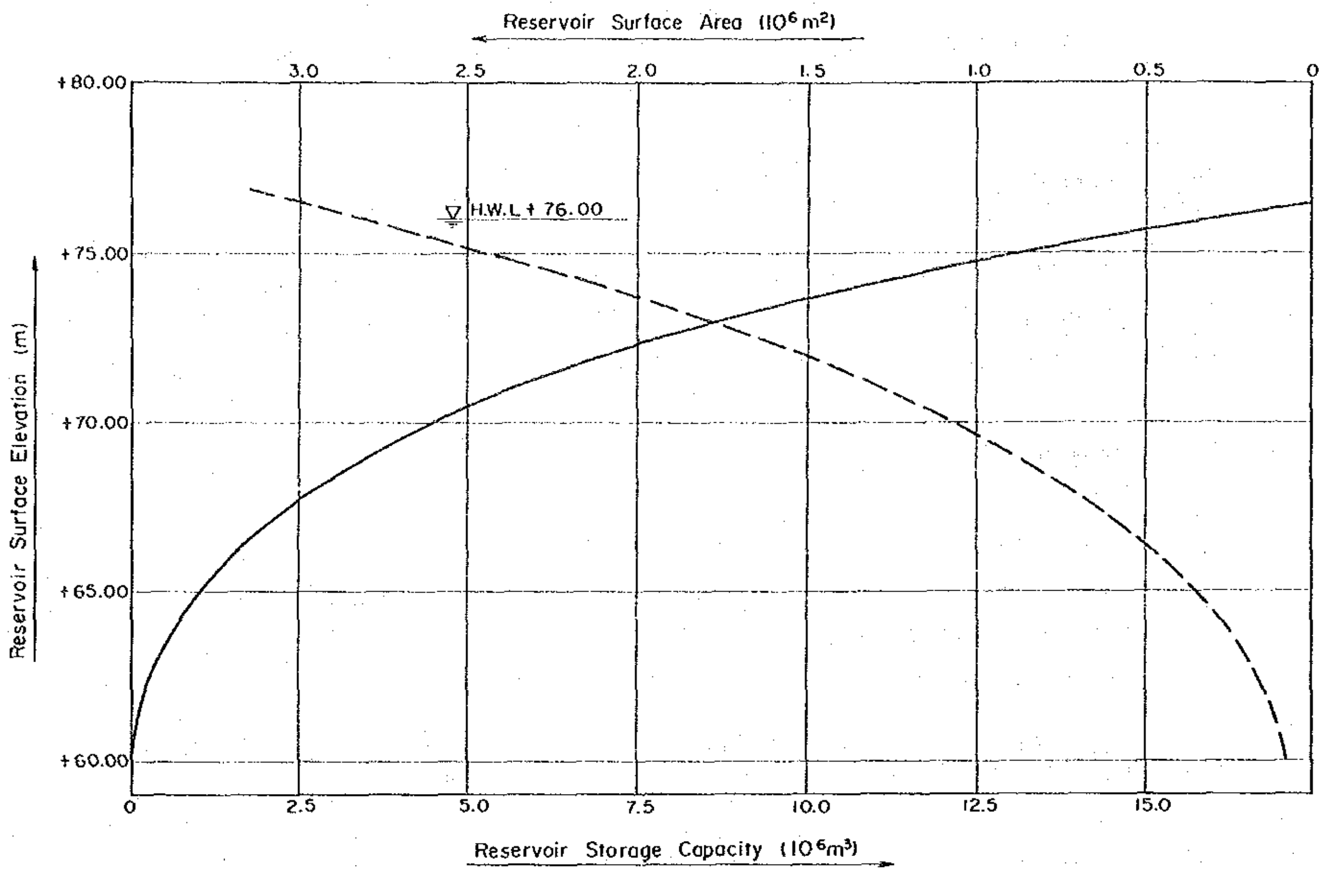


Fig. 1 Storage Capacity and Surface Area of Bang Kam Prat Reservoir

2. Demand of Water Resources

(1) Water Demand of Irrigation

Water demand of the irrigation project is as follows;

	Irrigation Area	Required Quantity
Wet Season (100 days, Oct.~Jan.)	4,650 rais ($7.44\ km^2$)	0.93 m^3/sec
Dry Season (135 days, Mar.~Jul.)	1,000 rais ($1.6\ km^2$)	0.20 m^3/sec

* unit quantity = 0.0002 m^3/sec/rai

(2) Water Demand of the Power Plant

Water demand of the power plant is 0.13 m^3/sec as mentioned in 4.3.4(6).

(3) Total Water Demand

Annual schedule of water consumption formulated based on each water demand mentioned above is shown in Table 1.

Table 1 Annual Schedule of Water Consumption

Item	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Power Plant						0.13 m^3/s						
Irrigation		0.2 m^3/s						0.93 m^3/s				0.2 m^3/s
Miscellaneous						0.07 m^3/s						
Total		0.40 m^3/s			0.20 m^3/s			1.13 m^3/s		0.20 m^3/s		0.40 m^3/s

3. Estimation of Discharge of Khlong Bang Kam Prat

(1) The Data for Estimation

Since Khlong Bang Kam Prat basin has no discharge record and no rainfall data, it is necessary to estimate the discharge by means of using the existing data of daily discharge recorded in the adjacent basins. The location of gaging stations in the basins is shown in Fig. 2.

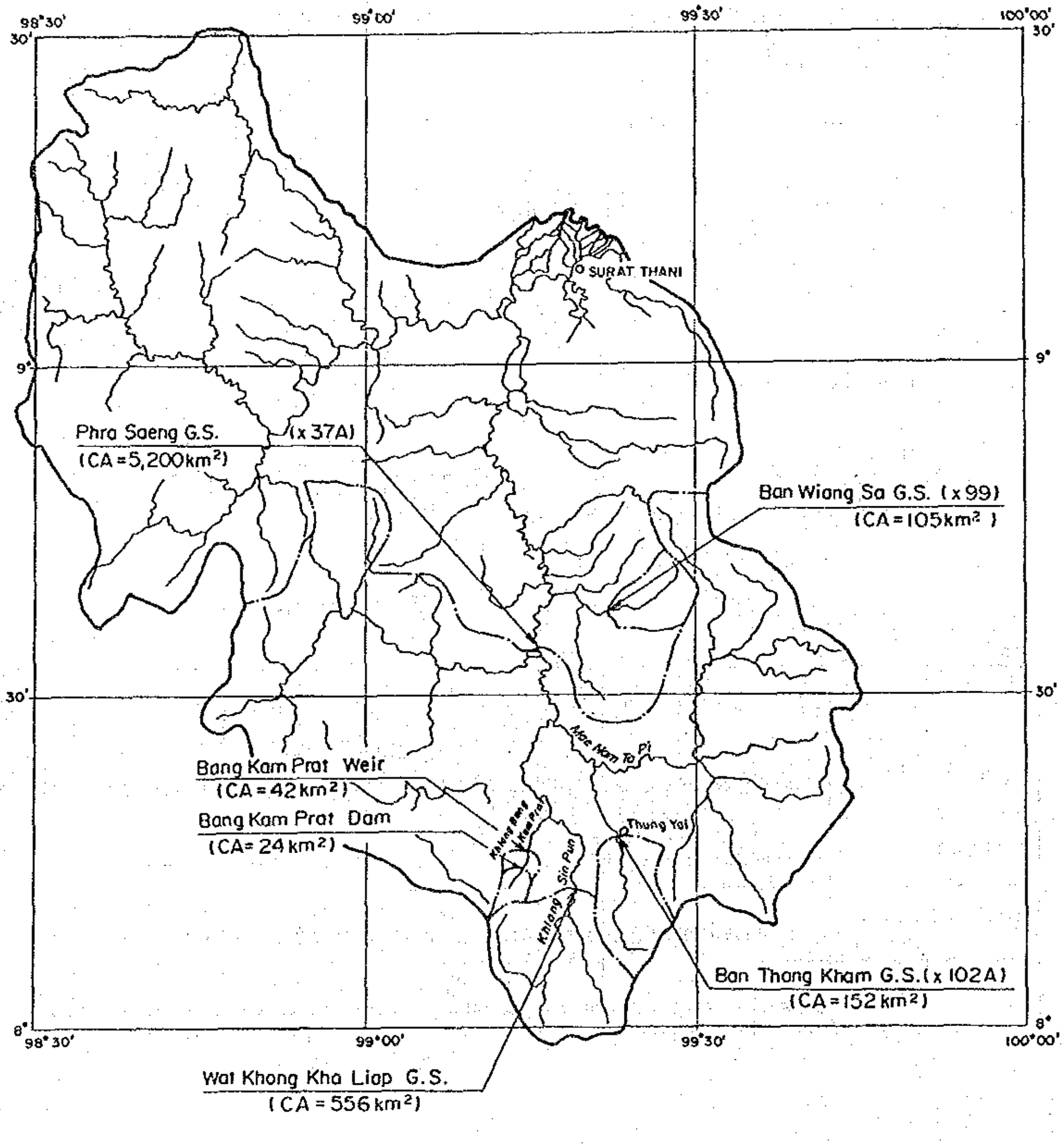


Fig. 2 Location of Gaging Stations

The data available for discharge estimation is shown in the following table.

Gaging Station	River	Catchment Area (km^2)	Data Available Period
Ban Wiang Sa	Khlong Sa	105	1977 ~ 1987
Phra Saeng	Mae Nam Tapi	5,200	1970 ~ 1988
Ban Thang Kham	Khlong Sang	152	1978 ~ 1988
Wat Khong Kha Liap	Khlong Sin Pun	556	1986 ~ 1989

(2) Estimation of Discharge of Khlong Bang Kam Prat

From four data shown above, the data of Ban Thang Kham G.S. has been selected for discharge estimation because of the following reasons;

- Its catchment area is not too large compared to that of Khlong Bang Kam Prat basin
- It is located near to Khlong Bang Kam Prat basin
- It has sufficient data of more than 10 years

The unit discharge of Khlong Bang Kam Prat basin might be larger than that of Ban Thang Kham G.S. as the former has smaller catchment area than the latter. However, the discharge of Khlong Bang Kam Prat has been estimated by means of multiplying the discharge data recorded at Ban Thang Kham G.S. simply by the ratio of the catchment area of each objective site to that of Ban Thang Kham G.S. in order to obtain safe results.

The formula for the discharge estimation of Khlong Bang Kam Prat is as follows;

$$Q = Qg \times \frac{A}{Ag}$$

where,

Q : estimated discharge at an objective site

Qg: discharge at Ban Thang Kham G.S.

A : Catchment area of an objective site

Ag: catchment area of Ban Thang Kham G.S.

(3) Correlation between Unit Discharge and Catchment Area

Using the obtained data of four gaging stations, the study on correlation between unit discharge and catchment area has been carried out for reference. The result is described as follows;

1) Study Case

Unit Discharge at each gaging station has been calculated by using the average of annual mean discharges for the two periods, which have been defined in view of data available period. The result is shown in the following table.

Gaging Station	Unit Discharge		Data Available Period
	Case 1	Case 2	
Ban Wiang Sa	0.0187	N.A.	1977 ~ 1987
Phra Saeng	0.0240	0.0275	1970 ~ 1988
Ban Thang Kham	0.0213	0.0286	1978 ~ 1988
Wat Khong Kha Liap	N.A.	0.0220	1986 ~ 1989

Case 1 : Calculated based on the annual mean discharge recorded from 1978 to 1987.

Case 2 : Calculated based on the annual mean discharge recorded from 1986 to 1988.

2) The Result of Case 1

The correlation between unit discharge and catchment area of Case 1 is shown in Fig. 3.

Since all gaging stations are located in a same basin (i.e. Mae Nam Ta Pi basin), theoretically unit discharge should be decreasing as catchment area becomes large. However, the result is opposite to the theory, as it is obvious by Fig. 3 showing that unit discharge is increasing gradually as catchment area becomes large. That means those sub-basins where three gaging stations are located have different hydrological characteristics respectively. Particularly, it is derived that the characteristic of the catchment of Phra Saeng G.S. is considerably different from that of Khlong Bang Kam Prat basin, as the catchment area of the former is very large compared to that of the latter.

3) The Result of Case 2

Considering the result mentioned above, it seems suitable to exclude the data recorded at Phra Saeng G.S. from the analysis. Consequently, the correlation between unit discharge and catchment area of Case 2 has been obtained by the data recorded at Ban Thang Kham G.S. and Wat Khong Kha Liap G.S., which are located nearer to Khlong Bang Kam Prat basin and also catchment areas of which are not too large compared to that of it. The result of Case 2 is shown in Fig. 4 and it is reasonable that unit discharge is decreasing as catchment area becomes large.

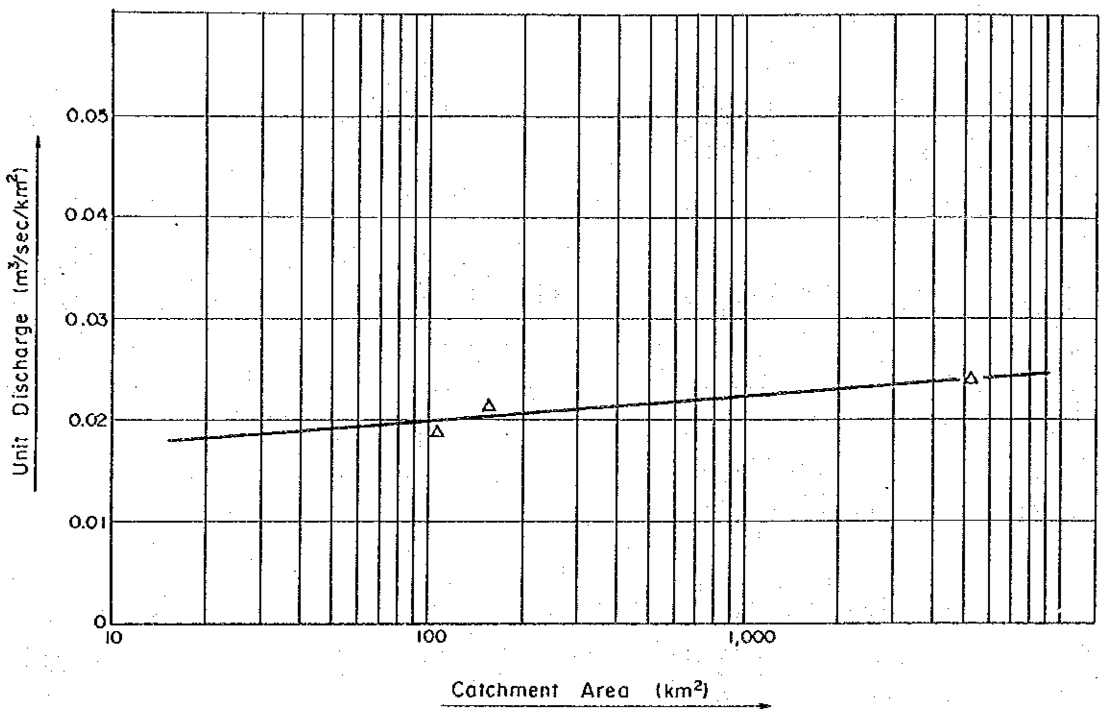


Fig. 3 Correlation between Unit Discharge and Catchment Area (Case 1)

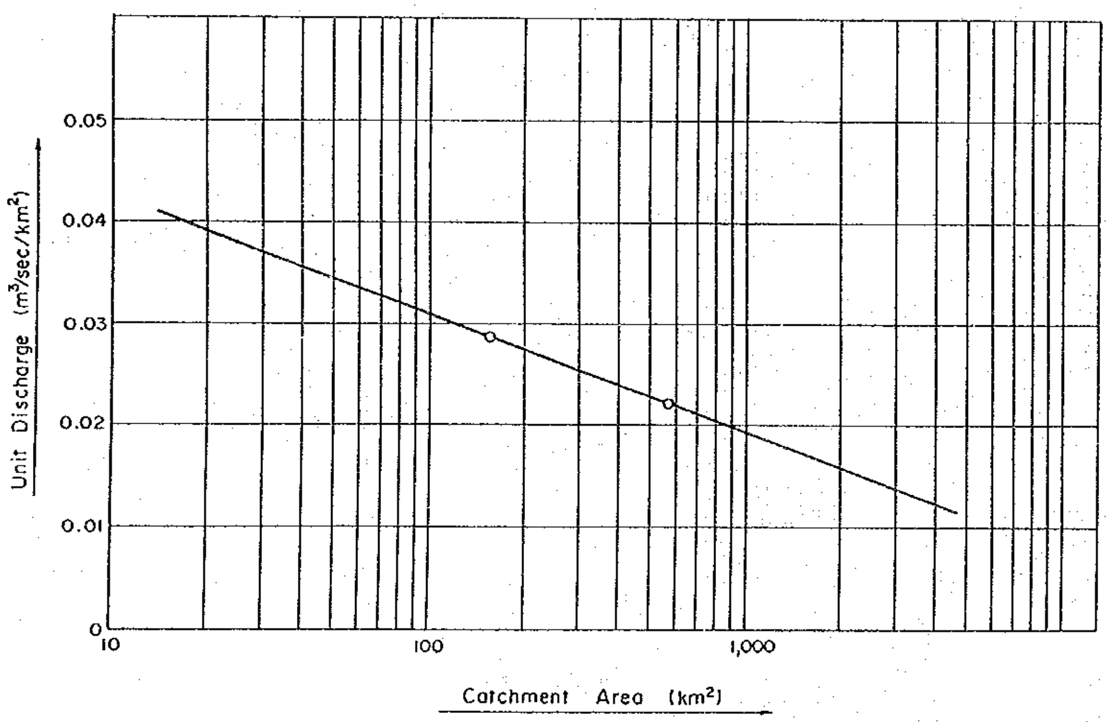
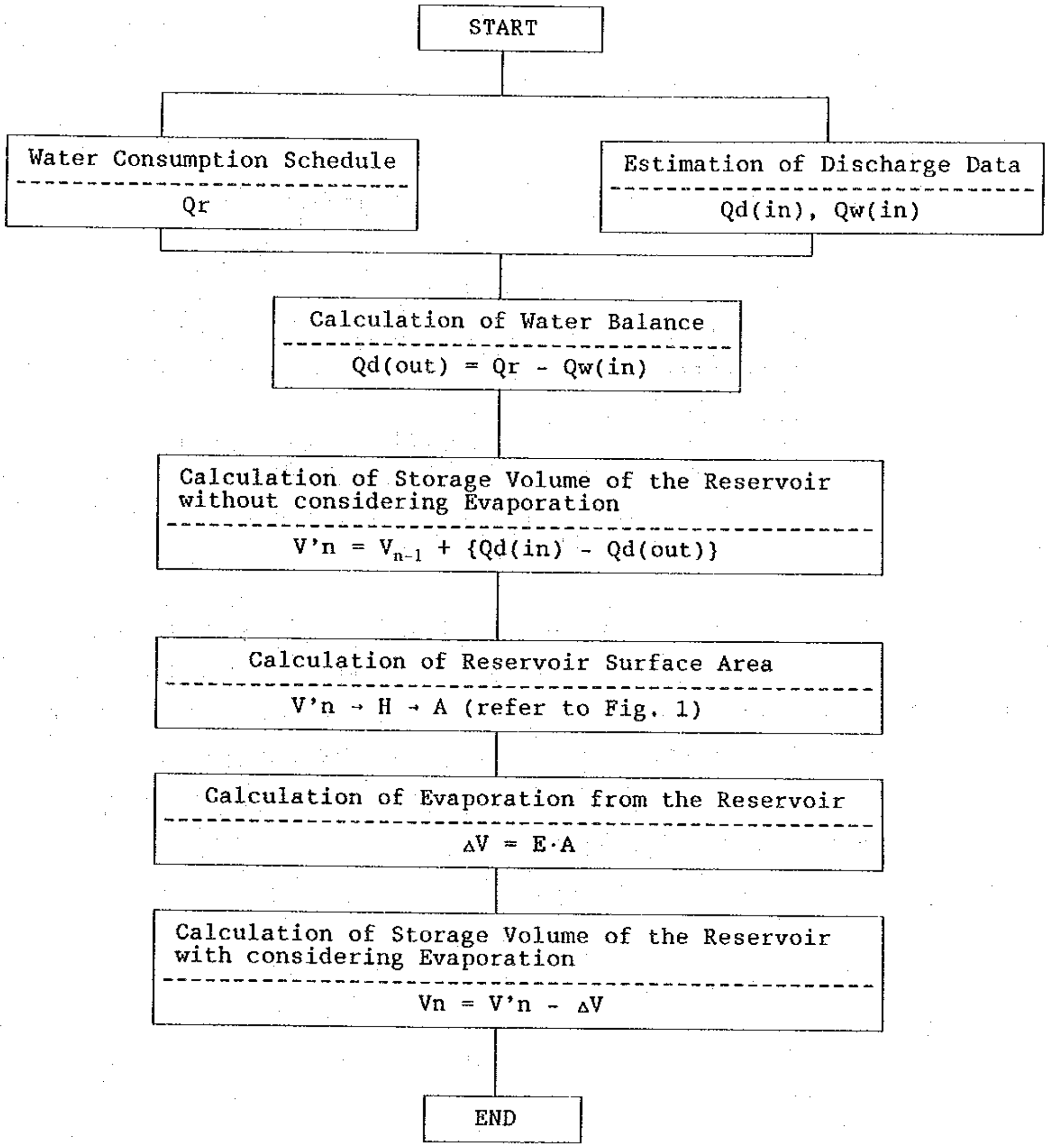


Fig. 4 Correlation between Unit Discharge and Catchment Area (Case 2)

4. Study on the Capability of Bang Kam Prat Reservoir for Water Supply to the Power Plant

The water supply capability of Bang Kam Prat Reservoir has been checked by the simulation explained by the following flow chart.



where;

Qr :	quantity of water consumption (refer to Table 1)
Qd(in) :	in-flow at the dam site
Qw(in) :	in-flow at the weir site
Qd(out):	discharge from the reservoir for water supply Qd(out) $\geq$ 0

V'n	:	storage volume of the reservoir as of N-th day (without considering evaporation)
Vn	:	storage volume of the reservoir as of N-th day (with considering evaporation)
V_{n-1}	:	storage volume of the reservoir as of N-1-th day (with considering evaporation)
H	:	reservoir surface elevation
A	:	reservoir surface area
ΔV	:	quantity of evaporation from the reservoir
E	:	unit evaporation calculated based on the data shown in the following table.

Monthly Evaporation (70% of Class A-pan Evaporation)

(mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.
85.63	76.87	100.37	97.25	85.60	74.60
Jul.	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
88.00	80.92	72.52	79.06	74.27	73.33

Note: Average of the data recorded from 1981 to 1987 at Ban Tha Yang (X.102A)

The result of the simulation is shown in Fig. 5. In this simulation, the start of calculation is Oct. 1977 because the largest water demand commences from October which is in the last stage of rainy season. Since the minimum storage volume of the reservoir is about 7.4×10^6 m^3 (June 1980), Bang Kam Prat Reservoir is considered to be capable of supplying water stably to both the power plant and the irrigation.

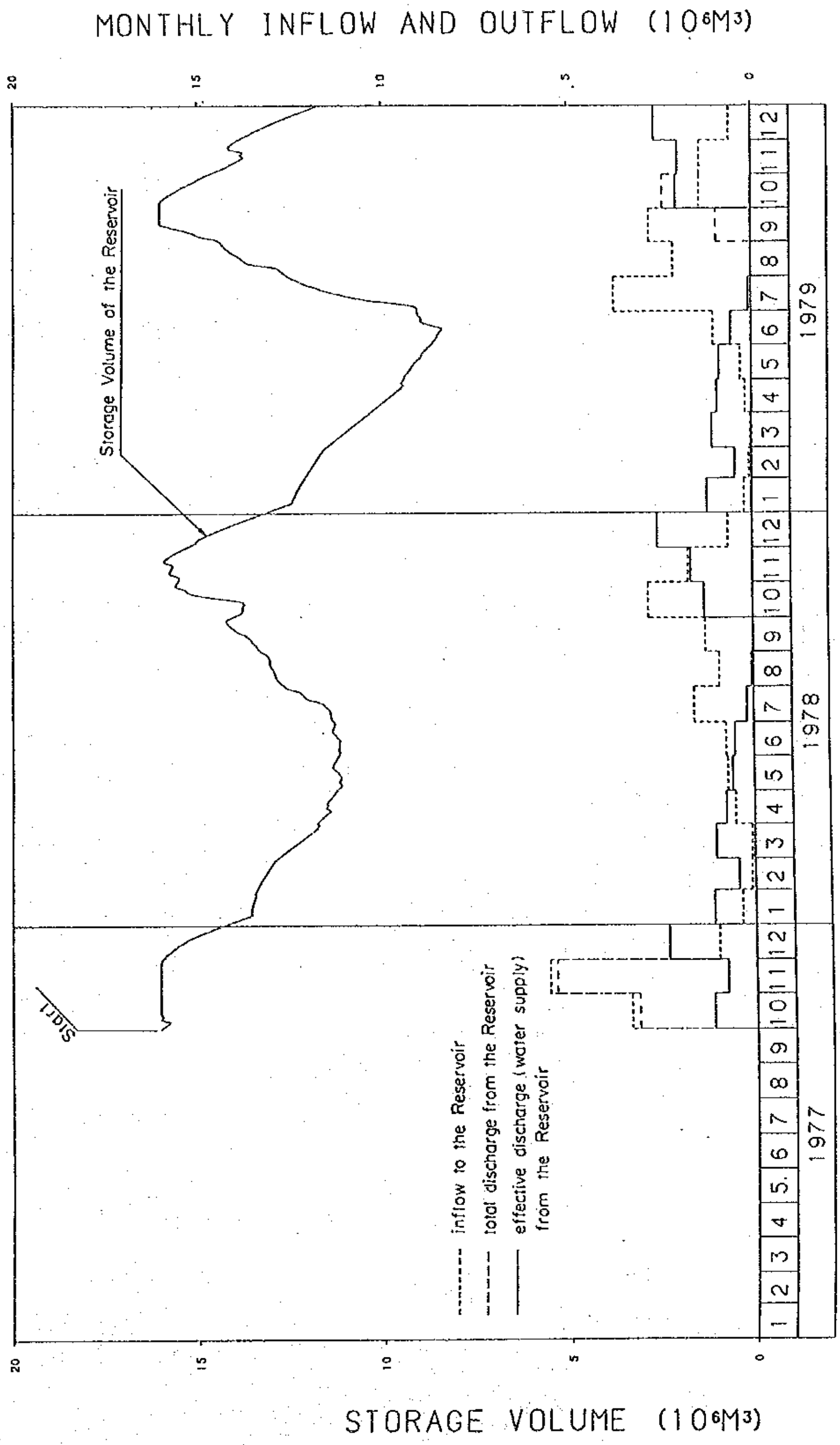


Fig. 5 Storage Volume and Monthly Inflow/Outflow of Bang Kam Prat Reservoir (1/4)

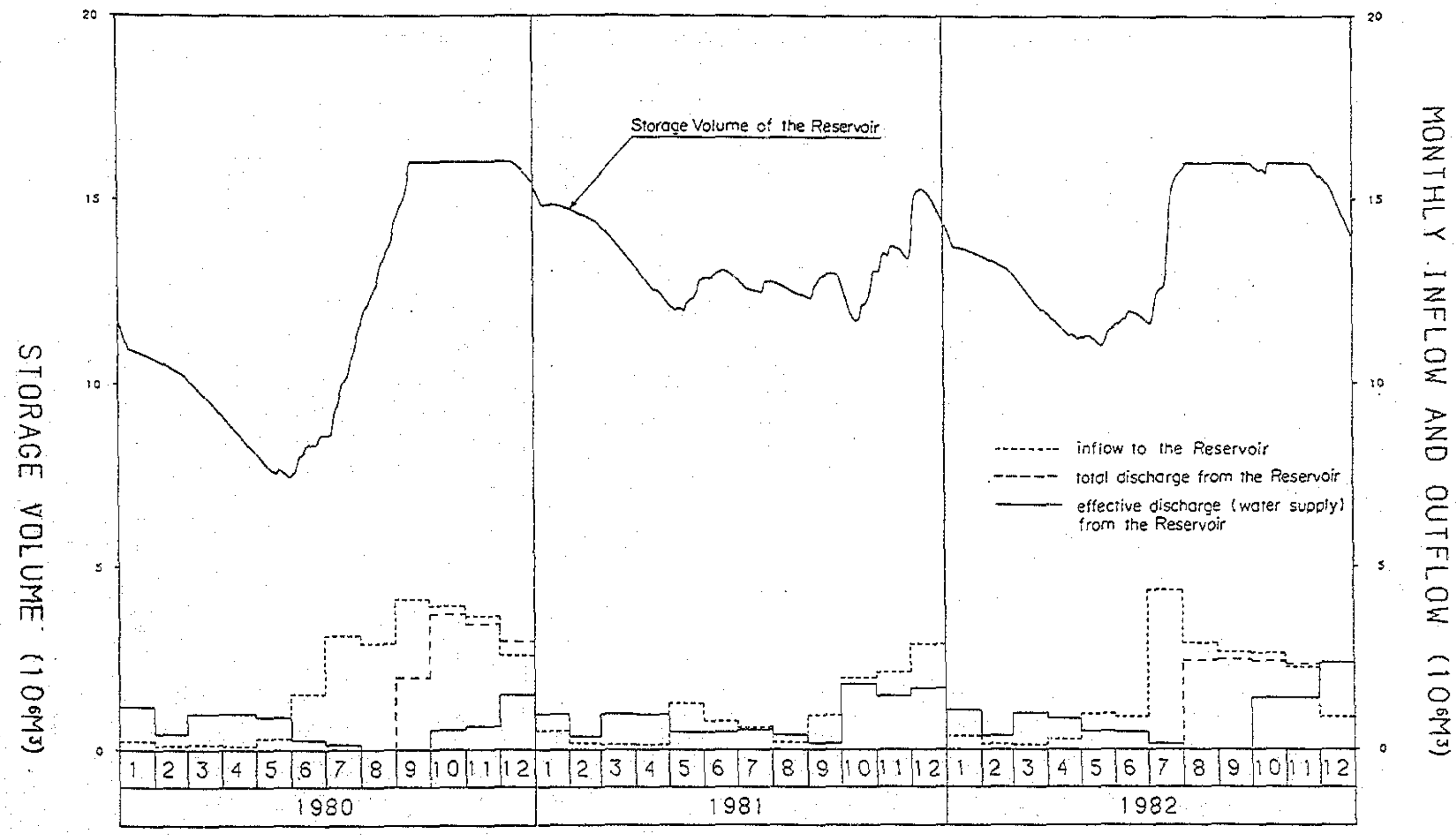


Fig. 5 Storage Volume and Monthly Inflow/Outflow of Bang Kam Prat Reservoir (2/4)

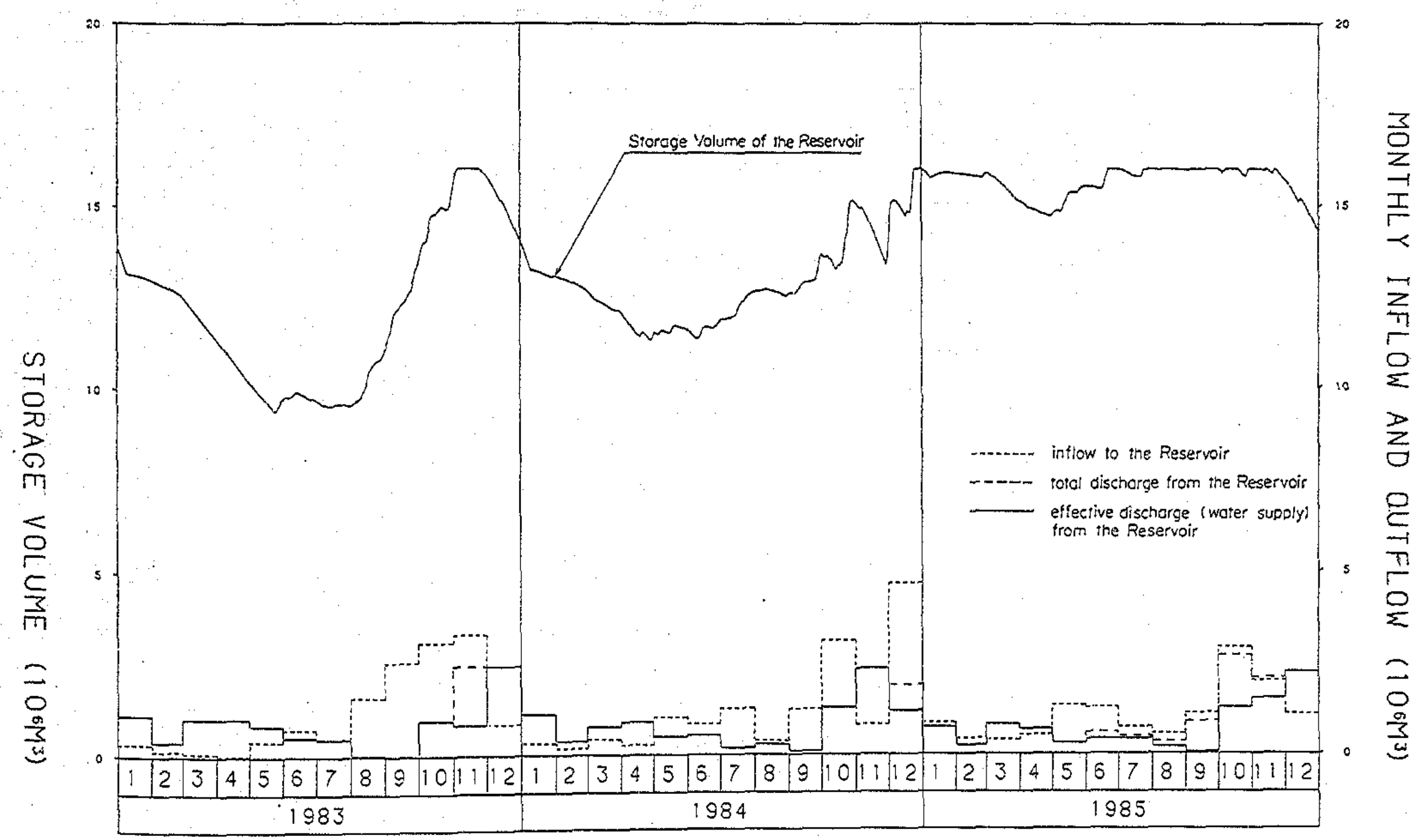


Fig. 5 Storage Volume and Monthly Inflow/Outflow of Bang Kam Prat Reservoir (3/4)

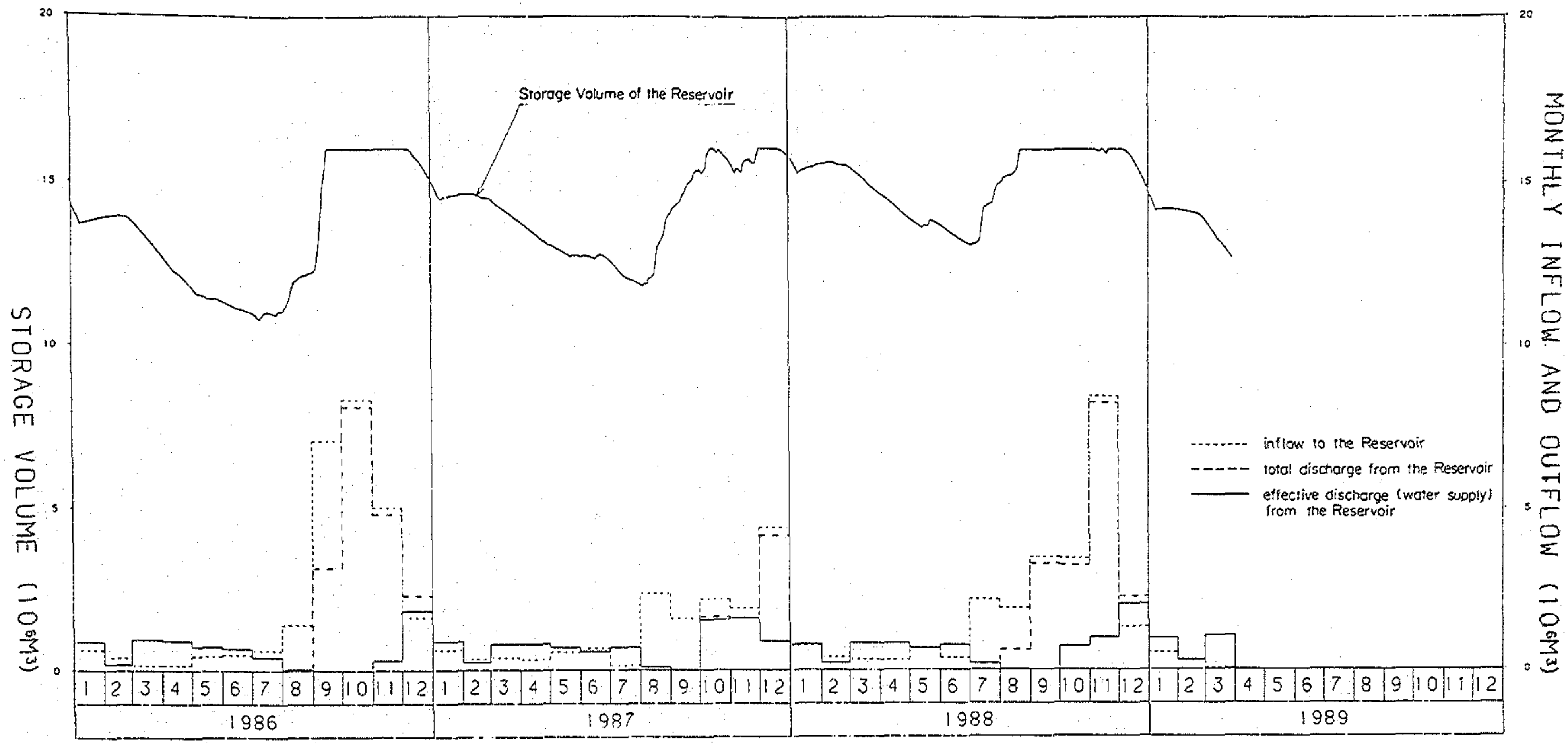


Fig. 5 Storage Volume and Monthly Inflow/Outflow of Bang Kam Prat Reservoir (4/4)

5. Recommendation

In this study, the discharge record of Khlong Sang has been adopted for discharge estimation of Khlong Bang Kam Prat without analyzing the correlation on streamflow and precipitation between the both basins due to lack of the data in Khlong Bang Kam Prat basin. In order to carry out more reliable study, it is recommended that the following items should be observed consecutively;

- rainfall at Bang Kam Prat Dam
- surface elevation of Bang Kam Prat Reservoir
- discharge from Bang Kam Prat Reservoir

Appendix II Thermal Analysis Method

(a) Thermogravimetry (TG)

Thermogravimetry method is measuring the sample weight continuously during increasing temperature of sample at constant rate.

(i) Equipment for Analysis

The flowsheet of analyzing system is shown in Figure 1. Sample is heated by electric heater. The temperature of sample is increasing at constant rate that is controlled automatically.

At this time the weight of sample is measured by the thermobalance, the temperature of sample is measured by the thermocouple. These data are indicated by X-Y plotter. This figure is named "Thermolysis curve" or "Pyrolysis curve".

(ii) Evaluation

This method is used for evaluating following items.

1) Thermolysis reaction process
2) Weight of the crystallized water (see Figure 2)
3) Decision of melting point and boiling point

(b) Differential thermal analysis (DTA)

This method is measured by the differential temperature between sample and basis material during increasing temperature of sample at constant rate.

(i) Equipment for analysis

The flowsheet of analyzing system is shown in Figure 3. Sample is put into electric heater with basis material. The temperature and atmosphere (oxidized or reduced) of sample are controlled by this equipment. Sample temperature and the differential temperature between sample and basis material are measured, during increasing temperature of sample at constant rate. These data are indicated by X-Y plotter. This figure is named "DTA curve" or "Thermogram".

(ii) Evaluation

If the differential temperature indicates 'plus' value, it means that heat release reaction happens, and 'minus' value means heat absorption reaction. This method is used for evaluating following items.

1) Phase changing (melting, vaporization)
2) Various reaction (oxidization, reduction and resolution)

In general, these two figures are plotted on the same street and evaluated together (Figure 4).

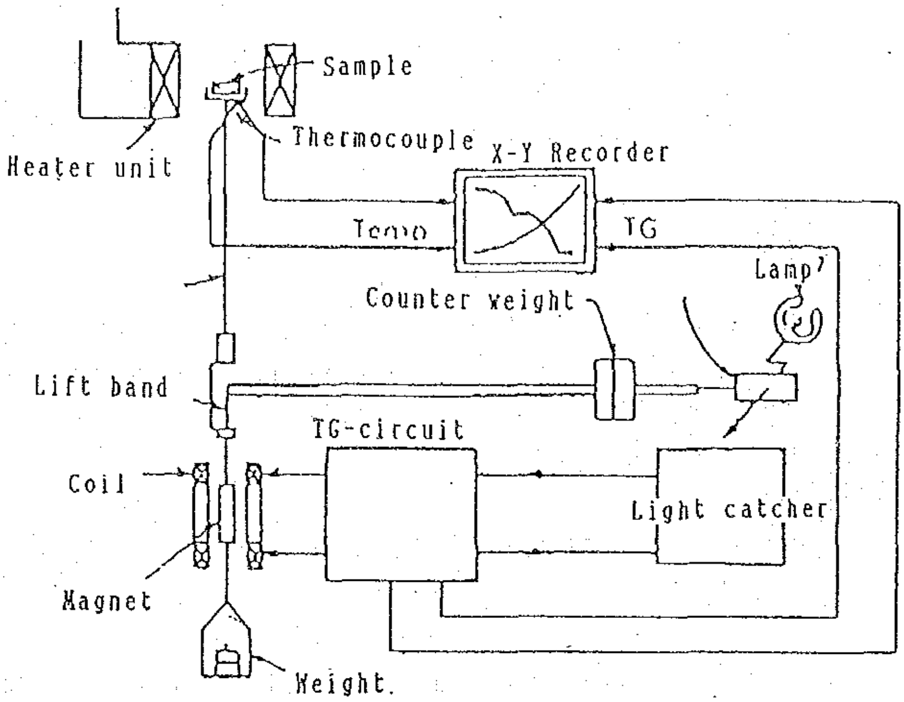


Figure 1. Flowsheet of TG method (Electromagnetic type)

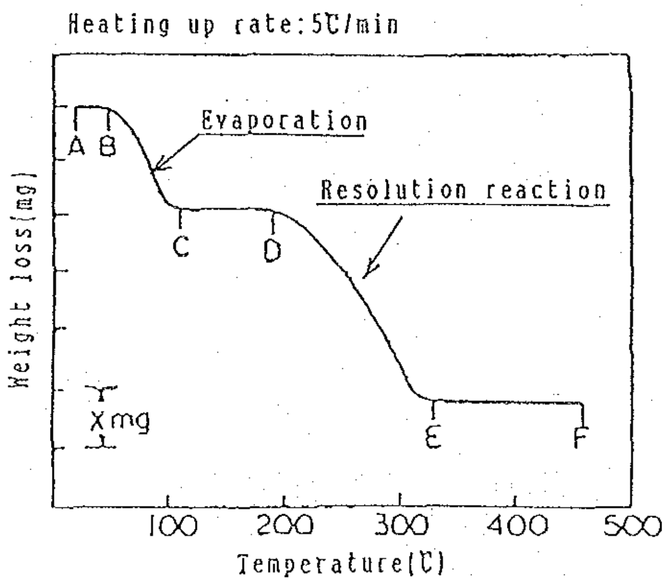


Figure 2. Weight loss curve of $MX_2 \cdot 6H_2O$

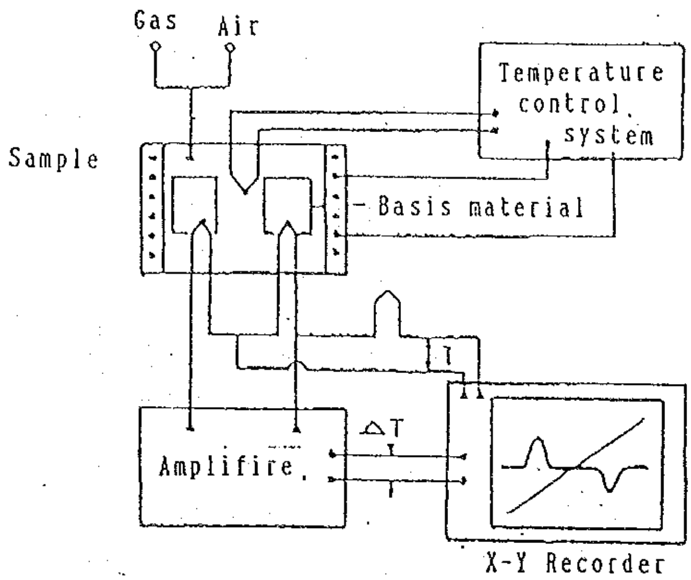


Figure 3. Flowsheet of DTA equipment

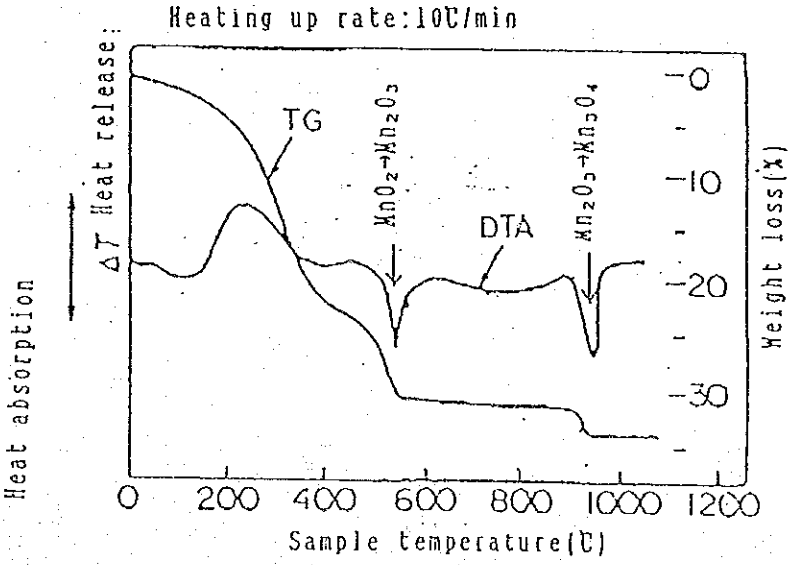


Figure 4. DTA-TG curve for $MnCO_3$

APPENDIX III
PHOTO

Ecology
Lignite
Limestone
Cooling Water
Substation
Port Facility
Road and Bridge

Rubber Tree

Palm Tree

Cashew Nut

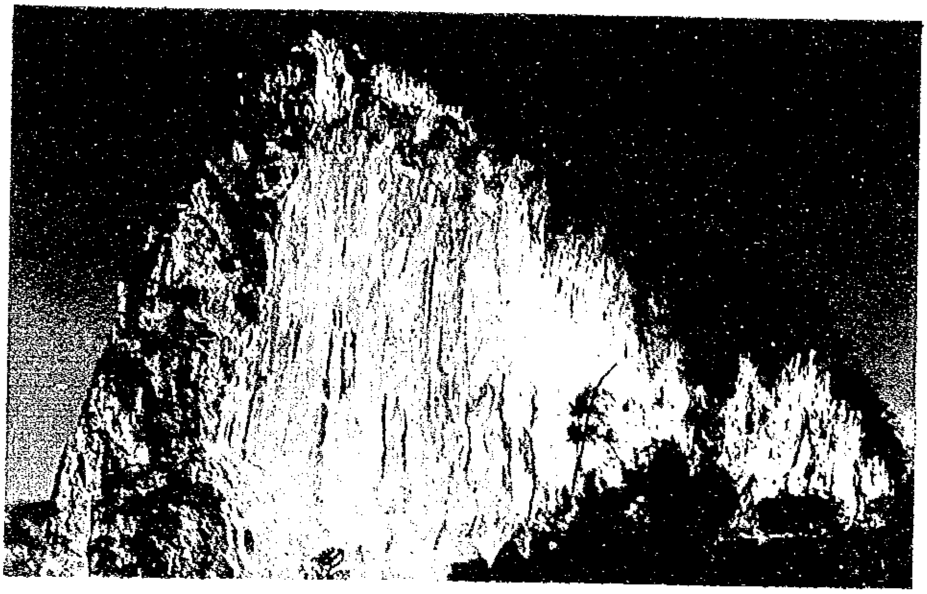
Lignite

Sin Pun Resource

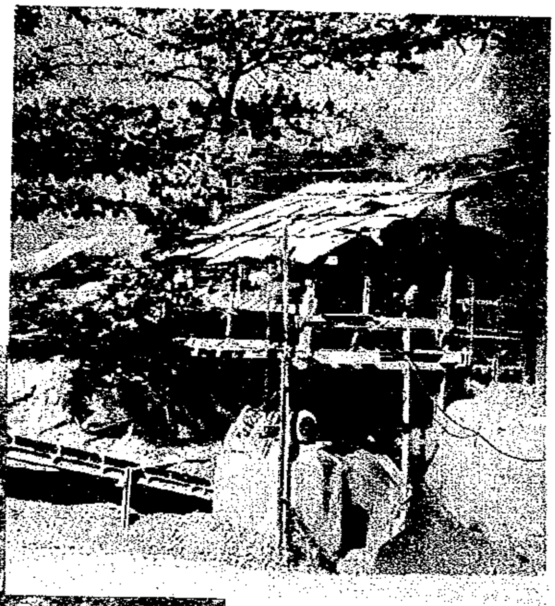
Krabi Mine

Limestone

(Sin Pun)



Khao Tham Hora



Thung Song

Thung Song

Limestone

(Sin Pun)

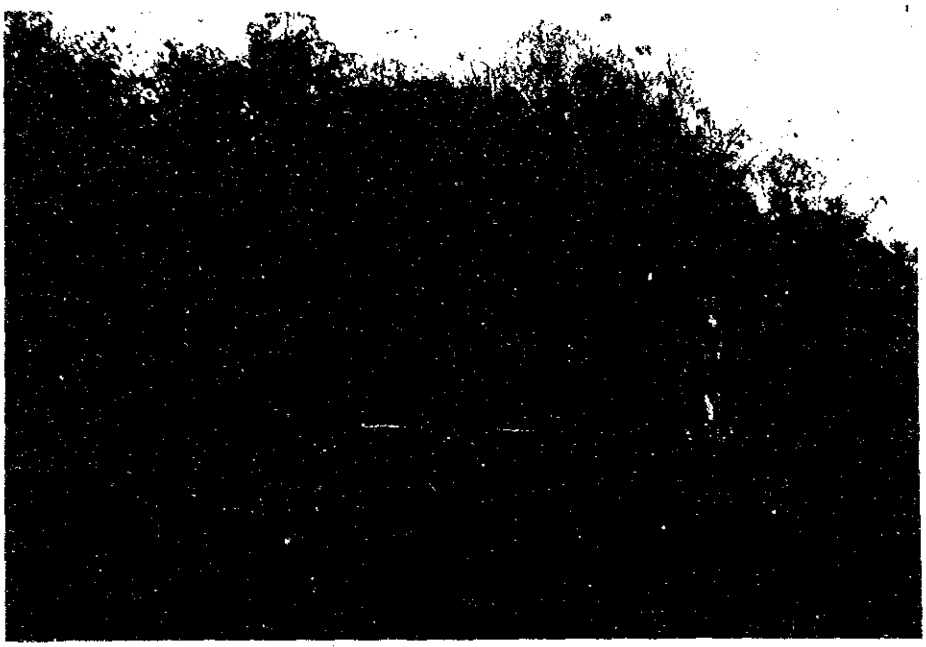
Khao Tham Padam

Wat Khao Din

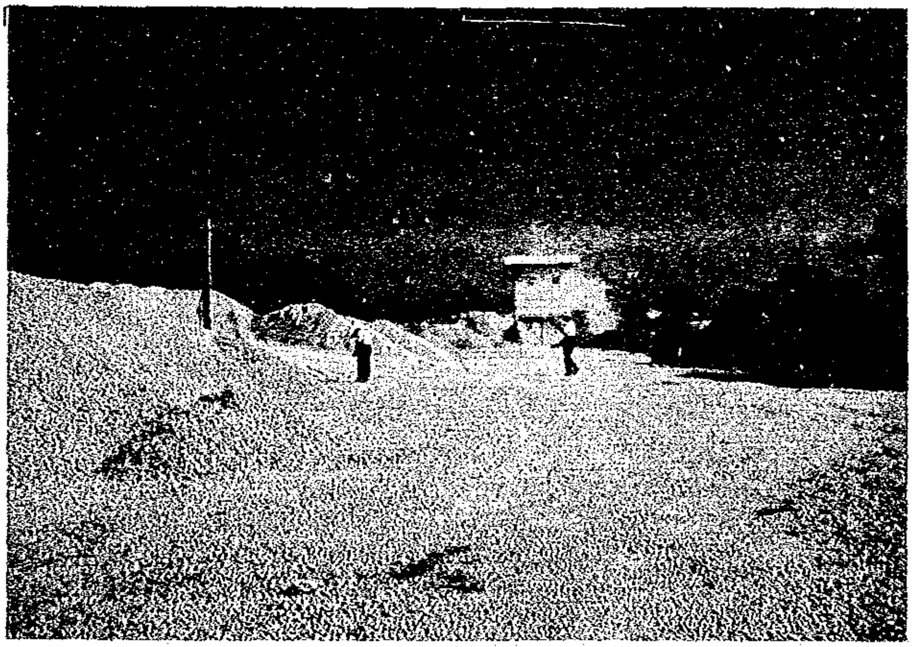
Limestone

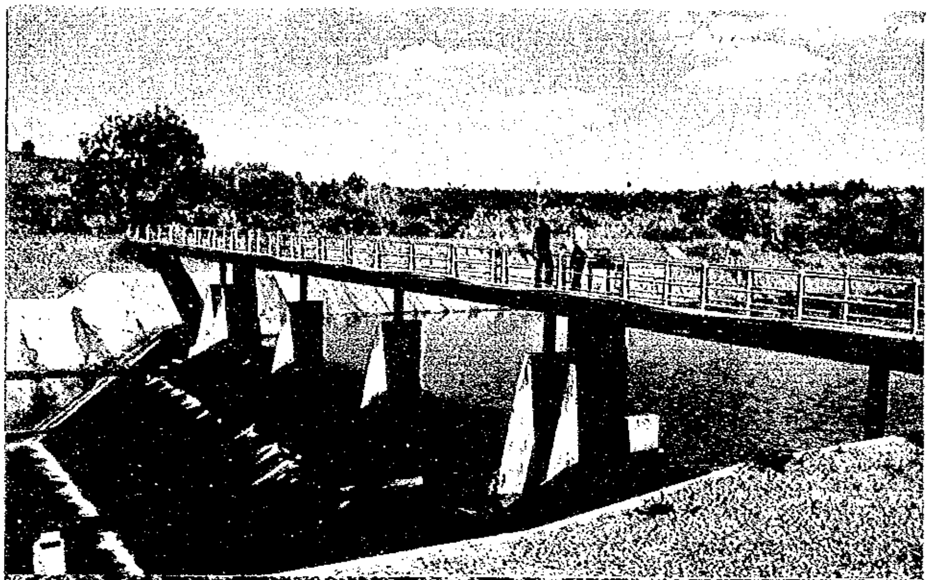
(Krabi)

Khao Kaew



Yod Po Sila Thong





Sin Pun

Bang Kam Prat Weir

Site No. 2 and No. 3 take cooling water from Bang Kam Prat Weir in site selection study.

Sin Pun

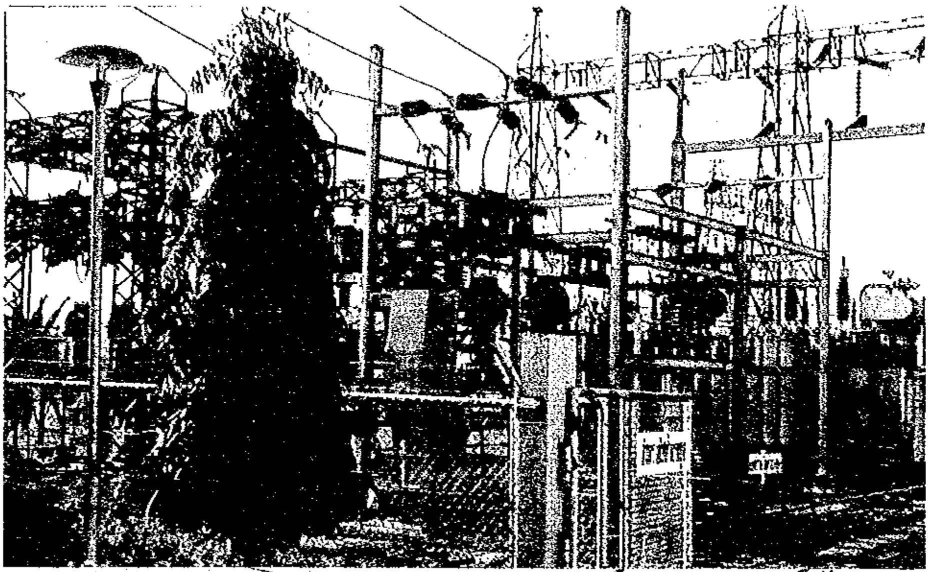
Sin Pun River

An alternative water resources for site No. 3.

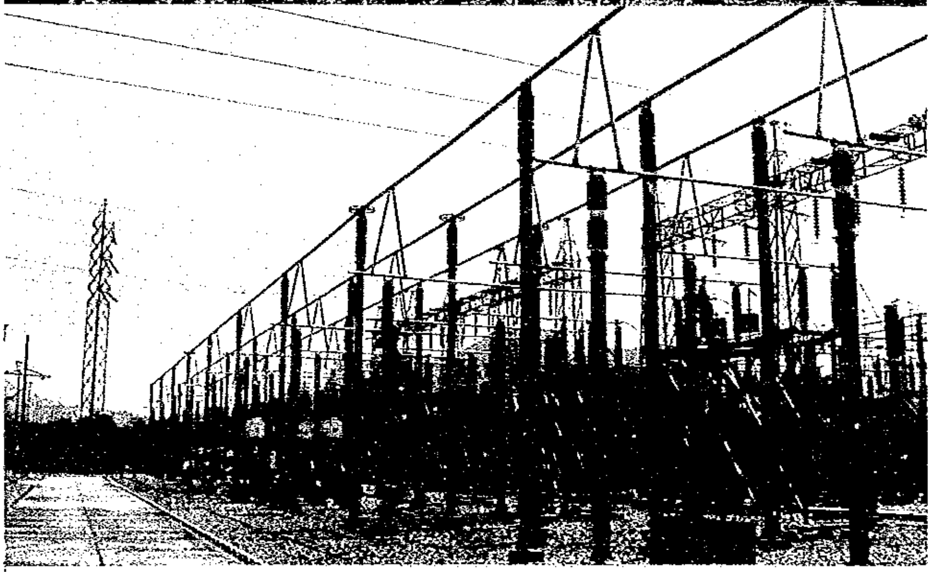
Krabi

Phakasai River

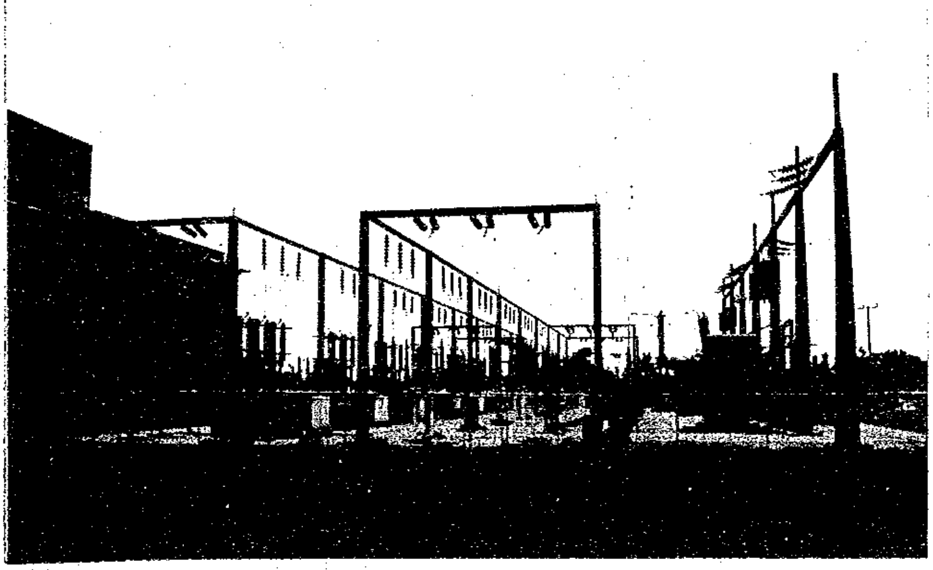
Water resources for site No. 4.



Thung Song S/S
(115 kV)

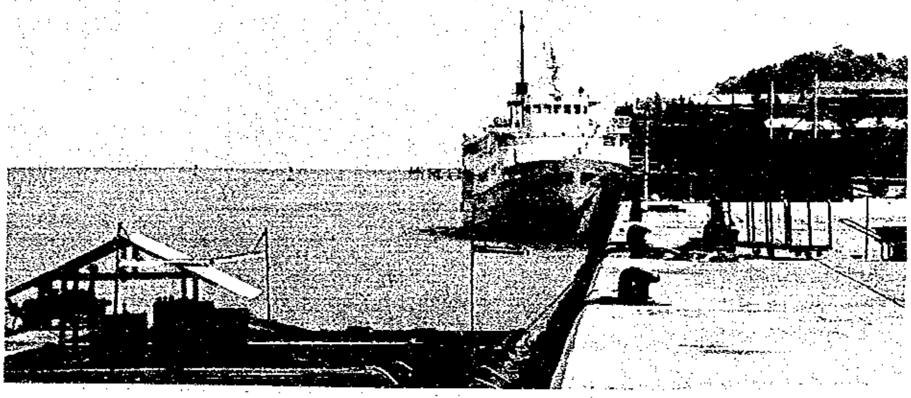


Phangnga S/S
(115 kV)



Krabi P/S
(115 kV)

Songkhla International Port



Phuket International Port

Krabi P/S

Road

Typical road in southern region of Thailand

Bridge

Typical bridge in southern region of Thailand

APPENDIX IV
CORRESPONDENCE

Date	Subject
22nd March '91	Minutes of Meeting for Inception Report March '91
11th April '91	Limestone Analysis Result for Krabi Area
28th June '91	Confirmation of Coal Shipping Schedule for Bench Scale Combustion Test
9th July '91	Request for the Final Report of "Sin Pun Conceptual Mining Study"
7th October '91	Minutes of the Second Meeting
5th November '91	Power Plant Scale
28th November '91	Cost Evaluation for Site Selection
12th December '91	Pilot Scale Combustion Test and Visit of EGAT Engineers to Japan
24th December '91	Pilot Scale Combustion Test
31st January '91	Minutes of the Third Meeting
23rd April '92	Request for Environmental Impact Assessment Report
21st July '92	Minutes of the Fourth Meeting

APPENDIX V

CALCULATION ON INFLUENCE OF THERMAL EFFLUENT

1. General

Cooling water absorbs heat of steam while passing through condenser and is discharged through cooling water outlet.

The temperature of cooling water rises 7°C at this time.

As the thermal effluent has a temperature higher than the surrounding river water, it has the property of density current due to reduced density which spreads thinly over the river surface.

Such thermal effluent diffusing and cooling process takes place mainly by the following three physical phenomena which are complicatedly combined.

- Movement of heat by water flow caused by discharged of thermal effluent itself
- Mixing and dilution with surrounding cool river water
- Heat radiation from river surface to atmosphere

Meanwhile, the following conditions govern the diffusion of thermal effluent.

1) Discharge conditions of thermal effluent

- Layout and shape of thermal effluent outlet
- Discharge velocity
- Discharge volume
- Discharge water temperature

2) Natural conditions

- Cross-sections of the river
- River water flow and diffusion characteristics

- Meteorological conditions

2. Analysis

(1) Analysis Method

As an analysis method of diffusion area of thermal effluent at this feasibility study stage, we adopted the simulation model using computer, which is convenient and widely used.

The prediction model is "Central Research Institute Model" developed by the Japan Central Research Institute of Electric Power Industry.

Assuming the temperature difference of water between the intake and outlet to be 7°C, the extent of temperature rise in front of the intake was calculated.

(2) Analysis Procedure

Procedure for the analysis is as follows.

1) Preparation of cross-sections of the river
2) Calculation of backwater
3) Calculation of flow velocity
4) Calculation of thermal effluent diffusion
5) Estimation of temperature distribution

The results obtained from the hydraulic model experiment conducted by AIT in May 1990 were taken into consideration to determine some unknown factors for all the above calculations.

(Refer to the draft final report titled "A STUDY ON IMPACTS OF THERMAL DISCHARGE AND ASH POND EFFLUENT ON THE RECEIVING ENVIRONMENT FROM 75 MW LIGNITE KRABI THERMAL POWER PLANT")

(3) Basic Calculation Conditions

Basic Calculation conditions are as follows.

1) Discharge rate : 7.5 m^3/s (2 units operation)

2) Intake water temperature: 32°C

3) Temperature difference : 7°C

4) Flow rate of the river

- Slack tide : 0.0 m^3/sec
- Flood flow : 71.4 m^3/sec
- Ebb flow : 86.1 m^3/sec

5) Assumed cross-sections of the river

- Shape : Trapezoid
- Number : 45
- Location : Same as the hydraulic experiment
- Flow velocity and water level should be determined based on the results of hydraulic experiment
- River bed gradient should be determined at each cross-section based on the results of hydraulic experiment

3. Calculation Results

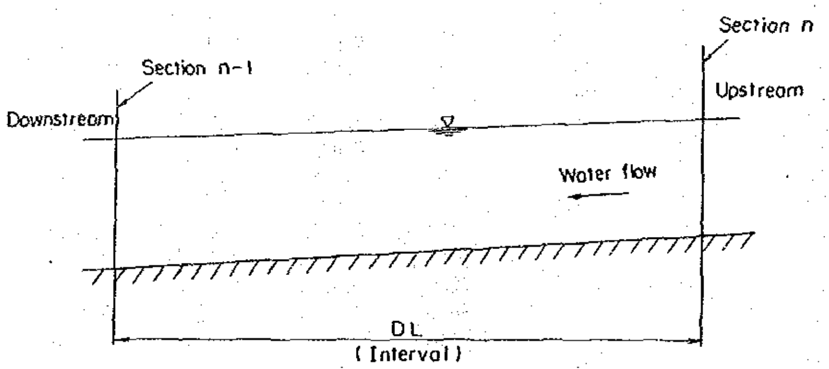
(1) Calculation of Backwater

Input data of each section for backwater calculation are as follows.

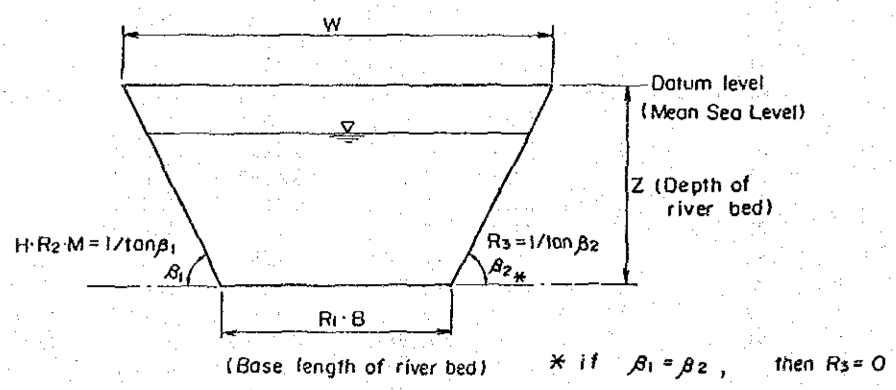
Table 1 Input Section Data List
- Flood Flow Without Power Plant -

ID No.	Type	DL	Z	N1	N2	R1.B	H.R2.M	R3
1	3	0.0	-3.8032	0.0250	0.0250	21.6127	3.7321	0.0
2	3	87.0	-3.1612	0.0250	0.0250	38.4124	2.6236	0.0
3	3	82.0	-4.0742	0.0250	0.0250	27.1227	2.4394	0.0
4	3	92.0	-5.7844	0.0250	0.0250	9.2148	2.7475	0.0
5	3	97.0	-4.7795	0.0250	0.0250	19.7369	2.7475	0.0
6	3	92.0	-4.7101	0.0250	0.0250	14.8436	3.732	0.0
7	3	109.0	-4.4524	0.0250	0.0250	20.2327	4.1290	0.0
8	3	103.0	-3.8750	0.0250	0.0250	3.0763	3.7321	0.0
9	3	94.0	-4.4746	0.0250	0.0250	25.6010	3.7321	0.0
10	3	89.0	-4.1322	0.0250	0.0250	25.1059	6.5212	0.0
11	3	80.0	-3.4682	0.0250	0.0250	40.6618	5.6713	0.0
12	3	80.0	-3.9767	0.0250	0.0250	26.8941	5.6713	0.0
13	3	115.0	-3.7894	0.0250	0.0250	45.0185	5.6713	0.0
14	3	137.0	-7.0616	0.0250	0.0250	21.7128	2.1445	0.0
15	3	137.0	-4.7806	0.0250	0.0250	38.3170	3.7321	0.0
16	3	112.0	-5.0651	0.0250	0.0250	22.1932	3.7321	0.0
17	3	92.0	-5.6150	0.0250	0.0250	15.0892	3.7321	0.0
18	3	100.0	-4.5292	0.0250	0.0250	33.1939	3.7321	0.0
19	3	95.0	-5.0228	0.0250	0.0250	14.3116	6.5391	0.0
20	3	110.0	-3.8831	0.0250	0.0250	39.4554	5.6713	0.0
21	3	127.0	-3.6118	0.0250	0.0250	68.7169	1.9081	0.0
22	3	122.0	-4.1395	0.0250	0.0250	48.9655	1.9367	0.0
23	3	110.0	-3.5625	0.0250	0.0250	58.4301	2.6071	0.0
24	3	115.0	-4.0801	0.0250	0.0250	43.7211	5.6713	0.0
25	3	140.0	-4.5701	0.0250	0.0250	30.1637	5.6713	0.0
26	3	115.0	-4.3887	0.0250	0.0250	46.6970	3.8511	0.0
27	3	58.0	-4.2213	0.0250	0.0250	43.4919	3.7321	0.0
28	3	42.0	-5.1658	0.0250	0.0250	31.8422	3.7321	0.0
29	3	50.0	-5.1530	0.0250	0.0250	32.0378	3.7321	0.0
30	3	45.0	-4.2488	0.0250	0.0250	50.6579	2.3468	0.0
31	3	34.0	-5.0912	0.0250	0.0250	48.8334	2.9626	0.0
32	3	24.0	-4.1001	0.0250	0.0250	69.5928	6.6349	0.0
33	3	18.0	-6.0880	0.0250	0.0250	30.5259	8.5803	0.0
34	3	20.0	-7.3644	0.0250	0.0250	47.1014	3.1841	0.0
35	3	27.0	-4.8636	0.0250	0.0250	54.8306	2.5875	0.0
36	3	35.0	-5.0724	0.0250	0.0250	45.1924	2.9776	0.0
37	3	37.0	-3.5741	0.0250	0.0250	55.8447	4.3584	0.0
38	3	48.0	-4.1491	0.0250	0.0250	47.8011	4.1213	0.0
39	3	55.0	-3.7699	0.0250	0.0250	60.0297	3.3118	0.0
40	3	50.0	-3.0163	0.0250	0.0250	87.8603	4.3331	0.0
41	3	45.0	-2.9154	0.0250	0.0250	90.9318	5.6713	0.0
42	3	45.0	-3.5759	0.0250	0.0250	75.4405	5.6713	0.0
43	3	45.0	-2.9589	0.0250	0.0250	104.1210	2.1763	0.0
44	3	40.0	-3.7160	0.0250	0.0250	74.4613	3.1672	0.0
45	3	20.0	-3.6875	0.0250	0.0250	80.5046	1.6216	0.0

Indication of Column	Meaning
ID No.	Number of Section
Type	Type of Calculation ("3" means trapezoid)
DL	Section Interval (Δ X)
Z	Depth of river bed
N_1	Roughness coefficient for invert
N_2	Roughness coefficient for side wall
R1.B	Base length of trapezoid
H.R2.M	Slope (left)
R_3	Slope (right) (When same value as R_2 is applied, R_3 is put as 0.0.)



Setting up of cross-sections



Section

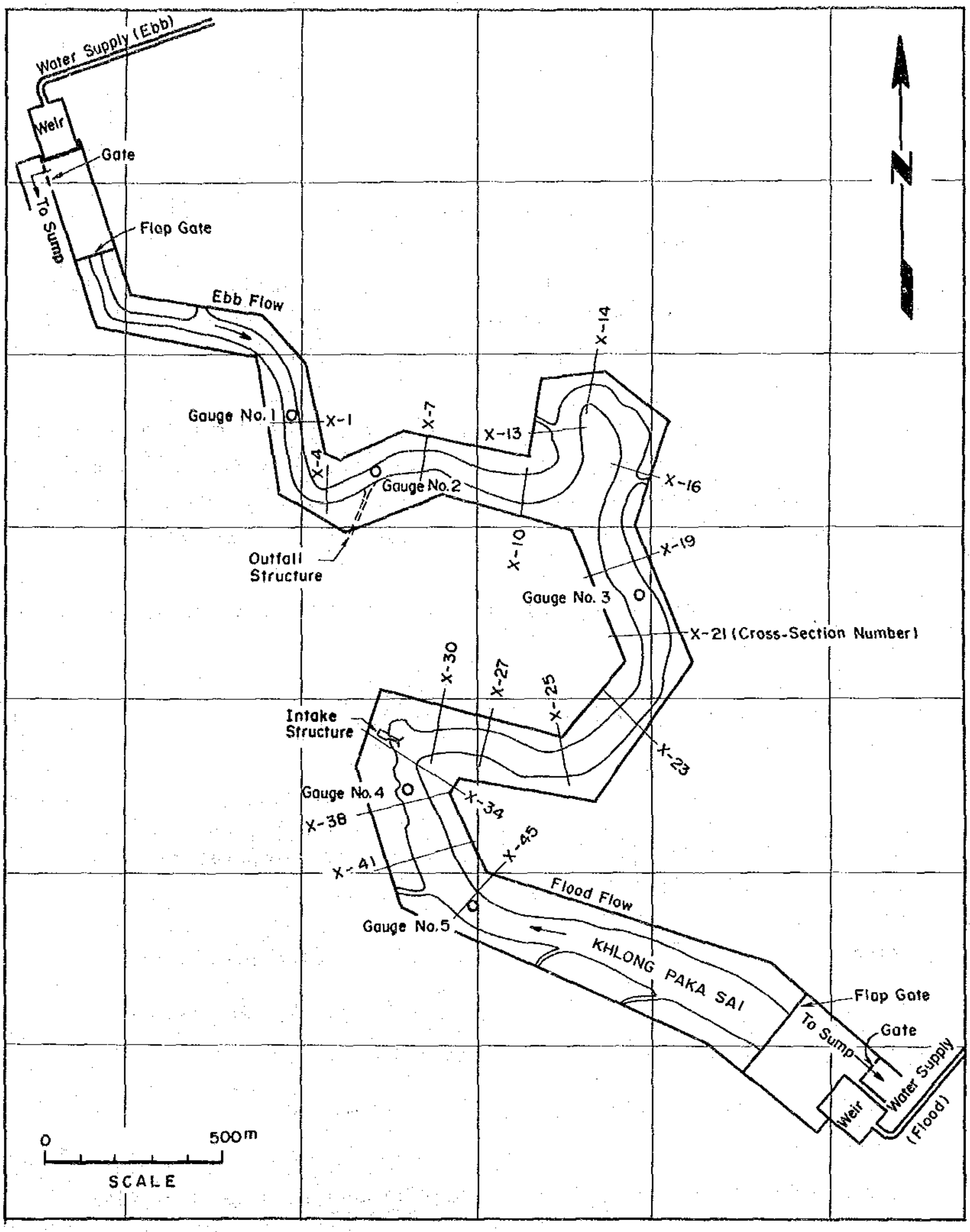


Fig.-a General Layout of the Model with Locations of Some Selected Cross Sections

The equation for backwater calculation is as follows,

$$\frac{\alpha}{2g} \bullet \frac{\partial u^2}{\partial x} + \frac{\partial \eta}{\partial x} + u^2 \bullet \frac{n^2}{R^{4/3}} = 0$$

where,

- α : energy compensation coefficient
- g : gravitational acceleration (m/s^2)
- u : flow velocity (m/s) (= Q/A)
- η : water level (m)
- R : hydraulic radius (m)
- n : Manning's roughness coefficient ($s/m^{1/3}$)

Appropriate cross-section were assumed taking into consideration the results of the hydraulic experiment, that is, dimension of each section was adjusted to get almost same flow velocity observed at the experiment by calculating backwater using various conditions.

As a result, aforementioned input section data shown in Table 1 were determined.

(2) Conditions for Diffusion Calculation

Item	Value
• Discharge Water Temperature	Ambient water temperature +7°C
• Discharge Volume	3.6 m^3/s (1 unit operation) 7.5 m^3/s (2 units operation)
• Diffusion Coefficient	10.0 m^2/s
• Atmospheric Heat Transfer Coefficient	0.4 cal/cm2 s.C°
• Atmospheric Temperature	Same as ambient water temperature

(3) Calculation of Thermal Effluent Diffusion

- Advection Diffusion Equation

$$\frac{\partial(TA)}{\partial t} + \frac{\partial(TAu)}{\partial x} = \frac{\partial}{\partial x}\left(AK\frac{\partial T}{\partial x}\right) + \frac{Q_{out}\,T_{out}}{\partial x} - \frac{Q_1\,(T-Ta)}{C\rho}\,W$$

where,

T	:	water temperature (°C)
t	:	time (s)
A	:	cross-sectional area of flow (m^2)
u	:	flow velocity (m/s)
K	:	diffusion coefficient (m^2/s)
Q_{out}	:	discharge volume (m^3/s)
T_{out}	:	discharge water temperature (°C)
δx	:	section interval (m)
Q_1	:	atmospheric heat transfer coefficient ($kg/s^3/°C$)
C	:	specific heat ($m2/s^2/°C$)
ρ	:	density (kg/m^3)
Ta	:	atmospheric temperature (°C)
W	:	river width (m)

Table 2 Calculation Cases

No.	Tidal Stage	Discharge from Power Plant	Backwater	Diffusion
1	Slack tide	3.6 m^3/s	O	O E
2	Slack tide	7.5 m^3/s	O	O
3	Flood flow	0 m^3/s (without power plant)	O E	
4	Flood flow	3.6 m^3/s	O E	E
5	Flood flow	7.5 m^3/s	O	
6	Ebb flow	0 m^3/s (without power plant)	O E	
7	Ebb flow	3.6 m^3/s	O E	O E
8	Ebb flow	7.5 m^3/s	O	O

Note: "E" indicates that the case is corresponding the hydraulic experiment by AIT.

(4) Conditions for Backwater Calculation

Item	Value
• Riverbed Configuration	
• Number of Sections	45
• Shape	Assumed to be trapezoid
• Dimensions and Riverbed gradient	Determined by adjusting to the experimental results
• Manning's Roughness Coefficient	0.025 (same as the experiment)
• Energy Compensation Coefficient	1.1

Item	Value
• Boundary Conditions	
• Flow rate at the downstream end	Slack Tide 0.0 m^3/s
	Flood Flow 71.4 m^3/s
	Ebb Flow 86.1 m^3/s
• Discharge Volume	3.6 m^3/s or 7.5 m^3/s
• Intake Volume	3.6 m^3/s or 7.5 m^3/s

(5) Calculation Results

Calculation results are shown in Fig. 1 - Fig. 15.

Section No. 6 and No. 33 indicate outlet point and intake point respectively. As shown in Fig. 15, the maximum temperature rise at intake point (Sec. No. 33) is approximately 0.3°C under the condition of ebb flow and two units operation.

Fig. 1 Velocity (1)
At Slack Tide with Power Plant (3.6 m^3/s)

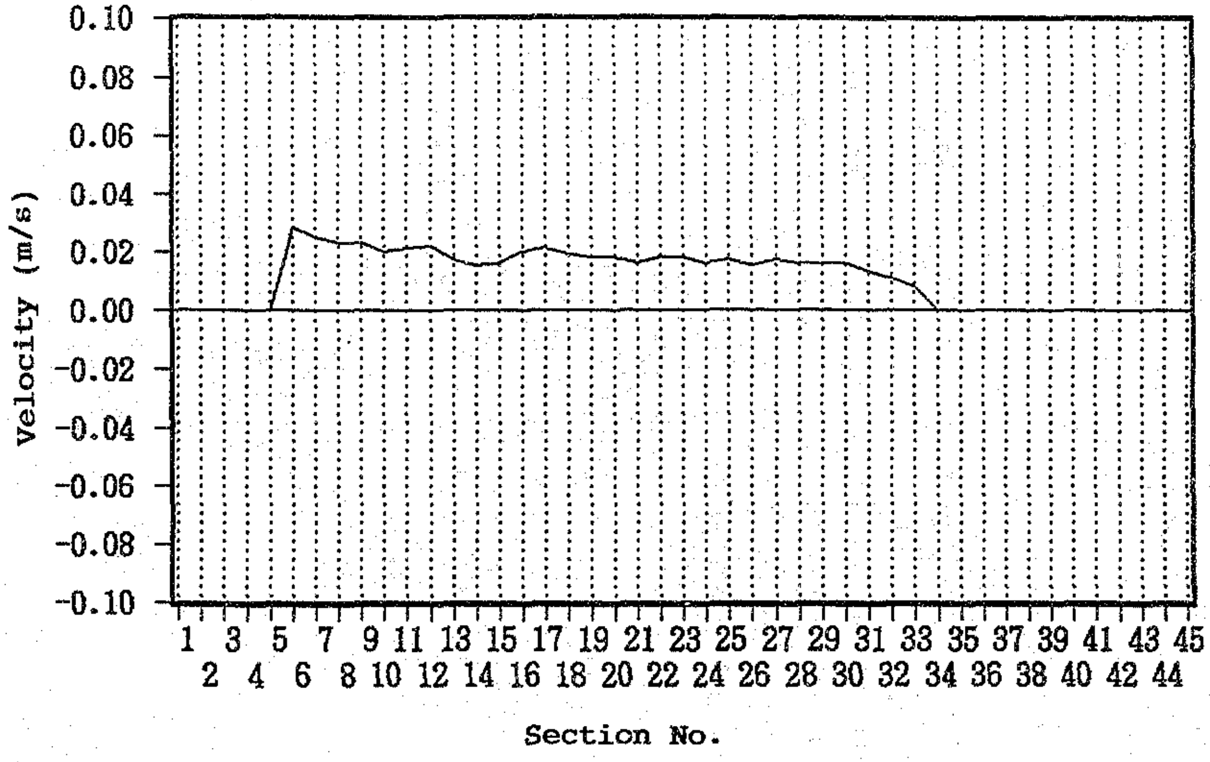


Fig. 2 Velocity (2)
At Slack Tide with Power Plant (7.5 m^3/s)

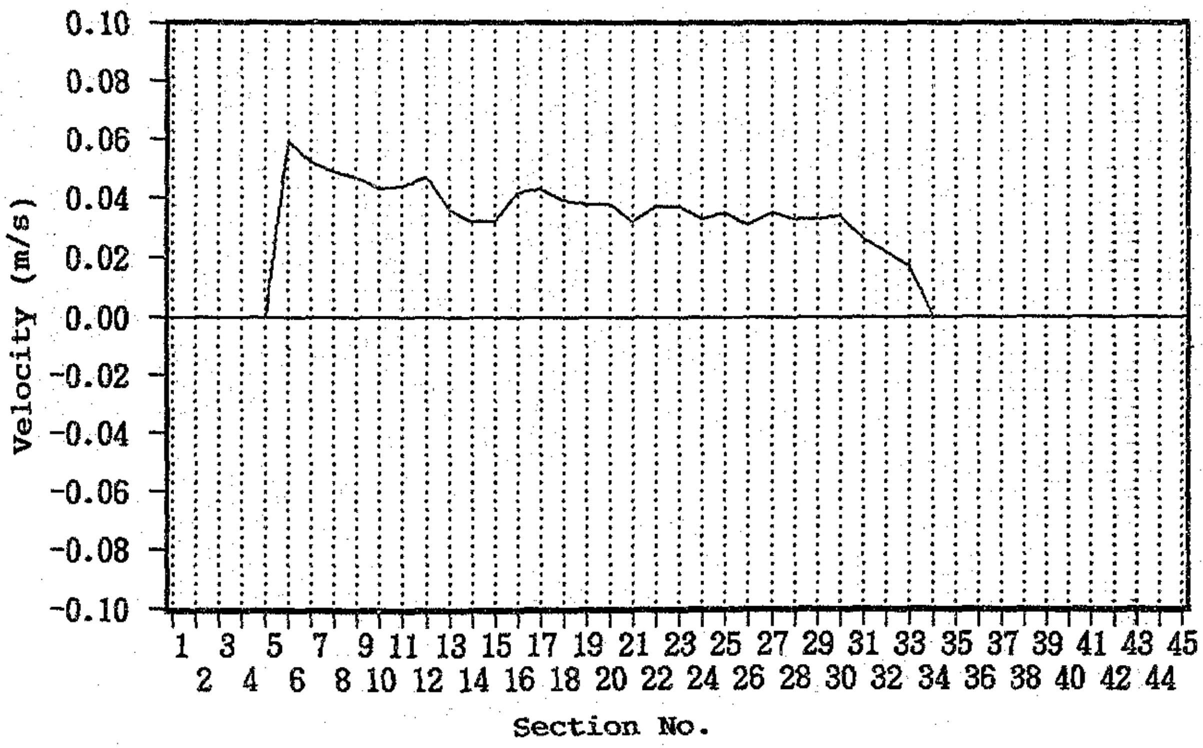


Fig. 3 velocity (3)
In Flood Flow without Power Plant

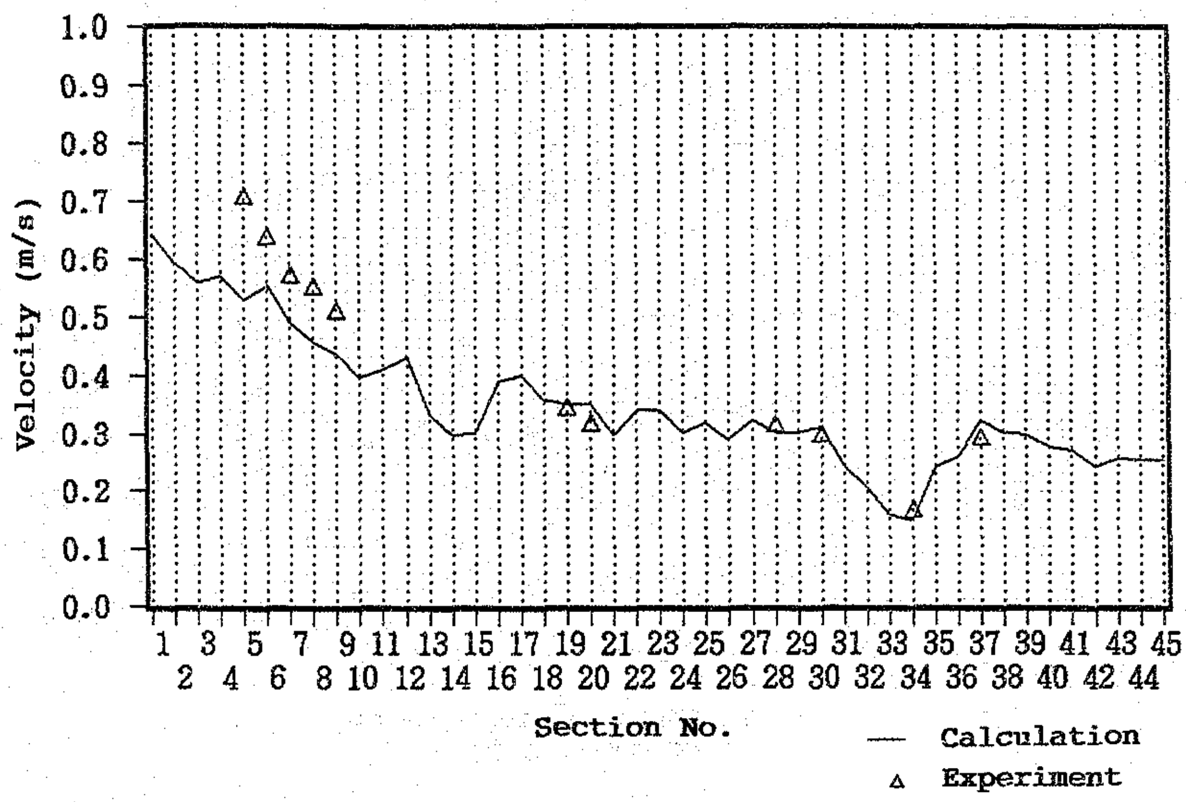


Fig. 4 Velocity (4)
In Flood Flow with Power Plant (3.6 m^3/s)

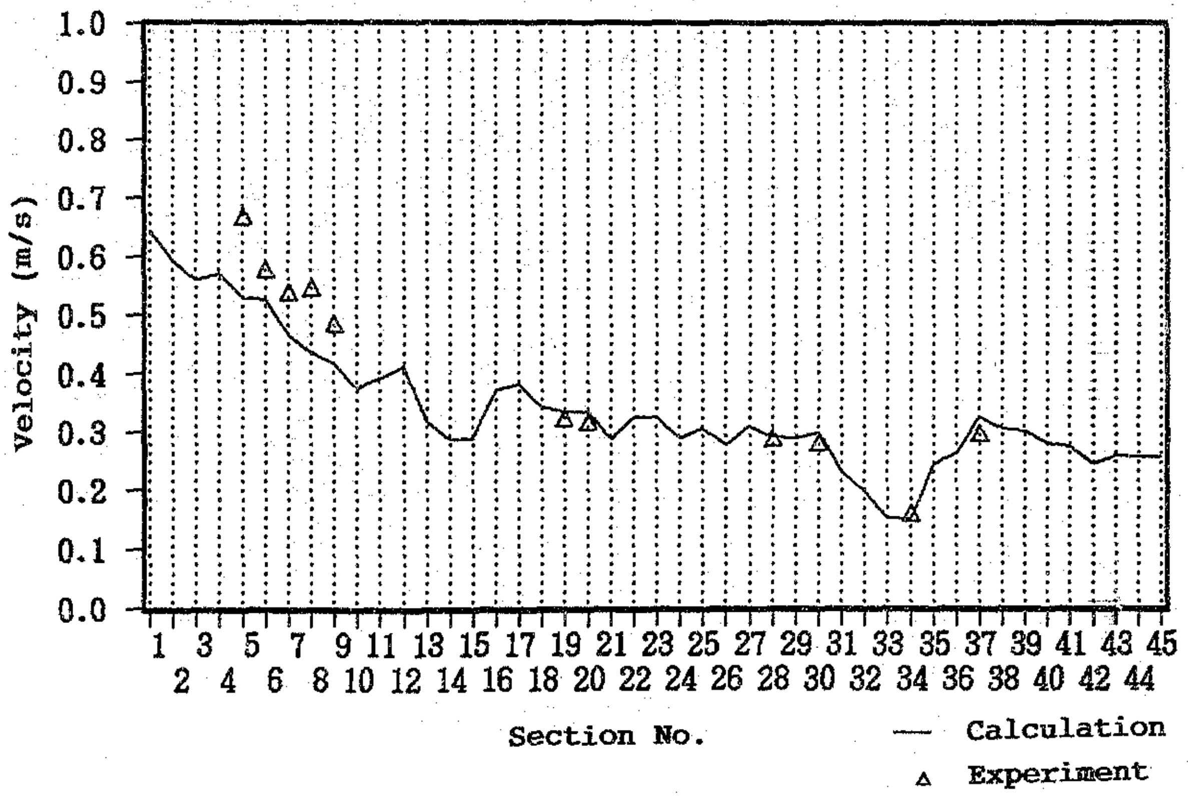


Fig. 5 Velocity (5)
In Flood with Power Plant (7.5 m^3/s)

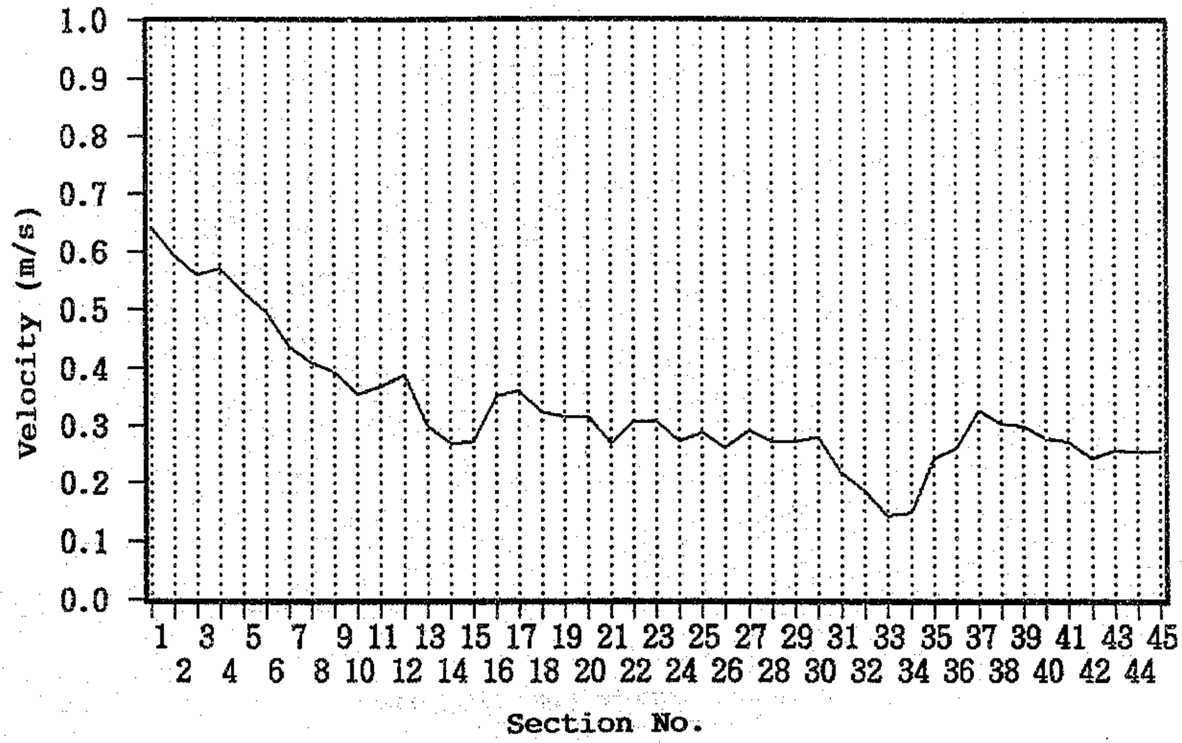


Fig. 6 Velocity (6)
In Ebb Flow with Power Plant

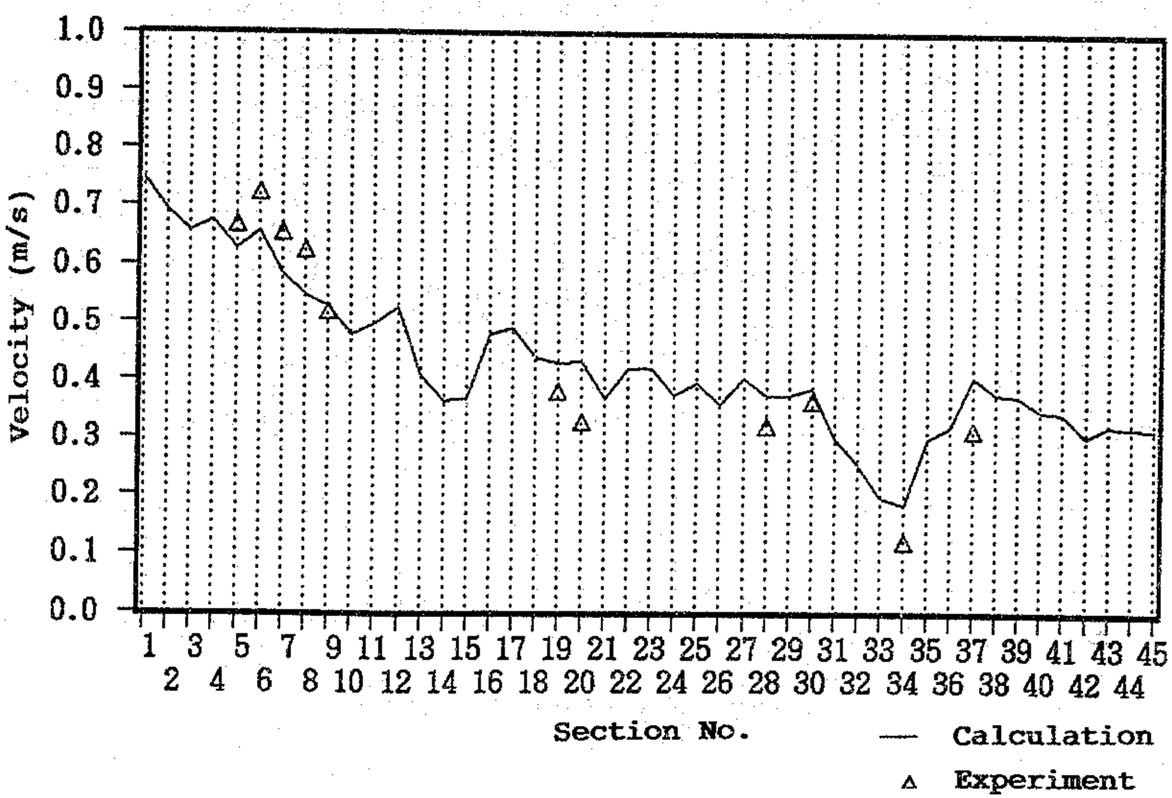


Fig. 7 Velocity (7)
In Ebb Flow with Power Plant (3.6 m^3/s)

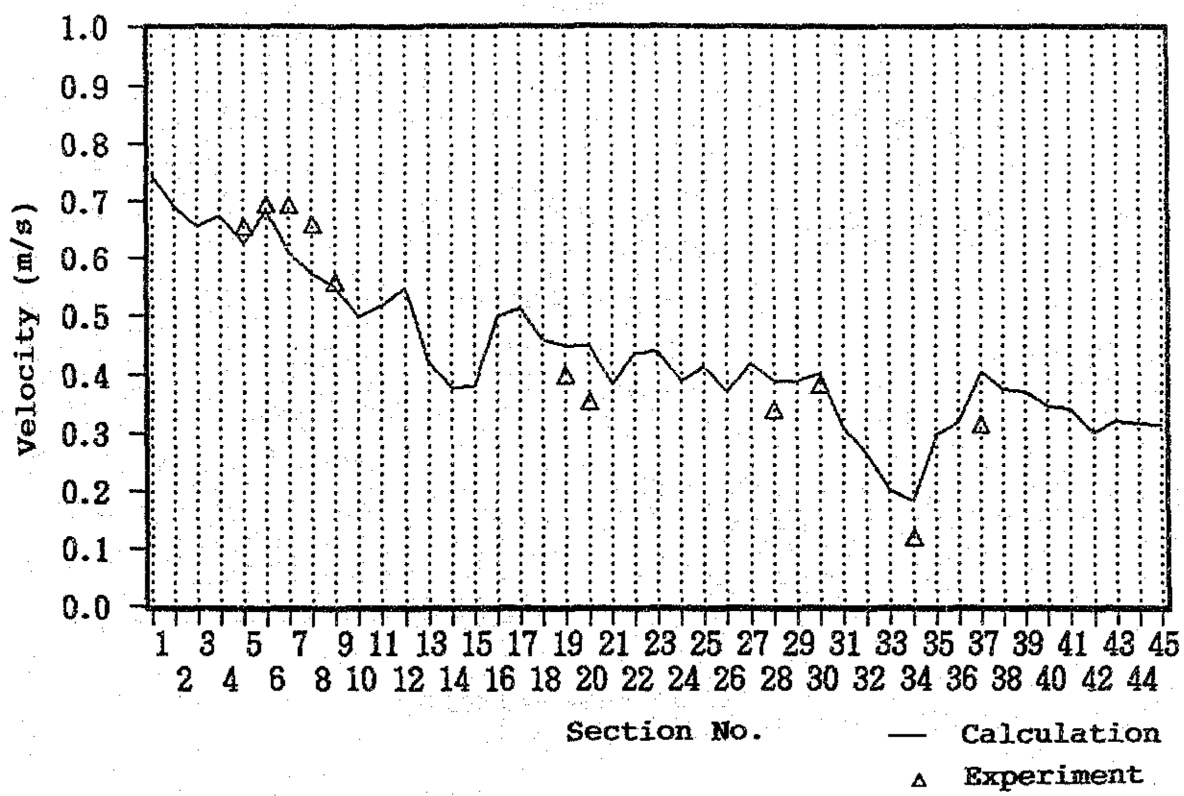


Fig. 8 Velocity (8)
In Ebb Flow with Power Plant (7.5 m^3/s)

Fig. 9 Water Level (1)
In Flood and Ebb Flow without Power Plant

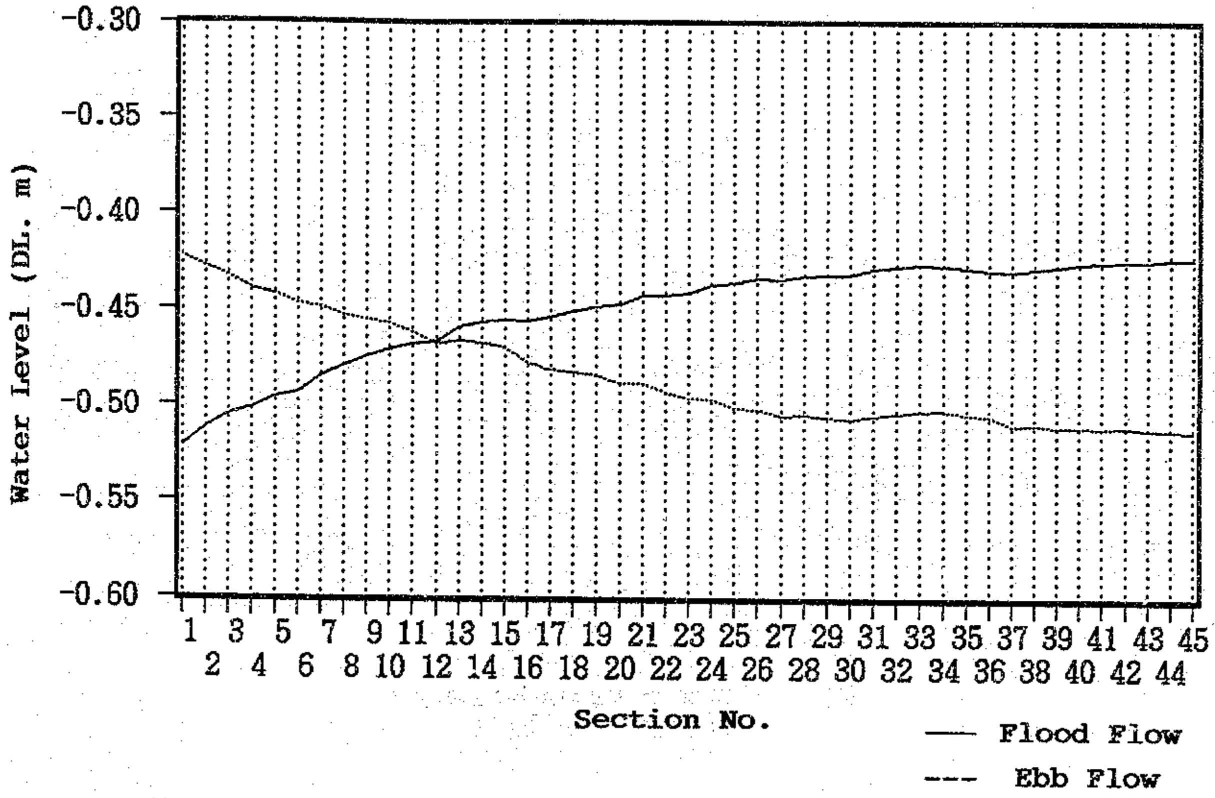


Fig. 10 Water Level (2)
In Flood and Ebb Flow with Power Plant (3.6 m^3/s)

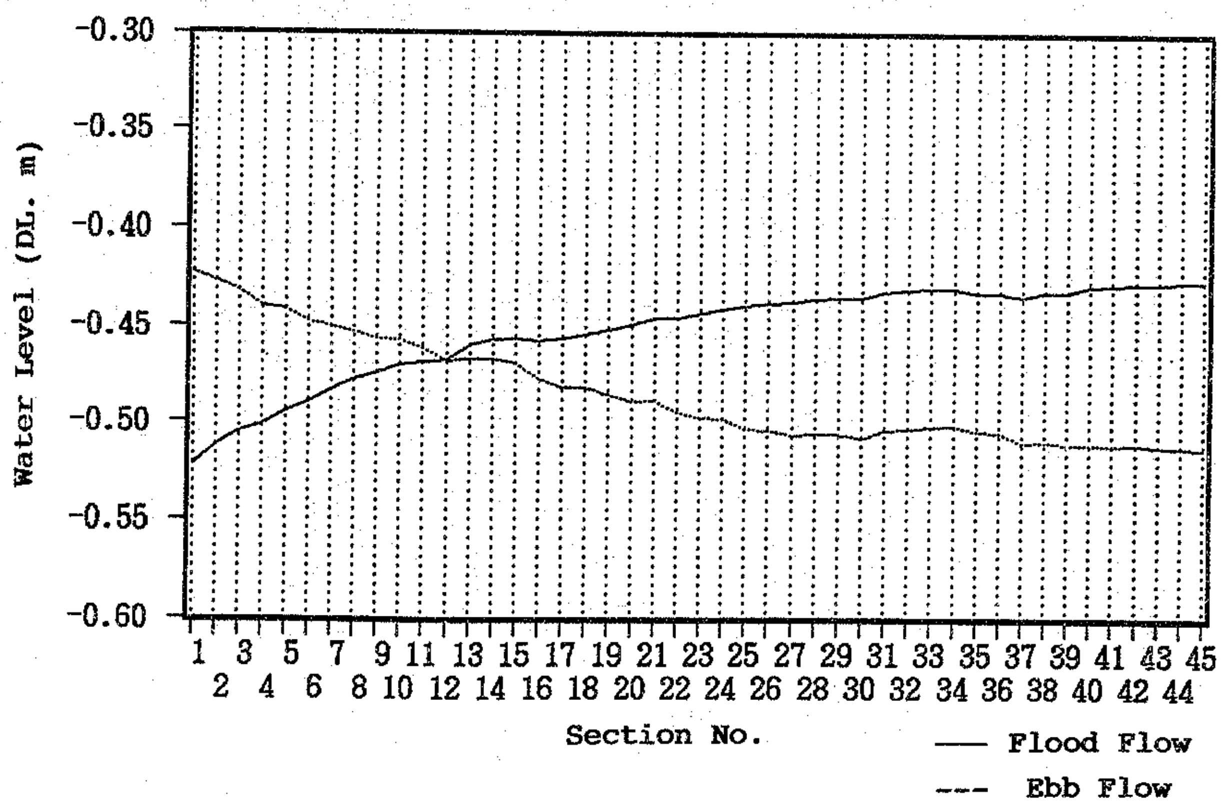


Fig. 11 Water Level (3)
In Flood and Ebb Flow with Power Plant (7.5 m^3/s)

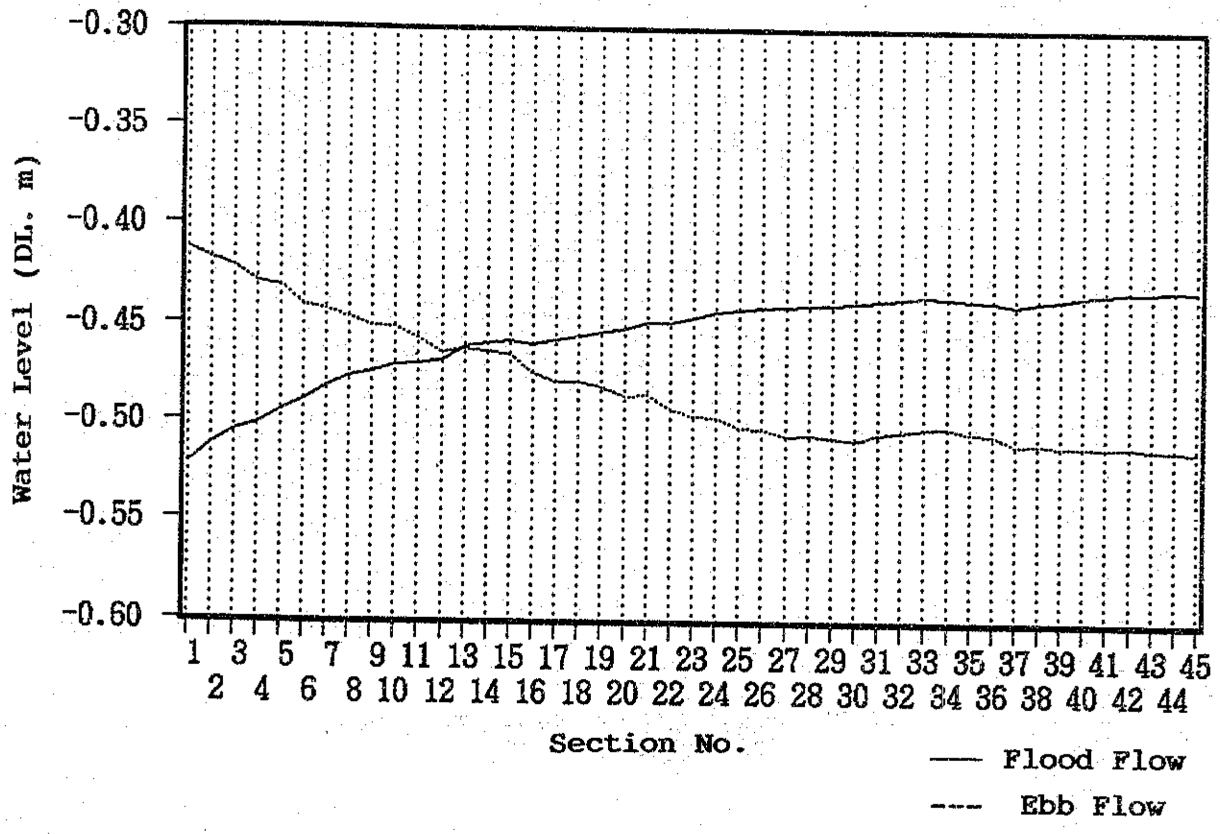


Fig. 12 Water Temperature (1)
At Slack Tide with Power Plant (3.6 m^3/s)

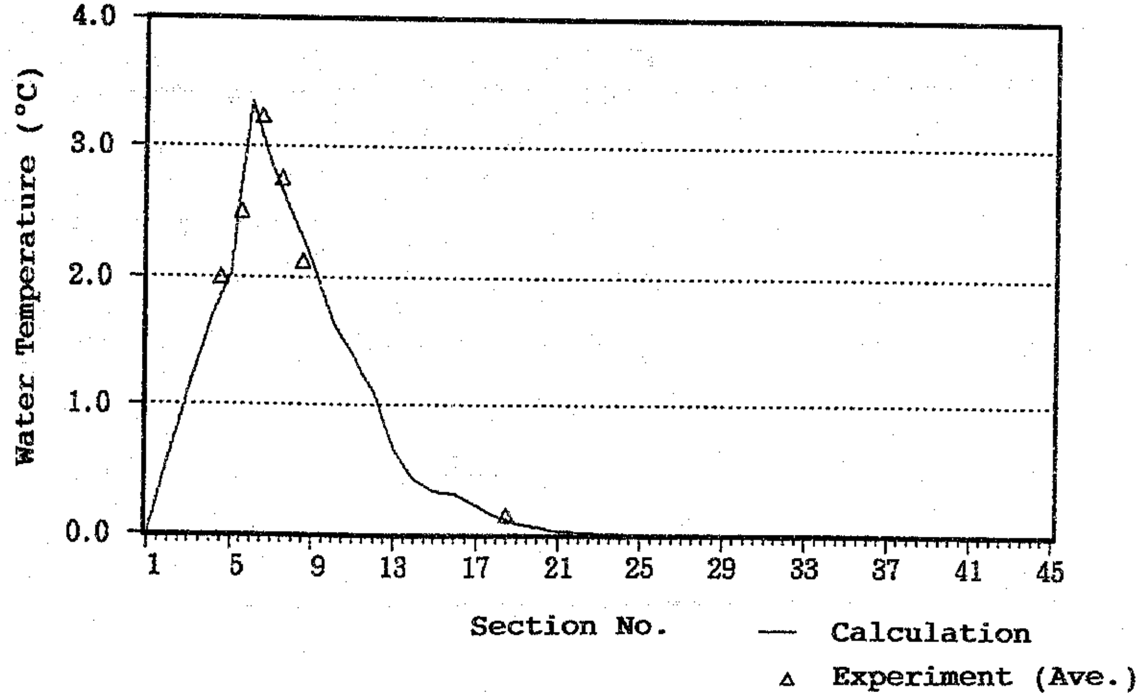


Fig. 13 Water Temperature (2)
At Slack Tide with Power Plant (7.5 m^3/s)

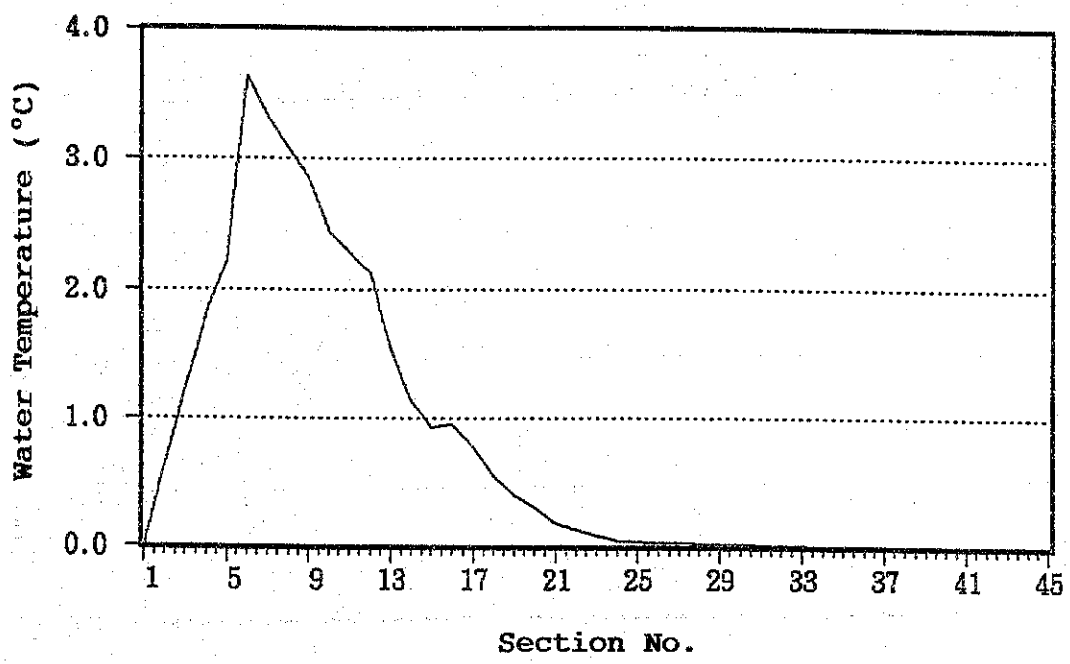


Fig. 14 Water Temperature (3) in Ebb Flow with Power Plant (3.6 m^3/s)

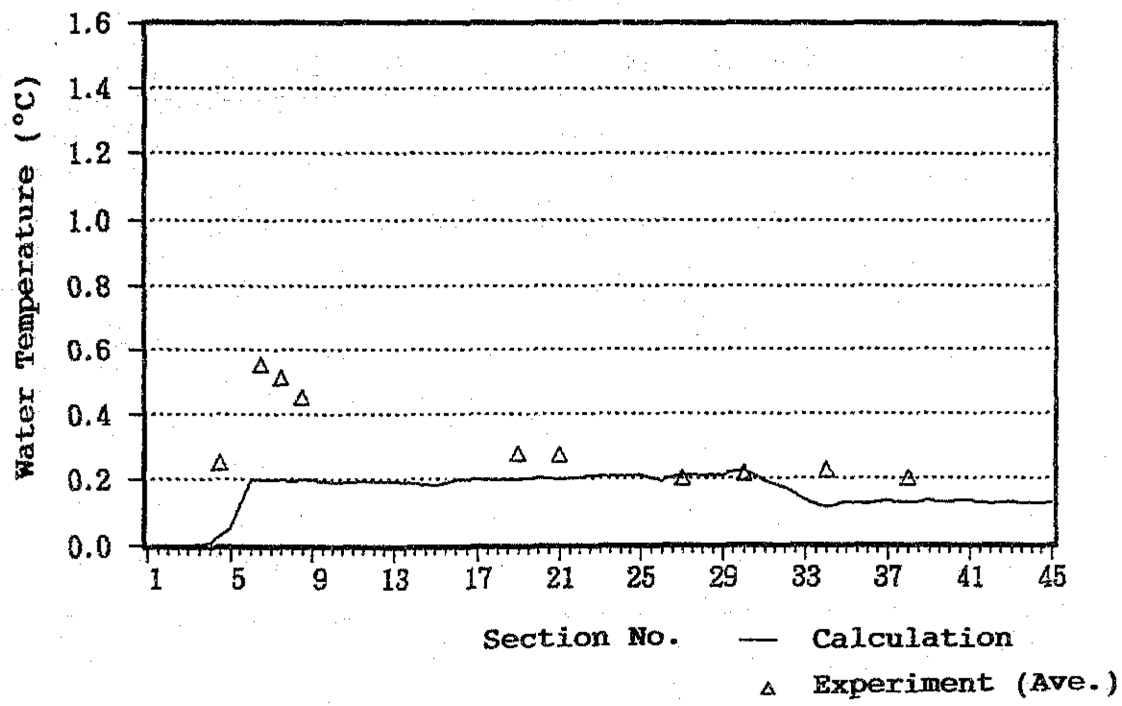
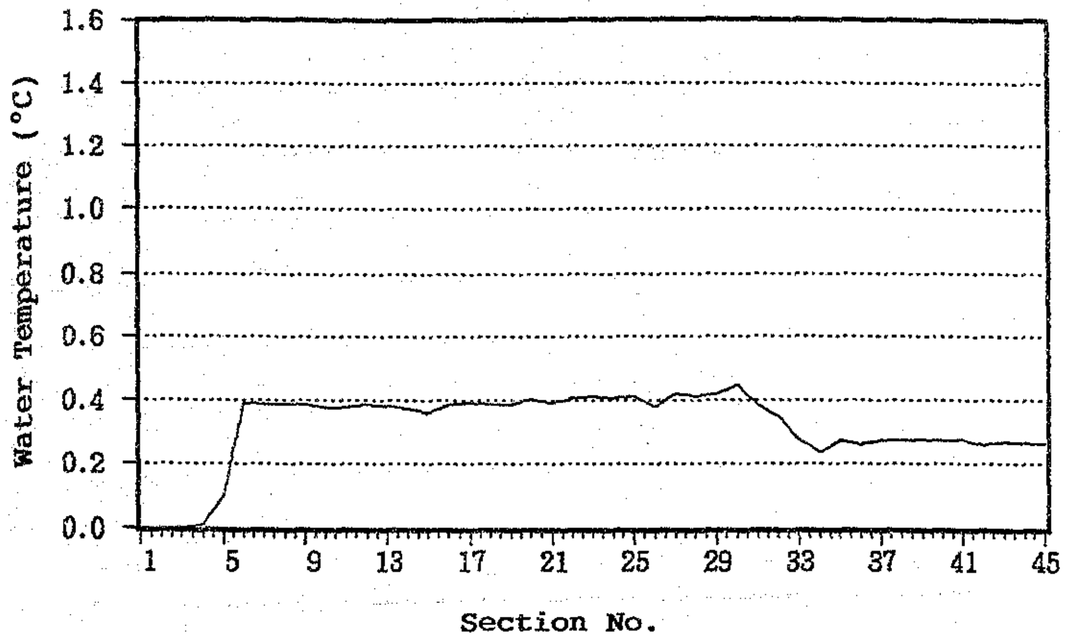


Fig. 15 Water Temperature (4)
In Ebb Flow with Power Plant (7.5 m^3/s)



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