Table 2-20 Existing Situation of Agricultural Cooperatives in Chon Buri Province (1980)

Amphoe	Ban Bung	
Cooperative	Ban Bung	Livestock
Coops official	2	
Coops staff	4	1
Agriculture household	8,946	
Member's number	1,200	
(Ratio)	13%	
Puchasing		
Agri-chemical	-	
Chemi-fertilizer ฿	900,000	
Agri-machine	-	
Seeds (paddy)	-	
Others	-	
Marketing	-	
Paddy		
Fruits	-	
Vegetable	-	
Livestock	-	
Others	Sugarcane Cassave 1,000 t	
Storage house Capacity (ton)	-	
Credit		
Short-term used number	65%	
amount	6,500,000 ฿	
Middle-term used number	35%	
amount	3,500,000 ฿	
Long-term used number	-	
Rice mill	-	
Banana processing	-	
Agriculture household	8,946 (63.9%)	
Total household	13,990	
Total population	76,348	
Agricultural population	48,821 (63.9%)	

Table 3-1 Production by Year in Nong Pla Lai Area

Unit: Area - ha
Yield - kg/ha
Production - ton

No. 1 Paddy Wet Season

Item		1	2	3	4	5	6	7	Remark
		1/ 1,260 ha	2/ 1,260 ha	3/ 1,320 ha	-	-	-	-	
Present									
Planting Area		2,580	1,320		-	-	-	-	
Yield		1,440	1,440		-	-	-	-	
Production									
Project									
Planting Area		1,200	1,200	1,200	1,200	1,200	1,200	1,200	
Yield		1,950	2,210	2,720	3,490	4,000	4,000	4,000	
Production		2,340	2,652	3,264	4,188	4,800	4,800	4,800	
Planting Area			1,200	1,200	1,200	1,200	1,200	1,200	
Yield			1,950	2,210	2,720	3,490	4,000	4,000	
Production			2,340	2,652	3,264	4,188	4,800	4,800	
Planting Area				1,250	1,250	1,250	1,250	1,250	
Yield				1,950	2,210	2,720	3,490	4,000	
Production				2,438	2,763	3,400	4,363	5,000	
Total Production		2,340	4,992	8,354	10,215	12,388	13,863	14,600	

1/ 2/ 3/: Land Consolidation Area by year

No. 2 Paddy Dry Season (Continued)

Item	1st	2nd	3rd	4	5	6	7	8	Remark
Planting Area		325	325	325	325	325	325	325	
Yield		2,190	2,490	3,060	3,930	4,500	4,500	4,500	
Production		712	809	995	1,277	1,463	1,463	1,463	
Planting Area			325	325	325	325	325	325	
Yield			2,190	2,490	3,060	3,930	4,500	4,500	
Production			712	809	995	1,277	1,463	1,463	
Planting Area				325	325	325	325	325	
Yield				2,190	2,490	3,060	3,930	4,500	
Production				712	809	995	1,277	1,463	
Total Production		712	1,521	2,516	3,081	3,735	4,203	4,389	

No. 3 Groundnuts (Continued)

Item	1st (1,200)	2nd (1,200)	3rd (1,250)	4	5	6	7	8	Remark
Planting Area		645	645	645	645	645	645	645	180%
Yield		1,215	1,335	1,500	1,740	1,900	1,900	1,900	
Production		784	861	968	1,122	1,226	1,226	1,226	
Planting Area			650	650	650	650	650	650	
Yield			1,215	1,335	1,500	1,740	1,900	1,900	
Production			790	868	975	1,131	1,235	1,235	
Planting Area				650	650	650	650	650	
Yield				1,215	1,335	1,500	1,740	1,900	
Production				790	868	975	1,131	1,235	
Total Production		784	1,651	2,626	2,965	3,332	3,592	3,696	

Table 3-2 Tendency of Population by Industrial Development

Unit: 1,000 person

Location	(1) 1980	(2) 1990	(3) 2000	(4) (2) - (1)	(5) (3) - (1)
Rayong					
Municipality	37	57	80	20	43
Muan	84	161	203	77	119
Sub Total	121	218	283	97	162
Chon Buri					
Municipality	50	53	56	3	6
Am.Chon Buburi	119	150	180	31	61
Am. Si Racha	85	124	166	39	81
Sattahip	85	105	123	20	38
Am.Phanat Nikhon	110	126	142	16	32
Phattaya	35	59	84	24	49
Sub Total	484	617	751	133	267
Total	605	835	1,034	230	429

Table 3-3 Agricultural Material

	Kg/ha	Area (ha)	Quantity (t)	Unit Price	Value 1,000 ฿
Wet S. Paddy					
Nursery Seed	800	256	204.8	5 ฿/kg	1,024.0
Fertilizer	250	256	64.0	5.200 ฿/t	332.8
Padan Mipcin.	25	256	6.4	20 ฿/kg	128.0
Paddy Field					
Fertilizer Co.	225	3,650	821.25	5.200 ฿/t	4,270.5
A.S.	190	3,650	693.5	3.600 ฿/t	2,496.6
Padan Mipcin.	25 x 2	3,650	182.5	20 ฿/kg	3,650.0
Saturn D.G.	25	3,650	91.25	17.5 ฿/kg	1,597.0
Sub Total					13,498.9
Dry S. Paddy					
Nursery Seed	800	50	40	5 ฿/kg	200.0
Fertilizer	250	50	12.5	5.200 ฿/t	65.0
Padan Mipcin.	25	50	1.3	20 ฿/kg	26.0
Paddy Field					
Fertilizer Co.	240	975	234	5.200 ฿/t	1,216.8
A.S.	200	975	195	3.600 ฿/t	702.0
Padan Mipcin.	25 x 2	975	49	20 ฿/kg	980.0
Saturn D.G.	25	975	25	17.5 ฿/kg	437.5
Sub Total					3,336.3
Groundnut					
Seed	125	1,945	244	20 ฿/kg	4,880.0
Fertilizer					
N. 20%	94	1,945	183	3.600 ฿/t	658.8
P. 46 - 48%	120	1,945	234	8.400 ฿/t	1,965.6
K. 60%	63	1,945	123	5.800 ฿/t	713.4
Asodrin	2,500 cc x 2	1,945	9,800 l.	220 ฿/l.	2,156.0
Dimethoate	2,500 cc x 2	1,945	9,800 l.	220 ฿/l.	2,156.0
					12,529.8

Table 3-4 Machinery Requirement

Machinery	Capacity	Quantity	Unit Cost (1000¥)	Amount (1000¥)
Tractor	65 sp	60	345	20,700
Tractor	35 sp	7	190	1,330
Trailer	2 t	20	40	800
Pick-up	2 t	10	70	700
Combine	w 1.4 t	16	350	5,600
One way harrow	26 x 7	14	24	336
Rotary	w 1.6 m	13	60	780
Drive harrow	w 4.0	12	80	960
Broadcaster	500 l.	6	19	114
Ridger	3 row	23	30	690
Cultitater	5 row	35	35	1,225
Duster	by hand	200	4.6	960
Thresher	5 sp	24	30	720
Total		440	1,277.6	34,875

Table 3-5 Efficiency of Farm Operation

Machinery	(1) Ope. Width (m)	(2) Ope. Speed km/hr	(3) (1)x(2)/10 Theoretic Ope. Capacity ha/hr	(4) Efficiency in Field %	(5) (3)x(4) Ope. Capacity in Field ha/hr	(6) Hours per ha hr/ha	(7) Ope. Hours per days (7 hr) ha/day	8 hr/day
One way harrow 26" x 7	1.7	7.0	1.19	80	0.95	1.05 (1.2)	6.7	
Rotary 1.6 m	1.6	4.0	0.64	80	0.51	1.96 (2.2)	3.6	
Drive harrow 4.0 m	4.0	5.0	2.00	80	1.60	0.63 (0.7)	11.2	
Broadcaster 1,000 l.	8.0	7.0	5.60	65	3.64	0.27 (0.3)	25.5	
Fertilizer 3 row	1.8	4.0	0.72	65	0.47	2.13 (2.4)	3.3	
Ridger 3 row	1.8	4.0	0.72	70	0.50	2.00 (2.3)	3.5	
Cultivator 3 row	1.8	4.0	0.72	70	0.50	2.00 (2.3)	3.5	
Combine 1.4 m	1.4	4.0	0.56	65	0.36	2.70 (3.1)	2.5	2.0
Paddy by hand fertilizer topdressing	4.0	2.0	0.8	60	0.48	2.08 (2.4)		
Cultivator (G.N.) 5 row (Ridging)	2.0	5.0	1.0	80	0.8	1.25 (1.4)	5.6	
G.N. by hand fertilizer	0.5	4.0	0.2	80	0.16	6.25	1.12	
" " sowing	0.5	2.0	0.1	80	0.08	12.5		
Duster	4.0	2.0	0.8	60	0.48	2.4		

Note: Figure in parenthesis are man-power

Table 3-6 Labour Requirements by Farming Practice (Paddy Wet Season)

Item	Work. Season	No. of times	Machinery	Working hour		Monthly Labour (hr/ha)											
				Machinery	Man	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seedbed preparation	May-Jun		Tractor Rotary	2.2	2.2					(2.3)	(1.1)						
			one way harrow	1.2	1.2					2.3	1.1						
Sowing, Fertilizing	Jun		Tractor, Trailer Pick-up	2.0	12.0						(2.0) 12.0						
					440.0						(7.0)	(3.0)					
Management	Jun-Jul	2	Duster	10.0	11.4						274.6	176.8					
Pulling & hauling seed	Jul		Tractor, Trailer									(3.0)					
			Pick-up	3.0	83							83					
Nursery Total				18.4	549.8					(2.3) 2.3	(10.1) 287.7	(6) 259.8					
Plowing	May-Jul		Tractor One way harrow	1.2	1.2					(0.6) 0.6	(0.6) 0.6						
Puddling	May-Jul		" Drive harrow	0.7	0.7						(0.1) 0.1	(0.6) 0.6					
Fertilizing (basal)			Tractor Broad-caster, etc.	0.5	0.5						(0.1) 0.1	(0.4) 0.4					
Irrigating & etc.	Jul-Nov		By hand		244							30	62	60	62	30	
Transplanting	Jul				80							80					
Weeding		2	By hand		160								50	60	50		
Herbicide	Jul		Chemical Duster		2.4							2.4					
Insecticide		3			7.2							2.2	2.4	2.6			
Fertilizing (Topdressing)	Aug-Sep		By hand, T. Trailer		2.4								1.2	1.2			
Harvesting	Nov		Combine Tractor	3.0	6.0											(6.1)	
			Trailer, Truck	3.1	6.2											12.2	
Harresting	Nov		By hand		120.5											120.5	
Bunding	Nov		By hand		30.0											30.0	
Thrashing	Nov-Dec		Thrasher	2.6	11.7											(0.9) 4.0	(1.7) 7.7
Trans-portation	Nov-Dec		Pick-up, T. Trailer	4.0	20.0											(1.3) 6.7	(2.7) 13.3
TOTAL				C 8.5 by hand	510.6					(0.6)	(0.8)	(1.0)	-	-	-	(6.1) C 42.2 h(2.2)	(4.4)
				9.0	680.6					0.6	0.8	115.6	115.6	123.8	112.0	191.2	21.0

Table 3-7 Labor Requirements by Farming Practice (Paddy Dry Season)

Item	Work. Season	No. of times	Machinery	Working hour		Monthly Labour (hr/ha)											
				Machinery	Man	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seedbed preparation	Dec		T. One way harrow Rotary	3.4	3.4												(3.4) 3.4
Sowing Fertilizing	Jan		T. Trailer	2.0	12.0	(2.0) 12.0											
Management	Jan-Feb		Duster	10.0	440.0 11.4	(7.0) 274.6	(3.0) 176.8										
Pulling & hauling	Jan-Feb		T. Trailer	3.0	83.0	(1) 27.7	(2) 55.3										
Nursery Total				18.4	549.8	(10) 314.3	(5) 232.1										(3.4) 3.4
Plowing	Dec-Jan		T. One way harrow	1.2	1.2	(0.6) 0.6											(0.6) 0.6
Harrowing	Dec-Jan		T. Rotary	1.1	1.1	(0.6) 0.6											(0.5) 0.5
Puddling	Jan-Feb		T. Drive harrow	0.7	0.7	(0.3) 0.3	(0.4) 0.4										
Fertilizing	Jan-Feb		T. Broadcaster	0.5	0.5	(0.2) 0.2	(0.3) 0.3										
Irrigating & etc.	Jan-May				184	10.0	26	62	60	26							
Transplanting	Jan-Feb		By hand		80	25.0	55.0										
Weeding	Feb-Apr				160		40	80	40								
Herbicide	Jan-Feb				2.4	1.0	1.4		-								
Insecticide		3			7.2		2.2	2.4	2.6								
Fertilizing (Topdressing)			By hand		2.4			2.4									
Harvesting			Combine, T. Trailer	6.1	12.2		→			(6.1) 12.2							
TOTAL				9.6	451.7	1.7 37.7	0.7 125.3	102.6	6.1 38.2								1.1 1.1

Table 3-8 Labor Requirements by Farming Practice (Groundnuts)

Item	Work. Season	No. of times	Machinery	Working hour		Monthly Labour (hr/ha)											
				Machi.	Man	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing	Nov-Dec		Tractor, One way harrow	1.2	1.2											(0.2) 0.2	(1.0) 1.0
Harrowing	Nov-Dec		Tractor, Rotary	2.2	2.2											(0.2) 0.2	(2.0) 2.0
Ridging	Dec-Jan		Tractor Cultivator	1.8	1.8	(1.6) 1.6											(0.2) 0.2
Fertilizing	Jan		T. Trailer By hand	0.3	6.6	(0.3) 6.6											
Sowing	Jan		By hand		12.5	12.5											
Ridging	Jan-Feb		T. Ridger	2.3	2.3	(2.2) 2.2	(0.1) 0.1										
Cultivating	Jan-Mar	2	T. Cultivator	4.6	4.6	(0.6) 0.6	(3.7) 3.7	(0.3) 0.3									
Weeding			By hand		40.0		20.0	20.0									
Control	Jan-Mar	4	Duster	40	40	(2.0) 2.0	(25.0) 25.0	(13.0) 13.0									
Harvesting	Apr		T. Ridger	2.3	2.3				(2.3) 2.3								
Picking, Bundling	Apr-May		By hand		180.0				90.0	90.0							
Transporting	Apr-May		Pick-up	4.0	4.0				(2.0) 2.0	(2.0) 2.0							
TOTAL				58.7	297.5	6.7 25.5	28.8 48.8	13.3 33.3	4.3 94.3	2.0 92.0						0.4 0.4	3.2 3.2

Table 3-9 Labor Requirement by Month

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Paddy W. S.													
Nursery (256 ha) hr		508.8	73,651.2	66,508.8									140,748.8
With Combine (1,000 ha) hr		600.0	800.0	115,600	115,600	123,800	112,000	42,200					510,600
Without Combine (2,650 ha) hr		1,590	2,120	306,340	306,340	328,070	296,800	506,680	55,650				1,803,590
Sub Total hr		2,778.8	76,571.2	488,448.8	421,940	451,870	408,800	548,880	55,650				2,454,938.8
Man/day		347	9,571	61,056	52,743	56,484	51,100	68,610	6,956				306,867
Paddy D. S.													
Nursery (50 ha) hr									14	1,310	967		2,291
With Combine (975 ha) hr	100,035	37,245							1,073	36,758	122,168	143,130	440,409
Sub Total hr	100,035	37,245							1,087	38,068	123,135	143,130	442,700
Man/day	12,504	4,656							136	4,759	15,392	17,891	55,338
Groundnut (1945 ha) hr	183,414	178,940						778	6,224	49,598	94,168	64,769	578,639
Man/day	22,927	22,371						97	778	6,200	11,865	8,096	72,331
Total Man/day	35,431	27,371	9,571	61,056	52,743	56,484	51,100	68,707	7,870	10,959	27,257	25,987	434,536
Man/month	1,417	1,095	383	2,442	2,100	2,259	2,044	2,748	315	438	1,090	1,039	17,380

Fig. 1-1 Soil Map (Nong Pla Lai Area)

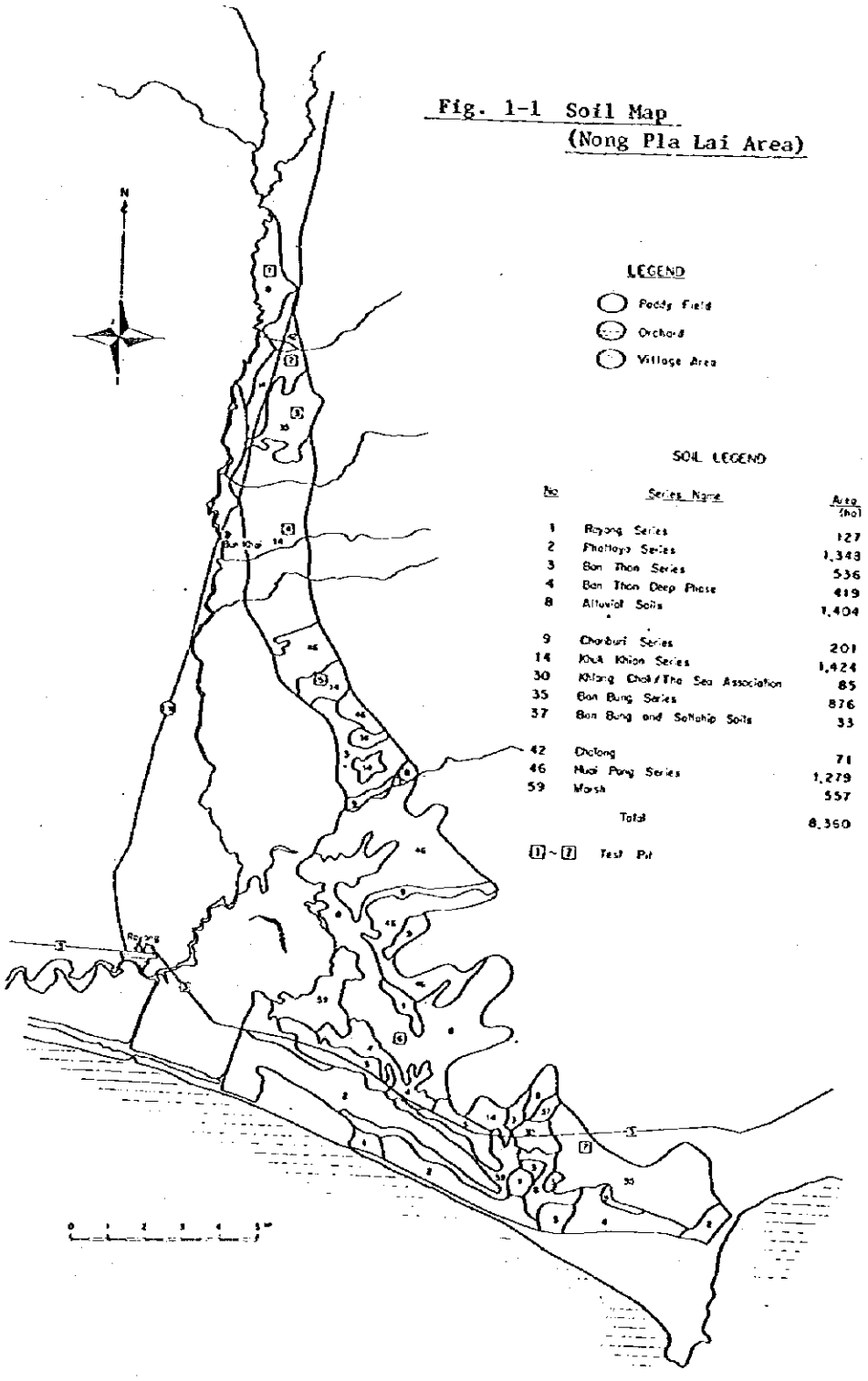
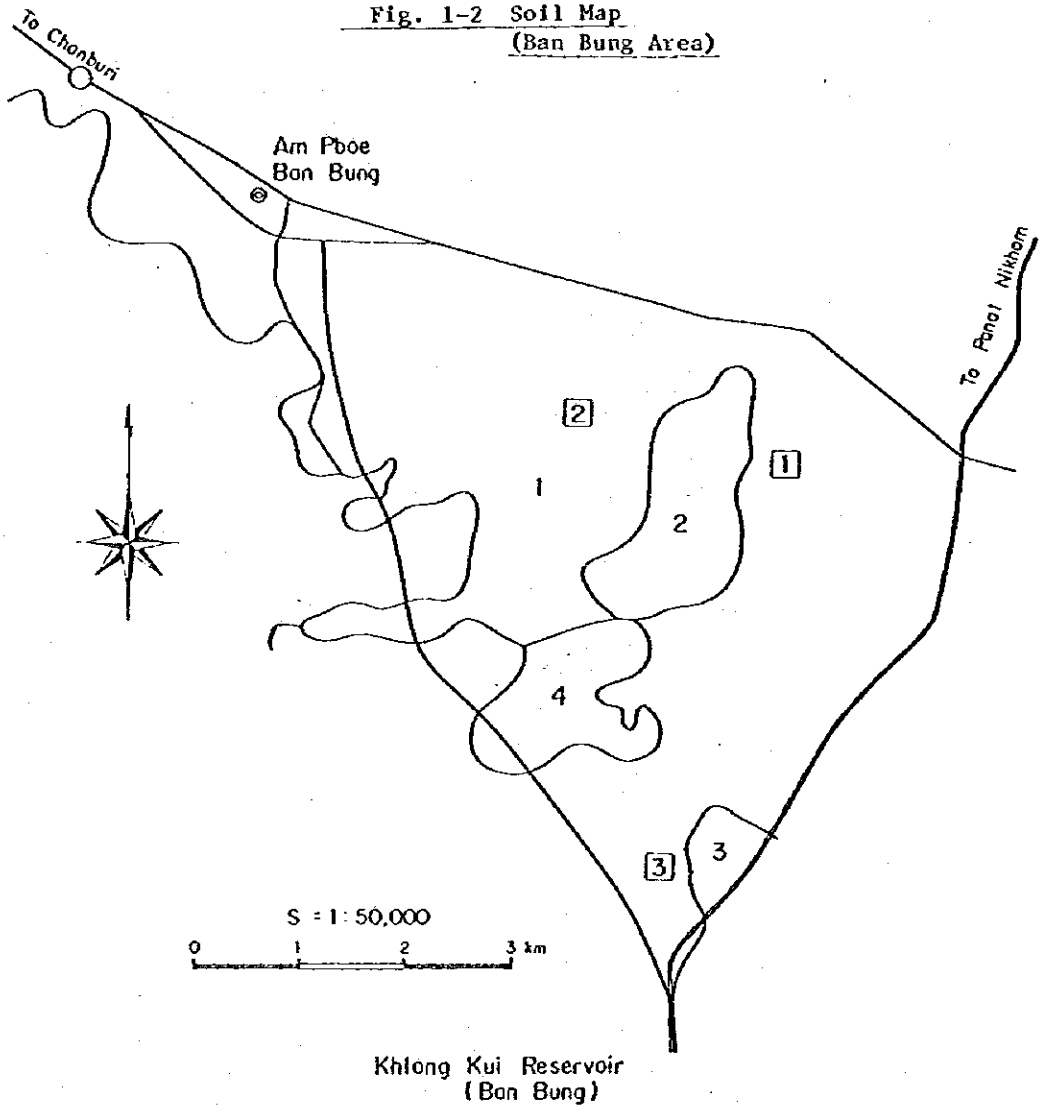


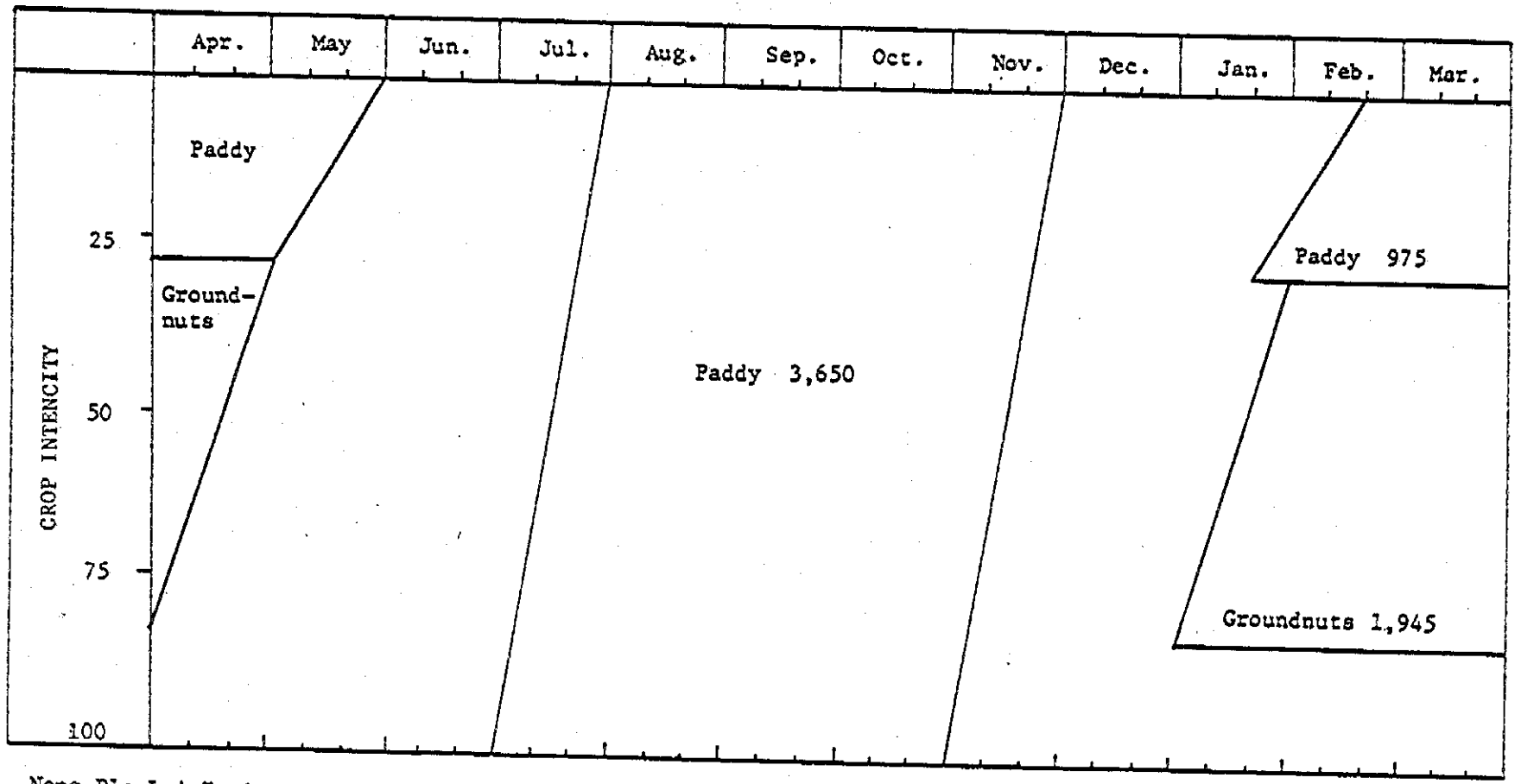
Fig. 1-2 Soil Map
(Ban Bung Area)



SOIL LEGEND

No.	Series Name	Area (ha)	
1	Ban Bung Series	1,958	Test pit
2	Sattahip Series	214	[1] ~ [3]
3	Hup Kapeng Series	50	
4	Nong Mot Strong Brown Variant	98	
	Total	2,320	

Fig. 3-1 Proposed Cropping Pattern



Nong Pla Lai Irrigation Area :: Paddy: Wet Season 3,650 ha
Dry season 975 ha
Ground Nuts: Wet Season –
Dry Season 1,945

Fig. 3-2 System of Farming Practice by Machinery

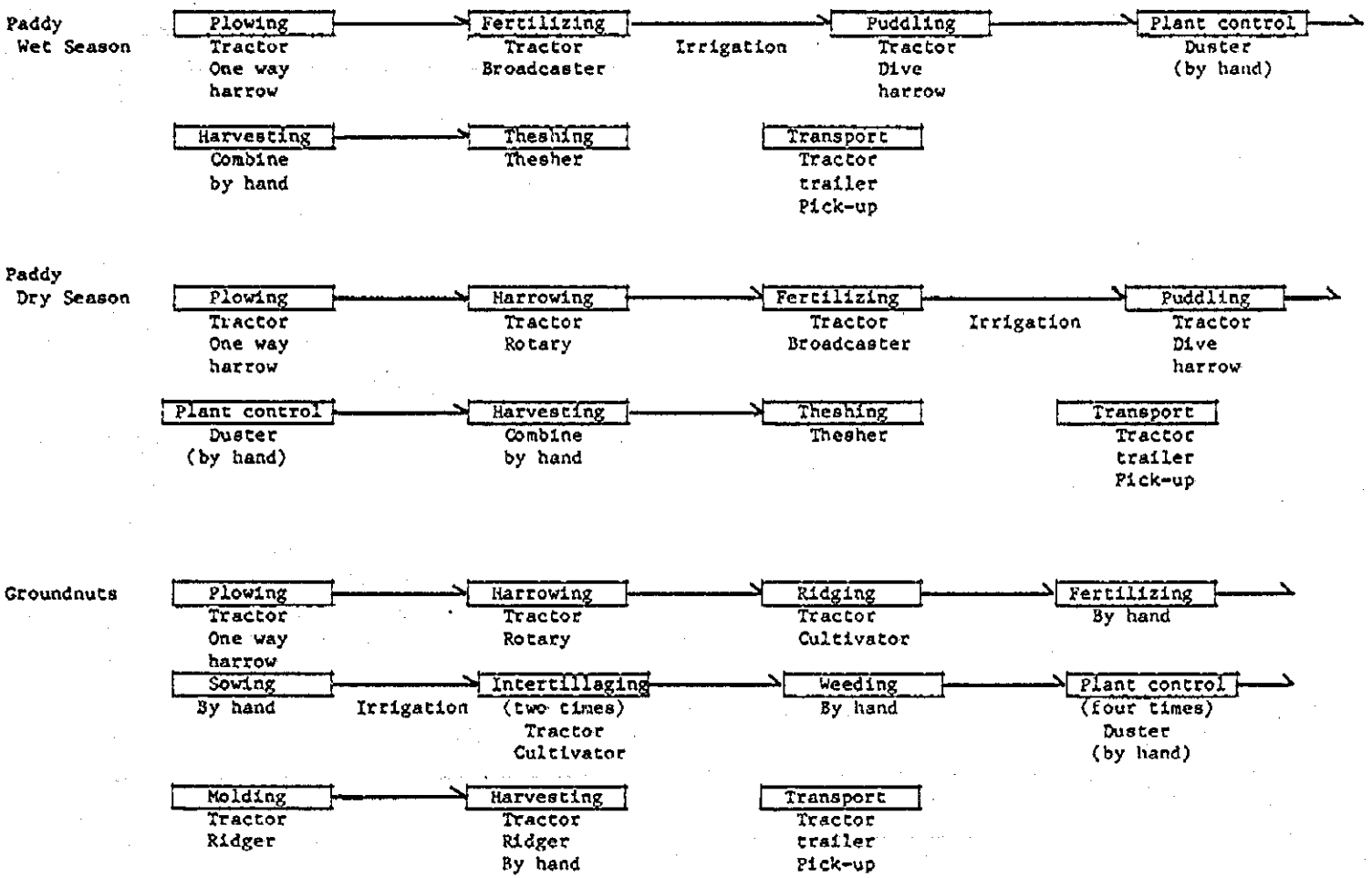


Fig. 3-3 Schedule for Machinery Operation

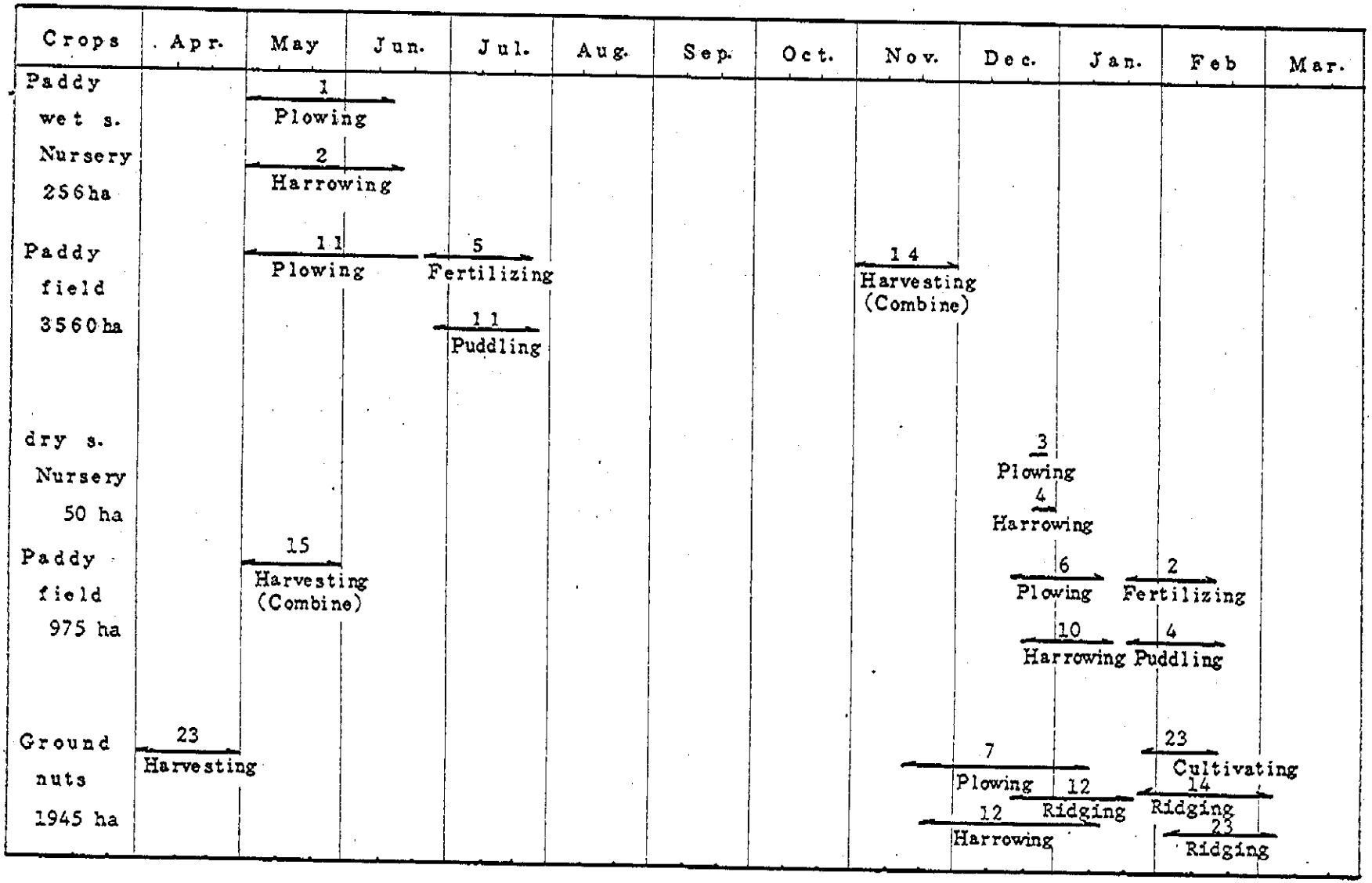
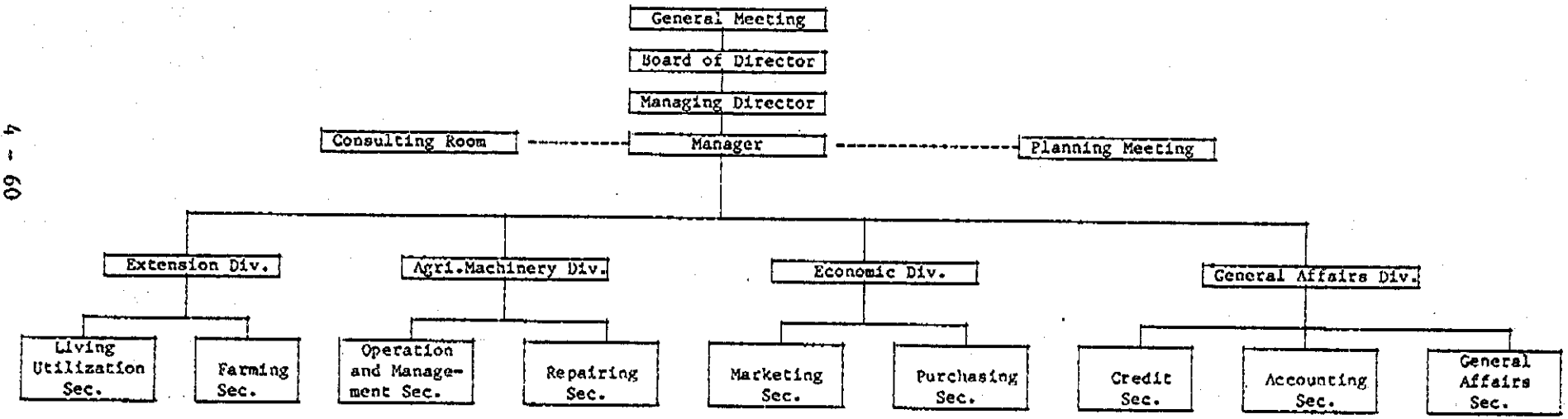


Fig. 3-4 Proposed Organization Chart for Agricultural Cooperative



V . WATER RESOURCES DEVELOPMENT

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 2

CHAPTER 3

LIST OF FIGURES

CHAPTER 2

CHAPTER 3

CHAPTER 4

WATER RESOURCERS DEVELOPMENT

1. GENERAL

To supply a sufficient industrial and municipal water to meet the future water demand in Changwats Chon Buri and Rayong in the east coast area, it is required to conduct a comprehensive study including the estimation of the future water demand and the potentiality of water resources development, and the stepwise water resources development scheme is to be proposed and determined in accordance with the incremental demand of water.

Basic concepts for the study to attain and justify the above substance are as follows:

1) Target year for the water resources development is to be established for the water demand of the year 2000.

2) As for the design drought year, the extraordinary drought year is not to be the design year and the second severest drought year during ten or more years in adopted as the design year.

3) Countermeasure for the water resources development is to be considered by dams.

4) Concerning the target areas to be supplied with the newly developed water, two plans, namely PLAN I or base plan and the alternative PLAN II are studied. In PLAN I, they are the four development centers of Rayong Area, Sattahip Area, Leam Chabang Area and Ban Bung Area and in PLAN II, they are three development conters of Rayong, Sattahip and Ban Bung Area.

5) Agricultural development areas to be taken into consideration are the area in downstream side of the proposed dam, Nong Pla Lai Irrigation Area (3,650 ha) and Thap Ma Irrigation Area (6,400 ha), the required irrigation water is to be supplied by using the proposed reservoir volume.

6) Stepwise water resources development scheme is to be proposed to cope with the incremental water demand, and to be secured by water balance by the year 2000.

7) In order to cope with the severe drought, such a large reservoir that does not every year reach to the full stage, is proposed.

2. WATER DEMAND

The future water demands is to be estimated from the population, living standard, industrial production activities and irrigation requirement. The purpose of this estimate for water demand is to study the structure of water demand caused by the Government's guideline for the regional development.

2.1 METHOD AND CONDITION FOR DEMAND ESTIMATE

2.1.1 Municipal Water

Macro-scale estimate based on the future population estimate has been adopted and conducted until the target year 2000 year by using the following formula:

$$MWD = [(Pn \times UIp \times Wp) + IP] \times PCC \times 365 \text{ days} \times RC$$

here,

MWD = Municipal water annual demand
Pn = Population
Up = Urban population ratio
Wp = Water pervasion
PCC = Per capita consumption
IP = Induced population
RC = Raw water converter (1.1)

Factors in the above formula are as mentioned below:

Population (Pn)

According to the 1976 - 1980 statistics in Changwats Chon Buri and Rayong, the average population growth rate is 2.14% and 2.00% respectively, and the total population is estimated at about 1,300 thousands in 1990 and at about 1,500 thousands in 2000 in Changwats Chon Buri and Rayong (refer to Table 2-1).

Urban Population Ratio (Up), Water Pervasion (Wp) and Per Capita Consumption (PCC)

Parameters of Up, Wp and PCC in the above equation are shown below:

Year	Area	Up (%)	Wp (%)	PCC /1 (t)
1980	Chon Buri	30.0	45.3	0.345
	Rayong	9.9	58.6	0.220
1990	Chon Buri	35.0	60.0	0.350
	Rayong	30.0	70.0	0.300
2000	Chon Buri	45.0	75.0	0.350
	Rayong	40.0	80.0	0.350

/1: Per capita consumption is estimated from the data of actual consumption compiled by PWWA.

Induced population

Tables 2-2 and 2-3 show the projection of the induced population and labor force by areas in the year 1990 and 2000 respectively.

The induced population consists only of manpower for port and industry sectors where skilled labor is required.

The induced population of port and industry sector are 20 and 80% of the total employed work force. The service sector related to the above two sectors is assumed to rely on local manpower and thus excluded from induced population. Also, the induced population is assumed to settle in planned residential areas where Wp is 100%. Further, the intra-regional movement of local work force due to port or industry to be developed has not been accounted for induced population.

2.1.2 Industrial Water

The estimate for water demands of industrial and port use in the project area has been based on the figures released in the Final Report of the Committee /1 , except Laem Chabang and Rayong Areas.

Among the figures thus released, the one for soda ash industry in Sattahip is different from what has been published in its feasibility report by JICA. The larger figure of feasibility report has been adopted here for the planning on safer side.

In Laem Chabang and Rayong Areas where no estimate is released, the water demand is estimated by multiplying the area of development by unit water requirement in ton/ha.

The area of development in Rayong industrial complex is estimated in the Final Report as 96 to 160 ha which has no account for aspects of potential as sub-sectoral industries of proposed basic industry and possible airport oriented industry around U-Tapao. With full account of such development potentials, the estimate of required land development would be 320 ha. The Laem Chabang industrial complex of IEAT has an area of 448 ha. Water requirement for these two industrial complexes will be calculated from an average water requirement per unit area of five representative industrial parks of Thailand, which is 90 ton/ha.

/1: Basic Industries Development Committee, Secretariat Office, Thailand.

2.1.3 Irrigation Water

The diversion water requirement will be estimated by the following procedure. Crop consumptive use is the depth of water to meet the water loss through evaportranspiration; it is estimated from the climatic data and crop growing stage for each crop. The percolation is also taken into account for the paddy cropping. The water needed for land preparation is considered. The detailed procedure and results are shown in IX IRRIGATION AND DRAINAGE, while the irrigation water for the existing Ban Khai area and the proposed Thap Ma area is estimated in the manner that these areas have the same unit demand.

2.2 ESTIMATED FUTURE WATER DEMAND

The estimated future water demand by aforementioned four target areas, Rayong, Sattahip, Laem Chabang and Ban Bung Area, are obtained as below mentioned:

Rayong Area

	1990	1995	2000
Industrial	23.1 MCM/year	23.1 MCM/year	27.9 MCM/year
Industry-related municipal	8.5	8.5	15.5
Other municipal	4.4	6.8	12.6
Irrigation	69.4	128.1	194.7

Sattahip Area

	1990	1995	2000
Industrial	13.7 MCM/year	14.3 MCM/year	17.2 MCM/year
Industry-related municipal	0.8	0.9	1.5
Other municipal	3.1	4.2	5.3

Laem Chabang Area/1

	1990	1995	2000
Industrial	6.6 MCM/year	12.0 MCM/year	16.8 MCM/year
Industry-related municipal	3.4	6.0	7.0
Other municipal	2.9	4.2	5.5

/1 : In PLAN II, Laem Chabang area is not supplied with water but the water is transferred to Rayong Municipality.

Ban Bung Area

Municipal water demand is based on the population projection without taking into consideration the induced population by the industrial and urban developments. As for industrial water demand, it is assumed that the current consumption of 1.8 MCM will increase by 10% per annum.

	1990	1995	2000
Industrial	2.9 MCM/year	3.8 MCM/year	4.8 MCM/year
Municipal	2.5	3.2	4.2

Breakdown of the above estimation results are as shown in Tables 2-4, 2-5, 2-6, 2-7, 2-8 and Fig.2-1.

3. WATER RESOURECES DEVELOPMENT PLAN I

3.1 GENERAL

The Water Resources Development Plan is studied to meet the industrial and municipal water demand of the target year 2000 in the area to be developed in accordance with the Regional Development Plan formulated by the Government as well as to supply irrigation water to proposed irrigation area.

In this Chapter, the Water Resources Development Plan is studied to supply water to four development centers, that is, Rayong, Sattahip, Laem Chabang and Ban Bung, and to Nong Pla Lai and Thap Ma irrigation areas.

3.2 PROPOSED DAM DEVELOPMENT

Dam development program for the east coast area has already been prepared by RID. It includes, as main dams, Nong Pla Lai, Khlong Yai, Thap Ma, Khlong Luang and Prasae Dams and expansion of Ban Bung Dam (refer to Fig. 3-1). Among above dams, Nong Pla Lai, Thap Ma, Khlong Yai and Ban Bung Dams are nominated to be studied for their high development potentiality and vicinity to the demand area.

Dam	Catchment Area	Storage Capacity
Nong Pla Lai	426 km^2	144.4 MCM
Thap Ma	154	35.0
Khlong Yai	223	45.0
Ban Bung	53	8.0/1

/1: Proposed Capacity (10 MCM) - Existing Capacity (2MCM) = Increased Capacity (8 MCM)

Features of the above selected four dams are as follows:

Nong Pla Lai Dam

With a largest catchment area in the project area, Nong Pla Lai Dam is located in the upstream of Rayong River, the stream that flows down the center of A.M. Rayong. The developed water can be conveyed to A.M. Rayong, a principal development center in the east coast, to Mab Ta Pud with proposed industrial complex, and to Sattahip and Laem Chabang where industrial complex and deep sea port development is planned. The water can also be supplied for municipal and industrial use and for irrigation purpose to the newly developed tract in the middle reaches.

The flooding water in Rayong River could be lessened by flood control function of the dam, which would protect the property assets in the river basin.

Khlong Yai Dam

The proposed dam is located in the upstream tributary of the Rayong River, and supply the water to the same area mentioned in the above Nong Pla Lai Dam.

The flood damage in the mid-low reaches of the river may also be mitigated by the dam.

Thap Ma Dam

The dam is proposed in a tributary of the Rayong River, that meets the main course in its middle reaches. Developed water can be supplied for municipal-industrial use in A.M. Rayong and its vicinity as well as for irrigation.

Ban Bung Dam

The proposed dam is located in the Ban Bung River, the secondary tributary of the Ban Pakon River. The existing Ban Bung Dam will be expanded to 10 MCM from 2 MCM. This developed volume of water is meant to ease the acute shortage of municipal-industrial supply to A.M. Ban Bung Area. The latent demand and future demand to be induced by regional development will also be met.

3.3 PRIORITY OF DAM CONSTRUCTION

For the priority ranking of the proposed dams in the Project area, phasing of water supply for municipal, industrial and irrigation demand was carried out, and water resources development was studied based on the below mentioned aspects,

1) To ensure the development capacity of the reservoirs to make the water supply meet the increased future demand in the target areas.

2) To develop the water resources stepwise in accordance with the development efficiency.

3) To give the priority of dam construction taking the urgency of water demand in the respective area into consideration.

Nong Pla Lai, Kholong Yai and Thap Ma Dam

The most urgent demand is to supply the industrial water to the Mab Ta Pud Development Center by 1984, and Nong Pla Lai Dams which is expected to cope with the future demand with its big reservoir capacity, cannot successfully supply the required amount of water on time, because its construction period requires rather long.

The existing Dok Krai Dam, which was constructed in 1975, is for the irrigation purpose to supply the water to the Ban Khai Area, and it has still leeway reservoir capacity beside the actual irrigation requirement on the ground that water is not taken to the whole irrigation area due to the insufficient secondary and tertialy irrigation canals.

Therefore, Dok Krai Dam can be utilized to meet the urgent municipal and industrial water demand by construction of appropriate water supply system until the year 1986. Nong Pla Lai Dam is for the demand until 1995, and Thap Ma and Khlong Yai Dams both with rather small reservoir capacity are for the long range demand until the target year 2000.

Ban Bung dam

With regard to Ban Bung Area, the only expansion of Ban Bung Dam can meet the required municipal and industrial water demand until the target year 2000.

3.4 WATER DEMAND AND SUPPLY

As the result of the simulation of water demand and supply, the scale of the dams and phasing of water supply are determined. Though the severest drough occured in 1980, it is considered as an extra ordinary drought and the second serverest drought year or the year 1978 is adopted as the design drought year.

3.4.1 Phasing of Water Supply

Detailed stepwise water resources development scheme for water supply is as follows:

First Stage

According to the industrial development schedule, the Natural Gas Separation plant in Mab Ta Pud, Rayong will come into operation in 1984 and the water demand for this plant will take place, but the proposed dams can not be completed up to the year because of longer construction period.

In place of the proposed dams, utilization of surplus water of existing Dok Krai Dam is proposed. Dok Krai Dam was constructed in 1975 for the purpose of irrigation water supply to Ban Khai Irrigation Area (4,800 ha) located in the middle reaches of the Rayong River. As the irrigation systems are not fully completed yet, there exists surplus water of 22.8 MCM/year at Dok Krai Dam. Through the proposed water transmission system, this surplus water can be conveyed to Mab Ta Pud and meet the water demand up to 1986. (Refer to Fig. 3-2

Second Stage

1) Completion of Nong Pla Lai

Nong Pla Lai Dam will be completed by year 1986 with storaged capacity of 144.4 MCM taking physical and economical conditions into considerations.

After completion of Nong Pla Lai Dam, Dok Krai Dam is utilized fully to meet to industrial and municipal water demand in Rayong, Sattahip and Laem Chabang area.

Nong Pla Lai Dam is utilized to ensure the vested water right of Ban Khai Irrigation Area which is transferred from Dok Krai Dam to Nong Pla Lai and meet the irrigation demand in proposed Nong Pla Lai Irrigation Area.

As the result of the simulation of dam operation, Dok Krai Dam can meet the water demand of 80 MCM/year in following areas and Nong Pla Lai Dam can supply irrigatin demand of 69.4 MCM/year in Nong Pla Lai Irrigation Area in case of cropping intensity 100% for paddy in wet season and 80% for combination of paddy and grandnuts in dry season.

Location	Water Demand at 1995 MCM/year
Rayong Municipality	8.4
Mab Ta Pud	30.0
Sattahip	19.2
Laem Chabang	22.2
Nong Pla Lai Irrigation Area	69.4

The schematic diagram of water utilization system on the second stage and water balance in Dok Krai Dam and Nong Pla Lai Dam are shown in Fig. 3-3, 3-4 and 3-5.

2) Completion of Ban Bung Dam

In order to save the Ban Bung area from seriously chronic water shortage and to meet the increasing industrial-municipal water demand at target year of 2000, the expansion of existing Ban Bung Dam is completed with storage capacity of 12.5 MCM by 1986.

Based on the simultation of dam operation, proposed Ban Bung Dam can meet the industrial-municipal water demand at year 2000 including vested right water.

Industry and Municipality including vested right water	9.0 MCM/year
Vested right of irrigation water	0.8 MCM/year

Water Balance in Ban Bung Reservoir is shown in Fig. 3-6.

Third Stage

In order to meet the increase of water demand after 1995, construction of Khlong Yai Dam is proposed in 1995 with storage capacity of 45 MCM.

Khlong Yai Dam can meet the industrial-municipal water demand of 22.2 MCM/year which is expected to occur in the period from 1995 to 2000 in Rayong and Sattahip area.

As for the water demand in Laem Chabang area, the volume of 22.2 MCM/year which is the water demand in 1995, only can be supplied because of limited water transmission capacity.

Simultaneously with the supply to industry and municipality, Khlong Yai Dam can meet the irrigation water demand of 58.7 MCM/year in Thap Ma Irrigation Area of 3,000 ha.

Location	Water Demand
Rayong Municipality	22.2 MCM/year (Demand in 2000)
Hab Ta Pud	33.8 MCM/year (- ditto -)
Sattahip Area	24.0 MCM/year (- ditto -)
Laem Chabang Area	22.2 MCM/year (Demand in 1995)
Nong Pla Lai Irrigation Area (3,650 ha)	69.4 MCM/year
Thap Ma Irrigation Area (3,000 ha)	58.7 MCM/year

Schematic Diagram of Water Utilization System is shown in Fig. 3-7.

Fourth Stage

Thap Ma dam will be completed by 1998, in order to meet the irrigation water demand increasing in Thap Ma Irrigation Area. Utilizing developed water from Thap Ma Reservoir, Thap Ma Irrigation Area can be expanded to 6,400 ha from 3,000 ha in case of cropping intensity 100% for paddy in wet season and 80% for combination of paddy and grandnuts in dry season.

Schematic Diagram of Water Utilization System is shown in Fig. 3-8.

3.4.2 Water Balance

The balance calculated from estimated water demand and supply is tabulated in Table 3-1 and Fig. 3-9. It is apparent from the table that 17.3 20 MCM/year of shortage would occur in 1985 for the total area of Rayong, Sattahip and Laem Chabang. It would be difficult to expedite the completion of Nong Pla Lai and Ban Bung Dams because they require long construction periods. The delay, on the other hand, of the operation at start of these two dams would cause shortage of industrial and municipal water in 1986 by about 26.5 MCM/year.

After the year 1987 until the target year 2000, required water demand can be satisfactorily supplied.

The result of water balance calculation shows the severest drought will occur in the year 1979 in Nong Pla Lai dam, but this drought year is considered as the extraordinary one and not taken as the design year. The adopted design year is the year 1978 or second severest drought year.

4. WATER RESOURCES DEVELOPMENT PLAN II

4.1 GENERAL

The formulated Nong Pla Lai Sub-project consists of the Nong Pla Lai Dam, Water Transmission System comprising three routes to Mab Ta Pud (Rayong Area), Sattahip and Laem Chabang and Nong Pla Lai Irrigation System.

In the course of study, however, supply system to Laem Chabang area is likely to be excluded from the Sub-project since the cost of conveyence is very high and alternative water source can be found in the vicinity of Laem Chabang area.

The present project formulation in PLAN II has been carried out excluding the water supply to Laem Chabang and contains specifically Nong Pla Lai Dam, water transmission routes to Mab Ta Pud (Rayong Area) and Sattahip, and Nong Pla Lai Irrigation Area. The target year is set to 2000.

4.2 WATER DEMAND AND SUPPLY

4.2.1 Water Demand

Industrial and Municipal

Demand for industrial-municipal water in the two supply areas of Rayong and Sattahip in the year 2000 has been estimated on the basis of the foregoing study as shown below.

unit: MCM/year

	Rayong Area		
	Rayong Municipality	Mab Ta Pud	Sattahip
- Industry	6.4	21.5	17.2
- Industry-related municipality	3.2	12.3	1.5
- Other municipality	12.6	-	5.3
Total	22.2	33.8	24.0

The increase of water demand in Rayong and Sattahip areas from 1996 to 2000 is equivalent to Laem Chabang's demand in 1995.

Irrigation

The irrigation water demand in the Nong Pla Lai irrigation area in the size of 3,650 ha is estimated at 69.4 MCM/year when the croppping intensity is 100% in wet season and 80% in dry season. Cropping pattern and other conditions of production are assumed to be the same as discussed in the PLAN I.

4.2.2 Water Supply Plan

The water supply plan in the areas are broadly divided into two stages utilizing the surplus volume of the existing Dok Krai Reservoir which is exploited for Ban Khai Irrigation System and by constructing the proposed Nong Pla Lai Dam. The two stages are summarized below.

First stage

The surplus water from Dok Krai Dam with storage capacity of 49 MCM will be utilized to meet the water demand in Mab Ta Pud through the water transmission system until 1986, when the construction of Nong Pla Lai Dam is completed. The water demand in 1986 is estimated at 22.8 MCM/year.

Second stage

The Nong Pla Lai Dam will be developed by 1986 with storage capacity of 144.4 MCM taking physical and economical conditions into consideration.

After completion of Nong Pla Lai Dam, the Dok Krai Dam will be fully utilized to meet the industrial-municipal water demand in Rayong and Sattahip areas and the function of water supply to Ban Khai irrigation area is transferred from Dok Krai Dam to Nong Pla Lai Dam.

Nong Pla Lai Dam is utilized to meet to vested right of water in Ban Khai irrigation area and new demand of 69.4 MCM/year to proposed Nong Pla Lai Irrigation Area of 3,650 ha.

Schematic Diagram of Water Utilization System is shown in Fig. 4-1.

Table 2-1 Future Population Based on Current Trend

Unit: Person

Changwat Rayong	Future Population			Population Increase	
	1980	1990	2000	1980-1990	1980-2000
Rayong Municipality 1/	37,305	56,629	79,773	19,324	42,468
A. Muang 1/	83,693	90,474	93,065	6,781	9,372
A. Klaeng	100,484	127,383	154,338	26,899	53,854
A. Ban Khai	71,190	77,522	83,524	6,332	12,334
K.A. Pluak Daeng	25,791	30,804	35,676	5,013	9,885
K.A. Ban Chang 1/	27,594	28,264	29,047	670	1,453
K.A. Wang Chang	12,839	21,414	29,834	8,575	16,995
Total	358,896	432,490	505,257	73,594	146,361

Unit: Person

Changwat Chon Buri	Future Population			Population Increase	
	1980	1990	2000	1980-1980	1980-2000
Chon Buri Municipality	50,106	52,897	55,557	2,791	5,451
Panat Nikhon M.	13.411	14,408	15,392	997	1,981
Tambon Si Racha M. 1/	21,632	32,611	43,339	10,979	21,707
A. Muang Chon Buri	119,281	150,115	180,290	30,834	61,009
A. Panat Nikhon	110,203	126,154	142,024	15,951	31,821
A. Pan Thong	38,289	42,069	45,957	3,780	7,668
A. Ban Bung 2/	78,262	83,894	89,555	5,632	11,293
A. Si Racha 1/	84,516	100,426	116,795	15,910	32,279
A. Ban La Mung	43,789	45,824	47,765	2,035	3,976
A. Sattahip	85,112	98,377	111,528	13,265	26,416
K.A. Ko Si Chang	2,955	3,553	4,157	598	1,202
K.A. Nong Yai	17,386	20,486	23,491	3,100	6,105
K.A. Bo Thong	24,779	36,579	48,372	11,800	23,593
Muang Pattaya	34,706	59,380	84,173	24,674	49,467
Total	724,427	866,773	1,008,395	142,346	283,968

1/: Nong Pla Lai Sub-Project

2/: Ban Bung Sub-Project

Table 2-2 Projection of the Induced Population and Labor Force by Area (1990)

Unit: Person

Area	Projects	direct workers	indirect workers	induced workers	local workers	1980-1990 net natural growth 4/	expected work force (40%) (50%)	net induced population
Sattahip	Soda Ash 1/	800	400	640	560	13,265		
	Sea port 2/	5,280	1,186	1,056	5,410	335		
	SUB TOTAL	6,080	1,586	1,696	5,970	13,600	5,440 - 6,800	6,784
Laem Chabang	Sea port /3	-	-	-	-	10,979		
	Industrial Estate 2/	7,500	3,750	6,000	5,250	15,910		
	SUB TOTAL	7,500	3,750	6,000	5,250	26,889	10,756 - 13,445	24,000
Rayong	Sponge Iron 1/					335		
	Natural Gas Separation					19,324		
	Petro Chemical	9,464	4,732	7,571	6,625	6,781		
	Chemical Fert.					6,332		
	Industrial Estate	12,500	6,250	10,000	8,750			
	SUB TOTAL	21,964	10,982	10,571	15,375	32,772	13,109 - 16,386	70,284

Note: 1/ 100% operation : 2/ 50% operation : 3/ 0%
4/ Sattahip .. A. Sattahip + 1/2 K.A. Ban Chang, Laem Chabang .. Si Racha M. + A. Si Racha
Rayong-Sattahip.. 1/2 K.A. Ban Chang + Rayong M. + A. Muang + A. Ban Khai
5/ The long term plan of Chonburi states that the labor force is 46% of the population and employment is 16% of the total population. Population & Housing Census-1970 indicates that employment population for Chonburi and Rayong are 41.9%, 43.6% of the population respectively.

Table 2-3 Projection of the Induced Population and Labor Force by Area (2000)

Unit: Person

Area	Projects	direct workers	indirect workers	induced workers	local workers	1980-2000 net natural growth	expected work force	net induced population
Sattahip	Soda Ash	800	400	640	560	26,416		
	Sea port	10,560	2,371	2,112	10,819	726		
	SUB TOTAL	11,360	2,771	2,752	11,379	27,142	10,857 - 13,571	11,008
Laem Chabang	Sea port /1	2,112	474	422	2,164	21,707		
	Industrial Estate	15.000	7,500	12,000	10,500	32,279		
	SUB TOTAL	17,112	7,974	12,422	12,664	53,986	21,594 - 26,993	49,688
Rayong	Sponge Iron					726		
	Natural Gas Separation					42,468		
	Petro Chemical	9,464	4,732	7,571	6,625	9,372		
	Chemical Fert.					12,334		
	Industrial Estate	25,000	12,500	20,000	17,500			
	SUB TOTAL	34,464	17,232	27,571	24,125	64,910	25,964 - 32,455	110,284

/1 20% operation

Table 2-4 Water Demand for Industrial Use (Nong Pla Lai Sub-Project)

Unit: MCM/Year

Year	Rayong Area			Sattahip Area			Sub-total		Laem Chabang Area			Total	
	Plant	Demand	Increase Demand	Plant	Demand	Increase Demand	Demand	Increase Demand	Plant	Demand	Increase Demand	Demand	Increase Demand
1984	Gas Separation Petrochemical	7.8	7.8				7.8	7.8				7.8	7.8
1985	Sponge Iron	1.0	8.8				1.0	8.8				1.0	8.8
	Chemical Fertilizer	9.5	18.3	Soda Ash	10.2	10.2	19.7	28.5	Industrial Estate	3.3	3.3	23.0	31.8
1986	Industrial Estate	2.4	20.7	Sattahip Port	2.1	12.3	4.5	33.0				4.5	36.3
1990	Industrial Estate	2.4	23.1	Sattahip Port	1.4	13.7	3.8	36.8	Industrial Estate	3.3	6.6	7.1	43.4
1995									Industrial Estate	3.6	10.2	3.6	47.0
				Sattahip Port	0.6	14.3	0.6	37.4	Laem Chabang Port	1.8	12.0	2.4	49.4
1996				Sattahip Port	1.2	15.5	1.2	38.6	Industrial Estate	3.0	15.0	4.2	53.6
2000	Industrial Estate	4.8	27.9	Sattahip Area	1.7	17.2	6.5	45.1	Laem Chabang Port	1.8	16.8	8.3	61.9

Table 2-5 Water Demand for Industrial and Municipal Use (Nong Pla Lai Sub-Project)

Unit: MCM/Year

Year	Rayong				Sattahip				Sub-Total				Laem Chabang				Total				Year
	Industry	Industry -related municipal	Other municipal	Total	Industry	Industry -related municipal	Other municipal	Total	Industry	Industry -related municipal	Other municipal	Total	Industry	Industry -related municipal	Other municipal	Total	Industry	Industry -related municipal	Other municipal	Total	
1980	-	-	1.5	1.5	-	-	0.3	0.3	-	-	1.8	1.8	-	-	0.3	0.3	-	-	2.1	2.1	1980
1981	-	-	1.8	1.8	-	-	0.6	0.6	-	-	2.4	2.4	-	-	0.5	0.5	-	-	2.9	2.9	1981
1982	-	-	2.1	2.1	-	-	0.9	0.9	-	-	3.0	3.0	-	-	0.7	0.7	-	-	3.7	3.7	1982
1983	-	-	2.4	2.4	-	-	1.1	1.1	-	-	3.5	3.5	-	-	1.0	1.0	-	-	4.5	4.5	1983
1984	7.8	-	2.7	10.5	-	-	1.4	1.4	7.8	-	4.1	11.9	-	-	1.3	1.3	7.8	-	5.4	13.2	1984
1985	18.3	-	3.0	21.3	10.2	0.3	1.7	12.2	28.5	0.3	4.7	33.5	3.3	1.7	1.6	6.6	31.8	2.0	6.3	40.1	1985
1986	20.7	3.7	3.2	27.6	12.3	0.6	2.0	14.9	33.0	4.3	5.2	42.5	3.3	1.7	1.8	6.8	36.3	6.0	7.0	49.3	1986
1987	20.7	3.7	3.5	27.9	12.3	0.6	2.3	15.2	33.0	4.3	5.8	43.1	3.3	1.7	2.1	7.1	36.3	6.0	7.9	50.2	1987
1988	20.7	3.7	3.8	28.2	12.3	0.6	2.5	15.4	33.0	4.3	6.3	43.6	3.3	1.7	2.4	7.4	36.3	6.0	8.7	51.0	1988
1989	20.7	3.7	4.1	28.5	12.3	0.6	2.8	15.7	33.0	4.3	6.9	44.2	3.3	1.7	2.6	7.6	36.3	6.0	9.5	51.8	1989
1990	23.1	8.5	4.4	36.0	13.7	0.8	3.1	17.6	36.8	9.3	7.5	53.6	6.6	3.4	2.9	12.9	43.4	12.7	10.4	66.5	1990
1991	23.1	8.5	4.9	36.5	13.7	0.8	3.3	17.8	36.8	9.3	8.2	54.3	6.6	3.4	3.2	13.2	43.4	12.7	11.4	67.5	1991
1992	23.1	8.5	5.3	36.9	13.7	0.8	3.5	18.0	36.8	9.3	8.8	54.9	6.6	3.4	3.4	13.4	43.4	12.7	12.2	68.3	1992
1993	23.1	8.5	5.8	37.4	13.7	0.8	3.8	18.3	36.8	9.3	9.6	55.7	6.6	3.4	3.7	13.7	43.4	12.7	13.3	69.4	1993
1994	23.1	8.5	6.3	37.9	13.7	0.8	4.0	18.5	36.8	9.3	10.3	56.4	6.6	3.4	3.9	13.9	43.4	12.7	14.2	70.3	1994
1995	23.1	8.5	6.8	38.4	14.3	0.9	4.2	19.4	37.4	9.4	11.0	57.8	12.0	6.0	4.2	22.2	49.4	15.4	15.2	80.0	1995
1996	23.1	8.5	8.0	39.6	15.5	1.2	4.4	21.1	38.6	9.7	12.4	60.7	15.0	7.0	4.5	26.5	53.6	16.7	16.9	87.2	1996
1997	23.1	8.5	9.2	40.8	15.5	1.2	4.6	21.3	38.6	9.7	13.8	62.1	15.0	7.0	4.7	26.7	53.6	16.7	18.5	88.8	1997
1998	23.1	8.5	10.4	42.0	15.5	1.2	4.9	21.6	38.6	9.7	15.3	63.6	15.0	7.0	5.0	27.0	53.6	16.7	20.3	90.6	1998
1999	23.1	8.5	11.6	43.2	15.5	1.2	5.1	21.8	38.6	9.7	16.7	65.0	15.0	7.0	5.2	27.2	53.6	16.7	21.9	92.2	1999
2000	27.9	15.5	12.6	56.0	17.2	1.5	5.3	24.0	45.1	17.0	17.9	80.0	16.8	7.0	5.5	29.3	61.9	24.0	23.4	109.3	2000

Note: Rayong includes Rayong Municipality, Amphoe Muang Rayong, King Amphoe Ban Chang, Amphoe Ban Khai.
Sattahip includes Amphoe Sattahip.
Laem Chabang includes Amphoe Si Racha, Si Racha Municipality.

Table 2-6 Water Demand for Industrial and Municipal Use (Ban Bung Sub-Project)

Unit: MCM

Year	Industry	Municipality	Total
1980	1.8	1.3	3.1
1981	1.8	1.4	3.2
1982	1.8	1.5	3.3
1983	1.8	1.6	3.4
1984	1.8	1.7	3.5
1985	1.8	1.8	3.6
1986	1.8	2.0	3.8
1987	2.0	2.1	4.1
1988	2.3	2.3	4.6
1989	2.6	2.4	5.0
1990	2.9	2.5	5.4
1991	3.0	2.6	5.6
1992	3.2	2.7	5.9
1993	3.4	2.9	6.3
1994	3.6	3.0	6.6
1995	3.8	3.2	7.0
1996	4.0	3.4	7.4
1997	4.2	3.6	7.8
1998	4.4	3.8	8.2
1999	4.6	4.0	8.6
2000	4.8	4.2	9.0

Table 2-7 Water Demand of Nong Pla Lai Irrigation Area (Cropping Intensity 180%)

Unit: MCM

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL
1968	6.68	1.13	0.00	12.35	11.59	9.38	9.48	6.63	0.00	0.67	7.16	6.01	71.14
1969	5.33	0.88	0.51	10.33	8.56	5.92	5.72	5.55	0.00	1.45	2.30	6.98	53.59
1970	2.81	0.95	0.27	12.89	8.67	7.19	9.48	5.21	0.00	4.47	8.15	8.79	60.93
1971	4.87	1.01	0.56	14.92	8.26	5.57	6.96	7.40	0.00	4.47	8.84	9.67	72.58
1972	2.85	1.93	0.29	15.83	14.77	3.21	10.46	4.86	0.00	3.47	8.84	6.77	73.34
1973	5.72	0.74	0.29	12.58	10.22	4.72	7.26	5.10	0.00	4.47	7.42	8.77	67.33
1974	2.83	0.91	0.46	14.56	9.49	4.19	0.00	5.87	0.00	1.31	8.84	7.31	55.80
1975	5.10	0.90	0.43	12.80	10.02	6.37	3.53	6.35	0.00	4.47	6.80	8.25	65.09
1976	4.50	0.98	0.61	17.24	6.47	7.21	5.19	6.41	0.00	3.45	8.84	9.68	70.61
1977	5.00	1.18	0.49	5.23	12.70	7.25	6.35	7.14	0.00	1.27	4.70	10.05	61.43
1978	4.90	1.21	0.28	8.21	11.29	6.44	9.54	6.91	0.00	4.47	6.46	9.66	69.41
1979	4.53	1.84	0.25	12.84	14.97	6.26	10.12	7.40	0.00	4.47	8.84	7.13	78.69
1980	4.20	1.76	0.28	10.16	8.12	8.37	6.82	6.10	0.00	4.47	8.04	8.56	66.88

Table 2-8 Water Demand of Thap Ma Irrigation Area (Cropping Intensity 180%)

Unit: MCM

	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL
1968	11.71	1.98	0.00	21.65	20.32	16.45	16.62	11.62	0.00	1.17	12.55	10.70	124.74
1969	9.35	1.54	0.89	18.11	15.01	10.38	10.03	9.73	0.00	2.54	4.03	12.24	93.97
1970	4.93	1.67	0.47	22.08	15.20	12.61	16.62	9.14	0.00	7.84	14.29	15.41	106.84
1971	8.54	1.77	0.98	26.16	14.48	9.76	12.20	12.96	0.00	7.84	15.50	16.96	127.26
1972	5.00	3.38	0.51	27.76	25.90	5.63	18.34	8.52	0.00	6.08	15.50	11.87	128.60
1973	10.03	1.30	0.51	22.06	17.92	8.28	12.73	8.94	0.00	7.84	13.01	15.38	118.06
1974	4.96	1.60	0.81	25.53	16.64	7.35	0.00	10.29	0.00	2.30	15.50	12.82	97.84
1975	8.94	1.58	0.75	22.44	17.57	11.17	6.19	11.13	0.00	7.84	11.92	14.47	114.13
1976	7.89	1.72	1.07	30.23	11.34	12.64	9.10	11.24	0.00	6.05	15.50	16.97	123.81
1977	8.77	2.07	0.86	9.17	22.27	12.71	11.13	12.52	0.00	2.23	8.24	17.62	107.71
1978	8.59	2.12	0.49	14.40	19.80	11.29	16.73	12.12	0.00	7.84	11.33	16.94	121.71
1979	7.94	3.23	0.44	22.51	26.25	10.98	17.74	12.98	0.00	7.84	15.50	12.50	137.98
1980	7.36	3.09	0.49	17.81	14.24	14.68	11.96	10.70	0.00	7.84	14.10	15.01	117.27

Table 3-1 Water Balance of Supply and Demand

Year	Nong Pla Lai Sub-Project Area					Ban Bung Sub-Project Area		
	Water Demand			Water Supply	Water Balance	Water Demand	Water Supply	Water Balance
	Ind.&Mun.	Irrigation	Total			Ind.&Mun.		
1980	2.1	-	2.1	-	- 2.1	3.1	-	-
81	2.9	-	2.9	-	- 2.9	3.2	-	-
82	3.7	-	3.7	-	- 3.7	3.3	-	-
83	4.5	-	4.5	-	- 4.5	3.4	-	-
/1 84	13.2	-	13.2	22.8	9.6	3.5	-	-
85	40.1	-	40.1	22.8	17.3	3.6	-	-
/2 86	49.3	69.4	118.7	149.4	30.7	3.8	9.0	5.2
87	50.2	69.4	119.6	149.4	69.4	4.1	9.0	5.9
88	51.0	69.4	120.4	149.4	29.0	4.6	9.0	5.4
89	51.8	69.4	121.2	149.4	28.2	5.0	9.0	4.0
90	66.5	69.4	135.9	149.4	I3.5	5.4	9.0	4.6
91	67.5	69.4	136.9	149.4	12.5	5.6	9.0	4.4
92	68.3	69.4	137.7	149.4	11.7	5.9	9.0	4.1
93	69.4	69.4	138.8	149.4	10.6	6.3	9.0	3.7
94	70.3	69.4	139.7	149.4	9.7	6.6	9.0	3.4
/3 95	80.0	128.1	208.1	230.3	22.2	7.0	9.0	2.0
96	87.2	128.1	215.3	230.3	15.0	7.4	9.0	1.6
97	88.8	128.1	216.9	230.3	13.4	7.8	9.0	1.2
/4 98	90.6	194.7	285.3	296.9	11.6	8.2	9.0	0.8
99	92.2	194.7	286.9	296.9	10.0	8.6	9.0	0.4
2000	109.3	194.7	304.0	296.9	- 7.1	9.0	9.0	0

/1 Completion of Dok Krai Transmission System
/2 Completion of Nong Pla Lai Dam and Ban Bung Dam
/3 Completion of Khlong Yai Dam
/4 Completion of Thap Ma Dam

Fig. 2-1 Industrial & Municipal Water Demand

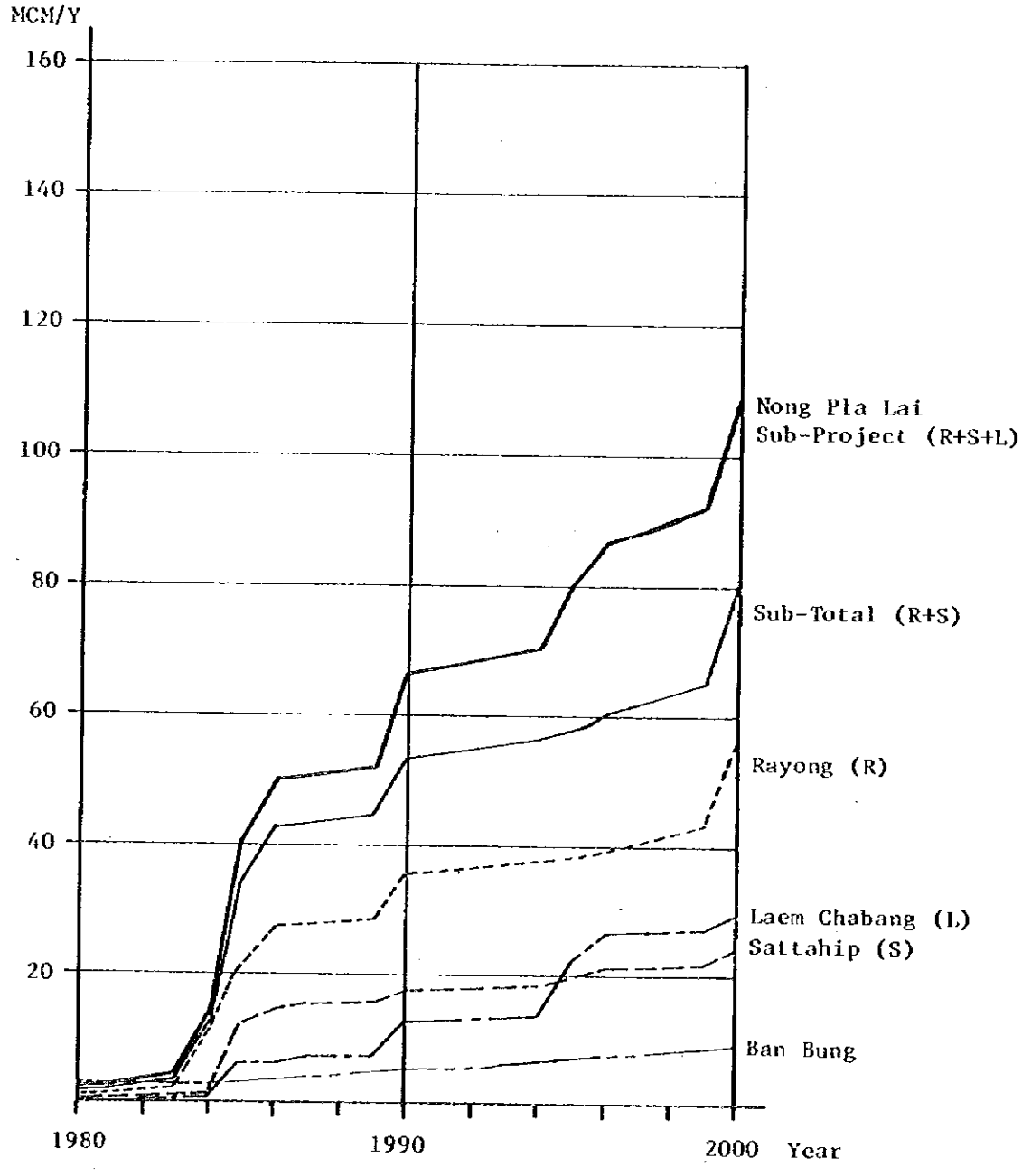


Fig 3-1 Location of Existing and Proposed Reservoir

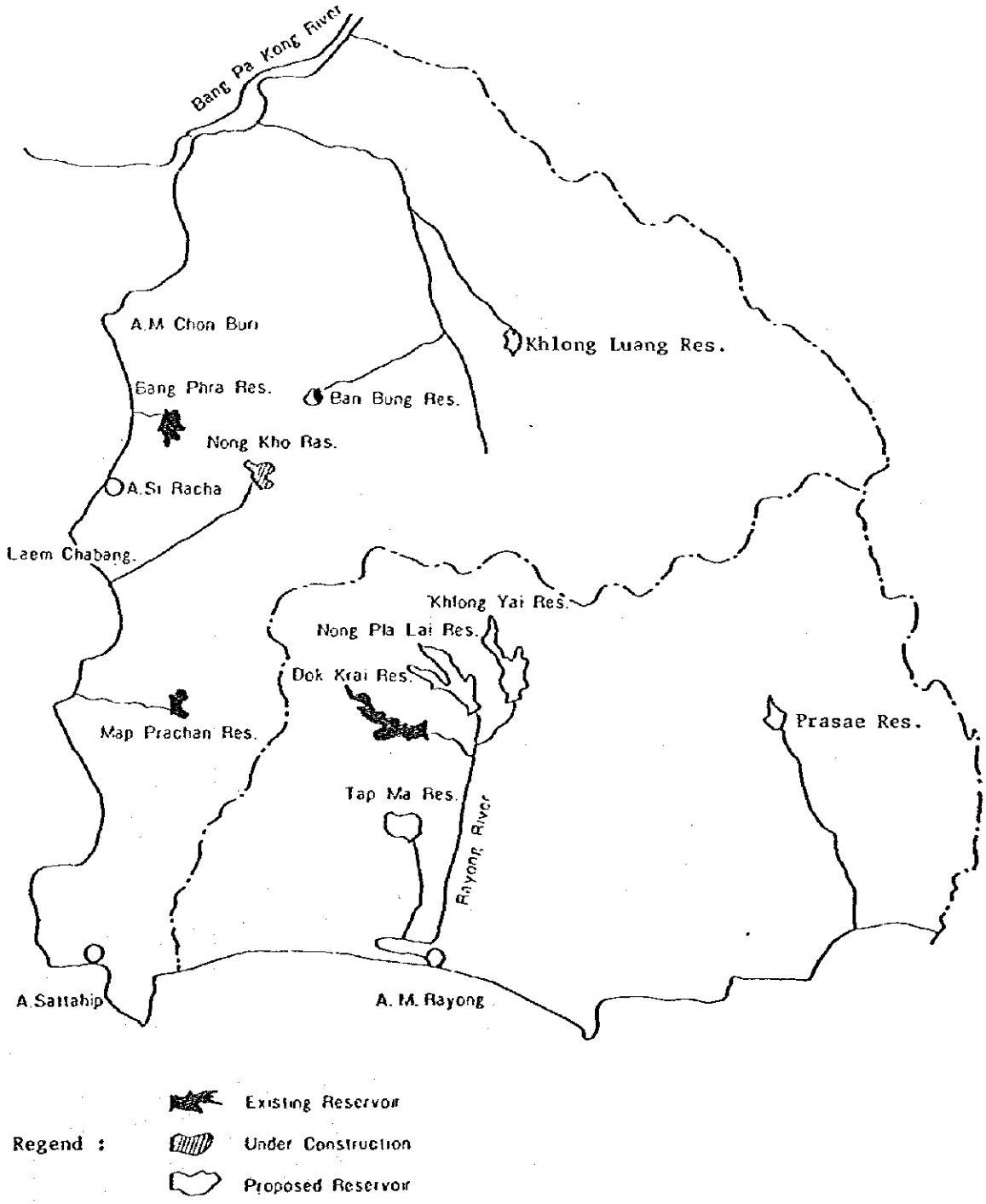


Fig. 3-2 Water Balance in Dok Krai Reservoir (First Stage)

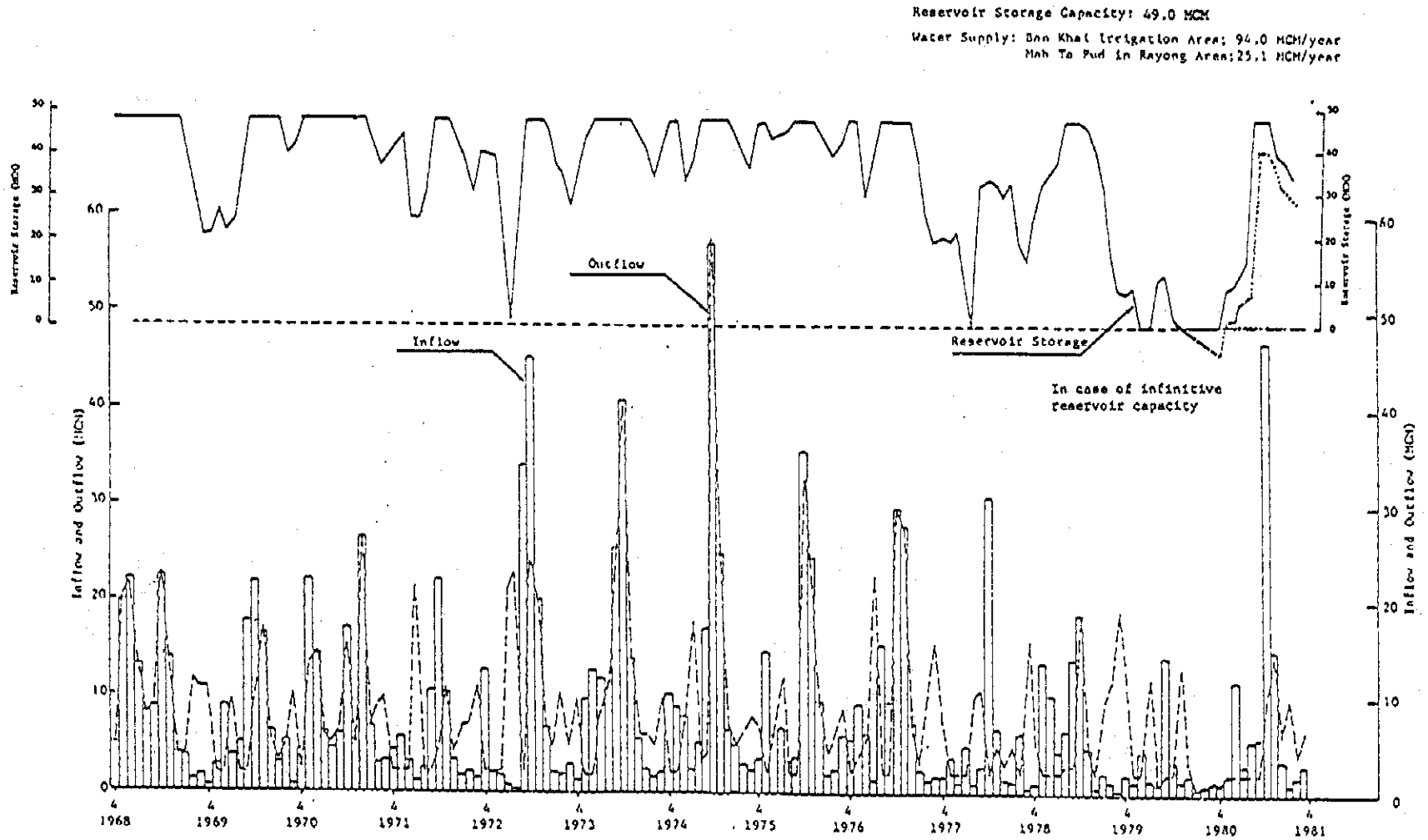
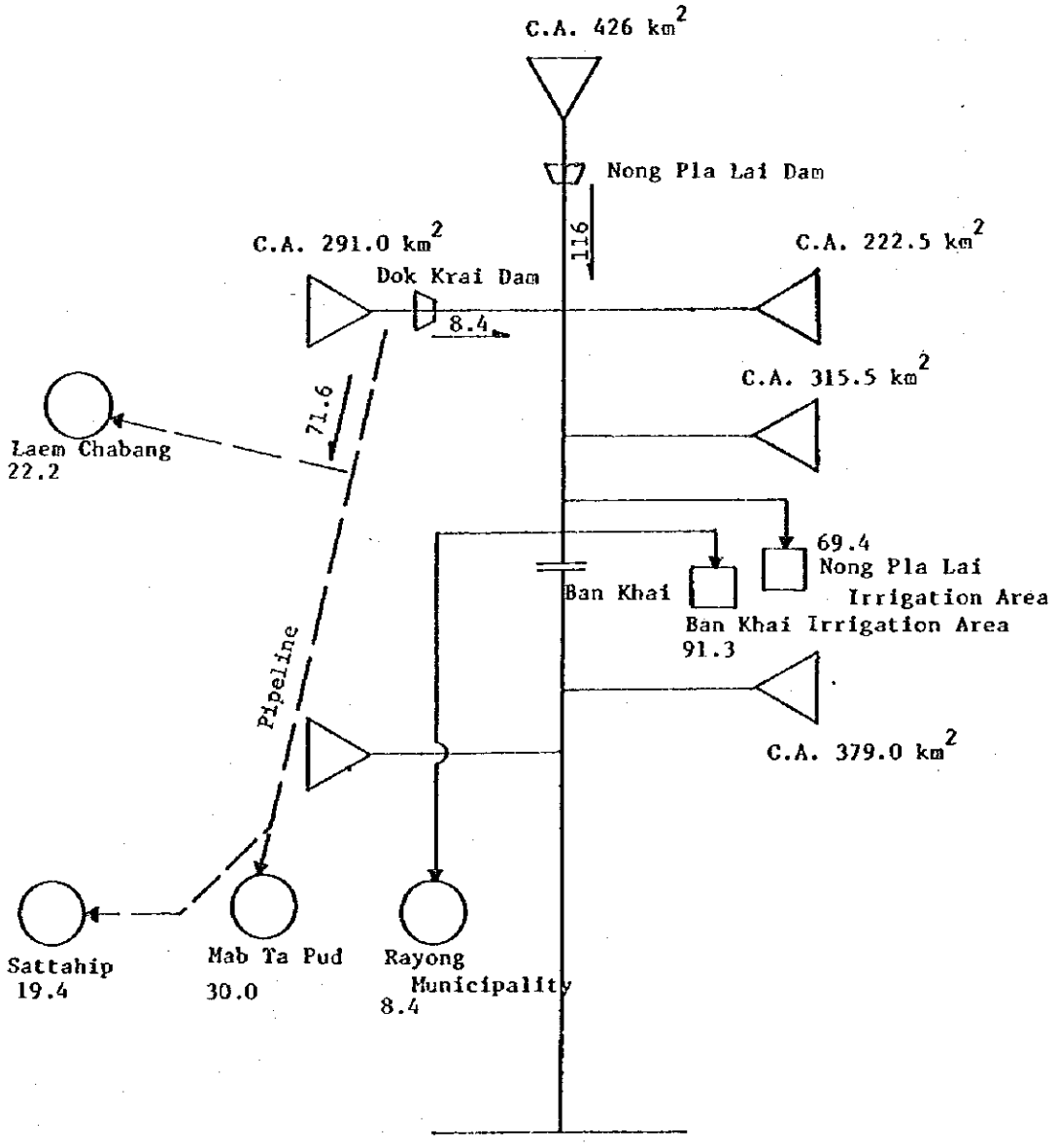


Fig. 3-3 Schematic Diagram of Water Utilization System

(Second Stage:2 Dams)

Unit: MCM/year



Industrial and Municipal Water Demand

Irrigation Water Demand

C.A. Catchment Area

Note:
Figures in the parenthesis stand for the water supply from dam including water loss.

Fig. 3-4 Water Balance in Dok Krai Reservoir (Second Stage)

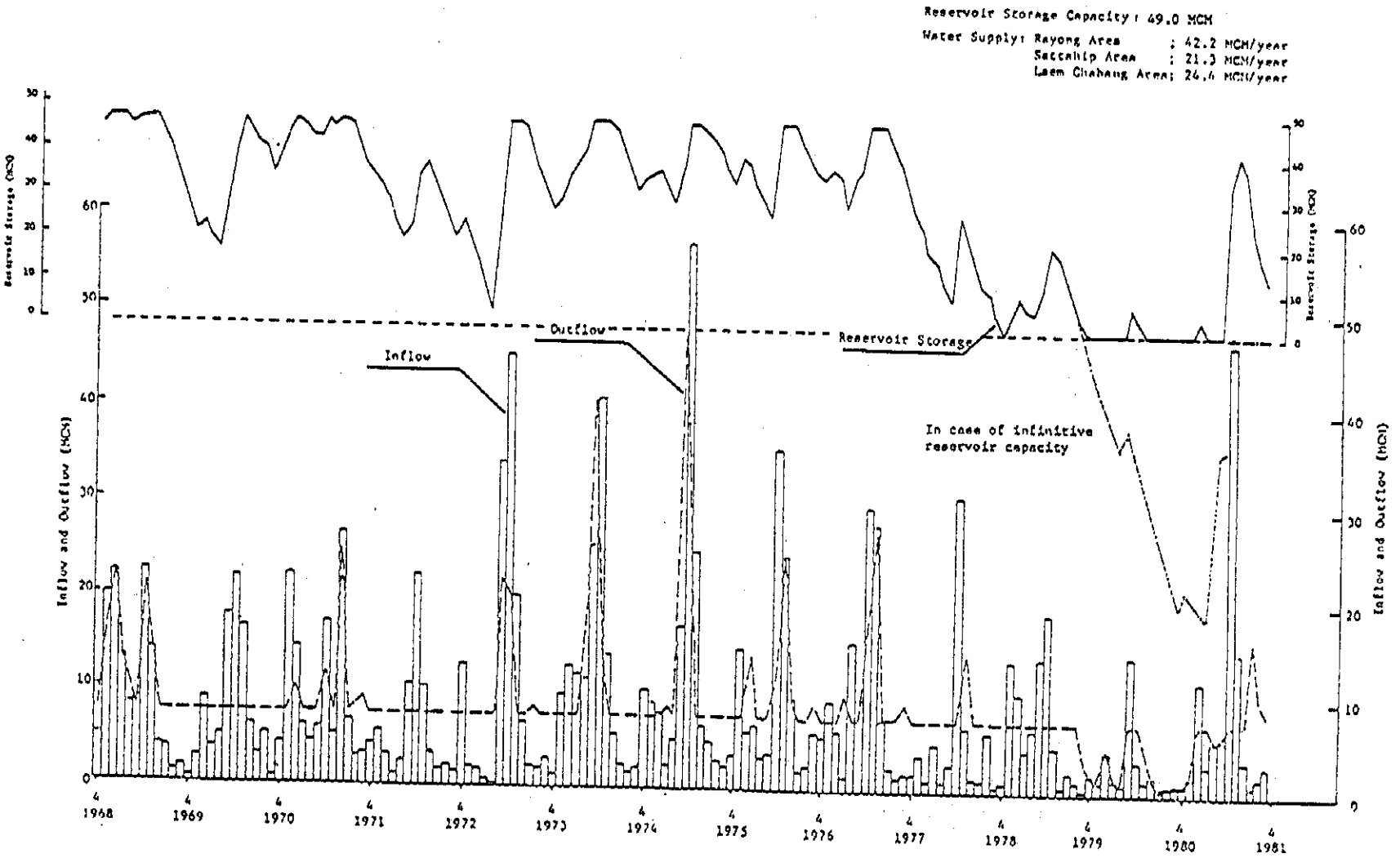


Fig. 3-5 Water Balance in Nong Pla Lai Reservoir (Second Stage)

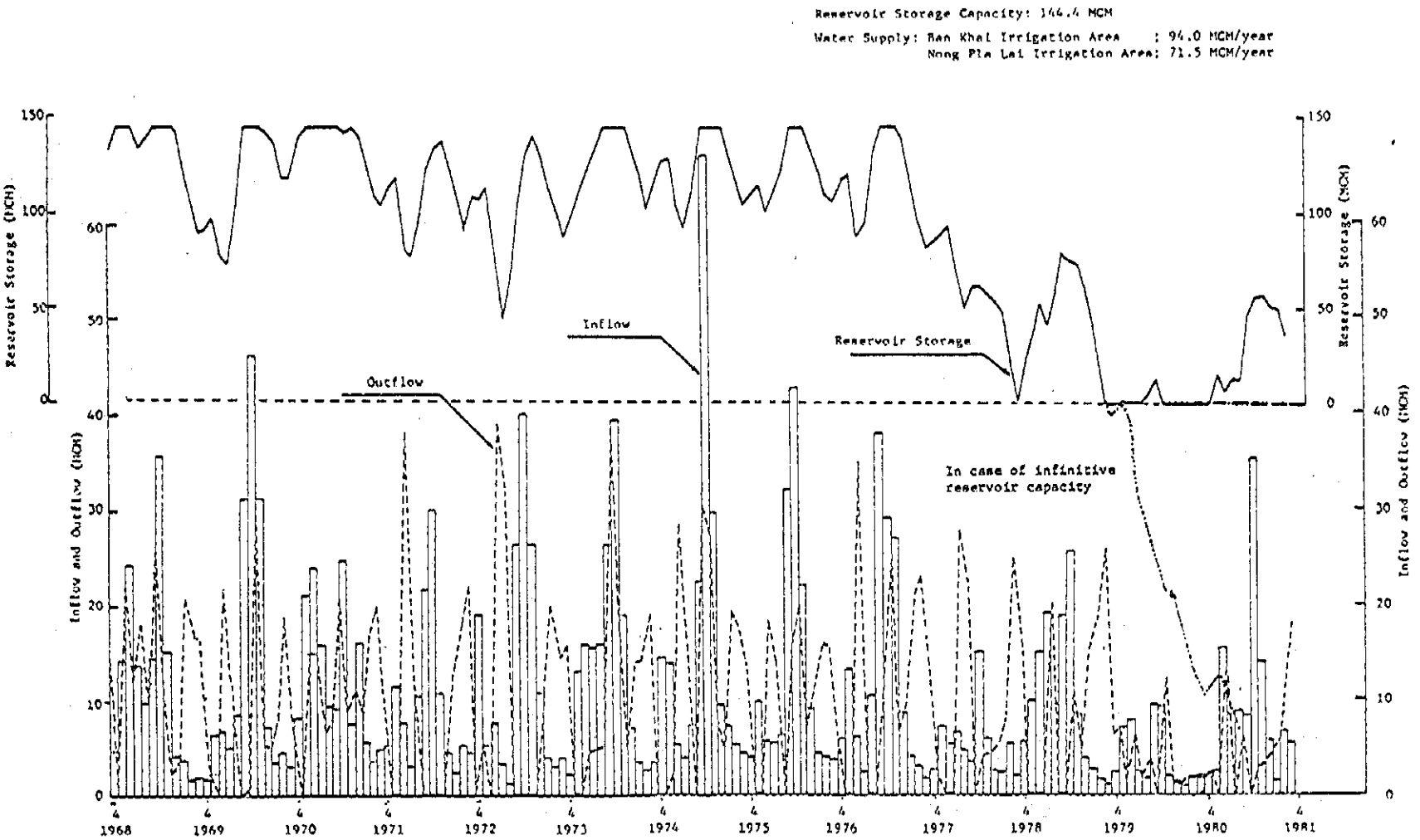


Fig. 3-6 Water balance in Ban Bung Reservoir

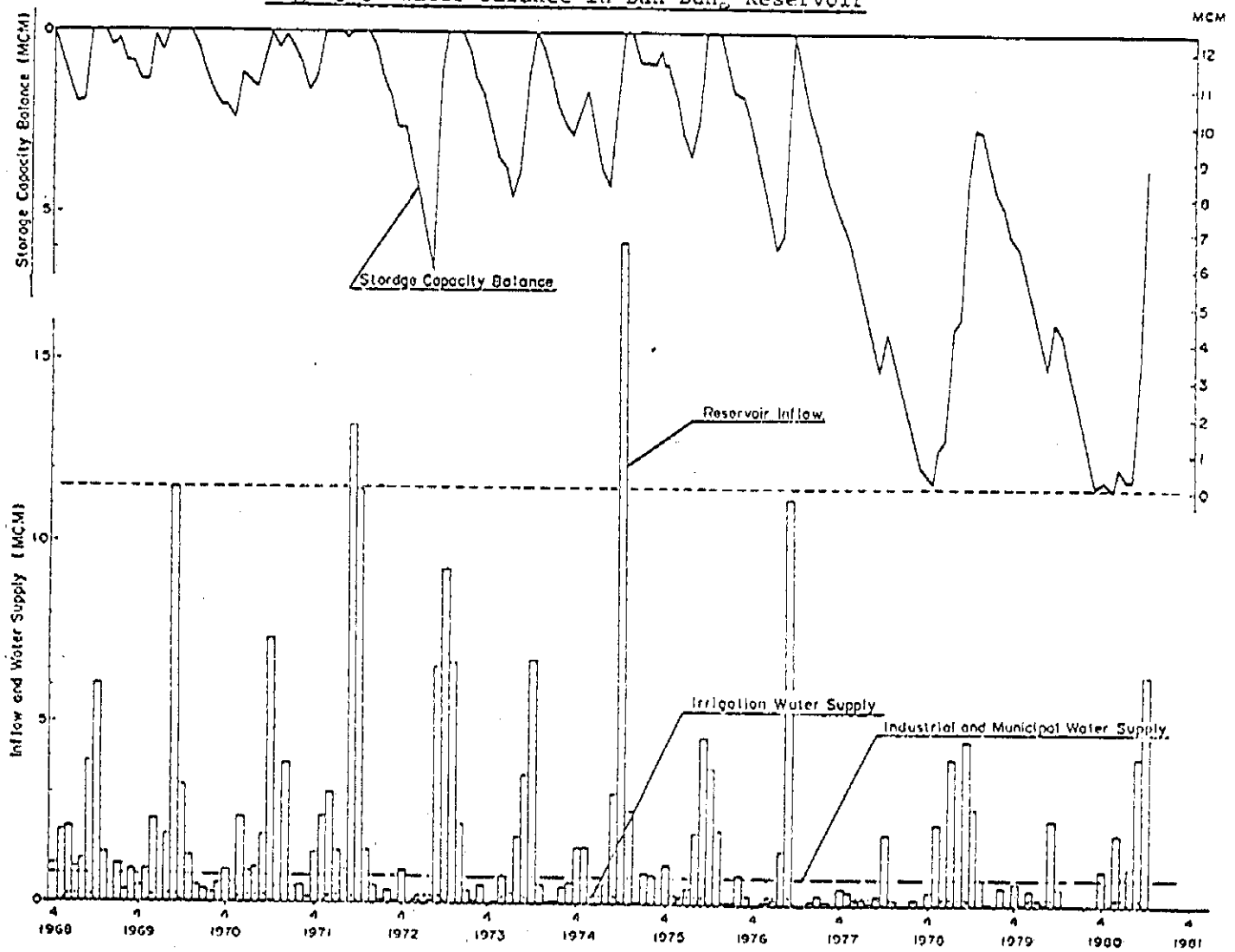
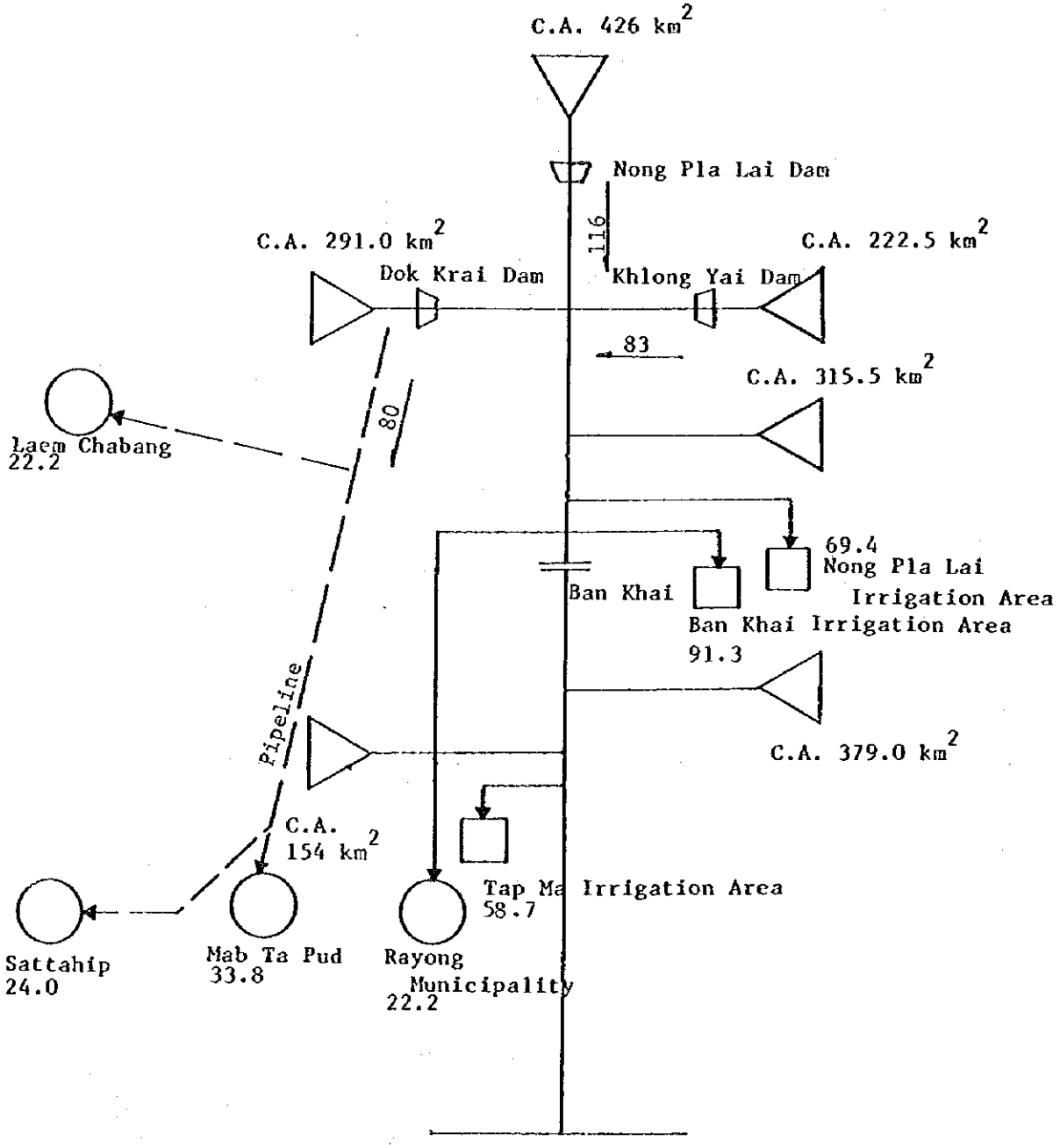


Fig. 3-7 Schematic Diagram of Water Utilization System

(Third Stage:3 Dams)

Unit: MCM/year



Industrial and Municipal Water Demand

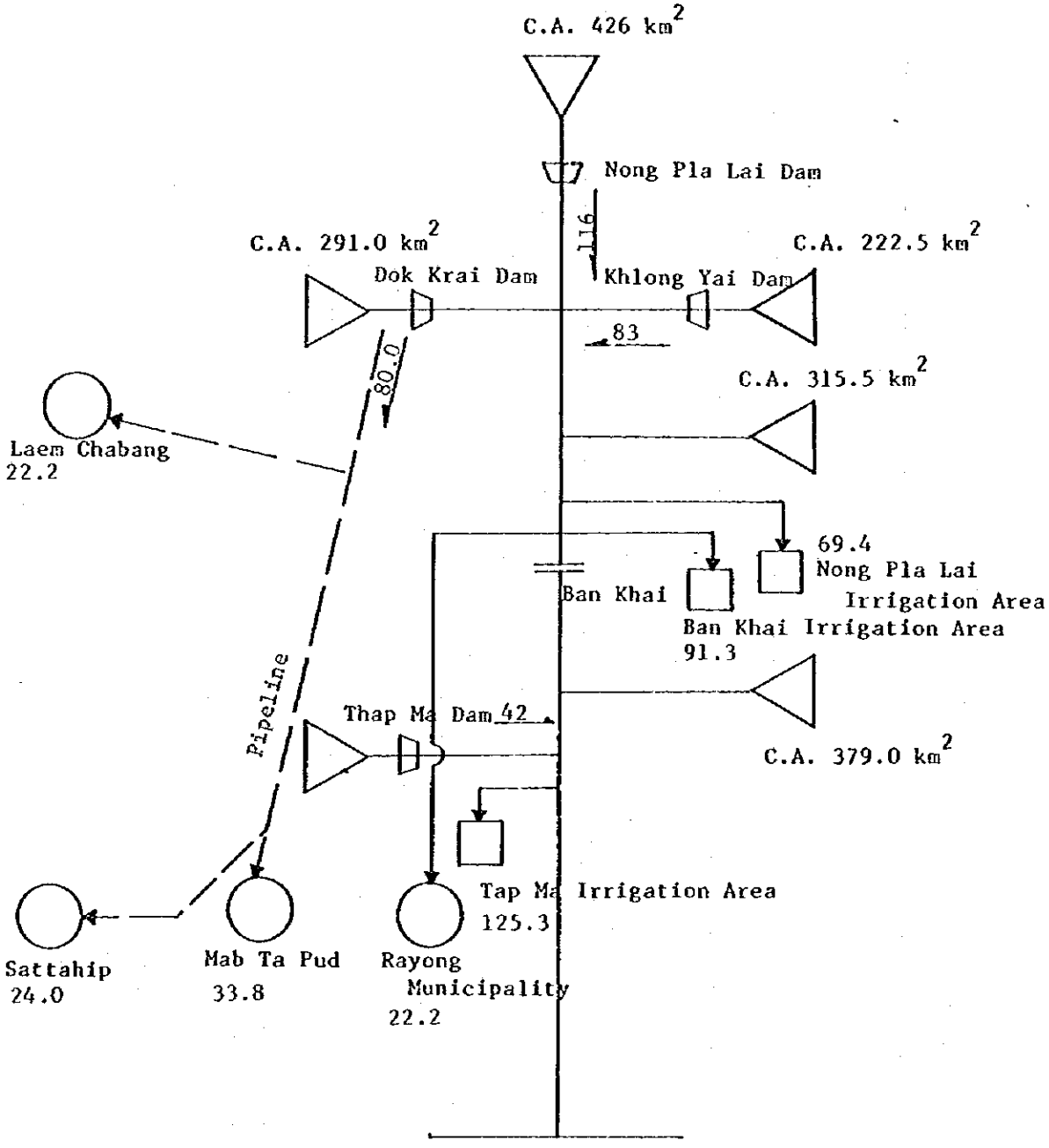
Irrigation Water Demand

C.A. Catchment Area

Note:
Figures in the parenthesis stand for the water supply from dam including water loss.

Fig. 3-8 Schematic Diagram of Water Utilization System
(Fourth Stage:4 Dams)

Unit: MCM/year



Industrial and Municipal Water Demand

Irrigation Water Demand

C.A. Catchment Area

Note:
Figures in the parenthesis stand for the water supply from dam including water loss.

Fig. 3-9 Water Supply and Demand

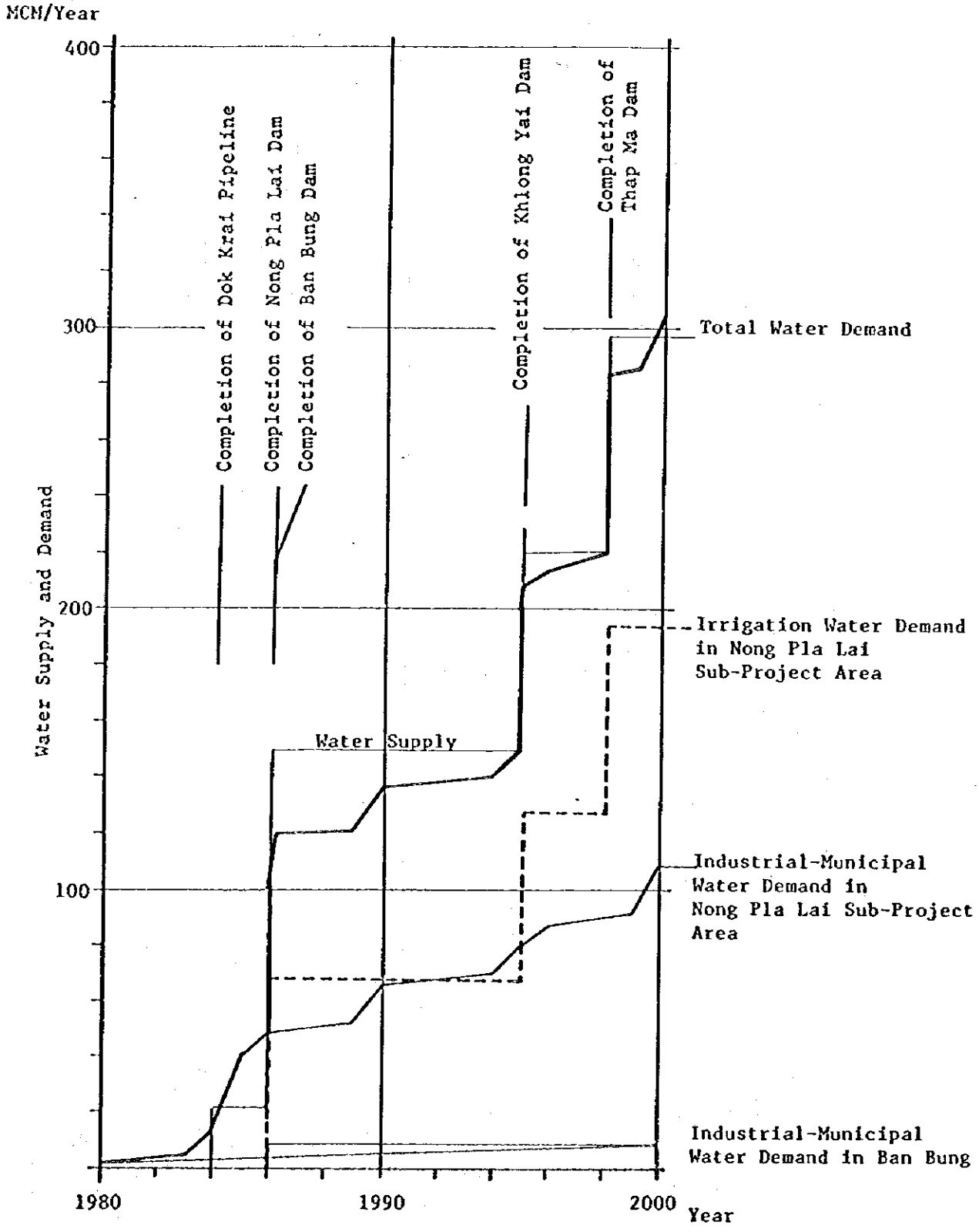
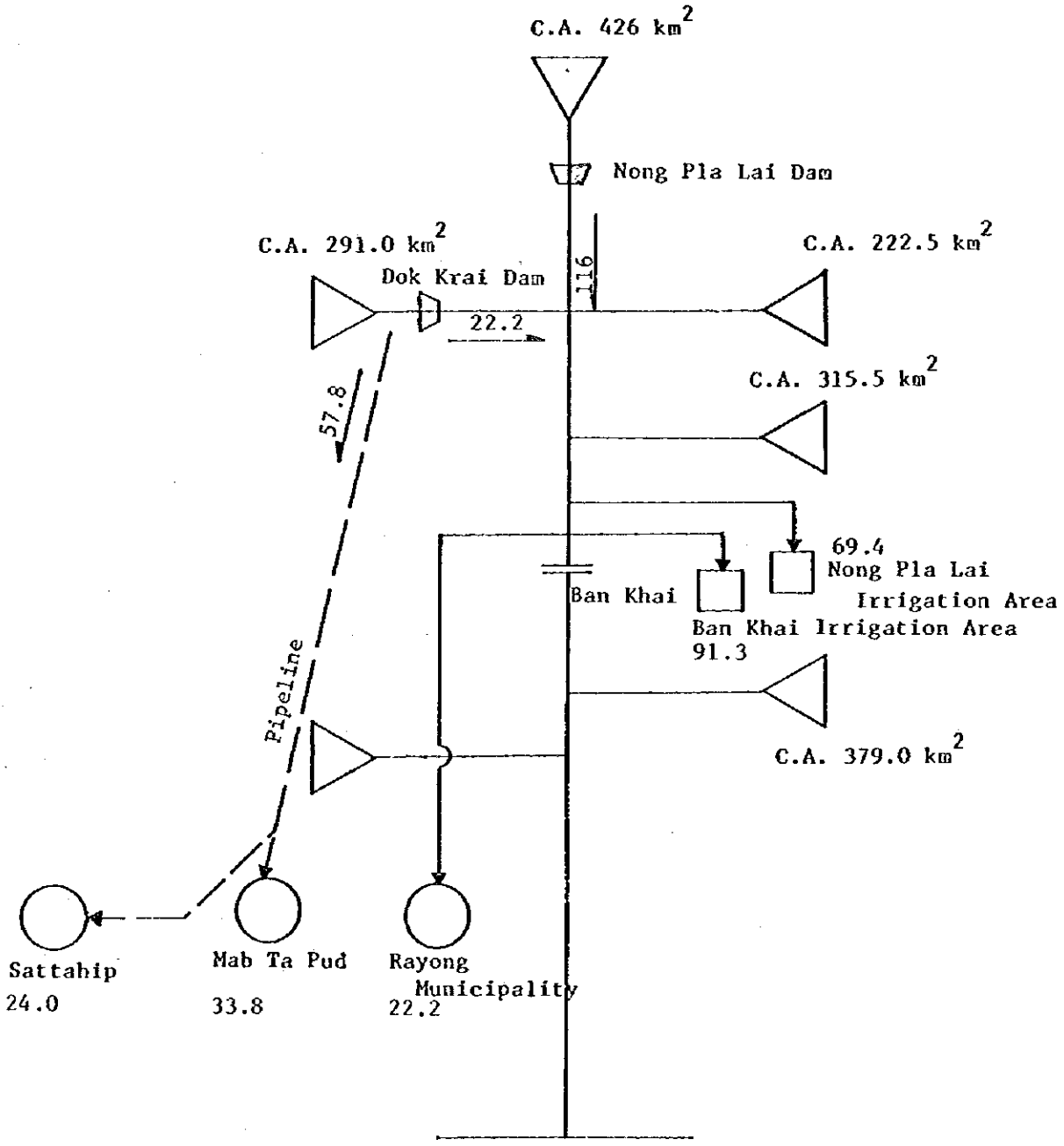


Fig.4-1 Schematic Diagram of Water Utilization System [PLAN II]

(2 Dams)

Unit: MCM/year



Industrial and Municipal Water Demand

Irrigation Water Demand

C.A. Catchment Area

Note:
Figures in the parenthesis stand for the water supply from dam including water loss.

VI. DAM

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

CHAPTER 2

LIST OF FIGURES

CHAPTER 1

CHAPTER 2

1. NONG PLA LAI DAM

1.1 DESIGN CONDITION

1.1.1 Function of Dam and Reservoir

Nong Pla Lai Dam is to be designed so as to have the following functions and facilities.

1) Storage Capacity

Utilization	144.4 MCM
Surcharge	43.5
Sediment	12.8
Gross	200.7

2) Spillway for inflow of 1.2 times 200-year flood

3) Intake and outlet

4) Facilities for emergency draw-down of water level

5) Branch Valve for Power Generation (in future)

6) Diversion Conduit for 10-year flood

1.1.2 Design Formulation

The proposed plan of Nong Pla Lai Dam and Reservoir scheme has been refined through alternative study on various structures.

Dam

1) Type

The geological and topographical conditions of the dam site don't accept concrete gravity type.

Rockfill type dam, that is structually superior to earth-fill type dam, is not suitable for this dam because of the difficulty of economical securement of rock materials in the vicinity of the dam site.

It appears that earth-fill type dam would be the only type recommendable for this dam site from the view points of abundant availability of embankment materials and relatively small height of the dam. A series of investigations and laboratory tests up to date reveals that the embankment materials that are classified into clayey sand or silty sand are distributed widely in the vicinity of the dam site with the quality enough to be the embankment materials for a earth-fill type dam.

The foundation of the dam will be excavated to the impervious strata on the dam axis so as to prevent leakage over permissive amount through the foundation.

Grouting method, an alternative treatment of improving permeable foundation, is eliminated because grouting is technically difficult under grouting the unsuitable soil condition.

2) Dam axis

Studies are carried out to find the most recommendable dam axis in the proposed site from the view points of topography, geology and economy.

The followings are the results of the comparison among the proposed and two alternative axes that are shown in Figs. 1-1 and 1-2.

- There are no great difference among the three axes in geology and topography.

- The embankment volumes are estimated roughly under the condition that the crest elevation of dam is set at 2 m above H.H.W.L. that corresponds to the total storage volume of the reservoir of 200.7 million cubic meter.

	Proposed	Alternative I	Alternative II
Total storage volume (MCM)	200	200	200
H.H.W.L. (EL.m)	47.0	46.5	48.0
Crest elevation of dam (EL.m)	49.0	48.5	50.0
Embankment volume (MCM)	3.2	3.1	3.9

- The proposed dam axis, on which the geological profile has been revealed through the geological investigations, is finally recommended in spite of the slight inferiority of embankment volume compared to alternative I. As for the Alternative I and II, such a detailed geological investigations on the proposed axis have not been performed.

Spillway

1) Type

As the types of spillway, the following 4 alternatives are studied.

Type of Spillway

Alternative	Control Structure	Discharge Carrier	Energy Dissipator
Proposed	Slide Overflow type	Chute type	Hydraulic jump type
Alt. I	Center overflow type	Chute type	Hydraulic Jump type
Alt. II	Semi-circular overflow type	Chute type	Hydraulic jump type
Alt. III	Morning glory type	Conduit type	Hydraulic jump type

Proposed Side overflow - Chute - Hydraulic jump types are adopted in consideration of the following matter.

- Other types less the proposed one for control structure are not suitable for such a wide width of 120 m required for this spillway.

- Conduit type for discharge carrier has some problem to be cleared such as:

  Safety against leakage through the contact face of concrete and embankment, resulting in piping action due to the vibration of the structure when big amount of discharge flow. This problem will be amplified when the foundation is not composed of rock like this dam site.

  Safety against blockade by floating matters that make the flow capacity lessen.

- Morning glory type of control structure has also the problem to be blockaded by floating matters in the reservoir.

2) Location and alignment

From the viewpoint of the dam site topography, it is desirable to select the left abutment of the dam for the location of the spillway. It can provide a satisfiable foundation in bearing power for the spillway structure.

The proposed alignment shown in Fig. 1-3 has the shortest total length compared with two alternative alignments.

3) Size and capacity

Size and capacity of spillway relates to the height of dam. If a spillway of larger discharge capacity is provided, it will require less flood control capacity of the reservoir and resulting in the construction of lower dam. Conversely, small spillway capacity will require a higher dam.

Nong Pla Lai Reservoir is required to store water to a maximum extent for the purpose of larger development of the Rayong river basin and the normal high water level is determined at EL 45.0 m.

The followings are considered for the determination of the size and capacity of the spillway:

- Gate is eliminated from the spillway for easy operation and maintenance.
- Normal high water level is EL. 45.0 m.
- Possible highest high water level is limited to EL. 47.0 m because a relatively big municipality will be submerged at the water level over EL. 47.0 m.
- The spillway has a role of flood control. The higher the highest high water level is, the bigger the flood control effect.

The highest high water level of EL. 47.0 m is finally adopted in consideratin of the above conditions.

Diversion Conduit

The dam site is located 3 km upstream of the confluence of two rivers, namely Khlong Ra Woeng (left side river) and Khlong Pong Nam Bit. The river flows through these two rivers have to be diverted into diversion conduit during the construction works of the dam for the sake of smooth and safe execution of works.

The proposed plan is that the river flow through Khlong Pong Nam Bit will be firstly diverted through an open channel into Khlong Ra Woeng and then conveyed into a diversion conduit together with the river flow of Khlong Ra Woeng. Therefore, in this plan, only one diversion conduit will be constructed beneath the dam embankment.

An alternative is to construct two diversion conduits for the exclusive use of two rivers.

The construction cost comparison between the proposed plan and the alternative show the superiority of the proposed one.

Construction Cost

	Proposed	Alternative
Open Channel	US$32,000	-
Conduit	US$800,000	US$1,600,000
Total	US$ 832,000	US$1,600,000

1.2 DESCRIPTION OF PROJECT

1.2.1 Principal Features of Dam and Reservoir

Reservoir

Catchment area	426 km^2
Reservoir area at H.H.W.L.	23 km^2

Reservoir stage

- Highest high water level (H.H.W.L.)	EL. 47.0 m
- Normal high water level (N.W.L.)	EL. 45.0 m
- Low water level (L.W.L.)	EL. 33.3 m

Reservoir storage

- Gross	200,700,000 m^3
- Surcharge	43,500,000 m^3
- Utilization	144,400,000 m^3
- Sediment	12,800,000 m^3

Dam

- Dam	Earth-fill type with cut-off trench	
- Crest elevation		EL. 49.0 m
- Max. dam height		31.0 m
- Crest length		4,000.0 m
- Slope gradients	Upstream slope	1:3.0
-	Downstream slope	1:2.5
- Embankment volume		3,200,000 m^3

Spillway

- Type: Side overflow weir with emergency gate
- Capacity: 700 m^3/s at H.H.W.L
- Gate: Roller gate B 5.0m x H 5.0m x 1 No.
  (Emergency gate for draw-down of water level)

Intake & Outlet

- Intake: Type : Vertical Tower
- Outlet for irrigation water
  Regulating valve: Jet flow gate ø1,500 mm x 1 No.
  Discharge capacity: 14 m^3/s at L.W.L

The reservoir capacity and area curve is shown in Fig. 1-4.

1.2.2 Geology

Geology of the Proposed Area

The geology of the project area is granite-based with flood plains covered with alluvium. (Refer to Figs. 1-5 and 1-6) Granite is of biotite type extensively eroded to form superficial strata of residual soil. No exposure of fresh granite is observed in the project area.

Boring test results and topographical distribution of the alluvium in flood plain show that the strata is old rather than new. The new alluvium strata is widely spread over the present flood plain with semi-compact alternating layers of clay, silt and sand. The old strata is observed in the center of the riverbed in the proposed damsite as well as in terrace which is elevated 3 to 5 meters above river bed at both banks of downstream area. The old strata is of semi-compact clayey sand.

Geology of Dam Site

Geology of dam site is composed of coarse-biotite granite as basement with alluvium spread over the river beds. (Refer to Figs. 1-7 and 1-8). This basement granite is exposed on both right and left bank, and the surface has been weathered down to residual soil. The residual soil is distributed as such the depth is in the range of 3 to 6 meters, with deposit thicker on the right bank than on the left. The feature of the soil is that of clayey sand with N-value not greater than 20. Beneath this residual soil decomposed granite is distributed. Decomposed granite is also dominated by clayey sand with N-value greater than 50 owing to high density.

Alluvium distribution in the valley area comprise either clayey sand or silty sand with old stratum having the deposit thickness as much as 15 meters and the young stratum 6 meters. Both strata have wide range of N-value which are found to be between 1 and 20 for the young, and between 2 and 50 over for the old one.

Test Boring and Permeability Test

Test boring of 15 pits along the proposed dam axis has been conducted by S.P.I. (Sverdrup & Parcel International, Inc.) in 1973, the results of which are presented as geological profile in Figs. 1-9 to 1-12. To confirm this previous test for continuation and permeability of strata, auger boring was carried out along dam axis, and the results have revealed that geological section of dam site was adequate. The results of four test boring conducted for the present study are presented as Figs. 1-9 and 1-12. Geologic Log of Drill Hole. The log shows that alluvium layers have thickness of 11 to 15 meters, running continuously from upper to lower reaches of dam.

The permeability test by means of gravity method was carried out in boring holes. The results as shown on boring log indicate that the permeability coefficients are relatively low or in the range of $K = 1 \times 10^{-5}$ cm/sec in the decomposed granite layer and $K = 1 \times 10^{-5}$ to $K = 1 \times 10^{-4}$ cm/sec in the sand or silt of alluvium layer. It may be concluded from the boring tests that permerbility of foundation is generally low and presents no problem.

Underground water level detected at boreholes or nearby wells is in the range of 1.0 to 1.5 meter below surface at river banks and 3 to 6 meters on hills.

Soil Survey and Laboratory Test

For both up and down stream area of the damsite recommended by S.P.I., auger boring tests were conducted for soil survey. Characteristics of soil as well as depth of weathering of foundation were studied. Some soil samples were collected and analysis was entrusted to the Research and Laboratory Division of the RID. The results are shown in Figs. 1-13 to 1-15 Graduation Test. According to the test soils are classified into either SC or SM, which are well usable as fill materials. The borrow areas proposed are large enough to supply quantity for the construction of embankment.

Concrete aggregates and rip rap materials may be obtained in a large quantity at a quarry located 12 km north of Sattahip. Other sources of these materials could be found in the highlands of granite rock located 8 km to the east or 20 km to the north east.

In addition to the above test results, the summary of soil tests conducted by S.P.I. in 1973 is shown in Figs. 1-16 to 1-19.

Engineering Geological Analysis

1) Foundation of Dam

In the flood plain area the foundation of dam is to be the top layer of granite. The alluvium in this area have poor N-value, and relatively permeable sand layer found by boring test may have to be stripped. The elevation of the foundation is expected to be EL. 18 meters.

As for the abutments, a top layer of decomposed granite is to be accepted for the foundation after removal of loose layer in residual soil distributed for 3 to 6 meters thick.

1.2.3 Dam and Reservoir

Reservoir

The reservoir created by the construction of the dam will have a surface area of 23 km^2 (14,400 rai) at the highest high water level (EL. 47.0 m) during the inflow of extraordinary flood and a gross storage capacity of 200.7 million m^3.

The normal high water level is EL. 45.0 m and the low water level is EL. 33.3 m. The storage between them will be 144.4 million m^3 which is an effective storage for the supply of irrigation water.

The surcharge storage of 43.5 million m^3 above the normal high water level is expected to perform flood control.

Highest high water level (H.H.W.L.) will be EL. 47.0 m which is 2.0 m above the normal high water level. The extraordinary flood discharge will be discharged at H.H.W.L through the spillway.

Dam

The dam will be of earth-fill type dam with such principal features as: Crest elevation - EL. 49.0 m; Height of dam - 31 m; Crest length - 4,000 m and Embankment volume - 3.2 million m^3.

The crest elevation of the dam of EL. 49.0 m provides a freeboard of 2.0 m above the highest high water level and 4.0 m above the normal high water level. The freeboard required for the dam can be calculated as below.

$$Hf > hw + hi$$

- hw is a height of wave due to wind and is estimated at 1.0 m in the case of wind velocity of 20 m/s and fetch distance of 9.0 km by means of the combining method of S.M.B and Saville methods.

- hi is an additional allowance according to type and importance of dam. For fill type dam, 1.0 m is adopted.

Therefore the freeboard required for the dam crest elevation is 2.0 m above the highest high water level.

The main embankment material will be clayey sand and silty sand which are found in plentiful supply in the vicinity of the dam site.

The slopes of the dam body to both up and down stream are 1:3.0 and 1:2.5 with the protection against erosion by rip-rap and sodding, respectively.

The foundation of the dam will be cut-off to the impervious strata with the bottom width of 6.0 m to 8.0 m on the dam axis. No curtain grouting will be provided for the improvement of the foundatin.

A part of the excavated material from the spillway will be used for the dam embankment after temporary storage.

The stability analysis of dam was carried out for the preliminary design of standard cross-section of dam.

Stability analysis was made for the following cases:

1) Normal high water level without earthquake,

2) Normal high water level with horizontal earthquake acceleration,

3) Empty reservoir just after completion of dam embankment without earthquake acceleration,

4) Rapid draw-down of reservoir water level from normal high water level to low water level.

Assumptions and constants used in the analysis are given below:

1) Unit weight

Water $pw = 1.0\ t/m^3$
Embankment material (core & shell)
wet $Wt = 1.8\ t/m^3$
saturated $Wsat = 2.0\ t/m^3$

2) Angle of internal friction of material

$$\phi = 25°$$

3) Cohesion of material

$$C = 3.0\ ton/m^2$$

4) Seismic coefficient (horizontal directin)

$$K = 0.05$$

The result of calculation is shown in Fig. 1-20.

The safety factor is the smallest in the case of just after completion of embankment.

Rather high pore pressure in embankment was assumed in this analysis standing on the safety side analysis. Therefore, actual safety factor will show more stable condition of the dam embankment.

No problem in other cases are found in this stability analysis.

1.2.4 Spillway

The proposed Spillway, on the left bank, consists of an side overflow weir of 120 m wide, concrete lined discharge carrier with energy dissipator of 200 m and downstream channel of 750 m. The total length of the spillway including the downstream channel reaches to about 1,000 m.

The design flood discharge of the spillway is estimated at 700 m^3/s that is based on the figure which is 1.2 times the discharge of 1/200 probability. Storage effect of the reservoir is then taken into consideration to derive the outflow peak discharge of 700 m^3/s.

	Inflow peak discharge (m^3/s)	Outflow peak discharge (m^3/s)	Storage volume (m^3)
Design flood (1.2 x 1/200 probability)	1,050	700	43,500,000

Fig. 1-21 shows the inflow-outflow hydrograph of the extraordinary flood.

The spillway will also be used as a flood control facility. The surchrge capacity for the 30-year flood is as follows and shown in Fig. 1-22.

	Inflow peak discharge (m^3/s)	Outflow peak discharge (m^3/s)	Storage volume (m^3)
30-year Flood	695	475	34,200,000

A roller gate of 5.0 m wide and 5.0 m high is provided for the emergency draw-down of water level of reservoir. The water level will be drawn down from the natural high water level to the low water level through the spillway and the intake facilities within 20 days.

1.2.5 Intake and Outlet

The intake and the outlet erected at the upstream and downstream ends of the diversion conduit will serve to tap irrigation water and to cope with emergency draw-down of water level of the reservoir.

The diversion conduit will be diverted to a part of the tapping irrigation water facilities after it is plugged with concrete on the dam axis and provided with a penstock.

Maximum intake volume based on monthly mean water requirement would be 10 m^3/s. When the daily fluctuation of irrigation requirement and the capacity for emergency discharge are considered, the capacity of the facilities would be 14 m^3/s at the low water level.

The discharge volume will be controlled by a valve (jet flow gate ϕ 1,500 m/m) installed at the outlet. Another gate (slide gate ϕ 1,500 m/m) provided on just upstream of the jet flow gate is for the maintenance of the jet flow gate.

The discharged water will be dissipated in the stilling basin and conveyed to the existing river through a channel of 510 m long.

1.2.6 River Diversion

The river flow will be diverted through the diversion conduit during the construction works of the dam for the sake of smooth execution of the works.

The main facilities of the diversion works are diversion conduit, upstream channel, downstream channel, connection channel of two rivers, upstream of the dam site, primary upstream coffer dam, upstream main coffer dam and downstream coffer dam.

The facilities are designed to be safe against the estimated flood of 1/10 probability. This flood discharge will be controlled in the reservoir resulting in rising of the water level to EL.38.0 m. The diameter of the conduit is 3.0 m.

The diversion conduit is erected on the left bank of Khlong Ra Woeng river (left side river). Another river, namely Khlong Pong Nam Bit (right side river) is diverted to the Khlong Ra Woeng river through the open channel connecting two rivers.

Upon completion of the dam construction, the conduit will be plugged with concrete on the dam axis and diverted to a part of the tapping irrigation water facilities.

Fig. 1-23 shows diameter of conduit vs. maximum reservoir water level to be raised in case of the floods of 1/5 and 1/10 probability.

1.2.7 Road Relocation and Land Acquisition

The reservoir area of 24.6 km^2 at EL. 48.0 m which is 1.0 m high above the highest high water level should be acquired before the completion of the dam construction.

When other areas such as dam site, borrow area and right of way for road to be relocated are added to the above areas, the total land acquisition will be 31 km^2.

Most of this land is presently under cassava production. Approximately 200 houses now occupy the area.

Local roads to be submerged have to be relocated. The relocated road will be on the right bank of the reservoir with the total length of some 17.3 km as shown in Fig. 1-24.

As for the compensation problem of the people in the reservoir, they will receive compensation money to move in other places.

Two alternatives are to make land for resettlement in the reservoir by embankment or to get compensation land. The costs required for both alternatives are roughly estimated as shown in Table 1.1 on the basis of the assumptions that each compensation house is to be provided with 1.6 ha (10 rai) of land.

Figs. 1-25 and 1-26 shows the illustration of these alternative plans.

1.2.8 Design Drawings

The drawings are shown in Fig. 1-27 to Fig. 1-33. They include general plan, longitudinal profile and standard cross-section of dam, plan and longitudinal profiles of spillway and waterway and details of spillway.

1.3 CONSTRUCTION PLAN

1.3.1 Basic Consideration

The construction plan of the Nong Pla Lai Dam is to be formulated taking availability of construction materials on the site, weather conditions, topographic and geologic conditions, etc., into consideration.

Wherever practically possible, mechanical execution of work is to be adhered in major items of the work. The commencement of the construction work will be in May 1984 for the earliest possible start of impounding water. The work will be performed by 2-shift of 8 hours (actual work hours of 7), i.e., 2-shift 16 hours (actual work hours of 14) per day.

1.3.2 Construction Materials

Embankment Materials

The volume of earth materials to be embanked for the main dam and main coffer dam is estimated at about 3,195,000 m^3 in total consisting of core, shell, filter and rip-rap materials.

Item	Main dam	Main coffer dam	Total
Core, Shell)	2,220,000	604,000	2,824,000
Filter	120,000	-	120,000
Rip-Rap	163,000	88,000	251,000
Total	2,503,000	692,000	3,195,000

The results of boring survey and field reconnaissance show that abundant major construction materials, such as core & shell are found in the vicinity of the dam site, and no problem is expected in securement of the materials. In this plan, the borrow area is located at left and right bank abutments down-stream of the dam site.

A considerable volume of earth from the excavation of the dan foundation and spillway will be used for embankment materials after temporary storage during excavation.

Item	Total excavation volume	Coefficient of efficiency	Volume to be embanked
Dan foundation	800,000	0.6	480,000
Spillway	150,000	0.8	120,000
Total	950,000		600,000

For the filter material (drain material), sand obtained from the upper layer of the borrow area is expected to be used. Prior to securing the earth for core and shell, this will be temporarily stored in the shed and then embanked in compliance with the work schedule.

Rip-rap material which is estimated at about 250,000 m^3 in total, is to be purchased from the local source.

Concrete Materials

The total amount required of concrete for spillway, intake, etc., is estimated at about 48,000 m^3. Coarse aggregate and fine aggregate are to be purchased from the local source.

Item	Q'ty (m^3)	
Diversion	13,400	48,000 m^3
Spillway	31,000	
Intake & Outlet	1,000	
Miscellaneous	2,600	

As for cement (12,000 tons) and reinforcement bars (3,000 tons), it is also possible to get these materials locally.

Construction Equipment

Construction equipment to be used in the construction work consist of motor scraper, (Capacity: 16 m^3 heaped) bulldozer (Capacity: 21 and 32 tons), wheel loader (Capacity: 3.3 m^3), Crawler loader (Capacity: 3.3 m^3), heavy dump truck (Capacity: 20 tons), etc. These construction equipments are imported by the contractor.

Metal

Gates and valves of spillway and intake facilities are all imported.

Local Materials

Local materials will be utilized to the maximum extent. The major items are cement, steel bars, wooden materials, bricks, stone products, oil product, etc.

1.3.3 Construction Facilities

Such facilities as office, living quarters, storage house, motor pool, repair shop, form assembly, reinforcement fabrication, concrete batching, water supply, power supply, rip-rap materials, temporary shed for aggregate and rip-rap materials, etc., and construction road are required for the smooth execution of the construction work.

A part of the office will remain after completin of construction of the dam and will become parmanently a part of the administration office building.

1.3.4 Relocation Road

Upon completion of the dam construction, the existing road will be submerged in the reservoir. The relocation road, about 17.3 km in length, are constructed along the right bank of the reservoir.

1.3.5 Construction Schedule

The construction works of this dam involve preparatory works, construction works of river diversion, main coffer dam, main dam, spillway, intake and outlet structures.

All works are scheduled to be completed in about 2.5 years starting in May 1984 and ending in September 1986.

The construction works are to be executed on contract bases and to be performed by 2 shift (1 shift of 8 hours, actual work hours of 7).

The construction time schedule is shown in Fig. 1-34 and the main works in each year are described below.

First year (1983)

Land acquisition work is to be started in this year.

Second year (1984)

Major preparatory works such as the construction of camps and shops and construction road etc., are to be executed. These works shall be completed by the end of this year except a part of construction road.

Prior to the commencement of main works, diversion conduit and open channel construction works are to be executed starting in September and ending up in March of next year.

Excavation works of the main dam are to be started in October. Road relocation work is also started in this year.

Third year (1985)

The main work of this year is embankment of the main dam including the main coffer dam.

The embankment work is scheduled to be started in February. Approximately 70% of dam volume is to be embanked in this year.

The main portion of the spillway and about a half length of the downstream channel are also to be constructed.

The road relocation work is continued in this year.

Fourth year (1986)

The main dam embankment, construction of spillway and downstream channel are continued in this year.

Erection works of spillway gate is to be done in this year.

An intake tower and outlet valve house are constructed in this year and valves and penstock are erected following the completion of the main dam embankment and plugging of the diversion conduit.

All works are to be completed at the end of September of this year.

1.4 COST ESTIMATE

1.4.1 Construction Cost

The construction cost to be financed for Nong Pla Lai Dam is estimated at US$66,550,000 equivalent consisting of US$29,850,000 equivalent of foreign currency and US$36,700,000 equivalent of local currency, respectively.

The cost estimate is based on the following considerations.

1) Exchange rate US$1.00 = ¥230 = ฿23

2) The unit cost for each item is estimated in the price level of February, 1981.

3) The costs equivalent to CIF prices of construction equipment, metal, steel bar, fuel and oil, and cement are included in the foreign currency portion. Duty and Imposts and misc., local expenses are included in the local currency portion.

   As for cement, steel bar, fuel and lubrications these are included in the foreign currency portion in spite of the possibility of securement in the local market, considering that their raw materials must be imported.

4) Contingencies consist of price and physical contingencies. Price escalation ratio of 7% and 12% per annum are adopted for foreign and local currency portions respectively. Physical contingency of 15% is adopted. Physical contingency of 15% is adopted.

The breakdown of the cost estimate by each work item and the annual disbursement schedule are shown in Tables 1-2 to 1-5.

2. BAN BUNG DAM

2.1 DEISN CONDITION

2.1.1 Function of Dam and Reservoir

Ban Bung Dam is to be designed so as to have the following functions and facilities.

1) Strage Capacity

Utilization	12.5 MCM
Surcharge	7.8
Sediment	1.6
Gross	21.9

2) Spillway for inflow of 1.2 times 200-year flood

3) intake and Outlet for vested irrigation water/1

4) Facilities for emergency draw-down of water level

/1 The existing pumping stations for industrial-manicipal water are transferred to the right abutment of the new dam. The new water transmission system including pumping station for Ban Bung Municipality is to be constructed by the beneficiary and not included in the project.

5) Branch Valve for Power Generation (in future)

6) Diversion Conduit for 10-year flood

2.1.2 Design Formulation

Dam

1) Type

The geological and topographical condition of the dam site do not accept concrete gravity dam. The difficulty of economical securement of rock material makes Ban Bung Dam difficult to adopted rock-fill type as the dam type.

Earth-fill type dam would be the only type recommendable for this site from the viewpoints of abundant availability of embankment materials and relatively small height of the dam.

From the series of investigations and laboratory tests up to date, it is revealed that the embankment materials with abundant quantity and enough quality can be provided in the vicinity of the dam site.

Homogeneous earth-fill type dam is then adopted for Ban Bung Dam.

For the foundation treatment, cut-off method to impervious strata of foundation shows suitability for this dam site. It is superior than grouting method in technical and economical viewpoints.

2) Dam axis

The proposed dam axis is set at 100 m down-stream of and in parallel with the existing Ban Bun Dam.

An alternative of the dam axis is the existing one. The existing dam body will be used in this case with some trimming of the surface of the slope. (Refer to Figs. 2-1 and 2-2)

From the results of comparative studies of these two dam axes, it is said that the alternate axis will require a smaller embankment volume of about 85% to the proposed one. However, the alternate axis causes such technical by difficult problems during the construction works as:

- Leakage through the foundation of the existing dam will cause trouble to the excavation and embankment works of the cut-off portion just downstream of the existing dam body.

- The execution of the construction works such as spillway, intake & outlet, diversion conduit are very difficult under full reservoir condition of the existing reservoir.

The proposed dam axis, on which a series of geological investigations have been carried out, is therefore recommendable in spite of the slight inferiority of the embankment volume.

Spillway

1) Type

Among the spillway types mentioned in 1.1.2 (Nong Pla Lai Dam), the following types are judged to be the most suitable for Ban Bung Dam's spillway.

Control structure : Center overflow type without gate

Discharge carrier : Chute type

Energy dissipator : Hydraulic jump type

The followings were taken into consideration for the above judgements.

- For the control structure, center overflow type of the width of 20 m will fit enough to the dam with easy construction works.

- Morning glory type of control structure, as one of alternative, has the problem to be blockaded by floating matters in the reservoir resulting in less flow capcity.

- When the center overflow type is adopted, chute and hydraulic jump types are defined for discharge carrier and energy dissipator, respectively.

- Gate is eliminated from the spillway for the sake of easy operation and maintenance.

2) Location and alignment

From the viewpoint of the dam site topography, it is desirable to serect the spillway on the right bank of the river. The geology of this portion can provide a foundation for it with sufficient bearing power and imperviousness.

The proposed alignment of the spillway is the only recommendable one, therefore, no alternative was studied.

3) Size and capacity

Size and capacity of spillway relate to the height of dam. If a spillway of larger discharge capacity provided, it will require less surcharge capacity of the reservoir and resulting in the construction of lower dam. Conversely, small spillway will require a higher dam.

The followings are considered for the determination of the size and capacity of the spillway:

- Gate is eliminated from the spillway for easy operation and maintenance.
- Normal high water level of EL. 82.1 is set from the water balance calculation to provide a reservoir capacity of 14 MCM including sediment.
- The spillway has a role of flood control. The higher the highest high water level is, the bigger the flood control effect.

The size of the overflow weir of 20 m is finally adopted from the flood control study. The inflow peak discharge of 150 m^3/s will be decreased to 70 m^3/s of outflow peak in 30-year flood.

Diversion Conduit

A diversion conduit will be built for smooth and safe execution of the construction works of the dam together with appurtenant structures such as coffer dams.

Flood occurred in the basin firstly flows into the existing reservoir resulting in an effective peak discharge control.

The regulated discharge from the spillway and/or outlet of the existing dam will be diverted into the diversion conduit.

The proposed diversion conduit is on the right side of the existing river. This location is the only one recommendable for this site from the viewpoint of topography and geology. No alternative, therefore, was studied.

2.2 DESCRIPTION OF PROJECT

2.2.1 Principal Features of Dam and Reservoir

Reservoir

Catchment area	53 km^2
Reservoir area at H.H.W.L	4 km^2
Reservoir stage	
- Highest high water level (H.H.W.L)	EL. 84.3 m
- Normal high water level (N.W.L)	EL. 82.1 m
- Low water level (L.W.L)	EL. 76.1 m

Reservoir storage

- Gross	21,900,000 m^3
- Surcharge	7,800,000 m^3
- Irrigation, industrial & municipal	12,500,000 m^3
- Sediment	1,600,000 m^3

Dam

- Dam	Earth-fill type with cut-off trench	
- Crest elevation		EL. 86.3 m
- Max. dam height		21.5 m
- Crest length		2,800.0 m
- Slope gradients	Upstream slope	1:3.0
-	Downstream slope	1:2.5
- Embankment volume		1,400,000 m^3

Spillway

- Type	Overflow weir without gate
- Capacity	125 m^3/s at H.H.W.L

Intake & Outlet

- Intake — Type : Vertical Tower
- Outlet for vested irrigation water
  Regulating valve Jet flow gate ϕ1,000m/m x 1 No.
  Discharge capacity 5 m^3/s at L.W.L

The intake and pumping station for the industrial-minicipal water of Ban Bung Municipality is to be constructed by the beneficiary and not included in the project.

The existing pumping stations are transferred to the right abutment of the new dam.

The reservoir capacity and area curve is shown in Fig. 2-3.

2.2.2 Geology

Geology of the Proposed Area

The geology of the project area is granite-based with flood plains covered with colluvial deposit and alluvium (Refer to Figs. 2-4 and 2-5). Granite is of two mica type extensively eroded to form superficial strata of residual soil. Some exposure of fresh granite may be observed in the mountains within the project area.

Flood plain and present reservoir area is covered by loose layers of clay, silt or sand. Plains and foothills among the nearby hilly land are covered by colluvial deposit of loose sandy clay, spread over the basement of granite.

Geology of Damsite

Geology of damsite is composed of two mica granite as basement with alluvium spread over the river beds. (Refer to Figs. 2-6 and 2-7). This basement granite is exposed on both right and left bank, the surface being weathered down to residual soil. Fresh rock is observed only in boreholes taken at the river beds.

The residual soil is distributed as such the deposit is thicker on the right bank than on the left ranging from 4 to 8 meters. The feature of the soil is that of clayey sand with N-value between 10 and 50.

Colluvial deposit carried over from surrounding highlands is mostly semi-compact fine grain sandstone and covers the residual soil deposited underneath. The layer is 1 to 3 meters thick and thicker at slopes.

Alluvium distribution in the valley comprise mainly the clayey sand which is up to 7 meters thick. N-value is below 10 characterized by loose layer.

In addition to the above, small hill of slate may be observed which interferes with the granite.

Of the bed-rock in the dam site area, residual soil, decomposed granite and fresh rock are semi-impervious to impervious in permeability while the alluvium is permeable to semi-permeable.

Test Boring

Test boring of 13 pits along the proposed dam axis has been conducted by S.P.I. (Sverdrup & Parcel International, Inc.) in 1973, the result of which is presented as geological profile in Fig. 2-7. To confirm this previous test, auger boring was carried out along dam axis, and the results have revealed that the geological profile of damsite was adequate.

The permeability test by S.P.I. for soil samples collected at the damsite show that except for some sections permeability coefficient is generally small which is less than $K = 1 \times 10^{-5}$ cm/s. The foundation poses no problem concerning permeability.

Underground water level at the riverbank is 1.0 meter below surface and at left and right abutments, 2 to 3 meters below.

Soil Survey and Laboratory Test

For both up and down stream area of the damsite recommended by S.P.I., auger boring test was conducted for soil survey. Characteristics of soil as well as depth of weathering of foundation was studied. Some soil samples were collected and analysis was entrusted to the Research and Laboratory Division of the RID. The results are shown in Figs. 2-8 and 2-9 as gradation test.

According to the testresults, the soils are classified into either SC or SM, which are well usable as fill materials. The borrow areas proposed is large enough to supply quantity for construction of embankment.

As for the core material, a small hill of laterized surface layer located 2 km down-stream of damsite would be a good source.

Aggregates and rip-rap materials may be acquired in a large volume at a quarry of limestone 7.5 km south of Chon Buri. Another source is found in a hill of granite rock adjacent to the right bank of the damsite.

In addition to the above test results, the summary of soil tests conducted by S.P.I. in 1973 is shown in Figs. 1-16 and 2-10 to 2-11.

Engineering Geological Analysis

- Foundation of Dam

  In the flood plain area, the top layer of granite is enough to be the foundation of dam. The alluvium present in this area have small N-value, and relatively permeable sand layer found by boring test may have to be excavated. The elevation of the foundation is expected to be EL. 64 to 65 meters.

  As for the abutments, a layer having N-value of more than 50 is to be accepted after removal of loose layer in residual soil distributed for thickness of 1 to 5 meters.

2.2.3 Dam and Reservoir

Reservoir

The reservoir created by the construction of Ban Bung dam will have a surface area of 4.0 km^2 (2,500 rai) at the surcharge water level (EL. 84.3) during the inflow of the extraordinary flood and a gross storage capacity of 21,900,000 m^3.

The normal high water level (N.W.L.) of EL. 82.1 can provide an effective storage of 12,500,000 m^3 for vested and new water demands of irrigation, municipal and industrial water supply.

A storage capacity for sediment is also provided below the low water level (L.W.L.) of EL. 76.1 m. This capacity can store 1.6 MCM of sediment that corresponds to 100 years sedimentation.

For flood control purpose, a surcharge capacity of 7,800,000 m^3 is provided between the highest high water and normal high water level.

Highest high water level will be EL. 84.3 m.

Dam

The dam will be of earth-fill type dam with such principal features as: Crest elevation EL 86.3 m - Height of dam - 21.5m; Crest length 2,800 m and Embankment volume - 1.4 million m^3.

A freeboard of 2.0 m is provided above the highest high water level for the determination of the dam crest elevation. The freeboard is for the wave due to wind and additional allowance given for earth-fill dam.

$$Hf \geq hw + hi$$

where, Hf : freeboard (m)
hw : height of wave due to wind (m)
hi : additional allowance according to type and importance of dam (m)

- hw is estimated at 0.6 m in the case of wind velocity of 20 m/s and fetch distance of 3.0 km by means of the combining method of S.M.B. and Saville methods.

  hi is 1.0 m for fill-type dam.

Therefore the freeboard required for the dam is determined to be 2.0 m above the highest high water level by making round computed Hf.

The main embankment material will be clayey sand and silty sand which is found in plentiful supply in the vicinity of the dam site.

The slopes of the dam body to both up and down streams is 1:3.0 and 1:2.5 with the protection against erosion by rip-rap and sodding, respectively.

The foundation of the dam will be cut-off to the impervious strata with the bottom width of 6.0 to 4.0 m on the dam axis. No curtain grouting is to be provided to improve the foundation.

A part of the excavated material from the foundation may be used for the dam embankment after a temporary storage.

The stability analysis was carried out for the preliminary design of standard cross-section of dam.

The stability analysis was made for the following cases:

1) Normal high water level without earthquake,

2) Normal high water level with horizontal earthquake acceleration,

3) Empty reservoir just after completion of dam embankment without earthquake,

4) Rapid draw-down of reservoir water level from normal high water level to low water level.

Assumptions and constants used in the analysis are given below:

1) Unit weight

Water $pw = 1.0\ t/m^3$
Embankment material (core & shell)
wet $Wt = 1.8\ t/m^3$
saturated $Wsat = 2.0\ t/m^3$

2) Angle of internal friction of material

$$\phi = 25°$$

3) Cohesion of material

$$C = 3.0\ ton/m^2$$

4) Seismic coefficient (horizontal directin)

$$K = 0.05$$

The result of calculation is shown in Fig. 2.12. The safety factor is the smallest in the case of just after completion of embankment.

Rather high pore pressure of embankment was assumed in this analysis standing on the safety side analysis. Therefore, actual safety factor will show more stable condition of the dam embankment.

No problem in other cases are found in this stability analysis.

2.2.4 Spillway

The proposed spillway on the right bank consists of an center overflow weir of 20 m wide, concrete lined discharge carrier and energy dissipator of hydraulic jump type. The total length of the spillway including the downstream channel is about 250 m.

The design flood discharge of the spillway is estimated at 125 m^3/s that is based on the figure which is 1.2 times the discharge of 1/200 probability. Storage effect of the reservoir is then taken into consideration to derive the outflow peak discharge of 125 m^3/s.

	Inflow peak discharge (m^3/s)	Outflow peak discharge (m^3/s)	Storage volume (m^3)
Design flood (1.2 x 1/200 probability)	245	125	7,800,000

The spillway will be used as a flood control facility. For example surcharge capacity for the 30-year flood is as follows.

	Inflow peak discharge (m^3/s)	Outflow peak discharge (m^3/s)	Storage volume (m^3)
30-year-flood	150	70	5,200,000

The Inflow-outflow hydrographs of the extraordinary flood and 30-year flood are shown in Fig. 2-13 and Fig. 2-14, respectively.

2.2.5 Intake and Outlet

The intake and the outlet erected at the upstream and downstream ends of the diversion conduit will serve to tap irrigation water and to cope with emergency drawdown of water level.

The diversion conduit will be diverted to a part of the tapping irrigation water facilities after it is plugged with concrete on the dam axis and provided with a penstock.

The capacity of the facilities are determined to drawdown the reservoir water level in emergency. The required volume of water for the vested irrigation is small.

A main valve of 1,000 m/m in diameter is provided at the outlet for the said purpose. It is accompanied by a slide gate of 1,000 m/m in diameter on the upstream for the maintenance and repair.

The discharged water will be dissipated in the stilling basin and conveyed to the downstream channel.

2.2.6 River Diversion

The river flow will be diverted through the diversion conduit during the construction works of the dam.

The main facilities of the diversion works are diversion conduit, upstream channel, downstream coffer dam.

The facilities are designed to be safe against the discharge released from the existing reservoir when 10-year probable flood occurred.

The diversion conduit with 3 m in diameter is erected on the right side of the river. Upon completion of the dam construction, the conduit will be plugged with concrete on the dam axis and works as a permanent structure for tapping irrigation water. A steel penstock will be installed.

2.2.7 Road Relocation and Land Acquisition

The reservoir area of 2.7 km^2 at EL. 85.3 m which is 1.0 m high above the highest high water level should be acquired before the completion of the dam construction.

Most of this land is presently under cassava production except the existing reservoir area. Approximately 40 houses now occupy the area.

Local roads to be submerged have to be relocated. The relocated road is to be on the right bank of the reservoir with the total length of some 3.7 km as shown in Fig. 2-15.

2.2.8 Design Drawings

The design drawings are shown in Fig. 2-16 to Fig. 2-21. They include general plan longitudinal profile of and standard cross-section of dam, plan of spillway and waterway details of spillway and longitudinal profile of waterway.

2.3 CONSTRUCTION PLAN

2.3.1 Basic Consideration

The construction plan of the Ban Bung Dam is to be formulated taking availability of construction materials on the site, weather conditions, topographic and geologic conditions, etc., into consideration.

Wherever practically possible, mechanical execution of work is to be adhered in major items of the work. And the commencement of the construction work will be in May 1984 for the earliest possible start of impounding water. The work will be performed by 2-shift of 8 hours (actual work hours of 7), i.e., 2-shift 16 hours (actual work hours of 14) per day.

2.3.2 Construction Materials

Embankment Materials

Earth materials to be embanked for the main dam and coffer dams is estimated at about 1,400,000 m^3 in total consisting of core, shell, filter and rip-rap materials.

Item	Main dam	Coffer dam	Total
Core Shell)	1,140,000	40,000	1,180,000
Filter	80,000	-	80,000
Rip-Rap	140,000		140,000
Total	1,360,000	40,000	1,400,000

The results of boring survey and field reconnaissance show that abundance of major construction materials, such as core & shell are found in the vicinity of the dam site, and no problem is expected in securement of the materials. In this plan, the borrow area is located at left and right bank abutments of the proposed dam site.

A volume of earth from the excavation of the dam foundation and spillway will be used for embankment materials after temporary storage during excavation.

Item	Total excavation volume	Coefficient of efficiency	Volume to be embanked
Dam foundation	400,000	0.6	240,000
Spillway	25,000	0.8	20,000
Total	425,000		260,000

For the filter material (drain material), sand obtained from the upper layer of the borrow area is expected to be used. Prior to securing the earth for core and shell, this will be temporarily stored in the shed and then embanked in compliance with the work schedule.

Rip-rap materials which is estimated at about 140,000 m^3 in total, is to be purchased from the local source.

Concrete Materials

The total amount required of concrete for spillway, intake, etc., is estimated at about 12,000 m^3. Coarse aggregate and fine aggregate are to be purchased from the local source.

Item	Q'ty (m^3)	
Diversion	2,100	12,000 m^3
Spillway	8,500	
Intake & Outlet	800	
Miscellaneous (5%)	600	

For cement (3,000 tons) and reinforcement bars (700 tons), it is also possible to get these materials locally.

Construction Equipment

Construction equipment to be used in the construction work consist of motor scraper, (Capacity: 16 m^3 heaped) bulldozer (Capacity: 21 and 32 tons), wheel loader (Capacity: 3.3 m^3), Crawler loader (Capacity: 3.3 m^3), heavy dump truck (Capacity: 20 tons), etc. These construction equipment are imported by the contractor.

Metal

Gates and valves for outlet facilities are all imported.

Local Materials

Local materials will be utilized to the maximum extent. The major items are cement, steel bars, wooden materials, bricks, stone products, oil product, etc.

2.3.3 Construction Facilities

Such facilities as office, living quarters, storage house, motor pool, repair shop, form assembly, reinforcement fabrication, concrete batching, water supply, power supply, rip-rap materials, temporary shed for aggregate and rip-rap materials, etc., and construction road are required for the smooth execution of the construction work.

The part of the office will remain after completion of construction of the dam and will become parmanently a part of the administration office building.

2.3.4 Relocation Road

Upon completion of the dam construction, the existing road will be submerged in the reservoir. The relocation road, about 3.7 km in length, is constructed along the right bank of the reservoir.

2.3.5 Construction Schedule

The construction works of this dam involve preparatory works, construction works of river diversion, main coffer dam, main dam, spillway, intake and outlet structures.

All works are scheduled to be completed in about two years starting in May 1984 and ending in May 1986.

The construction works are to be executed on contract bases and to be performed by 2 shift (1 shift of 8 hours, actual work hours 7).

The construction time schedule is shown in Fig. 2-22 and the main works in each year are described as follows:

First year (1983)

Land acquisition work will be started in this year.

Second year (1984)

Major preparatory works such as the construction of camps and shops, construction facilities and construction road, etc., are to be executed. These works shall be completed by the end of this year.

Diversion conduit with the appurtenant open channels are constructed.

Third year (1985)

The main works of this year are excavation, embankment and spillway construction.

The excavation work which is started at the end of the previous year shall be ended in April.

The embankment work is scheduled to be commenced in March and ending in February of the next year. Approximately 80% of the total volume shall be embanked this year.

As for the spillway, excavation and concrete works shall be completed within this year.

The intake tower and outlet valve house works are also executed.

Fourth year (1986)

The remaining embankment shall be completed by February.

Metal works of intake tower and outlet valve shall be executed mainly this year.

All works including miscellaneous works are to be ended by the end of May this year.

2.4 COST ESTIMATE

2.4.1 Construction Cost

The construction cost to be financed for Ban Bung Dam is estimated at US$23,590,000 equivalent consisting of US$12,470,000 equivalent of foreign currency portion and US$11,120,000 equivalent of local currency portion, respectively.

The breakdown of the cost estimate by each work item and the annual disbursement schedule are shown in Tables 2-1 to 2-4.

The cost estimate is based on the following considerations.

1) Exchange rate US$1.00 = ¥230 = ฿23

2) The unit cost for each item is estimated in the price level of the beginning of 1981.

3) The costs equivalent to CIF prices of construction equipment, metal, steel bar, fuel and oil, and cement are included in the foreign currency portion. Duty and imposts and misc., local expenses are included in the local currency portion.

   As for cement, steel bar and fuel and oil, these are included in the foreign currency portion in spite of the possibility of securement in the local market, considering that their raw materials must be imported.

4) Contingencies consist of price and physical contingencies. Price escalation ratio of 7% and 12% are adopted for foreign and local currency portions respectively. Physical contingency of 15% is adopted.

Table 1-1 Cost Comparison of Compensation

Unit: Million US$

Item	Proposed	Alt. 1	Alt. 2
1. Compensation for Resettlement	3.9	-	-
2. Land Acquisition			320ha x 700$ = 0.2
3. Earth Work Embankment (incl. Excavation and Transportation)	-	10,000,000 m^3 x 2.5$ = 25.0	1,000,000 m^3 x 2.5$ = 2.5
4. Drainage Channel	-	5,000 m x 500$ = 2.5	2.5
5. House	-	200 houses x 10,000$ = 2.0	2.0
6. Road	-	10,000 m x 100$ = 1.0	1.0
7. Water Supply Electricity and Others		2.5	2.5
(Sub-Total)	3.9	33.0	10.7
o. Contingency 15%	0.6	5.0	1.6
TOTAL	4.5	38.0	12.3

Note: Costs for land acquisition and earth work required for Alternative 2 have been broadly estimated.

Table 1-2 Financial Cost (Nong Pla Lai Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Q'ty	Unit	Total MILLION US$		
			Total	F.C	L.C
1. Main Civil Works			24.62	14.07	10.55
1.1 Preparatory Works	1	L.S	1.61	0.81	0.80
1.2 Diversion Works	Con. 13,400	m^3	1.84	0.99	0.85
1.3 Main Coffer Dam	Emb. 690,000	m^3	3.54	1.87	1.67
1.4 Main Dam	Emb. 2,500,000	m^3	12.48	7.63	4.85
1.5 Spillway	Con. 31,000	m^3	4.92	2.66	2.26
1.6 Intake & Outlet	Con. 1,000	m^3	0.23	0.11	0.12
2. Equipment & Materials	1	L.S	0.93	0.70	0.23
3. Road Relocation	17.3	km	2.08	1.30	0.78
(Sub-Total 1 - 3)			(27.63)	(16.07)	(11.56)
4. Land Acquisition & Compensation	3,100 200	ha houses	9.37	-	9.37
5. Engineering Service	1	L.S	3.15	3.02	0.13
6. Contingencies					
6.1 Physical Cont. (15%)	1	L.S	6.04	2.87	3.17
6.2 Price Cont.	1	L.S	19.22	6.75	12.47
Total			65.41	28.71	36.70
7. Interest during Construction (3%)	1	L.S	1.14	1.14	-
GRAND TOTAL			66.55	29.85	36.70

Table 1-3 Disbursement Schedule of Financial Cost (Nong Pla Lai Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Total MILLION US$			Annual Disbursement							
				1983		1984		1985		1986	
	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1. Main Civil Works	24.62	14.07	10.55			1.60	1.34	8.39	6.28	4.08	2.93
2. Equipment & Materials	0.93	0.70	0.23							0.70	0.23
3. Road Relocation	2.08	1.30	0.78			0.65	0.39	0.65	0.39		
(Sub-Total 1 - 3)	(27.63)	(16.07)	(11.56)			(2.25)	(1.73)	(9.04)	(6.67)	(4.78)	(3.16)
4. Land Acquisition & Compensation	9.37	-	9.37	-	2.34	-	4.69	-	2.34		
5. Engineering Service	3.15	3.02	0.13	1.90	0.03	0.40	0.03	0.39	0.03	0.33	0.04
6. Contingencies											
6.1 Physical Cont. (15%)	6.04	2.87	3.17	0.29	0.36	0.40	0.97	1.41	1.36	0.77	0.48
6.2 Price Cont.	19.22	6.75	12.47	0.32	0.69	0.69	3.01	3.37	5.97	2.37	2.80
Total	65.41	28.71	36.70	2.51	3.42	3.74	10.43	14.21	16.37	8.25	6.48
7. Interest during Construction (3%)	1.14	1.14	-	0.03	-	0.09	-	0.35	-	0.67	-
GRAND TOTAL	66.55	29.85	36.70	2.54	3.42	3.83	10.43	14.56	16.37	8.92	6.48

Table 1-4 Economic Cost (Nong Pla Lai Dam)

1 US$ = 23 ฿ = ≒ 230

Item	Q'ty	Unit	Total Million US$		
			Total	F.C	L.C
1. Main Civil Works			20.95	14.07	6.88
1.1 Preparatory Works	1	L.S	1.38	0.81	0.57
1.2 Diversion Works	Con. 13,400	m^3	1.56	0.99	0.57
1.3 Main Coffer Dam	Emb. 690,000	m^3	3.02	1.87	1.15
1.4 Main Dam	Emb. 2,500,000	m^3	10.61	7.63	2.98
1.5 Spillway	Con. 31,000	m^3	4.18	2.66	1.52
1.6 Intake & Outlet	Con. 1,000	m^3	0.20	0.11	0.09
2. Equipment & Materials	1	L.S	0.74	0.70	0.04
3. Road Relocation	17.3	km	1.78	1.30	0.48
(Sub-Total 1 - 3)			(23.47)	(16.07)	(7.40)
4. Land Acquisition & Compensation	3,100 200	ha houses	4.31	-	4.31
5. Engineering Service	1	L.S	3.15	3.02	0.13
6. Contingencies					
6.1 Physical Cont. (15%)	1	L.S	4.65	2.87	1.78
TOTAL			35.58	21.96	13.62

Table 1-5 Disbursement Schedule of Economic Cost (Nong Pla Lai Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Total Million US$			Annual Disbursement							
				1983		1984		1985		1986	
	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1. Main Civil Works	20.95	14.07	6.88			1.60	0.97	8.39	4.08	4.08	1.83
2. Equipment & Materials	0.74	0.70	0.04							0.70	0.04
3. Road Relocation	1.78	1.30	0.48			0.65	0.24	0.65	0.24		
(Sub-Total 1 - 3)	(23.47)	(16.07)	(7.40)			(2.25)	(1.21)	(9.04)	(4.32)	(4.78)	(1.87)
4. Land Acquisition & Compensation		-	4.31	-	1.08	-	2.15	-	1.08		
5. Engineering Service	3.15	3.02	0.13	1.90	0.03	0.40	0.03	0.39	0.03	0.33	0.04
6. Contingencies											
6.1 Physical Cont. (15%)	4.65	2.87	1.78	0.29	0.17	0.40	0.51	1.41	0.81	0.77	0.29
TOTAL	35.58	21.96	13.62	2.19	1.28	3.05	3.90	10.84	6.24	5.88	2.20

Table 2-1 Financial Cost (Ban Bung Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Q'ty	Unit	Total Million US$		
			Total	F.C	L.C
1. Main Civil Works			9.96	5.31	4.65
1.1 Preparatory Works	1	L.S	1.05	0.48	0.57
1.2 Diversion Works	Con. 2,100	m^3	0.43	0.22	0.21
1.3 Main Dam	Emb. 1,360,000	m^3	7.20	3.93	3.27
1.4 Spillway	Con. 8,500	m^3	1.11	0.60	0.51
1.5 Intake & Outlet	Con. 800	m^3	0.17	0.08	0.09
2. Equipment & Materials	1	L.S	0.36	0.28	0.08
3. Road Relocation	3.7	km	0.50	0.30	0.20
(Sub-Total 1 - 3)			(10.82)	(5.89)	(4.93)
4. Land Acquisition & Compensation	40	houses	1.26	-	1.26
5. Engineering Service	1	L.S	2.39	2.25	0.14
6. Contingencies					
6.1 Physical Cont. (15%)	1	L.S	2.19	1.23	0.96
6.2 Price Cont.	1	L.S	6.45	2.62	3.83
Total			23.11	11.99	11.12
7. Interest during Construction (3%)	1	L.S	0.48	0.48	-
GRAND TOTAL			23.59	12.47	11.12

Table 2-2 Disbursement Schedule of Financial Cost (Ban Bung Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Total Million US$			Annual Disbursement							
				1983		1984		1985		1986	
	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1. Main Civil Works	9.96	5.31	4.65			0.89	0.83	3.36	2.89	1.06	0.93
2. Equipment & Materials	0.36	0.28	0.08					0.14	0.04	0.14	0.04
3. Road Relocation	0.50	0.30	0.20			0.15	0.10	0.15	0.10		
(Sub-Total 1 - 3)	(10.82)	(5.89)	(4.93)			(1.04)	(0.93)	(3.65)	(3.03)	(1.20)	(0.97)
4. Land Acquisition & Compensation		-	1.26	-	0.63	-	0.63				
5. Engineering Service	2.39	2.25	0.14	1.57	0.07	0.27	0.02	0.26	0.02	0.15	0.03
6. Contingencies											
6.1 Physical Cont. (15%)	2.19	1.23	0.96	0.24	0.11	0.20	0.24	0.59	0.46	0.20	0.15
6.2 Price Cont.	6.45	2.62	3.83	0.26	0.21	0.34	0.73	1.40	2.01	0.62	0.88
Total	23.11	11.99	11.12	2.07	1.02	1.85	2.55	5.90	5.52	2.17	2.03
7. Interest during Construction (3%)	0.48	0.48	-	0.02	-	0.07	-	0.18	-	0.21	-
GRAND TOTAL	23.59	12.47	11.12	2.09	1.02	1.92	2.55	6.08	5.52	2.38	2.03

Table 2-3 Economic Cost (Ban Bung Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Q'ty	Unit	Total Million US$		
			Total	F.C	L.C
1. Main Civil Works			8.45	5.31	3.14
1.1 Preparatory Works		1 L.S	0.89	0.48	0.41
1.2 Diversion Works	Con.	2,100 m^3	0.37	0.22	0.15
1.3 Main Dam	Emb.	1,370,000 m^3	6.10	3.93	2.17
1.4 Spillway	Con.	8,500 m^3	0.95	0.60	0.35
1.5 Intake & Outlet	Con.	800 m^3	0.14	0.08	0.06
2. Equipment & Materials			0.30	0.28	0.02
3. Road Relocation		3.7 km	0.42	0.30	0.12
(Sub-Total 1 - 3)			(9.17)	(5.89)	(3.28)
4. Land Acquisition & Compensation		40 houses	0.81	-	0.81
5. Engineering Service		1 L.S	2.39	2.25	0.14
6. Contingencies					
6.1 Physical Cont. (15%)		1 L.S	1.86	1.23	0.63
TOTAL			14.23	9.37	4.86

Table 2-4 Disbursement Schedule of Economic Cost (Ban Bung Dam)

1 US$ = 23 ฿ = ¥ 230

Item	Total Million US$			Annual Disbursement							
				1983		1984		1985		1986	
	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1. Main Civil Works	8.45	5.31	3.14			0.89	0.66	3.36	1.87	1.06	0.61
2. Equipment & Materials	0.30	0.28	0.02					0.14	0.01	0.14	0.01
3. Road Relocation	0.42	0.30	0.12			0.15	0.06	0.15	0.06		
(Sub-Total 1 - 3)	(9.17)	(5.89)	(3.28)			(1.04)	(0.72)	(3.65)	(1.94)	(1.20)	(0.62)
4. Land Acquisition & Compensation	0.81	-	0.81	-	0.41	-	0.40				
5. Engineering Service	2.39	2.25	0.14	1.57	0.07	0.27	0.02	0.26	0.02	0.15	0.03
6. Contingencies											
6.1 Physical Cont. (15%)	1.86	1.23	0.63	0.24	0.07	0.20	0.17	0.59	0.29	0.20	0.10
TOTAL	14.23	9.37	4.86	1.81	0.55	1.51	1.31	4.50	2.25	1.55	0.75

Fig. 1-1 Comparison of Dam Axis (Plan)

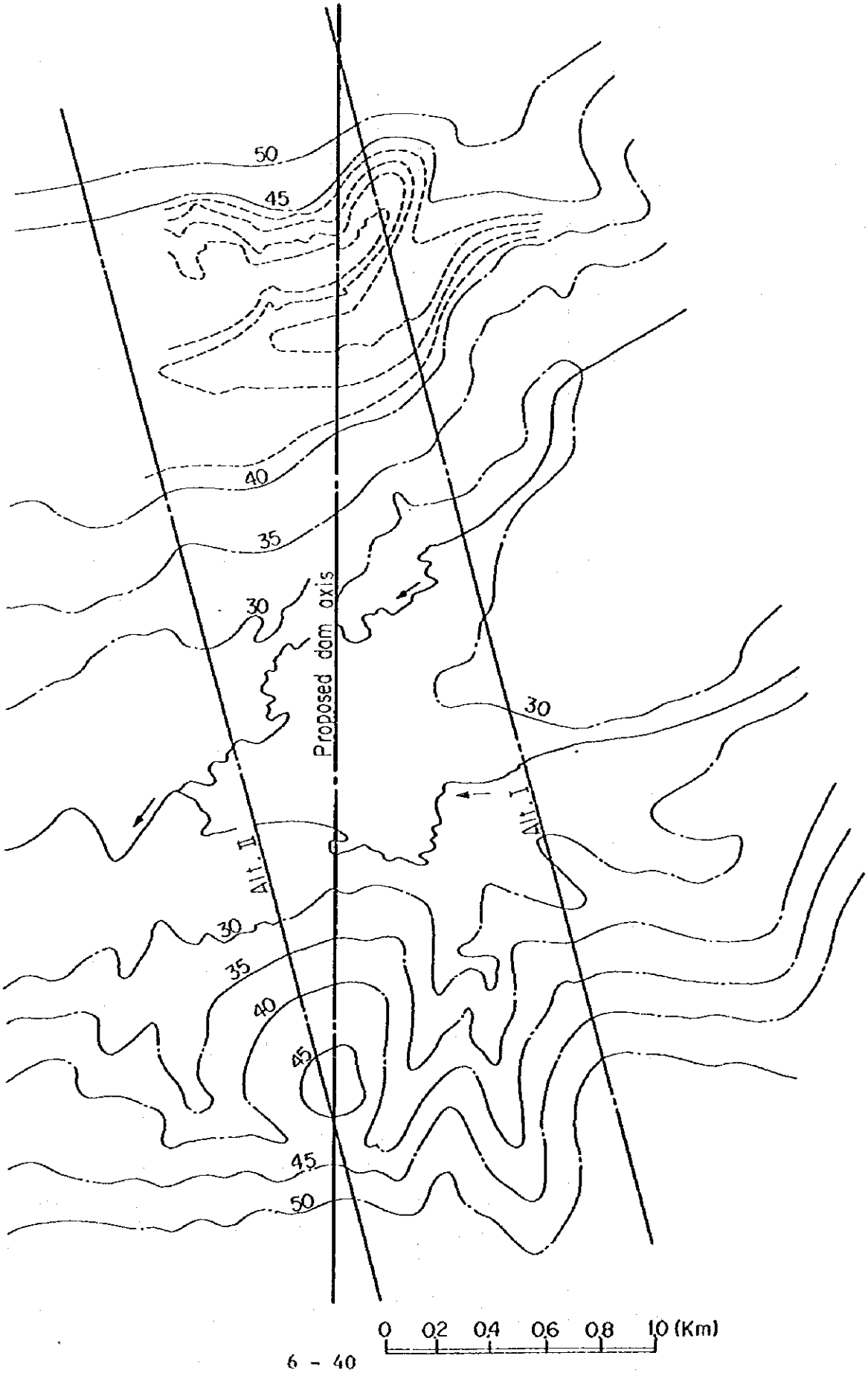


Fig. 1-2 Comparison of Dam Axis
(Reservoir Capacity Curve)

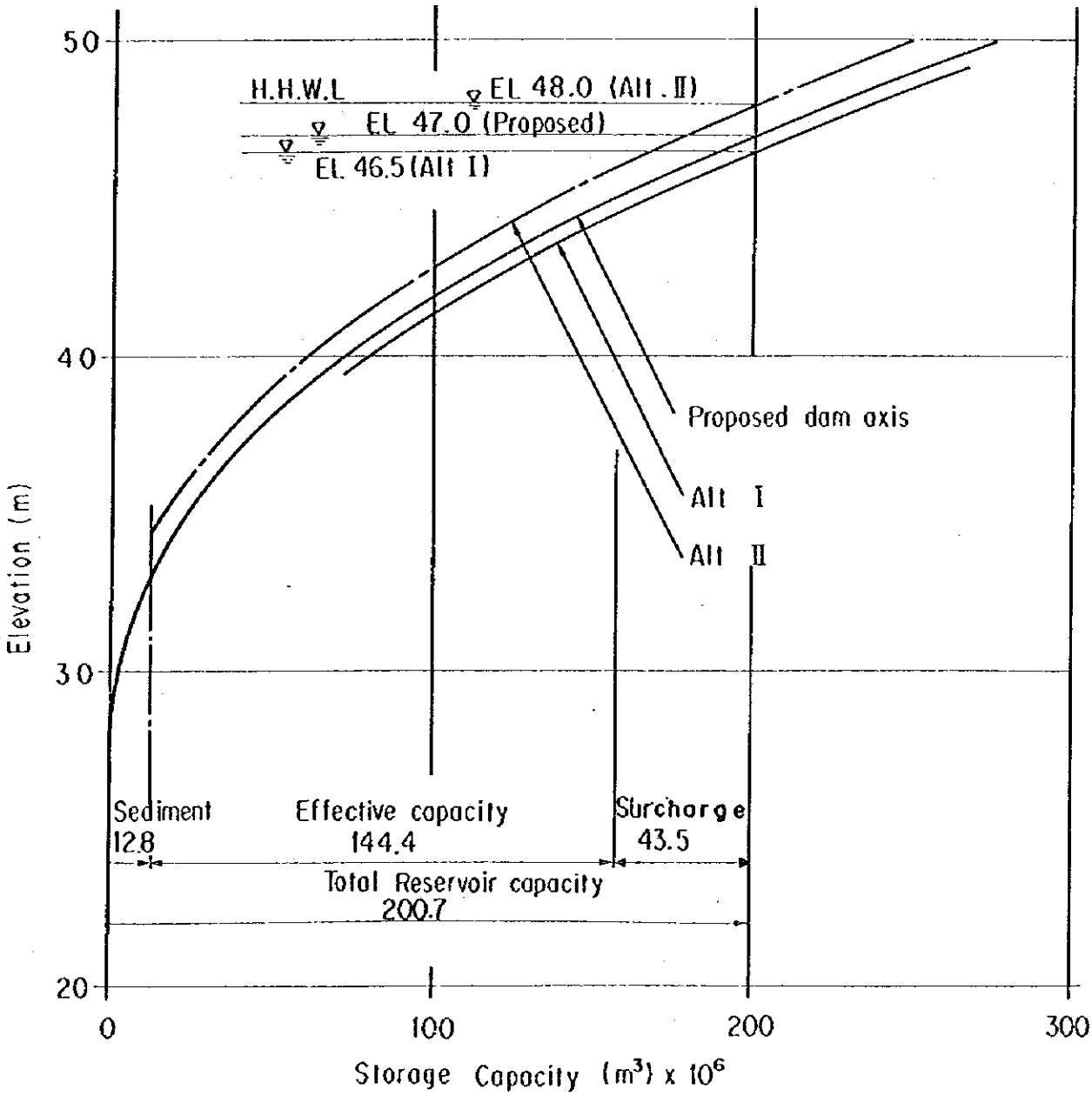


Fig. 1-3 Alternatives of the Alignment of Spillway and Diversion

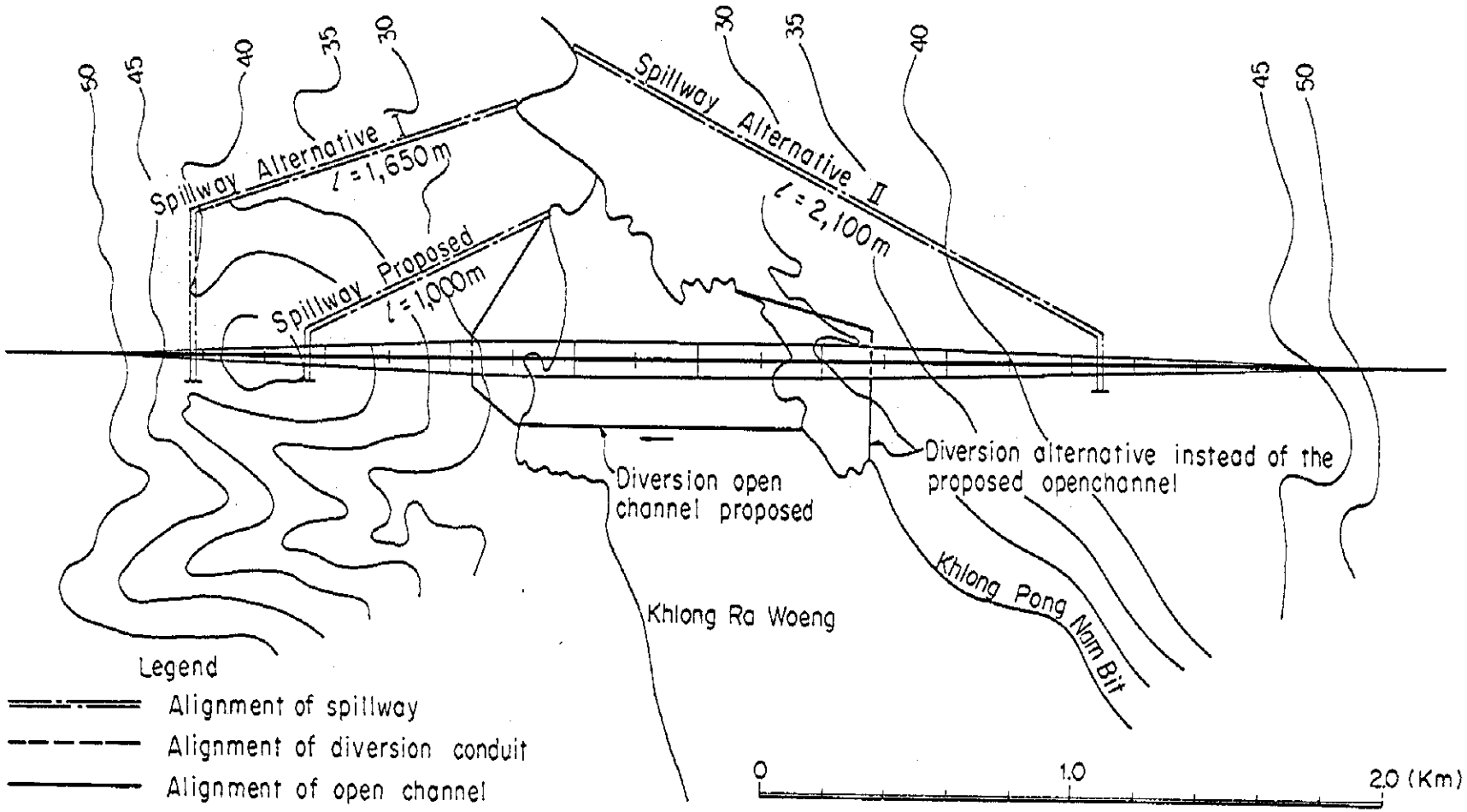
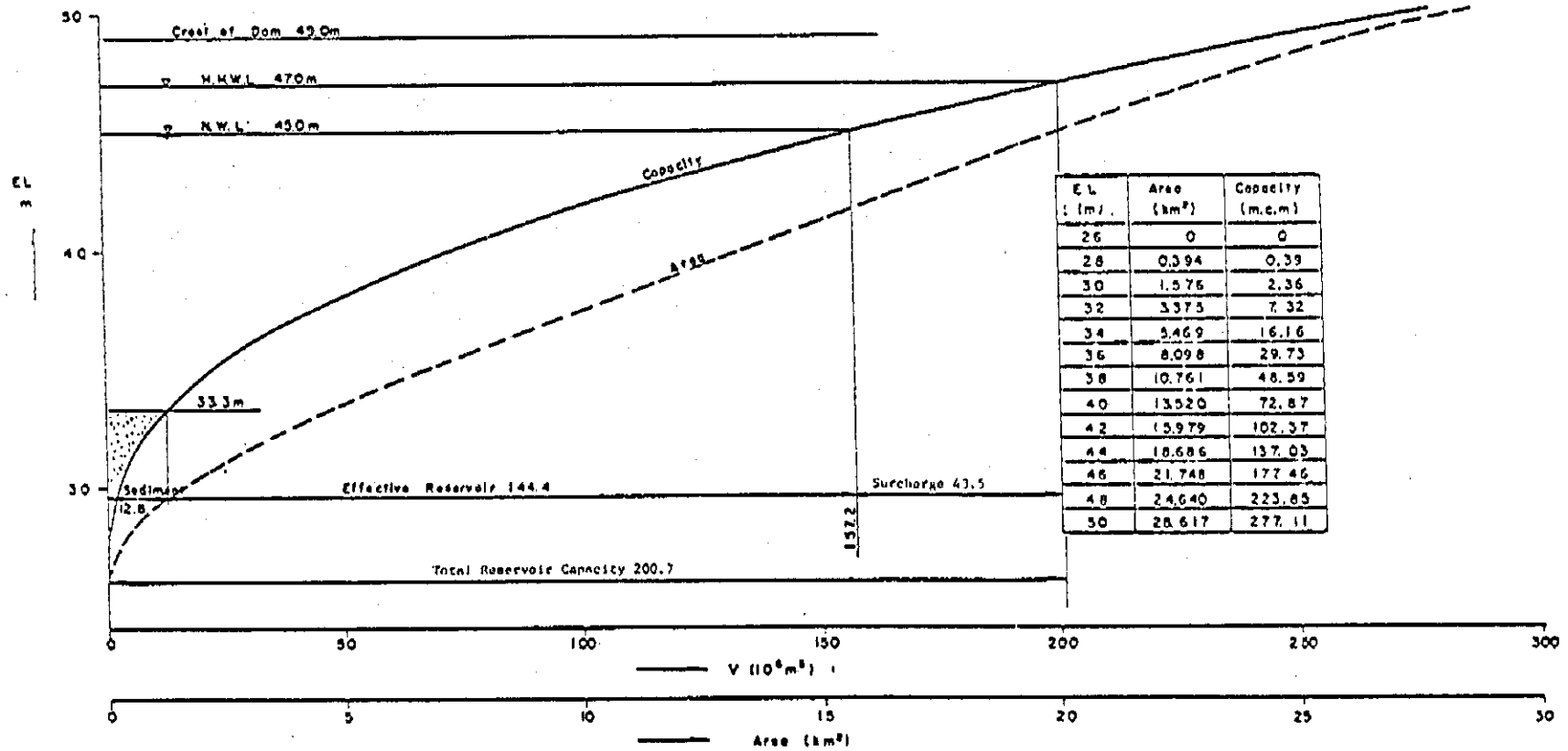


Fig.1-4 Reservoir Capacity and Area
(Nong Pla Lai Reservoir)



E.L. (m).	Area (km^2)	Capacity (m.c.m)
26	0	0
28	0.394	0.39
30	1.576	2.36
32	3.375	7.32
34	5.469	16.16
36	8.098	29.73
38	10.761	48.59
40	13.520	72.87
42	15.979	102.37
44	18.686	137.03
46	21.748	177.46
48	24.640	223.85
50	28.617	277.11

Fig. 1-5 Geological Map of Nong Pla Lai Dam Site and Reservoir (Scale 1:50000)

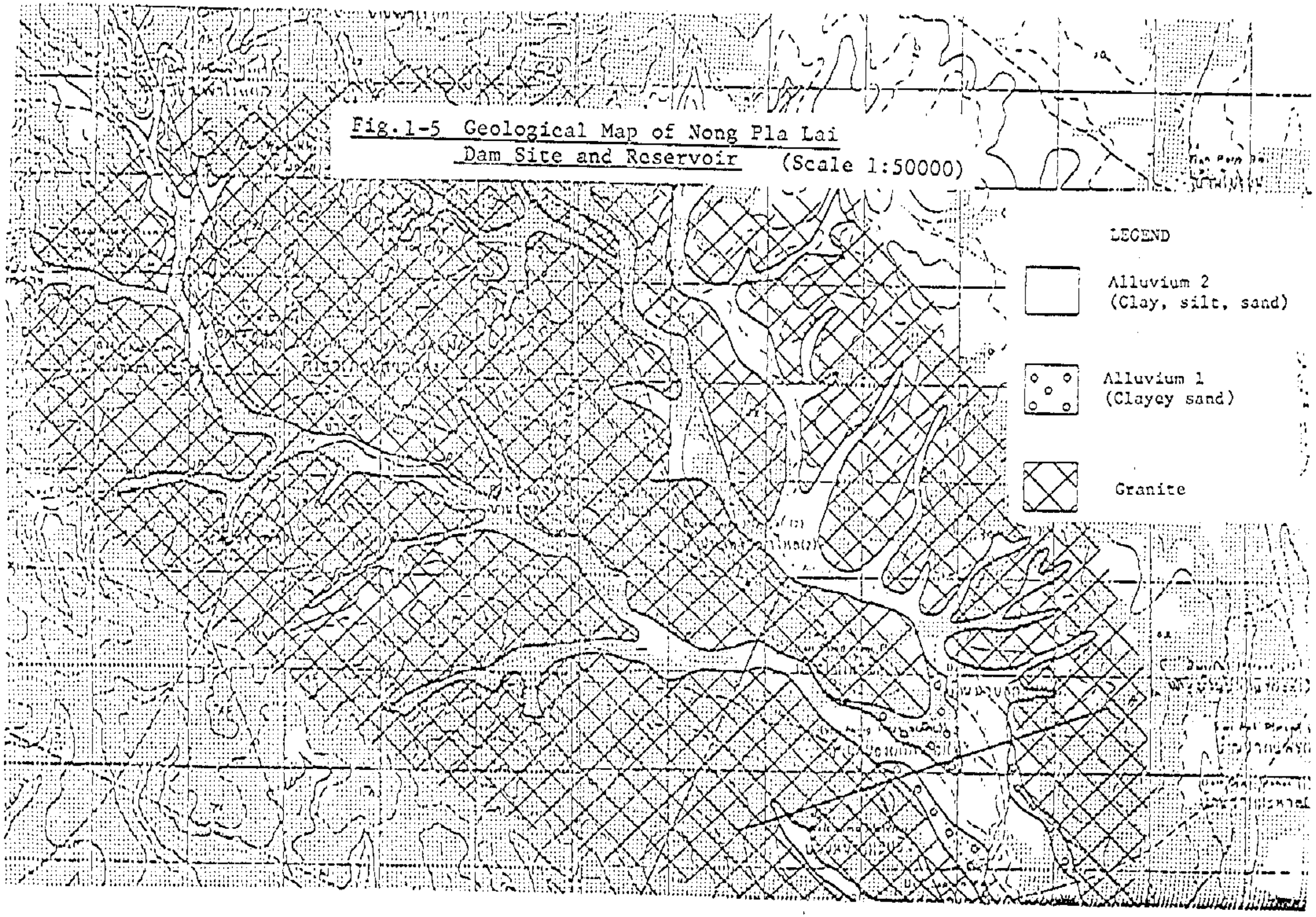


Fig. 1-6 Geological Cross Section of Nong Pla Lai Dam Site

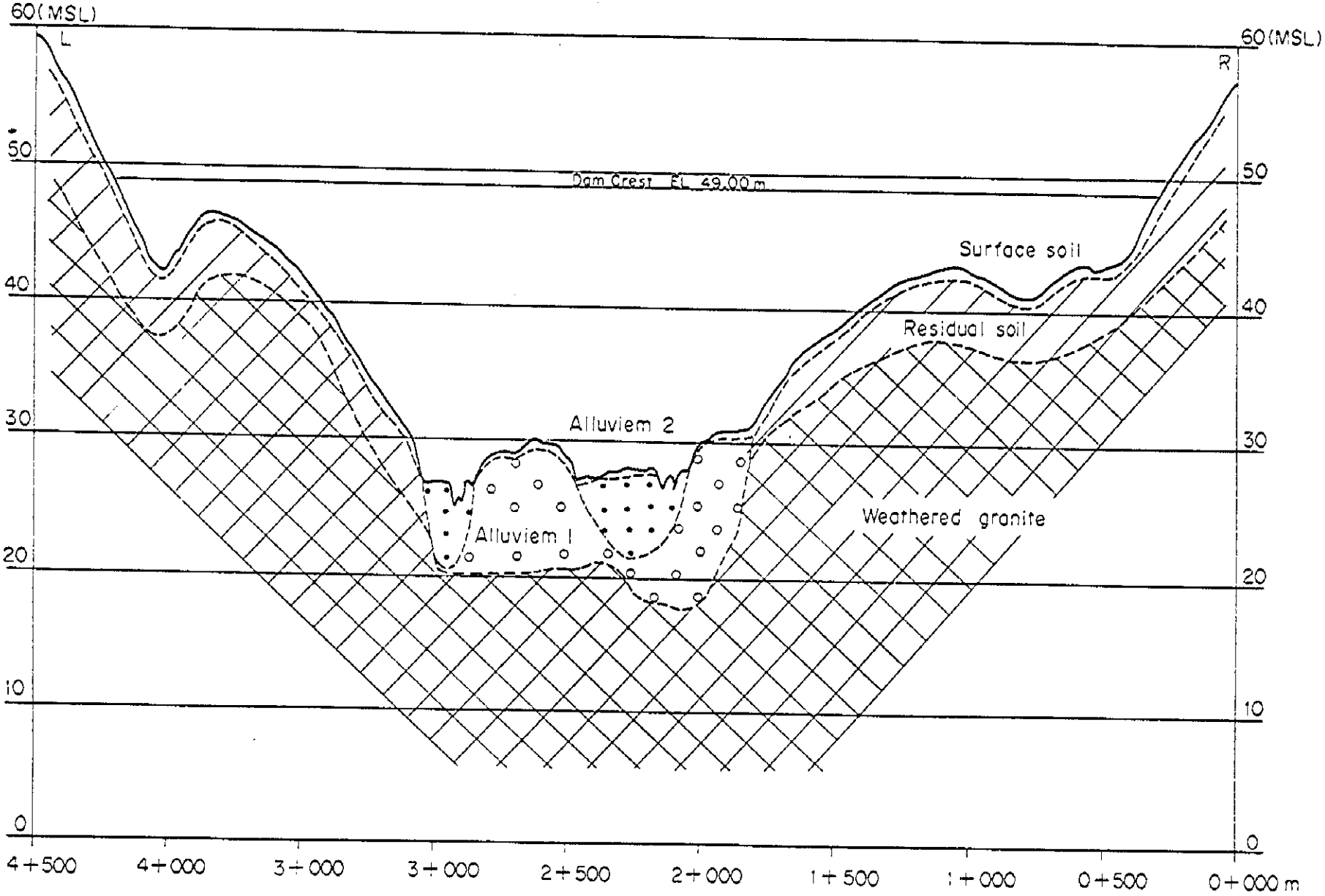


Fig. 1-7 Geological Map of Nong Pla Lai Dam Axis

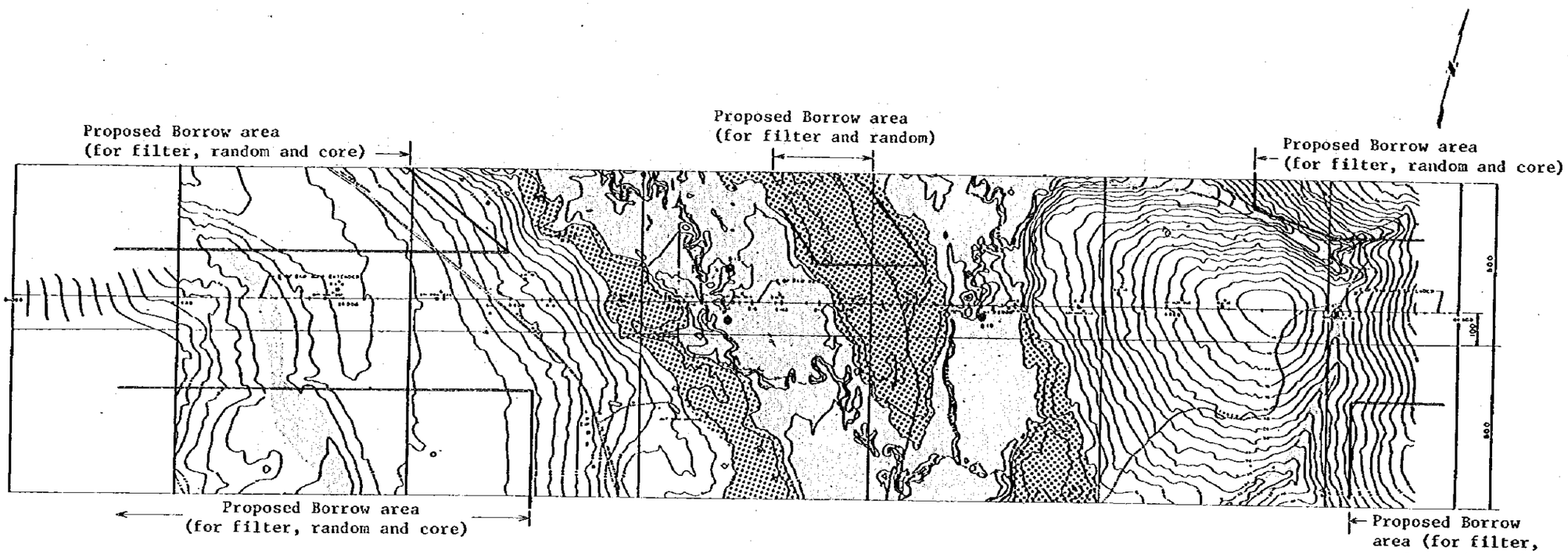


Fig. 1-8 Geological Profile along Nong Pla Lai Dam Axis

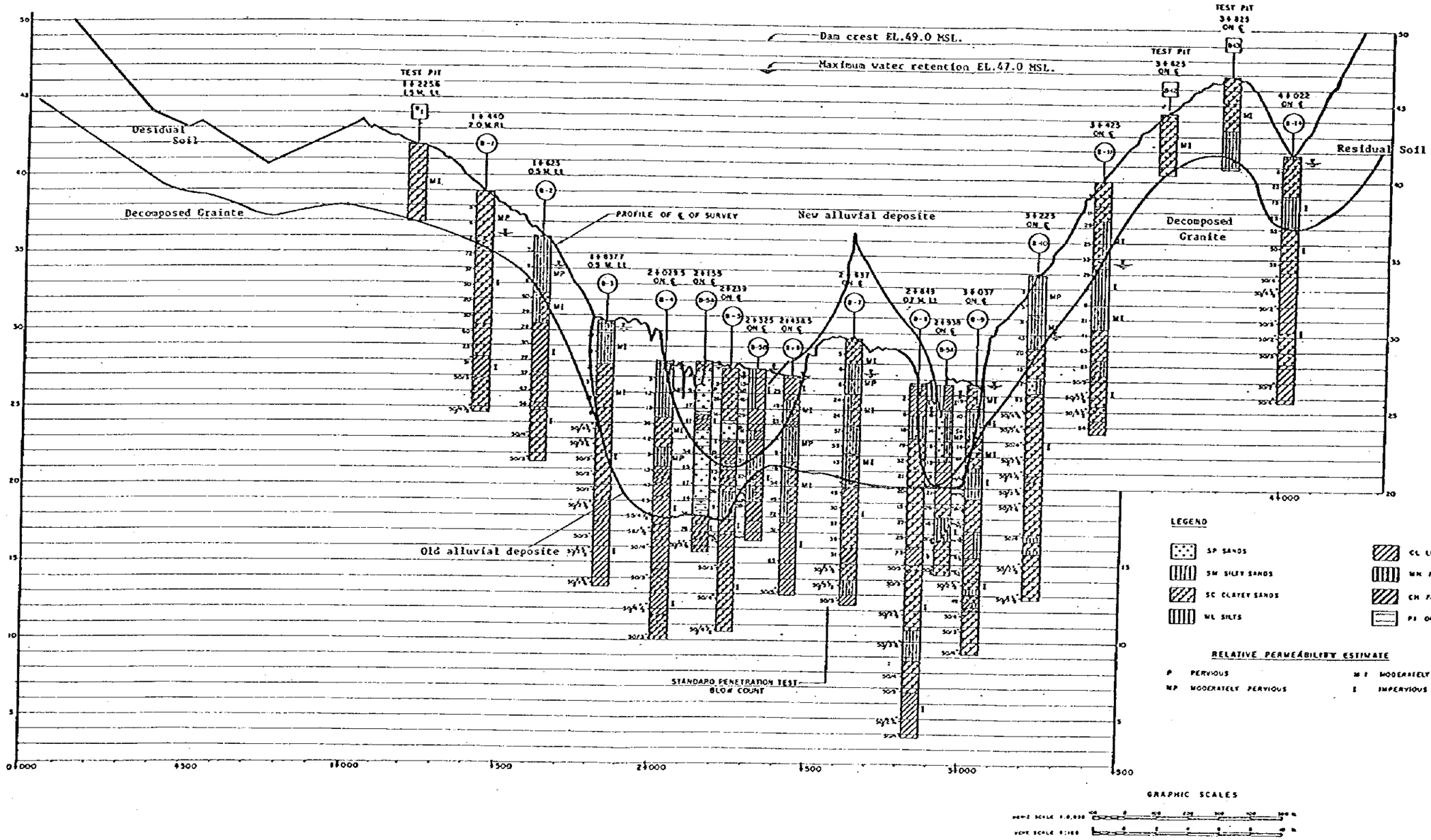


Fig. 1-9 Geologic Log of Drill Hole
Hole No. B.15 (1/2)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1—01
(I.W.B.2519)

Hole No. B.15

GEOLOGIC LOG OF DRILL HOLE Sheet 1 of 2

FEATURE RESERVIOR PROJECT NONG PLALAI PROV. RAYONG
HOLE NO. B.15 LOCATION UP-STREAM
COORDINATES GROUND ELEVATION ANGLE FROM VERTICAL 0°
BEGUN MAY 5, 81 FINISHED MAY 6, 81 DEPTH OF OVERBURDEN TOTAL DEPTH 15.00M BEARING OF ANGLE HOLE
DEPTH OR ELEV. OF WATER TABLE 0.27 m. HOLE LOGGED BY N.RUTH & T.WIT FOREMAN AMNUAY

NOTES On water table levels, water return, change of drilling etc.	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: Depth (M.) From (P, Cs or Cm)	To	Flow in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG: Sample for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
Overburden was drilled by soil sampling equipment and wash boring method. Dropped Bx-casing at depth 0.00 - 3.00 m., 3.00-4.50 m, 4.50-6.00 m, 6.00-7.50 m, 7.50-9.00 m. Permeability test by gravity Standard penetration resistance test :- -dropped weight 140lbs. -free fall 30" -N=number of blow At depth 11.30-15.00 m. during drilling there were flood :water over top of casing pipe,soil samples were			0.00	1.30	.65	G	10		1	N=3	0.00-2.30 m. ML (Silt) Soft to medium, about 90% slightly plasticity fines, 10% fine sand, brown,moist.	6.96×10^{-5}
			0.00	2.30	.53	G	10		2	N=6		2.11×10^{-5}
			BxCS 3.00	3.30	.03	G	10		3	N=8	2.30-3.30 m.SP-SM (Poorly graded sand) Loose,about 90% fine to coarse sand,and some fine gravel,10% non plasticity fines, brown,wet.	1.64×10^{-6}
			3.00	4.30	.08	G	10		4	N=6		1.52×10^{-6}
			BxCS 4.50	6.30	.42	G	10		5	N=5	3.30-5.30 m.ML(Silt) Medium, about 85% slightly plasticity fines,15% fine sand,brown, moist.	8.33×10^{-6}
			BxCS 4.50	6.30	.55	G	10		6	N=9		5.62×10^{-6}
			4.50	6.30	.3	G	10					3.06×10^{-6}
			6.00	7.30	.3	G	10		7	N=7	5.30-7.30 m. SM (Silty sand) Loose,about 60% fine sand, 40% slightly plasticity fines, brown, moist.	3.14×10^{-6}
			6.00 BxCS	7.30	.22	G	10					2.30×10^{-6}
									8			
									9		7.30-9.00 m.SP-SM (Poorly graded sand) Medium,about 90% fine to coarse	
									10			

EXPLANATION
Type of hole ..... D = Diamond, H = Hayward, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (Metric) — Em = 1", Am = 1 7/8", Bm = 2 3/8", Nm = 3"
Approximate size of core (Metric) — Em = 7/8", Am = 1 1/8", Bm = 1 5/8", Nm = 2 1/8"
Outside diameter of casing (Metric) — Em = 1 13/16", Am = 2", Bm = 2 7/8", Nm = 3 1/2"
Inside diameter of casing (Metric) — Em = 1", Am = 1 29/32", Bm = 2 3/8", Nm = 3"

Core Loss
Core Recovery

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

Fig. 1-9 Geologic Log of Drill Hole
Hole No. B.15 (2/2)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1-01
(I.W.S.2519)

Hole No. B.15

GEOLOGIC LOG OF DRILL HOLE Sheet 2 of 2

FEATURE RESERVIOR PROJECT NONG PLALAI CHV. RAYONG
HOLE NO. B.15 LOCATION UP-STREAM
COORDINATES GROUND ELEVATION ANGLE FROM VERTICAL 0°
BEGUN MAY. 5,81 FINISHED MAY. 6,81 DEPTH OF OVERBURDEN TOTAL DEPTH 15 DOMBEARING OF ANGLE HOLE
DEPTH OF ELEV. OF WATER TABLE 0.17 m. HOLE LOGGED BY NIRUTH & TWIT FOREMAN AMNUAY

NOTES On water table levels, water returns, character of drilling etc	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: Depth (M.) From (R.L. or Cm) To; Loss in (LPM); Pressure (PSI); Length of Test (min.)	ELEVATION	DEPTH	LOG (Samples for testing)	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
collected by diamond core bit with double tube core barrel.					11 12 13 14 15		sand, predominantly fine sand, 10% non plasticity fines, brown, wet. 9.00-11.30 m. ML (Silt) Very stiff to hard, about 90% slightly plasticity fines 10% fine sand, greenish gray, moist. 11.30-13.50 m. SM (Silty sand) About 60% fine to coarse sand, predominantly fine sand, 40% low plasticity fines, greenish gray, moist. 13.50-15.00 m. CL (lean clay) About 90% medium plasticity fines, 10% fine sand, green, moist. *11.30-15.00 m. Decomposed Granite	NOTE: Calculted by the JICA Survey team

EXPLANATION

Core Loss / Core Recovery

Type of hole ..... D = Diamond, H = Hammer, S = Shell, C = Chum
Hole sealed ..... P = Packer, Co = Cemented, Ca = Bottom of casing
Approximate size of hole (Metric) — Ex = 15", Ax = 1 1/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (Metric) — Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (Imperial) — Ex = 1 13/16", Ax = 2", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (Imperial) — Ex = 1", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

Angle hole ☐
Vertical hole ☑

Fig. 1-10 Geologic Log of Drill Hole
Hole No. B.16 (1/2)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1—01
(A.D.2519)

Hole No. B.16

GEOLOGIC LOG OF DRILL HOLE Sheet 1 of 2

FEATURE RESERVOIR PROJECT NONG PLALAI CHV. RAYONG
HOLE NO. B.16 LOCATION DOWN-STREAM
COORDINATES GROUND ELEVATION ANGLE FROM VERTICAL 0°
BEGUN MAY 3, 81 FINISHED MAY 4, 81 DEPTH OF OVERBURDEN TOTAL DEPTH 15.80 M. BEARING OF ANGLE HOLE
DEPTH OR ELEV. OF WATER TABLE 0.59 M. HOLE LOGGED BY NIRUTH & TWIT FOREMAN AMNUAY

NOTES On core table levels, water return, character of drilling etc.	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: DEPTH (M.) From (P, Cs or Cm)	To	Loss in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG: Samples for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
Overburden was drilled by soil sampling equipment and wash boring method. Dropped Bx-casing at depth 0.00 - 1.50 m, 1.50-4.50 m, 4.50-6.00 m, 6.00-7.50 m, 7.50-9.00 m, 9.00-12.00 m. Permeability test by gravity; Standard penetration resistance t test :- -dropped weight 140 lbs. -free fall 30" -N=number of blow			0.00	1.30	-	G	10		1		0.00-1.30 m. ML (Silt) Stiff, about 80% slightly plasticity fines, 20% fine sand, brown, moist.	
			1.60	2.30	-	G	10		2		1.30-2.30 m. SP-SM (Poorly graded sand) Medium, about 95% fine sand, 5% non plasticity fines, light brown, moist.	1.18×10^{-4}
			1.60	3.30	.05	G	10		3		2.30-7.00 m. SP (Poorly graded sand) Medium, about 100% fine to coarse sand, predominantly medium sand, brown, wet.	2.27×10^{-4}
			4.00	4.30	.22	G	10		4			4.58×10^{-5}
			4.50	5.30	.15	G	10		5			2.6×10^{-5}
			6.00	6.30	.05	G	10		6			9.75×10^{-6}
			6.00	6.30	.02	G	10				7.00-8.00 m. ML (Silt) Stiff, about 100% slightly plasticity fines, brown, moist to wet.	2.23×10^{-5}
			6.00	7.30	.1	G	10		7			1.57×10^{-5}
			6.00	7.30	.07	G	10					
			7.50	8.30	.03	G	10		8			9.16×10^{-6}
			7.50	8.30	.03	G	10					9.16×10^{-6}
			7.50	9.30	.35	G	10		9		8.00-9.00 m. SP (Poorly graded sand) Medium, about 100% fine sand, brown wet.	6.06×10^{-5}
			7.50	9.30	.32	G	10					5.51×10^{-5}
									10			

Core Loss
Core Recovery

EXPLANATION
Type of hole ..... D = Diamond, H = Hopkinson, S = Shot, C = Churn
Hole coated ..... P = Packer, Cm = Cemented, Cs = Section of casing
Approximate size of hole (Metric) — Em = 1½", Am = 3 7/8", Bm = 2 3/8", Nm = 3"
Approximate size of core (Metric) — Em = 7/8", Am = 1 1/8", Bm = 1 3/8", Nm = 2 1/8"
Outside diameter of casing (Metric) — Ex = 1 13/16", Ax = 2½", Bx = 2 7/8", Nx = 3 1/8"
Inside diameter of casing (Metric) — Ex = 1½", Ax = 1 20/32", Bx = 2 3/8", Nx = 3"

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

Fig. 1-10 Geologic Log of Drill Hole
Hole No. B.16 (2/2)

Division of Soil and Geology
Royal Irrigation Department

U. S. 1-01
(I.N.D.2519)

Hole No. B.16

GEOLOGIC LOG OF DRILL HOLE Sheet 2 of 2

FEATURE RESERVOIR PROJECT NONG PLALAI DIV. RAYONG
HOLE NO. B.16 LOCATION DOWN-STREAM
COORDINATES GROUND ELEVATION ANGLE FROM VERTICAL
BEGUN MAY 3, 81 FINISHED MAY 4, 81 DEPTH OF OVERBURDEN TOTAL DEPTH 15.80 M. BEARING OF ANGLE HOLE
DEPTH OR ELEV. OF WATER TABLE 9.55 M. HOLE LOGGED BY N.RUTH & T.WIT FOREMAN AMNUAY

NOTES On water table levels, water return, character of drilling etc.	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: DEPTH (M.) From (F.Cs. or Cw)	To	Loss in (L/PM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG (Samples for testing)	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
			7.50	10.30	1.2	6	10			TN1 TN2	9.00-10.30 m. SM (Silty sand) Medium to dense, about 80% fine to coarse sand, predominantly coarse sand, and some fine gravel, 20% slightly plasticity fines, greenish brown, moist.	1.49×10^{-4}
			7.50	10.30	.95	6	10					1.18×10^{-4}
			9.00	11.30	.05	6	10					7.18×10^{-6}
			9.00	11.30	.03	6	10					4.33×10^{-6}
			9.00	13.00	.15	6	10					1.42×10^{-5}
			12.00	13.30	.15	6	10				10.30-11.60 m. ML (Sandy silt) Hard, about 70% low plasticity fines, 30% fine sand green, moist.	3.23×10^{-5}
			12.00	14.30	.22	6	10					3.20×10^{-5}
			12.00	15.80	.23	6	10				11.60-15.80 m. SM (Silty sand) Very dense, about 70% fine to coarse sand, and some fine gravel, 30% slightly plasticity fines, greenish brown, moist.	2.25×10^{-5}
											*11.60-15.80 m. Decomposed Granite	

EXPLANATION

Core Loss
Core Recovery

Type of hole ---------- D = Diamond, H = Hayatellite, S = Shot, C = Chum
Hole sealed ---------- P = Packer, Ce = Cemented, Ct = Bottom of casing
Approximate size of hole (Metric) -- Ex = 1½", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (Metric) -- Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (Metric) -- Ex = 1 13/16", Ax = 2½", Bx = 2 7/8", Nx = 3 1/8"
Inside diameter of casing (Metric) -- Ex = 1½", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

Fig. 1-11 Geologic Log of Drill Hole
Hole No. B.17 (1/2)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1—01
(I.R.O.2519)

Hole No. B.17

GEOLOGIC LOG OF DRILL HOLE Sheet 1 of 2

FEATURE RESERVOIR PROJECT NONG PLALAI ENV. RAYONG
HOLE NO. B.17 LOCATION UP-STREAM GROUND ELEVATION ANGLE FROM VERTICAL 0°
COORDINATES TOTAL
BEGUN MAY 9, 81 FINISHED MAY 10, 81 DEPTH OF OVERBURDEN DEPTH 12.15M. BEARING OF ANGLE HOLE
DEPTH OF ELEV. OF WATER TABLE 2.47 m HOLE LOGGED BY NIRUTH & TWIT FOREMAN AMNUAY

NOTES Ground water table levels, water returns, character of drilling etc.	Type and size of hole	Core recovery (%)	PERCOLATION TESTS Depth (M.) From (P, Cs or Cm)	To	Loss in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG Samples for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
Overburden was drilled by soil sampling equipment and wash boring methoed. Dropped Bx-casing at depth 0.00-3.00 m, 3.00-4.50 m, 4.50-6.00 m, 6.00-7.50 m, 7.50-9.00 m. Permeability test by gravity. Standard penetration resistance test :- -dropped weight 140 lbs. -free fall 30" -N=number of blow.			0.00	1.30	1.9	G	10		1	N=4	0.00-2.00 m. ML (Sandy,silt) Soft,about 60% slightly fines, 40% fine sand, brown,wet.	4.16×10^{-4}
			0.00	2.30	2.5	G	10		2	N=2	2.00-5.00 m. SP-SM (Poorly graded sand) Loose,about 90% fine to cearse sand,predominantly fine sand 10% non plasticity fines, gray, wet.	3.61×10^{-4}
			BXCS						3	N=5		8.39×10^{-4}
			3.00	3.30	1.55	G	10					
		1st TEST	4.00	4.30	.16	G	10		4	N=5		8.78×10^{-5}
		2nd TEST	4.00	4.30	.17	G	10					9.1×10^{-5}
			BXCS									
			4.50	5.30	.18	G	10		5	N=5	5.00-6.00 m. SM (Silty sand) Loose,about 65% fine to cearse sand, 35% low plasticity fines, brown, moist.	5.49×10^{-5}
			4.50	5.30	.15	G	10					4.58×10^{-5}
			BXCS						6	N=20		5.49×10^{-5}
			4.50	6.30	.18	G	10					5.49×10^{-5}
			4.50	6.30	.18	G	10					
			6.00	7.30	.12	G	10		7	N=20	6.00-8.00 m. SP (Poorly grnded sand) Very loose to medium,about 100% fine sand, brown, wet.	2.62×10^{-5}
			6.00	7.30	.1	G	10					2.23×10^{-5}
			BXCS									
			7.50	8.22	.6	G	10		8	N=50/5		1.96×10^{-4}
			7.50	8.22	.6	G	10					1.96×10^{-4}
			BXCS								8.00-8.22 m. GP-GM (Poorly graded gravel) Very dense,about 50%subangular fine gravel,40% sub-	
			7.50	9.30	.85	G	10		9	N=50/3		1.48×10^{-4}
			7.50	9.30	.6	G	10					1.48×10^{-4}
									10			

EXPLANATION
Core Loss
Core Recovery
Type of hole ..... D = Diamond, R = Rotary/Auger, S = Shot, C = Chum
Hole sealed ..... P = Packer, Co = Cemented, Ce = Bottom of casing
Approximate size of hole (Metric) — Ex = 1½", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (Metric) — Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (Metric) — Ex = 1 13/16", Ax = 2", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (Metric) — Ex = 1½", Ax = 1 25/32", Bx = 2 3/8", Nx = 3"
Angle Hole ☐
Vertical Hole ☑

NOTE:Calculted by the JICA Survey team

Fig. 1-11 Geologic Log of Drill Hole
Hole No. B.17 (2/2)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1-01
(I.N.U.2519)

Hole No. B.17

GEOLOGIC LOG OF DRILL HOLE Sheet 2 of 2

FEATURE RESERVOIR PROJECT NONG PLALAI CHW. RAYONG
HOLE NO. B.17 LOCATION UP-STREAM
COORDINATES GROUND ELEVATION ANGLE FROM VERTICAL 0°
BEGUN MAY. 9, 81 FINISHED MAY. 10, 81 DEPTH OF OVERBURDEN TOTAL DEPTH 15.15 M BEARING OF ANGLE HOLE
DEPTH OR ELEV. OF WATER TABLE 2.57 M. HOLE LOGGED BY NIRUTH & TWIT FOREMAN AMNUAY

NOTES On water table levels, water return, character of drilling etc.	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: DEPTH (M.) From (P, Cs, or Cm)	To	Loss in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG: Samples for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
			9.00	10.20	.4	6	10				rounded fine to coaree sand, 10% non plasticity fines, brown, wet.	9.30×10^{-5}
			9.00	11.70	.4	6	10				8.22-10.00 m. CL (Lean clay) Hard, about 90% medium plasticity figes, 10% fine to cearse sand, greenish brown, moist.	5.14×10^{-5}
			9.00	12.25	.52	6	10					5.80×10^{-5}
			9.00	13.80	.54	6	10					4.92×10^{-5}
			9.00	14.10	.65	6	10				10.00-10.20 m. CL (Sandy clay) Hard, about 70% medium plasticity fines 30% angular fine sand, greenish gray, moist.	5.06×10^{-5}
			9.00	15.15	1.15	6	10				10.20-15.15 m. SM (Silty sand) Very dense, about 70% fine to cearse sand 30% slightly fines, gray, moist.	7.76×10^{-5}
											*14.80-15.15 m. Decamposed Granite	

Core Loss
Core Recovery

EXPLANATION
Type of hole ..... D = Diamond, H = Hydrolitic, S = Shot, C = Chop
Hole cased ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (Metric) -- Em = 15", Am = 17 7/8", Bm = 2 3/8", Nm = 3"
Approximate size of core (Metric) -- Em = 7/8", Am = 1 1/8", Bm = 1 3/8", Nm = 2 1/8"
Outside diameter of casing (Metric) -- Em = 1 13/16", Am = 2 1/2", Bm = 2 7/8", Nm = 3 1/2"
Inside diameter of casing (Metric) -- Em = 1 1/2", Am = 1 29/32", Bm = 2 3/8", Nm = 3"

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

Fig. 1-12 Geologic Log of Drill Hole
Hole No. B.18 (1/3)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1—01
(B.E.2519)

Hole No. B.18

GEOLOGIC LOG OF DRILL HOLE Sheet 1 of 3

FEATURE RESERVIOR PROJECT NONG PLALAI CKY. BAYONG
HOLE NO. B.18 LOCATION DOWN-STREAM GROUND ELEVATION ANGLE FROM VERTICAL 0°
COORDINATES TOTAL
BEGUN MAY. 19, 81 FINISHED MAY. 28, 81 DEPTH OF OVERBURDEN DEPTH 15 B.S.M BEARING OF ANGLE HOLE
DEPTH OR ELEV. OF WATER TABLE -0.00 M. HOLE LOGGED BY NIRUTH & TWIT FOREMAN AMNUAY

NOTES On—new rods, levels, water return, character of drilling etc.	Type and size of hole	Core recovery (%)	PERCOLATION TESTS: Depth (M.) From (P, Ca or Cw)	To	Loss in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG: Samples for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
Overburden was drilled by soil sampling equipment and wash boring method. Dropped Bx-casing at depth 0.00-2.00 m, 2.00-3.00 m, 3.00-4.50 m, 4.50-6.00 m. Permeability test by gravity. Standard penetration resistance test :- -dropped weight 140 lbs. -free fall 30" -N=number of blow.	BXCS		0.00	1.30	1	G	10		1	N=2	0.00-3.00 m. SP (Poorly graded sand) Loose to mediu about 100% fine to coarse sand, predominantly coarse sand brown wet.	2.23×10^{-5}
	BXCS		2.00	2.30	.1	G	10		2	N=5		5.53×10^{-5}
	BXCS		3.00	3.30	.5	G	10		3	N=4	3.00-4.00 m. SM (Silty sand) Very loose, about 60% fine sand, and some fine gravel, 40% slightly plasticity fines, brown, wet.	2.70×10^{-4}
			3.00	4.30	.1	G	10		4	N=8		2.23×10^{-5}
	BXCS		3.00	4.30	.1	G	10					2.23×10^{-5}
			4.50	5.30	.12	G	10		5	N=11		3.66×10^{-5}
	BXCS		4.50	5.30	.12	G	10				4.00-4.30 m. SP (Poorly graded sand) Loose, about 100% fine to medium sand, brown, wet.	3.66×10^{-5}
			6.00	6.30	.05	G	10		6	N=9		1.63×10^{-5}
			6.00	6.30	.04	G	10					2.28×10^{-5}
			6.00	7.30	.06	G	10		7	N=9	4.30-6.00 m. SM (Silty sand) Loose, about 60% fine sand, 40% slightly plasticily fines brown, moist.	1.31×10^{-5}
			6.00	7.30	.04	G	10					9.18×10^{-6}
			6.00	8.30	.17	G	10		8	N=25		2.42×10^{-5}
			6.00	8.30	.17	G	10					2.42×10^{-5}
			6.00	9.30	.01	G	10		9	N=8	6.00-7.30 m. ML (silt) Stiff, about 80% low plasticity	6.71×10^{-5}
			6.00	9.30	.6	G	10					5.05×10^{-5}

Core Loss
Core Recovery

EXPLANATION
Type of hole ..... D = Diamond, H = Hammerbore, S = Shot, C = Chum
Hole sealed ..... P = Packer, Ce = Cemented, Cr = Bottom of casing
Approximate size of hole (Metric) — Exm = 1", Axm = 1 7/8", Bxm = 2 3/8", Nxm = 3"
Approximate size of core (Metric) — Exm = 7/8", Axm = 1 1/8", Bxm = 1 5/8", Nxm = 2 1/8"
Outside diameter of casing (Metric) — Ex = 1 13/16", Ax = 2", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (Metric) — Ex = 1", Ax = 1 25/32", Bx = 2 3/8", Nx = 3"

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

Fig. 1-12 Geologic Log of Drill Hole
Hole No. B.18 (2/3)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1--01
(I.W.B.2519)

Hole No. B.18

GEOLOGIC LOG OF DRILL HOLE Sheet 2 of 3

FEATURE RESERVOIR PROJECT NONG PLALAI CHW. RAYONG
HOLE NO. B.18 LOCATION DOWN - STREAM GROUND ELEVATION ANGLE FROM VERTICAL 0°
COORDINATES TOTAL
BEGUN MAY 11, 81 FINISHED MAY 12, 81 DEPTH OF OVERBURDEN DEPTH 15.25 M BEARING OF ANGLE HOLE
DEPTH OF ELEV. OF WATER TABLE 0.00 M. HOLE LOGGED BY NIRUTH & TNIT FOREMAN AMNUAY

NOTES On water table levels, water return, character of drilling etc.	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: DEPTH (M.) From (P, Cs or Cm)	To	Loss in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG: Samples for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
			6.00	10.30	1.2	6	10					1.07×10^{-5}
			6.00	10.30	1.42	6	10				fines, 20% fine sand, green, moist.	1.00×10^{-4}
			6.00	11.25	1.4	6	10		11		7.30-8.30 m. CL (Lean clay) Very stiff, about 90% medium plasticity fines, 10% fine sand, yellowish brown, moist.	1.07×10^{-4}
			6.00	12.25	.76	6	10		12			5.06×10^{-5}
			6.00	13.20	.12	6	10		13		8.30-9.30 m. SM (Silty sand)	7.11×10^{-6}
			6.00	14.10	.19	6	10		14		Medium, about 70% fine sand, 30% non plasticity fines, light green, moist.	1.04×10^{-5}
			6.00	15.25	.15	6	10		15 / 15.25		9.30-10.30 m. ML (Silt)	7.26×10^{-6}
											Hard, about 80% slightly plasticity fines, 20% fine sand, green, moist.	
											10.30-13.00 m. SM (Silty sand) Very dense, about 65% fine sand, 35% slightly plasticity fines, green, moist.	
											13.00-13.20 m. ML (Silt) Hard, about 100% slightly plasticity	

Core Loss / Core Recovery

EXPLANATION

Type of hole ---------- D = Diamond, H = Hydraulic, S = Shot, C = Chop
Hole sealed ---------- P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (Metric) -- Em = 13", Am = 1 7/8", Bm = 2 3/8", Nm = 3"
Approximate size of core (Metric) -- Em = 7/8", Am = 1 1/8", Bm = 1 5/8", Nm = 2 1/8"
Outside diameter of casing (Nominal) -- Ex = 1 13/16", Ax = 2 1/2", Bx = 3 1/2", Nx = 3 1/2"
Inside diameter of casing (Nominal) -- Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

Fig. 1-12 Geologic Log of Drill Hole
Hole No. B.18 (3/3)

Division of Soil and Geology
Royal Irrigation Department

U.S. 1-01
(B.E.2519)

Hole No. B.18

GEOLOGIC LOG OF DRILL HOLE Sheet 3 of 3

FEATURE RESERVOIR PROJECT NONG PLALAI CHV. RAYONG
HOLE NO. B.18 LOCATION DOWN-STREAM
COORDINATES GROUND ELEVATION ANGLE FROM VERTICAL 0°
BEGUN MAY 1, 1981 FINISHED MAY 12, 81 DEPTH OF OVERBURDEN TOTAL DEPTH 15.25 M BEARING OF ANGLE HOLE
DEPTH OR ELEV. OF WATER TABLE HOLE LOGGED BY NIRUTH & TWIT FOREMAN AYNUAY

NOTES On water table levels, water return, character of drilling etc.	Type and size of hole	Core Recovery (%)	PERCOLATION TESTS: Depth (M.) From (Ft. Co or Cs) To	Loss in (LPM)	Pressure (PSI)	Length of Test (min.)	ELEVATION	DEPTH	LOG: Samples for testing	CLASSIFICATION AND PHYSICAL CONDITION	Coefficient of Permeability (cm/sec)
										fines, green, moist. 13.20-15.00 m. SP (Poorly graded sand) Very dense, about 100% fine to coarse sand, brown, wet.	

EXPLANATION
Type of hole ..... D = Diamond, H = Hammerlite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (Metric) -- Em = 76 mm, Am = 117/8", Bm = 2 3/8", Nm = 3"
Approximate size of core (Metric) -- Em = 3/8", Am = 1 1/8", Bm = 1 13/16", Nm = 2 1/8"
Outside diameter of casing (Metric) -- Em = 1 13/16", Am = 2 1/2", Bm = 2 7/8", Nm = 3 1/8"
Inside diameter of casing (Metric) -- Em = 1 5/8", Am = 1 29/32", Bm = 2 3/8", Nm = 3"

Core Loss
Core Recovery

Angle Hole ☐
Vertical Hole ☑

NOTE: Calculted by the JICA Survey team

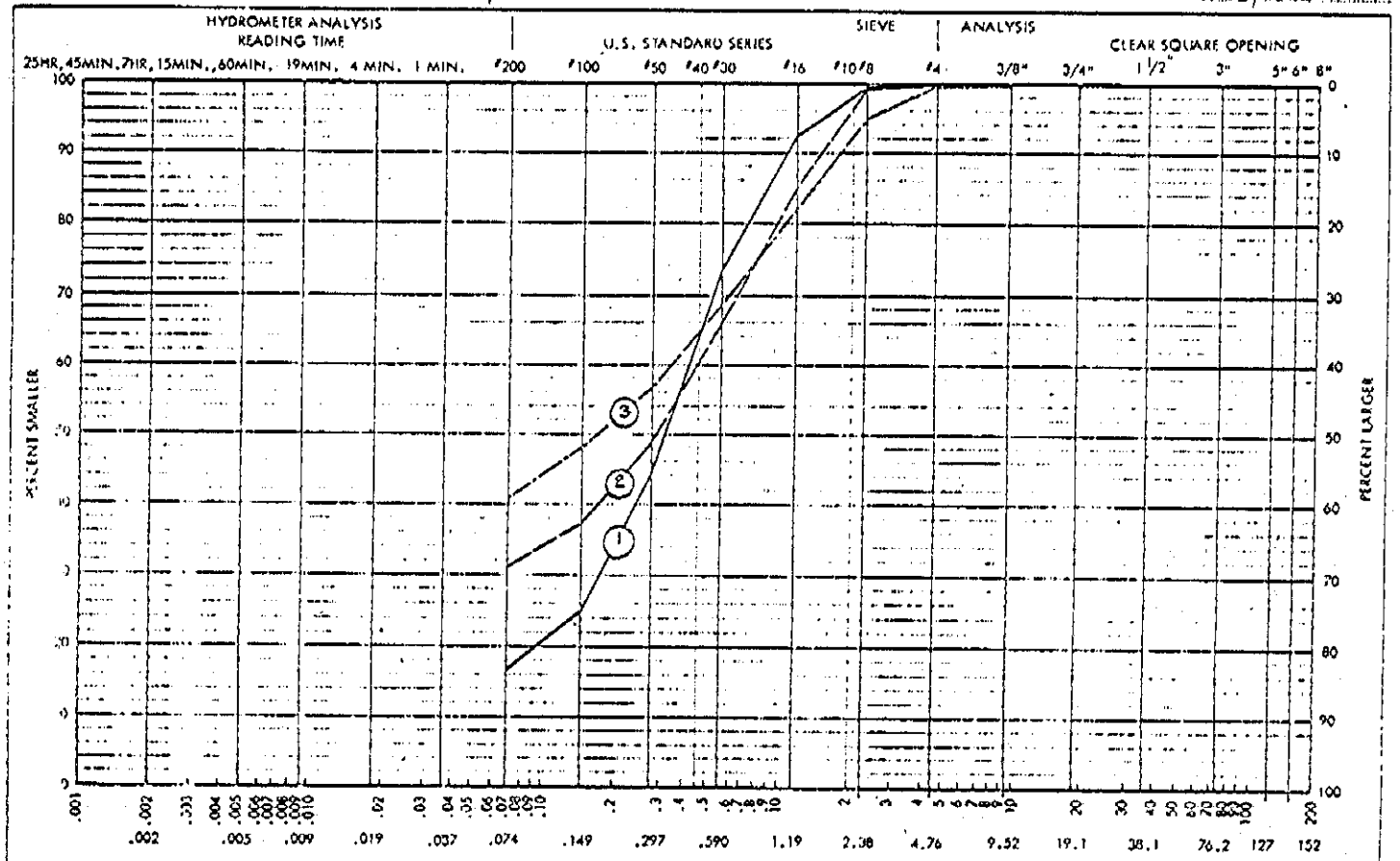
Fig. 1-13 Nong Pla Lai Borrow Pit Gradation Test

Technical Division
Royal Irrigation Department

Project The East Coast Water Resources Development — GRADATION TEST

T.M. 4-36 (พ.ศ.2517)

Memo. 73/2524



CLAY (plastic) TO SILT (non-plastic)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

Notes: No.	Samples From	Location	Elevation (m.)	Atterberg Limits L.L.	P.L.	P.I.	Unified Soil Classification	Nat. Moisture Content
①	Nong Pla Lai	R(0+400) ฝ่ง 225 m	2.10 - 2.20	Non-Plastic			SM	13.75 %
②	" "	R. ด้าน pit #5	2.20 - 2.20	35.2	18.3	16.9	SC	8.69 %
③	" "	R ด้าน pit #5	4.00 - 4.10	38.1	20.1	18.0	SC	10.73 %

Drawn ..... Checked ..... Date ..... April 29, 1981 ..... Sheet 1 of 5

Fig. 1-14 Nong Pla Lai Borrow Pit Gradation Test

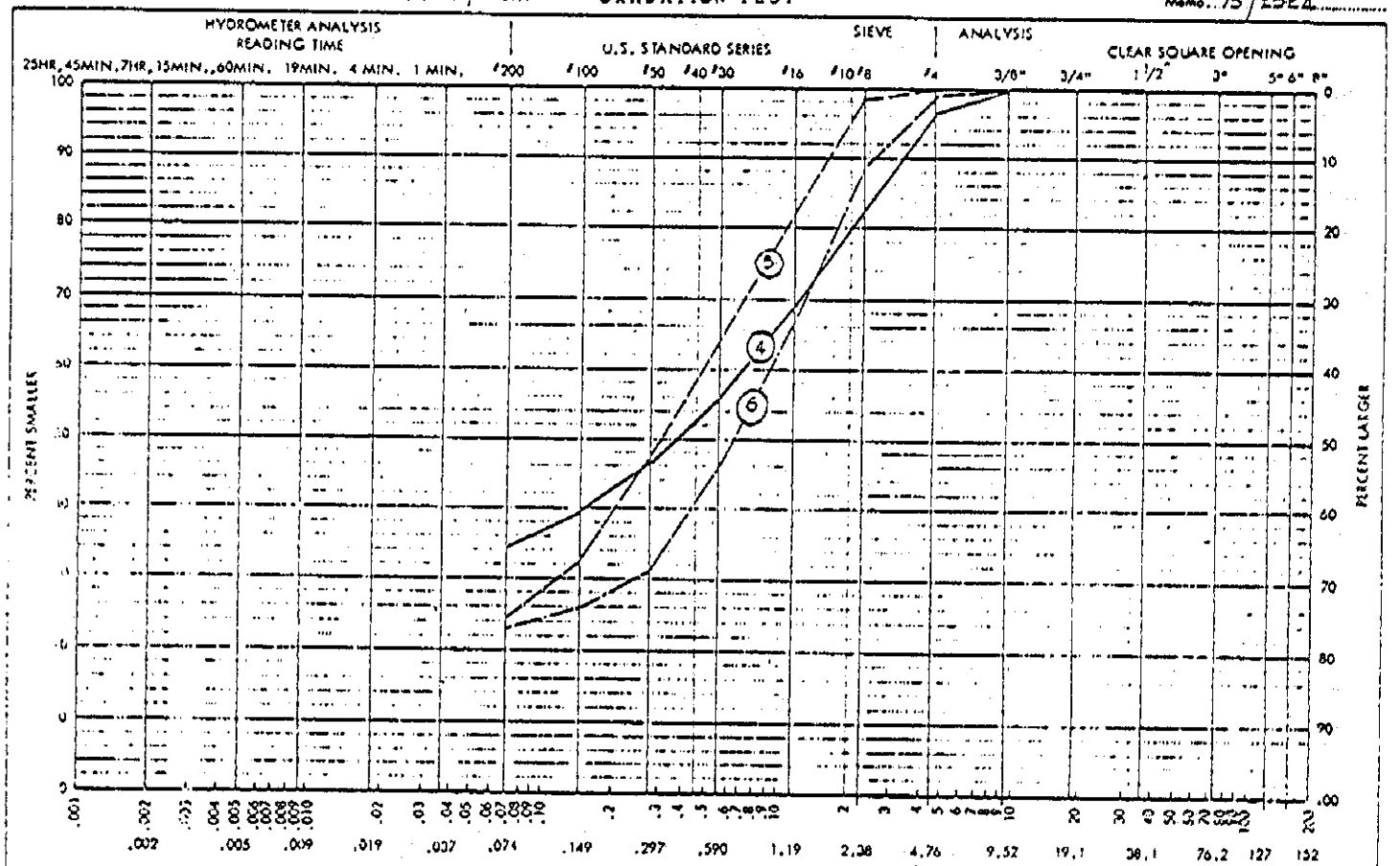
Technical Division
Royal Irrigation Department

2.11, 4-36
(N.S.2517)

Project The East Coast Water Resources Development

GRADATION TEST

Memo. 75 / 2564



CLAY (plastic) TO SILT (non-plastic)	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL: FINE	GRAVEL: COARSE	COBBLES

Notes:

No.	Samples From	Location	Elevation (m.)	Atterberg Limits L.L.	P.L.	P.I.	Unified Soil Classification	Nat. Moisture Content
④	Nong Pla lai	R.D/s pit #5	3.60 - 3.60	47.7	21.3	26.4	SC	9.98 %
⑤	" —— "	℄ u/s 660 m	2.20 - 2.30	Non- Plastic			SM	8.61 %
⑥	" —— "	℄ u/s 660 m	4.00 - 4.20	24.2	16.3	7.9	SC	13.72 %

Drawn RT. Checked SR. Date April 23, 1981

Sheet 6 of 5

Fig. 1-15 Nong Pla Lai Borrow Pit Gradation Test

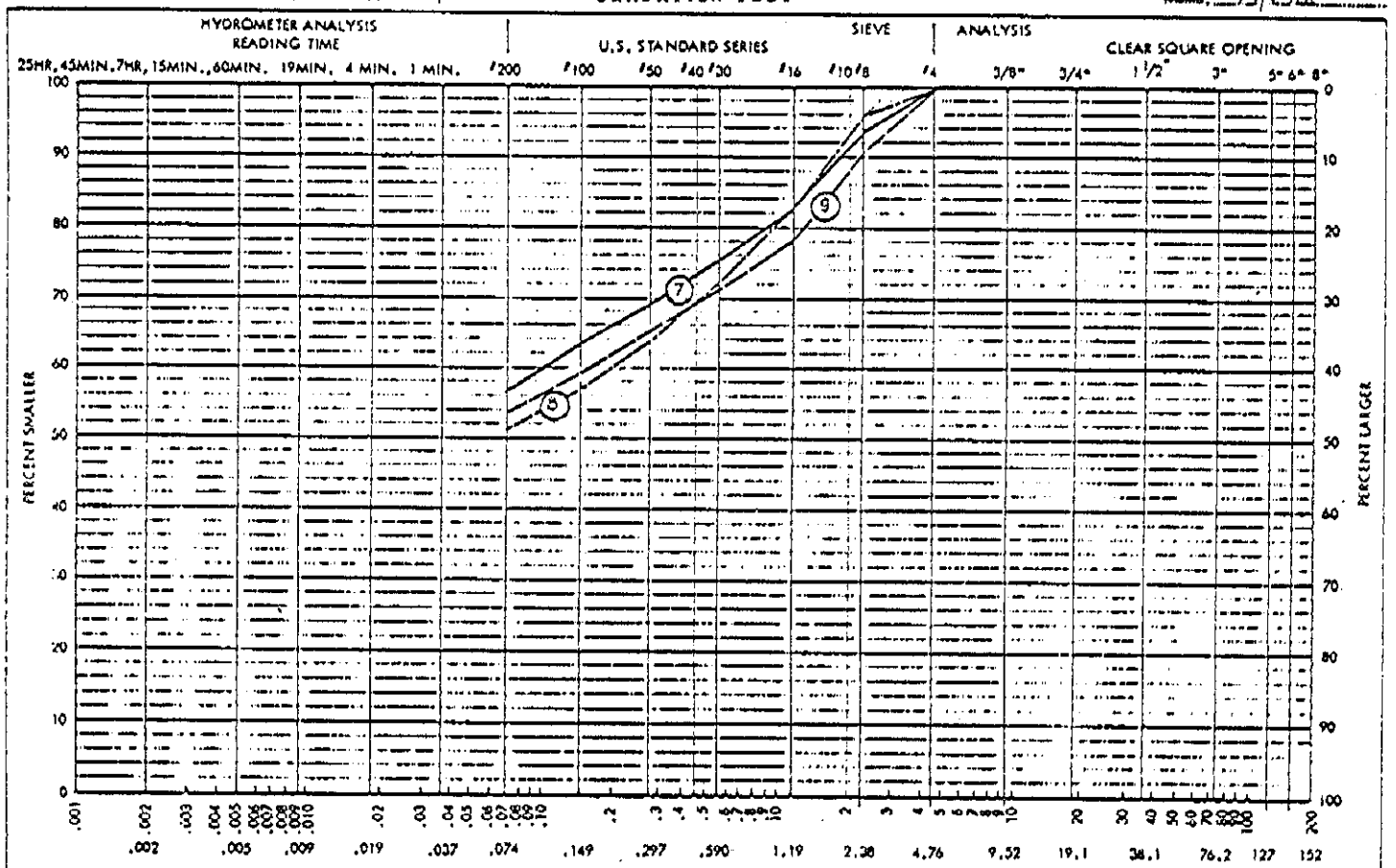
Technical Division
Royal Irrigation Department

GRADATION TEST

211.4-38
(N.R.2517)

Project The East Coast Water Resources Development

Memo. 73/6524



CLAY (plastic) TO SILT (non-plastic)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

Notes: NO.	Samples from	Location	Elevation (m.)	Atterberg Limits			Unified Soil Classification	Nat. Moisture Content
				Liq.	Pl.	P.I.		
(7)	Nong Pla lai	L U/S	0.00 - 0.10	46.7	24.6	22.1	CL	11.58 %
(8)	" "	L D/S -	0.00 - 0.10	45.9	25.6	20.3	CL	11.88 %
(9)	" "	Ban Kabak Taew	0.00 - 0.10	45.0	25.0	20.0	CL	11.51 %

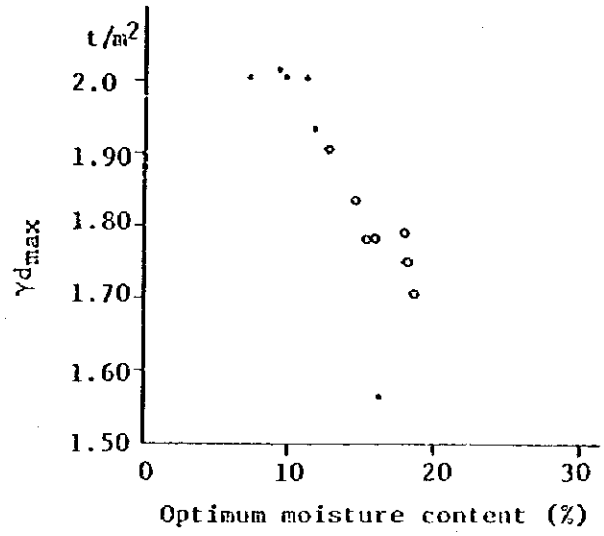
Drawn ____ RT. ____ Checked ____ SR. ____ Date April 23, 1981

Sheet 3 of 5

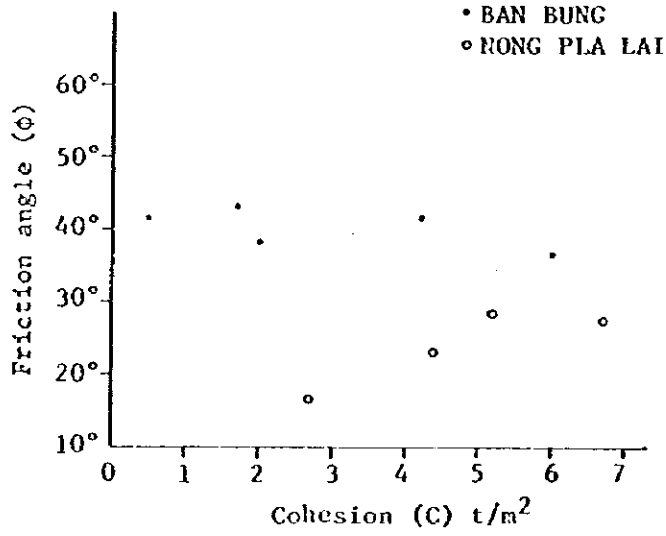
Fig. 1-16 Result of Laboratory Test for Borrow Materials

(After 1973 reports)

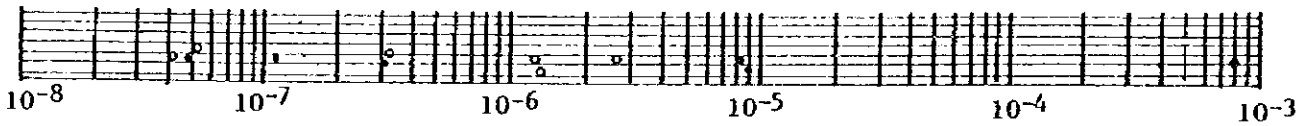
◦ Result of Compaction Test



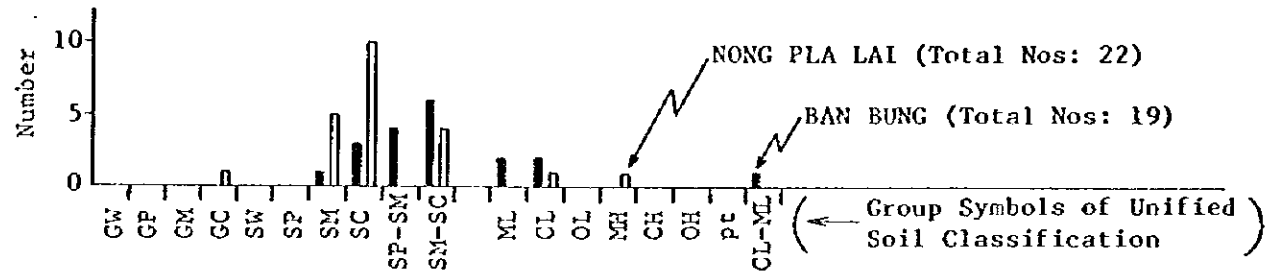
◦ Result of Direct Shear Test



◦ Result of Permeability Test



◦ Result of Unified Soil Classification



◦ Result of Grain Size Analysis