Kingdom of Thailand
Royal Irrigation Department
Ministry of Agriculture and Cooperatives

FEASIBILITY STUDY

ON

MAE CHANG IRRIGATION PROJECT

EXECUTIVE SUMMARY

JANUARY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

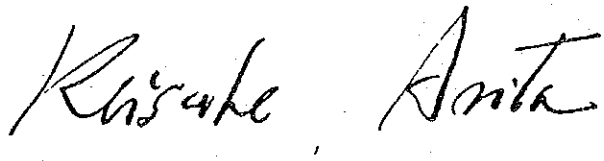
In response to the request of the Government of the Kingdom of Thailand the Japanese Government decided to conduct a feasibility study on the Mae Chang Irrigation Project and entrusted the study to the Japan International Cooperation Agency. The JICA sent to Thailand a preliminary survey team in October, 1982, the first survey team from January to March, 1983, and the second survey team from June to August 1983.

The teams exchanged views with the officials concerned of the Government of Thailand. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

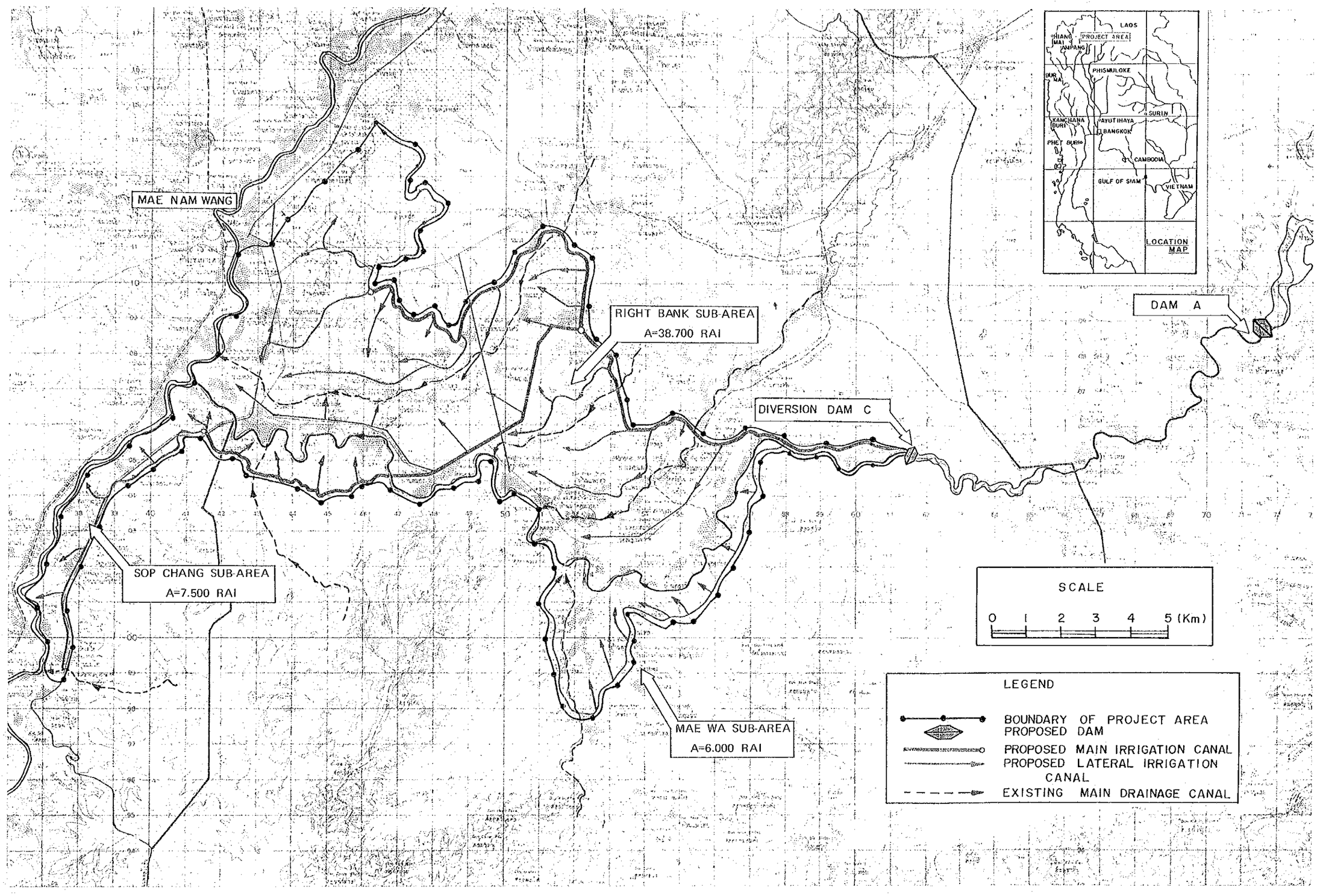
January, 1984



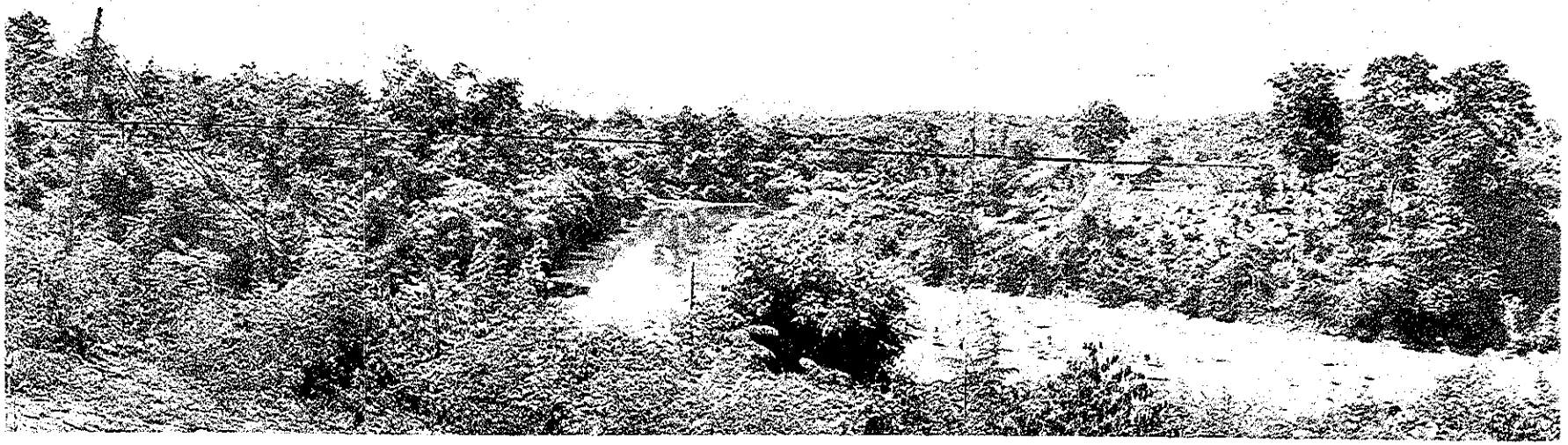
Keisuke Arita
President
Japan International Cooperation Agency

CONTENTS

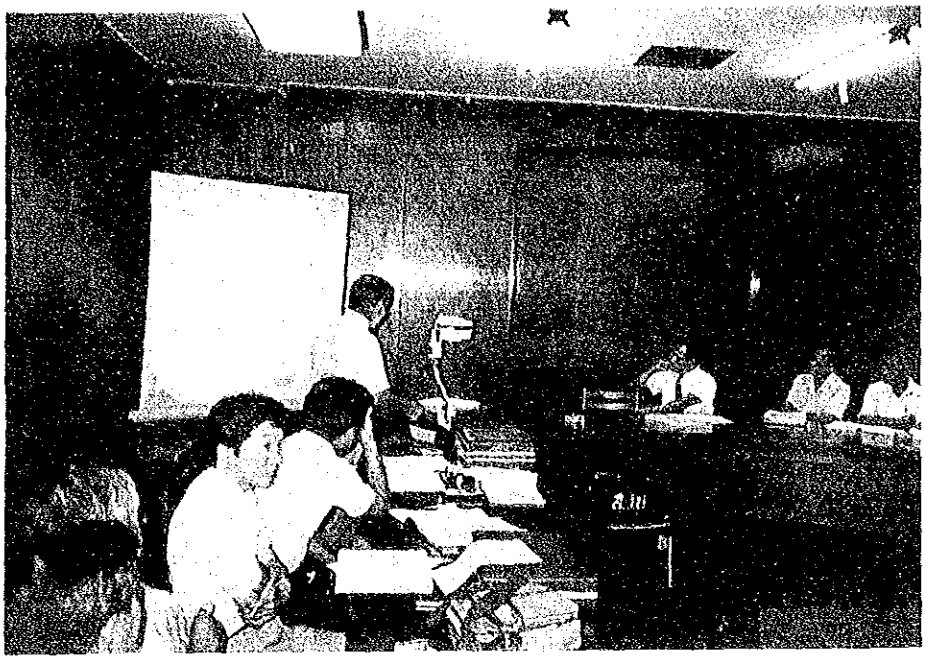
GENERAL PLAN OF MAE CHANG IRRIGATION PROJECT



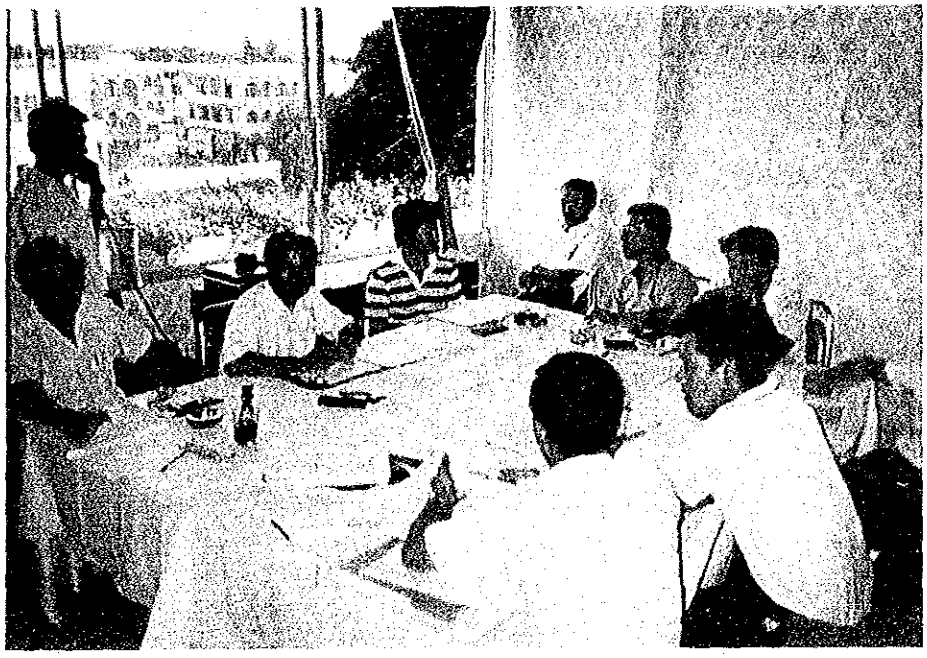
- PHOTO 1 -



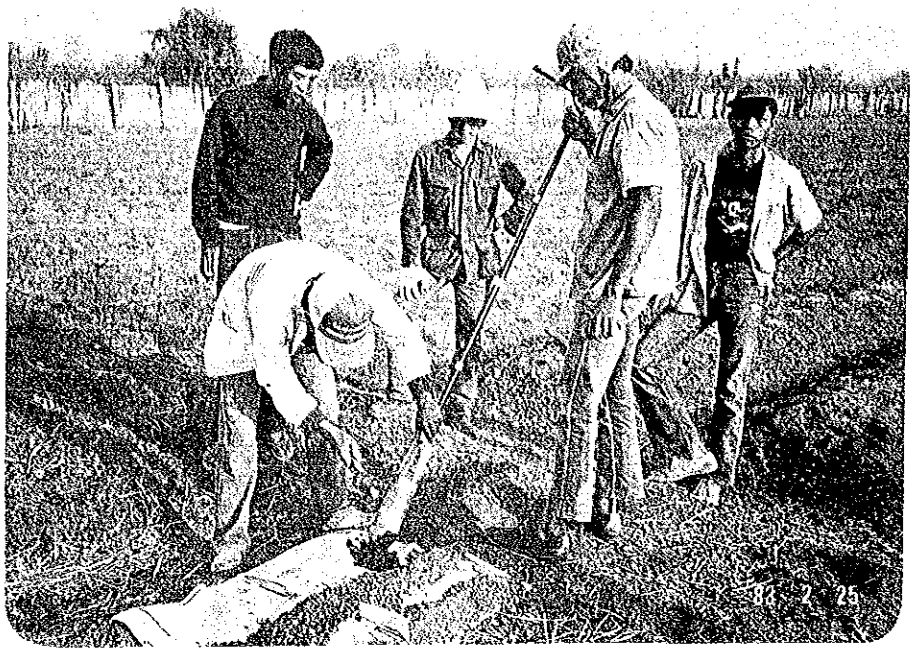
Diversion Dam C View from Upstream



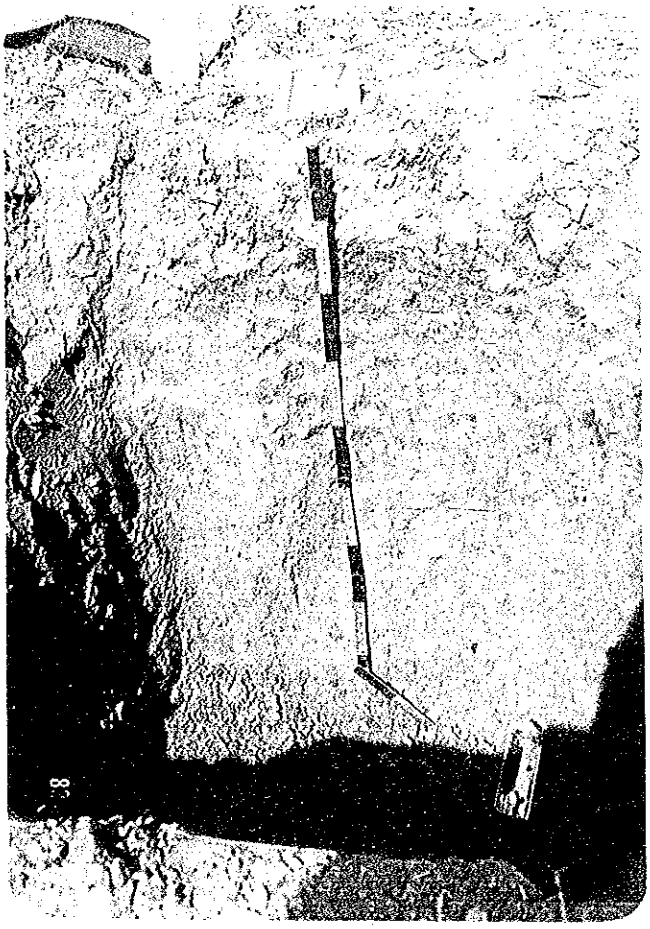
Discussion with Projector Presentation
between RID and Study Team in Bangkok



Project Planning Discussion by
Study Team Member in Lampang

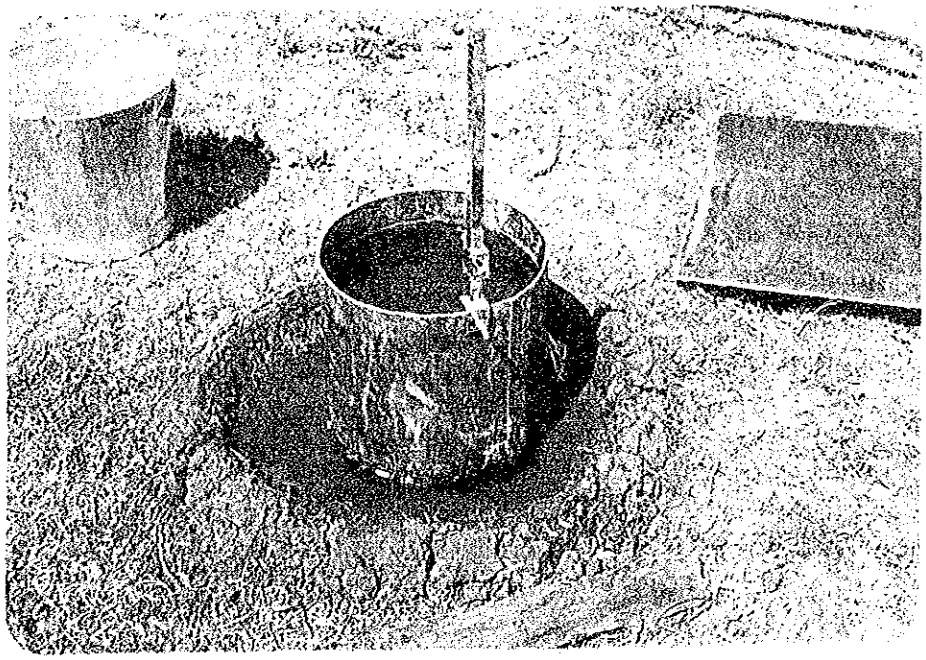


Soil Sampling by Auger

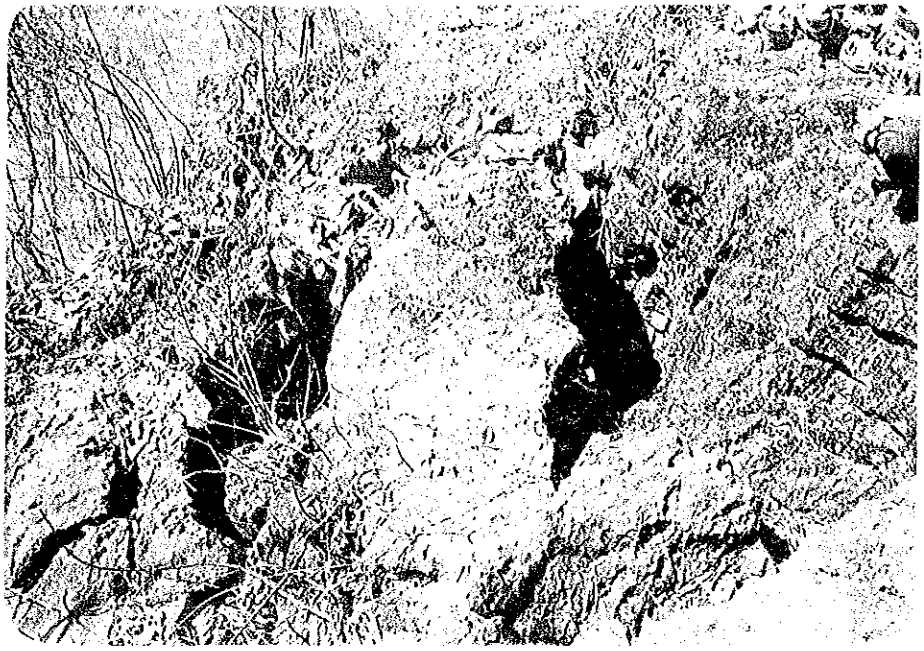


Test Pit for Soil Survey

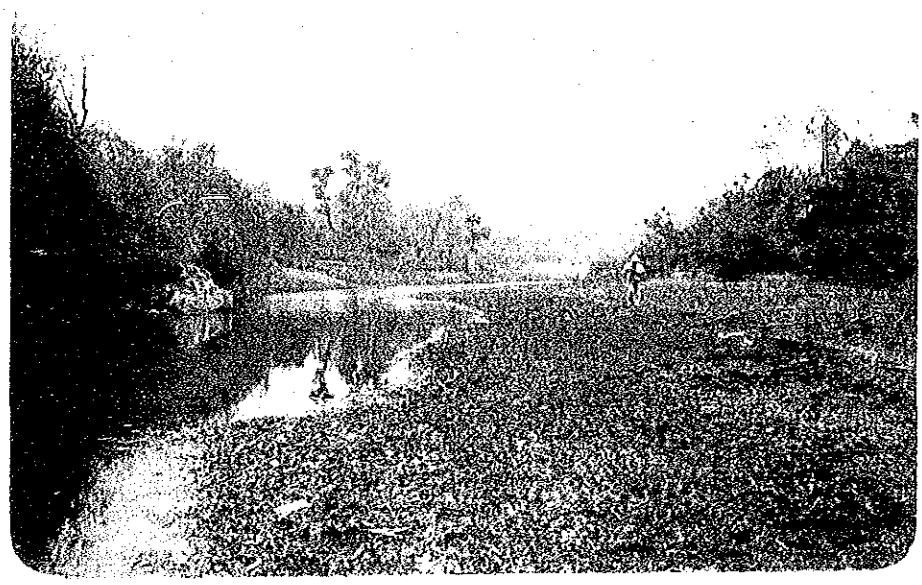
Observation of Percolation



Observation of Basic Intake Rate



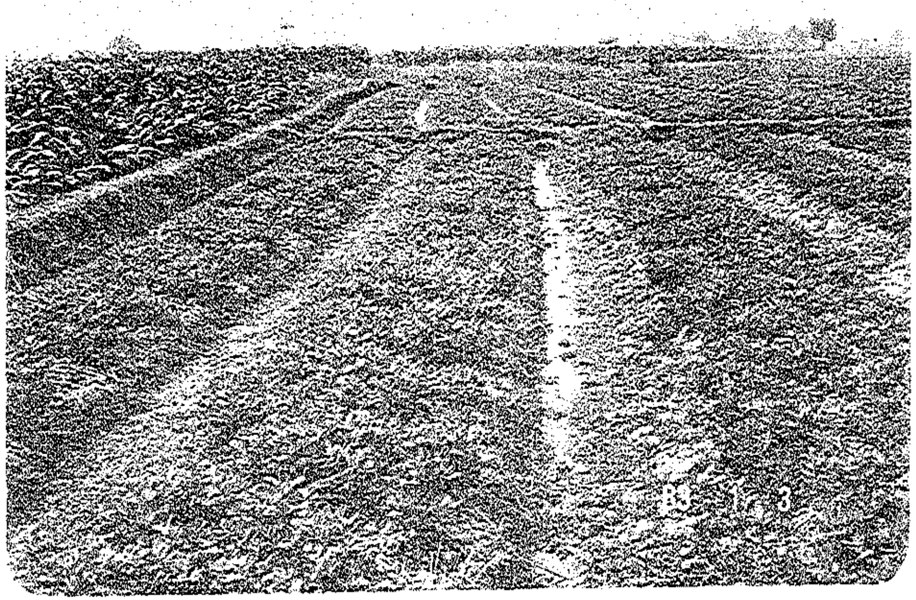
Sinkhole in Limestone Zone
Near Dam Site C



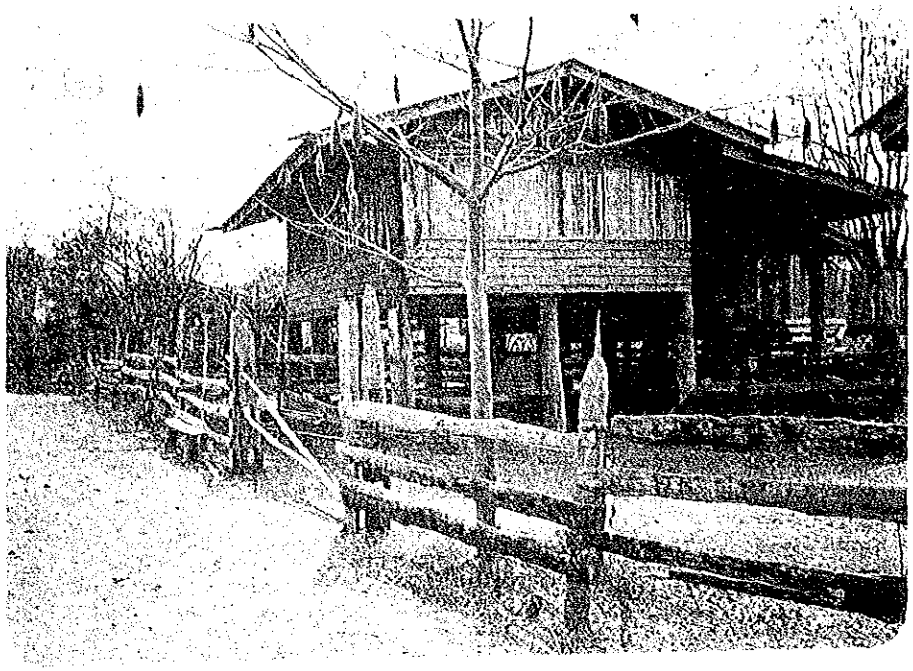
Mae Chang River Deposite
at Dam Site D

Nurseries

Transplanting



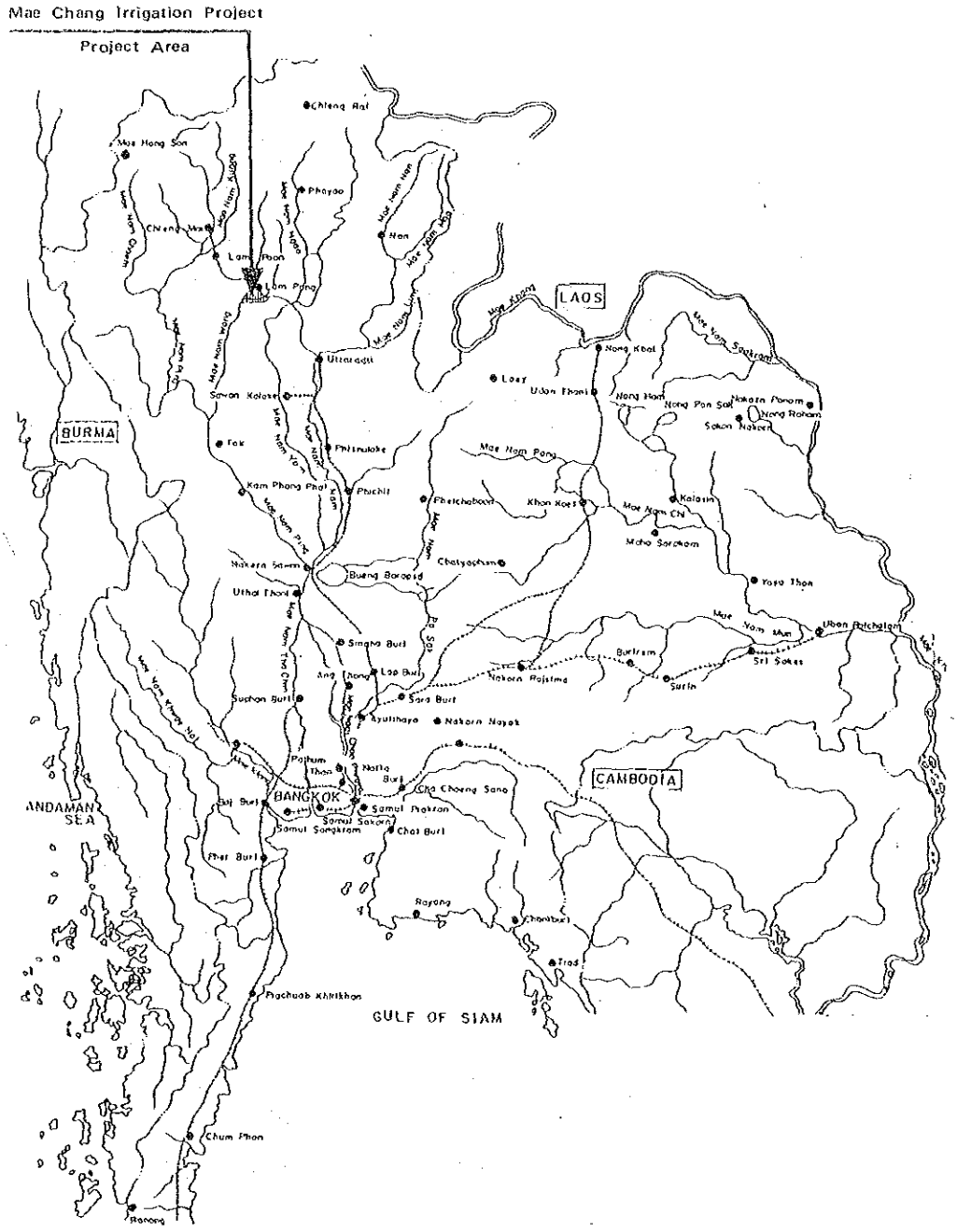
Above : Irrigation for Tobacco
Left Above : Irrigation for Groundnuts
Left Bottom: Garlic



Farmer's House at Ban Mae Lu
to be Submerged by Storage Dam A

Communal Living at Rural Area

SUMMARY



LOCATION MAP

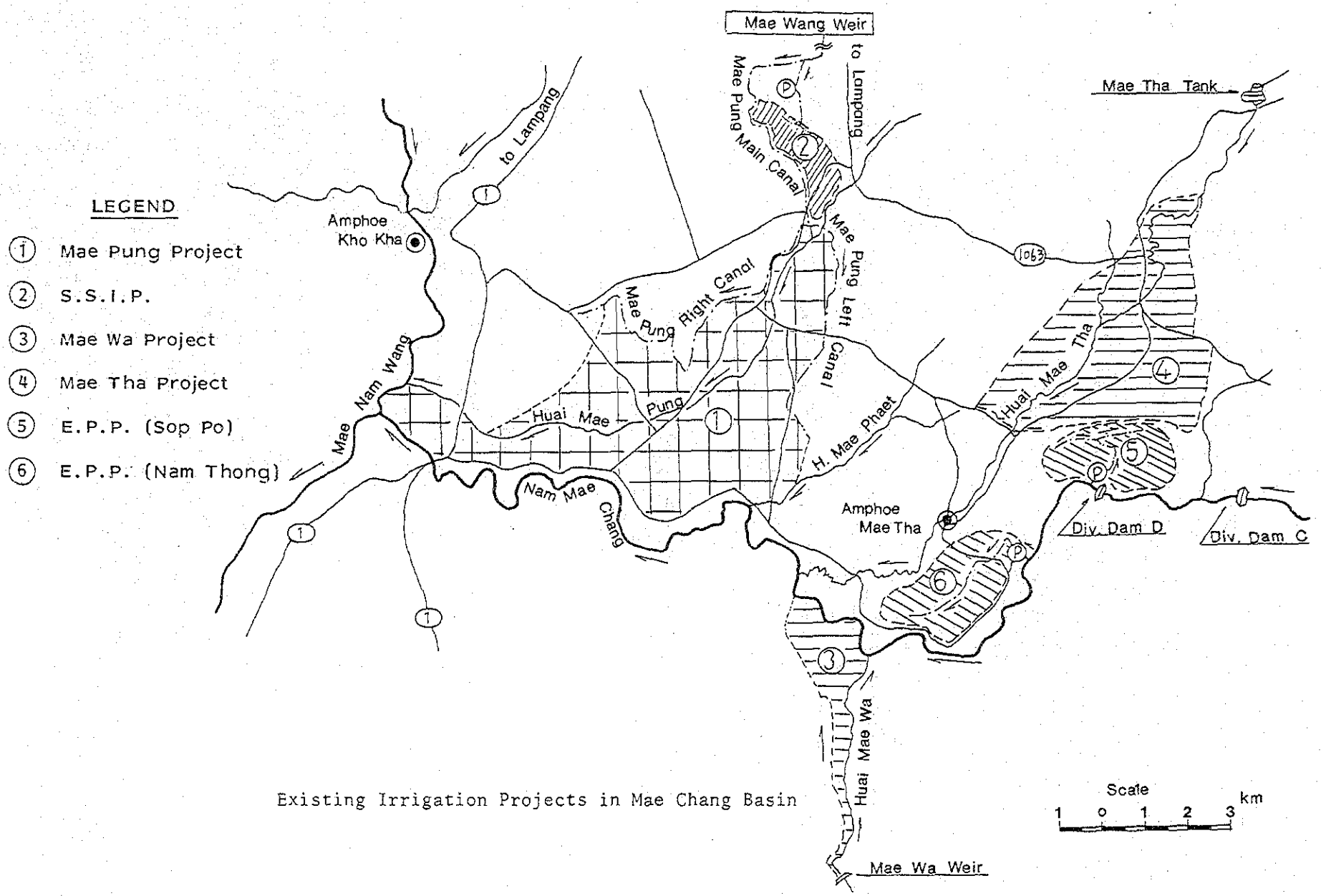
SUMMARY

Introduction

1. Most of the Project Area has never been under an irrigation system and is instead subject to a rainfed system so that farmers in this area have suffered from continuous droughts in the past, and these have resulted in frequent and great damage to the cultivated lands. For improvement of the situation in this area, RID and its regional office have made every endeavor to provide an irrigation system since the farmers in Amphoe Mae Tha, Changwat Lampang petitioned for the provision of an irrigation system in 1967. As a part of the activities, a development plan of the upper basin of the Mae Wang River was studied and implementation of five projects including Kew Lom Dam and Mae Chang Dam was recommended.

2. Since Kew Lom Dam and the irrigation system were completed in 1972 under the development plan of the Mae Wang River basin and agricultural productivity in the Mae Wang area was significantly improved and gave a great impact to the implementation of the Mae Chang Dam. As it is a large project requiring a large amount of fund to finance implementation, the Government of Thailand requested the Government of Japan to extend technical cooperation for the formulation of the development plan in this area.

3. In compliance with the scope of works for the feasibility study on the Mae Chang Irrigation Project agreed on between the Government of Thailand and the Government of Japan on November 4, 1982, the Japan International Cooperation Agency dispatched a feasibility study team for the first field work starting on January 30, 1983 and for the second field work starting on June 5, 1983 each for an approximately two month period.



Existing Irrigation Projects in Mae Chang Basin

Objectives of the Mae Chang Irrigation Project

4. The objectives of the Project are considered to be as follows:

(1) To intensify land use and increase agricultural production through water resources development by constructing a storage dam, a diversion dam and an irrigation system.

(2) To create employment opportunities throughout the year for farmers in and around the Project Area, and

(3) To improve the farm land for stable production and the rural environment for better farm life by the construction of irrigation and drainage facilities and road networks together with strengthening of the agricultural extension services.

Project Components

5. Project components are considered as follows:

(1) Water Resources Development

A storage dam and a diversion dam shall be constructed to provide water resources for irrigated agriculture.

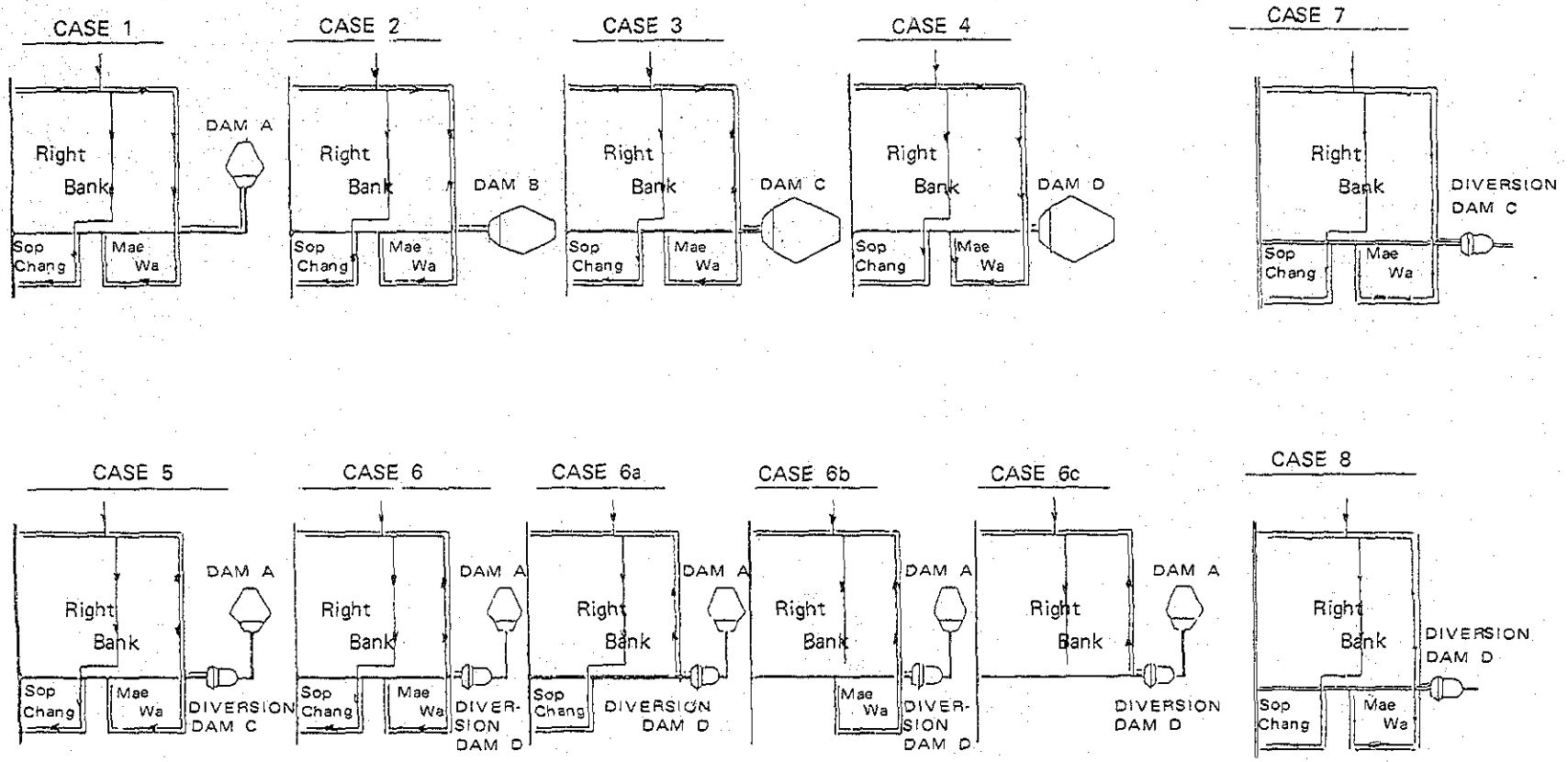
(2) Irrigated Agricultural Development

Irrigation and drainage canals, roads and fully organized agricultural extension services shall be provided to develop irrigated agriculture,

(3) Hydropower Development

Hydropower shall be generated for O & M of the irrigation system and to electrify villages neighboring the dam to be constructed.

ALTERNATIVE CASE STUDIES



Alternative Studies for Optimum Scale of Development

6. Alternative studies for optimum scale of development for the Mae Chang Irrigation Project have been discussed;

(1) Alternative dam site

Through the field reconnaissance and field survey along the Mae Chang basin, the following four alternative dam sites were selected after consideration of the maximum scale of dam construction on both geological and topographical bases:-

Dam Site A ..... Coordinates 47QNA 716 - 090,
NE 1.0 km from Ban Don Mun

Dam Site B ..... Coordinates 47QNA 658 - 048,
1.0 km downstream of Highway Bridge

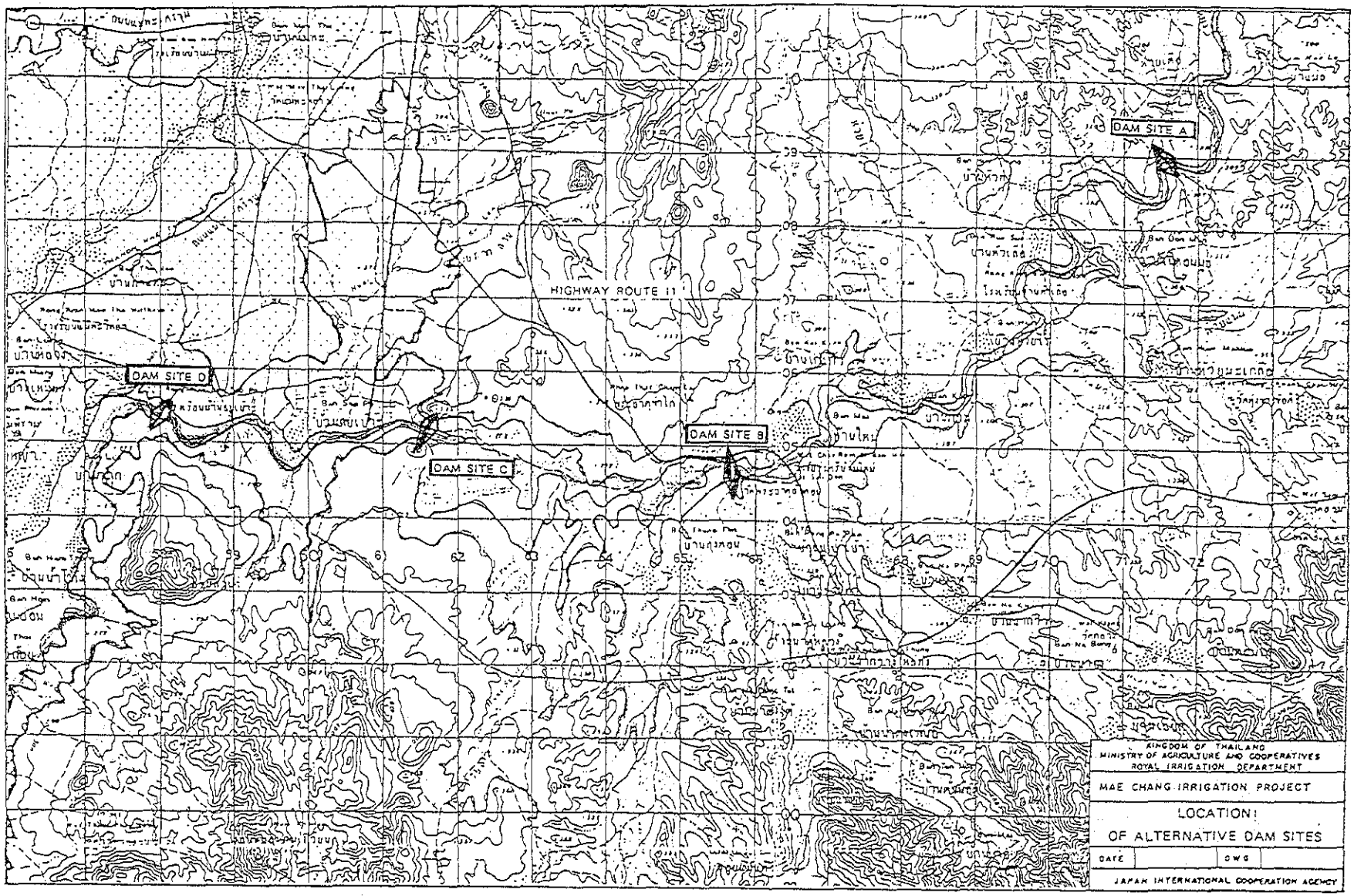
Dam Site C (RID) .. Coordinates 47QNA 615 - 052,
1.5 km upstream of Ban Sop Po

Dam Site D ..... Coordinates 47QNA 580 - 055,
2.0 km downstream of Ban Sop Po

(2) Alternative case studies

Case-1: Storage dam A at dam site A
Case-2: Storage dam B at dam Site B
Case-3: Storage dam C at dam site C
Case-4: Storage dam D at dam site D
Case-5: Combination of Storage dam A and Diversion dam C
Case-6: Combination of Storage dam A and Diversion dam D
Case-6a: Same as Case-6, covering the Area w/o Mae Wa
Case-6b: Same as Case-6, covering the Area w/o Sop Chang
Case-6c: Same as Case-6, covering the Mae Chang Right Bank only
Case-7: Diversion dam C only
Case-8: Diversion dam D only

LOCATION OF ALTERNATIVE DAM SITES



Results of Alternative Case Studies

7. A study regarding the engineering, economic, social and environmental aspects was made for each reservoir area to be submerged by the dam construction and based upon cost estimates for the compensation of private properties and the resettlement cost for the inhabitants concerned.

Results of the alternative case studies are summarized as follows:

Case	Dam Capacity (MCM)	H.W.L.	Submerged Area		Project Cost (฿/rai)	EIRR (%)
			No. of Ban	Family		
Case-1	35	283.00	1	22	31,160	9.8
Case-2	58	268.00	7	1,024	51,900	7.3
Case-3	72	266.00	8	1,328	41,100	9.8
Case-4	87	263.00	9	819	32,900	11.2
Case-5	42	254.00	5	125	33,900	9.9
Case-6	37	250.00	2	22	28,300	11.7
Case-6a	37	250.00	2	22	28,600	11.6
Case-6b	37	250.00	2	22	28,900	11.3
Case-6c	37	250.00	2	22	32,200	10.3
Case-7	7	254.00	4	103	21,700	9.2
Case-8	2	250.00	1	0	16,200	4.9

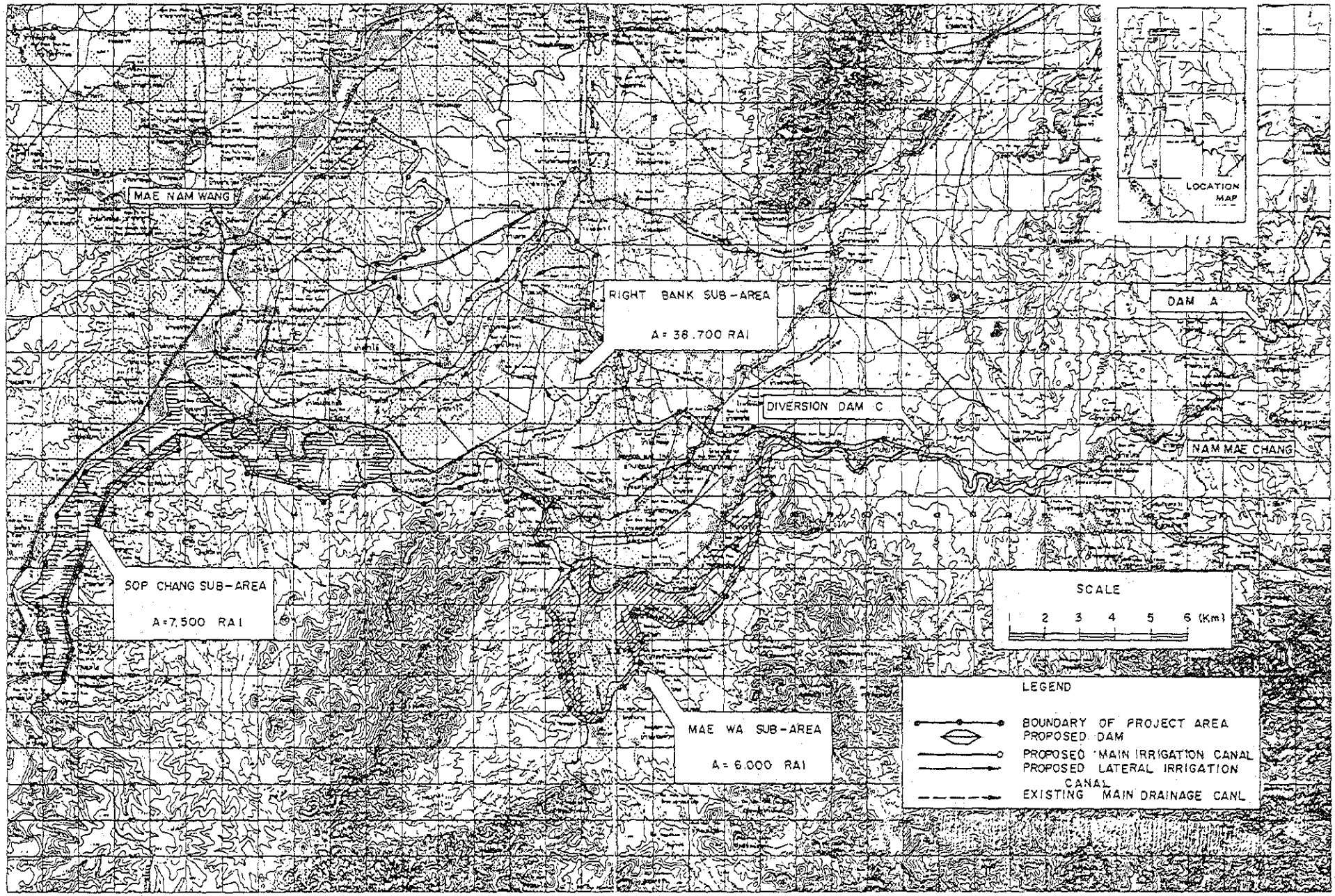
* Note: 1) The above-mentioned alternative case studies were made based upon the roughly estimated construction cost as investment of the Project and also a conservative estimate of the benefits from the Project which does not including benefits from livestock and fisheries.

2) Therefore, a detailed case study should be made after selection of the optimum scale of development.

Selection of Optimum Scale of Development

8. In conclusion, among the various alternative cases, Cases 5 and 6 involve construction of storage dam A with either diversion dam C or D required priority and so more detailed studies were conducted for these cases.

GENERAL PLAN OF MAE CHANG IRRIGATION PROJECT



Proposed Development Plan

9. According to the results of the detailed case studies for cases 5 and 6, the economic internal rate of return (EIRR) for cases 5 and 6 are 13.6 percent and 13.5 percent, respectively, which are both higher than the opportunity cost of investment. Therefore, from the point of view of economics, both Case 5 and Case 6 can be said to be economically feasible.

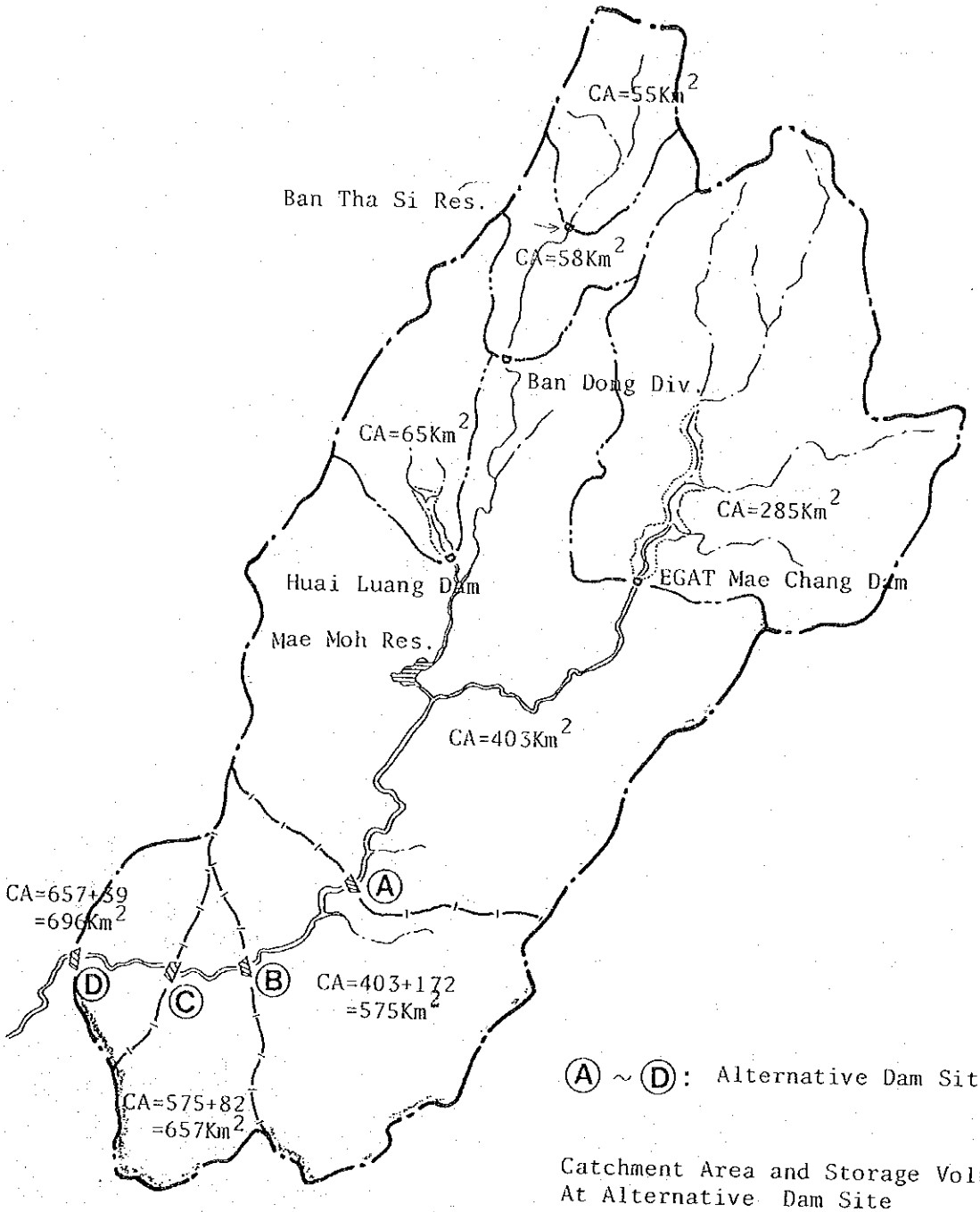
In the case of a drought year, the difference in storage capacity will be very effective in stabilizing the agricultural production.

In this regard, it is recommended that the development of Case 5 should be given priority and second priority given to Case 6.

Summary of Detailed Case Studies

Description	Case-5	Case-6
Development Scheme ...	Storage Dam A with Diversion Dam C	Storage Dam A with Diversion Dam D
Effective Storage .... Capacity	42 MCM (35 + 7)	37 MCM (35 + 2)
Project Area	52,200 rai (8,346 ha)	47,400 rai (7,576 ha)
Cropping Intensity		
- Wet season		
Paddy	80% (40,500 rai)	80% (36,400 rai)
Upland Crops	20% (10,100 rai)	20% (9,500 rai)
- Dry Season		
Upland Crops	30% (15,200 rai)	35% (16,050 rai)
Total	130% (65,800 rai)	135% (62,000 rai)

CATCHMENT AREA



Ⓐ ~ Ⓓ: Alternative Dam Site

Catchment Area and Storage Volume
At Alternative Dam Site

Dam Site	CA(Km^2)	V(MCM)
A	403	76
B	575	108
C	657	124
D	696	131

Meteorology and Hydrology

10. The climate of Thailand has generally tropical characteristics with the climatic seasons of the region influenced by two different monsoons. One is the north-east monsoon which begins in November and ends in the middle of March while the other is the south-west monsoon which lasts from the middle of May to September. Two seasons are defined by the annual distribution of rainfall, namely the wet season and the dry season.

(1) The annual rainfall ranges from 900 to 1,140 mm and is 1,090 mm on average.

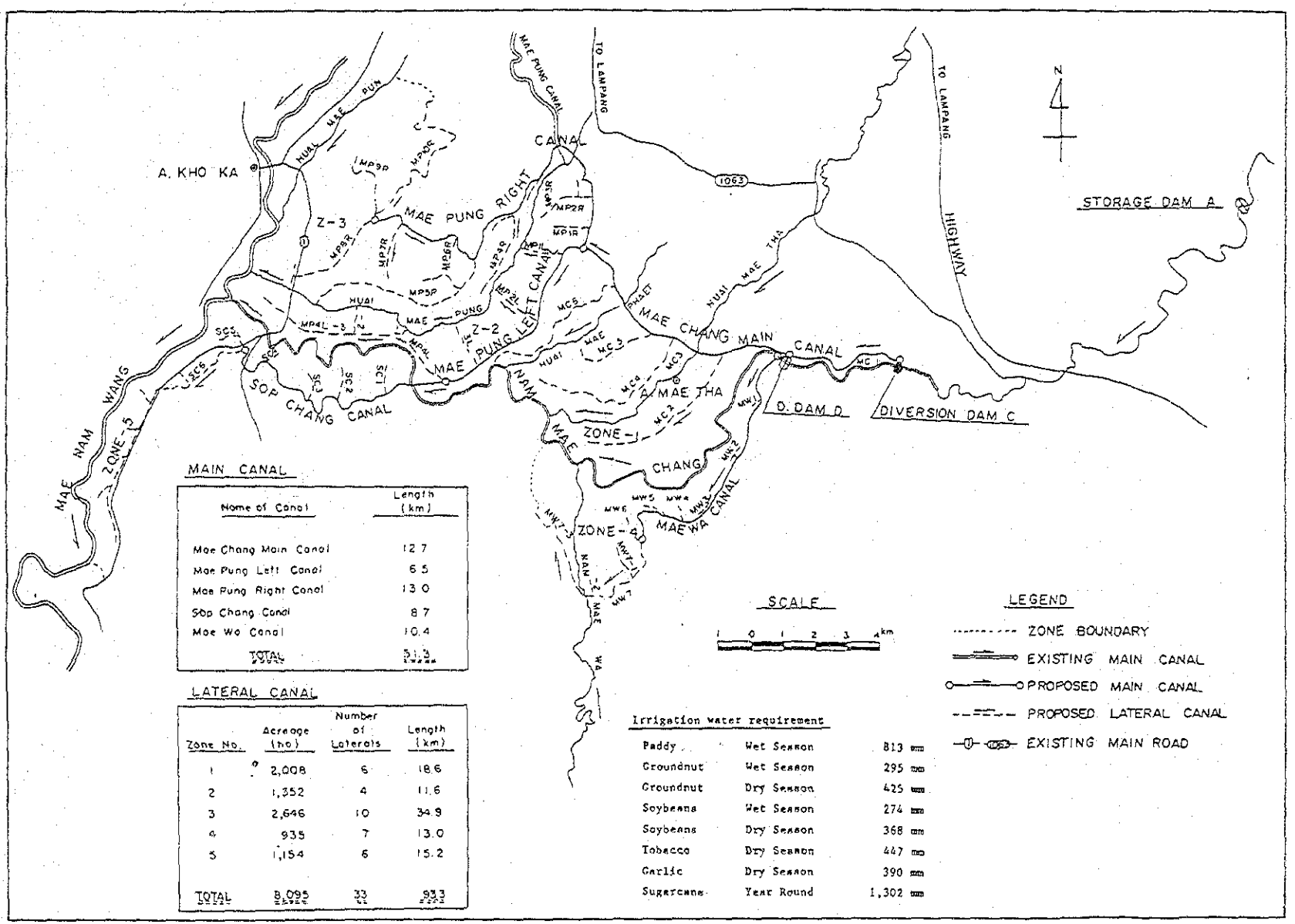
(2) The annual average runoff observed between 1971 and 1980 at station W-15 is 203.6 MCM, corresponding to a comparable runoff of 0.188 cubic meter per square kilometer per year. On the basis of this runoff, the runoff for the four alternative dam sites was analyzed as follows:

Dam Site	Catchment Area (sq.km)	Annual Average Runoff (MCM)
A	403	76
B	575	108
C	657	124
D	696	131

(3) The design flood discharge was estimated based on the hydrograph which was prepared by applying Nakayasu's Synthetic Unit Hydrograph Method and the spilled discharge from the EGAT Mae Chang dam. The design flood at each alternative dam site is as follows:

Dam site	A	B	C	D
Design flood m^3/sec	1,660	1,776	1,803	1,809

(4) Specific sediment was analyzed at 0.24 mm/year based on the analysis of observed data.



MAIN CANAL

Name of Canal	Length (km)
Mae Chang Main Canal	12.7
Mae Pung Left Canal	6.5
Mae Pung Right Canal	13.0
Sop Chang Canal	8.7
Mae Wa Canal	10.4
TOTAL	51.3

LATERAL CANAL

Zone No.	Acreage (ha)	Number of Laterals	Length (km)
1	2,008	6	18.6
2	1,352	4	11.6
3	2,646	10	34.9
4	935	7	13.0
5	1,154	6	15.2
TOTAL	8,095	33	93.3

Irrigation water requirement

Paddy	Wet Season	813 mm
Groundnut	Wet Season	295 mm
Groundnut	Dry Season	425 mm
Soybeans	Wet Season	274 mm
Soybeans	Dry Season	368 mm
Tobacco	Dry Season	447 mm
Garlic	Dry Season	390 mm
Sugarcane	Year Round	1,302 mm

Irrigation Plan

11. Irrigation water requirement, diversion water requirement and others are planned by the following manner:

(1) Reference crop evapotranspiration is estimated by the modified Penman method which offers the best results and the minimum possible errors under the climatic conditions. The irrigation water requirement for the proposed cropping pattern are computed on the basis of the consumptive use of crops which is predicted by applying the appropriate crop coefficient and the additional water supply for nursery beds, land preparation and paddy field percolation.

(2) Irrigation efficiency is applied at 54 percent for paddy fields and 46 percent for upland crops.

(3) Diversion water requirement is calculated in considering effective rainfall and irrigation efficiency.
Design discharge of main and lateral canals is determined at 1.30 liter/sec/ha.

(4) Irrigation area each for Case-5 and Case-6 are planned as follows:

	Case-5	Case-6
Gross Cultivation Land	52,200 rai	47,400 rai
(Project Area)	(8,346 ha)	(7,576 ha)
Net Cultivation Land	50,600 rai	45,900 rai
(Irrigable land with-Project)	(8,095 ha)	(7,349 ha)

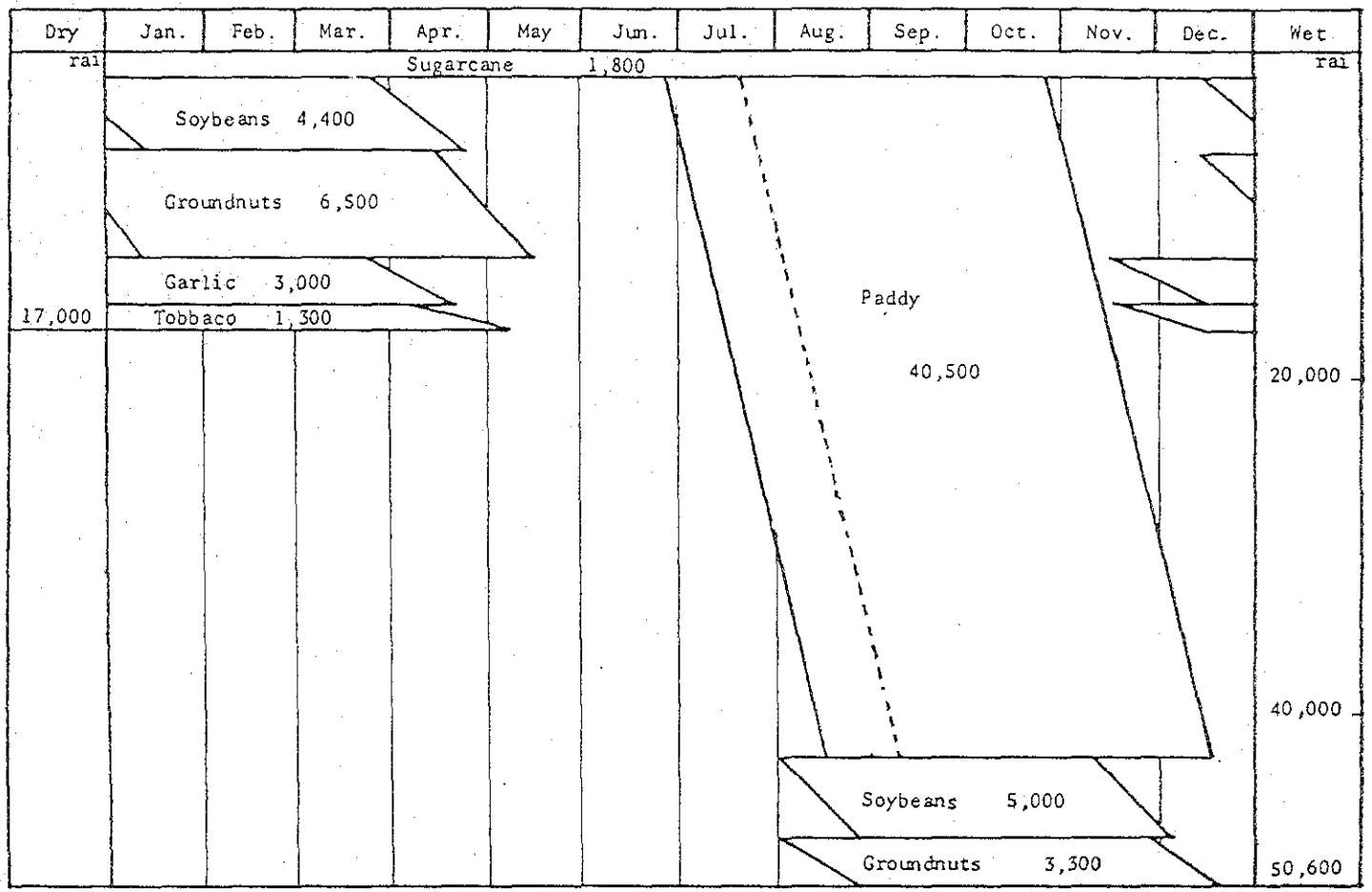
Drainage Plan

12. Drainage plan was provided according to the present conditions of the existing facilities and the drainage modulus.

(1) Drainage modulus in the irrigated paddy field is computed at 4.88 liter/sec/ha taking into consideration probable rainfall with 5- and 10- year return period and that a little damage will not be given to paddy plants when the flood lasts less than three days and remains less than 20 centimeter in depth on an average.

(2) Drainage from the hilly area is estimated at 24.3 liter/sec/ha by Rational method. However, this value will be modified depending upon the drainage area by using the reduction rate.

Cropping Calendar Case 5 (130%)



Proposed Agricultural Development

13. Agricultural development is proposed as follows:

(1) The total project area is surveyed at 71,940 rai (11,510 ha) and 66,200 rai (10,591 ha) for Case-5 and Case-6, respectively.

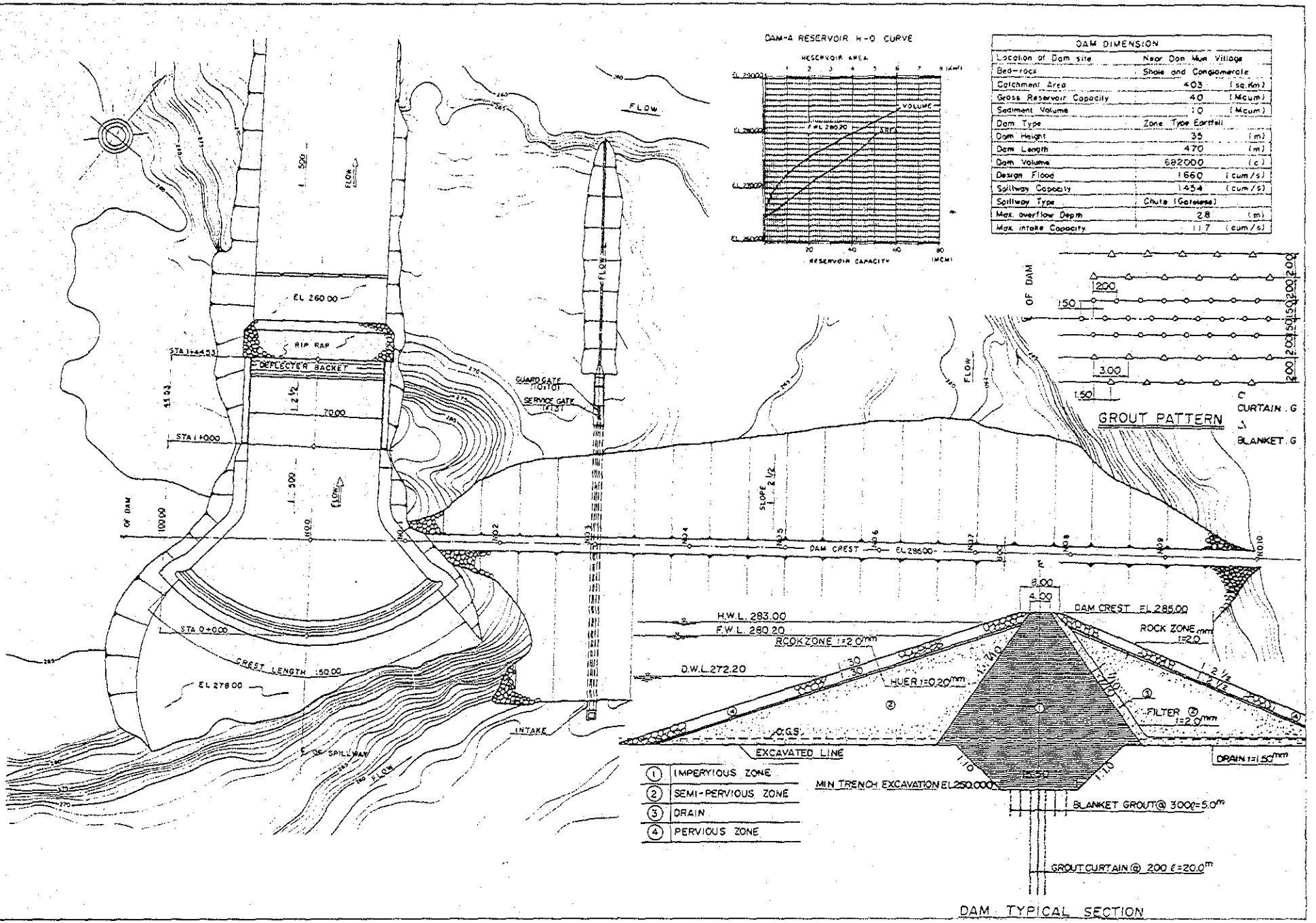
(2) Crop yield (kg/rai) are planned as follows:

			Soybeans	(Wet)	270
Paddy Glutinous		580		(Dry)	300
Non-glutinous		660	Tobacco		2,600
Groundnut	(Wet)	250	Garlic		700
	(Dry)	300	Sugarcane		8,000

(3) Planting ratio of glutinous and non-glutinous varieties of paddy is 40 to 60.

(4) Cropping pattern for Case-5 and Case-6 is proposed as follows:

Description	Case-5	Case-6
Wet Season		
- Paddy	40,500 rai(6,480 ha)	36,400 rai(5,819 ha)
- Soybeans ..	5,000 " (795 ")	4,600 " (740 ")
- Groundnuts.	3,300 " (530 ")	3,100 " (500 ")
- Sugarcane .	1,800 " (290 ")	1,800 " (290 ")
Sub-total	50,600 rai(8,095 ha)	45,900 " (7,349 ha)
Dry Season		
- Soybeans ..	4,400 rai(700 ha)	4,800 rai(770 ha)
- Groundnuts.	6,500 " (1,050 ")	7,300 " (1,160 ")
- Garlic	3,000 " (480 ")	3,000 " (480 ")
- Tobacco ...	1,300 " (200 ")	1,000 " (160 ")
- Sugarcane .	(1,800 ")(290 ")	(1,800 ")(290 ")
Sub-total	15,200 rai(2,430 ha)	(16,050 rai(2,570 ha)
Total	65,800 rai(10,525 ha)	(62,000 rai(9,919 ha)
Cropping Intensity	130%	135%


DAM-A RESERVOIR H-O CURVE
RESERVOIR AREA
VOLUME
F.W.L 280.20
RESERVOIR CAPACITY
DAM DIMENSION
Location of Dam site: Near Don Mun Village
Bed-rock: Shale and Conglomerate
Catchment Area: 403 (sq.Km)
Gross Reservoir Capacity: 40 (Mcum)
Sediment Volume: 10 (Mcum)
Dam Type: Zone Type Earthfill
Dam Height: 35 (m)
Dam Length: 470 (m)
Dam Volume: 682000 (c)
Design Flood: 1660 (cum/s)
Spillway Capacity: 1434 (cum/s)
Spillway Type: Chute (Gateless)
Max. overflow Depth: 2.8 (m)
Max. intake Capacity: 11.7 (cum/s)
EL 260.00
RIP RAP
DEFLECTER BACKET
STA 1+44.53
11.53
1:2½
70.00
STA 1+000
STA 0+00
CREST LENGTH 150.00
EL 278.00
OF DAM
100.00
FLOW
GUARD GATE (1.0T)
SERVICE GATE (1.2T)
INTAKE
SPILLWAY
SLOPE 1:2½
DAM CREST EL.286.00
H.W.L. 283.00
F.W.L. 280.20
RCOKZONE 1:2.0mm
D.W.L.272.20
HUER 1:0.20mm
O.G.S.
EXCAVATED LINE
8.00
4.00
DAM CREST EL.285.00
ROCK ZONE mm 1:2.0
FILTER ② 1:2.0mm
DRAIN 1:1.50mm
MIN TRENCH EXCAVATION EL.250.000
BLANKET GROUT@ 3.00ℓ=5.0m
GROUT CURTAIN @ 2.00 ℓ=20.0m
1.10
15.50
1 IMPERVIOUS ZONE
2 SEMI-PERVIOUS ZONE
3 DRAIN
4 PERVIOUS ZONE
GROUT PATTERN
200
150
3.00
1.50
CURTAIN . G
BLANKET . G
DAM TYPICAL SECTION

14. Storage Dam A

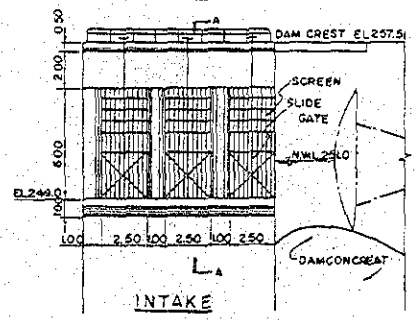
(1) According to the results of geological boring and the field investigation, the bedrock of the dam site consists of mainly mudstone and interbedded sandstone and conglomerate with thin layers of mudstone.

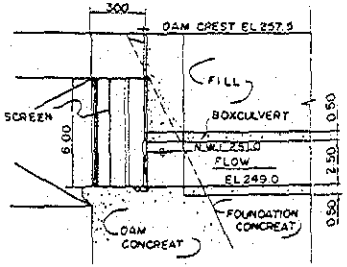
(2) A fill type dam is suitable for dam site A from the viewpoint of topography and geology. A homogeneous fill type dam is suitable because the borrow area is in vicinity of the dam site. The fill dam will become a zone type earth fill dam similar to a homogeneous dam type because the majority of dambody is occupied by both of the above materials.

(3) The type of spillway selected is a chute type without gate from the viewpoint of maintenance of the facilities and prevention of flood arising from inadequate gate operation. The crest length requires a 150 m overflow crest based on the design flood discharge (about 1,000 year return period) of 1,660 m^3/s, maximum spillway discharge of 1,464 m^3/s and overflow depth of 2.8 m.

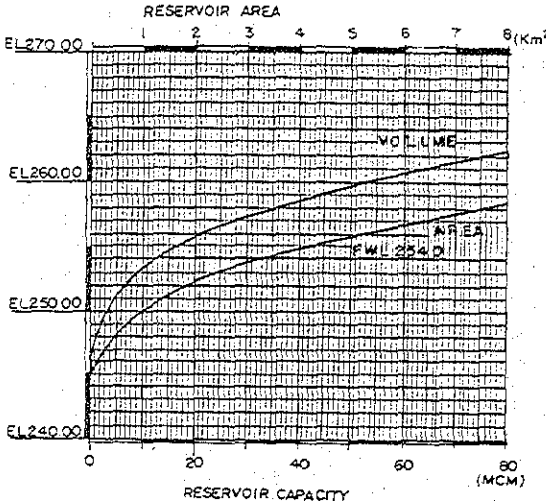
(4) Outlet facilities are so designed as to satisfy the demand of irrigation water as well as flood discharge during the the construction of the dam in the dry season A two-meter diameter steel liner conduit with a jetflow gate 1.3 meter as a regulating gate and a slide gate 1.0 x 1.0 m as a guard gate are considered.

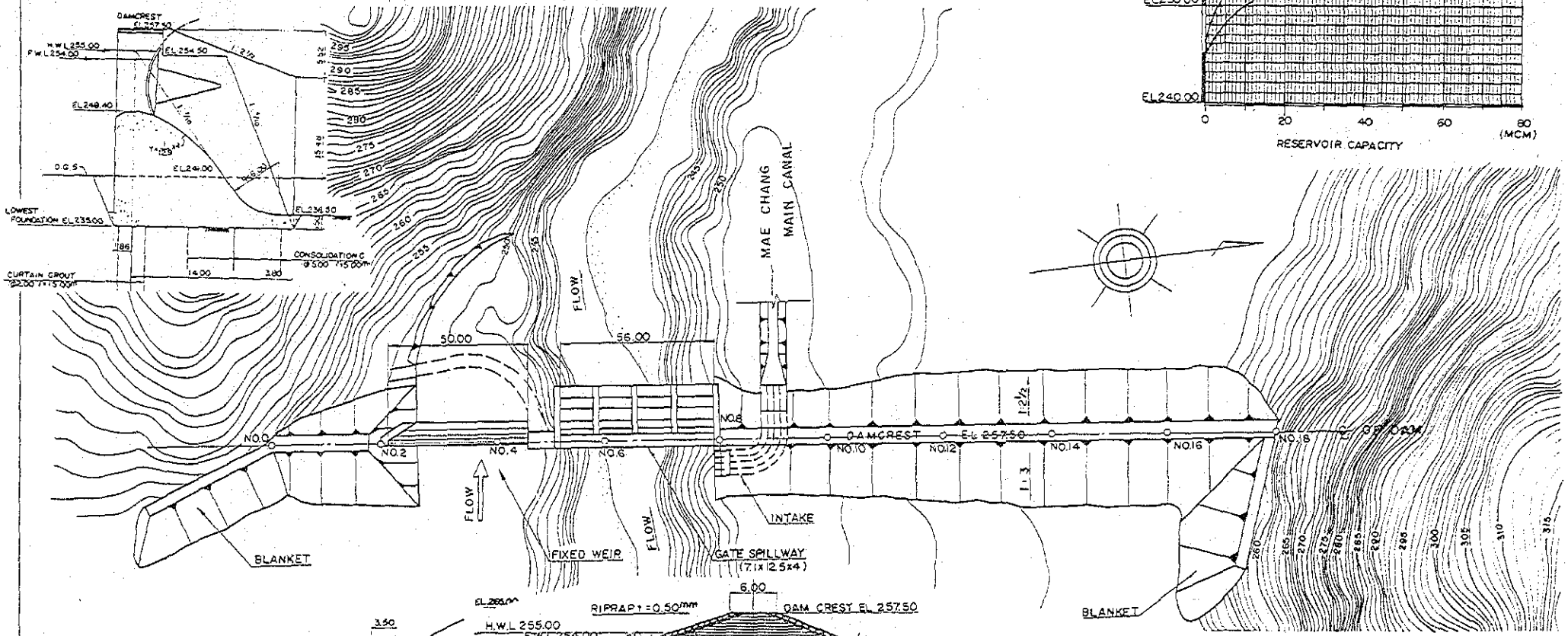
(5) The bedrock and foundation layer of the dam site have no particular problems for bearability except for river and lower terrace deposits. However, seepage control should be carried out with careful attention paid to the middle and higher terrace deposits in the contact face between the rocks and terrace, and the weathered rocks in the high permeability zone. Due consideration of the

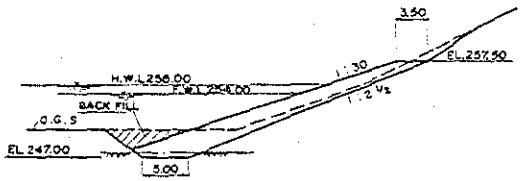




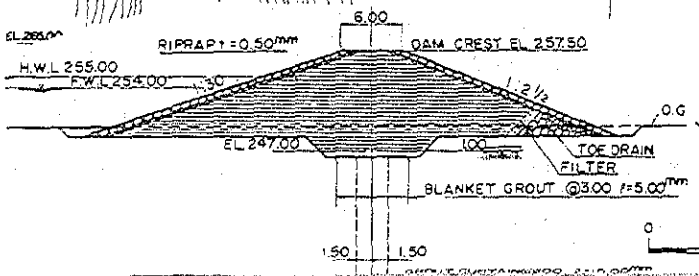
DAM DIMENSION		
Location of Dam site	Near Ban Sop Po Village	
Bed-rock	Limestone	
Catchment Area	254	(sq.Km)
Gross Reservoir Capacity	12	(Mcum)
Usable Reservoir Capacity	7	(Mcum)
Dam Type	Combination Type	
Dam Height	22.5	(m)
Dam Length	360	(m)
Dam Volume (cum)	CONC. 11,700 FILL 67,700	
Design Flood	1803	(cum/s)
Spillway Capacity	1803	(cum/s)
Spillway Type	Gated Type (12.5 x 7.1 x 4)	
Max. overflow Depth	6.6	(m)
Max. intake Capacity	10.5	(cum/s)







TYPICAL CROSS SECTION OF BLANKET



NOTE : 1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

2. ALL ELEVATIONS (EL) ARE IN METERS

SCALE

15. Diversion Dam C

(1) The bedrock of dam site C consists of very hard massive limestone which has no problem about bearing capacity for the dam structures.
At this dam site, the most important matter to be considered for the plan of the dam is how to control the water leakage through the bedrock and caused by the existence of sink holes and heavy open cracks.
In the case of the diversion dam, the high water level is 255 m and the water depth is nine meters for most of the Area near the dam site. Rock surface covered with terrace deposits composed of lean clay three to five meters in thickness and at the riverbed, water depth will be about 20 m measured up to the trench.

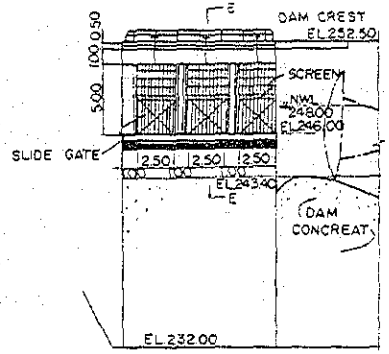
(2) From the viewpoint of topographical and geological conditions, the type of diversion dam C is considered to be a combination dam of the homogeneous type.

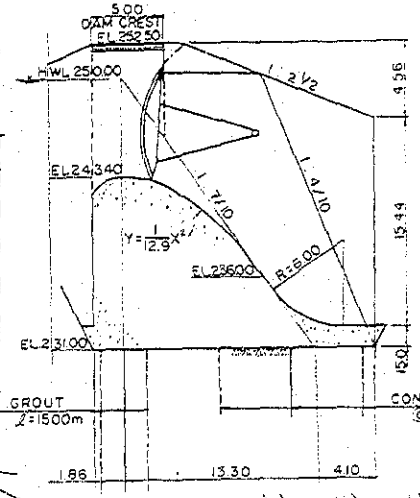
(3) It is expected that there will be small sinkhole or a big open crack at this limestone area and so foundation treatment should be carried out according to the geological conditions.
The grouting zone is planed deep and wide in comparison with the dam height after taking into account the properties of the limestones and the over-estimate.

(4) A spillway with a gate was adopted to create an effective storage capacity as large as possible. However, taking into consideration safety of the operation of the gate, a 50 m longs fixed weir is designed in addition to the gated spillway which accommodateds for 105 m^3/sec of flood without gate operation. The design flood discharge is taken to be at 1,803 m^3/sec in case of a 1,000 year return period.

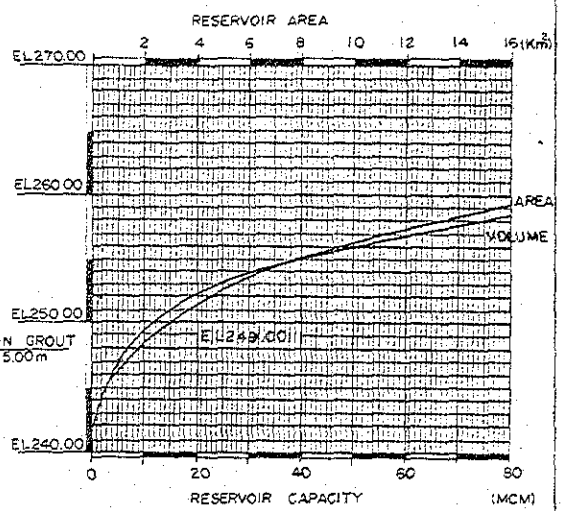
(5) An intake structure with three sets of 2.5 m x 2.5 m slide gates is planned to be located on the right bank of the diversion dam, because most of the irrigable area is on this of the Mae Chang River.

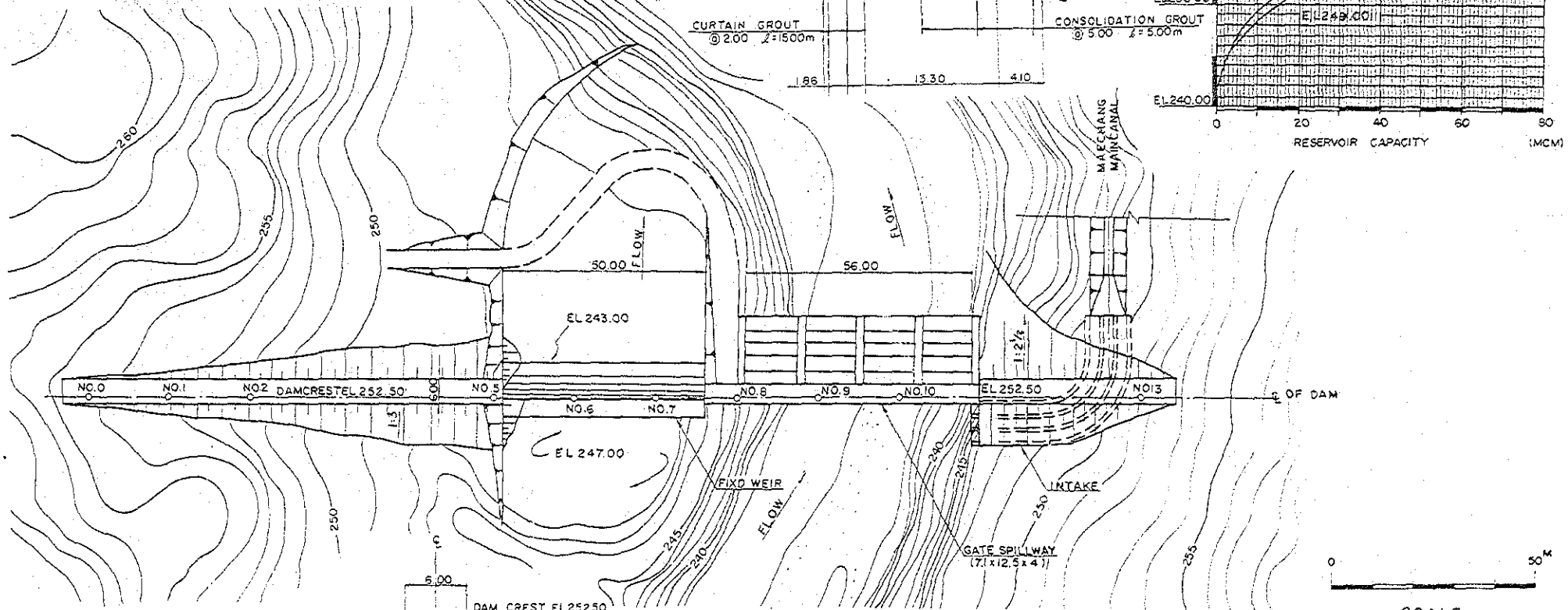
DAM DIMENSION		
Location of Dam site	Near San Sop Po Village	
Bed-rock	Limeston	
Catchment Area	293	(sq.Km)
Gross Reservoir Capacity	9	(Mcum)
Usable Reservoir Capacity	2	(Mcum)
Dam Type	Combination Type	
Dam Height	21.5	(m)
Dam Length	257	(m)
Dam Volume (cum)	CONC. 11800	FILL 13200
Design Flood	1809	(cum/s)
Spillway Capacity	809	(cum/s)
Spillway Type	Gated Type (12.5x7.1x4)	
Max. overflow Depth	6.6	(m)
Max. intake Capacity	10.5	(cum/s)

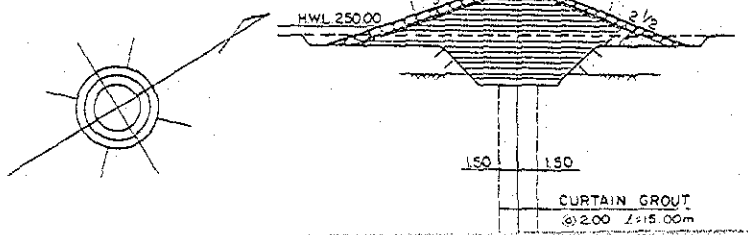




DAM-D RESERVOIR H-Q CURVE
DIVERSION DAM D AREA-VOLUME CURVES







NOTE : 1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

2. ALL ELEVATIONS (EL) ARE IN METERS.

16. Diversion Dam D

(1) According to geological boring conducted by RID, the bedrock at dam site D consists of sandstone, shale, calcareous sandstone, limestone and conglomerate. On the right bank, there is fine to medium sandstone, which is not particularly hard and distributed in alternate layers. At the riverbed and right riverside, there is distributed hard calciferous sandstone and partly banded limestone, while on the left riverside, there is distributed alluvium terrace deposits. On the left bank, there is massive limestone and sandstone and shale in alternate layers, and partly interbedded conglomerate.

(2) According to the topographical conditions, diversion dam D is suitable to apply a combination dam with a homogeneous fill type.

(3) The high water level and intake water level of diversion dam D are EL 250.00 and 248.00, respectively. A gated spillway combined with a 50 m fixed weir is proposed because of the small difference of both water levels. The gated spillway is located at the river course while a fixed weir is provided at the left bank in consideration of the location of the intake facilities located on the right bank and which is expected to wash out the sediments incurred in front of the intake structure.
structure.

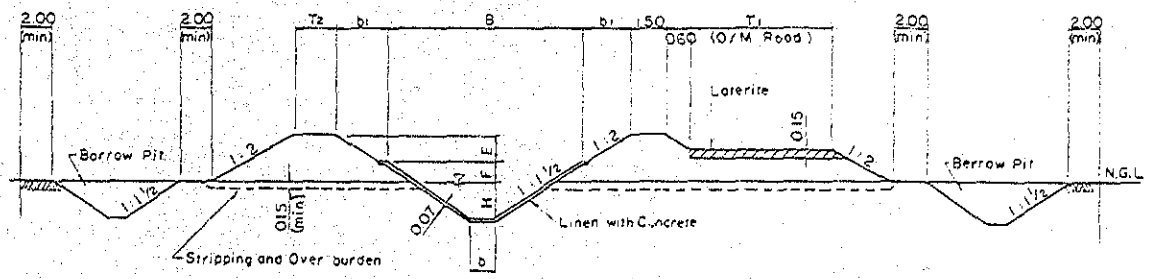
(4) The bedrock is favourable in bearability and permeability at the river bed and the right bank. Only the curtain grouting will be satisfactory with foundation treatment.

As for foundation treatment, the grouting method is suitable for seepage control due to the water pressure which is not particularly great.

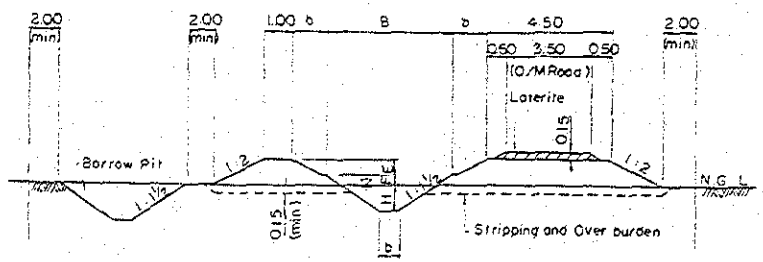
Careful attention should be paid to the middle terrace deposit on the left bank. The terrace deposit seems low in permeability, but judging from unconsolidated layer the curtain grouting should be adopted to carried out at the rock surface level.

TYPICA CROSS SECTION

MAIN CANAL



LATERAL CANAL



DIMENSION TABLE

MAIN CANAL

Name of Canal	Length (Km)	Discharge (cu.m/sec)	Velocity (m/sec)	Slope (I)	b (m)	H (m)	F (m)	E (m)	B (m)	b_1 (m)	T_1 (m)	T_2 (m)
Mae Chang Main Canal	1.60	10.52	0.93	1:7,000	2.70	1.99	0.35	0.50	9.75	1.15	5.00	3.50
	2.80	10.45	0.93	1:7,000	2.70	1.98	0.35	0.50	9.75	1.15	5.00	3.50
	2.10	9.23	0.90	1:7,000	2.70	1.87	0.35	0.50	9.45	1.15	5.00	3.50
	1.00	8.17	0.87	1:7,000	2.70	1.76	0.30	0.45	9.00	1.05	5.00	3.50
	1.30	8.09	0.87	1:7,000	2.70	1.75	0.30	0.45	8.85	1.05	5.00	3.50
	0.70	7.41	0.85	1:7,000	2.70	1.67	0.30	0.45	8.70	1.05	5.00	3.50
	1.80	7.05	0.84	1:7,000	2.70	1.63	0.30	0.45	8.55	1.05	5.00	3.50
	1.40	6.70	0.83	1:7,000	2.70	1.59	0.30	0.45	8.40	1.05	5.00	3.50
	(12.70)											
Mae Pung Left Canal	0.80	3.26	1.11	1:2,000	1.80	0.93	0.20	0.40	5.25	0.95	3.50	2.00
	2.50	2.96	1.07	1:2,000	1.80	0.88	0.20	0.40	5.10	0.95	3.50	2.00
	2.00	2.66	1.05	1:2,000	1.80	0.84	0.20	0.40	9.45	0.95	3.50	2.00
	1.20	2.23	1.00	1:2,000	1.80	0.76	0.20	0.40	4.80	0.95	3.50	2.00
	(6.50)											
Mae Pung Right Canal	0.90	3.44	0.75	1:6,000	1.80	1.26	0.20	0.40	6.30	0.95	3.50	2.00
	1.00	3.24	0.74	1:6,000	1.80	1.22	0.20	0.40	6.15	0.95	3.50	2.00
	2.60	2.99	0.72	1:6,000	1.80	1.17	0.20	0.40	6.00	0.95	3.50	2.00
	1.80	2.91	0.72	1:6,000	1.80	1.16	0.20	0.40	6.00	0.95	3.50	2.00
	2.30	2.43	0.68	1:6,000	1.80	1.05	0.20	0.40	5.55	0.95	3.50	2.00
	1.30	1.78	0.67	1:5,000	1.80	0.86	0.20	0.40	5.10	0.95	3.50	2.00
	2.30	1.65	0.66	1:5,000	1.80	0.83	0.20	0.40	4.95	0.95	3.50	2.00
	0.80	1.25	0.62	1:5,000	1.20	0.83	0.20	0.40	4.35	0.95	3.50	2.00
	(13.00)											
Mae Na Canal	2.40	1.22	0.61	1:5,000	1.80	0.71	0.20	0.40	4.65	0.95	3.50	2.00
	2.30	1.07	0.58	1:5,000	1.80	0.66	0.20	0.40	4.50	0.95	3.50	2.00
	1.30	0.99	0.64	1:4,000	1.20	0.70	0.15	0.30	3.75	0.75	3.50	2.00
	1.00	0.83	0.63	1:4,000	1.20	0.68	0.15	0.30	3.75	0.75	3.50	2.00
	0.50	0.80	0.61	1:4,000	1.20	0.65	0.15	0.30	3.60	0.75	3.50	2.00
	2.90	0.68	0.58	1:4,000	1.20	0.58	0.15	0.30	3.45	0.75	3.50	2.00
	(10.40)											
Sop Chang Canal	2.30	1.50	0.69	1:4,000	1.80	0.74	0.20	0.40	4.65	0.95	3.50	2.00
	1.40	1.33	0.67	1:4,000	1.80	0.70	0.20	0.40	4.50	0.95	3.50	2.00
	1.80	1.14	0.64	1:4,000	1.80	0.64	0.20	0.40	4.35	0.95	3.50	2.00
	1.80	1.01	0.62	1:4,000	1.80	0.60	0.20	0.40	4.20	0.95	3.50	2.00
	1.40	0.92	0.62	1:4,000	1.20	0.67	0.15	0.30	3.75	0.75	3.50	2.00
	(8.70)											
	(51.30)											

LATERAL CANAL

Name of Canal	Length (Km)	Discharge (cu.m/s)	Velocity (m/s)	Slope (I)	b (m)	H (m)	F (m)	E (m)	B (m)	b_1 (m)
MC1	0.50	0.08	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MC2	1.80	1.06	0.66	1:1,500	1.20	0.75	0.20	0.40	4.05	0.90
	2.10	0.80	0.62	1:1,500	0.80	0.70	0.15	0.30	3.35	0.70
	1.40	0.40	0.52	1:1,500	0.50	0.60	0.15	0.30	1.85	0.70
MC3	0.10	0.09	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MC4	1.40	0.68	0.59	1:1,500	0.80	0.65	0.15	0.30	3.20	0.70
	2.20	0.45	0.53	1:1,500	0.50	0.60	0.15	0.30	2.75	0.70
	1.70	0.25	0.52	1:1,000	0.50	0.40	0.15	0.30	2.15	0.70
MC5	2.50	0.36	0.51	1:1,500	0.50	0.55	0.15	0.30	2.60	0.70
MC6	2.50	0.36	0.51	1:1,500	0.50	0.55	0.15	0.30	2.60	0.70
	2.60	0.12	0.45	1:1,500	0.50	0.40	0.15	0.30	2.15	0.70
	(18.6)									
MP1L	1.10	0.30	0.48	1:1,500	0.50	0.50	0.15	0.30	2.45	0.70
MP2L	1.20	0.29	0.48	1:1,500	0.50	0.50	0.15	0.30	2.45	0.70
MP3L	1.20	0.44	0.53	1:1,500	0.50	0.60	0.15	0.30	2.75	0.70
MP4L	1.40	0.75	0.61	1:1,500	0.80	0.70	0.15	0.30	3.35	0.70
	1.10	0.52	0.56	1:1,500	0.80	0.60	0.15	0.30	3.05	0.70
MP4L-1	0.60	0.21	0.45	1:1,500	0.50	0.45	0.15	0.30	2.30	0.70
MP4L-2	0.80	0.15	0.51	1:1,500	0.50	0.55	0.15	0.30	2.60	0.70
MP4L-3	5.20	0.20	0.45	1:1,500	0.50	0.45	0.15	0.30	2.30	0.70
	(11.6)									
MP1R	1.20	0.20	0.52	1:1,000	0.50	0.40	0.15	0.30	2.15	0.70
MP2R	0.50	0.25	0.56	1:1,000	0.50	0.45	0.15	0.30	2.30	0.70
	2.20	0.15	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MP3R	0.50	0.80	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MP4R-1	3.10	0.34	0.59	1:1,000	0.50	0.50	0.15	0.30	2.45	0.70
MP4R-2	1.00	0.14	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MP5R	1.70	0.65	0.59	1:1,500	0.80	0.65	0.15	0.30	3.20	0.70
	1.30	0.47	0.53	1:1,500	0.50	0.60	0.15	0.30	2.75	0.70
	4.20	0.22	0.52	1:1,000	0.50	0.40	0.15	0.30	2.15	0.70
MP6R	0.90	0.14	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
MP7R	1.40	0.39	0.62	1:1,000	0.50	0.55	0.15	0.30	2.60	0.70
MP8R	2.40	0.69	0.65	1:1,000	0.50	0.60	0.15	0.30	2.75	0.70
	2.00	0.25	0.56	1:1,000	0.50	0.45	0.15	0.30	2.30	0.70
MP9R	0.80	0.62	0.45	1:5,000	0.80	0.75	0.15	0.30	3.50	0.70
	3.10	0.36	0.46	1:2,000	0.50	0.60	0.15	0.30	2.75	0.70
MP10R	8.10	0.38	0.46	1:2,000	0.50	0.60	0.15	0.30	2.75	0.70
	(34.9)									
MM1	0.50	0.15	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
MM2	0.70	0.08	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MM3	0.50	0.06	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MM4	0.50	0.08	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
MM5	1.10	0.18	0.52	1:1,000	0.50	0.40	0.15	0.30	2.15	0.70
MM6	1.30	0.17	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
MM7	1.20	0.51	0.51	1:2,000	0.80	0.65	0.15	0.30	3.20	0.70
	1.20	0.34	0.51	1:1,500	0.50	0.55	0.15	0.30	2.60	0.70
MM7-1	1.20	0.17	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
MM7-2	0.80	0.14	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
MM7-3	4.00	0.20	0.51	1:1,000	0.50	0.40	0.15	0.30	2.15	0.70
	(13.0)									
SC1	0.70	0.17	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
SC2	1.10	0.19	0.45	1:1,500	0.50	0.40	0.15	0.30	2.15	0.70
SC3	0.70	0.13	0.49	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
SC4	0.40	0.09	0.45	1:1,000	0.50	0.30	0.15	0.30	1.85	0.70
SC5	1.10	0.21	0.45	1:1,500	0.50	0.45	0.15	0.30	2.30	0.70
SC6	4.20	0.71	0.47	1:3,000	0.80	0.80	0.15	0.30	3.65	0.70
	2.60	0.36	0.51	1:1,500	0.50	0.55	0.15	0.30	2.60	0.70
	4.40	0.10	0.45	1:1,000	0.50	0.35	0.15	0.30	2.00	0.70
	(15.2)									

17. Irrigation Facilities

(1) In the wet season, the existing irrigation area is located in the left bank area (Mae Wa 400 ha) and in the right bank area (Mae Pung 2,500 ha).

(2) The irrigable area can be divided into right and left banks and in detail into five zones as follows:

Name of Zone	Name of Sub-area	Case-5	Case-6
1	Mae Chang	12,550 rai (2,008 ha)	11,600 rai (1,860 ha)
2	Mae Pung Left	8,450 " (1,352 ")	8,100 " (1,302 ")
3	Mae Pung Right	16,540 " (2,646 ")	14,400 " (2,300 ")
	Sub-total of Right Bank	37,540 rai (6,006 ha)	34,100 rai (5,462 ha)

Name of Zone	Name of Sub-area	Case-5	Case-6
4	Mae Wa	5,850 rai (935 ha)	4,800 rai (761 ha)
5	Sop Chang	7,210 " (1,154 ")	7,000 " (1,126 ")
	Sub-total of Left Bank	13,060 rai (2,089 ha)	11,800 rai (1,887 ha)
	Total	50,600 rai (8,095 ha)	45,900 rai (7,349 ha)

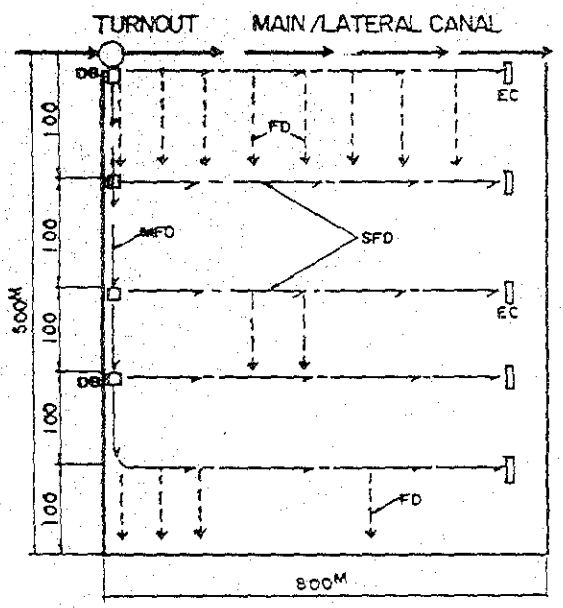
(3) Five canals are named as the main irrigation canal to irrigate the Project Area. Out of the five, two canals take the routes of existing canals and will be improved as a new irrigation network. The other three will be newly constructed.

18. Drainage Facilities

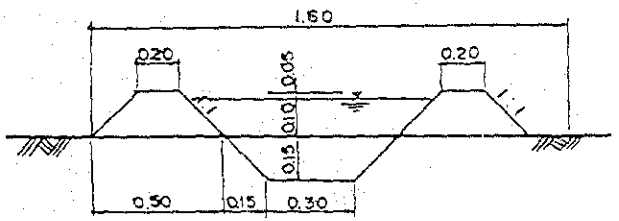
(1) Major works for drainage facilities are proposed as the upgrading of trunk channels, their enlargement removal of existing weirs and enlargement of crossing structures.

(2) Upgrading and enlargement of trunk channels, removal of existing weirs and enlargement of existing cross structures are listed as follows:

ON-FARM DEVELOPMENT FACILITIES

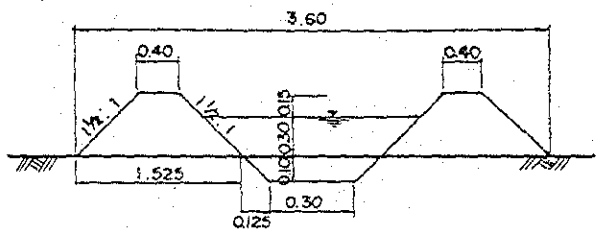


TYPICAL IRRIGATION BLOCK (CHAK)
AVERAGE ARER 250RAI (40HA)

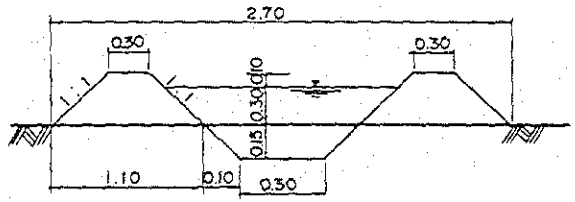


FIELD DITCH (FD)

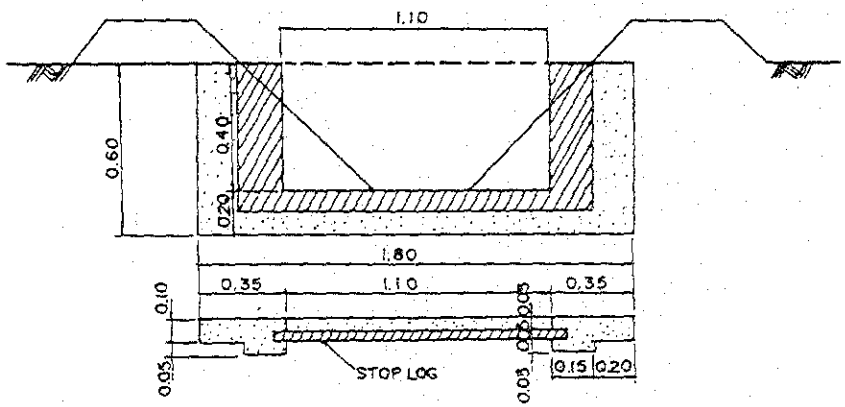
TURNOUT (TO)
DIVISION BOX (DB)
END CHECK (EC)
MAIN FARM DITCH (MFD)
SUPPLEMENTARY FARM DITCH (SFD)
FIELD DITCH (FD)



MAIN FARM DITCH (MFD)



SUPPLEMENTARY FARM DITCH (SFD)



DIVISION BOX (DB) AND END CHECK (EC)

19. On-farm Development

(1) The provision of on-farm facilities is essential work for irrigated agriculture with farm mechanization and the farmers' eagerness for agriculture will act as the prime mover. To carry out the proper water management, careful control and measurement of water are required.

(2) It is recommended to implement the on-farm development by by the RID quickly to realize the purpose of the agricultural development. However, taking the recent Thai Government policy on the agricultural development into consideration, implementation of on-farm development should be carried out by farmers themselves under assistance of the Project office and Regional office of RID after completion of construction of main and lateral canals.

(3) The on-farm facilities are projected to be so that an irrigation block (chak) covers 250 rai (40 ha) of cultivated land. Main farm ditches, supplementary farm ditches, field ditches, division boxes and end checks are major structures.

(4) Construction cost of the on-farm facilities was estimated at 800 Baht per rai in total, and 200 Baht per rai and 600 Baht per rai were, respectively projected for foreign currency and local currency.

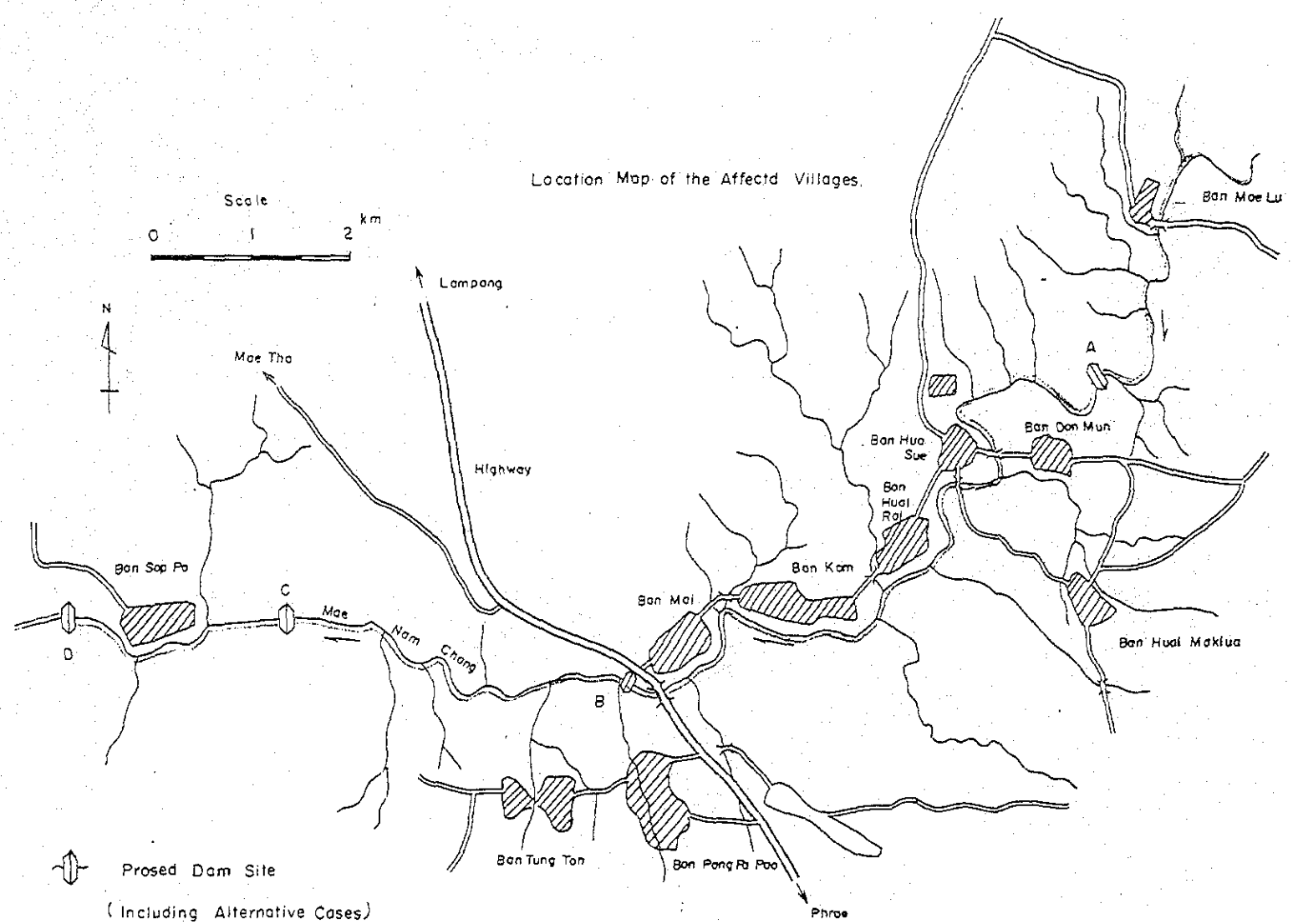
20. Hydropower Development

(1) The purpose of the hydropower development plan is to generate electric power by of a hydropower plant proposed for immediately downstream of the planned storage dam A.

(2) The designed installed capacity is 164 KW (two units of 82 KW) and will generate about 1.18 GWH of energy.

(3) The power plant was so designed that a firm peak can be secured to obtain a maximum output of 338 KW (two units of 119 KW) for the net head of 17 meter and a discharge of 1.65 cubic meter per second. For this plant, horizontal shaft, twin Francis turbine-generator unit was proposed.

(4) Taking into consideration the objectives of the Mae Chang Irrigation Project, the hydropower generation will be developed in the near future as Phase II development after the completion of the irrigation project.


Location Map of the Affectd Villages.
Scale
0 1 2 km
N
Lampang
Mae Tha
Highway
Ban Mae Lu
A
Ban Don Mun
Ban Hua Sue
Ban Huai Rai
Ban Kam
Ban Mai
Ban Huai Maklua
Ban Sop Po
C
Mae Nam Chang
D
B
Ban Tung Ton
Ban Pong Pa Poo
Phrae
Prosed Dam Site
(Including Alternative Cases)

21. Compensation and Resettlement of the Affected Reservoir Area

For Case-5 and Case-6, the following compensation and resettlement shall be countermeasured:

(1) Farm Land Area to be compensated

(Unit: rai)

Villages	Storage Dam A			Diversion Dam C			Diversion Dam D		
	Paddy	Upland	Other	Paddy	Upland	Other	Paddy	Upland	Other
Ban Mae Lu	200	200	10	–	–	–	–	–	–
Ban Kon	–	–	–	25	17	1	–	–	–
Ban Mai	–	–	–	98	53	–	–	–	–
Ban Pong Pa Pao	–	–	–	251	31	5	–	–	–
Ban Thung Ton	–	–	–	267	137	9	–	–	–
Ban Sop Po	–	–	–	–	–	–	150	100	4
Total	200	200	10	641	238	15	150	100	4

(2) Number of family to be compensated and resettled

	Compensated			Resettled		
	Storage A	Diversion C	Diversion D	Storage A	DD-C	DD-D
Ban Mae Lu	22	–	–	22	–	–
Ban Kom	–	10	–	–	–	–
Ban Mai	–	140	–	–	56	–
Ban Pong Pa Pao	–	26	–	–	26	–
Ban Thung Ton	–	21	–	–	21	–
Ban Sop Po	–	–	–	–	–	–
Total	22	197	0	22	103	0

(3) Type of Farming for Resettlement

Paddy	6 rai (irrigated by pumping)
Upland	2
Others	2 " (homelots, roads, ditches etc.)
Total	10 rai

(4) Resettlement areas of both cases are calculated below.

	Case 5	Case 6
Number of settlers	125	22
Distributed area	1,250 rai	220 rai
Roads & canals	125 "	22 "
Public use	25 "	12 "
Total Area	1,400 rai	254 rai

Investment Cost of the Project

Description	Case 5 Total ฿ '000	Case 5 Total $ '000	Case 5 Foreign C ฿ '000	Case 5 Local C ฿ '000	Case 6 Total ฿ '000	Case 6 Total $ '000	Case 6 Foreign C ฿ '000	Case 6 Local C ฿ '000
1. Civil Works (Sub-total)	523,780	22,773	280,600	243,180	496,200	21,573	269,280	226,920
1-1. Pre-engineering	10,000	435	1,000	9,000	10,000	435	1,000	9,000
1-2. Preparation	39,640	1,723	12,430	27,210	38,030	1,653	12,140	25,890
1-3. Storage Dam A	208,930	9,084	141,960	66,970	208,930	9,084	141,960	66,970
1-4. Diversion Dam C or D	76,480	3,325	45,280	31,200	67,660	2,942	39,000	28,660
1-5. Main Canal	116,920	5,083	47,190	69,730	106,300	4,621	45,790	60,510
1-6. Lateral Canal	65,520	2,849	28,970	36,550	58,990	2,564	25,620	33,370
1-7. Improvement of Drainage Facilities	6,290	274	3,770	2,520	6,290	274	3,770	2,520
2. Land Acquisition & Compensation (Sub-total)	59,760	2,598	-	59,760	21,000	913	-	21,000
2-1. Reservoir Area	39,700	1,726	-	39,700	8,400	365	-	8,400
2-2. Resettlement	12,200	530	-	12,200	5,400	235	-	5,400
2-3. Project Area	7,860	342	-	7,860	7,200	313	-	7,200
3. Construction Equipment	6,000	261	6,000	-	6,000	261	6,000	-
4. Project Facilities	10,000	435	-	10,000	10,000	435	-	10,000
5. Project Administration	16,100	700	-	16,100	16,100	700	-	16,100
6. Consulting Services	89,000	3,870	55,000	34,000	89,000	3,870	55,000	34,000
Total (1 to 6)	704,640	30,637	341,600	363,040	638,300	27,752	330,280	308,280
7. Contingency	70,460	3,063	34,160	36,300	63,830	2,775	33,030	30,800
Total (1 to 7)	775,100	33,700	375,760	399,340	702,130	30,527	363,310	338,820
8. Price Escalation	242,720	10,553	121,910	120,810	225,570	9,808	117,860	107,710
Grand Total	1,017,820	44,253	497,670	520,150	927,700	40,335	481,170	446,530

22. Project Cost

(1) Construction method was considered on the contract basis through international competitive bidding.

(2) The cost of construction works is estimated on the basis of the prevailing unit costs used in Mae Kuang Dam Project and Mae Wang Project as of March 1983.

(3) The cost of construction works is divided into two portions of foreign and local components, which were estimated by using the following rate:

	Rate Foreign Currency	Rate of Local Currency
Cement	60%	40%
Steel Bar	70	30
Lumber	20	80
Fuel & Oil	80	20
Labour	-	100
Explosive	80	20
Construction Equipment		
Depreciation Cost	100	-
Repair Cost including Spare Parts	80	20
Administration Cost	-	100

(4) Contingencies are estimated at the rate of 10 percent of the project cost, while price escalation rates are applied with the following annual rate being used by the IBRD and ADB.

Year	Escalation Rate (%) Foreign Currency	Local Currency
1984	7.5	8.0
1985	7.0	8.0
1986 to 1987	6.0	7.0
1988 to 1990	6.0	6.0

Annual Incremental Benefits at Full Development

(Unit: '000 ฿)

Case	(1) 'Without' Project Benefits	(2) Present Benefits Inundated Area	(3) Future 'With' Project Benefits	(4) Expected Benefits Resettlement Area	(5) Fishery Benefits	(6) Livestock Benefits	Annual Incremental Benefits Full Development (3+4+5+6) - (1+2)
5	51,641	2,504	192,101	3,853	1,856	1,891	145,556
6	46,207	988	180,271	678	1,604	1,685	137,043

Annual Incremental Agricultural Benefits

(Unit: ฿'000)

Case	"With" Project NPV	"Without" Project NPV	Annual Incremental Agricultural Benefits
5	192,101	51,641	140,460
6	180,271	46,207	134,064

Fishery Benefits

	FWL (m)	Reservoir (rai)	Area (ha)	Total Yield (kg)	Benefit (฿'000)
Storage Dam A	280.1	3,250	520	48,750	1,141
Diversion Dam C	254	2,037	326	30,555	715
Diversion Dam D	249	1,319	211	19,785	463

Livestock Benefits

Case	Number of Head	Number to be sold Annually	Total Value (฿'000)	Production Cost (฿'000)	Net Benefit (฿'000)
5	6,545	1,182	4,718	2,837	1,891
6	5,832	1,053	4,212	2,527	1,685

Estimated Farm Budgets

Item	'Without' Project	'With' Project (Case 5)		
1. Farm Size (rai)	8	5	8	12
2. Cropping Intensity (%)	100	130	130	130
3. Farm Household Income (฿)				
On-farm	9,508	24,359	34,576	40,067
Off-farm	1,902	-	-	-
Total	11,410	24,359	34,576	40,067
4. Expenditures (฿)				
Agri-inputs	2,089	7,300	9,532	10,376
Land Tax	40	25	40	60
(Disposal Income	9,281	17,034	25,004	29,631)
Household	6,497	11,924	17,503	20,742
Total	8,626	19,249	27,075	31,178
5. Surplus Income (฿)	2,784	5,110	7,501	8,889

23. Project Evaluation

(1) The economic evaluation presented here compares the economic returns of the proposed project to the whole economy of Thailand by calculating the economic internal rate of return (EIRR). In order to determine the EIRR the present worths of both cost and benefit streams are discounted over the entire project life (50 years). The discount rate which makes the present worths of the cost and benefit streams equal is the EIRR.

(2) Economic prices were calculated from financial prices by applying the following conversion factors from a World Bank publication which also includes an economic appraisal study on an irrigation project in Thailand.

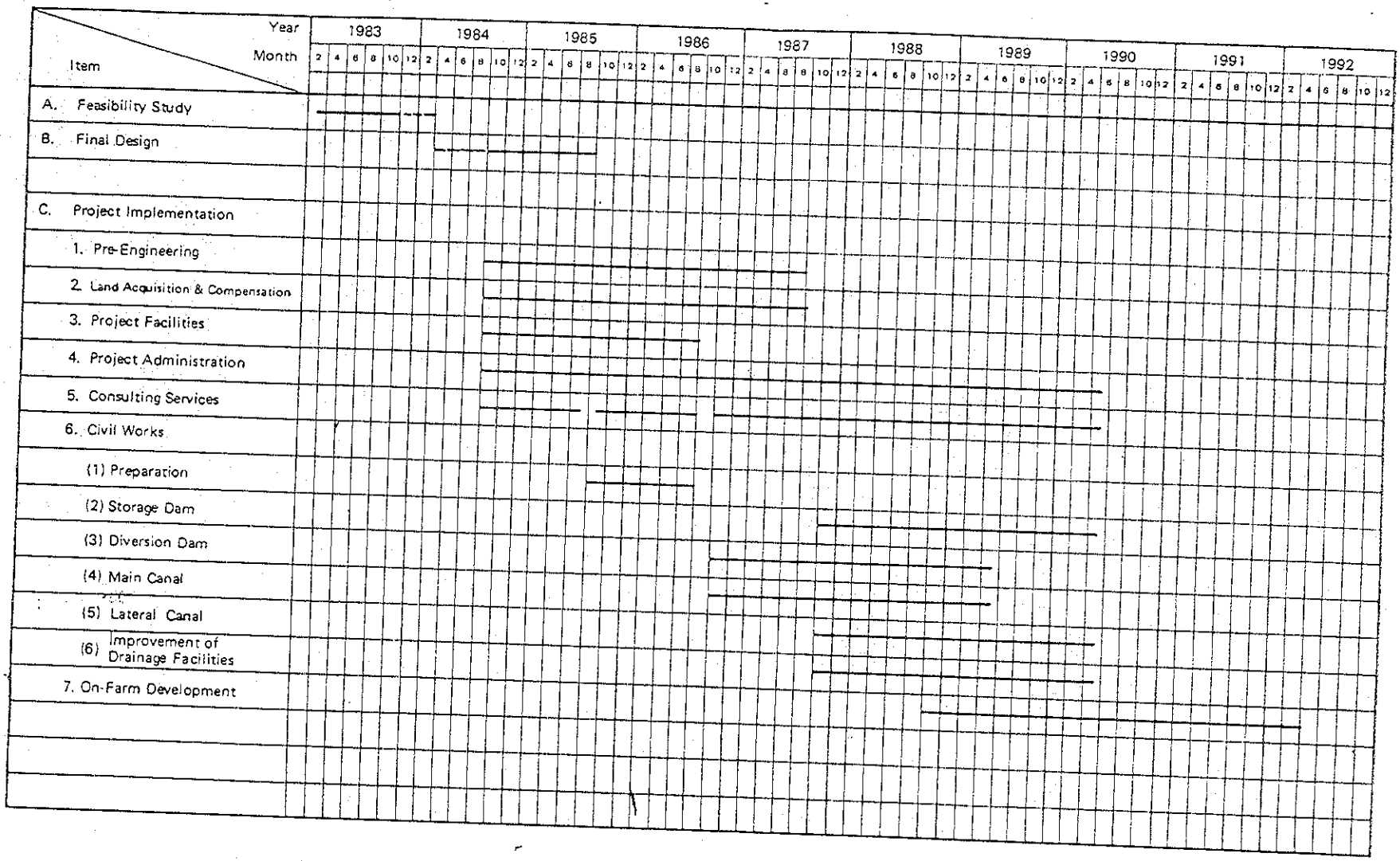
Standard conversion factor	0.80
Conversion factor for construction	0.74
Conversion factor for transpotation	0.76
Conversion factor for government services	0.65

(3) On the basis of the estimated economic costs and benefits the economic internal rate of return (EIRR) was calculated at 13.6 percent for Case 5 and at 13.5 percent for Case 6.

(4) A sensitivity test is an effective way to check what happens to the earning capacity of a project if something does not go according to plan. For this project an analysis has been made on the following items for Case 5:

		Result (EIRR)
1)	Project cost overrun of 20 percent	11.9%
2)	Extension of the construction period	
	One year	12.7%
	Two years	11.8%
3)	Decrease in crop target unit yields by 10%	11.8%
4)	Delay in reaching the target year by five years	11.4%
5)	Applying conversion factors from Table-3, Summary of Country Parameter for Thailand (1980) in the Draft Report, Shadow Price for Economic Appraisal in Thailand (IBRD March 1982)	12.9%

IMPLEMENTATION PROGRAMME FOR THE PROJECT



24. Implementation Schedule

The implementation schedule is carefully programmed taking into account the work volume and the Project Cost. As a result, it is scheduled that detailed design and preparation of tendering and procedures for implementation will be taken about one year period each after the completion of the feasibility study and budgetary arrangement in September 1984 and then construction of the diversion dam and main canals will be begun taking a period of three years from November 1986 followed by the construction of the storage dam and lateral canals also taking a period of three years from November 1987.

25. Consulting Services

The consulting services for the implementation of the Project include those for the detailed design and supervision of the Project.

The consulting services are divided into the following two stages:

(1) The detailed design of the Project as well as the preparation of tender documents. It will cover a 186 man-month period, with 87 man-months for foreign consultants and 99 man-months for local consultants, starting from September 1984.

(2) The second stage is for tendering and construction supervision in all aspects of the Project activities. The service period will cover 210 man-month, with 132 man-months for foreign consultants and 88 man-months for local consultants, from November 1985 to June 1990.

B. CONCLUSIONS

1. The results of economic evaluation for both Case-5 and Case-6 show the economic internal rate of return (EIRR) of 13.6 percent and 13.5 percent, respectively, which exceeds the opportunity cost of capital in this country. Therefore, it can be said that both cases are feasible from the viewpoint of the national economy.

2. According to the farm income analysis of the representative farmer in the Area, the farm income is only ฿2,784 and therefore the farmer cannot live in ease unless he can acquire an off-farm income of more than ฿2,200. After completion of the Project, however, the farm income of the representative farmer will become ฿7,501 without taking off-farm income into consideration. This means that farmer can save some surplus of his farm income without any off-farm income.

   Through the above farm budget analysis, it is quite clear that the proposed irrigation project is feasible from the viewpoint of the individual farmer's economy.

3. Although both Case-5 and Case-6 of the development plan are technically sound and economically feasible, and taking into consideration the difference of proposed project area and the total cropping area between Case-5 and 6 since the Mae Chang Irrigation Project aims at the development of irrigated agriculture by the development of water resources, it is recommended that the development of Case-5 be given priority.

4. The proposed scope of the Mae Chang Irrigation Project is, delineated as follows as a condition of the feasibility study:

Storage Dam A

Reservoir

Catchment Area	403.00	sq.km
High Water Level	EL 283.00	m
Full Water Level	EL 280.20	m
Intake Water level	EL 272.20	m
Usable Reservoir Capacity	40.00	MCM
Usable Water Depth	8.0	m

Dam

Dam Height	35.00	m
Dam Crest Elevation	EL 285.00	m
Min. Trench Elevation	EL 250.00	m
Crest Length	470.00	m
Dam Volume	682,000	cu.m

Diversion Dam C

Reservoir

Catchment Area	254.00	km^2
High Water Level	EL 255.00	m
Full Water Level	EL 254.00	m
Intake Water Level	EL 251.00	m
Usable Reservoir Capacity	7	MCM
Usable Water Depth	3	m

Gravity Concrete Dam

Dam Height	22.50	m
Dam Crest Elevation	EL 257.50	m
Min. Trench Elevation	EL 235.00	m
Crest Length	67.50	m
Dam Volume	11,700.00	cu.m

Fill Dam

Dam height	10.50	m
Dam Crest Elevation	EL 257.50	m
Min. Trench Elevation	EL 247.00	m
Crest Length	242.50	m
Dam Volume	60,000.00	cu.m

Blanket

Height	10.50	m
Crest Elevation	EL 257.50	m
Min. Trench Elevation	EL 247.00	m
Length	250.00	m
Volume	6,500	cu.m

Irrigation Canals

Main Canal

Name of Canals	Service Area (ha)	Length (km)	Max. Discharge (m^3/sec)	Canal B.Width (m)
Mae Chang Main Canal	2,008	12.70	10.52	2.70
Mae Pung Left Canal	1,352	6.50	4.26	1.80
Mae Pung Right Canal	2,646	13.00	3.44	1.80
Mae Wa Canal	935	90.40	1.22	1.80
Sop Chang Canal	1,154	8.70	1.50	1.80
Total	8,095	51.30		

Lateral Canals and Canal Structures

Name of Canals	Lateral Canal Number	Lateral Canal Length (km)	No. of Diversion	No. of Siphon	No. of Turnout
Mae Chang M.C.	6	18.60	6	5	52
Mae Pung L.C.	7	11.60	7	3	34
Mae Pung R.C.	11	34.90	11	8	69
Mae Wa C.	10	13.00	10	6	31
Sop Chang C.	6	15.20	6	5	24
Total	40	93.30	40	27	210

Drainage Facilities

Name of Channels	Length of Upgrading (km)	Length of Enlargement (km)	Removal of Exist.Weir (places)	Enlargement of Exist.Structures (places)
Huai Mae Tha	0.7	1.3	5	2
Huai Mae Thaet	-	1.2	2	1
Huai Mae Pung	0.8	3.0	5	2
Nam Mae WA	-	-	-	-
Others	-	-	-	-
Total	1.5	5.5	12	5

C. RECOMMENDATIONS

1. The following test pit and laboratory test with sufficient detail and accuracy in borrow area of storage dam A for the final design should be completed prior to the commencement of the final design.

(1) Location of Borrow Area : Approximately 1.5 km North-west of Ban Hua Sua

(2) Interval of Test Pit : 100 m interval
64 places test pit
3.0 m depth each

(3) Laboratory Test

Five (5) representative samples among the above mentioned samples should be taken and the following impervious material test shall be conducted:

a) Physical Test

Chloride Content of Soils	JSF T11-1968
Content of Water-soluble Component of Soils	JSF T12-1968
Water content	ASTM D2216-71
Specific gravity	ASTM D854-58
Grain size analysis	ASTM D422-63
Liquid limit	ASTM D423-66
Plastic limit	ASTM D424-59
Shrinkage limit	ASTM D427-61

b) Mechanical Property Test

Compaction	ASTM D698-78
Permeability (Falling head)	ASTM D2434-68
Triaxial test	(C-U)

(4) Note: Two test points should be used i.e. a maximum dry density and a 95 percent of maximum dry density both under the optimum water content.

2. The following rock material test should be conducted:

(1) Location of Quarry Site: Surrounding Doi Wiang Ho Approximately 6 km East of Ban Mae Tha

(2) Rock Material Test

Three (3) representative samples from outcrop at the quarry site should be taken and the following rock material tests conducted:

Absorption	ASTM C97-47
Specific Gravity	ASTM C97-47
Sodium Sulfate Soundness	ASTM C88-76
Compressive Strength	ASTM D2938-79

(Geological Survey at Storage Dam A)

3. Drilling of borehole at Storage dam A should be carried out at the following location and depth:

(i) Dam axis : 3 boreholes (two 30 m each and 25 m)
(ii) Right Abutment : 5 boreholes (35 m each)

(iii) Left Abutment : 2 boreholes (35 m each)

(iv) Spillway Center line : 3 boreholes (20 m each)

Total 13 boreholes and 370 m in depth

Standard penetration test should be carried out at every 1.5 meters of depth until the bedrock and excepting difficult layers, such as gravel, hard clay, etc. And permeability test should also be conducted at every 2.0 m of depth from the rocksurface at maximum water pressure of 10 kg/cm^2 in hard rock and 3 to 5 kg/cm^2 in soft rock.

(Geological Survey at Diversion Dam C)

4. Drilling of two observation wells (25 m of depth each) should be carried out at the location of approximately 60 m upstream dam axis on the terrace of approximately 251 meters above mean sea level at the both river side.

The boring depth will be required to be 5 meters below the riverbed. After completing the borehole, a strainer pipe should be inserted into the finished borehole and fixed with groundsurface by mortar cement.

Water table measuring at the boring point should be carried out 2 to 4 times a month at least for a period of one year.

(Survey of Submerged Area)

5. Submerged area by construction of dams should be surveyed on topography and private and public properties for negotiation of countermeasures on this matter as soon as possible.

(Investigation of Sinkholes)

6. There are some sinkholes confirmed on the left and the right bank upstream from the dam site C. Among them, those on the left bank have some fear for leakage out of the reservoir area. For these sinkholes, groundwater trace was carried out in salt water (NaCl) but could not detect any new spring water in and out the reservoir area. Also, the Mae Chang river water contains chloride radical and therefore, the experiment of the groundwater trace could not find out ways of water flow from the sinkholes. Such being the case, it is difficult to confirm the groundwater way even if using other chemicals.

The purpose of this trial is to find out the groundwater way and to check the permeability of the rocks and consequently, it is considered better to measure the groundwater table at the boring points for the purpose.

In the reservoir area near the dam site, it is necessary to set up a grid on a map for selecting boring points at least with 100 meters intervals. Groundwater table measuring and permeability test are necessary to the borehole drilling.

It is necessary to observe the changing groundwater table at the boring points and new spring water points near boring sites by using a large about of Fluoresser solved water.

(Survey on Quality of Mae Chang)

7. Sampling of water of the Mae Chang and quality analysis of the sample shall be carried out during the detailed design in order to confirm a suitability of water for irrigation purpose.