projects for the improvement of existing ones and 13 dredging projects for irrigation and domestic water supply purposes.

4) Other River Basins

The medium scale Huai Khok reservoir project has been proposed in the Nong Khai east drainage area to irrigate a land area of some 990 ha and 400 ha in the rainy and dry seasons, respectively. The project costs are estimated at about 212.2 million baht. The project may be feasible, for the economic internal rate of return is estimated to be about 11%, but there is a problem due to a large area of submerged land, about 330ha, in the reservoir. In addition, the existing Bang Phuang reservoir will require rehabilitation and improvement in its irrigation system. The rehabilitation of canals and structures, improvement/provision of checks and turnouts, and upgrading of on-farm facilities will be the main component for the improvement of project facilities. The costs will be estimated at about 9.4 million baht.

The small scale projects programmed for the construction of the reservoirs and weirs are 30 in number, 11 improvement projects of existing ones and 31 dredging projects.

3. 6. 5 Utilization of Mekong River Water

According to the farm economic survey carried out during the first step of the field work, about 80% of the farmers in the Study Area are interested to practice irrigated agriculture during the dry season. On the contrary, as shown in Table 3.6-1, even if all the planned water resources development projects are implemented, the irrigated area would not become more than 23% of the total agricultural land from its present share of 9%. Therefore, any increase in irrigated agriculture will depend on the use of Mekong river water.

A plan for using Mekong river water has been formulated as shown in Figures 3.6-3 and 3.6-4. The plan includes (1) intake by floating pump at Ban Bha Tang located at the north-western edge of the Study Area, (2) pumping up the Mekong river water to the foot of Phuphankham mountain range with an elevation of about EL. 220 m and (3) conveying the water through feeder canal to the existing Huai Luang reservoir and middle reaches of Nam Suai and Huai Luang rivers. The total length of the feeded canal from the planned pump

TABLE 3.6-1 WATER RESOURCES IN THE THREE RIVER BASINS

	Huai Mong Basin	Nam Suai Basin*1)	Huai Luang Basin	Total	Remarks
1. Area	2,711 sq.km.	1,796 sq.km.	4,100 sq.km.	8,607 sq.km.	*1) including Nong Khai and other basins of 482 sq.km.
2. Agricultural Land	140,000ha (875,000rai)	105,000ha (656,250rai)	215,000ha (1,343,750rai)	460,000ha (2,875,000rai)	
3. Ratio of Agricultural Land	52%	58%	52%	53%	
Existing Irrigated Area	(Storage)	(Storage)	(Storage)	(Storage)	
4. Large Scale (RID)	-	-	13,760ha (113.30 MCM)	13,760ha (113.30 MCM)	
5. Medium Scale (RID)	- -	2,050ha (10.64 MCM)	1,640ha (12.45 MCM)	3,690ha (23.09 MCM)	
6. Small Scale (RID)	2,552ha (8.78 MCM)	2,848ha (13.11 MCM)	4,280ha (16.47 MCM)	9,680ha (38.36 MCM)	
7. Swamp & Farm Pond (RID)	350ha*2) (2.38MCM)	525ha*2) (3.58MCM)	875ha*2) (5.96MCM)	1,750ha (11.92MCM)	*2) estimated : (6,814 cum/ha)
8. Sub-Total	2,902ha (11.16MCM)	5,423ha (27.33MCM)	20,555ha (148.18MCM)	28,880ha (186.67MCM)	
9. Huai Mong Project (DEDP)	3,170ha (26.00MCM)	-	-	3,170ha (26.00MCM)	
10. Pump Irrigation (DEDP)	3,075ha -	4,305ha -	1,850ha -	9,230ha -	
11. Sub-Total	6,245ha (26.00MCM)	4,305ha -	1,850ha -	12,400ha (26.00MCM)	
12. Total (Existing) 8+11	9,147ha (37.16MCM)	9,728ha (27.33MCM)	22,405ha (148.18MCM)	41,280ha (212.67MCM)	
13. Ratio of Irrigated Area (Existing)	6.5%	9.3%	10.4%	9.0%	
RID Projects	2.1%	5.2%	9.6%	6.3%	
DEDP Projects	4.4%	4.1%	0.8%	2.7%	
On-going & Proposed Project					
14. Medium Scale (RID)	4,290ha (45.60 MCM)	2,910ha (27.10 MCM)	3,810ha (38.90 MCM)	11,010ha (111.60 MCM)	
15. Small Scale (RID)	6,070ha (15.40MCM)	3,628ha (6.30MCM)	10,450ha (16.20MCM)	20,148ha (37.90MCM)	
16. Lower Huai Luang Project (DEDP)	-	-	19,200ha (154.87MCM)	19,200ha (154.87MCM)	
17. Nam Suai Basin Project (DEDP)	-	17,750ha (215.00MCM)	-	17,750ha (215.00MCM)	
18. Sub-Total	10,360ha (61.00MCM)	24,288ha (248.40MCM)	33,460ha (209.97MCM)	68,108ha (519.37MCM)	
19. Total (Irrigated Area) 12+18	19,507ha (98.16MCM)	34,016ha (275.73MCM)	55,865ha (358.15MCM)	109,388ha (732.04MCM)	
20. Ratio of Irrigated Area (Future)	13.9%	32.4%	26.0%	23.8%	
RID Projects	9.5%	11.4%	16.2%	13.1%	
DEDP Projects	4.4%	21.0%	9.8%	10.7%	
21. Stored Water for 19	98MCM	276MCM	358MCM	732MCM	
22. Potential Water Resources	724MCM	593MCM	1,294MCM	2,611MCM	
23. Ratio 21:22	12.5%	44.6%	28.5%	27.6%	
24. Rained Area 2-19	120,493ha (753,070 rai)	70,984ha (443,640 rai)	159,135ha (994,600 rai)	350,612ha (2,191,310 rai)	
25. Requested Area for Irrigation*	92,490ha (578,060rai)	49,980ha (312,380rai)	116,130ha (725,810rai)	258,600ha (1,616,250rai)	*3) = 2×80% - 19
26. Required Capacity of Pump Station	92.5cu.m/s	50.0cu.m/s	116.1cu.m/s	258.6cu.m/s	q = 1.0 l/ha

Note: Based on the result of farm economic survey, it is assumed that about 80% of the farmers in the Study Area want to practice irrigated agriculture. The figures in items 25 and 26 indicate the supply of irrigation water for all of those farmers.

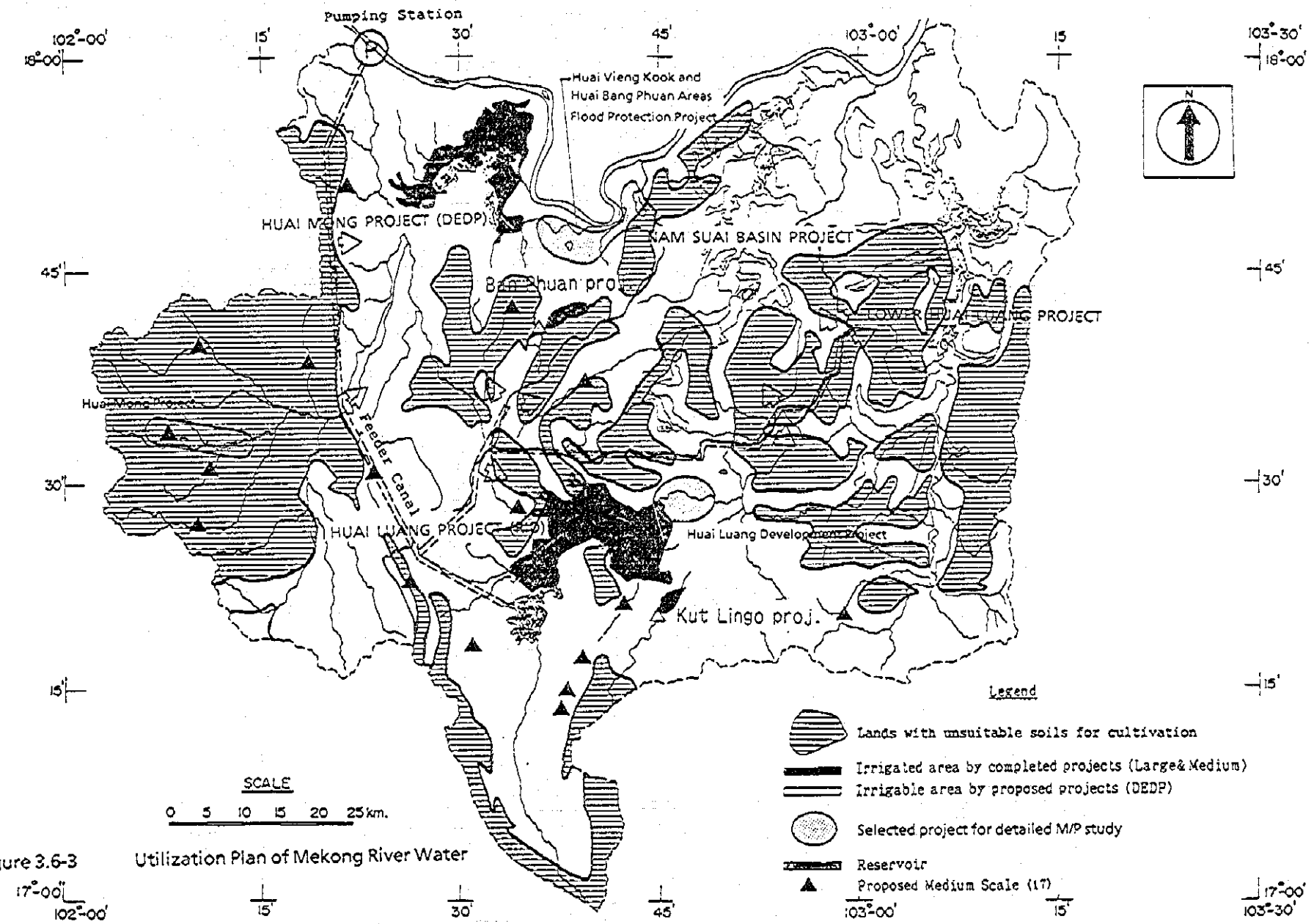
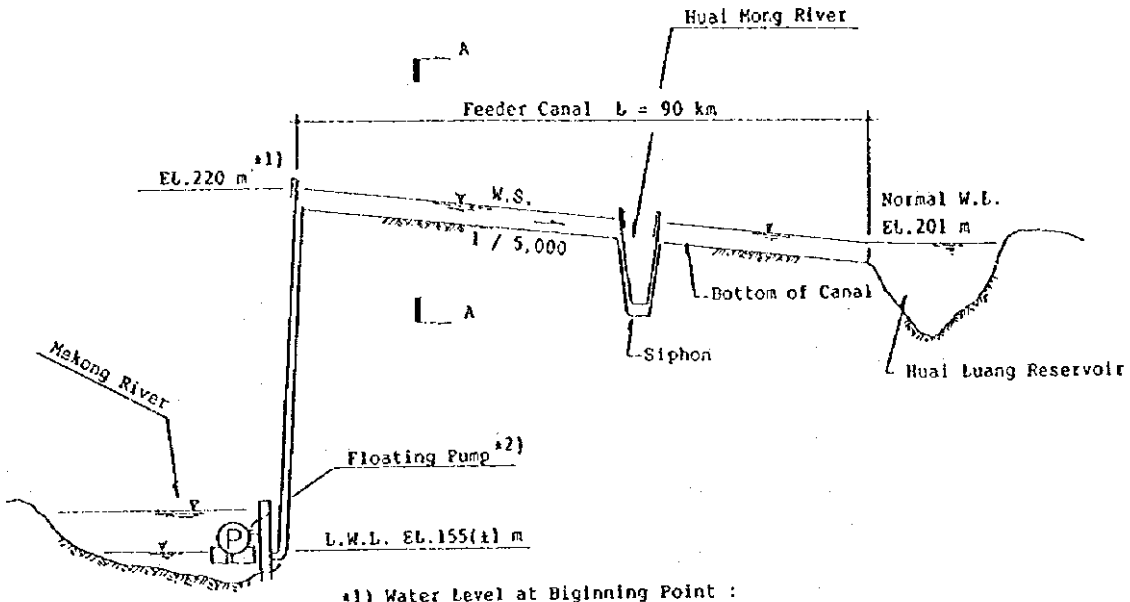


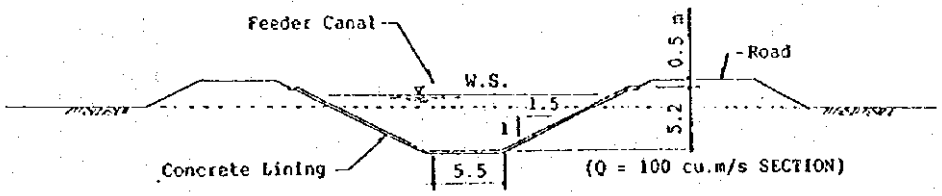
Figure 3.6-3 Utilization Plan of Mekong River Water



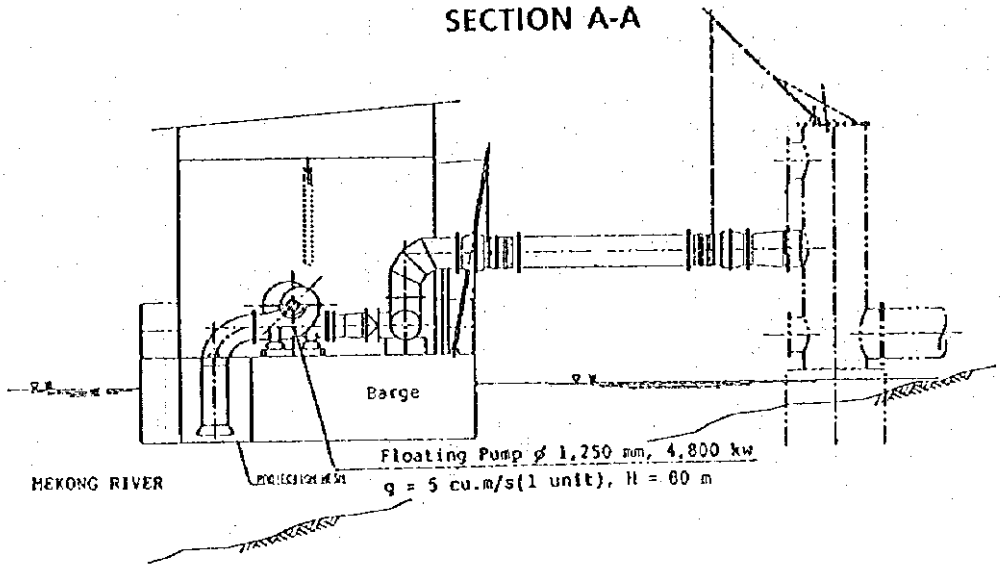
*1) Water Level at Biginning Point :
WL = EL.201 m + (90,000/5,000) x 1.2 = EL.220.8 ≒ EL.220 m

*2) Total Pump Head
H1 = EL.220 - EL.155 = 65 m (Actual Pump Head)
H2 = = 15 m (Loss Head assumed)
Total Pump Head = 80 m

PROFILE OF FEEDER CANAL



SECTION A-A



FLOATING PUMP

Figure 3.6-4 Floating Pump and Feeder Canal

station to existing Huai Luang reservoir is about 90 km. The feeder canal should be provided with division works and regulating reservoirs. The capacity of the pump is specified as 5 cu.m/s/unit, 80 m total pump head and 4,800 kw motor output.

A plan has been drawn up for the utilization of Mekong river water which is shown in Figure 3.6-3 and the preliminary cost for the implementation of the plan has also been estimated, as shown below.

Cost Required for Mekong Water Utilization

Item					
Pump Capacity(cms)	150	100	50	30	10
Dry season Capacity(cms)	60	40	20	12	4
Irrigation Area(ha)	150,000	100,000	50,000	30,000	10,000
Construction Cost(million baht)					
- Pump Station	4,400	2,900	1,600	1,100	400
- Feeder Canal	3,200	3,100	2,400	2,100	1,900
- Distribution System	11,200	7,500	3,700	2,200	700
Total(million baht)	18,800	13,500	7,700	5,400	3,000
Baht/Rai	20,100	21,600	24,640	28,800	48,000

The Study Area expects its future development to be based on agro-industrial development. The water resources of the Study Area to be used for dry season irrigation, however, are limited by constraints such as low run-off during the dry season, few sufficient storage damsites, etc. Therefore, the utilization of Mekong water will be essential for the future development of the Study Area. Utilization of Mekong water will be carried out as follows:

First Step (Implementation of Planned Projects) within the Study Area

-	Pump irrigation project (Existing : DEDP)	9,230 ha
-	Huai Mong project (Existing : DEDP)	3,170 ha
-	Nam Suai Basin project (Planned : DEDP)	17,750 ha
-	Lower Huai Luang Project (On-going : DEDP)	19,200 ha
	Total	49,350 ha

Second Step (Increased Utilization of Mekong Water)

There will be two methods of increasing withdrawal of water from Mekong as shown below:

1) Direct withdrawal from Mekong (refer to Fig.3.6-3)
2) Withdrawal from three reservoirs created by the DEDP projects at the lower reaches of Huai Mong, Nam Suai and Huai Luang.

The second step will be implemented after the Study's target year of 2006. The utilization plan of Makong water will be shown in Chapter 3.10.

3.7 Flood Protection Plan

3.7.1 Flood Conditions

1) Flood phenomena

The Floods in the Study Area are classified into the following types according to causes.

a) Upper and middle reach: heavy rain, lack of river capacity

b) Lower reach: heavy rain, inflow from upstream, back water from Mekong river and lack of drainage capacity

Floods in the upper and middle reaches gradually subside in a few days after heavy rain , but floods in lower reaches are continuous until lowering the water level of Mekong river and will bring severe problems for the area. Duration of the high water level of Mekong river is one and half months, maximum water level comes in August or September generally (See Fig 3.7-1, Table 3.7-1). Fig. 3.7-2 shows in/out flood water levels in the Huai Vieng Kook and Huai Bang Phuan areas from 1993 to 1995.

Heavy rainfall in June and July do not cause flooding because the Mekong river's water level is not so high that gravity drainage is fully available. Then in August, the water level rises with the water level of the

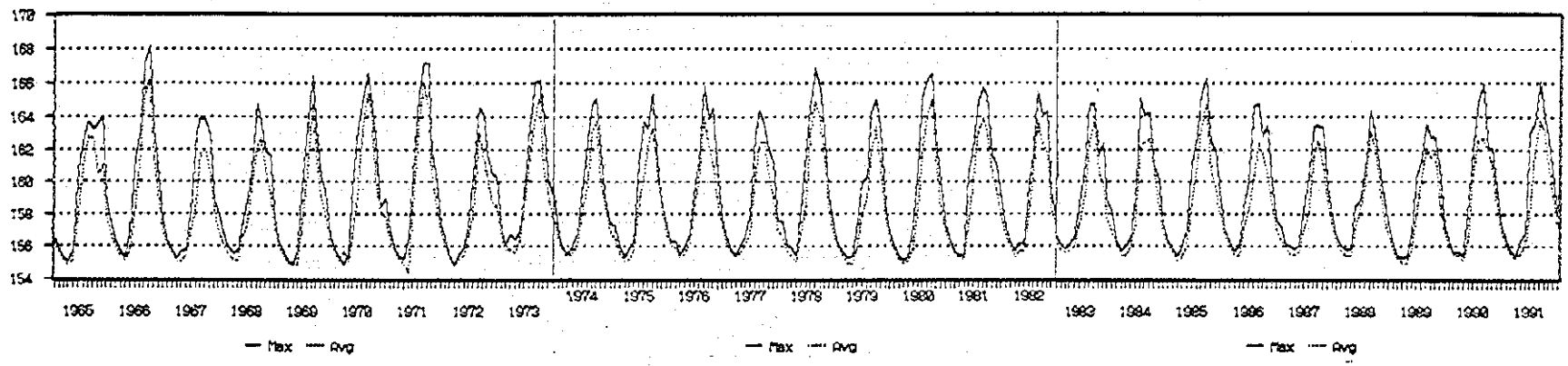


Figure 3.7-1 Water Level at Mekong River at Nong Khai(DEDP)

Table 3.7-1 Water Level of Mekong River

Data source : Mekong Secretariat

Year	Tha Bo					Nong Khai					Phon Phisal				
	Max	Day	Rk	Min	Day	Max	Day	Rk	Min	Day	Max	Day	Rk	Min	Day
1965	-	-	-	-	-	163.68	Aug.21	25	154.74	Apr.09	-	-	-	-	-
1966	-	-	-	-	-	168.25	Spt.10	1	154.97	Apr.07	-	-	-	-	-
1967	-	-	-	-	-	163.95	Aug.24	24	154.78	Apr.07	-	-	-	-	-
1968	-	-	-	-	-	164.80	Aug.18	16	154.87	Apr.03	-	-	-	-	-
1969	-	-	-	-	-	166.46	Spt.20	6	154.75	Apr.10	-	-	-	-	-
1970	-	-	-	-	-	166.56	Aug.16	5	154.57	Mar.24	-	-	-	-	-
1971	-	-	-	-	-	167.14	Aug.22	2	154.68	Apr.20	-	-	-	-	-
1972	-	-	-	-	-	164.59	Aug.27	19	154.66	Mar.28	-	-	-	-	-
1973	-	-	-	-	-	166.14	Spt.06	8	155.33	Apr.11	162.85	Spt.06	2	150.95	Mar.06
1974	-	-	-	-	-	165.08	Spt.02	15	155.09	Mar.22	161.85	Spt.03	6	151.23	Mar.25
1975	-	-	-	-	-	165.38	Spt.05	14	154.78	Apr.01	161.85	Spt.05	6	150.95	Mar.19
1976	-	-	-	-	-	165.79	Aug.17	11	155.21	Mar.10	161.76	Aug.15	11	150.85	Mar.26
1977	-	-	-	-	-	164.40	Aug.02	20	155.18	Mar.24	160.35	Aug.02	16	150.95	Apr.01
1978	-	-	-	-	-	166.86	Aug.16	3	154.81	Apr.09	163.02	Aug.16	1	150.35	Mar.09
1979	-	-	-	-	-	164.26	Aug.30	23	154.71	Apr.06	160.95	Spt.15	12	150.80	Apr.05
1980	-	-	-	-	-	166.57	Spt.08	4	154.75	Mar.27	162.85	Spt.09	2	150.73	Mar.29
1981	168.10	Aug.08	3	157.82	Apr.14	165.68	Aug.08	12	155.04	Mar.31	161.95	Aug.08	4	150.95	Apr.16
1982	168.04	Aug.26	4	157.78	Apr.01	165.49	Aug.26	13	155.15	Mar.24	161.85	Aug.19	6	151.23	Mar.25
1983	167.43	Aug.08	6	157.78	Apr.14	164.75	Aug.08	17	155.36	Mar.14	160.85	Spt.19	13	151.45	Mar.24
1984	167.71	Jly.16	5	157.58	Apr.11	164.30	Spt.08	22	155.17	Apr.11	160.85	Aug.19	13	150.73	Apr.08
1985	168.78	Spt.02	2	157.58	Mar.24	166.27	Spt.02	7	155.02	Mar.26	161.95	Spt.02	4	150.49	Mar.29
1986	167.14	Aug.01	7	157.71	Mar. 6	164.73	Aug.01	18	155.15	Apr.07	160.45	Aug.02	15	150.71	Apr.07
1987	165.75	Spt.28	10	157.53	Apr.06	163.44	Spt.28	27	155.25	Apr.04	159.61	Aug.26	18	150.45	Apr.06
1988	166.74	Aug.19	9	157.46	Apr.14	164.37	Aug.19	21	155.08	Apr.14	160.09	Aug.13	17	150.61	Mar.23
1989	166.87	Aug.19	8	158.28	Apr.21	163.55	Aug.19	26	154.77	Apr.21	159.25	Aug.19	19	150.65	Apr.20
1990	-	-	-	-	-	165.94	Aug.02	10	154.93	Apr.21	161.85	Aug.03	6	150.61	Apr.22
1991	169.58	Aug.21	1	158.84	Mar.30	166.09	Aug.21	9	155.19	Mar.13	161.85	Aug.19	6	150.77	Mar.30
AVR	167.61			157.84		165.35			154.96		161.37			150.81	

Table 3.7-2 Monthly Rainfall in Flooded Year(1965-1993)

Udon Thani

WL Rank	Year	WL max	Month	Jly		Aug		Spt		Jly+Aug		Remarks
				R (mm)	Rank	R (mm)	Rank	R (mm)	Rank	R (mm)	Rank	
1	1966	162.85	Spt.10	168.1	(20)	491.7	(2)	176.2	(22)	659.8	(3)	
2	1972	167.14	Aug.22	282.3	(8)	360.6	(7)	228.4	(13)	642.9	(5)	
3	1978	166.86	Aug.16	449.3	(1)	499.7	(1)	213.4	(15)	949.0	(1)	
	Avg			218.1		283.2		242.9		601.3		
	Max	(Year)		449.3	(1978)	499.7	(1978)	642.1	(1970)	948.5	(1978)	

Nong Khai

WL Rank	Year	WL max	Month	Jly		Aug		Spt		Jly+Aug		Remarks
				R (mm)	Rank	R (mm)	Rank	R (mm)	Rank	R (mm)	Rank	
1	1966	162.85	Spt.10	185.4	(21)	539.4	(3)	118.5	(27)	724.8	(7)	
2	1972	167.14	Aug.22	425.0	(3)	231.5	(22)	171.0	(24)	656.5	(9)	
3	1978	166.86	Aug.16	393.6	(5)	432.8	(7)	293.9	(11)	826.4	(1)	
	Avg			240.2		320.9		261.0		561.2		
	Max	(Year)		437.1	(1992)	583.2	(1980)	620.5	(1967)	826.4	(1978)	

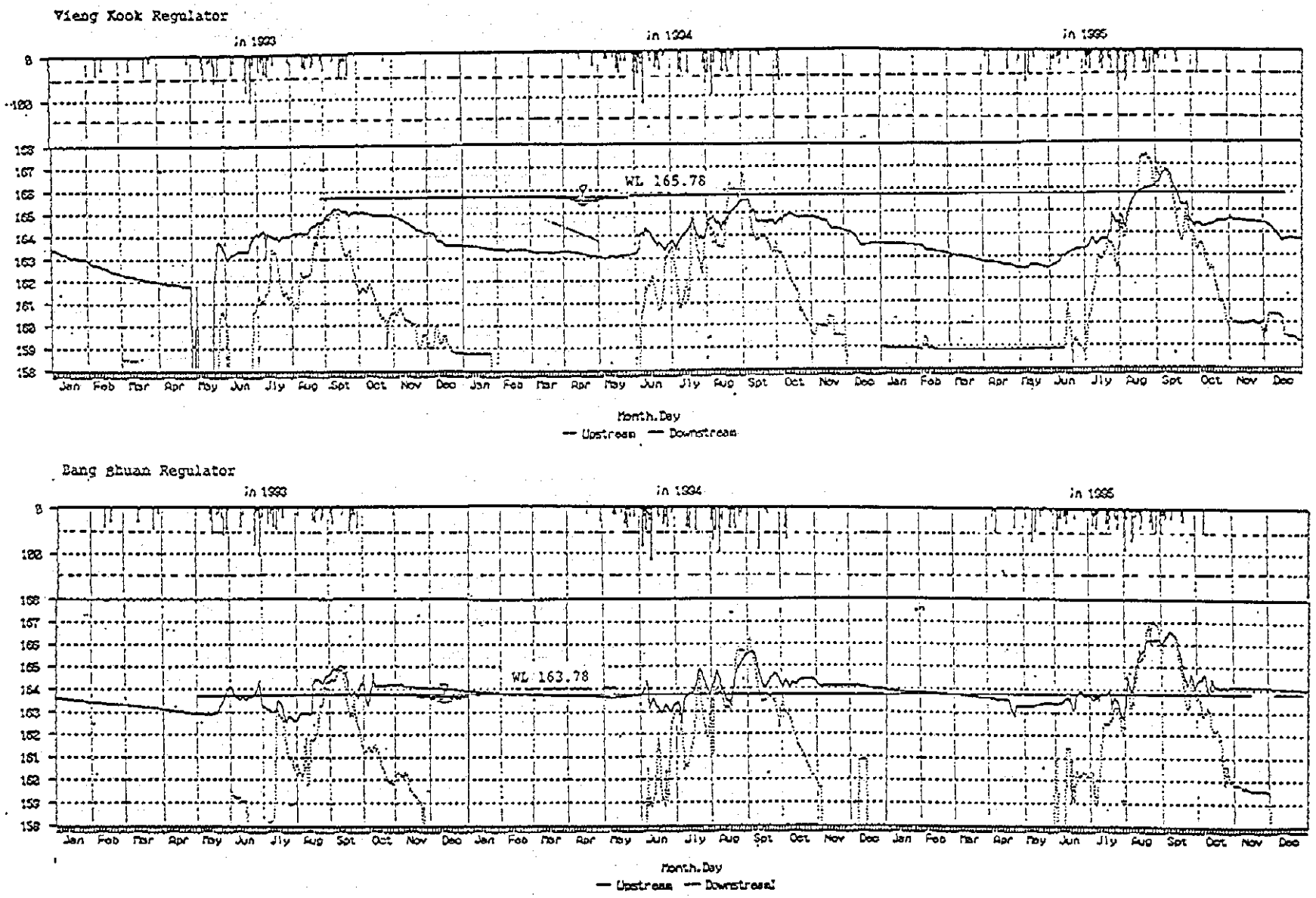


Figure 3.7-2 Water Level and Rainfall at Bang Phuan and Vieng Kook

Mekong river and/or rainfall or inflow from upstream. Gates will close when the water level of the Mekong river is higher than inside water level inside the gates.

In August 1995, the high water level of the Mekong river which was about ten yeas return period with runoff from heavy rains brought large scale flooding in the down stream areas of the Study Area. Fig. 3.7-3 shows in/out water level in Huai Mong Project Area. As regulator gates were opened from July, water level of project area shows a similar tendency mentioned above except P-4. Each block of this project area equipped drainage pumps, but theirs capacity were not enough for heavy rain.

2) Inundated Area and flood damage

The Study Area was visited by four periods of heavy rain resulting from one low pressure and three tropical depressions, namely, Gary, Erwing and Lois, from 22 July to 10 August 1995. Total rainfall in July and August amounted up to 984 mm at Huai Vieng Kook station.

a) Inundated Area

Inundated area in 1995 and 1966 (heaviest flooding in recent years) were estimated at 700 sq.km and 1,260 sq.km based on the Mekong river water levels, 1/50,000 topo-maps and influence of back water gradient.

Area	Unit	In 1995	In 1966
Huai Mong	sq.m	200	400
Huai Vieng Kook & Bang Phuan	sq.km	35	115
Nam Suai	sq.km	160	335
Haui Luan	sq.km	305	410
Total	sq.km	700	1260

Inundated area is shown in Fig.3.7-4.

b) Flood Damage

According to Nong Khai and Udon Thani Province office, flood damage in the Study Area were reported as follows:

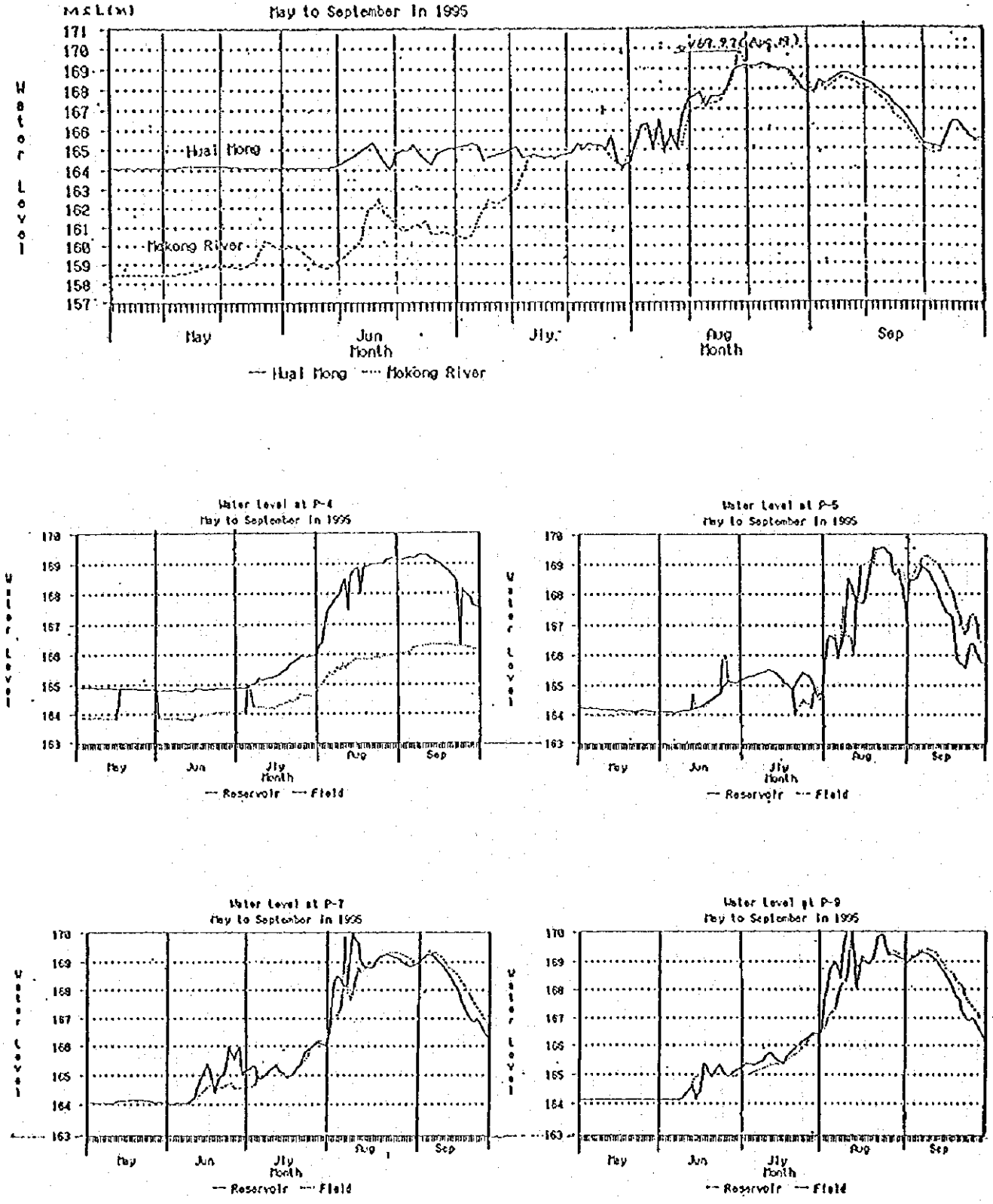


Figure 3.7-3 Water Level at Huai Mong Regulator(DEDP)

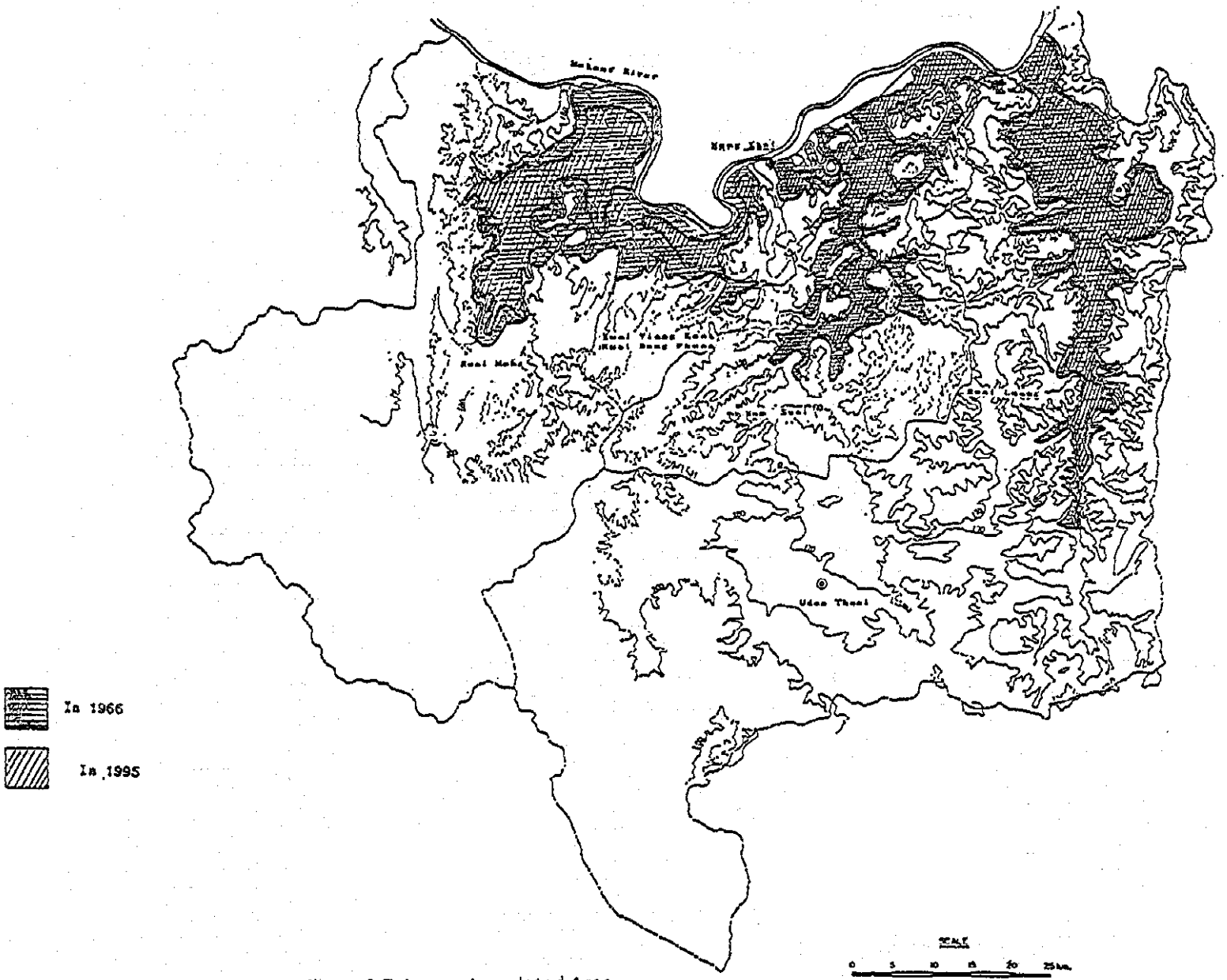


Figure 3.7-4 Inundated Area

Area and Number of People affected		Nong Khai	Udonthani
Tambom	Nos.	46	103
Muban	Nos.	316	661
Household	Nos.	45,153	N.A
People	Nos.	169,780	20,116
Area	rai	N.A	531,020(*)

(*) Damaged ratio is more than 50 % -- 279,890 rai
〃 100 % -- 251,130 rai

And Nong Khai Province reported area of damage and number of livestock as follows.

Damaged area and numbers of livestock

Plantation Area	rai	204,080	(32,650 ha)
Effected animals			
Cattle/Buffalo	Head	31,000	
Poultry	Head	145,270	
Swine	Head	2,490	
Number of dead	Head	88,370	
Fishery Pond	Nos.	7,670	
Public facilities			
Roads	Nos.	291	
Bridges	Nos.	12	
Dams	Nos.	32	
Schools	Nos.	32	

DOAE of Nong Khai estimated damaged area and crops as follows.

Flooded area	rai	251,420	(40,230 ha)
Damaged area	rai	219,053	(35,048 ha)
Damaged crops			
Rice	rai	216,200	
Vegetables	rai	1,710	
Fruit	rai	1,100	

3) Existing Flood Protection Projects

Flood protection projects in the Study Area are as follows.

Project Name	Implementing Agency	Progress
Flood protection dike	RID	Completed in 1955
Huai Mong project	DEDP	Completed in 1986

Lower Huai Luang project	DEDP	On going
Nam Suai Basin project	DEDP	Proposed

Major opening points with regulators across the dike constructed by RID are Huai Vieng Kook and Huai Bang Phuan. Big flood attacked this area in August 1995, and inundation occurred widely in the beneficial area.

Ground Level in the Study Area

Huai Mong	Less than 160 m MSL	3.2 sq.km
Huai Kook,Phuang		- sq.km
Nam Suai		19.7 sq.km
Huai Luang		196.2 sq.km

4) Flood Water Level of Mekong River

Three gauging stations to measure water level of the Mekong river in the Study area are as follows.

Name	Watershed (sq.km)	Distance(km) from sea	Collected Data (Daily WL Records)
Tha Bo	299,000	1,575	1980,Jan01 -- 1991 Dec31
Nong Khai	320,000	1,550	1965,Jan01 -- 1991 Dec31
Phon Phisai		1,503	1972,Apr01 -- 1991 Dec31

From these records,it is said that maximum water levels occurred normally in August or September and Minimum water levels in March or April. At Nong Khai station, maximum and minimum water levels observed from 1965 to 1991 are as follows.

Rank	Maximum water level		Minimum water level	
1	168.25 m MSL	(1966 Spt,10)	154.57 m MSL	(1970 Mar,24)
2	167.14	(1971 Aug,22)	154.66	(1872 Mar,28)
3	166.86	(1978 Spt,16)	154.68	(1971 Mar,24)
Average	165.35		154.96	

(Details are shown in Table 3.7-1 "Water Level of Mekong River Maximum water level in 1995 is estimated at 166.90 m MSL.)

Taking into consideration these records, Nam Suai F/S report and RID records, water levels at each opening were assumed as follows.

Opening	Unit	1966	1995
Huai Mong	m.MSL	170.96	169.97
Huai Vieng Kook & Bang Phuan	m.MSL	169.61	168.44
Nam Suai	m.MSL	165.14	163.96
Huai Luang	m.MSL	164.19	163.06

Notes ; RID Nong Khai -- 167.58 m.MSL in 1966,162.23 m.MSL in 1995.

5) Rainfall and Runoff

From rainfall data of Nong Khai and Udon Thani Station observed from 1965 to 1993, monthly rainfalls in July and August estimated as follows.

Rank	July (mm)		August (mm)	
	Nong Khai	Udon Thani	Nong Khai	Udon Thani
1	437.1(1992)	449.3(1978)	582.3(1986)	499.2(1978)
2	427.2(1981)	308.7(1986)	547.2(1970)	491.7(1966)
3	425.0(1971)	290.3(1974)	539.4(1966)	455.1(1974)

High water level occurs one month after heavy rainfall. (Monthly rainfalls of Nong Khai and Udon Thani in flood years are shown in Table 3.7-2.

Maximum average runoff are as follows.

Huai Mong	KH 18	Monthly base	114 l/s/sq.km
Nam Suai	(F/S)	Monthly base	105 l/s/sq.km(1970,Spt)
		Daily base	217 l/s/sq.km(1959,Spt,13)

3.7.2 Flood Protection Plan

Flood have taken place yearly and caused the people considerable losses in both their personal and social properties. As the possible countermeasures for flooding, the following can be considered.

- Reduction of peak flood discharge by reservoirs

There are hardly suitable damsite in the Study Area, making it difficult to construct flood control dams.

- Drainage improvement

Inundation are very common in the Area due to the lack of cross drain for roads and insufficient drainage capacity. The said situation has to be improved as soon as possible.

- River improvement and banking

Provision of rubber dam after the river improvement works will make it possible to store the water in the river course and to feed the river discharge to the neighboring storage facilities. As mentioned in Chapter 3.6.1, Basic Concept for Water Resources Development, it is considered necessary to include both flood control scheme and water utilization scheme in the river improvement project plan.

- Construction of regulator and drainage pump station

Lower reaches of the rivers in the Study Area used to be affected by the Mekong high water and runoff from the drainage area of each river, causing periodical inundation in considerably wide areas. Though it may be possible to shut out the back water from Mekong river by closing the regulator gates, runoff from the drainage area during the period has to be drained out by using drainage pumps.

- Establishment of information network

At the upper reach of Huai Luang river, there is the existing Huai Luang dam and at the lower reach, the Lower Huai Luang project is currently under construction. The Huai Luang dam is provided with a gates spillway and releases of water impounded by the dam into the river is undertaken by operating the said gates. It is necessary to have a network system so that the releases of flow from the dam can be promptly informed to the O/M office for the Lower Huai Luang project which will be established in future.

In general, a flood protection scheme may not always carries high economic return, however, measures for flood protection are of vital importance in securing peoples' life and properties among various types of social infrastructure facilities. In other words, it may be noted that a safe and active

society could be realized only after the flood protection measures be implemented and people there could live well at ease and feel easy circumstances. From view of the above, it is recommended that the flood protection plan should be implemented one after another depending on the priority orders based on humanitarian grounds as per the available budget.

Flood protection plan in the lower reaches are discussed in the followings.

1) Causes of inundation

The followings aspects are pointed out as the major causes of inundation.

- Back water with high water level from Mekong River
- Runoff water from the basin with wide catchment area

As the results of a review of the Huai Mong Project, the flood protection works are described as follows.

- Poor flood protection facilities (regulator,dikes)
- Poor drainage facilities
- Considerable runoff water from the outside to beneficiary area

2) Countermeasure against the flood protection

Basic flood protection plans ;

- To block the backwater from Mekong River by regulators and
- To drain off excess water to Mekong River by pumps
- To construct high river banks

These plans require high construction costs. Huai Mong project is equipped with such facilities and a reservoir, and can protect land from small and medium scale floods but not available from big flood. Countermeasures against the inundation caused by big floods in the area are as follows.

Case-1 Increase of drainage capacity of the facilities
Case-2 Provision of powder dikes

Case-3 Bypass of natural drainage (Short cut for outside run- off)

In Case-2 and 3,drainage in gravity or combination of drainage blocks shall be introduced as much as possible.

As for independent flood protection works, this not feasible from an economic point of view. Farmers do not allow these plan which do not include plans to use the high land or compensation of water supply in dry season. The projects executed in this area mostly did not aim to protect land from flooding, but mainly aim to use flood water for water resources, and alleviate the flood. It is understood that the flood water is utilized actively for irrigation in the dry season.

3) Huai Mong Project (Existing Project) Area

To stabilize the rainy season crops production, preventing from inundation is needed. For this purpose, the improvement of drainage system and facilities is required.

Capacity of regulating pumps should be 309 cu.m/s, while existing pump capacity is 10 cu.m/s.

A = 2711 sq.km q = 114 l/s/sq.km (KH-18 monthly peak discharge)

In the case of additional drainage pumps in the beneficiary area, proposed pump capacity is estimated at 22.6 cu.m/s, by applying A = 190 sq.km, q = 114 l/s/sq.km

Total existing pump capacity is 10.7 cu.m/s
(Summing up P-4,P-5,P-6,P-7,P-8,P-9,P-10(D))

Combined plan of cases-2 & 3 is drawn up, which is to enclose the land with a powder dike, together with the improvement of natural drainage systems, such as new bypass drains, combined drains and short cut for outside runoff.

- To drain off using a drainage canal directly to the Mekong River

- To drain off excess water to reservoir with force of gravity, connecting rivers and heightening of levee elevations.

If floods of ten-year return period is acceptable, the combined plan is recommended because other plans are too costly.

4) Huai Vieng Kook and Huai Bang Phuan Area

This area, extended from Huai Mong project area to Muan, Nong Khai is protected by RID flood protection dikes. Floods this year (1995) not more serious than in the Huai Mong area because of its small catchment area. The purpose of regulating gates (no regulating pumps) is to cut off the high water from Mekong during flood periods and retain irrigation water for dry season. Irrigation area is about 4000 ha. Farmers are irrigating the land with their own small pumps from reservoir/swamps. This area is situated with good access to Nong Khai marketing, extensive agriculture, and fishery area.

The following integrated agriculture projects are proposed in the area.

- Rehabilitation of regulators and new regulating Pumps
- To increase reservoir capacity and raise the water level
- New irrigation and drainage system (Pump irrigation)
- Land consolidation,farm road construction

5) Nam Suai Basin Project

This project has so far not been implemented. In the last 14 years, agricultural policy has changed. And the purpose of this project for irrigation requires amendment. Introduction of upland crops, water requirement, and irrigation facilities including reservoir, the necessity of 67 MCM of water pumped from Mekong River during the dry season are required to be reviewed before the project implementation.

As for the flood conditions,this project looks better than the Huai Mong project. Regulators control water level of reservoir from EL. 160 m to EL. 162 m. In rainy season crops, floating rice was proposed for paddy lower than EL. 162 m which has a flooded area to minimize crop damages by flood. If floating

rice is not allowed and pump control is requested, pump capacity will need to be 138 cu.m/s.(Designed pump capacity is 13.6 cu.m/s)

To eliminate flooding and to use farm land effectively, dikes around reservoirs will be proposed; the same as in Huai Mong and Huai Luang Projects and gravity irrigation by using a high reservoir water level would be tried to irrigate the low land area.

6) Lower Huai Luang Project

Construction work began in September 1995. Flood conditions in this area will be improved. But supplemental drainage facilities are proposed in order to prevent inundation originating from runoff from outside. This project has the major object of supplying water to the central area of Northeastern Region of Thailand,and is expected to solve various problems caused by severe water shortages and to realize the Green E-sarn.

3.8 Program to Strengthen Farmers' Organization

1) Strengthening of Farmers' Cooperative

The farmers' organization is important in providing linkages between the farmers and the government agencies. The activities of farmers' organization can be divided into two categories. One is related to the production activities themselves and the other concerns support for the production activities such as procuring production materials, handling products and so on.

The former type is basically subject to extension activities. The latter type is usually organized into cooperatives. The basic objective of the farmers' organization plan is the development of the farmer beneficiaries within the Study Area, an organized, self reliant and productive community, sharing resources for their mutual benefits. Farmers' associations will be organized so that they will be able to participate in the operation and maintenance of the facilities and utilities to be introduced in the Study Area and to support specific activities to increase income. Since the beneficiaries are simple farmers with limited skills and experiences in agricultural production, initially, the farmers organization in the Study Area will be activity-specific. Considering the

present condition of farmers' organization as mentioned, the major strengthening programs are as follows:

- To promote training and development of administration and management capability for members and leaders of the farmer's group and executives of Agricultural Cooperative, to make these organizations more practicable.

- To promote a special program for creation of qualified leaders of farmers and to encourage the present active informal farmer's groups to be a registered group.

- To promote Agricultural Cooperatives a at amphoe and tambon levels to take part in implementation of the government's agricultural supporting programs when Agricultural Cooperatives are able to establish proper administrative capability.

- Formulate a strong backup body at provincial and/or amphoe levels in all activities relating to strengthening farmers' organization not only at the initial stage of establishment but also during the subsequent operation period.

- Encourage the strengthening of existing farmers' group and mount a campaign to establish farmers' groups in accordance with the specific kind of activities such as vegetable plantation, beef cattle, handicraft, etc.

2) Strengthening Program for Water Users' Organization

To ensure the long life and sustainability of irrigation projects, it is important that the provision of maintenance and operation systems be in place prior to implementation. Since the farmers are the end users of the irrigation facilities, they should be made aware that the maintenance and operation of the facilities are their responsibility. It is therefore necessary to establish Water Users' Groups even before the completion of the facilities. Considering the present condition of Water Users' Organizations as mentioned, the major strengthening programs are as follows:

- To promote training and development of administration and management capability for members and leaders of the Water Users' Group.

- To evaluate the Water Users' Group (after construction of project facilities), that will become the focal point in the decision to form Water Users' Associations. The decision will have to come from the farmers themselves.

- To undergo activities (or training by actual experience) from successful Water User Groups outside the Study Area to learn by actual experience, the principals and basic knowledge of organization and managing a federated cooperative.

3) Women in Development (WID)

Women in rural project areas are playing various kinds of roles, not only within the household but also in agricultural production. Within the household, it is the duty of the women not only to handle such housekeeping activities as cooking, looking after children, washing clothes, cleaning the house, etc., but also to take care of such backbreaking duties as transporting water and animal feed. Concerning farming works, women make contributions to the household economy by helping not only their own farms but also the planting and harvesting work on other farms. Female work force is seen also at construction sites. As can be seen from the facts mentioned above, the role played by the female work force in the project areas is very important, but in terms of daily wages, women laborers receive low salary compared with their male counterparts.

However, the role played by women within the development process cannot be neglected under any circumstances. Woman must play a proper role as "bearers of the development process" and at the same time they must enjoy brought about by the development, as "beneficiaries of the development process". This would contribute to promoting the welfare and the position of the women, and to make development still more effective and significance.

With the implementation of the irrigation project, it will be possible to transform the agriculture from the rain-season-centered type, that has been

practiced conventionally, into a round-the-year type in which crops will be available also during the dry season. Such a transformation in the agriculture of the country is expected to contribute to increasing the employment opportunity for the women. As can be seen, the implementation of this project will bring about direct benefits to women enabling them to become " beneficiaries of the development".

Concerning the role to be played by women as "bearers of the development process," it is proposed that the following steps should be taken, with the object of not only promoting the participation of women in the present project, but also elevating their levels of technical skills, education level and social position, so as to transform them into an active element within the development process, instead of limiting them to the role of passive beneficiaries.

- To promote the participation of women in the operation and maintenance of the irrigation facilities on the farms.

- To promote the participation of women in agricultural extension and training programs.

- To promote the participation of women in the Water Users' Groups and other organizations for collective activity of the farmers.

The promotion of the activity of women in groups is also proposed. For example, women have the possibility of playing an extremely important role for increasing the income levels of rural households and for protecting the environment, through the following activities:

- Pig raising
- Processing of rice

It is presumed that the financial support of BAAC and other organizations will be required in order to promote activities of this kind to be carried out by women.

3.9 Strengthening of Agricultural Supporting Services

3.9.1 Agricultural Research and Experimentation Station

Regarding the agricultural experimentation station in the Study Area, names and activities are proposed in chapter 2.8.5. Agricultural experimentation stations are researching new techniques required for the development of agriculture in the region.

However, regarding the existing farming conditions and some constraints affecting agriculture in the Study Area, the following subjects should be considered to be researched more deeply to get rid of the obstacles and to advance the agricultural development plans.

1) Agriculture

- Improvement of fertility of soil in both paddy and upland fields.
- Selection of green manure crops for paddy and upland fields and the methods to be used.
- Using farm byproducts as organic matter for soil and feed for animals.
- Adaptability of new crops, for example, wheat and melon in dry season paddy.
- Cultivation method for new promising crops, and raising up of yield and productivity.
- Adaptability and improvement of cultivation techniques of mulberry and tea.
- Cycle among farm enterprises and inland fishery.
- How to control weeds, especially in dry season paddy fields.
- How to control insects and diseases in vegetables and promising crops without using or by minimum use of insecticides and fungicides.
- Tests for adaptability and suitability of some fruit trees such as oranges and grapes.
- Production of high quality and high demand flowers such as orchids and chrysanthemums.
- Selection of pasture species and mixtures of grass and leguminous plants in the region.

- Processing methods of vegetables and some industrial crops and young bamboo shoots.
- Use of greenhouses for the rearing of young fruit trees and flowers.

2) Livestock

- Selection and breeding of suitable varieties and strains of beef cattle in the region.
- Selection and breeding of suitable varieties and strains of milk cow in the region.
- Breeding methods, feed supply and the increase of body weight and the quality of meet.
- How to control the parasitic worm and disease of beef cattle and chicken.
- Putting the transplanting techniques of fertilized ova to practical use

3) Inland Fishery

- Selection of high income fish, shrimps and prawns in fish ponds and breeding of fry.
- Methods of removing mud and muddy water in fish pond to protect the spreading of disease of fishes.
- Relation and the composition of the size of fish ponds, number of chicken and the amount of fish in the pond.

3. 9. 2 Agricultural Extension Services

On the organization and the activity of the agricultural extension office in the region, detailed description was proposed in chapter 2.8.5. The agricultural extension office is one of the most important offices for the development of agriculture, because the office is most familiar to the farmers as the leading training office for the farmers.

Activities of the extension office have a direct effect upon the cultivation and production of the village. For example, in some villages in Nong Bua Lamphu, by the enthusiastic leading of the extension office, soy bean in dry season paddy is now increasing in the area markedly.

For the development of agriculture in the area, the following activities are expected.

1) How to Spread New Farming Technique to Farmers

It is not easy to teach new farming technique to the farmers by using the printed matter and speech. It takes a long time to spread the new farming technique to farmers. The best way to spread new farming technique is to teach some progressive farmers who are enthusiastic to introduce new technology and new species. Many farmers can learn the technology by seeing the new methods used by progressive farmers.

2) Introduction of New Crops by Showing them in the Demonstration Farm

Another way to introduce new species and varieties to farmers are by practical demonstrations in small fields. The field can be borrowed from some farmers near the office.

3) Distribution of Young Seedlings of Fruit Trees

Many extension offices have some nursery areas for young fruit trees and distribute the trees to the farmers without charge. It is very recommendable way to introduce promising fruit trees in the area and to increase the acreage under fruit trees.

4) Guidance to the Cooperative Use of Farming Machines

In recent years, two-and four-wheel tractors and power tillers are being introduced in some farms. Agricultural machines are so expensive that they are best used by many farmers. As for the methods of using big machines, a cooperative use is better. Big machines can plow the paddy and upland field deeply and plow the rice straw into the soil.

5) Improvement of Information System to Farmers and Their Organizations.

Many farmers don't know much about the new agricultural policy, promising crops, new farming technique and the marketing condition of

agricultural products. It is necessary to strengthen the information system among farmers and the extension office.

6) Quality Improvement and Classification of Agricultural Products

Many agricultural products are not classified by quality such as grade of maturity, size, color or freshness because it causes disadvantageous transactions for the farmers and results in low farmgate prices for agricultural products. Improvements in the quality of agricultural products and setting the standard for classification of agricultural products will bring more advantageous dealings to farmers and better prices for their products.

7) Cooperative Cargo Booking and Shipping System for Agricultural Products

Many agricultural commodities are sold through a middle man. However, many farmers have little knowledge of market information. Cooperative cargo booking will make the negotiation advantageous to farmers. Extension offices have the leadership as farmers can make the cooperative cargo booking and shipping system for their products.

8) Rearrangement of Paddy Fields

Most paddy field in the Study Area are of variable size and shaped irregularly. These situations disturb the effective use of paddy field. Paddy field should be rearranged in uniform size and shape to enable the effective management and use of farming machines.

3.9.3 Supporting Services for Agricultural Credit

Apart from technical aspects, strong supporting services regarding agricultural credit are required to realize the proposed agricultural plan. The Thai government has provided a special credit service to reform the cropping system from traditional crops to high-value crops since 1994, for which 5 % of interest and 15 year's payment period are applied.

However, statistics on farmer's indebtedness show that about 15 % of farmer's debt in the Study Area is from non-institutional services such as

merchants, wholesalers, relatives and neighbors on which higher interest is usually applied.

Meanwhile, the entire agricultural production condition in future will be considered rather severe. Along with a possible increase in demand for agricultural credit in future, the function of agricultural cooperatives should be strengthened to become more capable of performing the institutional credit service.

All the interest rates on agricultural credit should be lowered not only for the national policy-related projects but for overall agricultural investment to motivate farmers. Easy access to agricultural credit must also be considered.

3. 10 Summary of Overall Agriculture and Water Resources Development

3. 10. 1 Necessity for Development

The necessity for agricultural water resources development in the Study Area may be justified by the following reasons:

1) The result of the farm economic survey, revealed that about 80% of the farmers in the Study Area want to practice irrigated agriculture.

2) In the Study Area, the annual income of a farm household is 34,000 baht including a share of off-farm income of about 22,000 baht, which is equal to only 40 percent of the average income of a household in Thailand. Owing to this fact, it can be said that the Study Area is one of the less developed areas.

   In order to improve the income disparity between rural and urban areas and to stop migration from rural areas, agricultural development in the Northeastern Region including the Study Area has been given special priority in national development policy.

3) NESDB has a plan to develop the middle and northern parts of the Northeastern Region as a promotion zone for agro-industry, and some towns such as Nong Khai, Udon Thani, etc. as its center. In order to

realize the plan, a stable supply of large amounts of diversified agricultural products for industry will be needed.

4) Agricultural water resources development in the Study Area also meets the national water resources development policy of the government as explained below.

- Budgetary allocation for medium scale projects, formulated according to sound planning.

- Budgetary allocation for small scale projects, emphasizing these areas which are less well developed.

3.10.2 Size of the Development

The soils a distributed in the Study Area are mostly red-yellow podzolic soil or gray podzolic soil in upland areas, and humin gray soil in paddy land. In general, organic matter is insufficient and soil pH ranges from 5 to 6.

In addition to low soil fertility, there is another problem of soil salinity in the Study Area. However,very severely salt-affected soil which may cause damage to the plants (degree 1 and 2) exists only in very small areas. For upland crops or paddy rice, land suitability may not be the best but also not unsuitable for cultivation. Therefore, it can be said that there is no severe problem regarding the soil and land in developing the Study Area.

Under such conditions, the size of the development will be decided on the basis of farmers' requests. The area to be developed is determined as 64% of total agricultural land taking into consideration the following.

1) 80% of the farmers desire to practice irrigated agriculture.
2) Considering the land that will be lost due to right-of-way of on-farm development and also the land unsuitable for water supply due to its topographical condition, 80% of the area mentioned in 1) above will remain as an irrigation area. According to this assumption, the net area for development will be decided by subtracting the existing irrigated area from 64% of total agricultural land.

Target Area for Agricultural Development

Item	Mong Basin	Suai Basin	Luang Basin	Total
Agri. Land(ha)	140,000	105,000	215,000	460,000
" (rai)	875,000	656,250	1,343,750	2,875,000
Existing Irri. Area(ha)	9,100	9,700	22,400	41,200
(rai)	56,900	60,600	140,000	257,500
Target Area for Development(ha)	80,000	57,000	115,000	252,000
(rai)	500,000	356,000	718,000	1,574,000

3.10.3 Agricultural Development Strategy

The main objectives of the agricultural water resources development in the Study Area are to improve the living standard of farm households and to discourage the migration from rural areas through water based development. To accomplish the objectives , the following strategies will be adopted.

- Increase of irrigated agriculture, focusing on diversified cropping.
- Development of rural industry, based on the raw materials from diversified cropping and integrated farming.
- Introduction of integrated farming, especially in the rainfed agriculture areas.
- Promotion of small scale projects to serve the basic necessities of rural life.

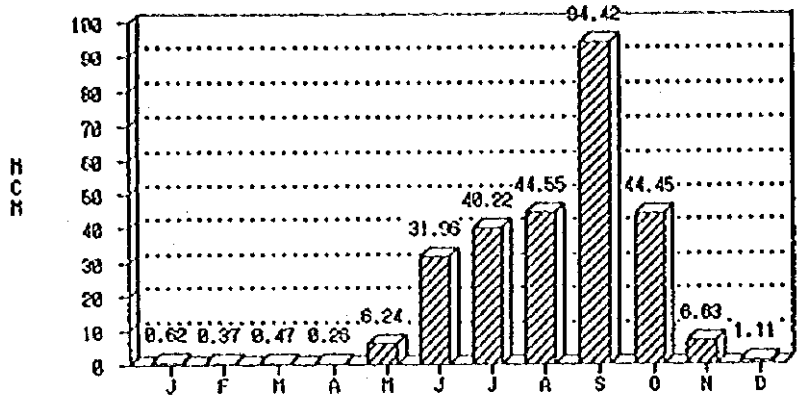
According to the above mentioned strategy and considering the national policy for restructure of agricultural productions, the crops as shown in Table 3.10-1 may be recommended.

3. 10. 4. Agricultural Water Resources Development

The monthly average discharge of KH-18, a representative discharge measuring station, upstream on the Huai Mong river is presented below.

Table 3. 10-1 Some Agro-Industries Utilizing the Agro-Products in the Study Area

Recommended Agro-Products		Methods for Processing	Main Products
Grains	Non-glutinous rice	Milling	Flour, Candy, rice cracker,
	Glutinous rice		Unbaked cake, Bun cake
	Soy bean	Milling, Oil	Flour, Oil, Feed for animals
	Mung bean	Sprouting Milling	Sprout of mungbean, Flour,
	Ground nut	Oil & cake making	Oil & cake
	Maize	Oil manufacture	Corn salad oil
	Maize	Grinding & mixing	Feed for animals, poultry, fishes
	Sorghum	〃	
	Sun flower	Oil manufacture	Sunflower oil for machines
Vegetables	Baby corn	Vacuum Packing	Canned & Vacuum Packing of
	Asparagus	and canning	baby corn & asparagus
	Cucumber, Egg plant	Salt-pickling	Salt-pickling of vegetables
	〃	Canning, Packing	Canned & Vacuum packed vegetables
	Tomato	Juice, Ketchup	Juice and Ketchup of tomato
Spice	Chilli	Pepper manufacture	Chilli
	Pepper		Pepper
Sugar	Sugar cane	Sugar manufacture	Refined sugar
Starch	Cassava	Starch, Feed	Cassava starch, feed for animals
Cotton	Cotton	Cotton manufacture	Cotton goods
		Seed manufacture	Cotton oil, Feed for animals,
Fruits Fruits		Canning, Juice	Canning and juice of fruits
		Refrigerating	Refrigerating of fruits
	Pine apple	Canning, Juice	Canning and juice of pine apple
Industrial	Young bamboo shoot	Canning	Canning of bamboo shoots
Livestock	Cattle.Swine.	Ham. Sausage	Ham, Sausage
	Chicken	Processing of Innards & bone	Pet Feed



Monthly Average Discharge (Huai Hong)
(C.A.=1,387 sq.km, Ban Na Ang)

From the figure it can be understood that 97% of the annual runoff flows down during the months of May through October(rainy season), which means runoff in the dry season is only 3%. Therefore, in order to preserve water for dry season irrigation, the construction of storage dams is essential.

Agricultural land of the Study Area is 53% of the total area. In general, for a satisfactory irrigation system, the reservoir must have a catchment area six to ten times larger than its command area. Therefore, even if there are many damsites in the area, it will not be possible to irrigate all the agricultural land with the existing surface water resources potential if withdrawal of Mekong river water is not considered.

From the above circumstances, it is recommended that the agricultural water resources development (1) within the Study Area should be given first priority and (2) to the use of Mekong water.

1) Development of Water Resources in the Study Area

Since there are very few damsites and on the other hand the agricultural water demand is very high, water resources will be developed as much as possible in the Study Area. The development strategy will consider the following points.

- Construction of medium scale projects considering sound planning.
- Construction of more small scale projects
- Rehabilitation/Improvement of existing Facilities
- Encourage the participation of farmers in O/F water management emphasizing the improvement of irrigation efficiency.

Keeping in mind the problem of land acquisition and irrigation efficiency, introduction of a pineline water supply system should be examined.

Considering all the points that are explained above, the agricultural water resources development plan for the Study Area is formulated as presented below:

RID Projects

Large Scale	:	Rehabilitation of Huai Luang Project
Medium Scale	:	Construction of 17 new and improvement of 7 projects
Small Scale	:	Construction of 263 new and improvement of 121 projects, 138 dredging projects.

DEDP Projects

Nam Suai River Basin Project (Cropped area = 17,750ha(110,940rai)

Lower Huai Luang Project (Cropped area = 19,200ha(120,000rai)

When all of the above mentioned projects are implemented, the total irrigated area would be as tabulated below.

Item	Mong Basin	Suai Basin	Luang Basin	Total
Target area(ha)	80,000	57,000	115,000	252,000
" (rai)	500,000	365,000	718,000	1,574,000
Developed Area(ha)	10,360	24,288	33,460	68,108
(rai)	64,750	151,810	209,120	425,680
Remained area(ha)	69,640	32,712	81,540	183,892
(rai)	435,250	213,190	508,880	1,157,320
Develop. Ratio(%)	13.0	42.6	29.1	27.0

The maximum development of the water resources potential will cover 27 % of the target area. If a larger area is planned to be brought under irrigation, withdrawal of Mekong river water will be necessary.

2) Utilization of Mekong River Water

When utilization of the Mekong water is considered, the high elevated area of Huai Mong and Huai Luang upstream areas will be excluded. In that case, areas to be developed may be summarized as follows.

Water Resources Development of Mekong River

Item	Mong Basin	Suai Basin	Luang Basin	Total
Case 1 :				
Target area (ha)	41,000	32,000	72,000	150,000
(rai)	256,250	200,000	481,250	937,500
Case 2 :				
Target area (ha)	33,000	21,000	51,000	105,000
(rai)	206,250	131,250	318,750	656,250

Case 1 : Traget area based on the request of the farm families

Case 2 : Area excluding unsuitable land for cultivation from target area of Case 1

The Mekong water utilization plan is presented in Figures 3.6-3 and 3.6-4.

The target area for development by using the Mekong river water is planned at 150,000 ha as indicated in the above table. This figure represents the request of the farm families as confirmed in the farm economic survey, however, the figure may be decreased down to 105,000 ha when the lands with unsuitable soils for cultivation as designated in General Potential Map for Agricultural Land Use prepared by DLD are subtracted.

In case Mekong water withdrawal in the rainy season would be easier but withdrawal in the dry season will require the permission of the Joint Committee of Mekong River Commission. In case of a plan to irrigate all of the planned area i.e. 150,000ha(937,500rai), the required amount of water for the dry season would be about 60cu.m/s. On the other hand, the dry season discharge of the Mekong river at Vientiane varies from 900 to 1,200 cu.m/s in normal years.

3) Implementation Plan for Agricultural Water Resources Development

The implementation plan for agricultural water resources development in the Study Area may be shown as follows.

Phase	Mekong water		Increased area	Total
	R. season	D. season		
Existing				41,280ha
				258,010rai
Phase-I(~2006 year)			68,110ha	109,390ha
(only within the Study Area)			425,680rai	683,690rai
Phase-II(2007~2016 year)	50cu.m/s	20cu.m/s	50,000ha	159,390ha
			312,500rai	996,190rai
Phase-III(2017~)	150cu.m/s	60cu.m/s	100,000ha	259,390ha
			625,000rai	1,621,190rai

At present, amount of available water from Mekong river for development of the Study Area. The development of Mekong river water for use in the area may be implemented under the Phases II and III of the subject agricultural water resources development. In the Phase II, the target area of about 50,000 ha may be selected along the feeder canal favoured with comparatively better soil conditions, as shown in Figure 3.6-3. In case if the available water from Mekong river is less than the amount required for Phase II project development, the target area might be reduced. If the available water have some allowance, then Phase III project could be proceeded after the year 2017. Water supply to the development area under Phase III project will be made by providing additional pumping facilities and extending irrigation facilities of Phase II project and DEDP's projects such as Huai Mong project, Nam Suai Basin project and Lower Huai Luang project. Further, it is noted that the capacity of feeder canal to be constructed inr Phase II should be capable of supplying water for Phase III development.

CHAPTER 4. SELECTION OF PROJECTS FOR DETAILED M/P STUDY

CHAPTER 4. SELECTION OF PROJECTS FOR DETAILED M/P STUDY

4.1 General Description

The priority project area, which has a good water resources development potential, will be selected from each river basin. And then suitable projects will be selected to carry out the detailed Master Plan Study on water resources development for irrigation or flood protection.

4.2 Priority Project Area

4.2.1 Division of River Basin

The river basin is divided into some sub-basins for the purpose of selection of the priority project area as shown in Table 4.1-1 and Figure 4.1-1, as summarized as shown below.

Division of River Basin for Selection of Priority Project Area

River Basin	Sub-Basin	Area(sq.km)
1) Huai Mong River Basin	1-1. Upper Reach	1,307
	1-2. Middle Reach	747
	1-3. Lower Reach	657
2) Nam Suai River Basin	2-1. Upper Reach &Other River Basin	885
	2-2. Lower Reach	911
3) Huai Luang River Basin	3-1. Upper Reach	1,730
	3-2. Middle Reach	1,355
	3-2. Lower Reach	1,015

4.2.2 Criteria of Selection

The priority project area is defined as the area with good potential for agricultural water resouces development which is capable of supporting irrigated agriculture during the dry season. Accordingly, high prioriy should be given to the area with availability of water resources, especially for dry season irrigation.

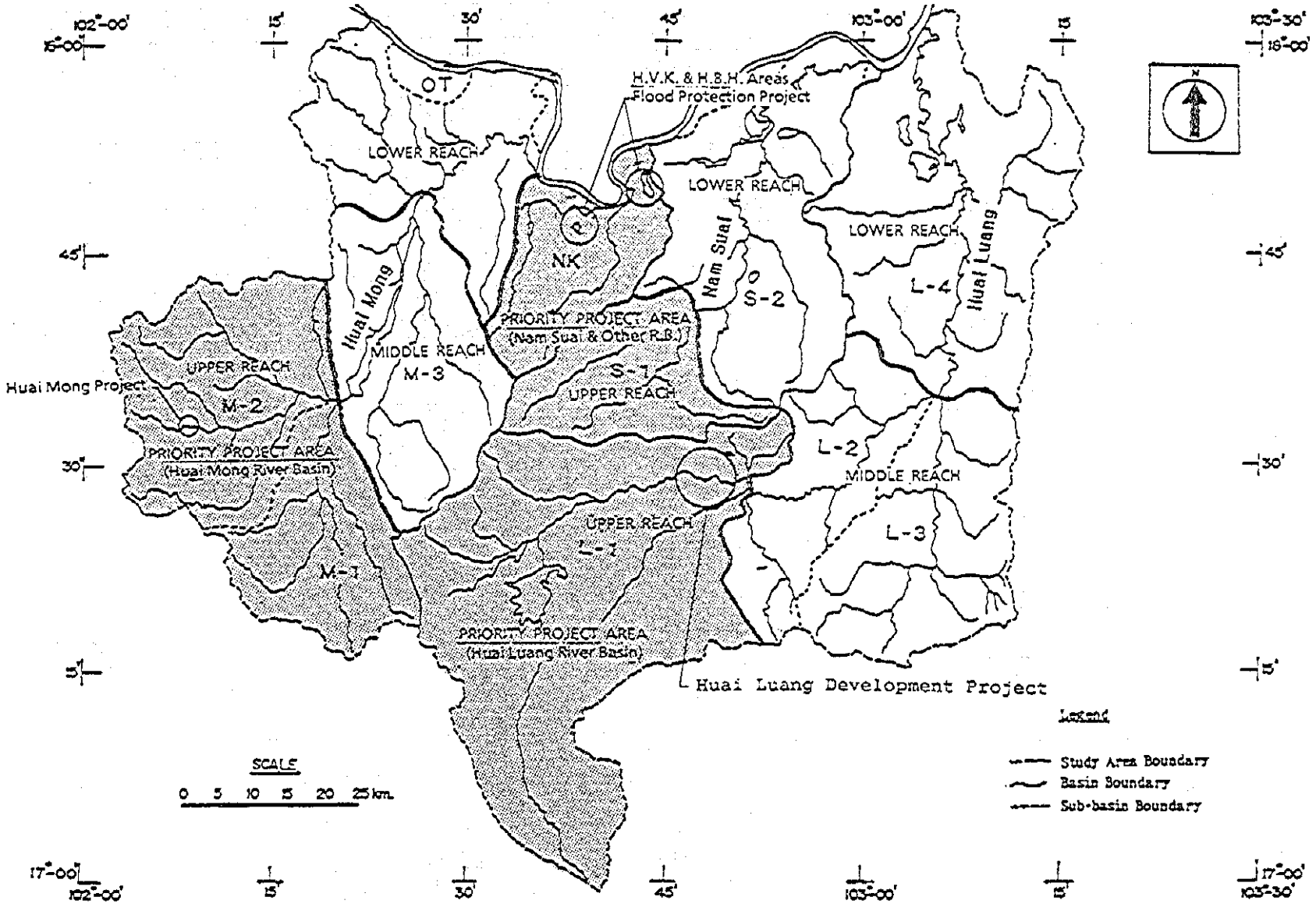


Figure 4.1-1 Division of River Basin for Selection of Priority Project Area

Table 4.1-1 Sub-Basins for Selection of the Priority Project Area

Sub-basin	Drainage Area (sq.km)	Small Scale Project		Medium Scale Project		Total		BMH *1)
		Nos.	Storage Cap. (MCM)	Nos.	Storage Cap. (MCM)	Nos.	Storage Cap. (MCM)	
1. Huai Mong River Basin		*2)						
1-1 Upper Reach (M-1, M-2)	1,307	23	11.3	5	29.6	28	40.9	8-14/37 (2)
1-2 Middle Reach (M-3)	747	4	2.0	1	9.8	5	11.8	6-11/37 (3)
1-3 Lower Reach (M-4)	657	4	2.1	1	6.2	5	8.3	9-15/37 (1)
Sub-Total	2,711	31	15.4	7	45.6	38	61.0	
2. Nam Suai River Basin								
2-1 Upper Reach & Other River Basin (S-1, NK-1, OT-1)	885	6	2.6	2	27.1	8	29.7	10-13/37 (1)
2-2 Lower Reach (S-2)	911	7	3.7	-	-	7	3.7	7-14/37 (2)
Sub-Total	1,796	13	6.3	2	27.1	15	33.4	
3. Huai Luang River Basin								
3-1 Upper Reach (L-1)	1,730	4	1.8	7	31.6	11	33.4	8-11/37 (2)
3-2 Middle Reach (L-2, L-3)	1,355	26	12.5	1	7.3	27	19.8	7-8/37 (3)
3-3 Lower Reach (L-4)	1,015	4	1.9	-	-	4	1.9	9-11/37 (1)
Sub-Total	4,100	34	16.2	8	38.9	42	55.1	
4. Study Area (Total)	8,607	78	37.9	17	111.6	95	149.5	

*1) BMH: Basic Minimum Needs by the data of the Ministry of Interior.
*2) Nos. of reservoir projects only.

Limited water resouces should be distributed widely in the sub-basin , therefore the number of projects proposed in the sub-basin will be considered in selecting the priority project area.

The projects proposed in environmentally sensitive areas such as Conserved Forest land should be given low priority.

The main objective of the integrated agriculture and water resources development is to improve the living conditions of farm families. High priority will be given to the sub-basin where the quality of life is comparatively low. As mentioned in Chapter 2.8.9, Basic Minimum Needs(BMN) has already been studied to know the quality of life in sub-basins by using the data of the Ministry of Interior. There are 37 categories for estimating BMN and the quality of life can be judged by the number of categories which do not meet the target.

Based on the above considerations, the selection criteria of the priority project area as shown in Table 4.2-1 are adopted.

Table 4.2-1 Criteria of Priority Project Area Selection

1) Availability of Water Resouces (40%)

Rank	Point	Weighted Point
A	50	20
B	30	12
C	10	4

2) Number of Medium and Small Scale Projects (20%)

Rank	Point	Weighted Point
A	50	10
B	30	6
C	10	2

3) Location of Project (20%)

Rank	Point	Weighted Point	
A	50	10	(Other than conserved forest land)
B	30	6	(conserved forest land)

4) Quality of Life (20%)

Rank	Point	Weighted Point
A	50	10
B	30	6
C	10	2

4. 2. 3 Priority Project Area

The sub-basins divided for selection of the priority project area are screened by the criteria of selection shown in Table 4.2-1, and the results are as follow.

Selection of Priority Project Area

Sub-Basin	Water Resouces	Num. of Project	Project Location	B.M. Needs	Total
1. Huai Mong River Basin					
1-1. Upper Reach	(A) 20	(A) 10	(B) 6	(B) 6	42 (1)
1-2. Middle Reach	(B) 12	(B) 6	(A) 10	(C) 2	30 (2)
1-3. Lower Reach	(C) 4	(B) 6	(A) 10	(A) 10	30 (2)
2. Nam Suai River Basin					
2-1. Upper Reach & Others	(A) 20	(A) 10	(A) 10	(A) 10	50 (1)
2-2. Lower Reach	(B) 12	(B) 6	(A) 10	(B) 6	34 (2)
3. Huai Luang River Basin					
3-1. Upper Reach	(A) 20	(B) 6	(A) 10	(B) 6	42 (1)
3-2. Middle Reach	(B) 12	(A) 10	(A) 10	(C) 2	34 (2)
3-3. Lower Reach	(C) 4	(C) 2	(A) 10	(A) 10	26 (3)

From the results of screening by the criteria, the priority project area for each river basin is selected as follows:

Priority Project Area

1.Huai Mong River Basin	Upper Reach
2. Nam Suai River Basin	Upper Reach & Other River Basin
3. Huai Luang River Basin	Upper Reach

4. 3 Projects for the Detailed Master Plan Study

The selection of the projects for the detailed Master Plan Study has been made giving importance to the various types/nature of the projects which is more beneficial to RID, as mentioned below. A list of the proposed medium scale projects is presented in Table 4.2-2.

1) Huai Mong River Basin

The EIRR and irrigable area stated in Table 4.2-2 shows that the Huai Mong project is the most economical and has the largest irrigable area in the

Table 4.2-2 List of Proposed Medium Scale Projects

Project Name	Catchment Area Sq.km.	Effect. Storage MCM	Irrigable Area	Crop Intensity %	EIRR *1)% Case-1	EIRR *1)% Case-2	Agri. Land in Reservoir Area
HUAI MONG RIVER BASIN							
1. H. Kholo (U/R)	80.0	9.8	800 ha (5,000 rai)	140	-4.4	0.2	86 ha (540 rai)
2. H. Mong (U/R)	57.1	12.2	1,000 ha (6,250 rai)	140	4.8	19.6	36 ha (230 rai)
3. H. Yap (U/R)	27.9	2.0	160 ha (1,000 rai)	140	-4.7	-0.2	56 ha (350 rai)
4. H. Khanan (U/R)	18.4	4.3	400 ha (2,500 rai)	130	0.2	0.2	118 ha (740 rai)
5. H. Han (U/R)	5.6	1.3	130 ha (810 rai)	120	-2.4	1.8	7 ha (40 rai)
6. H. Ngao (M/R)	85.3	9.8	800 ha (5,000 rai)	140	-0.4	5.8	608 ha (3,800 rai)
7. H. Ma (L/R)	27.1	6.2	1,000 ha (6,250 rai)	110	0.1	4.2	40 ha (250 rai)
Sub-Total	301.4	45.6	4,290 ha (26,810 rai)	131			
NAM SUAI RIVER BASIN & OTHERS							
1. H. Thong (U/R)	74.0	17.5	1,920 ha (12,000 rai)	130	6.5	6.5	421 ha (2,630 rai)
2. H. Khuk (Others)	37.0	9.6	990 ha (6,190 rai)	140	10.5	10.5	330 ha (2,060 rai)
Sub-Total	111.0	27.1	2,910 ha (18,190 rai)	133			
HUAI LUANG RIVER BASIN							
1. H. Hin (U/R)	48.9	10.6	1,100 ha (6,880 rai)	110	-0.4	3.4	344 ha (2,150 rai)
2. H. Sai-1 (U/R)	9.0	1.9	200 ha (1,250 rai)	110	-4.6	-1.7	48 ha (300 rai)
3. H. Takrai (U/R)	5.4	1.2	120 ha (750 rai)	110	-6.4	-3.5	12 ha (80 rai)
4. H. Pla Da (U/R)	10.6	2.3	230 ha (1,440 rai)	110	-4.3	-1.2	7 ha (40 rai)
5. H. Limi (U/R)	22.5	4.8	500 ha (3,120 rai)	110	-3.9	-0.9	23 ha (140 rai)
6. H. Mek (U/R)	26.5	5.7	580 ha (3,620 rai)	110	-0.6	-3.0	30 ha (190 rai)
7. H. Chaing (U/R)	23.7	5.1	480 ha (3,000 rai)	110	-3.0	-0.2	8 ha (50 rai)
8. H. Dan (M/R)	120.6	7.3	600 ha (3,750 rai)	140	-2.9	-1.6	384 ha (2,400 rai)
Sub-Total	267.2	38.9	3,810 ha (23,810 rai)	115			
Total	679.6	111.6	11,010 ha (68,810 rai)				

*1) EIRR was calculated for Case 1 and 2. (Refer to Part 5 of Appendix G)
Case 1 Cropping pattern (wet paddy + selected crops such as soybean, mungbean, tomato) and
Case 2 Cropping pattern (wet paddy + tomato)

Upper Reach of Huai Mong Basin. Therefore, Huai Mong project (medium scale irrigation project with a dam/reservoir) has been selected as the project for detailed Master Plan Study.

2) Nam Suai River Basin

In the Upper Reach of Nam Suai basin and the Other River Basins, two medium scale projects have been identified. These projects are economically viable for irrigation purposes but have large amounts of agricultural land in the reservior area. Therefore, considering the importance of flood protection in the lower reach of the basin, the Huai Vieng Kook and Huai Bang Phuan areas flood protection project is selected for detailed Master Plan Study.

3) Huai Luang River Basin

Cost analysis shows that there is no economically feasible project for irrigation purposes in Huai Luang basin, although there are eight identified projects. Thefore, considering the future water demand for domestic/industry in and around Udon Thani province and the importance of small scale projects, Huai Luang Development project with the following project components is taken up as a project for detailed Master Plan Study.

Huai Luang Development Project

1. Improvement and Rehabilitation of Existing Project
2. River Training and Water Impounding project
   - Huai Luang River training
   - River Water Impounding
   - Small Scale Irrigation Project

Improvement and Rehabilitation of the existing Huai Luang project is excluded from detailed Master Plan Study according to RID's request, because RID has a plan to study the rehabilitation of existing Huai Luang project.

PART-2 DETAILED MASTER PLAN STUDY

CHAPTER 5. HUAI MONG PROJECT

CHAPTER 5. HUAI MONG PROJECT

5.1 Project Area

5.1.1 Project Location and Area

The Huai Mong Projec Area is the rural area developed between the mountains/hills, which is situated in the most upper reaches of the Huai Mong. The land area is some 1,000 ha extended over the Tambon Bun Than and Ban Khok, Amphoe Suwan Khuha, Nong Bua Lamphu province.

Project Area

Tambon	Area (ha)
Bun Than	200
Ban Khok	800
Total	1,000

5.1.2 Topography and Geology

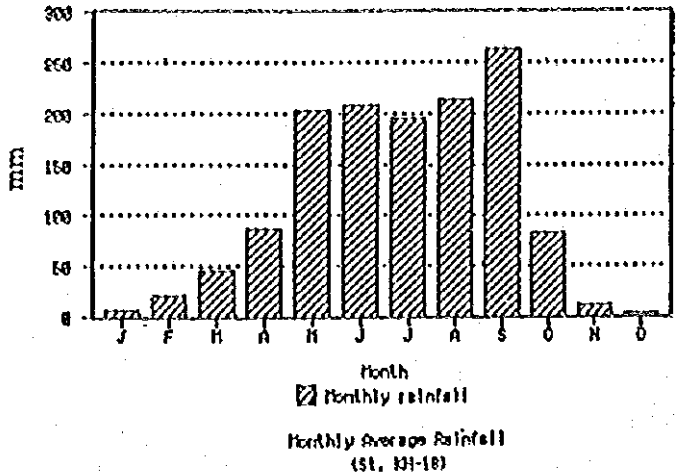
The land extends, as a long strip of land with a width of about 1 km and a length of about 15 km, along the said river. The lands have a gentle slope from the upstram to the downstream with a gradient of about 1 in 500 to 800. The lands elevation are about 250 m MSL in the upstream area and about 200 to 220 m MSL in the middle and downstream area.

The lands consists geologically of the paleozoic sandstone, siltstone and shale in most areas, the limestone in some areas of the down-stream and phyllite/quartzite in the upstream area.

5.1.3 Hydrology

The project area is located in the upstream of Huai Mong river itself. There is a mountainous ridge with the height of 300-500MSL crossing the Huai Mong main stream and other tributaries of Huai Mong. The other tributaries are Huai Khana, Huai Yap and Huai Kholo. In the rainy season the main stream including all tributaries become very active but in the dry season there found almost no flow. During the field visits, farmers in the area reported that they experience flush floods in the years when there is a heavy rainfall. In the

main stream there are few weirs constructed by RID to hold water for the dry season irrigation or for domestic uses. There is no rainfall or discharge measurement station in the vicinity of the dam site but KH-18 which is about 30 km down stream can be used as a representative station. The average monthly rainfall of KH-18 is presented in the figure below. Monthly discharge is presented in Figure 2.2-5 of Chapter 2.



Monthly Average Rainfall
(St. KH-18)

5.1.4 Soil and Land Classification

Most of the soil in upper paddy field in the area is Clayey Paleustults, and the soil in middle paddy field is Skeletal Plinthustalts as per the USDA classification. The most of the mountainous area is covered by the so-called Slope Complex.

The characteristics of the soil are of loam or sandy loam in texture, red-yellow or dark brown in color, low in organic matter and CEC and low soil pH in general. The land classification by the soil suitability group for paddy rice may be grade 2 or 3 from the view point of productivity. That is moderately suited for rice production. The area of saline is not existed in the area, as is already shown in Appendix Figure 2.6-2.

5.2 Present Agriculture

5.2.1 Land Use

Agricultural land use in two tambon in Amphoe Suwan Khuha is shown in Table 5.2-1.

Table 5. 2-1 Agricultural Land Use in Huai Mong Upper Area.

(whole Tambon Bases)

Tambon	Bun Than		Ban Khok		Total Area		Area
Unit	Rai	ha	Rai	ha	Rai	ha	(%)
Total Area	60,625	9,700	79,744	12,759	140,369	22,459	
Agricultural Land	57,465	9,194	60,000	9,600	117,465	18,794	100.0
Paddy Field	13,626	2,180	18,817	3,011	32,443	5,191	27.6
(Use of dry season paddy)	1,450	232	4,568	731	6,018	963	
Upland Field	18,242	2,919	19,580	3,133	37,822	6,052	32.2
Vegetables Field	171	27	233	37	404	64	0.3
Fruit & Perennial	1,549	248	1,255	201	2,804	449	2.4
Forest & Grassland	23,879	3,821	20,115	3,218	43,994	7,039	37.5

As shown in Table, the area of paddy field is not so large in the area comparing to the other districts in the Study Area, due to the topography of mountainous area. However, the cropping intensity of paddy field is very high comparing to other districts of the Study Area. The farmers are utilizing intensively the paddy field even in dry season, and cultivating soy bean in wide area.

The area of upland field, forest and grassland occupy about 32.2 % and 37.5 % of the total agricultural area. In upland field, many kinds of crops such as cassava, maize and ground nut are cultivated. However, land use of forest and grassland remains at low level.

5. 2. 2 Water Use

Water use in the area may be classified into three purposes as agricultural, domestic and drinking water. In the rainly season agricultural activity is dependent on rain. In the dry season water is very scarce. Only 5% (18% of paddy area) of total agricultural land is cultivated. There are some weirs constructed across the Huai Mong river to hold water for the dry season use but amount is very limited. Farmers also use the swamp water to irrigate small area by using small pumps or carrying water manually from the nearest source.

For domestic purpose, underground water (digging well) is mainly used. Drinking water source is rain water as collected during the rainy season and reserved in a big Jar for the whole season. However, scarcity of water, especially in the dry season, is a chronic problem in the area.

5. 2. 3 Population, Farm Households and Farm Labour Force

The area covers two Tambon, that is, Bun Than and Bang Khok in Amphoe Suwan khuha in Nong Bua Lamphu province. Population in the beneficial area is estimated at about 800 with 80 persons/km^2 of population density.

The number of households are also estimated at about 140 and all of these households live on farming with 5.8 family size and 2.97 of farm labour force per family.

5. 2. 4 Agricultural Production

The planted area of major rice and soybean in dry season paddy field in two Tambon is shown in Table 5.2-2 with cropping intensity. The more detail data is shown in Appendix Table 5.2-5. The number of agricultural machines is shown in Table 5.2-3.

Table 5.2-2 Planted Area of main crops in two Tambon in Suwan Khuha

Tambon	Bun Than		Ban Khok		Total Cropping Area	
Crops Unit	Rai	ha	Rai	ha	Rai	ha
Glutinous Rice	13,363	2,138	13,035	2,086	26,398	4,224
Non-glutinous Rice	263	42	5,782	925	6,045	967
Dry-season Crops in Paddy Field						
Soybean	1,450	232	4,568	731	6,018	963
Cropping intensity in paddy		110.6		124.3		118.6

Source: By Amphoe Agricultural Office.

Table 5.2-3 Number of Agricultural Machines in two Tambon in Suwan Khuha

Tambon	Bun Than	Ban Khok	Total
2 & 4 wheel Tractor	18	15	33
Powr Tiller	83	426	509
Water Pump	8	315	323
Rice Mill	4	19	23
Threshing Machine		12	12

Source: By Amphoe Agricultural Office.

As shown in Table 5.2-5, paddy field is used for rice cultivation almost 100 % in rainy season, and in dry season 18.6 % of paddy field is used for cultivation of soybean.

The average yield of major rice in Suwan Khuha are comparatively high in the Amphoe of the Study Area. One reason of high yield of major rice in the Amphoe Suwan Khuha may be attributed to the intensive use of paddy field in dry season by leguminous crops.

As to the farming machines, the farmers of the Area are holding many number of 2 & 4 wheel tractor, power tiller and water pump, and these machines are utilized by cultivating the paddy and upland field for cultivating the major rice, soybean and upland crops.

5. 2. 5 Livestock

The number of livestock in two Tambon in Suwan Khuha is shown in Table 5.2-4.

Table 5.2-4 Number of livestock in two Tambon in Suwan Khuha

Tambon	Bun Than	Ban Khok	Total
Buffaloes	224	1,295	1,519
Beef Cattle	160	1,036	1,196
Weine	568	545	1,113
Chicken	3,061	8,908	11,969
Duck	2,655	3,640	6,295

Source: By Amphoe Agricultural Office.

The number of buffaloes and beef cattle in Tambon Bun Than is fewer than Tambon Ban Khok from the view point of the number of farmhousehold. The reason is not clear, but Tambon Bun Than has wider area of forest and grassland than Ban Khok, so, it will show the possibility of increasing the number of cattle.

5. 2. 6 Marketing

The major crops in this area are paddy, maize and cassava in rainy season and soybean, sweet corn in dry season. Paddy and cassava are marketed through middlemen to Ban Phu which is the adjacent Amphoe.

5. 2. 7 Agricultural Supporting Services

Agricultural extension workers are disposed in the Amphoe agricultural extension office to advise farmers on farming techniques, etc.

Branch office of BAAC exists at Muang Nong Bua Lamphu for credit agricultural services.

5. 2. 8 Farm Household Economy

The annual household incomes in the area are estimated at about 25,000 Bahts/family which derives from farm income and off-farm incomes. This income level is lower than that of average of Province Nong Bua Lamphu and lower than the poverty line of 33,800 Bahts/family/year. Some 35 % to 40 % of farmers go outside the village to get off-farm incomes.

Basic minimum needs (BMN) which is studied by the Ministry of Interior shows that the quality of life in this area are judged relatively lower than that of Province Nong Bua Lamphu. Some 14 categories among 37 categories are not met with the target. Poverty is also the main issue in the area(refer to Part-4 of Appendix G).

Electricity is supplied but constraints are in irrigation and domestic water supply depending on rainfall, groundwater and rivers.

5. 3 Development Plan

5. 3. 1 Objectives of the Project

The Project aims to increase the income and create the employment opportunity and upgrade the living standard of peoples residing in the remote

rural area between the hills through the provision of irrigation facilities, mitigation of flood damages and improvement of rural infrastructures. The people in the project area are very poor within the Study Area, as pointed out as lower in 14 items out of 37 items of Basic Minimum Needs (BMN). Around 35 to 40 % of young and middle aged men are working in the outside area. It is expected that the project will cause the peoples to come back home and overcome their poverty.

5. 3. 2 Water Resources Development

1) River Runoff

Runoff for the dam reservoir has been calculated using the developed Tank Model. The length of of the runoff generation is twenty years (1974-93). Monthly average is presented below.

Unit: MCM

J	F	M	A	M	J	J	A	S	O	N	D	Total
0.34	0.30	0.32	0.30	1.24	3.03	2.37	3.07	3.47	1.64	0.39	0.38	16.85

2) Water Requirements

a) Irrigation Water Requirement

Irrigation water requirement was calculated according to the proposed cropping intensity of 140%, i.e., 100% in the rainy season and 40% in the dry season. These intensities were decided considering the stabilization of supplemental irrigation in rainy season and maximization of dry season irrigable area with the available water resource.

b) Crop Consumptive Use

In order to acquire the consumptive use of crops, reference crop evapotranspiration (ETo) was calculated applying the modified Penman Method. In the calculation, meteorological data (1961-90) of Udon Thani was used. The monthly basis ETo is as presented below.

Unit:mm/day

J	F	M	A	M	J	J	A	S	O	N	D	Avr.
5.4	5.6	5.8	5.3	4.1	3.4	3.3	3.6	4.0	5.0	5.4	5.4	4.7

Thus, multiplying the ETo by crop coefficient, consumptive use of crop was determined. Crop coefficients for various crops are presented in Appendix I.

In calculating total crop water requirement, 1.5mm/day percolation loss and 250mm as land preparation requirement were assumed in case of rice cultivation, and 80mm was assumed as an additional requirement for dry season crops. The estimated requirements may be summarized as follows. Deatail of the calculation is presented in the Appendix I.

Estimated Water Requirement

Wet season paddy rice(HYV)	:	757mm
Dry season upland crops(Soybean)	:	569mm

c) Effective Rainfall

Not all of the rainfall can be used effectively. Therefore, from the experience of other projects the following assumptions are made.

Crop	Effec. rainfall (mm)	Maximum	
		Month (mm)	10-day (mm)
Paddy	0.75 R	200	70
Upland	0.75 R	120	50

R= Monthly or 10-day rainfall

d) Irrigation Efficiency

Irrigation Efficiency of 50 % is adopted for calculation of water requirement.

3) Water Balance Study

In order to know the optimum size of the reservoir, trial operations with different capacities and proposed cropping pattern have been made. The

operation was performed for twenty years on a 10-day basis. The best suited result was found when reservoir capacity was set at 12.2 MCM. The study shows that with a crop intensity of 140%, the water shortage occurs twice in twenty years, in other words a probability of once in ten years. Which may be taken as an ideal case. Figure 5.3-1 shows the result of the reservoir operation. Detail of the calculation is presented in the Appendix C.

Assumptions:

Reservoir water surface area : 1.65-0.40 sq.km	
Percolation loss	: 1.5mm/day
Evaporation loss	: Muang Udon Thani
Inflow/Outflow	: 10day basis for 20 years
Wet season area	: 1,000ha
Dry season area	: 400ha
Effective storage	: 12.2 MCM
Dead storage	: 1.1 MCM

4) Water Duty

Main Canal

Taking effective rainfall into account, maximum water requirement during the land preparation was analysed and a 1/10 year drought year is selected for main canal capacity and it shows a value of 1.80 l/s/ha. The calculation may be done as follows.

Net water requirement/day	= 78/10 = 7.8 mm/day
Irrigation efficiency	= 50%
Water duty	= 7.8/0.50 = 15.6 mm/day
	= 1.80 l/s/ha

On-farm Facilities

In calculating water duty for on-farm facilities, it was assumed that 30 days will be required for land preparation and water for land preparation(250mm) will be supplied in three times in such a way that 150mm as 1st irrigation, 39mm as 2nd irrigation and 61mm as 3rd irrigation. Thus

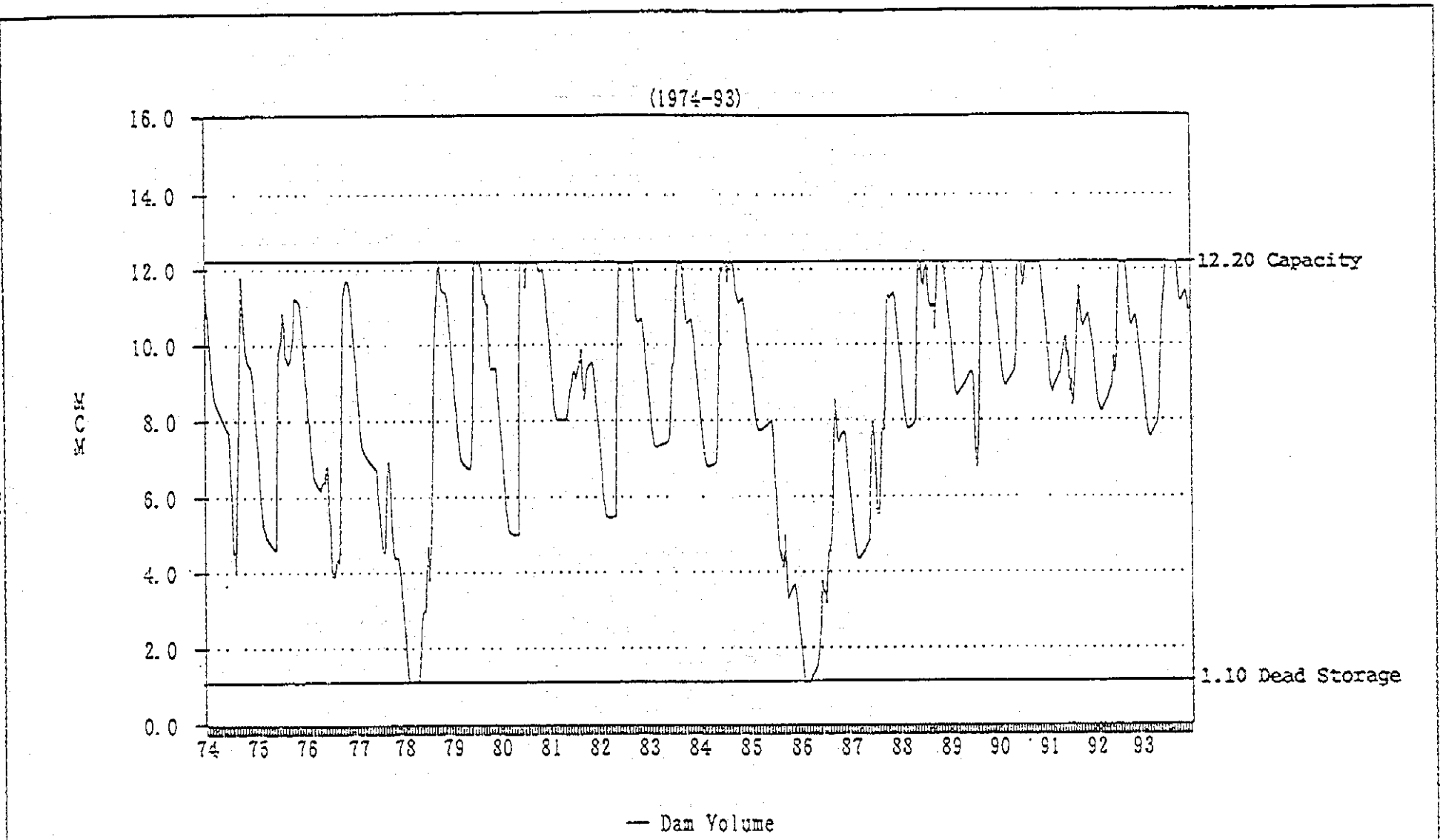


Figure 5.3-1 Reservoir Operation(Huai Mong)

water duty becomes 2.30 l/s/ha for farm-ditches. The calculation procedure may be shown as follows.

$$Qp = \{(1/n * p) + 1/n*(n-1)*d\} * A/E = 2.27 \text{ l/s/ha} = 2.30 \text{ l/s/ha}$$

Where, Qp = peak field water requirement

n	= Time to prepare land	= 30 days
p	= Land preparation water	= 150 mm/day
E	= Irrigation efficiency	= 0.50
d	= Consumptive use + percolation	= 5.0mm/day
A	= Unit irrigation area	= 1.0 ha

5. 3. 3 Agricultural Development

1) Irrigation Area and Selection of Crops

The total paddy field area in Tambon Bun Than and Ban Khok are 5,191 ha as already shown in Table 5.2-1. In this field, 200 ha of paddy field in Tambon Bun Than, 800 ha of paddy field in Tambon Ban Khok, total 1,000 ha of paddy field were selected as the irrigation area for the project.

As the crops in this selected irrigated paddy field of two Tambons, major rice in rainy season and soybean in dry season were selected, and the area of soybean in dry season was proposed to be 400 ha by the limitation of water in dry season. The variety of major rice in rainy season is high yield variety under supplemental irrigation, and the crop in dry season is soybean. Farmers have a fixed level of techniques and experiences on cultivation of soybean, and the crop has the high demand as for the most suitable oil crops in Thailand. Soybean will be a promising crop in the dry season paddy field of the Project Area.

On the irrigation plan in the Project Area, 1,000 ha of paddy field will be used for the supplemental irrigation area of major rice, and 400 ha of paddy field in dry season will be used for soybean cultivation including the existing area in both Tambons of Bang Khok and Bun Than.

Irrigation plan in the Project Area will be summarized as follows;

Table 5.3-1 Irrigation Plan in the Project Area

(Unit : ha)

Tambon	Bun Than		Ban Khok		Total	
Existing/Plan	Existing	Plan	Existing	Plan	Existing	Plan
Total Paddy Area	2,180		3,011		5,191	
Supplemental Irrigation Area		200		800		1,000
Proposed Soy Bean Area		80		320		400
Other Soy bean Area	211		537		748	
Cropping Intensity in Paddy Field		113.3%		128.5%		122.1% [140]

2) Yield Projection

Expecting the higher yield of major rice in the Project Area than the other area, supplemental irrigation was planned in land preparation period, transplanting time and in some insufficient time in growing period. The variety of major rice was planned to use the high yielding variety. In parallel with the supplemental irrigation and high yielding variety, more intensive management such as fertilization, weed control and water management will be implemented to get higher yield of major rice.

Irrigation for soybean cultivation in dry season is also carried out one for sowing time and several times for growing period, and intensive management is planned to use some chemicals such as herbicides suitably. So the yield of two crops will be expected to be higher than usual one.

The outlines of cropping management and yield projection on two crops are shown in Table 5.3-4 of Appendix F, and the cropping season of main crops and land use plan in Huai Mong Project Area is shown in Fig. 5.3-3 of Appendix F.

3) Integrated Agricultural Development

a) Development of Animal Husbandry

Existing number of buffaloes and beef cattle in two Tambons are 1,519 and 1,196 heads respectively. The two Tambons have about 7,000 ha of wide forest and grassland in hilly and mountainous area. Using the area as grassland for beef cattle and using the byproduct of farming such as rice straw

and shell of soybean, 1,000 heads of beef cattle can be fed in the area in addition to the existing number.

b) Development of Fruit trees

Existing area of fruit trees in two Tambons is 449 ha, and are growing many kinds of fruit trees such as mango, sour tamarind, papaya and banana. Two hundred ha of fruit trees can be increased by using the unutilized field and grassland. Sweet tamarind, longan and cashew nut are promising fruit trees in the newly developed fruit tree's area.

c) Development of Upland Crops and Vegetables

The area of upland field is larger than paddy field in the Area. The development of upland field has a big role for the development of the agriculture in the Area. In upland field, cassava, maize and mungbean etc. are cultivated, but the area planted for cassava will be decreased by the government policy. As the promising upland crops in the area, corn, sweet corn, baby corn, mungbean, ground nut, sweet potato and soy bean are also promising ones as the crops in rainy season in upland field.

As for vegetables in the area, cucumber, string bean, water melon, tomato, garlic, Chinese cabbage, lettuce and asparagus are promising in rainy and dry seasons.

Developing the inland fishery, livestock husbandry and vegetables, agriculture and the life quality of the inhabitants in the Area will be raised up considerably.

4) Changes in Farming Types

By the projection, the areas of supplementarily irrigated paddy field for major rice and soybean and fish pond will increase. Agricultural development plans will also make the areas of fruit trees and number of beef cattle increase. It brings the changes in farming type.

The most of the existing farming types are paddy farming type. Farmers cultivate mainly major rice in rainy season and cultivate small area of

upland crops such as maize. Farmers also cultivate soybean in dry season paddy field using the river water.

Farming types after projection will be paddy and upland farming reflecting the projection. Farmers cultivate major rice in rainy season, and cultivate soybean in dry season paddy using the irrigation water. Farmers can also cultivate upland crops and fruit trees in upland field. Fish pond also bring some benefit to farmers.

5.4 Project Engineering

5.4.1 Reservoir and Dam

1) Geology

The geology at the dam site consists of agglomerate and andesite but the land is thickly overlaid with sandstone/siltstone with some outcropped rocks found in the mountain.

2) Reservoir

The reservoir land, which is located within the forest conservation area, mainly consists of grassland, though some 18 ha is rainfed rice fields. There are no dwellings in the submerged area. Based on the 1/50,000 map, the proposed reservoir elements have been outlined, as follows:

Reservoir Elements

Catchment Area	57.1 sq.km
Reservoir Capacity	
Effective Storage	12.2 MCM
Dead Storage	1.1 MCM
Total	13.3 MCM
Water Level	
Max. Water Level	269.0 m MSL
Design Water Level	268.0 m MSL
Dead Water Level	256.0 m MSL
Water Surface Area	
At Max. Water Level	178.0 ha
At Design Water Level	165.0 ha

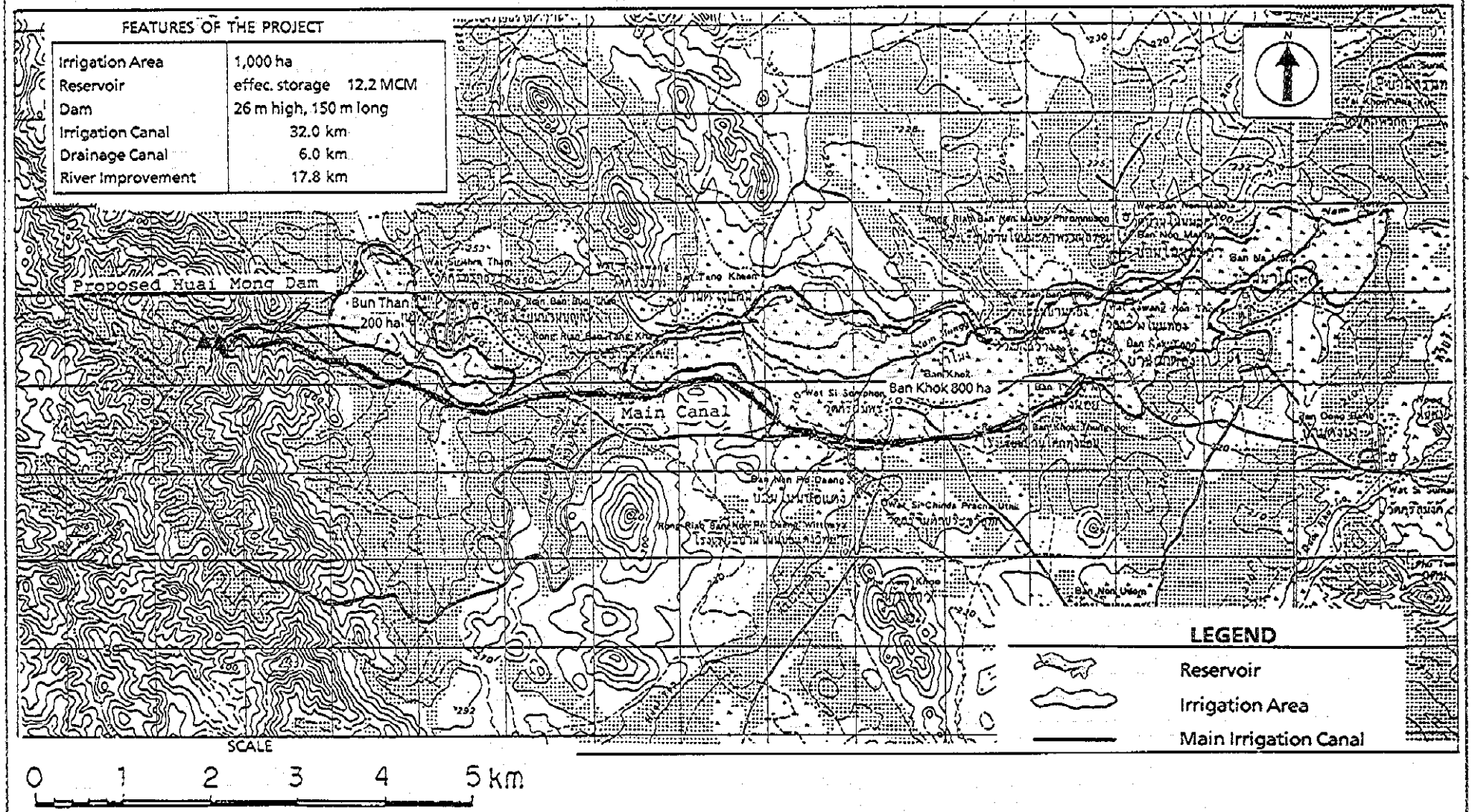


Figure 5.4-1 General Map of Huai Mong Project

3) Dam

The proposed dam will be located in the Amphoe Pak Chom, Loei province at about 400 m upstream from the boundary line between Loei and Nong Bua Lamphu province. Since the depth of envelope materials at the propposed dam site is uncertain, the dam will be constructed as the earthfill type by hauling the materials in the reservoir area and/or from the vicinity of the damsite.

Based on the reservoir plan and 1/50,000 topographic map, the dimension of dam have been drawn up, as follows:

Dimension of Dam

Type	Earthfill
Height	26.0 m
Length	150.0 m
Crest Width	7.0 m
Free Board	2.0 m
Elevation of Crest	271.0 m MSL
Reservoir Side Slope	1:3.0
Land side Slope	1:2.5

The appurtenant structures will be composed of one (1) intake, which will be used as diversion conduit during the construction and one (1) spillway and listed below:

Appurtenant Structures

Intake	
Design Discharge	1.80 cu.m/s
Conduit	Dia. 2.0 m
intake gate	0.8 m x 1.2 m
Spillway	
Type	Overflow type
Design Discharge	81.2 cu.m/s
Length	48.0 m
Energy Dissipator	Sky Jump type

5.4.2 Canal

1) Irrigation Canal

The main canal with the design discharge of 1.80 cu.m/s will be located along the right hill side. Two major laterals will be provided to irrigate the left river side land areas with the ground elevation of about 250 m MSL in the upstream area and about 200 to 220 m MSL in the middle and downstream areas.

The planned canals' length are as follows:

Canals	Length
Main Canal	13.0 km
Lateral A	1.5 km
Lateral B	7.5 km
Other Lats.	10.0 km
Total	32.0 km

In addition to the main and lateral canals, the on-farm facilities, such as farm ditches, farm drains and farm roads, shall be constructed to irrigate the land effectively through the turnouts. The density of such ditches, drains and roads per hectare will be 80 m, 20 m and 80 m excluding supplemental farm ditches and drains, respectively, taking into account the topographical conditions, farm-plot size, future agricultural development plan and so on.

2) Drainage Canal

The drainage canals, to remove the excess water from the locally inundated area promptly, will be required. The total length of the drainage canal is estimated to be about 6 km, assuming the canal length rate of 6m per ha.

Besides the land drainage, since the flood occurs frequently by over flowing from the rivers, according to the farmers in the Project Area, the rivers might as well be improved to mitigate the flood damages. The proposed river improvement will be composed of river training, dredging and dike construction. Major rivers to be improved are listed below:

	River Improvement		
Name of River	Drainage A.	Discharge	length
Huai Mong U/S	91 sq.km	108 cu.m/s	5.0 km
Huai Mong D/S	242 sq.km	214 cu.m/s	8.0 km
Huai Yap	36 sq.km	28 cu.m/s	0.8 km
Other three Streams	20 sq.km	16 cu.m/s	4.0 km
Total			17.8 km

5. 4. 3. Rural Infrastructure Development

The major village road (2097) with two-lane pavement will be connected with the lateral road which goes through Ban Khok with total length about 25 km. This lateral road, except for some parts of the road through or close to the village, paved with asphalt. There is a laterite road with the total length of about 6 km, branching from Ban Khok village to Ban Bun Than village. This road is under improvement for about 2 km from Ban Khok, but the remaining portion of about 4 km is a single lane laterite road.

All village roads in Ban Bun Than and Ban Khok are laterite road. It is therefore proposed that these roads should be paved with asphalt. The existing village road from Ban Khok to Ban Bun Than should be expanded for the whole for length.

At present, electricity supply, village water supply (pipeline system) are available in both villages. However, improvement of water supply to meet the demand of the villagers and improvement for adequate and stable electricity supply are required.

Telephone service in both villages will be available very soon.

5. 4. 4 Implementation Program

The Project will be implemented by the RID, as the leading agency, in cooperation with the other agencies concerned within the period of 5 years. For the project implementation, the water users' cooperatives shall be organized for smooth construction of on-farm facilities and operation and maintenance of the said facilities after implementation of the Project.

5.4.5 O/M Plan

The project facilities, after the completion of the Project, will be operated and maintained by the Nong Bua Lamphu province irrigation office with the guidance of Regional Office, and of course with the particiapation of water users' cooreratives concerned. The RID will deal with operation and maintenance of dam, main and lateral canals. The on-farm facilities will be maintained by the water users' cooperatives concerned.

5.4.6 Project Cost

The project costs have been estimated to be about 200.6 million Baht as contract works for major civil works, incuding the costs for the on-farm facilities, which will be done by the force account works or farmers themselves, at the price of 1995. The costs include the costs for engineering, land acquisition, administration, project contingences and price escalation. The cost breakdown is as follows:

Project Costs

Items	Quantity	Amount (Million B)
Dam	L.S.	44.3
Irrigation Canals	32 km	35.4
Drainage/River Improvement	23.8 km	25.2
Sub-total		104.9
On-farm Development	1,000 ha	3.6
Rural Infrastructures	L.S.	10.2
Total for Field Costs		118.7
Engineering Costs (3-6%)		7.1
Land Acquisition	107.4 ha	19.3
Administration Costs (10-12%)		14.2
Contingencies (10%)		15.9
Price Escalation (7%)		25.4
Total Project Costs		200.6

5. 5 Project Evaluation

5. 5. 1 Introduction

1) Project Components

The project has expected been selected aimed to irrigate 1,000 ha of cultivable area and the project is expected to improve rural people's life in this area through the agricultural development with integrated farming by providing the water resource development. Major components of this project will be as follows:

- Construction of reservoir
- Construction of irrigation and drainage canals and structures
- Provision of on-farm facilities

2) Method of Evaluation

The proposed project in the upstream of the Huai Mong river basin shall be comprehensively evaluated from viewpoint of economic, financial impact.

The economic evaluation has been made by calculating an economic internal rate of return(EIRR), in which a project cost and a tangible benefit are to be calculated by applying an economic price. The EIRR can be worked out by discounting both stream of economic cost and benefit over a period analysis with several discount rates.

3) Prices

All prices to be applied have been mainly estimated on the basis of the farm economic survey conducted in November 1995 including recent data and information available. Out of input and output, the internationally traded commodities have been estimated on the basis of border prices, by quoting forecasted commodity prices published by the World Bank. In addition, in order to calculate economic prices of internationally traded commodities, the following conversion factors have been quoted:

	Central Value	Range
Standard Conversion Factor(SCF)	0.92	0.91-0.94
Consumption Goods	0.95	0.77-0.98
Intermediate Goods	0.94	0.90-1.09
Capital Goods	0.84	0.83-0.96
Construction	0.88	0.86-0.92
Electricity	0.90	0.88-0.93
Transportation	0.87	0.85-0.90
Labour	0.92	0.91-0.94

Source. Thailand Managing Public Resources for Structural AdjustmentReport No.4366-7H

Table 5.5-1 shows both financial and economic farmgate prices of the agricultural input and output.

5. 5. 2 Economic Justification

1) Economic Cost and Benefit

After deducting the price contingency, cost for land acquisition and compensation and so on from the estimated financial investment cost (177.1 million Baht), the economic cost has been estimated at 132.8 million Bahts, by applying the conversion factor. (refer to Part-7 of Appendix G)

In the same way, the annual economic cost of operation and maintenance after completion of the project is estimated at 0.6 million Baht per year at full development stage.

Tangible benefits in monetary terms in this project are those generating from crop and fishery sector. In every case, these benefit are calculated as an incremental net production value (NPV) which is the difference between "with project" and "without project" cases. The NPV of crops can be calculated by deducting a respective crop production cost from a gross production value (GPV) which is obtained by multiplying crop yield with a respective crop price.

2) Economic Internal Rate of Return

A period of analysis for calculating EIRR is fixed at 50 years, on the basis of synthetic durable life of major facilities. In considering five (5) years gestation period until attaining full benefit, the EIRR for this project is calculated at 6.0 %. The estimated EIRR is considerably lower than 12% of the opportunity cost of capital in Thailand. However, in considering, lower quality of life in this area, which can be evaluated based on BMN as studied by the Ministry of Interior, the project will generate intangible benefit and impact in the area as shown below:

- Migrant workers will be reduced
- Poverty in the area will be alleviated
- Farmer's income during construction periosd will be increased
- Fetching water by female and children will be lessen
- Nutrient condition of farmers and children will be improved by intaking animal protein of fishes
- Quality of life in the area will eventually be improved

5. 5. 3 Farm Budget Analysis

In order to evaluate a financial impact on the beneficial farmers, farm budget analysis for the typical farm has been made in case of "without project" and "with project" cases. The farm size of the typical farms has been derived based on the farm economic survey and Tambon basis data.

As to off-farm incomes and household expenditure, the results of the farm economic survey are referred. All the prices for calculation of a NPV and cost of production are financial ones based on market prices.

The result of the financial analysis is summarized as shown below:

Farm Size: 4.0 Has
Farm Model-Without Project

1. Crop Production

	Planted Area (ha)	Yield (kg/ha)	Production (kg)	Unit Price (Bahts/kg)	Value (Bahts)	Production Cost (Bahts)	Net Income (Bahts)
W. Paddy-rainfed	3.35	1,540	5,159	4.65	23,989	7,690	16,299
D. Soybean-rainfed	0.30	1,125	338	11.94	4,030	1,634	2,396
Total	3.65					9,324	18,695

2. Off-farm Income (Bahts/year)	33,230
3. Total Income (Bahts))	51,925
4. Living Expense (Bahts/year)-Family size 5.8 person/family	38,944
5. Disposable Income (Bahts/year)	12,981

Farm Model-With Project

1. Crop Production

	Area (ha)	Yield (kg/ha)	Production (kg)	Unit Price (Bahts/kg)	Value (Bahts)	Production Cost / (Bahts)	Net Income (Bahts)
W. Paddy-Irrigated	3.11	3,200	9,952	4.65	46,277	15,646	30,631
D. Soybean	0.60	1,700	1,020	11.94	12,179	2,751	9,428
W. Maize	1.60	3,150	5,040	2.36	11,894	5,464	6,431
Tamarind	0.10						246,234
Fish pond	0.20	5,600	1,120	38.00	42,560	32,528	10,032
Beef cattle	4 head	500kg	4 head	20.00	40,000	29,720	10,280
Total	5.61						301,155

2. Off-farm Income (Bahts/year)	33,230
3. Total Income (Bahts))	334,985
4. Living Expense (Bahts/year)-Family size 5.8 person/family	251,239
5. Disposable Income (Bahts/year)	83,746

CHAPTER 6. HUAI VIENG KOOK AND HUAI BANG PHUAN AREAS FLOOD PROTECTION PROJECT

Chapter 6. HUAI VIENG KOOK AND HUAI BANG PHUAN AREAS FLOOD PROTECTION PROJECT

6.1 Project Area

6.1.1 Project Location and Area

The Project Area is located in the west of Nong Khai Province,extending to Amphoe Muang and Tha Bo on the right bank of Mekong river. The Area with a drainage area of about 384 sq.km is bounded by Huai Mong river basin on the west, Nam Suai basin on the south and east,and Mekong river on the north. The Project area consists of two river basins, namely Huai Vieng Kook and Huai Bang Phuan, the tributaries of Mekong river. The drainage areas are 151 sq.km and 233 sq.km respectively. Both rivers originate from boundary of Nong Khai and Udon Thani Province and flow down from south to north. The highway No.211 runs from east to west in the middle of the Area.

6.1.2 Topography

Topographic features of the Area range generally from undulating to flat and declines gently to the north with a slope of 1/500 to 1/1000. Elevation ranges from 220 to 165 m.MSL. But edge of north forms natural levee by Mekong river and area between highway No.211 and Mekong river is covered by depression land swamps, which are the remnant of old flood plain of Mekong river. The Area is divided into high and low land by highway. Highlands are situated in the south of highway with an elevation more than 170 m.MSL, and the elevation of lowlands in the north of highway are generally lower than 170 m.MSL. This area is frequency flooded by runoff from highlands and high water level of Mekong river. The most of land category in the area fall under paddy, however, upland crops along the natural levee and/or flooding area of the Mekong river are also cultivated in the dry season.

6.1.3 Hydrology

The Project Areas are located in the Nong Khai East sub-basin along the Mekong river. There are two main rivers namely Bang Phuan and Vieng Kook which flow directly to the Mekong. The outlet of these rivers are

controlled by regulators. In the upstream of Bang Phuan river RID has constructed a reservoir (medium scale) with a capacity 10.07 MCM. The areas have quite a number of swamps. In the rainy season when the swamps become full, runoff from the upstream follow the river course and flow into the Mekong by gravity but when the water level of Mekong becomes higher, the gates of the regulators are closed causing inundation in the areas. The situation becomes worst when there is a heavy rainfall (during July-Sept) and Mekong has a high water level. The maximum water levels of Vieng Kook river (upstream and downstream of the regulator) are presented below.

Vieng Kook

Unit:MSL

Year	July		Aug		Sept	
	Up	Down	Up	Down	Up	Down
1993	164.27	163.42	164.78	164.75	165.28	165.27
1994	164.84	165.05	165.51	166.32	165.61	166.74
1995	164.87	163.67	166.08	167.48	166.78	167.02

From the above records it can be seen that in 1993 there was no problem for gravity drainage. In 1994 all the three months have drainge problems. In 1995, except July, the other two months had problems.

In the dry season there is almost no flow in the rivers and the small swamps become dry. The swamps which are taken up for development hold little water only in the dredged or central parts.

The rainfall in the area shows higher than the rest of the Study Area and concentrates during the months of August and September. Annual rainfall measured at Bang Phuan regulator site(1993-95) is presented below.

Station: Bang Phuan Regulator

Year	Rainfall(mm)	July + August(mm)	
1993	1429.30	377.4	(26%)
1994	1907.70	851.9	(45%)
1995	1630.30	984.1	(60%)

6.1.4 Soil and Land Classification

The soil of the Huai Vieng Kook and Huai Bang Phuan Flood Protection Area is differed by the topography. Most of the soil in Mekong river basin is Loamy Ustifluvents. The soil of little inner area is Clayey Tropaquepts. Most of the soil in flood area is Loamy Paleaquults. The soil of upper and middle paddy field is Skeletal Plinthustults as per the USDA classification.

It implies that the most of the soil in Mekong river side is low land soil, the soil in flood area is low humid gray soil and the soil in upper middle paddy is red yellow Podzolic soil by Thai classification.

The saline soil is recognized in some parts of the upper middle area as shown in Figure 2.6-2 of Appendix E, but the degrees and the area of damages are not so large.

The most of the soil in flood area and in intensive agricultural use are moderately sufficient in organic matter, available phosphate, potassium and CEC. So, the soil classification by the soil suitability for paddy is grade P-2, soil is classified as "well suited for paddy" from the view point of soil texture and structure, and productivity of rice is comparatively high, with some damages by deep flooding.

6.2 Present Agriculture

6.2.1 Land Use

The agricultural land use of each Tambon in Huai Vieng Kook and Huai Bang Phuan Flood Protection Areas are shown in Tables 6.2-1 and 6.2-2 of Appendix F, dividing the area in Huai Vieng Kook Area and Huai Bang Phuan Area.

As shown in two tables, the agricultural land use are quite different by Tambon. It is the difference of topography in the areas. Agricultural land use in the Tambon along Mekong river are so intensive and is cultivating many kinds of industrial crops such as tomatoes, tobacco in dry season and pineapple throughout the year. However, Agricultural land use in the Tambon in Hilly

Area near Udon Thani is so extensive and there are no crops grown in dry season. Only major rice is cultivated in rainy season and some upland crops such as cassava and sugar cane in upland. Middle area between area along Mekong river and Hilly Area near Udon Thani is low land area. The area has wide area of water reservoir and swamp and paddy field in the Area is suffering from flood damages almost every year.

So, the agricultural land in Huai Vieng Kook and Huai Bang Phuan Flood Protection Areas were divided into three zones by the topography. These are area along Mekong river, flood area in central area and hilly area including Udon Thani. The agricultural land use in three zones is shown in Table 6.2-1.

Table 6.2-1 Agricultural Land Use of the Flood Protection Area divided in Three Zones

Three Zones	Area alongMekong River		Flood Area		Hilly Area *	
Land Use	Area(rai)	(%)	Area(rai)	(%)	Area(rai)	(%)
Total Area	54,847		68,930		75,288	
Paddy field	22,380	77.4	57,236	90.2	35,851	71.8
Flood Area	6,666	(29.8%)*	5,991	(10.5%)	1,250	(3.4%)
Upland Crop Field	2,391	8.3	1,487	2.3	12,259	24.6
Vegetables	1,801	6.2	1,116	1.8	67	0.1
Fruit Trees Field	454	1.6	631	1.0	1,305	2.6
Flowers Field	103	0.4	129	0.2	0	0
Other Agric. Field	1,775	6.1	2,861	4.5	457	0.9
Total Agric. Field	28,904	100.0	63,460	100.0	49,903	100.0
Cropping Intensity in Dry Season	153.2		106.4		102.8	

Source: Data from Amphoe Agricultural Office in 1995. * % in flood area is to paddy in 1995.

*Each area includes following Tambon ;

Area along Mekong River	:	Kuan Wan, Pa Kho, Vieng Kook, Mi Chai, Phon Sa and Tha-Bo,
Flood Area	:	Muang Mi, Nong Kom Ko, Phra Tat Bang Phuan, Pho Chai, Ban Thon, Ban Dua,
Hilly Area	:	Ban Fang, Hai Sok, Nong Nang, Khom Bong.

As shown in upper Table, Area along Mekong River is suffering from damages of flood. However, the zone has wide area of industrial crops and

cropping intensity of paddy field is 153.2. On the contrary, in the Hilly Area, dry season crops in paddy field are very little. Copping intensity in paddy field is only 102.8, mostly because of the shortage of irrigation water in dry season. The middle area has widely planted paddy, but cropping intensity in paddy field is only 106.4.

6. 2. 2 Water Use

It is very difficult to get a quantitative picture of water use in the two areas. However, a general picture may be as follows. In the upper part of the Bang Phuan area agricultural water is supplied by the Bang Phuan reservoir, which has a command area of 1,920 ha and other source of agricultural water is small swamps dredged by RID. DEDP pumps are also used to withdraw water from Mekong river.

6. 2. 3 Population, Farm Household and Farm Labour Force

The area covers two(2) Amphoes and 15 Tambons in Nong Khai Province. population in the beneficial area is estimated at about 37,150 corresponding to 166 persons per sq.km.

Total number of households is estimated at about 11,360 and 8,360(74%) of which are farm households with 5.4 family size and 4.48 of farm labour per family.

6. 2. 4 Agricultural Production

Planted area of major rice, upland and industrial crops in the Huai Vieng Kook and Huai Bang Phuan area is shown in Table 6.2-2, dividing the area in three zones as former table.

As shown in Table, Mekong River Basin has wide area of industrial crops and vegetables in dry season. The industrial crops are transplanted early in dry season as September or October and harvested in February. Because, in this period, farmers can get enough water for crop cultivation from Mekong River or some rivers which inflow into Mekong. Other two zones have also some areas planted for industrial crops, but the area are also limited.

Table 6. 2-2 Planted Area of Main Crops (Unit:rai)

Crops/Zones	Area alongMekong R.	Flood A.	Hilly A.	Total(rai)	(ha)
Glutinous Rice	14,434	51,502	26,522	92,458	14,793
Non-glutinous Rice	3,149	6,551	9,295	18,995	3,039
Wet season Crops including Cassava and Sugarcane					
Upland Crops	251	0	6,738	6,989	1,118
Dry season Crops including Second Rice					
Dry season Crops	777	981	4	1,762	282
Industrial Crops	10,465	2,375	1,000	13,840	2,214
Vegetables	669	316	7	992	159

Source: Data from Tambon Offices.

Average yields of main crops in the Amphoe Muang Nong Khai and Tha Bo are higher in glutinous rice, non-glutinous rice, maize (in rainy season) and cucumber than those of average yields in Nong Khai Province. However, yields of cassava, soybean, groundnut, pineapple, tobacco and tomato vary every year.

Table 6.2-3 shows the number of agricultural machines in Flood Protection Areas dividing into three zones. Power tiller, sprayer for chemicals and water pump are now widely owned and operated by farmers.

Table 6.2-3 Number of Agricultural Machines

Kinds of Machines/Zone	Area alongMekongR.*	Flood A.**	Hilly A.***	Total
2 & 4 Wheel Tractor	24	3	23	50
Power Tiller	441	462	388	1,291
Sprayer for Chemicals	758	422	407	1,587
Water Pump	745	612	262	1,619
Number of Farmhousehold	3,418	3,240	2,253	8,911

Source : Data from Amphoe Office.* Data in Tha Bo are not obtained.

** Data in Ban Dua are not obtained, *** Data in Hai Sok are not obtained.

6. 2. 5 Livestock

The numbers of livestock in the Flood Protection Areas are shown in Table 6.2-4 dividing into three zones. As shown in table, the number of buffaloes, beef cattle and swine are not so much considering from the number of households and the agricultural land area. However, farmers are very keen to breed the chicken. Duck is also raised distinctively. Because there are so wide

area of fish pond in the Area and farmers are breeding the poultry combining with inland fishery.

Table 6.2-4 Number of Livestock

(Unit:heads)

Zone	Area alongMekong R.	Flood A.*	Hilly A.**	Total
Buffaloes	1,731	2,122	1,489	5,342
Beef Cattle	1,355	1,950	382	3,687
Swine	1,549	1,381	74	3,004
Chicken	33,645	18,312	13,303	65,260
Duck	2,366	9,245	1,537	13,148
Number of Farmhousehold	3,418	3,240	2,253	8,911

* Data in Ban Dua are not obtained, and ** data in Hai Sok (UdonThani) are not obtained.

6. 2. 6 Inland Fishery

As the Area is blessed with sufficient water supply, there are so many fish ponds in the Area. Table 6.2-5 shows the number of fish pond, total area of fish pond, number of fish rearing house and area of fish pond per house in the Flood Protection Area.

Table 6.2-5 Number and Area of Fish Pond

(Unit:rai)

Zone	Area along Mekong R.	Flood A.	Hilly A.	Total
No. of Fish Pond	658	256	503	1,417
Area of Fish Pond	1,942	380	603	2,925
Ave. Area of one fish pond	2.95	1.48	1.20	2.06
No. of Fish Rearing House	418	181	251	850
Ave. Area of Fish Pond /House	4.65	2.10	2.40	3.44

Source : Data from Amphoe Office.

As shown in table, Area along Mekong River has larger area of fish pond and large number of fish rearing households than the other two areas. Size of one pond and area of fish pond per household are also larger than those of the other two areas.

6. 2. 7 Marketing

The major crops in the rainy season are paddy, maize and cassava, and many kind of crops are planted in dry season, in case that water is available, tobacco and vegetables such as tomatoes, cabbage, cucumber, string-beans and some dry season paddy are planted. Paddy and cassava are mainly transported to Tha Bo, Nong Khai and Ban Phu through middlemen, and sugarcane to the sugar mill at Kumphawapi. Marketing of tobacco is managed by the cooperatives.

6. 2. 8 Agricultural Supporting Services

Amphoe agricultural extension offices are responsible for extension services in each Amphoe, that is, Tha Bo and Muang Nong Khai. While, Fishery experimental station exists in Nong Khai.

Agricultural credit services are available at BAAC branch offices at Tha Bo and Muang Nong Khai.

6. 2. 9 Farm Household Economy

Annual farm household incomes in this area ranges from 15,000 to 78,000 Baht. This is considered various due to water availability and cropping intensity. Actually, there is tendency in household incomes such that higher incomes in the Tambon along Mekong river in which water is available for high-value crops through the year by pumping irrigation. Incomes in the inland Tambon remains at generally lower level ranging from 25,000 to 30,000 Baht/year.

Basic Minimum Needs in this area are considerably met with the target set up by the Ministry of Interior, particularly in the Tambon along the Mekong river (refer to Part-4 of Appendix G).

6.3 Development Plan

6.3.1 Objectives of the Project

The low lands of the Area are blessed with fertile soil, but floods every year by the runoff from upstream and high water level of Mekong river cause damages to the agriculture in the Area. The objectives of the Project are to stabilize the production of agricultural crops and income of the farmers aiming at higher living standard by protecting the agricultural land from flood damages.

The Project consists of the following development plans.

(1) Flood protection plan
(2) Swamp area development plan

6.3.2 Flood Condition

1) Drainage Area

The Project Area is located at Amphoe Muang Nong Khai and Ta Bo of Nong Khai Province along right bank of Mekong river consisting of two small river basins. The drainage area of each basin is as follows.

Basin	Area
Huai Vieng Kook	151 sq.km (Amphoe Ta Bo)
Bang Phuan	233 sq.km (Amphoe Muang Nong Khai)

Ground elevation of the Project Area is lower than high water level of Mekong river, so that, lower portions of the area are flooded every year. As mentioned in Chapter 3 , big flood caused by heavy rainfall and high water level of Mekong river damaged this area in August 1995.

2) Flood situation in 1995

Total rainfall from July to September is measured as 1085.6 mm and monthly discharge is as follows.

Month	July	August	September
Rainfall	463.1 mm	521.00 mm	101.5 mm

Maximum flood water level was recorded as follows.

Maximum Water Level	U/S	D/S(Mekong river)
Huai Bang Phuan	W.L. 166.16	W.L. 167.07
Huai Vieng Kook	166.78	167.48

Monthly rainfalls and maximum in/out flood water level from 1993 to 1995 are shown in Table 6.3-1. Water level and rainfalls in July, August and September are shown in Fig.6.3-1. The water level of Mekong river starts rising from July and when it becomes same as the inside water level, inside water level also rises up along with the Mekong water level. Rainfall in July did not cause flood, but heavy rainfall of August raised inside water level during high water level of Mekong river.

Inundated areas in 1995 is estimated at 1,800 ha in Bang Phuan and 1,700 ha in Vieng Kook area, respectively.

3) Duration of flood

Duration of flood was about one month with an inundation depth of 1.5 m with more details as given below.

Bang Phuan		
Water Level	Depth (m)	Duration
164.5--165.0	(0.5 -- 1.0)	49 days (Aug.02--Spt.19)
165.0--165.5	(1.0 -- 1.5)	39 days (Aug.10--Spt.17)
165.5--166.0	(1.5 -- 2.0)	35 days (Aug.12--Spt.15)
166.0--166.61	(2.0 -- 2.61)	28 days (Aug.16--Spt.12)
Vieng Kook		
164.5--165.0	(0.5 -- 1.0)	66 days (Jly.27--Spt.30)
165.0--165.5	(1.0 -- 1.5)	50 days (Aug.09--Spt.27)
165.5--166.0	(1.5 -- 2.0)	36 days (Aug.14--Spt.18)
166.0--166.78	(2.0 -- 2.78)	18 days (Aug.28--Spt.15)

Table 6.3-1 Rainfall and Maximum Water Level at Bang Phuan

1. Rainfall RID Huai Bang Phuan Station Record

Unit mm (Daily max)

Year	1993	1994	1995
Jan	-- (--)	-- (--)	-- (--)
Feb	75.6 (40.3)	3.0 (3.0)	-- (--)
Mar	90.9 (45.1)	-- (--)	-- (--)
Apr	16.1 (15.2)	45.6 (30.4)	111.8 (50.2)
May	272.5 (60.4)	207.9 (45.1)	200.5 (70.3)
Jun	353.9 (105.2)	585.2 (115.3)	181.0 (45.2)
Jly	197.3 (45.3)	246.8 (50.4)	463.1 (90.9)
Aug	180.1 (30.4)	605.1 (95.2)	521.0 (70.9)
Spt	227.7 (50.3)	105.6 (90.2)	101.5 (25.3)
Oct	15.2 (15.2)	108.5 (15.2)	51.4 (50.9)
Nov	-- (--)	-- (--)	-- (--)
Dec	-- (--)	-- (--)	-- (--)
Total	1429.3	1907.7	1630.3

2. Maximum Water Level RID Huai Bang Phuan and huai Vieng Kook Station

High Water Level		Bang Phuan		Vieng Kook	
1993	U/S	165.09	Spt.10	165.28	Spt.12
	D/S	164.92	Spt.10	165.27	Spt.09
1994	U/S	165.60	Spt. 4	165.61	Spt.06
	D/S	166.28	Spt. 2	166.74	Spt.01
1995	U/S	166.61	Spt. 6	166.78	Spt.09
	D/S	167.07	Aug.23	167.48	Aug.20

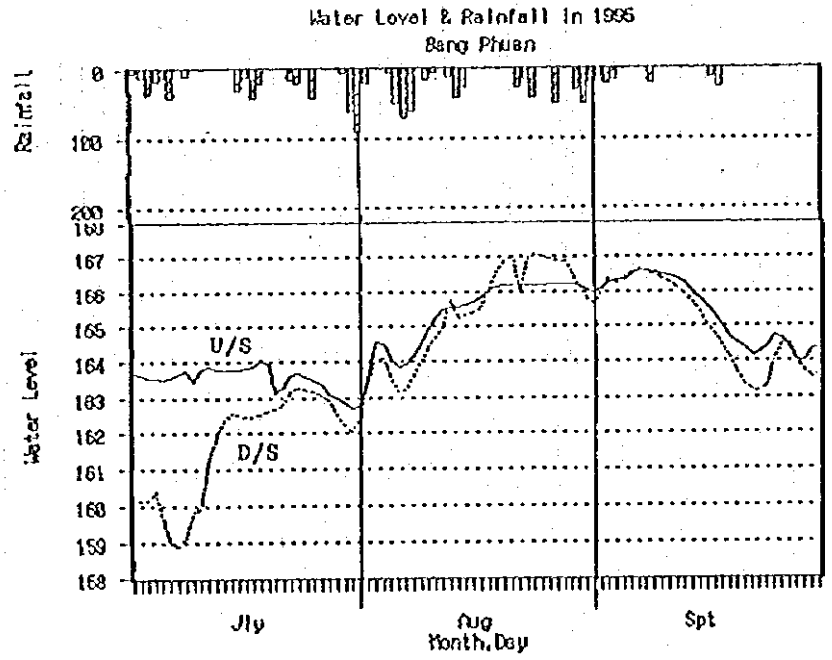


Figure 6.3-1 Water Level and Rainfall in July, August and September, 1995

4) Runoff

Here are no discharge gauging stations and runoff for this area. However peak runoff was assumed at 53.4 cu.m/s for Bang Phuan area, and 48.0 cu.m/s for Vieng Kook area (details are described in the following paragraphs).

5) Existing Facilities

In general both areas are protected from high water level of Mekong river by RID dikes equipped with regulators at river mouth. The dimensions are given below.

River	Dimensions	Bed level
Vieng Kook	2.50m * 3.25m * 2	161.78
Bang Phuan	2.50m * 3.25m * 1	160.78
Wang Who	D = 1.50 m * 2 mm	161.01

Bang Phuan area is bigger than Vieng Kook area, but regulator's size is smaller than Vieng Kook area.

6.3.3 Flood Protection Plan

1) Outline of plan

The ground level of downstream area is lower than high water level of Mekong river and flood duration is longer because of only gravity drainage system. Therefore to solve the flood problems and reduce the sufferings, new drainage facilities are proposed. Followings show the case studies which were conducted for the period from July to September of 1995.

Case A New drainage facilities at the both river mouths
Case A-1 Present facilities with future development
CaseA-2,3 Additional regulators and pumps

Case B Dividing upper and down stream(two regulators)
Case B-1 Present condition
CaseB-2 Additional regulators and pumps

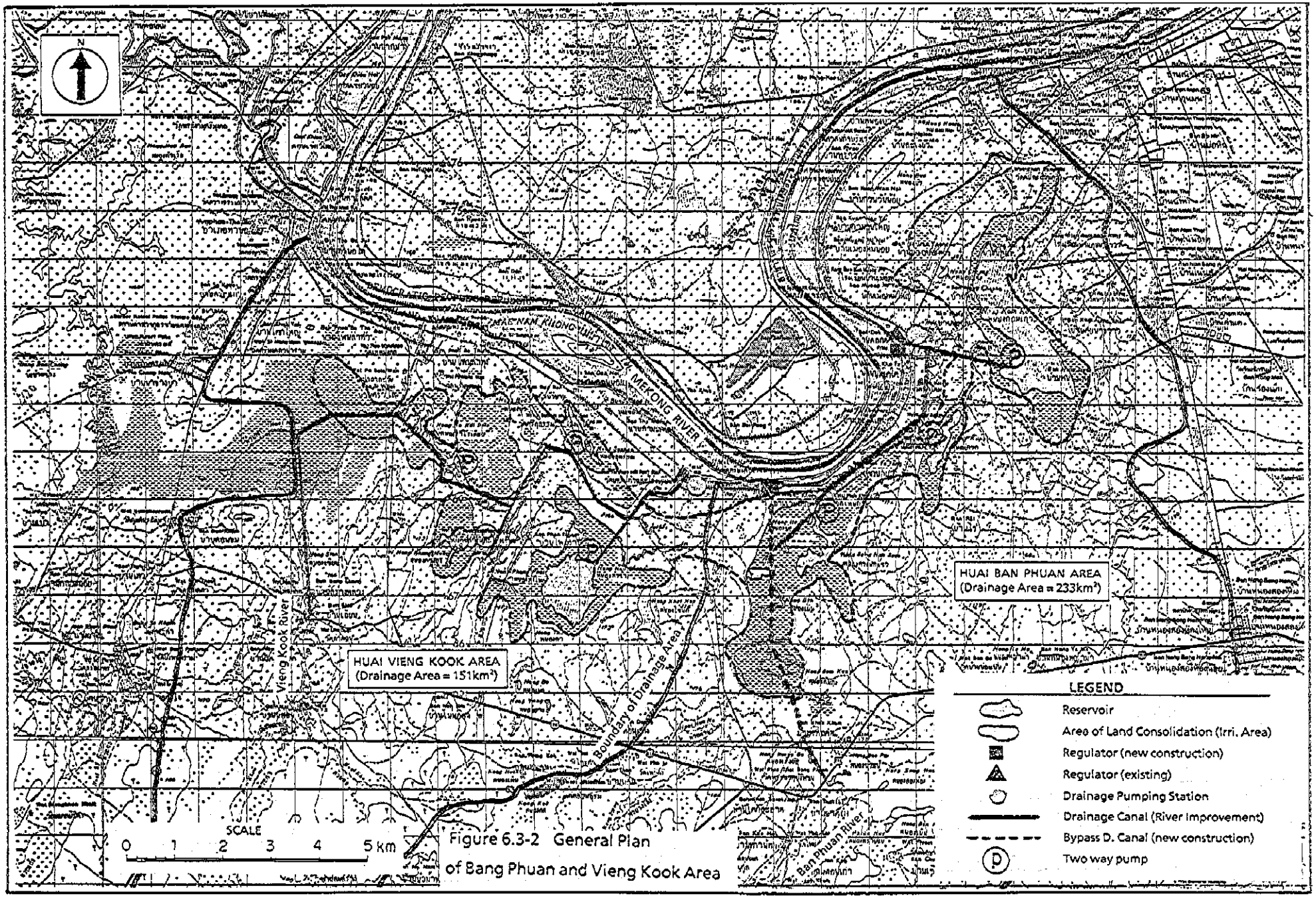


Figure 6.3-2 General Plan of Bang Phuan and Vieng Kook Area

Out line of each cases are shown in Appendix- N.

According to the result of study on inundated depth,days and construction cost, Case B-2 for Bang Phuan and Case A-2 for Vieng Kook were selected.The features are as follows.

Bang Phuan Area

Bang Phuan R. Additional regulator	2.50(m)*3.25(m)*1
New pumping station	6.37 cu.m/s
New regulator	2.50(m)*3.25(m)*1
New bypass river	L= 7.0 km
River rehabilitation	L= 9.0 km

Vieng Kook Area

Vieng Kook New pumping station	11.57 cu.m/s
River rehabilitation	L= 18 km

Proposed general plan is shown in Fig.6.3-2.

2) Rainfall and runoff

a) Rainfall : July to September in 1995

b) Runoff ratio

Present f=0.60

Planning f=0.65

c) Daily rainfall distribution

Day	1	2	3	4	5	6	7	8--10
Present	0.20	0.15	0.10	0.10	0.10	0.10	0.10	0.05
Planing	0.30	0.20	0.15	0.10	0.10	0.10	0.05	

(Planning distribution is considered of area development)

d) Peak discharge

The result of the peak discharge calculation is given.

		Area(sq.km)	P.Discharge(cu.m/s)
Bang Phuan	(Present)	233	Qmax=53.4 (q=0.229)
	(Planning)	233	74.1 (q=0.318)
Vieng Kook	(Planning)	151	48.0 (q=0.318)

(where q ; unit discharge cu.m/s/sq.km)

Figure 6.3-3 shows the rainfall and runoff of Bang Phuan area.

3) Inundated depth and days

Present flood conditions were reviewed by simulating Bang Phuan area flood based on the assumptions mentioned above. The results are found acceptable.(details are described in Appendix-N)

It is well known that the existing flood conditions are very severe, therefore, in the planning, maximum flood depth was allowed up to 1.0 meter and given a priority to gravity drainage. Optimum plan which is most economical is decided from comparative study of alternative plans (detail are described in Appendix-N).

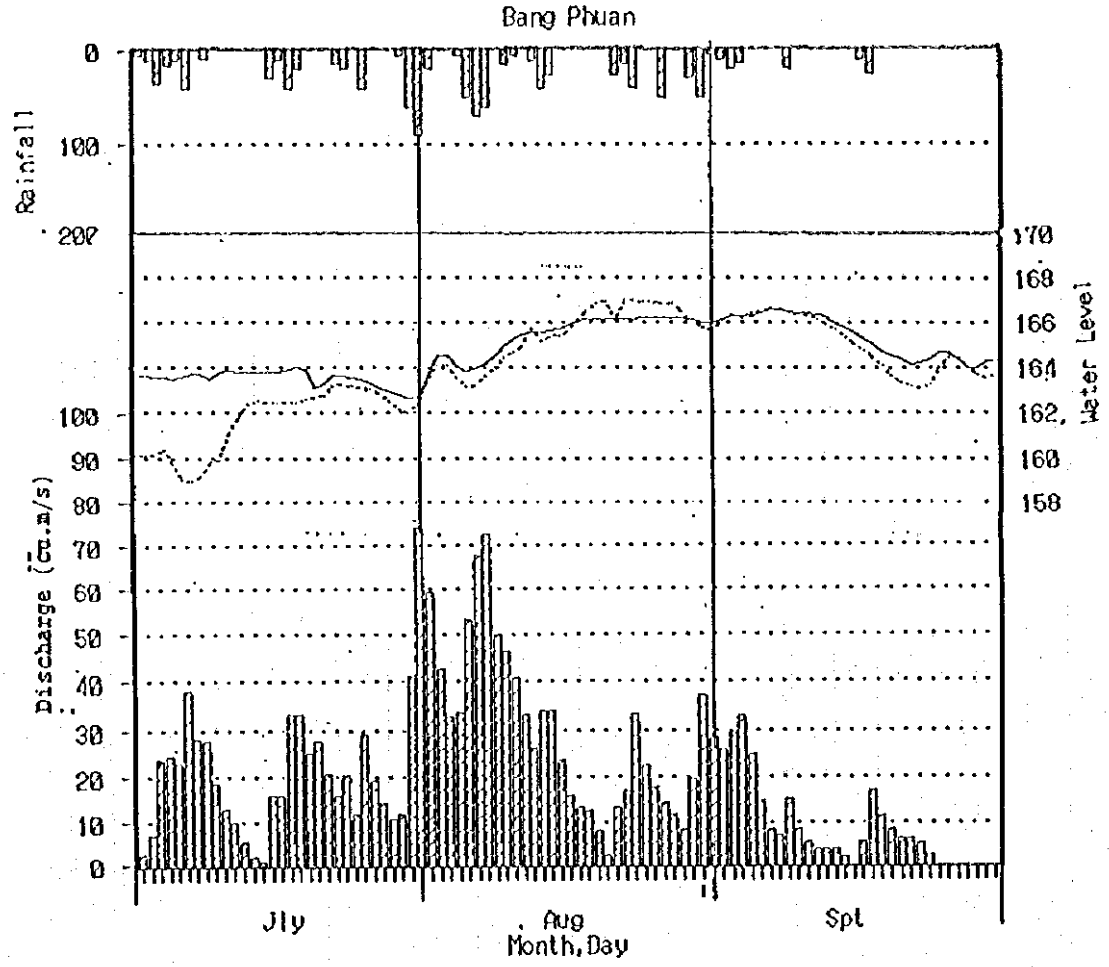
Maximum inundated depth is 1.0 meter and its days are as follows. (inundation curve in each case is shown in Figure 6.3-4 & 5)

Bang Phuan	1.0 m > Water depth > 0.5 m	----- 38 days : 1,800 ha
Vieng Kook	ditto	----- 39 days : 1,700 ha

6.3.4 Swamp Area Development

1) Swamp and Pond area

Total seven swamp areas selected for development planning of which three are in Bang Phuan and four in Vieng Kook. Total areas for swamp is 1,540 ha and for pond is 620 ha making a total project of 2160 ha. Detail of area distribution is as follows.



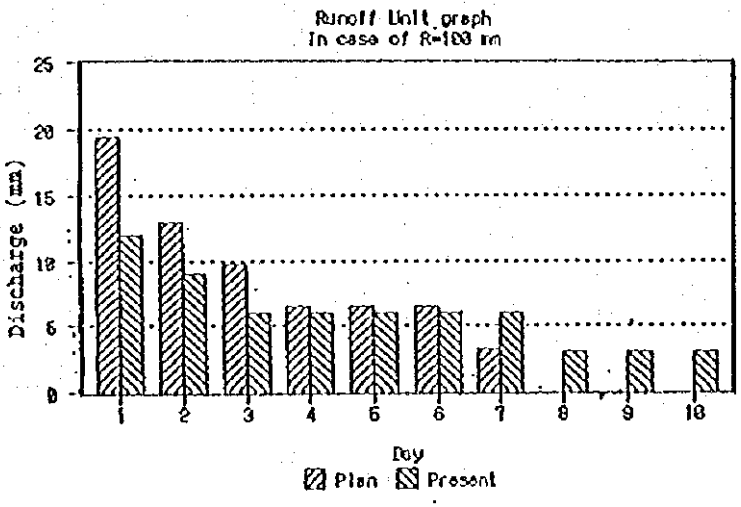


Figure 6.3-3 Runoff of Bang Phuan(Planning)

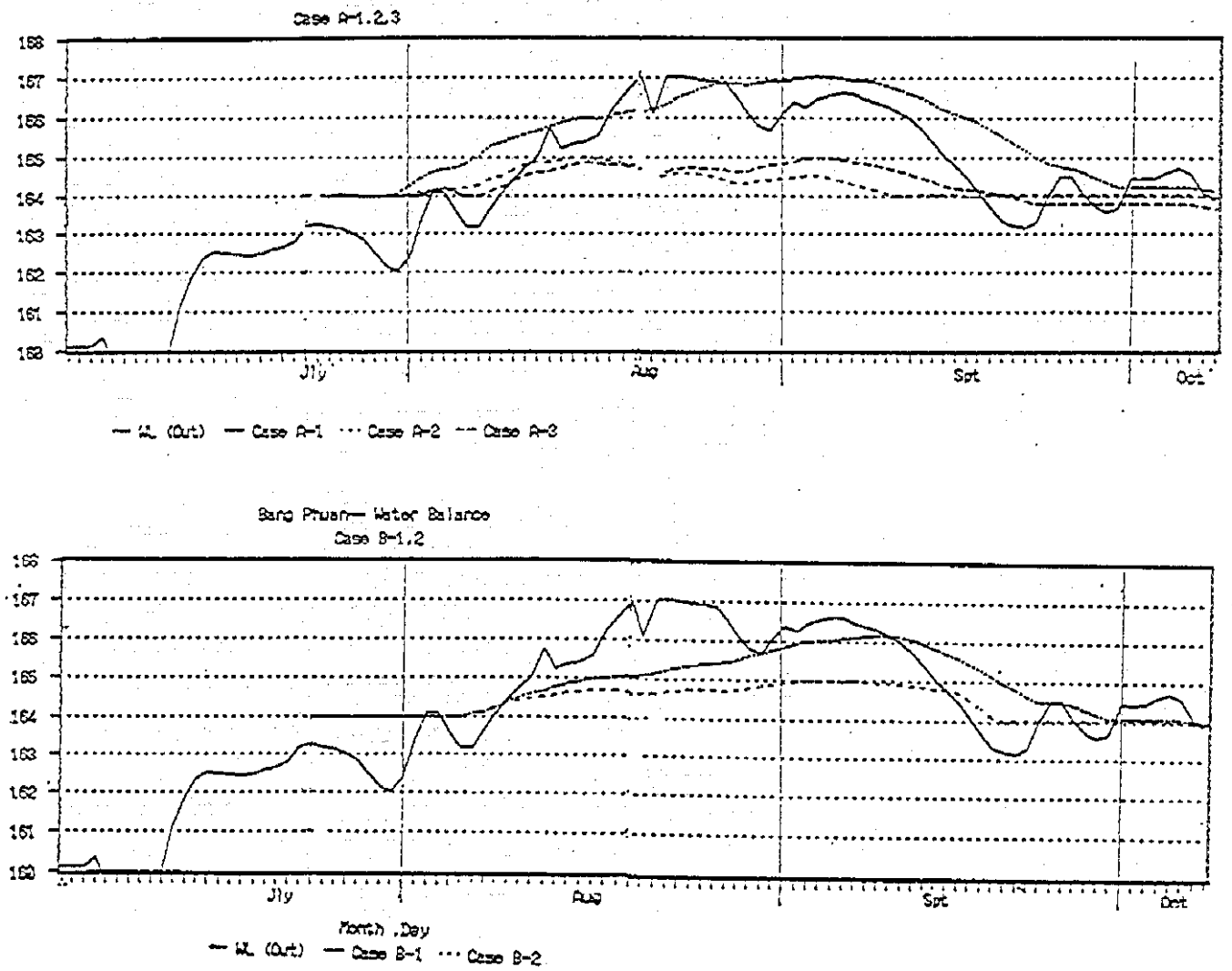


Figure 6.3-4 Inundation Curve(Bang Phuan Case A-1,2,3 and B-1,2)

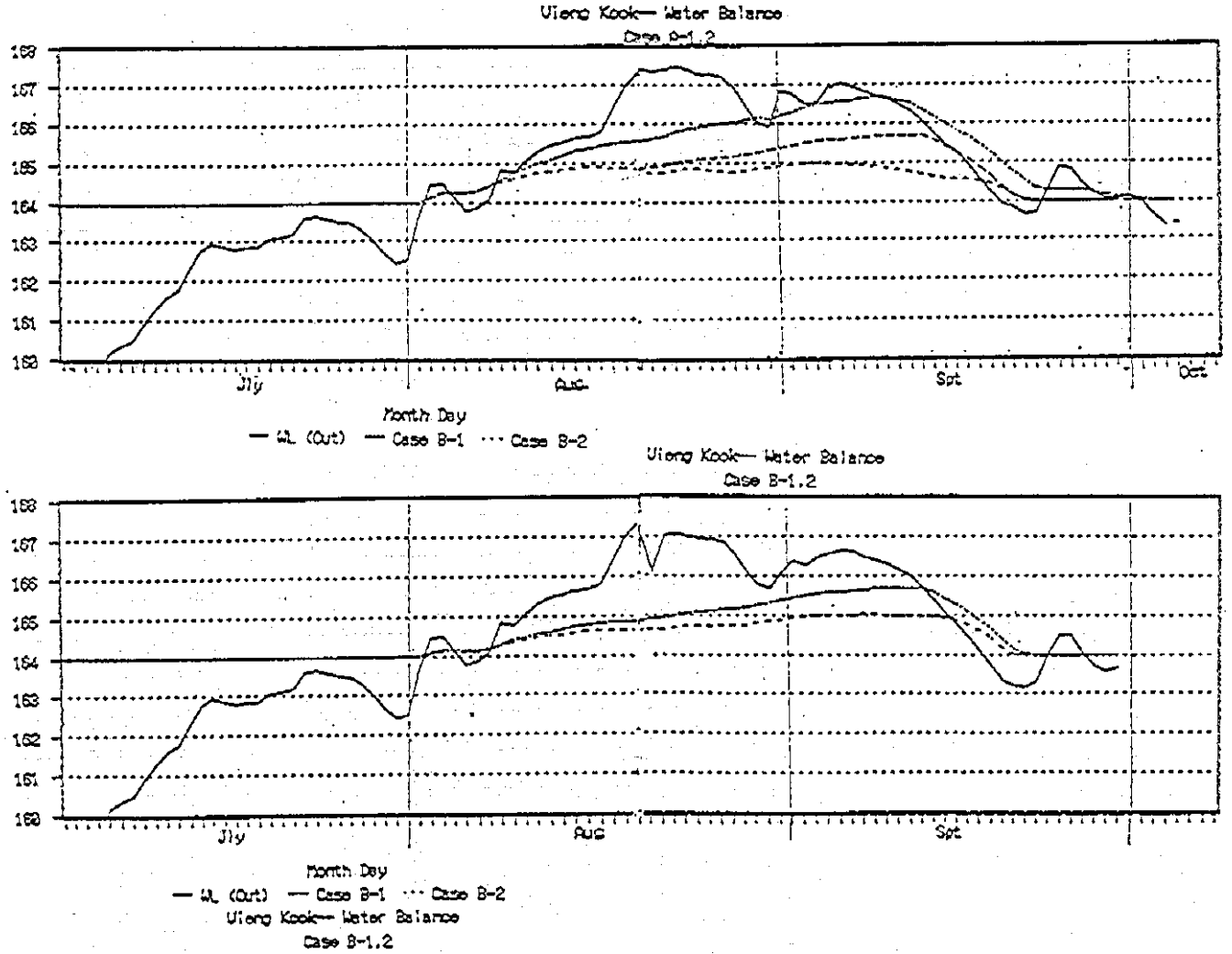


Figure 6.3-5 Inundation Curve (Vieng Kook Case A-1,2 and B-1,2)

	Swamp name	Swamp area(ha)	Pond area(ha)
Bang Phuan	Nong Kom Ko	240	310
	Nong Kuak	80	30
	Nong Bo & Nong Ben	620	60
	Total	940	400
Vieng Kook	Nong Hua Chang	290	130
	Nong Sung	50	30
	Nong Phang	110	20
	Nong Na Rai	150	40
	Total	600	220
	Grand Total	1,540	620

2) Components of Project

Project Components	Unit	Bang Phuan	Vieng Kook
Dredging (Exca. depth 1.0 m, 30% of pond area)	MCM	1.2	0.7
Dike (5.0 m wide, laterite paved.)	km	18.0	16.0
Two way pump	Nos.	3	4
On-farm	ha	880	560
Land reclamation area	ha	30	30
Fish pond	ha	30	20

6. 3. 5 Agricultural Development Plan

1) The Area of Flood Protection and Selection of Crops

The total land consolidation area by the drainage of swamp is 1,440 ha. It consists of 880 ha of Huai Bang Phuan Area and 560 ha of Huai Vieng Kook Area. The area that is left as the fish pond is 50 ha including both areas of Huai Bang Phuan and Huai Vieng Kook. Total area of water reservoir is 620 ha including 400 ha of Huai Bang Phuan Area and 220 ha of Huai Vieng Kook Area.

As already described, the lowland paddy field in the Project Area had suffered from flood almost every year in rainy season. The flood affects remarkable damage upon the rice production. The drainage of swamp and land consolidation will contribute to the stable production of major rice in flood area

in rainy season and it will also enable to cultivate many kinds of crops in dry season.

In this project, the total 1,440 ha of land consolidation area are projected for the cultivation of major rice. However, as the area has plenty of soil moisture in rainy season, so supplemental irrigation to major rice is not planned, and only improvement of management will be practiced for the stable production of major rice. Cropping area in dry season is 30 %, 420 ha, as the irrigation water has some limitation.

Crops and the area in dry season paddy is as follows; soybean is 160 ha, maize including maize for feed and sweet corn for human provisions is 80 ha, fresh vegetables for human provisions and vegetables for industries is 100 ha, and industrial crops such as tomato is 80 ha.

Followings are the outline of the cultivation plans in the area and the development plan of inland fishery.

a) Stable Production of Major Rice

For the stable production of major rice in the area, 1,400 ha of flood protected paddy field is proposed. The area is not projected to practice the supplemental irrigation , because the soil has plenty of soil moisture in rainy season as already described. However, transplanting by young seedling (about 25-30 days seedling) fertilization control of some injury by insects and disease will be practiced for the stable production of rice.

Variety of rice is local one, but as the introduction of some industrial crops are planned, so in that paddy field, high yield variety will be proposed.

b) Stable and High Yielding Production of Soybean

For the stable and high yielding production of soybean in the area, 160 ha of flood protected dry season paddy field is proposed. As soybean is expected as the most promising crops in the dry season paddy field, comparatively large area is proposed. Soybean will be cultivated by the hill sowing, irrigation and some level of intensive management. As the variety of soybean, S J-5 will be used expecting the high yielding production.

c) Stable and High Yielding Production of Corn

For the stable and high yielding production of corn including the maize for feed and sweet corn for human provision in the area, 80 ha of flood protected dry season paddy field is proposed. Cultivation techniques will be differed a little by both maize and sweet corn. However, both crops will be cultivated under some intensive management such as irrigation, fertilization and relay cropping of sweet corn. As the variety of maize, dent corn will be used and for sweet corn, super sweet variety will be used expecting the stable and high yielding production.

d) Stable Production of Fresh Vegetables.

For the stable and high yielding production of fresh vegetables in the area, 100 ha of flood protected dry season paddy field is proposed. Many kinds of vegetables will be introduced such as cucumber, Chinese cabbage, string bean, lettuce, kale, asparagus, water melon, tomato, big chilli, onion shallot, baby corn and so forth. These vegetables will be cultivated for human provisions in the area and for industries, introducing the relay cropping system to avoid the competition of labor for cultivation and harvesting.

e) Stable Production of Industrial Crops

For the stable and high yielding production of industrial crops in the area, 80 ha of flood protected dry season paddy field is proposed. The Area along Mekong river is the big area of the industrial crops such as tomato and tobacco. Farmers have the high techniques and experience to cultivate these crops. In general, industrial crops is transplanted in October and harvested in February or March and rainy season crops is not major rice but maize in Area along Mekong river. However, in this plan, early maturing high yield variety is proposed for the industrial crops and rice cultivation system.

f) Development of Inland Fishery Combined with the Breeding of Chicken.

In the plan, 50 ha of fish pond was proposed both in Bang Phuan and in Vieng Kook area. Inland fishery will be developed by combining with the breeding of chicken of local variety with better taste favoured by peoples.

g) Utilization of Water Reservoir for Inland Fishery.

By the drainage of swamp combined with dredging and dike and road construction, 400 ha in Bang Phuan area and 220 ha in Vieng Kook are established as the water reservoir. Total 620 ha of water reservoir can be used for the development of inland fishery.

The outline of the proposed development plan are summarized as in Table 6.3-2 and the cropping season of main crops will be shown in Fig. 6.3-1 of Appendix F.

Table 6.3-2 Outline of Agricultural Development Plan in the Area

(Unit:ha)

	Plan	Area(ha)	Outline
(i)	Stable Production of Major Rice	1,400	Mainly local variety, partly high yield v.
(ii)	Stable Production of Soybean	160	High yielding by intensive management
(iii)	Stable Production of Corn	80	Maize for feed, corn for human provision
(iv)	Stable Production of Vegetables.	100	Fresh vegetables for food, and for industries
(v)	Stable Production of Industrial Crops	80	Tomato production
(vi)	Development of Inland Fishery	50	Nile telapia, Mirror carp etc. with chicken
(vii)	Utilization of Water Reservoir	620	Snake head, Cat fish, Climbing parch, Prawn

2) Yield Projection

Expecting the better yield of major rice and dry season crops in the flood protection area, improvements of the selection of the varieties of these crops, irrigation and management are examined.

On the management of crops, sowing period, sowing methods such as relay cropping, fertilization and insects and pest controls are proposed to the crops.

The outline of cultivation of these crops and yield projection are shown in Tables 6.3-5, 6.3-6 and 6.3-7 of Appendix F.

The outline of management and the expected yield in fish pond and water reservoir are shown in Table 6.3-8 of Appendix F.

3) Changes in the Farming Types

By the projection as above described, the area of major rice, soybean, industrial crops and vegetables will increase. By these changes, farming types in the Area will also change.

Farming types in the Area is differed by the areas, Area along Mekong river has the industrial crop farming, and Hilly area has paddy farming in rainy season.

The flood protection project will bring the industrial crops farming. It will also bring the paddy and upland farming which cultivate major rice in rainy season and soybean in dry season paddy, and major rice and vegetables farming can also be seen in areas. It means the Huai Vieng Kook and Huai Bang Phuan Areas Flood Protection project will bring many kinds of farming types.

6.4 Project Engineering

6.4.1 Project Facilities

1) Dimensions of facilities

Design dimensions for the facilities were decided from the water simulation calculation and may be summarized as follows.

Bang Phuan

		Dimension	
U/S	Regulator	2.50 m * 3.25m * 1 row	
	Bypass	Q = 3.298 MCM/day = 39 cu.m/s	
	River improvement	Q = 3.105 MCM/day = 36 cu.m/s	
D/S	Regulator	2.50 m * 3.25m * 1 row	
	Pumping station	Q = 0.55 MCM/day = 6.37 cu.m/s	
		Suction water level	EL. 164.00
		Delivery	EL. 166.61
	Bed level of existing regulator		EL. 160.78
	Crest level of existing dike		EL. 168.78
	Retaining water level		EL. 163.78

Vieng Kook

River improvement	Q = 4.150 MCM/day (48.0 cu.m/s)	
Pumping station	Q = 1.00 MCM/day (11.57cu.m/s)	
	Suction water level	EL. 164.00
	Delivery	EL. 166.78
Bed level of existing regulator		EL. 161.78
Crest level of existing dike		EL. 169.28
Retaining water level		EL. 165.78

2) Drainage canal

Drainage canals would be unlined canal and trapezoid shape with side slope 1:2. Design maximum velocity would be 1.0 m/s, considering the soil conditions. Flow depth are proposed at 3.0 m (WL.164.00-161.00) in sections of the river improvement and 5.0 m (WL.167.00-162.00) in bypass canal. Longitudinal gradient is proposed as 1/5,000, considering the topography. The hydraulic cross section will be decided by applying Manning's formula with n=0.03, as roughness coefficient.

Minimum bed width of canals is calculated as follows.

In case river improvement;
Q= 48 cu.m/s -- W=15.0 m V=0.80 m/s
In case of bypass
Q= 39 cu.m/s -- W= 1.0 m V=0.83 m/s

Design bed width of 20.0 m is employed for increasing water storage volume in the river. The width of dike is 5.0 meter with laterite pavement.

Storage volume (V) and crest elevation (T.EL) in each river are as follows.

Bang Phuan				
	Improved river	L= 9 km	V= 0.58 MCM	T.EL 165.00
	Bypass	L= 7 km	V= 0.38 MCM	T.EL 168.00
Vieng Kook				
	Improved river	L=18 km	V= 1.13 MCM	T.EL 165.00

3) Regulator

Two regulators,one for D/S and another for U/S will be provided for Bang Phuan area and in case of Vieng Kook, existing regulator will be used but rehabilitation of the gate will be necessary. After rehabilitation, gates will be operated by means of electric motor.

4) Pump

Each pumping station will be equipped with three sets pumps, considering flood discharge. Including losses, total pump head is calculated at 3.5 m. Mixed flow pumps with vertical shaft are selected from operational point of view. Total capacity (Qt) and unit capacity (Q) are as follows.

Area	Total Capacity	Sets	Unit Capacity	Bore & output
Bang Phuan	6.37 cum./s	3	2.13 cu.m/s	1000 mm*110 kw
Vieng Kook	11.37 cu.m/s	3	3.79 cu.m/s	1350 mm*190 kw

6.4.2 Rural Infrastructure Development

Vieng Kook and Huai Bang Phuan flood protection project area are surrounded by Highway (2), main road (211) and service road on the embankment of Mekong river. These major roads are two-lane paved road with good condition except for some part of service road on the embankment of Mekong river which should be rehabilitated.

The village road networks within the project area which run along or close to natural swamp boundary are mostly single lane laterite road, connecting to those main roads. Laterite village road of about 3 km long in Ban Phon Ngam is flooded during rainy season. This village road should be improved for traffic in all season.

It is proposed that all village networks in the project area should be paved and some routes are required widening width to ensure stable and easy access.

At present, the electricity supply in the project area is well served by the provincial power office except for a few houses located far away from the main supply line.

In general, village water supply is available. Except for Ban Phon Ngam, no drinking water pipeline (Tap water) system exists in the village. It is proposed that existing village water supply should be improved to meet the future demand in each village and establish a new village water supply at Ban Phon Ngam.

At present telephone service in the flood protection project area is not available, however it will be available in the next few years.

6. 4. 3 Implementation Program

Implementation of Project will be carried out as follows.

1) Executing Agency of the project

The executing agency of the project will be RID (Royal Irrigation Department) under the Ministry of Agriculture and Cooperatives, which has sufficient capability and long experience in carrying out detailed design,construction of civil works and operation and maintenance of the completed facilities of the project.

The executing agency will implement the detailed design for major project facilities recruiting a consulting firm,the construction contracting with a competing contractor and the operation and maintenance guiding water users' association.

2) Construction Mode

A qualified contractor to construct the project's civil work will be selected by competitive bidding.