

Suitability of soils in the upper and lower sites as mentioned is shown in Table C-3.

C-4-3. Land Use Plan

Based on soil types characteristics and their suitability, the preliminary possible land use plan can be zoned into five zones as follows:

- Zone 1 : Paddy, Fishpond
- Zone 2 : Fruit Tree - Mulberry, Bamboo
- Zone 3 : Upland Crops - Sugarcane, Maize
- Zone 4 : Pasture/Rangeland and Forest and some Upland Crop
- Zone 5 : Paddy/Upland-Rice, Maize, Sugarcane

Distribution of areal coverage is shown in Figure C-6 and Table C-5.

C-4-4 Soil Profile Descriptions

Four pits were dug. Their locations are shown in soil map Figure C-2. Those pits are:

- S-1 : Chiang Rai Series (Cr)
- S-2 : Kamphaeng Saen Series
- S-3 : Si Samrong Series
- S-4 : Mae Sai Series

① Profile Code S-1 Date 30 Jan. 1991

- Soil Name : Chiang Rai Series (Cr)
- Location : East of Ban Lan Thong
- Topography : Flat
- Land Use : Paddy

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap ₁	0 - 10	Light brownish gray (10 YR6/2) dry, grayish brown (10 YR5/2) moist, silt loam with common fine distinct dark brown (7.5 YR4/4) mottlings along root channels; weak fine to medium crumb structure, and fine subangular blocky; hard, friable, slightly plastic; common fine vesicular and interstitial pores; many fine roots; slightly acid (pH 6.5); abrupt and smooth boundary.
Ap ₂	10 - 19	Gray (10 YR6/1) dry, gray (10 YR5/1) moist, clay loam with many fine distinct strong brown (7.5 YR5/6) mottlings; weak to moderate fine subangular blocky and medium crumb structure; very hard, firm, sticky, slightly plastic; few fine interstitial and common fine tubular pores; few fine roots; medium acid (pH 6.0); clear and smooth boundary.
B _{2t} g	19 - 42	Grayish brown (10 YR5/2) dry, light gray (10 YR7/1) moist, clay loam with common fine distinct strong brown (7.5 YR5/8), and many fine prominent red (2.5 YR 4/8) mottlings; moderate coarse and medium subangular blocky; very hard, firm, sticky and plastic; broke moderately thick clay coating on <u>ped</u> faces and along pores; few fine tubular pores, common fine interstitial pores; very few fine roots; very strongly acid (pH 5.0) clear and smooth boundary.
B _{22t} g	42 - 60	Gray to light brownish gray (10 YR6/1-6/2) clay with many medium prominent red (10 R4/8) mottling; strong coarse and medium subangular and angular blocky; very hard, very firm, sticky and plastic; continuous thick clay coating on <u>ped</u> faces; few fine tubular and common fine interstitial pores; few small Mn nodules; very few very fine roots; very strongly acid (pH 5.0); clear and wavy boundary.

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B23g	60 - 90	Light gray to light brownish gray (10 YR7/2-6/2); clay with medium prominent red (10 R4/8), and few fine distinct strong brown (7.5 YR5/8) mottlings; strong medium and coarse angular blocky; very firm, sticky, plastic; continuous thick clay coating on ped faces; few fine interstitial pores; very few small soft Mn strongly acid (pH 5.5) clear smooth boundary.
B24g	90 - 120	Light gray to light brownish gray (10 YR7/2-6/2); clay with coarse prominent red (10 YR4/8) and few fine distinct strong brown (7.5 YR5/8) mottles; strong medium and coarse angular blocky; very firm, sticky, plastic; continuous thick clay coating on <u>ped</u> faces; few fine interstitial pores; very few small soft Mn strongly acid (pH 5.5).

② Profile Code : S-2 Date 30 Jan. 1991

Soil Name : Kamphaeng Saen Series
 Location : Ban Wang Tamon
 Topography : Nearly Flat
 Land Use : Sugarcane, Cotton

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 12	Dark brown (10 YR 3/3); silt loam moderate fine to medium subangular blocky structure; slightly sticky, slightly plastic, slightly hard when dry, firm when moist; common fine and medium roots; clear smooth boundary; strongly acid (pH 5.0)
B21t	12 - 36	Brown (10 YR 5/3); silty clay loam; moderate fine to medium subangular blocky structure, slightly sticky, slightly plastic, firm when moist, slightly hard when dry, thin patchy clay coatings on ped faces and in pores; few very fine roots; diffuse, smooth boundary; medium acid (pH 6.0).

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B _{22t}	36 - 60	Brown (10 YR5/3); silty clay loam to silty clay; weak fine to medium subangular blocky structure; sticky and plastic; firm when moist; slightly hard when dry; patchy thin clay coating on ped faces and in pores; very few very fine roots; diffuse, smooth boundary; neutral (pH 7.0).
B _{23t}	60 - 80	Brown (7.5 YR4/4); silty clay; few fine faint strong brown (7.5 YR5/8) mottles; weak fine to medium subangular blocky structure; sticky and plastic when wet, hard when dry; patchy thin clay coating on ped faces and in pores; diffuse smooth boundary; neutral (pH 7.0).
B _{24t}	80 - 100	Brown (7.5 YR4/4); silty clay; few fine faint strong brown (7.5 YR5/8) mottles; weak fine to medium subangular blocky structure; sticky and plastic when wet, hard when dry; patchy thin clay coating on ped faces and in pores; diffuse smooth boundary; neutral (pH 7.0).
B _{25t}	100 - 120	Brown (7.5 YR4/4); silty clay; few fine faint strong brown (7.5 YR5/8) mottles; weak fine to medium subangular blocky structure; sticky and plastic when wet, hard when dry; patchy thin clay coating on ped faces and in pores; neutral (pH 7.0).

③ Profile Code S-3 Date 30 Jan. 1991 (Photo 11)

Soil Name : Si Samrong Series
 Location : East of Ban Wang Tamon
 topography : Flat
 Land Use : Paddy (Photo 12)

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 6	Dark brown (10 YR3/3); silty clay loam; many fine brown (7.5 YR4/4) mottles concentrate along root channels; weak coarse subangular blocky; slightly firm; sticky and plastic; common fine tubular and vesicular pores and common fine interstitial pores; common coarse roots; clear and smooth boundary; pH 5.5.

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
A ₁₂	6 - 14	Brown (10 YR5/3); silty clay loam; many medium and coarse strong brown and reddish yellow (7.5 YR5/8 and 7.5 YR6/8) mottles; moderate medium subangular blocky; slightly firm, sticky and plastic; patchy thin <u>cutans</u> on bed faces and in pores; many fine tubular and common medium interstitial pores; comon medium and coarse roots; gradual and smooth boundary; pH 6..
B _{21t}	14 - 22	Grayish brown (10 YR5/2); silty clay; many coarse strong brown (7.5 YR5/8) mottles; moderate medium and coarse subangular blocky; friable, sticky and plastic; patchy thin cutans on ped faces and in pores; common medium and fine tubular with few medium vesicular pores; few medium and fine roots; gradual and smooth boundary; pH 6.
B _{22t}	22 - 43	Pinkish gray (7.5 YR6/2); clay; many coarse red and reddish yellow (7.5 YR4/8 and 7.5 YR6/8) mottles; moderate medium subangular blocky; friable, sticky and plastic; moderate thick continuous clay coatings on ped faces; many fine tubular and common medium interstitial pores; few hard ironstone nodules; few fine and coarse roots; gradual smooth boundary pH 5.
B _{23t}	43 - 60	Pinkish gray (7.5 YR6/2); clay; many coarse red and reddish yellow (7.5 YR4/8 and 7.5 YR6/8) mottles; moderate medium subangular blocky; friable, sticky and plastic; moderate thick continuous clay coatings on ped faces; many fine tubular and common medium interstitial pores; few hard ironstone nodules; few fine and coarse roots; gradual smooth boundary pH 5.
B _{24t}	60 - 120	Pinkish gray (7.5 YR6/2); clay; many coarse red and reddish yellow (7.5 YR4/8 and 7.5 YR6/8) mottles; moderate medium subangular blocky; friable, sticky and plastic; moderate thick continuous clay coatings on ped faces; many fine tubular and common medium interstitial pores; few hard ironstone nodules; few fine and coarse roots; pH 5.

- ④ Profile Code : S-4, Date 30 Jan. 1991
 Soil Name : Mae Sai Series (Ms)
 Location : Ban Wang Takian
 Topography : Flat
 Land Use : Paddy

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 11	Light gray (10 YR7/2) dry, light brownish gray (10 YR6/2) moist, silty clay loam with common fine distinct strong brown (7.5 YR5/6) mottling along root channels; patchy on surface, massive structure; very hard very firm, sticky, plastic; many fine vesicular and tubular pores; many fine roots; medium acid (pH 6); clear and smooth boundary.
B ₁	11 - 30	Very pale brown (10 YR7/3), dry pale brown (10 YR6/3) moist, silty clay loam with many fine distinct dark brown (7.5 YR4/4) mottling; strong medium to coarse subangular blocky; very hard, very firm, sticky and plastic; many fine tubular pores, common fine interstitial pores; few fine roots; moderately alkaline (pH 8); clear and smooth boundary.
B _{21t}	30 - 72	Grayish brown to brown (10 YR5/2-5/3) silty clay loam with many fine distinct strong brown (7.5 YR5/6) mottlings; moderate medium and coarse subangular blocky; very hard, firm sticky, plastic; patchy thin cutan on ped faces; broken thick cutan in root channels and show evident of silt flow; very few Fe-Mn nodules; many fine tubular and few fine interstitial pores; moderately alkaline (pH 8.0); gradual and smooth boundary.
B _{22t}	72 - 100	Brown (10 YR6/3) silty clay loam with many fine distinct strong brown (7.5 YR5/6) mottling; moderate medium to fine subangular blocky; firm, sticky, plastic; broken thick cutans on ped faces and show evident silt flow; many fine tubular and few fine interstitial pores; few fine Fe-Mn nodules; gradual smooth boundary; moderately alkaline (pH 8.0).

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B _{23t}	100 - 120	Brown (10YR5/3) silty clay loam with many fine distinct strong brown (7.5 YR5/6) mottling; moderate medium to fine subangular blocky; firm, sticky, plastic; broken thick cutans on ped faces and show evident silt flow; many fine tubular and few fine interstitial pores; few fine Fe-Mn nodules; moderately alkaline (pH 8.0).

C-5 KHLONG SAMO KHON

C-5-1 Soils

(1) General Soil Feature

This model project area is situated in Amphoe Pran Kra Tai. Topography is nearly flat to flat to flat along Khlong Samo Khon which flows from north to south and bounded by high ground in the east and west. Soils in the proposed irrigation area is the recent alluvial deposits. In the northern portion of the stream valley, down stream from the proposed dam site around Ban Nam Dip Maphrow, the soils are very deep stratified sandy to loamy textures suitable for vegetable growing and fruit trees. In the middle part, the topography becomes flat valley bottom consisting of paddy soils having stratified textures of loamy to clayey underlain by sandy. Groundwater falls approximately 100 cm. These soils are suitable for paddy. The southernmost around Ban Samo Khon, the flat area become wider. Soils are very deep clayey texture best suited for paddy. Upland soils on the east are sandy to coarse loamy with laterite sheets exposing to the surface. They are mostly still under forest. In the west side, the coarse loamy soils are recognized along the boundary of the site. These are usable for upland crops. In the south west which the dipterocarpaceous forest exists the soils are very shallow having lateritic sheets exposing to the surface. These areas are not suited for crop cultivation. Forest and rangeland are best use.

(2) Soil Mapping Units and Their Characteristics

Six soil units are classified as shown in soil map of Figure C-3. Soil characteristic and area coverage are tabulated in Table C-1 and C-2. Those of which are as follows:

AC-p	:	Alluvial Complex-poorly Drained
Cm	:	Chiang Mai Series
Hd	:	Hang Dong Series
Kt	:	Korat Series
Ng	:	Nam Pong Series
Sk	:	Sakon Series

These mapping units are shown in soil map. Figure C-3. Area and their characteristics are tabulated in Table C-1 and C-2.

C-5-2 Soil Suitability Classification

Using the same criteria as described in para C-3-2 for Huai Sam Ru area, soils are interpreted four suitability of

- Paddy (P)
- Non-flooded Annual Crop (N) or Upland Crop
- Fruit Tree (F)
- Pasture or Rangeland Livestock Farming (L)

Suitability of soil units in this site is shown in Table C-3.

C-5-3 Land Use Plan

Based on soil types, soil characteristics and their suitability, possible land use potential can be planned and divided into four zones as follows:

Zone 1	:	Paddy
Zone 2	:	Fruit Tree - Mulberry, Bamboo
Zone 3	:	Upland Crop - Maize
Zone 4	:	Pasture and Forest

Map showing land use plan and area of each zone are shown in Figure C-7 and Table C-6 respectively.

C-5-4 Soil Profile Description

Two pits were dug as locations being shown in soil map Figure C-3. These pits are:

- K-1 : Hang Dong Series (Hd)
- K-2 : Alluvial Complex - poorly drained

(1) Profile Code K-1 : Date 26 Jan. 1991

- Soil Name : Hang Dong Series
- Location : West of Ban Samo Khon
- Topography : Flat
- Land Use : Paddy

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
A _{pg}	0 - 10	Dark gray (10 YR4/1); silty clay loam; common fine distinct brown (7.5 YR4/4) mottles along root channels; moderate medium to coarse subangular blocky; very hard, very firm, very sticky and very plastic; few fine roots; common fine interstitial pores; clear and wavy boundary; pH 6.
A _{2g}	10 - 30	Gray (10 YR5/1); clay loam; common fine distinct strong brown (7.5 YR5/6) few fine distinct dark reddish brown (5 YR3/4) mottles: moderate medium to coarse subangular blocky structure; very hard, firm, very sticky and very plastic; very few fine roots; very fine interstitial pores; clear and smooth boundary; pH 8.0.

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B ₂₁ tg	30 - 50	Gray (10 YR6/1); clay loam; common fine distinct dark brown (7.5 YR3/2) and few fine prominent dark reddish brown (5YR3/4) mottles; weak medium to coarse subangular blocky structure and coarse prismatic structure; very hard, firm; very sticky and plastic; patchy clay coating along pores and on ped faces; very few fine roots; very few fine Fe-Mn nodules; few fine interstitial pores; clear and smooth boundary; pH 7.0.
B ₂₂ tg	50 - 80	Gray (10 YR6/1); clay; few fine distinct brown (7.5 YR4/4) and common fine prominent reddish brown (5 YR4/4) mottles: weak medium and coarse prismatic and subangular blocky structure; hard very hard, firm, very sticky and very plastic; broken moderately thick clay coating along pores and on ped faces; very few fine roots; few fine Fe-Mn nodules; few fine interstitial pores; gradual smooth boundary; pH 6.0 - 6.5.
B ₂₃ tg	80 - 100	Gray (10 YR6/1); clay; few fine distinct brown (7.5 YR4/4) and common fine prominent reddish brown (5 YR4/4) mottles: weak medium and coarse prismatic and subangular blocky structure; hard very hard, firm, very sticky and very plastic; broken moderately thick clay coating along pores and on ped faces; very few fine roots; few fine Fe-Mn nodules; few fine interstitial pores; pH 6.0 - 6.5.

- ② Profile Code : K-2 Date 26 Jan. 1991
 Soil Name : Alluvial Complex - poorly drained soils (AC-P)
 Location : North of Ban Samo Khon
 Land Use : Paddy

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 15	Dark gray (10 YR4/1) silty clay loam, few fine distinct reddish brown (2.5 YR4/4) mottles along root channels; moderate medium to coarse subangular blocky; hard, firm; sticky, plastic; very few fine roots clear and wavy boundary; slightly acid (pH 6.5).

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B _{11g}	15 - 30	Dark grayish brown (10 YR4/2) clay loam; few fine distinct dark reddish brown (5 YR3/3) mottles along root channels and ped faces, moderate medium subangular blocky; hard, firm; sticky, plastic, very few fine roots, clear smooth boundary; slightly acid (pH 6.5).
B _{12g}	30 - 50	Dark grayish brown (10 YR4/2) loam; few fine faint brown (10 YR5/3) mottles on ped face, sticky and plastic; clear smooth boundary; slightly acid (pH 6.5).
C ₁	50 - 70	Dark grayish brown (10 YR4/2) sandy clay loam; weak fine subangular blocky; sticky, plastic; gradual smooth boundary; neutral (Ph 7.0).
C ₂	70 - 100	Yellowish brown (10 YR5/4) sandy loam; massive; slightly sticky slightly plastic; neutral (pH 7.0).

C-6 Khlong Sai Area

C-6-1 Soils

(1) General Soil Features

The model project area is located in Amphoe Muang Tak, on the west of the Mae Ping River along the main stream named Khlong Sai and Khlong Pradang. Topography of the site is undulating to rolling on the north and gentle undulating on the south tilting eastwardly. Soils are mainly derived from granitic rock forming the sandy soils poorly suited for crop cultivation. The area along main stream consists of non-calciic brown soils good for orchard, vegetable and also widerange of upland crops. Paddy soils are recognized only a limited extent in the east close to Ban Takian Duan and Ban Lat Yao.

C-6-2 Soil Mapping Units and Their Characteristics

There are five soil units in this area including:

- GrC : Granitic derived soil complex
- Hd : Hang Dong Series
- Ks : Kamphaeng Saen Series
- Ps : Phusana Series
- Tw : Thap Kwang Series

These units are depicted in soil map of Figure C-4 with areal coverages and soil characteristics being shown in Table C-1 and C-2 respectively.

C-6-2 Soil Suitability Classification

Using the same criteria as presented in para C-3-2 for Huai Sam Ru area, the soils are classified according to their suitability for:

- Paddy (P)
- Non-flooded annual crops (N) or Upland Crops
- Fruit Tree (F)
- Pasture or Rangeland for Livestock Farming (L)

Suitability of soil units of this site is tabulated in Table C-3.

C-6-3 Land Use Plan

Based on soil types, soil characteristics and their suitability possible land use potential can be planned and divided into four zones namely:

- Zone 1 : Paddy
- Zone 2 : Fruit Tree-Mulberry, Bamboo
- Zone 3 : Upland Crop-Maize
- Zone 4 : Pasture/Forest

Map showing land use plan is drawn in Figure C-8 and the area coverage is tabulated in Table C-7.

C-6-4 Soil Profile Description

Three pits were dug and described. Locations are shown in Soil map Figure C-4. They are:

- T-1 : Hang Dong Series (Hd)
 T-2 : Kampaeng Saen Series (Ks)
 T-3 : Phu Sana Series (Ps)

① Profile Code T-1 Data 28 Jan. 1991

Soil Name : Hang Dong Series (Hd)
 Location : Ban Takian Duan
 Topography : Flat
 Land Use : Abandon rice field.

Horizon	Depth (cm)	Description
Ap	0 - 15	Grayish brown (10 YR5/2) clay common fine distinct strong brown (7.5 YR5/6) mottles; moderate medium subangular blocky; very hard, very firm; very sticky, very plastic; few fine roots; clear and wavy boundary; slightly acid (pH 6.5).
B21g	15 - 30	Dark grayish brown (10 YR4/2) clay; common fine distinct strong brown (7.5 YR5/6) mottles; moderate medium subangular blocky; very hard very firm; very sticky very plastic; few fine roots; clear smooth boundary; slightly acid (pH 6.5).
B22gt	30 - 50	Dark gray (10 YR4/1) clay; few fine prominent yellowish red (5 YR4/6) moderate medium subangular blocky; hard, firm; very sticky very plastic; slickenside on ped faces gradual smooth boundary; neutral (pH 7.0).
B23gt	50 - 70	Dark gray (10 YR4/1) clay; few fine prominent yellowish red (5 YR4/6) moderate medium subangular blocky; hard, firm; very sticky very plastic; slickenside on ped faces gradual smooth boundary; neutral (pH 7.0)
B24gt	70 - 100	Dark gray (10 YR4/1) clay; few fine prominent yellowish red (5 YR4/6) moderate medium subangular blocky; hard, firm; very sticky very plastic; slickenside on ped faces gradual smooth boundary; moderately alkaline (pH 8.0).

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B _{25gt}	100 - 120	Dark gray (10 YR4/1) clay; few fine prominent yellowish red (5 YR4/6) moderate medium subangular blocky; hard, firm; very sticky very plastic; slickenside on ped faces gradual smooth boundary; moderately alkaline (pH 8.0).

(2) Profile Code T-2 Date 28 Jan. 1991

Soil Name : Kamphaeng Saen Series (Ks)

Location : Ban Lat Yao

Topography : Nearly Level

Land Use : Banana Plantation

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 15	Dark brown (10 YR3/3) Loam; weak fine subangular; friable; slightly sticky slightly plastic; few fine roots; wavy smooth boundary mildly alkaline (pH 7.5).
B ₁	15 - 30	Very dark grayish brown (10 YR3/2) loam; weak fine subangular blocky; friable; slightly sticky, slightly plastic; few fine roots; wavy smooth boundary; mildly alkaline (pH 7.5).
B _{21gt}	30 - 50	Very dark grayish brown (10 YR3/2) clay loam; weak fine subangular blocky; friable firm; sticky and plastic; clay coating on ped faces and in pores; clear smooth boundary; mildly alkaline (pH 7.5).
B _{22gt}	50 - 70	Brown to dark brown (10 YR4/3) clay loam; weak fine subangular blocky; friable, firm; sticky, plastic; clay coating on ped faces and in pores; gradual smooth boundary; mildly alkaline (pH 7.5).
B _{23gt}	70 - 90	Brown to dark brown (10 YR4/3) clay loam; weak fine subangular blocky; friable, firm; sticky, plastic; clay coating on ped faces and in pores; gradual smooth boundary; mildly alkaline (Ph 7.5).

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
B24t	90 - 120	Brown to dark brown (10 YR4/3) clay loam; weak fine subangular blocky; friable, firm; sticky, plastic; clay coating on ped faces and in pores; gradual smooth boundary; mildly alkaline (pH 7.5).

③ Profile Code T-3 Date 28 Jan. 1991

Soil Name : Phu Sana Series
 Location : South of Ban Lat Yao
 Topography : Undulating
 Land Use : Shrub

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
A1	0 - 15	Dark grayish brown (10 YR4/2) sandy loam; weak fine subangular blocky; slightly hard, slightly sticky, non plastic; common medium interstitial pores; many fine to coarse roots; slightly acid (pH 6.5) clear wavy boundary to B1.
B1	15 - 30	Dark brown to brown (7.5 YR4/4) gravelly sandy clay loam; moderate medium subangular blocky structure; hard, slightly sticky, slightly plastic; few fine tubular and interstitial pores; few fine to coarse roots; coarse fraction consist of 30 percent fine quartz gravels; medium acid (pH 6.0); gradual smooth boundary to B21t.
B21t	30 - 60	Strong brown (7.5 YR6/8) gravelly sandy clay; moderate medium subangular blocky structure; hard, sticky, plastic; few fine tubular and interstitial pores; few fine to medium roots; coarse fraction consists of 30 percent fine quartz gravels; medium acid; gradual smooth boundary.
B22gtC	60 +	Weathering granitic rock.

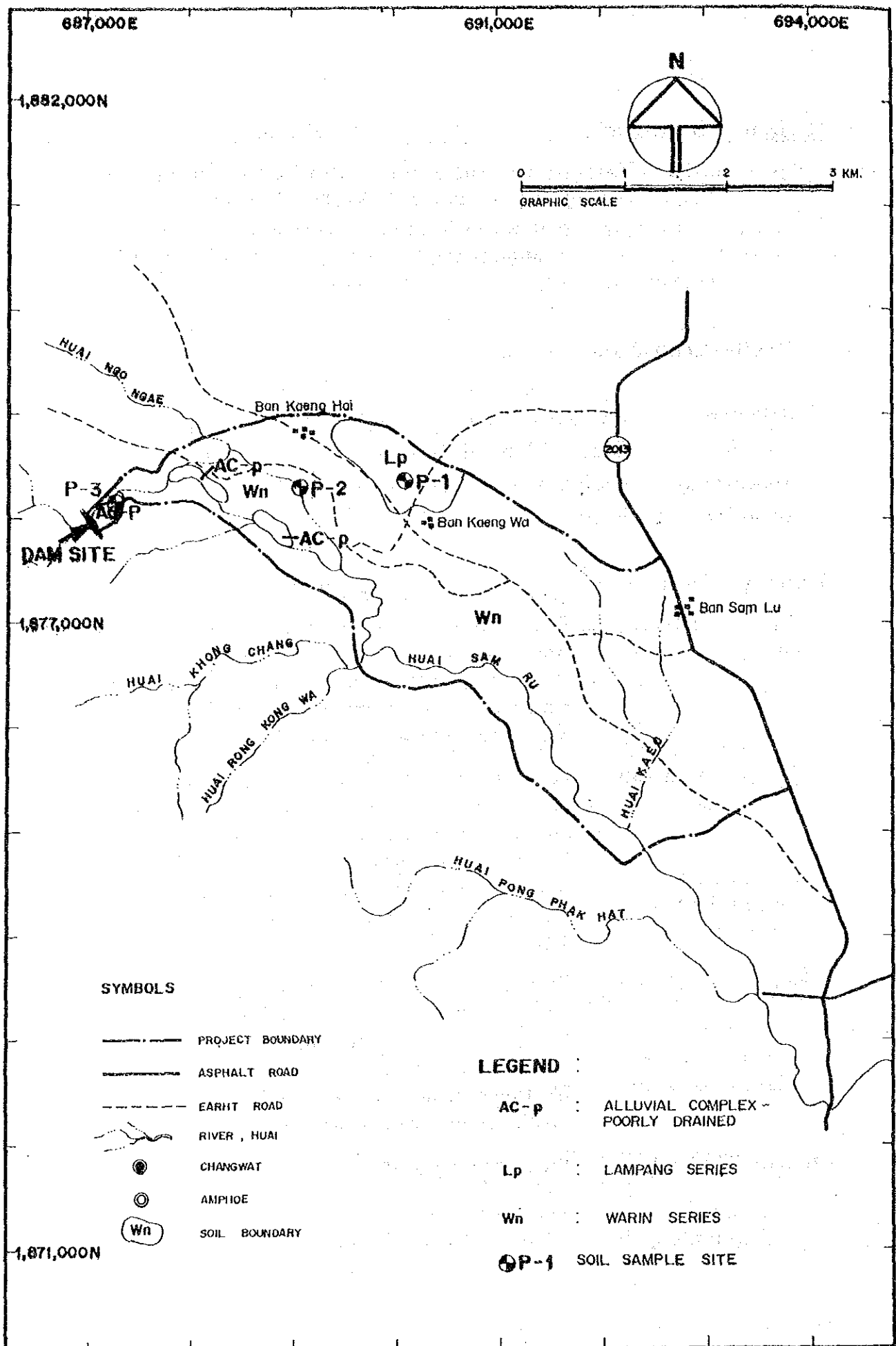


FIGURE 1 : SOIL MAP OF PHITSANULOK SITE

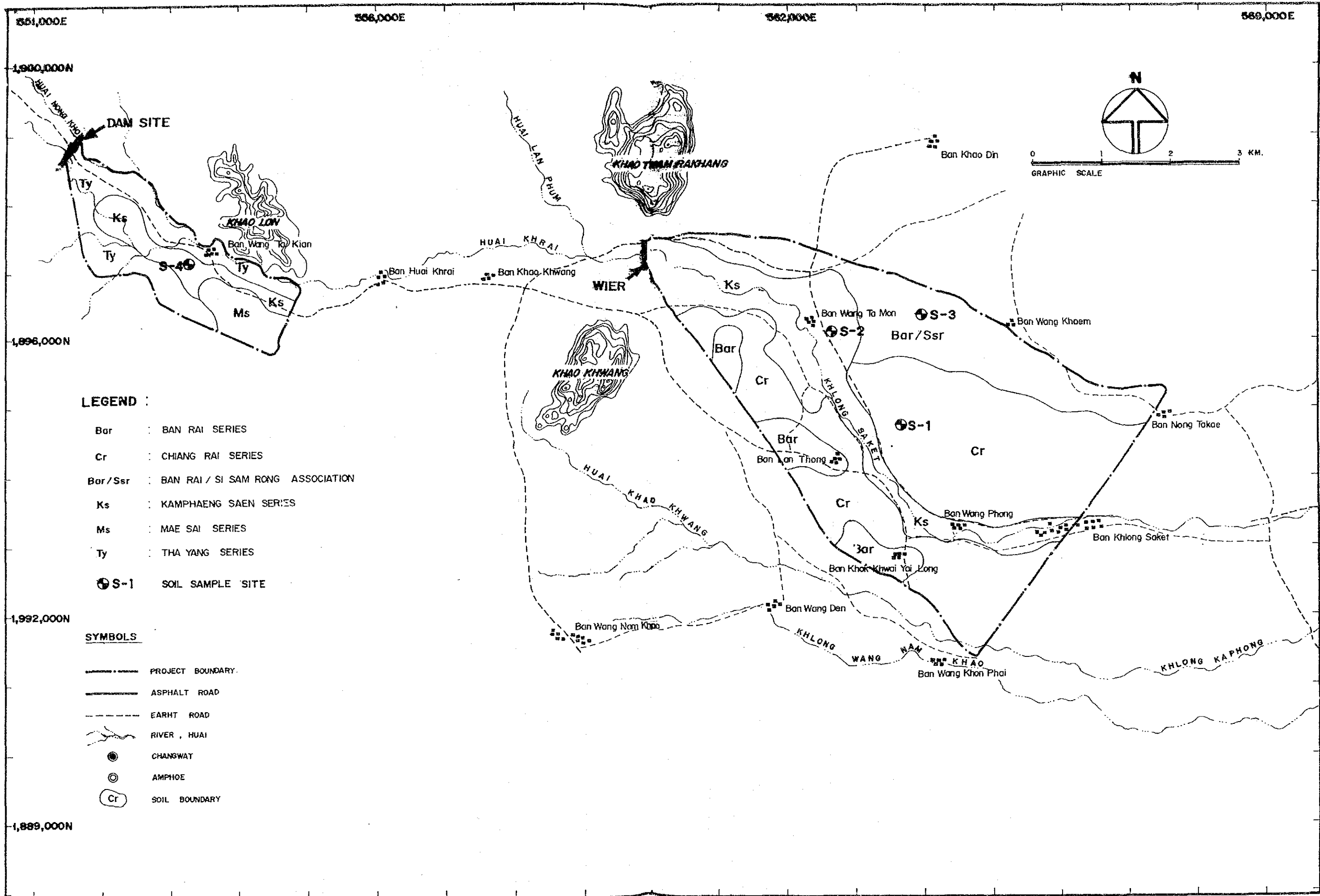


FIGURE 2 : SOIL MAP OF SUKHOThAI SITES

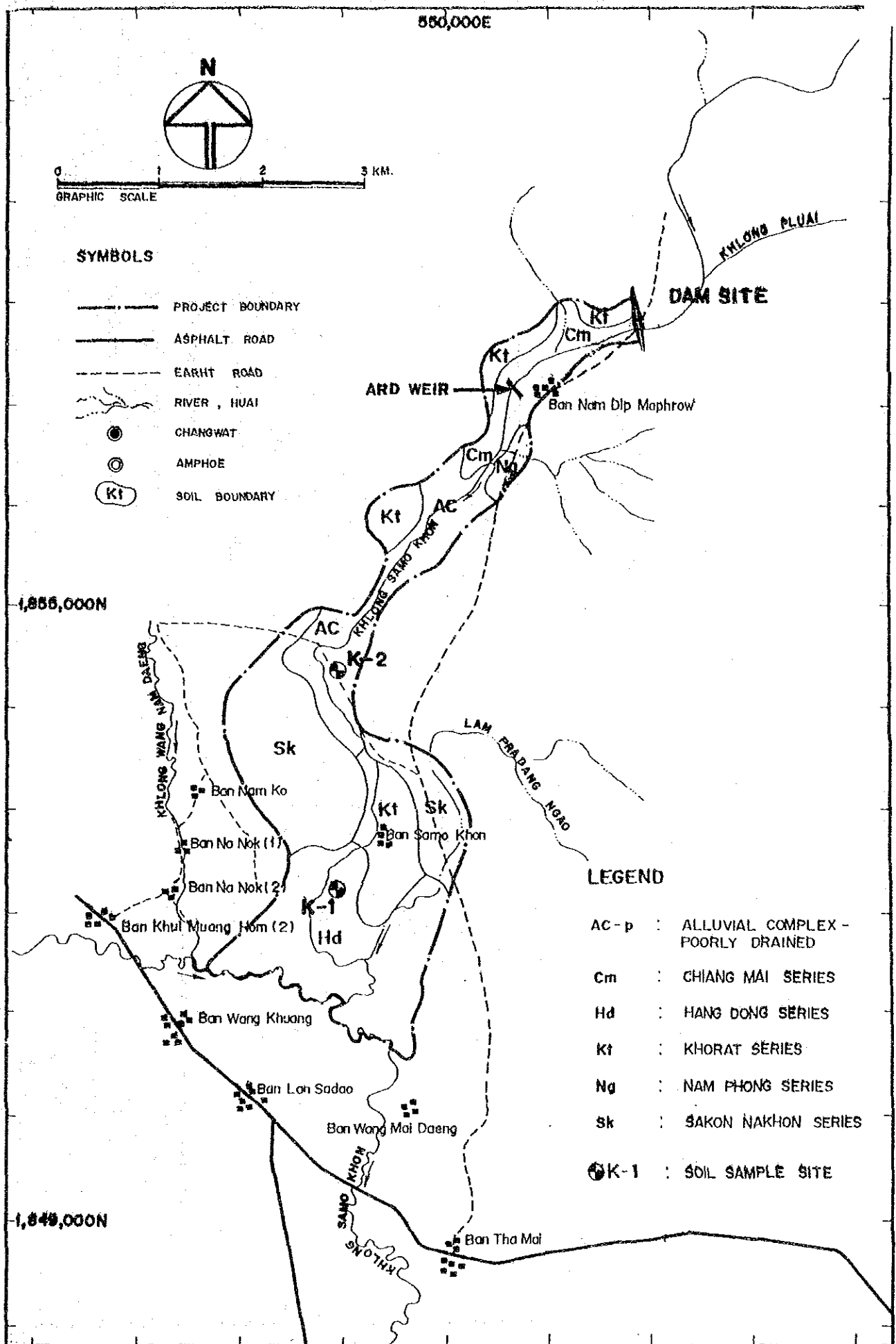


FIGURE 3 : SOIL MAP OF KAMPHAENG PHET SITE

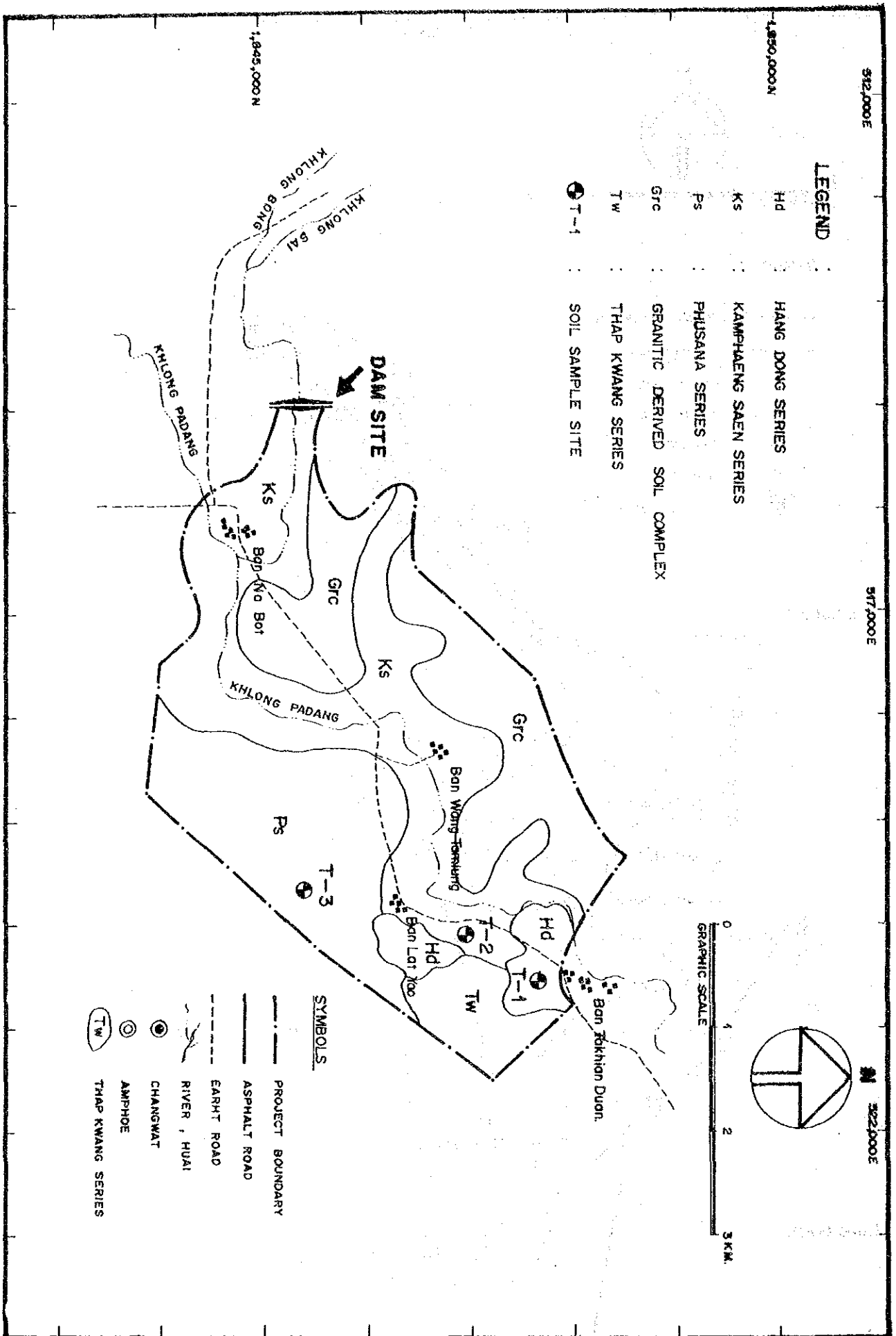


FIGURE 4 : SOIL MAP OF TAK SITE

APPENDIX D. AGRICULTURE

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TABLE D-1 CROP PRODUCTION IN 1989/1990, PHITSANULOK PROVINCE

Crops	Planting Area (rai)	Yield (kg/rai)	Production (ton)	Price (฿/kg)	Gross Products Value(1,000฿)
1. Rice (rainy season)	1,615,192	441	669,740	3.45	2,310,603.00
2. Rice(dry season)	219,233	670	143,260	2.50	358,150.00
3. Upland rice	23,125	273	6,313	2.30	14,519.90
4. Maize	413,314	379	151,672	3.10	470,183.20
5. Soybean(1st.)	70,221	195	13,693	7.20	98,589.60
6. Soybean(2nd.)	74,143	212	15,718	6.80	106,882.40
7. Mungbean	66,665	132	8,793	6.50	57,154.50
8. Blackgram	83,977	124	10,413	5.50	57,271.50
9. Groundnut	9,838	310	3,018	12.00	36,216.00
10. Cassava	306,483	2,847	728,239	1.50	1,092,358.50
11. Sugar cane	75,774	8,725	356,521	0.46	163,999.60
12. Sesame	20,871	92	1,874	17.00	31,858.00
13. Casterbean	3,650	133	485	8.00	3,880.00
14. Cotton	8,017	186	1,305	12.00	15,660.00

Source : Phitsanulok Agricultural Extension Office

TABLE D-2 CROP PRODUCTION IN 1989/1990, SUKHOTHAI PROVINCE

Crops	Planting Area (rai)	Harvesting Area (rai)	Yield (kg/rai)	Production (ton)
1. Rice (rainy season)	1,036,684	940,508	546	513,851
2. Rice(dry season)	45,355	45,355	664	30,166
3. Maize	126,769	126,769	407	51,644
4. Soybean	903,345	700,750	243	170,383
5. Mungbean	86,972	86,972	137	11,978
6. Groundnut	4,104	4,105	373	1,532
7. Sesame	36,037	36,037	74	2,667
8. Sugarcane	137,782	103,994	8,984	934,305
9. Cotton	88,848	88,615	214	19,007
10. Tobacco	34,623	34,623	350	12,124
11. Kenaf	2,268	2,268	288	655

Source : Sukhothai Agricultural Extension Office

**TABLE D-3 CROP PRODUCTION IN 1989/1990,
KAMPAENGPHEP PROVINCE**

Crops	Planting Area (rai)	Harvesting Area (rai)	Yield (kg/rai)	Production (ton)	Price (Baht)	Gross Product Value(1,000฿)
1. Rice (rainy season)	1,518,546	1,485,032	484	718,755	3,933	2,826.8
(dry)	248,943	248,943	661	164,551	3,276	539
2. Maize	409,155	375,437	278	104,371	3.11	324.6
3. Cassava	379,279	379,279	2,142	812,415	0.88	658
4. Sugarcane	384,401	384,401	7,821	3,006,400	460	1,382.9
5. Greengram	210,162	210,162	113	23,748	7.46	167.6
6. Black gram	18,915	18,915	120	2,269	6.40	14.5
7. Soybean	229,895	209,880		47,315		376.6
- 1st rainy season	78,976	58,976	179	10,556	8.87	93.6
- last rainy season	80,361	80,346	245	19,684	7.96	156.7
- dry season	70,558	70,558	242	17,075	7.40	126.3
8. Groundnut	1,786	1,786	250	446	7.50	3.3
9. Banana	30,176	30,176	212	6.39	38 *	243
10. Cotton	7,850	7,850	215	1,687	15	25.6
11. Sesame	2,650	2,650	60	159	17.16	2.7

Source : Kamphaeng Phet Agricultural Extension Office

TABLE D-4 CROP PRODUCTION IN 1989/1990, TAK PROVINCE

Crops	Planting Area (rai)	Yields (kg/rai)	Production (ton)	Remark
1. Major rice	291,849	445	129,872	1989 / 90
2. Second rice	10,535			
3. Upland rice	49,178	250	12,294	
4. Maize 1	600,507	290	124,147	
5. Maize 2	72,379	290	20,989	
6. Muangbean	16,903	170	2,873	
7. Soybean (rainy)	102,920	210	21,613	
8. Soybean (dry)	47,883	190	9,097	1989 / 90
9. Groundnut	7,992	225	1,798	
10. Castor bean	4,463	153	682	
11. Sugar cane	3,589	10,000	35,890	
12. Cotton	6,075	190	1,154	
13. Kapok	12,862	750	9,646	
14. Coffee	1,245	250	311	
15. Lemon	2,401	850	2,040	
16. Coconuts	10,444	550	5,744,200	Unit : Piece
17. Mango	4,703	1,500	7,054	
18. Mango	12,962	2,500	32,405	
19. Cashew nuts	1,950			
20. Tammallinda	3,586	2,500	8,965	
21. Jack Fruits	3,295	530	1,746,300	Unit : Piece
22. Banana	20,166	1,800	36,298,800	Unit : Wee
23. Krul Khai	7,232	2,000	14,464,000	Unit : Wee
24. Longan	3,750	750	2,812	
25. Chilly	2,733	470	1,284	
26. Chilly	2,243	550	1,233	
27. Garlic	6,872	970	6,665	
28. Cabbage	1,935	3,500	6,772	

Source : Tak Agricultural Extension Office

**Table D-5 HARVESTED AREA AND CROP PRODUCTION,
KAMPHAENG PHET**
Planted area, Harvested area, Damaged area Production and Yield
Kamphaeng Phet Province

Paddy (Major Rice)

Year	Planted Area (rai)	Harvested Area (rai)	Damaged Area (rai)	Production (ton)	Yield (kg/rai)	Damaged Area Ratio(%)
1983	1,556,019	1,445,158	110,861	519,725	360	7
1984	1,514,514	1,197,947	316,567	426,625	356	21
1985	1,506,032	1,200,000	306,032	456,000	380	20
1986	1,518,474	1,505,267	13,207	657,226	436	1
1987	1,413,623	1,149,125	264,498	489,122	425	19
1988	1,573,299	1,414,127	159,172	740,530	523	10
1989	1,518,546	1,485,032	33,514	718,755	484	2
1990	1,509,092					

Second Rice

1983	-	-	-	-	-	0
1984	58,530	58,530	-	38,044	650	0
1985	52,301	52,301	-	32,668	624	0
1986	46,357	46,356	-	28,741	620	0
1987	45,244	45,244	-	27,644	611	0
1988	96,542	96,542	-	60,821	630	0
1989	171,265	171,205	-	111,463	651	0
1990	248,943	248,943	-	164,551	661	0

Maize

1983	412,369	393,929	18,440	119,993	305	4
1984	439,213	329,322	109,891	115,793	358	25
1985	698,522	665,329	33,193	296,223	445	5
1986	568,440	53,823	514,617	17,331	332	91
1987	450,098	35,069	415,029	7,498	213	92
1988	414,689	412,726	963	154,933	375	1
1989	409,155	375,437	33,718	104,371	278	8
1990	267,823					

Source : Kamphaeng Phet Extension Office

**Table D-5 HARVESTED AREA AND CROP PRODUCTION,
KAMPHAENG PHET (Cont'd)**

Soybean (Rainy Season)

Year	Planted Area (rai)	Harvested Area (rai)	Damaged Area (rai)	Production (ton)	Yield (kg/rai)	Damaged Area Ratio(%)
1983	56,600	56,555	5	13,781	244	0
1984	84,951	84,451	500	22,909	271	1
1985	62,256	62,256	-	17,431	280	0
1986	77,619	77,619	-	20,801	268	0
1987	114,490	51,744	62,746	11,383	220	55
1988	144,520	142,795	1,725	37,090	259	1
1989	159,340	139,322	20,018	30,240	217	13
1990	127,275					

Soybean (Dry)

1983	-	-	-	-	-	-
1984	-	-	-	-	-	-
1985	19,563	19,563	-	4,695	240	0
1986	28,962	28,962	-	4,903	230	0
1987	50,857	50,857	-	11,697	230	0
1988	47,430	47,430	-	9,324	196	0
1989	50,340	50,340	-	11,207	222	0
1990	70,558	70,558	-	17,075	242	0

Mungbean

1983	362,000	361,137	863	50,676	140	0
1984	338,713	338,711	-	37,597	111	1
1985	342,282	337,418	4,864	37,790	112	1
1986	332,406	662,406	-	36,565	110	0
1987	157,475	152,761	4,714	14,970	98	3
1988	186,843	186,843	-	17,160	91	0
1989	210,162	210,162	-	23,748	113	0
1990	180,764					

Source : Kamphaeng Phet Extension Office

**Table D-5 HARVESTED AREA AND CROP PRODUCTION,
KAMPHAENG PHET (Cont'd)**

Groundnut

Year	Planted Area (rai)	Harvested Area (rai)	Damaged Area (rai)	Production (ton)	Yield (kg/rai)	Damaged Area Ratio(%)
1983	7,088	7,088	-	1,772	250	0
1984	6,884	6,884	-	1,700	247	0
1985	6,260	6,257	3	1,436	230	0
1986	6,780	6,770	10	1,422	210	0
1987	2,753	1,225	1,528	269	220	56
1988	5,306	5,303	3	1,184	223	0
1989	1,786	1,786	-	446	250	0
1990	3,215					

Sesame

1983	175	175	-	18	101	0
1984	313	313	-	31	97	0
1985	1,695	1,695	-	210	24	0
1986	2,164	1,974	190	234	120	8
1987	2,605	612	1,993	37.5	61	77
1988	3,863	3,863	-	273	71	0
1989	2,650	2,650	-	159	60	0
1990	1,797					

Cotton

1983	8,284	8,284	-	2,899	350	0
1984	6,350	6,350	-	1,524	240	0
1985	10,174	10,174	-	2,441	240	0
1986	7,288	7,054	234	1,658	235	3
1987	16,291	14,351	1,940	2,384	164	12
1988	11,233	10,799	434	2,317	214	4
1989	8,850	7,850	-	1,687	215	0
1990	7,702					

Source : Kamphaeng Phet Extension Office

**Table D-5 HARVESTED AREA AND CROP PRODUCTION,
KAMPHAENG PHET (Cont'd)**

Suger cane

Year	Planted Area (rai)	Harvested Area (rai)	Damaged Area (rai)	Production (ton)	Yield (kg/rai)	Damaged Area Ratio(%)
1983	286,442	286,442	-	2,006,014	7,000	0
1984	293,371	293,371	-	2,009,100	7,155	0
1985	235,366	235,366	-	1,682,868	7,150	0
1986	202,440	202,220	220	1,445,873	7,150	0
1987	255,651	252,436	3,215	1,445,873	7,120	1
1988	336,074	366,074	-	3,200,000	8,740	0
1989	384,401	384,401	-	3,006,400	7,821	0
1990	410,500					

Cassava

1983	225,433	225,433	-	563,983	2,502	0
1984	185,207	163,594	21,613	325,897	1,992	2
1985	157,555	157,555	-	346,621	2,200	0
1986	204,534	204,534	-	388,615	1,900	0
1987	344,202	221,961	122,241	466,118	2,100	36
1988	406,802	385,613	21,189	749,593	1,943	5
1989	379,279	379,279	-	812,415	2,142	-
1990	354,427					

Banana (Kro Khai Specie)

1983	20,115	20,115	-	5,028,750	250	0
1984	11,993	11,993	-	2,998,250	250	0
1985	13,963	13,963	-	3,490,750	250	0
1986	29,717	29,717	-	7,429,250	250	0
1987	27,744	27,744	-	6,908,256	249	0
1988	30,523	30,523	-	7,630,000	250	0
1989	30,176	30,176	-	6,390,000	212	0
1990	26,895	26,895	-	5,701,740	212	0

Source : Kamphaeng Phet Extension Office

Table D-6 CROP YIELD, MUANG TAK

Crops Area, Production and Yield in Muang Tak, Tak - 1988/89

	Planted	Harvested	Damaged	Production	Yield	
	Area A (rai)	Area B (rai)	Area C (rai)	D (ton)	D/B	D/A
Paddy	59,590	58,355	1,235	26,260	450	441
Maize	42,710	36,210	6,500	10,863	300	254
Soybean (1)	274	274	-	49	180	180
Soybean (2)	1,244	1,194	50	239	200	192
Soybean (dry)	1,115	1,115	-	256	230	230
Mungbean (1)	335	335	-	30	90	90
Mungbean (2)	6,560	3,645	2,915	365	100	56
Ground nut (1)	3,673	3,673	-	771	210	210
Ground nut (2)	486	426	60	81	190	167
Castorbean	1,067	1,067	-	85	80	80
Sesame	286	286	-	11	40	40
Cotton	4,586	4,586	-	1,043	227	227
Mango	3,850	2,984	866	1,492	500	388
Tamarind	1,207	950	257	1,425	1,500	1,181
Kapok	3,216	2,308	908	831	360	258
Banana	530	530	-	1,272,000	2,400	2,400
Banana Khro Khai	2,140	1,800	340	2,880,000	1,600	1,346
Bamboo	520					

Note : Unit of Banana Products is "Wee"

Source : Muang Tak Extension Office, Tak

**TABLE D-7 NUMBER OF EXTENSION WORKER, POPULATION,
FARMERS, 1989/1990**

Phitsanulok Ampoe	No. of Tambon	No. of Village	Extension Workers	Population	Household	Farmers	Farmers Household
1. Muang Phitsanulok	19	140	21	207,534	42,776	77,278	18,202
2. Chatra Kan	5	56	3	30,822	5,852	28,355	5,650
3. Nakhon Thai	10	116	9	66,761	13,398	58,633	12,264
4. Ban Kratum	9	86	7	49,402	8,513	42,470	8,088
5. Ban Rakam	9	104	10	86,768	16,014	48,009	13,607
6. Phrom Piram	12	104	14	74,569	15,928	65,903	14,703
7. Wang Thong	11	115	16	125,601	19,367	82,292	15,429
8. Wat Bot	6	55	7	34,730	10,825	33,662	10,515
9. Noen Maprang	7	59	7	50,024	9,561	44,606	8,534
Total	88	835	94	726,211	142,234	481,208	106,992

Source : Phitsanulok Agricultural Extension Office

**TABLE D-8 NUMBER OF EXTENSION WORKER, POPULATION,
FARMERS, 1989/1990**

Ampoe	No. of Tambon	No. of Village	Extension Workers	Population	Household	Farmers	Farmers Household
1. Muang Sukhothai	10	71	12	112,762	11,982	112,762	11,982
2. Khiri Mat	10	88	6	48,793	9,355	48,793	9,355
3. Kong Krilat	11	96	6	62,326	12,101	62,326	12,101
4. Si Satchanalai	11	80	12	89,234	17,025	89,234	17,025
5. Si Samrong	13	109	9	67,806	11,148	67,806	11,148
6. Sawan Khalok	14	104	13	89,568	14,840	89,568	14,880
7. Thung Saliam	5	40	6	44,973	9,189	44,973	9,189
8. Ban Dan Lan Hoi	5	44	3	37,962	6,625	37,962	6,625
9. Si Nakhon	4	26	4	30,018	5,230	30,018	5,230
Total	83	658	71	583,442	97,495	583,442	97,495

Source : Sukhothai Agricultural Extension Office

**TABLE D-9 NUMBER OF EXTENSION WORKER, POPULATION,
FARMERS, 1989/1990**

Lamphaeng Phet Ampoe	No. of Tambon	No. of Village	Extension Workers	Population (1989)	Household (1989)	Farmers (1989)	Farmers Household (1989)
1. Muang Kamphaeng Phet	16	175	22	307,595	33,212	153,435	27,516
2. Phran Kratai	8	93	7	65,170	12,942	52,171	8,918
3. Khlong Khlung	16	140	17	113,830	23,199	104,200	22,069
4. Khanu Worakburi	14	144	15	123,216	20,985	106,674	18,994
5. Sai Ngam	7	58	6	46,668	8,976	42,406	8,047
6. Lam Krabu	6	57	3	43,366	7,033	27,597	5,900
7. Khlong Lan	3	40	6	52,918	10,408	49,898	8,127
Total	70	707	76	643,763	116,755	536,381	99,571

Source : Kamphaeng Phet Agricultural Extension Office

**TABLE D-10 NUMBER OF EXTENSION WORKER, POPULATION,
FARMERS, 1989/1990**

Ampoe	No. of Tambon	No. of Village	Extension Worker	Population *	Household *	Farmers *	Farmers Household*
1. Muang Tak	11		100	102,023	18,611	54,344	12,126
2. Ban Tak	7		64	42,961	6,766	26,412	5,904
3. Sam Ngao	6		41	31,328	6,027	16,178	4,855
4. Mae Sod	10		72	76,787	17,712	57,457	11,597
5. Mae Ramad	5		48	32,188	6,400	24,765	5,120
6. Tha Song Yong	4		55	17,207	3,509	12,228	2,420
7. Umphang	5		33	12,215	2,154	15,831	1,723
8. Phop Phra	4		29	13,254	2,990	12,575	2,567
Total	52		442	717,963	64,169	219,792	46,312

Source : Tak Agricultural Extension Office

**TABLE D-11 FARMERS ASSOCIATION 1989/1990 IN
PHITSANULOK PROVINCE**

Amphoe	Farmers Group		Household Group		Young Youth Group	
	No.	Members	No.	Members	No.	Members
1. Muang Phitsanulok	13	2,306	28	666	23	662
2. Chatra Kan	-	-	12	302	8	205
3. Nakhon Thai	6	718	21	554	12	260
4. Ban Kratum	6	972	10	195	-	-
5. Ban Rakam	-	-	13	337	15	353
6. Phrom Piram	5	577	21	477	16	331
7. Wang Thong	8	933	16	455	17	475
8. Wat Bot	7	866	13	319	13	281
9. Noen Maprang	-	-	17	576	4	91
Total	45	6,374	151	3,886	108	2,658

Source : Phitsanulok Agricultural Extension Office

TABLE D-12 FARMERS ASSOCIATION 1989/1990 IN SUKHOThAI PROVINCE

Amphoe	Agriculture Clubs		Farm Women Group		Young Youth Group	
	#Clubs	# Members	#Clubs	# Members	#Clubs	# Members
1. Sri Satchanalai	11	1,404	52	1,502	14	296
2. Si Nakhon	1	120	13	345	5	132
3. Thung Salium	4	261	35	860	16	366
4. Sawan Khalok	10	487	15	331	19	410
5. Si Samrong	12	328	22	435	18	297
6. Muang	5	466	23	975	13	261
7. Khri Mat	3	370	20	415	9	187
8. Kong Krilat	5	118	9	185	10	191
9. Ban Dan Lan Hoi	5	386	24	628	17	354
Total	56	3,940	213	5,676	121	2,494

Source : Sukhothai Agricultural Extension Office

**TABLE D-13 FARMERS ASSOCIATION 1989/1990 IN
KAMPHAENG PHET PROVINCE**

Amphoe	Farmers Group		Farm Womem Group		Young Youth Group	
	No.	Members	No.	Members	No.	Members
1. Muang Kamphaeng Phet	13	2,557	16	269	11	207
2. Phran Kratai	5	208	9	167	13	228
3. Khlong Khlung	11	2,272	22	385	21	415
4. Kanu Worakburi	10	1,555	10	263	9	259
5. Sai Ngam	4	786	12	264	13	300
6. Lan Krabu	2	342	17	564	10	163
7. Khlong Lan	1	-	12	297	8	198
Total	46	7,720	90	2,209	85	1,770

Source : Kamphaeng Phet Agricultural Extension Office

TABLE D-14 FARMERS ASSOCIATION 1989/1990 IN TAK PROVINCE

Amphoe	Agriculture Clubs		Farm Womem Group		Young Youth Group	
	No.	Members	No.	Members	No.	Members
1. Muang Tak	3	375	18	573	7	154
2. Ban Tak	2	115	31	773	4	65
3. Sam Ngao	1	45	13	425	6	172
4. Mae Sod	3	310	18	672	15	414
5. Mae Ramad	2	308	15	482	7	181
6. Tha Song Yong	2	107	5	166	5	135
7. Umphang	2	181	7	165	10	405
8. Phop Phra	-	-	9	625	6	132
Total	16	1,441	87	2,952	47	1,305

Source : Tak Agricultural Extension Office

TABLE D-15 RAISING OF SILK WORM

Phitsanulok Province

	No. of Mulberry Farm	Mulberry Area (rai)	Sericulture		Cocoon (kg.)	for cottage industry (kg.)	for silk fabric (kg.)
			No. of time of ecdysis	No. of winnow (batches)			
1. Muang Phitsanulok	1	22	-	30	-	-	-
2. Wang Thong	2	12	2	18	3	3	-
3. Bang Rakam	11	12	5	200	312	102	210
4. Phrom Piram	-	1	-	-	-	-	-
5. None Maprang	25	122	5	180	300	120	180
6. Chatrakan	1	2	-	-	-	-	-
Total	40	171	2-5	428	615	225	390

Sukhothai Province

1. Ban Dan Lan Hoi	10	6	4	93	120	20	100
2. Kirimat	7	10	3	70	27	12	15
3. Thung Saliang	8	25	6	105	110	30	80
Total	25	41	3-6	268	257	62	195

Kamphaeng Phet Province

1. Muang Kamphaeng Pet	64	44	5	705	256	106	150
2. Phran Kratai	43	15	3	218	20	5	15
3. Khlong Kulung	620	303	5	10,150	1,083	481	602
4. Kanu Wanalakaburi	30	45	5	459	46	14	32
5. Sai Ngam	88	205	7	3,164	285	105	180
6. Lan Krabu	65	64	6	843	505	200	305
7. Khlong Lan	70	88	3	850	137	45	92
Total	980	764	3-7	16,389	2,332	956	1,376

Tak Province

1. Muang Tak	12	75	6	250	24	9	15
2. Mae Sot	3	3	6	45	13	6	7
3. Mae Ramad	6	4	6	60	25	4	21
4. Sam Ngao	3	3	8	32	12	3	9
Total	24	85	6-8	387	74	22	52

The report will end of December, 1988

Source : Sericulture REsearch Insriture, DOA

TABLE D-16 SMALL SWAMP INLAND FISHERIES PROJECT (PHASE I)

Changwat	Name of water Source	Amphoe	Tambon	Muban	Area (rai)
Kamphaeng Phet	Buang Ban Thung Thong	Khlong Khlung	Thung Sai	Mo 3	150
	Nong Khlong Wua	Kanu Woralok Buri	Salok Bat	Salok Bat	25
	Wang Salok Phra	Kanu Woralok Buri	Salok Bat	Nong Salok Phra	17
	Nong Plong	Kanu Woralok Buri	Wang Ham Hae	Mo 7	15
	Bueng Kok	Kanu Woralok Buri	Pa Phuttha	Mo 8	50
	Nong Chorakhe	Phran Kratai	Tha Mai	Nong Chorakhe	120
	Bueng Kra Pung	Sai Ngam	Sai Ngam	Mo 1	25
	Bueng Lam Ma Krol	Lan Krabu	Nong Luang	Lam Ma Krok	200
Phisanulok	Nong Huai	Phrom Piram	Sri Phirom	Ban Huai	35
	Nong Ma Main	Bang Rakam	Wang E Thok	Nong Tao Khan	40
	Bueng Kra Dan	Muang	Ban Pa	Mo 2	30
	Bueng Samo Khae	Muang	Samo Khai	Mo 4	20
	Bueng Ta KHiam	Bang Kratum	Phai Lom	Mo 9	35
Sukhothai	Bueng Noi	Muang	Ban Suan	Mo 1	30
	Nong Huai Lap	Muang	Pak Khaew	Mo 3	40
	Nong Bueng Khrop	Kong Krilat	Ban Mai Suk Kasem	Bueng Khrop	150
	Nong Mab Mai Daeng	Kong Krilat	Kok Lat	Mo 3	75
	Nong Yai	Sawan Khalok	Nong Klab	Mo 2	120
	Nong Phak Lung	Sri Satchanalai	Hat Siaw	Hat Siaw	141
	Nong Lat Hoi Khong	Sri Samrong	Ban Rai	Don Chan	150
	Nong I-Khong	Sri Samrong	Ban San	Ban San	78
	Ban Nong Yai	Khirimat	Ta Not	Yang Lam	100
	Thung Lan Chang				
	Publication Reservoir	Ban Dan Lan Hoi	Wang Ta Khro	Nong Mai Kong	40
	Nong Lum	Sri Nakhon	Sri Nakhon	No 4	180
Tak	Nong Bua Daeng	Ban Tak	Tak Tok	Mo 1	36
	Nong Nam Mae Long	Sam Ngao	Wang Man	Mo 7	17
	Nong Bua Pra Daeng	Muagn	Wang Hin	Mo 7	115

TABLE D-17 SMALL SWAMP INLAND FISHERIES PROJECT (PHASE II)

Item Swamp Name	No. of Swamp	Changwat	Ampoe	Tambon	Muban
<u>Kamphaeng Phet</u>					
11. Bueng Sakae	21	Kamphaeng Phet	Muang	Nong Pling	Kao Saba
12. Bueng Thab Rat	24	"	Lan Krabue	Lan Krabue	Bueng Tha Rat
13. Nong Khlong Du	25	"	Khong Khlung	Pho Thong	Mai Yao
14. Nong Sam Wai	ADD.1	"	Muang	Deluk Rat	-
15. Nong Wang Dam Nam	ADD.2	"	Muang	Lan Dek Mai Tok	1
16. Nong Mai Wang Yang	ADD.3	"	Khlong Khlung	Wang Yang	Wang Yang
<u>Phisanulok</u>					
27. Bueng La Mu	43	Phisanulok	Muang	Ma Kham Sung +-	Huai Wang Krang
28. Nong Phai Lom	44	"	Muang	Bueng Phra	Nong Phai Lom
29. Bueng Wat	45	"	Wat Bot	Hin Lat	Noi 3
30. Bueng Chang	47	"	Bang Krathum	Phailom	Bueng Chang
31. Bueng Ta Duang	48	"	Bang Krathum	Nakhon Pa Mak	Khlong Krang
32. Bueng Bang Dong	50	"	Bang Rakam	Chum Saeng Song Khrom	Dong 4
33. Nong Mon	51	"	Phrom Phiram	Dong Pra Kha	Phak Bueng 7
34. Nong Ra Han	52	Phisanulok	Phrom Phiram	Phiram	Phrom Phiram
35. Bueng Ratchanok	53	"	Wang Thong	Wang Phi Kun	Phrom Phiram
<u>Sukhotai</u>					
36. Nong Suai	54	Sukhothai	Sri Nakhon	Nakhon Dueat	1
37. Nong Yang	55	"	Sri Nakhon	Nakhon Dueat	2
38. Nong Phan Thala	58	"	Kirimat	Ta Net	3.13
39. Nong Pa To	59	"	Swan Kalok	Than Thong	1
40. Nong Si Da	60	"	Kirimat	Sam Pueng	Nong Sida
41. Nong Krasa	ADD.4	"	Srisamorong	Kaetaliang	5
<u>Tak</u>					
42. Nong Prabat	63	Tak	Ban Tak	Tak	7.8
43. Nong Chik	64	"	Ban Tak	Maesalit	5
44. Nong Bua Tai	65	"	Muang	Nongbuatai	2
45. Nongmai Ngam	67	"	Muang	Mai Ngam	1

APPENDIX E : IRRIGATION

APPENDIX E. IRRIGATION

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E-1 PRESENT CONDITION OF IRRIGATION

E-1-1 General Condition

The irrigation area in the 4 provinces is counted at (216,000 ha 1,349,000 rai) which is equivalent to 14 percent of the total farmland. The irrigated area in each province in the year 1988 is shown below.

<u>Province</u>	<u>Irrigated area</u> (1,000 rai)	<u>Farmland</u> (1,000 rai)	<u>Ratio</u> (%)
Phitsanulko	550	2,801	20
Sukhothai	238	2,292	10
Kamphaeng Phet	418	3,269	13
Tak	143	961	15
Total	1,349	9,323	14
Whole Kingdom	25,767	147,801	17

(Data Source: Agricultural Statistics of Thailand, Crop Year 1988/89)

The irrigation method and characteristics of each province can be summarized as follows:

(1) Phitsanulok Province

Both the irrigated area and the percentage of the irrigated area to the farmland is largest among the four provinces. The Mae Nam Nan runs down through the province. The river is regulated by the Sirikit Dam which is completed in 1973. The Naresuan Dam diverts the water released from the Sirikit Dam to the wide irrigation area of the Phitsanulok Project. The irrigation of this province is characterized as large scale depending on the Sirikit Dam.

(2) Sukhothai Province

There are several medium scale irrigation projects with reservoirs or weirs. However, the most characteristic project would be the groundwater irrigation project which was commenced in 1977 and completed in 1986. Half of the total irrigation area is covered by this project.

(3) Kampaeng Phet Province

There are several medium scale projects by weirs in the province. However, the irrigation of this province is characterized by SSIP (Small Scale Irrigation Program). The number of the projects and the irrigated area by SSIP are largest among the four provinces. The irrigated area by SSIP covers 75 percent of the total irrigated area in the province.

(4) Tak Province

There are four irrigation project with storage reservoir. The total storage capacity is 11 MCM. Besides the storage project, the RID has implemented the Ping Valley Pumping Irrigation Program. Altogether ten pumping irrigation project were implemented and the total irrigated area of (7,200 ha 45,000 rai) is covered by these project.

E-1-2 Existing Irrigation Project

(1) Existing Irrigation Project by ARD

A number of irrigation projects have been implemented by ARD. The major projects with storage reservoirs or weirs are listed in Table E-1. These irrigation facilities were constructed within these ten years and most of them were facilitated with irrigation main canal.

Other than these irrigation facilities, a considerable number of dug ponds have been constructed. A small plot of land from 40 rai to 50 rai is irrigated by the pond. However it can be considered that these ponds play important role for domestic use and animal drinking.

(2) Existing Irrigation Project by Other Agency

The Royal Irrigation Department (RID) of the Ministry of Agriculture and Cooperatives has long been executing the major irrigation projects in this country although several government agencies have been engaged in irrigation projects. The medium and large scale irrigation project executed by RID is shown in Table E-2.

The RID has also promoted implementation of the Small Scale Irrigation Program (SSIP) on the village level in order to provide water for irrigation, domestic use and animal drinking to the farmers suffering from water shortage since 1977. Many type of project included. All the project lists concerning four provinces has been obtained from RID. The locations of SSIP were plotted on the 1/50,000 topographical map in order to avoid the conflict with or ill effect on newly proposed ARD irrigation Project. The summary of SSIP is shown in Table E-3.

E-2 PROPOSED IRRIGATION PROJECT

E-2-1 General Concept

The Lower North area is suffered from poor precipitation that concentrates in the months from August to October and runoff discharge that fluctuates both in seasons and in years. Large paddy field remains without irrigation water supply. In most of the backward villages, water is insufficient for the minimum requirement of subsistent agriculture.

The poverty alleviation for the backward villages in these area should be accomplished through the increase of agricultural productivity, especially wet season paddy productivity. In this connection, water resources development with storage reservoir is essential to stabilize the irrigated agriculture.

It is most likely anticipated that the proposed damsites for storage reservoirs will be concentrated in the upper reaches of the tributaries in order to get more topographical advantages and to avoid resettlement of villages, relocation of infrastructures and compensation of cultivated lands.

The second priority should be placed on the irrigation with weir, though the weir cannot secure the year round irrigation water supply. The irrigation water can not be supplied even in wet season in a very dry year.

The pumping irrigation scheme is not included in the plan because the operation and maintenance cost will be high. Therefore, attention should be

paid on the maximum possibility of gravity irrigation system in this stage of planning.

E-2-2. Proposed Irrigation Project with Reservoir

(1) Selection of Damsite

The initial selection of damsites has been conducted based on the RTSD topographical maps with scale of 1/50,000. Those damsites were avoided that would cause a village or considerable area of paddy field to be submerged. The locations of all the major existing irrigation facilities have been plotted on the said maps and the damsites which would make a conflict with existing irrigation facilities are also avoided. The first selection of possible reservoir site are listed in Table E-4.

The major features of each damsites are briefly described as follows:

(a) Phitsanulok Province

1. Huai Nam Khlung

The damsite itself is located in Uttaradit Province. The damsite seems to be very suitable for a medium size reservoir. There would be some compensation for the farm land. The problem is that reservoir area belongs to Uttaradit Province and all the beneficial area belongs to Phitsanulok Province. Negotiation between the two provinces would be necessary.

2. Huai Sam Ru

The project area is located at 70 km east of the city of Phitsanulok. There are many backward villages in the immediate downstream of the damsite.

The farmers in these villages cultivate paddy in some part of the area and upland crops including upland rice in most of the area because of lack of water.

The damsite is a gorge with a fairly large pocket in the upstream reach. There is some cultivation land of cassava and corn in the proposed reservoir area but they are illegal.

3. Huai Kok Yai

The project area is located at east of the highway route 2013 and can be accessed by dirt road up to Ban Huai Kok and by small path up to 2 km downstream of the damsite. There is no road to access to the damsite which is located at the upstream of the waterfall. There seems to be no cultivation land in the proposed reservoir area.

4. Huai Nam Khu

The project area is located at east of the highway 2013 and can be approached through ARD road up to Ban Huai Hia and 3 km of dirt road. Outcrop of hard rock can be seen at the damsite. There is some cultivation land of upland crop in the proposed reservoir area.

5. Huai Nam Khamun

The project area is located at 5 km southeast of Amphoe Nakhon Thai and can be accessed by asphalt paved road. The damsite is widely developed trapezoidal valley. The wide bottom of the valley is used for paddy cultivation. There will be little possibility of realizing construction of the dam because of the compensation problem.

6. Khlong Nam Poi

The project are is located at the left bank of the Mae Nam Khek. There is no bridge to across the river from the highway route 12 which runs along the right bank of the river.

7. Huai Hin Fon

The damsite is located at the upper most of the Khlong Chom Phu. The catchment area at the damsite is 281 sq.km and the damsite has possibility to build a dam with storage capacity more than 100 MCM.

This site is not considered to be suitable for the medium scale irrigation project.

(b) Sukhothai Province

1. Huai Mae Than Noi

The damsite is located at 10 km west of Amphoe Thung Saliang. Catchment area, storage capacity and dam height are small. However, this damsite is so precious as Amphoe Thung Saliang has only one site like this.

2. Huai Nong Kho

The project area is located at 25 km northwest of Amphoe Ban Dan Lan Hoi. The damsite can be accessed by a car. There once built a weir in Small Scale Irrigation Program by Royal Irrigation Department in the proposed reservoir area, but it has not played the proper functions since the construction.

The farmers in Ban Huai Khrai which is located at 2.5 km downstream from the damsite are very eager to promote the project and no compensation problem exist.

3. Huai Mae Kong Khai

The project area is located at the western most part of the Sukhothai Province. The catchment area is bordered by the Tak Province on the west and by the Lampang Province on the Northeast. There is no backward villages defined by NESDB.

4. Nam Me Romphan

The irrigable area is located in Amphoe Ban Dan Lan Hoi, but the damsite itself belongs the Lampang Province. There is an old weir constructed by ARD at the damsite, but it is not functioning properly. There is some cultivation land in the reservoir area. The

compensation problem would be complicated because the reservoir area and beneficial area belong to the different provinces.

5. Huai Tha Pae

The damsite is located at 20 km west of the Amphoe Si Satchanalai. There is some paddy field in the proposed reservoir area. The catchment area is large (214 sq.km), and the pocket is large enough to store the annual runoff. This damsite is suitable for the large scale water resources development.

6. Huai Phan Rang

Fruit tree cultivation occupies most of the proposed reservoir area. The compensation problem would be very difficult to solve.

7. Huai Pok Khu

Fruit tree cultivation occupies most of the proposed reservoir area.

8. Huai Phung

Fruit tree cultivation occupies most of the proposed reservoir area.

9. Huai Mae Paeng Luang

The catchment area is large (95 sq.km), and the pocket is large enough to store the annual runoff. This damsite is suitable for large scale water resources development.

10. Huai Mae San

The damsite is suitable for large scale water resources development as both the catchment area and the pocket are large.

11. Huai Pong Wua

Fruit tree cultivation occupies most of the proposed reservoir area.

12. Huai Mae Sung

The damsite is located at 6 km northwest of the Amphoe Si Satchanalai. In the downstream of the damsite, there extends paddy field.

13. Huai Mae Sam

Fruit tree cultivation occupies most of the proposed reservoir area.

14. Huai Mae Hu

Fruit tree cultivation occupies most of the proposed reservoir area.

15. Huai Nam Pang

There is some illegal cultivation in the proposed reservoir area. In the downstream of the damsite, more than 1,000 rai of fruit tree cultivation is extending. This is one of the promising project in this province.

16. Huai San

The catchment area and storage capacity are topographically limited.

17. Huai Lam Sok

The damsite is considered to be suitable for the medium scale water resources development judging from the catchment area and the storage capacity. There is some fruit tree cultivation in the downstream.

18. Huai Satho

The damsite is located in the A1 reserved forest area and no permission is granted by Royal Forestry Department. This damsite should be abandoned.

(c) Kamphaeng Phet Province

1. Khlong Nam Lai

The damsite is located in the area of national park. Construction of a dam cannot be permitted in order to preserve the natural environment.

2. Khlong Khayaeng

The damsite is located at 27 km southwest of Kamphaeng Phet city. The project is under planning and it will be implemented by ARD in the fiscal year 1991.

3. Khlong Suan Mak

The damsite has topographical advantage for large dam construction. The Royal Irrigation Department has paid attention to the site for large scale water resources development and continues the hydrological observation.

However the right bank of the proposed reservoir area belongs to the national park area.

4. Khlong Mot Daeng

Most of the proposed reservoir area is under cultivation and the compensation is hard problem.

5. Khlong Phrai

The damsite is located at 30 km west of Kamphaeng Phet city. In the damsite and the proposed reservoir area, there is a village of hill tribe and cultivation land.

6. Khlong Wang Chao

The damsite is located on the boundary of the Kampaeng Phet Province and the Tak Province. The catchment area and the irrigable area also belong to both the province. Judging from the catchment area and the topography of the damsite, this site is suitable for large scale water resources development.

7. Khlong Wang Nam Daeng

The damsite is located at 25 km northwest of the Amphoe Phran Kratai. The project is now under-planning and it is decided that the project be implemented in the fiscal year 1991.

8. Khlong Khlung

The river Khlong Khlung makes a boundary between the Amphoe Muang and the Amphoe Khlong Khlung. The Royal Irrigation Department had an idea to construct a dam with storage capacity of several hundreds MCM at the gorge of 12 km downstream of the proposed damsite. However, many villages have been established in the reservoir area in the meanwhile and the idea seems to have been abandoned.

9. Khlong Sao Khon

The damsite is located at 5 km southeast of the proposed Khlong Wang Nam Daeng Damsite. The ARD road runs northward from the route 1132 to the damsite. The proposed reservoir area consist of bush with scattered thin forest. There exists no cultivation land nor villages.

10. Khlong Pa Bong

The Royal Irrigation Department has commenced the construction work of the dam. Therefore, the proposal of this dam is canceled.

11. Lam Dang

The damsite is characterized by very flat topographical condition. The expected gross storage capacity and the maximum water depth would be 2.5 MCM and 7 meters respectively. In taking the dead water storage capacity into account, the usable depth of the reservoir water would be very shallow and naturally, large evaporation loss is anticipated.

12. Khlong Huai Khon

The damsite is located at 8 km west of Amphoe Phran Kratai and it can be approached by the dirt road from the downstream. The topography of the damsite is very flat. There is some recently reclaimed cultivation land in the proposed reservoir area.

(d) Tak Province

1. Lam Pa Foeng

The damsite topography is very gentle. The reservoir area of 2 sq.km is required for the storage of 5 MCM of water. The most of reservoir area is under paddy cultivation. Because of the large compensation problem, the project would have less possibility of realization.

2. Khlong Sai

The project area is located in the Amphoe Muang. The distance from then ARD Provincial office to the damsite is about 30 km and it can be accessed by 30 minutes drive of a car. The dam length is estimated at 850 from the 1:50,000 topographical map. The site investigation revealed that the left abutment of the dam is hill slope whereas the right-abutment is very gentle. It seems that the dam length would be larger than the estimates by 1 : 50,000 map. There is some cultivation area of upland crop in the reservoir area. However, the compensation problem could be solved within a short period because most of the village farmers want the irrigation project to be implemented and they prefer their upland cultivation area in the

downstream to be turned into paddy field in spite of some loss of land by the reservoir.

3. Huai Nok Lae

The dams site is located at 4 km east of town of Mae Ramat and the last 2 km to the dams site can be approached only by four wheel drive car. The dams site is blessed with topographical condition to have a storage capacity of 5 MCM by the dam of 17 m high and 500 m long. However, the catchment area is so narrow (9 sq.km). Moreover, there is a compensation problem for the paddy field strip extended on the both sides of the river in the proposed reservoir area.

4. Huai Mae Kon Ken

The project area is located at 20 km south of the Mae Sot town. The dams site can be approached by car upto Ban Huai Mi and then by 2 km walk to the dams site. Most of the reservoir area is bush land. However, there are a few farm houses and cultivation land though they are illegal occupation.

5. Huai Khwae Luang

The dams site belongs to the AI reserved forest area. No permission of water resources development could be given by the Royal Forestry Department. In view of the preservation of the environment, this dams site should be abandoned.

6. Huai Song Khwae Tai

This dams site also belongs to the AI reserved forest area and, therefore, should be abandoned.

(2) Proposed Irrigation Project with Reservoir

The Study Team has conducted the site investigation on the possible reservoir sites, beneficial areas and backward villages and series of discussion has been made between the Study Team and ARD province officials concerned.

In the selection study, those damsites with catchment area of more than 100 sq.km are avoided because those damsites are suitable for large scale water resources development and for a construction of medium size dam, the cost for spillway construction will occupy the large portion of the total construction cost. It is advisable that the height of the dam is restricted to less than 25 m in due consideration of the easy construction, short construction period, simple operation and maintenance, etc. The irrigation projects with reservoirs are proposed as shown in Table E-5 taking consideration of topographical condition, project size, compensation and distribution of backward villages.

E-2-3. Proposed Irrigation Project with Weir

The sites for irrigation projects with weir have been so selected on the 1/50,000 RTSD topographical map as to ensure the proper and efficient function of weir. The location of weir site is decided at several hundred meters upstream of an identified backward village. However, those weirs with catchment area of less than 5 sq.km or larger than 100 sq.km are canceled because the weirs with catchment area of less than 5 sq.km cannot command enough irrigation areas and these with catchment area of larger than 100 sq.km require much construction cost. The weir site on the very flat topography (say river slope less than 1/3,000) is also avoided.

The irrigation area is assumed at 2,000 rai (320 ha) per weir on an average. The proposed irrigation project is listed in Table E-6.

E-3. Irrigation Water Requirement

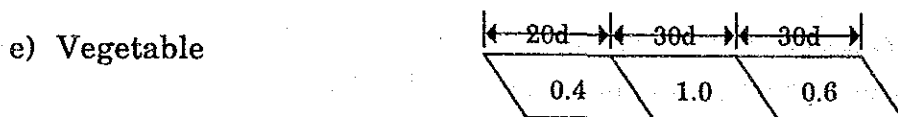
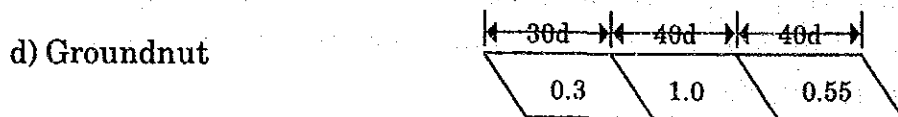
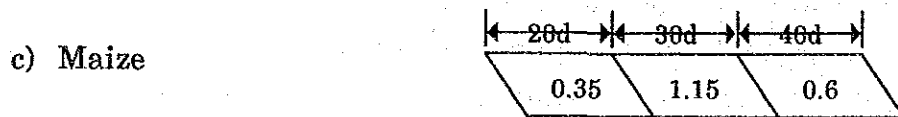
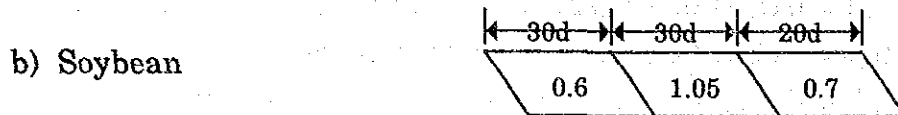
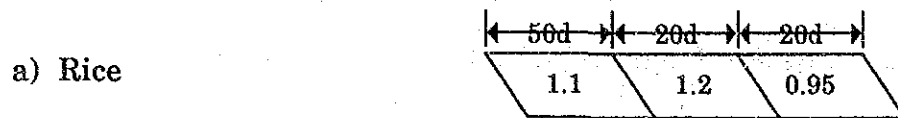
The irrigation water requirement has been estimated on monthly basis in accordance with the proposed cropping pattern.

E-3-1. Crop Evapotranspiration (ET crop)

Crop evapotranspiration (ET crop) has been induced from reference evapotranspiration (ET_o) and crop coefficient (K_c). ET_o has been estimated by the modified Penman method based on the meteorological data at the Phitsanulok synoptic station. The details are shown in Table E-7 and the ET_o is shown below:

	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Total</u>
mm/day	3.1	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	
mm/month	188	132	177	192	176	141	139	130	123	133	120	115	1,696

Kc Values relating ETo to ET crop depend on the crop characteristics, time of planting or sowing, and stage of crop development. Following Kc values have been adopted for each crop.



f) Pasture, Sugarcane 0.7 throughout season

g) Tree Crop 0.8 throughout season

E-3-2. Deep Percolation for Paddy

Current deep percolation rate for wet season paddy in the study area will be negligibly small mainly because of imperfectly to poorly drained condition of land and partly because a rather impermeable horizontal layer in the soil has been developed as a result of land preparation practices. However

after improvement of drainage in future, deep percolation will be promoted to a certain extent. It is therefore assumed to adopt 2.0 mm per day.

E-3-3. Additional Water Requirement

(a) Nursery for Paddy

The nursery bed shall be prepared 30 days before transplanting to the main field. The nursery bed water demand includes those for land soaking, plowing and harrowing, for maintaining standing water depth of about 50 mm during most of the period, for replenishment of standing water after each drainage to encourage the growth of vigorous seedlings and for supplying the evapotranspiration and deep percolation losses. It is assumed that about 400 mm of water is required during the entire nursery period covering about 4 percent of the main transplanting area.

(b) Land Preparation

150 mm for land saturation and ploughing at the initial stage and additional 50 mm to provide standing water at the final stage are needed in land preparation.

(c) Pre-irrigation

Pre-irrigation is required for dry season field crops during land preparation for sowing in order to replenish the end-of-season water depletion. The pre-irrigation requirement is estimated at 60 mm on the total area of dry season field crop cultivation which shall be applied at about 5 days prior to sowing.

E-3-4 Effective Rainfall

Not all of the local rainfall covering the proposed irrigation service area is effective. The amount of rainfall that can be considered effective will depend upon many factors such as (a) intensity and distribution of rainfall, (b) field storage available at the time of rainfall, (c) water requirement, (d) irrigation method, (e) topography and related drainage characteristics, (f) operation of the irrigation systems and others.

For paddy the method developed by the United State Bureau of Reclamation has been applied. The rate of effective rainfall to monthly rainfall is given as follows.

Monthly Rainfall (mm)	Rate of Effective Rainfall (%)
0 - 25	95
26 - 50	93
51 - 75	89
76 - 100	83
101 - 125	75
126 - 150	67
more than 151	58

For dry season field crops and fruit trees, the method developed by United State Department of Agriculture's Soil Conservation Service is applied. Details of the procedure and the reference table are given in, for example, FAO Irrigation and Drainage Paper 25 "effective rainfall in irrigated agriculture".

For the basis of calculating effective rainfall, the meteorological stations at amphoe muang of each province where the model projects are located are selected.

The probability of annual rainfall has been examined. The average annual rainfall, 10 years dry probability and 10 years wet probability of annual rainfall are as follows and the details are shown in Table E-8.

Unit: mm (): percent

	<u>Huai Sam Ru</u>	<u>Huai Nong Kho</u>	<u>Khlong Samo Khon</u>	<u>Khlong Sai</u>
Average	1,347 (100)	1,116 (100)	1,095 (100)	1,020 (100)
1/10 dry year	1,079 (80)	816 (73)	776 (71)	821 (80)
1/10 wet year	1,663 (123)	1,465 (131)	1,575 (144)	1,313 (129)

The monthly field water requirement of each crop for two cases of 1/10 dry year and 1/10 wet year are calculated as shown in Table E-9.

E-3-5 Irrigation Efficiency

For the proposed projects after full development with well designed system, built and operated for some years, the following irrigation efficiencies will be applicable.

Field application efficiency	(Ea)	:	85%
Field canal efficiency	(Eb)	:	85%
Farm efficiency	(Ea × Eb)	:	72%
Conveyance efficiency	(Ec)	:	80%
Overall efficiency	(Ea × Eb × Ec)	:	58%

The monthly diversion requirement of combined cropping pattern per 100 ha is shown in Table E-10.

TABLE E - 1 (1) ARD IRRIGATION PROJECT IN PHITSANULOK PROVINCE

<u>No.</u>	<u>Project</u>	<u>Amphoe</u>	<u>Type of Work</u>	<u>Completed Year</u>	<u>Capacity (MCM)</u>	<u>Irrigation Area (rai)</u>
1	PL 21001	Noeng Maprang	Weir	1988	-	3,100
2	PL 21002	Bang Kratum	Weir	1977	-	1,600
3	PL 21003	Wang Thong	Reservoir	1975	-	1,900
4	PL 21004	Nakhon Thai	Weir	1986	-	1,200
5	PL 21005	Phrom Phiran	Weir	1983	-	1,800
6	PL 21006	Muang	Weir	1986	-	2,500
7	PL 21007	Noen Maprang	Weir	1987	-	3,200
8	PL 21008	Bang Kratum	Weir	under construction	-	3,000
9	PL 21009	Wang Thong	Weir	under construction	-	4,500

TABLE E - 1 (2) ARD IRRIGATION PROJECT IN KAMPHAENG PHET PROVINCE

<u>No.</u>	<u>Project</u>	<u>Amphoe</u>	<u>Type of Work</u>	<u>Completed Year</u>	<u>Capacity (MCM)</u>	<u>Irrigation Area (rai)</u>
1	Klong Khayang	Muang	Weir	1980	-	1,500
2	Ban Wang Phan	Phran Kratai	Weir	1987	-	2,500
3	Ban Num Dip Ma Phrao	Phran Kratani	Weir	1989	-	2,090
4	Wang Ta Khien	Muang	Weir	1988	-	-
5	Nong Kong	Muang	Weir	1990	-	3000
6	Ponk Num Ron	Khlong Lan	Weir	under construction	-	-
7	Khlong Wang Num Daeng	Phran Kratai	Weir	under construction	-	-

TABLE E - 1 (3) ARD IRRIGATION PROJECT IN SUKHOHAI PROVINCE

No.	Project	Amphoe	Type of Work	Completed Year	Capacity (MCM)	Irrigation Area (rai)
1	Huai Hua Waen	Thung Saliam	Reservoir	1985	-	3,000
2	Huai Mae Thulao	Thung Saliam	Reservoir	under construction	-	-
3	Kui Yathaew	Ban Dan Lan Hoi	Reservoir	under construction	-	-
4	Huai Makhot	Si Satchanalai	Reservoir	under construction	-	-
5	Thung Pakha	Ban Dan Lan Hoi	Weir	1982	-	1,000
6	Mae Mok	Sawankhlok	Weir	1990	-	-

TABLE E - 1 (4) ARD IRRIGATION PROJECT IN TAK PROVINCE

No.	Project	Amphoe	Type of Work	Completed Year	Capacity (MCM)	Irrigation Area (rai)
1	Klong Si	Sam Ngao	Reservoir	1980	1.2	-
2	Song Kwa Luang	Sam Ngao	Reservoir	1983	5.0	-
3	Khlong Huai Sai	Muang	Reservoir	1987	3.0	-
4	Huai Cha Rad	Ban Tak	Reservoir	under construction	1.0	1,500
5	Song Kwa Nua	Sam Ngao	Reservoir	1982	5.0	4,200

TABLE E - 2 (1) LARGE AND MEDIUM SCALE WATER RESOURCES DEVELOPMENT PROJECT IN PHITSANULOK PROVINCE

No.	Project	Type of Work	Capacity (MCM)	Irrigable Area (ha)		Construction Year		Irrigation Area (ha)
				Stared	Completed	Stared	Completed	
1	Downstream of Sirikit Dam	IC	-	1,600	*/	1972	1977	1,600
2	Thung San	FC	-	32,000	-	1950	1955	32,000
3	Phitsanulok (Stage I)	ID	-	36,752	-	1973	1985	34,880
4	Khlong wang Nam Sai	C	-	1,600	-	1959	1962	1,600
5	Khlong Wat Ta Yom	C	-	8,480	-	1950	1953	8,480
6	Khlong Nae Khlong Ta Phy	C	-	720	-	1950	1951	720
Total				79,522				79,522

*/ Included in Phitsanulok Project

TABLE E - 2 (2) LARGE AND MEDIUM SCALE WATER RESOURCES DEVELOPMENT PROJECT IN SUKHOHAI PROVINCE

No.	Project	Type of Work	Capacity (MCM)	Irrigable Area (ha)		Construction Year		Irrigation Area (ha)
				Stared	Completed	Stared	Completed	
1	Si Chaliang	I	-	1,920	-	1955	1959	1,920
2	Nong Phak Lung	C	-	2,400	-	1970	1971	2,400
3	Grong Water	P	-	11,424	-	1977	1986	6,758
4	Khlong Hok Bak	I	-	640	-	1974	1974	640
5	Nong Pla Mo	P	-	1,280	-	1959	1962	1,280
6	Ramkhamhaeng Maharat	S	0.38	Domestic	-	1968	1969	-
7	Khlong Khangnai	SI	4.42	560	-	1985	1987	-
8	Khlong Krachong	FC	-	640	-	1976	1977	640
9	Ban Lum	*/	-	-	-	1970	1971	-
10	Khlong Tha-Chanuan	C	-	3,200	-	1975	1972	3,220
Total				22,064				16,838

*/ Protection Work against current

Abbreviation S : Storage of Water C : Conservaiton I : Irrigation P : Pumping
D : Drainage F : Flood Control R : Reclamation H : Hydropower

TABLE E - 2 (3) LARGE AND MEDIUM SCALE WATER RESOURCES DEVELOPMENT PROJECT IN KAMPHAENG PROVINCE

No.	Project	Type of Work	Capacity (MCM)	Irrigable Area (ha)		Construction Year		Irrigation Area (ha)
				Started	Completed	Started	Completed	
1	Tho Thongdaeng	C	-	16,600		1981	1985	
2	Tha Kradan	I	-	2,320		1980	1980	2,320
3	Wang Bua	I	-	3,200		1975	1981	3,200
4	Khlong Wang Sai	I	-	3,200		1983	1984	3,200
5	Klong Wang Yang	I	-	5,040		1974	1977	5,040
6	Khlong Nong Khwan	I	-	1,600		1969	1971	1,600
7	Huai Pabong	SI	1.4	640		1981	1985	640
Total				32,000				16,000

TABLE E - 2 (4) LARGE AND MEDIUM SCALE WATER RESOURCES DEVELOPMENT PROJECT IN TAK PROVINCE

No.	Project	Type of Work	Capacity (MCM)	Irrigable Area (ha)		Construction Year		Irrigation Area (rai)
				Started	Completed	Started	Completed	
1	Mae Ramat	I	-	320		1976	1977	320
2	Mae Charao	I	-	320		1976	1977	320
3	Rom Klao III	S	0.04	Domestic		1983	1983	-
4	Khiri Rat	SI	0.05	320		1981	1981	320
5	Mae Sot	SI	5.46	1,600		1970	1978	1,600
6	Huai Luk	SI	4.20	752		1985	1987	
7	Bhumibol Dam	SIFH	13,462.00	-		1958	1964	-
8	Sam Ngao	P	-	640		1966	1966	640
9	Ping Balley	P	-	6,720		1965	1973	6,720
10	Huai Chalom	I	-	272		1975	1975	272
Total				10,944				10,944

Abbreviation S : Storage of Water C : Conservaiton I : Irrigation P : Pumping
D : Drainage F : Flood Control R : Reclamation H : Hydropower

TABLE E-3 SUMMARY OF SSIP PROJECT

<u>Item</u>	<u>Phitsanulok</u>	<u>Sukhothai</u>	<u>Kamphaeng Phet</u>	<u>Tak</u>
1. Total Number of Project	70	59	82	55
1-1 Canal	5	7	6	4
1-2 Regulator	10	16	62	2
1-3 Weir	22	23	13	35
1-4 Reservoir	33	13	1	14
2. Total Storage Capacity (MCM)	4,658	5,219	12,735	2,210
3. Total Irrigation Area (rai)	120,977	113,710	316,000	80,700
(ha)	19,357	18,194	50,560	12,912

TABLE E - 4(1) PROPOSED IRRIGATION PROJECT IN PHITSANULOK PROVINCE
(First Selection of Possible Reservoir Site from Map)

No.	Project Name	Amphoe Name	Map Name	Coordinates	Catchment			
					Area (sq. km)	Capacity (1,000 cum)	Dam Height (m)	Dam Length (m)
1	Huai Nam Khlung */	Chat Trakan	5143 IV	640275	74	14,800	25	350
2	Huai Sam Ru	Nakhon Thai	5142 I	870779	23	4,000	25	200
3	Huai Kok Yai	Nakhon Thai	5142 I	013677	26	1,200	25	200
4	Huai nam Khu	Nakhon Thai	5142 I	058706	17	1,900	25	250
5	Huai Man Khamun	Nakhon Thai	5143 I	994872	126	-	-	-
6	Khlong Man Poi	Wang Thong	5142 I	912607	94	-	-	-
7	Khlong Hin Fon	Noen Maprang	5142 III	812451	281	-	-	-

*/ Damsite is located Uttaradit Province

TABLE E - 4 (2) PROPOSED IRRIGATION PROJECT IN SUKHOHAI PROVINCE
(First Selection of Possible Reservoir Site from Map)

No.	Project Name	Amphoe Name	Map Name	Coordinates	Catchment		Capacity (1,000 cum)	Dam Height (m)	Dam Length (m)
					Area (sq. km)	Area			
1	Huai Mae Than Noi	Thung Saliam	4843 I	508122	9	1,400	15	350	
2	Huai Nong Kho	Ban Dan Lan Hoi	4843 II	514990	33	8,000	20	1,000	
3	Huai Mae Kong Khai	Ban Dan Lan Hoi	4843 II	373108	25	6,600	25	750	
4	Nam Mae Romphan */	Ban Dan Lan Hoi	4843 II	410036	50	4,200	20	500	
5	Huai Tha Phae	Si Satchanalai	4943 IV	647340	214	-	-	-	
6	Huai Phan Rang	Si Satchanalai	4944 II	878527	27	4,600	20	400	
7	Huai Pok Khu	Si Satchanalai	4944 II	931554	26	4,900	15	250	
8	Huai Phung	Si Satchanalai	4944 II	913512	36	4,600	23	250	
9	Huai Mae Paeng Luang	Si Satchanalai	4944 III	672527	95	-	-	-	
10	Huai Mae San	Si Satchanalai	4944 III	693464	130	-	-	-	
11	Huai Pong Wua	Si Satchanalai	4944 III	701521	12	1,600	15	300	
12	Huai Mae Sung	Si Satchanalai	4944 III	754406	49	3,700	15	400	
13	Huai Mae Sam	Si Satchanalai	4944 II	818477	9	3,100	23	400	
14	Huai Mae Hu	Si Satchanalai	4944 III	790572	51	6,400	21	450	
15	Huai Mam Pang	Si Satchanalai	4944 III	760533	8	2,700	15	550	
16	Huai San	Si Satchanalai	4944 III	761500	8	1,100	13	250	
17	Huai Lam Sok	Si Satchanalai	4943 IV	622307	20	6,500	15	350	
18	Huai Satho	Si Satchanalai	4944 III	670605	39	6,700	25	300	

*/ Damsite is located in Lampang Province

TABLE E - 4 (3) PROPOSED IRRIGATION PROJECT IN KAMPHAENG PHET PROVINCE
(First Selection of Possible Reservoir Site from Map)

No.	Project Name	Amphoe Name	Map Name	Coordinates	Catchment Area (sq. km)	Capacity (1,000 cum)	Dam Height (m)	Dam Length (m)
1	Klong Nam Lai	Muang	4841 II	263908	37	5,200	25	300
2	Khlong Khayaenng	Muang	4841 I	375026	14	1,600	14	900
3	Khlong Suan Mak	Muang	4841 I	278052	241	-	-	-
4	Khlong Mot Daeng	Muang	4841 I	268139	22	8,400	25	850
5	Khlong Phrai	Muang	4841 IV	257224	42	3,900	25	300
6	Khlong Wang Chao	Muang	4842 III	240274	246	-	-	-
7	Khlong Wang Nam Daeng	Phran Kratai	4842 I	476614	21	7,100	9	1,550
8	Khlong Khlung	Khlong Khlong	4841 II	303733	54	4,300	25	400
9	Khlong Samo Khon	Phran Kratai	4842 I	509578	24	6,300	14	700
10	Khlong Pa Bong	Phran Kratai	4942 IV	596564	7	3,300	20	300
11	Lam Dang	Phran Kratai	4842 II	411481	15	2,500	13	500
12	Khlong Huai Khong	Phran Kratai	4942 III	555424	21	8,400	12	1,300

TABLE E - 4 (3) PROPOSED IRRIGATION PROJECT IN TAK PROVINCE
(First Selection of Possible Reservoir Site from Map)

No.	Project Name	Amphoe Name	Map Name	Coordinates	Catchment Area (sq. km)	Capacity (1,000 cum)	Dam Height (m)	Dam Length (m)
1	Lam Pa Foeng	Muang	4842 I	277618	12	5,700	13	700
2	Khlong Sai	Muang	4842 III	150454	38	5,000	14	850
3	Huai Nok Lae	Mae Ramat	4742 IV	525773	9	4,000	17	500
4	Huai Mae Kon Ken	Mae Sot	4742 III	598302	50	4,800	25	350
5	Huai Khwae Luang	Sam Ngao	4843 IV	019212	12	2,600	15	300
6	Huai Song Khwae Tai	Sam Ngao	4843 IV	126155	12	1,700	15	300

TABLE E-5 PROPOSED IRRIGATION PROJECT BY RESERVOIR

No.	Project Name	Amphoe Name	Map No.	Coordinates	Catchment		Dam		Irrigation Area (rai)	Beneficial Backward Village (rai)
					Area (sq. km)	Capacity (1,000 cum)	Height (m)	Length (m)		
Phitsanulok Province										
DP-1	Huai Sam Ru	Nakhon Thai	5142 I	870779	23	4,000	25	200	3,400	030708, 030709, 030711, 030717, 030718, 030610
DP-2	Huai Kok Yai	Nakhon Thai	5142 I	013677	26	1,200	25	200	2,700	030601
DP-3	Huai Nam Khu	Nakhon Thai	5142 I	058406	17	1,900	25	250	2,100	030603
Sukhotai Province										
DS-1	Huai Nong Kho	Ban Dan Lan Hoi	4843 II	514990	33	8,000	20	1,000	5,600	050408, 050406
DS-2	Nam Mae Romphan */	Ban Dan Lan Hoi	4843 II	410036	50	4,200	20	500	5,800	050203, 050208
DS-3	Huai Mam Pang	Si Satchanalai	4944 III	760533	8	2,700	15	550	1,400	060706
Kamphaeng Phet Province										
DK-1	Khlong Samo Khon	Pharan Kratai	4842 I	509578	24	6,300	14	700	4,200	040501, 040506, 040703
DK-2	Khlong Huai Khong	Pharan Kratai	4942 III	555424	21	8,400	12	1,300	4,600	040113, 040116
DK-3	Khlong Khlong	Khlong Khlong	4841 II	303733	54	4,300	25	400	6,200	031106
Tak Province										
DT-1	Khlong Sai	Muang	4842 III	150454	38	5,000	14	850	5,000	010509,
DT-2	Huai Nok Kae	Nae Remat	4742 IV	525733	9	4,000	17	500	1,600	040313, 040102, 040105
DT-3	Huai Mae Kon Ken	Mae Sot	4742 III	598302	50	4,800	25	350	6,000	051101, 051108, 051109

*/ Damsite is located in Lampang Province

TABLE E-6 (1) PROPOSED IRRIGATION PROJECT BY WEIR IN PHITSANULOK PROVINCE

No.	Project Name	Amphoe Name	Map No.	Coordinates	Catchment Area (sq. km)	Irrigation Area (rai)	Scale of Weir	Beneficial Backward Village (rai)
WP-1	Ban Nam Pat	Wang Thong	5142 III	692498	21	1,500	M	090202
WP-2	Ban Khao Din	Wang Thong	5142 III	789320	25	1,800	M	090605, 090604
WP-3	Khlong ban Muang	Wang Thong	5142 III	740317	53	2,000	L	090606, 090507, 090508, 090509
WP-4	Hui Tha Nua	Chat Trakan	5143 IV	621122	17	1,200	S	020111
WP-5	Huai Hoen	Chat Trakan	5143 IV	661088	9	600	S	020109
WP-6	Ban Nong Pai	Wat Bot	5043 II	418929	10	700	S	080609
WP-7	Khlong Huai Hip	Wat Bot	5043 II	497871	23	1,600	M	080509
WP-8	Khlong Tha Kuai	Wat Bot	5043 II	500828	24	1,700	M	080502
WP-9	Khlong Sai Dong Yang	Wang Thong	5141 IV	856188	12	800	S	090705, 090702, 090704
WP-10	Khlong Huai Pong	Wang Thong	5141 IV	825242	8	600	S	090106

TABLE E-6 (2) PROPOSED IRRIGATION PROJECT BY WEIR IN SUKHOHAI PROVINCE

No.	Project Name	Amphoe Name	Map No.	Coordinates	Catchment Area (sq. km)	Irrigation Area (rai)	Scale of Weir	Beneficial Backward Village (rai)
WS-1	Huai Tha Pae	Si Satchanalai	4844 II	512410	34	2,500	M	060306
WS-2	Ban Mae San	Si Satchanalai	4844 II	518503	24	1,700	M	060506
WS-3	Huai Yuak	Si Satchanalai	4944 III	555445	19	1,400	S	060305
WS-4	Ban Mae Khru	Si Satchanalai	4944 II	378523	27	2,000	M	060405, 060408
WS-5	Ban Than Thong	Si Satchanalai	4944 II	951367	11	800	S	061104, 061105
WS-6	Ban Pong Sawing	Si Samrong	4943 III	538053	10	700	S	070407
WS-7	Khlong Nam Tok	Khiri Mat	4942 IV	670578	21	1,500	M	030905, 030906
WS-8	Khlong Lan	Khiri Mat	4942 IV	739551	6	400	S	030404
WS-9	Khlong Lan Taback	Ban Dan Lan Hoi	4843 II	452814	52	3,000	L	050210, 050503

TABLE E-6 (3) PROPOSED IRRIGATION PROJECT BY WEIR IN KAMPHAENG PHET PROVINCE

No.	Project Name	Amphoe Name	Map No.	Coordinates	Catchment Area		Irrigation Area (rai)	Scale of Weir	Beneficial Backward Village	
					(sq. km)	(rai)				(rai)
WK-1	Khlong Wang Pta	Muang	4842 II	480283	21	1,500	M	011401		
WK-2	Khlong Khamin	Phran Kratai	4942 IV	606527	7	500	S	040915		
WK-3	Khlong Bu Cham	Phran Kratai	4942 III	594480	13	900	S	040112		
WK-4	Khlong Wang Chaiang	Phran Kratai	4942 III	770413	32	2,300	M	040315		
WK-5	Khlong Mae Khrua	Muan	4841 I	462229	33	2,400	M	010607		
WK-6	Khlong Khayuk	Khlong Lan	4841 I	320084	7	500	S	060209		
WK-7	Ban Nong Yoay	Muan	4941 I	494057	52	3,000	L	011517, 011504		
WK-8	Khlong Yao	Sai Ngam	4941 I	958160	42	3,000	M	050703, 050705		
WK-9	Khlong Rua	Khlong Khiung	4941 I	959999	13	900	S	031404		
WK-10	Khlong Chum Nok	Khlong Khiung	4941 I	954010	8	600	S	031405		
WK-11	Ban Non Makok	Khlong Khiung	4941 IV	776994	19	1,400	M	030303		
WK-12	Khlong Nan Lai	Khlong Lan	4841 II	388955	15	1,100	S	060105, 060112		
WK-13	Khlong Ta Noi	Khlong Khiung	4841 II	408714	62	3,000	L	031102, 031101		
WK-14	Khlong Na Suan	Khlong Lan	4841 II	325962	56	3,000	L	060110, 060309		
WK-15	Khlong Nam Hae	Khanuworalak Buri	4941 III	605794	22	1,600	M	020212, 020209, 021206		
WK-16	Ban Nong Hin	Khlong Khiung	4941 III	566780	34	2,500	M	031506		
WK-17	Huai Map Sanuan	Khanuworalak Buri	4940 IV	540641	8	600	S	021114, 021109		
WK-18	Ban Roi Painan	Khanuworalak Buri	4940 IV	754627	27	2,000	M	020405, 020404		
WK-19	Khlong Lan	Khlong Lan	4841 II	333831	76	3,000	L	060301		

TABLE E-6 (4) PROPOSED IRRIGATION PROJECT BY WEIR IN TAK PROVINCE

No.	Project Name	Amphoe Name	Map No.	Coordinates	Catchment Irrigation		Scale of Weir	Beneficial Backward Village (rai)
					Area (sq. km)	Area (rai)		
WT-1	Bang Samong	Sam Ngao	4743 I	803212	23	1,700	M	060204
WT-2	Ban Mong Wa	Mae Ramat	4743 III	495836	14	1,000	S	040206, 040503
WT-3	Ban Chok Pok	Ban Tak	4743 II	890872	37	2,700	M	030508, 030406
WT-4	Ban Ma Pon Sap Sip	Sam Ngao	4843 III	150050	17	1,200	S	060606, 060605
WT-5	Ban Nam Dip	Muang	4843 III	227830	31	2,300	M	030707, 030708
WT-6	Ban Pong San	Mae Sot	4742 I	781571	10	700	S	051202
WT-7	Ban Nong Marun Ngam	Muang	4842 IV	265638	16	1,200	S	011503, 001502
WT-8	Lan Huai Krapok	Muang	4842 I	390595	33	2,400	M	011410
WT-9	Ban Chodi Kho	Mae Sot	4742 III	702300	7	500	S	051110
WT-10	Ban So O	Mae Sot	4742 III	697250	53	3,000	L	080302
WT-11	Ban Thung Na Noi	Umphang	4740 I	903482	40	2,900	M	070307, 070302, 070308
WT-12	Ban Be Khi	Umphang	4740 I	927448	24	1,700	M	070306
WT-13	Huai Tawe	Umphang	4740 III	653352	8	600	S	070207
WT-14	Huai Pha Yai	Umphang	4840 III	019269	10	700	S	070404
WT-15	Ban Mae U So	Tha Song Yang	4643 IV	136150	51	3,000	L	020104, 020103 020108, 020105
WT-16	Huai Mu Nok	Tha Song Yang	4544 II	935385	27	2,000	M	020216, 020207
WT-17	Ban Klo Tho	Umphang	4741 III	638430	9	700	S	070201, 070202

TABLE E-7 REFERENCE EVAPOTRANSPIRATION (ETo)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Temperature (C°)	23.9	26.4	28.9	30.6	29.6	28.5	27.9	27.7	27.7	27.5	26.0	24.1
Relative Humidity (%)	66.5	64.4	62.2	62.4	71.6	77.8	79.5	91.3	81.9	79.0	73.7	68.8
Wind Speed (km/h)	1.44	2.24	3.20	3.68	3.20	2.72	2.56	2.40	2.08	1.76	1.60	1.60
Actual Sunshine Hours (h)	8.54	8.96	8.65	9.22	8.23	6.23	5.71	5.16	5.42	7.33	8.36	8.54
ea (Table 5) (mbar)	29.6	34.4	39.9	43.9	41.5	39.0	37.6	37.2	37.2	36.8	33.6	30.0
ed = ea × RH (mbar)	19.7	22.2	24.8	27.4	29.7	30.3	29.9	30.2	30.5	29.1	24.8	20.6
f (u) = 0.27 (1 + v/100)	0.36	0.42	0.48	0.51	0.48	0.45	0.44	0.43	0.40	0.38	0.37	0.37
w (Table 9)	0.73	0.75	0.77	0.79	0.78	0.77	0.77	0.77	0.77	0.77	0.75	0.73
Ra (Table 10) (mm/day)	11.8	13.1	14.7	15.6	16.0	16.0	16.0	15.7	15.0	13.8	12.2	11.4
N (Table 11) (h)	11.2	11.6	12.0	12.5	12.9	13.1	13.0	12.9	12.2	11.8	11.3	11.1
Rns = (1 - d) (0.25 + 0.50 n/N) Ra	5.60	6.25	6.73	7.24	6.83	5.85	5.64	5.30	5.31	5.80	5.67	5.43
f (T) (Table 13)	15.4	16.1	16.5	16.9	16.6	16.4	16.3	16.3	16.3	16.2	15.9	15.4
f (ed) (Table 14)	0.14	0.13	0.12	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.14
f (n/N) (Table 15)	0.79	0.79	0.75	0.76	0.67	0.53	0.50	0.46	0.50	0.66	0.77	0.79
Rnl = f(T) (ed) (n/N)	1.70	1.65	1.49	1.41	1.11	0.85	0.82	0.75	0.82	1.07	1.47	1.70
Rn = Rns - Rnl	3.90	4.60	5.24	5.83	5.72	5.00	4.82	4.55	4.49	4.73	4.20	3.73
ETo (mm/day)	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7
ETo (mm/month)	117.8	131.6	176.7	192.0	176.7	141.0	139.5	130.2	123.0	133.3	120.0	114.7

$$ETo = c [W Rn + (1 - w) f(u) (ea - ed)] \quad Rn = Rns - Rnl \quad Rns = (1 - a) (0.25 + 0.50 n/N) Ra \quad Rnl = f(T) f(ed) f(n/N)$$

TABLE E - 8 PROBABLE MONTHLY RAINFALL

unit : mm

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Phitsanulok													
Average	48.5	184.5	184.3	195.6	250.3	260.7	138.5	30.5	4.5	6.6	11.9	31.4	1,347.3
1/10 Dry Year	38.8	147.8	147.6	156.6	200.5	208.9	110.9	24.4	3.6	5.3	9.5	25.1	1,079.0
1/10 Wet Year	59.9	227.7	227.5	241.4	309.0	321.7	171.0	37.6	5.6	8.1	14.7	38.8	1,663.0
Sukhothai													
Average	41.5	152.3	151.6	133.1	173.9	258.8	143.1	27.2	1.6	6.4	8.1	18.5	1,116.1
1/10 Dry Year	30.3	111.3	110.8	97.3	127.2	189.3	104.6	19.9	1.2	4.7	5.9	13.5	816.0
1/10 Wet Year	54.5	199.9	199.0	174.7	228.3	339.8	187.8	35.7	2.1	8.4	10.6	24.2	1,465.0
Kamphaeng Phet													
Average	44.9	148.3	138.1	122.8	164.0	245.9	164.9	25.9	2.2	3.8	15.7	18.1	1,094.6
1/10 Dry Year	31.8	105.1	97.9	87.0	116.3	174.4	116.9	18.4	1.6	2.7	11.1	12.8	776.0
1/10 Wet Year	64.6	216.4	198.7	176.7	236.0	353.7	237.3	37.3	3.2	5.8	22.6	26.0	1,575.0
Tak													
Average	41.6	159.0	108.2	94.8	111.4	232.1	179.5	56.7	5.1	6.0	5.6	19.7	1,019.7
1/10 Dry Year	33.5	128.0	87.1	76.3	89.7	186.9	144.5	45.7	4.1	4.8	4.5	15.9	821.0
1/10 Wet Year	53.6	204.7	139.3	122.1	143.4	298.9	231.1	73.0	6.6	7.7	7.2	28.4	1,313.0

TABLE E - 9 (1) FIELD WATER REQUIREMENT (RICE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ET _o	3.8	4.7	5.8	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
(mm/day)													
Number of Days							11	31	30	18			
Crop Factor							1.1	1.11	1.16	0.95			
ET crop, Percolation, L.P							276	207	203	110			796
(mm)													
Nursery						5	11						60
Huai Sam Ru	5	10	25	39	148	148	157	201	209	111	24	4	1,081
1/10 Dry Rainfall													
F.W.R.						5	196	90	82	27			400
1/10 Wet Rainfall	8	15	39	60	228	228	241	309	322	171	38	6	1,665
F.W.R.						5	147	28	16	11			207
Huai Nong Kho	5	6	14	30	111	111	97	127	189	105	20	1	816
1/10 Dry Rainfall													
F.W.R.						5	206	122	93	31			457
1/10 Wet Rainfall	8	11	24	55	200	199	175	228	340	188	36	2	1,466
F.W.R.						5	186	77	6	1			275
Khlong Samo Khon	3	11	13	32	105	98	87	116	174	117	18	2	776
1/10 Dry Rainfall													
F.W.R.						5	215	120	102	22			464
1/10 Wet Rainfall	6	23	26	65	213	199	177	236	354	237	37	3	1,576
F.W.R.						5	184	70	0	0			259
Khlong Sai	5	5	16	34	128	87	76	90	187	145	46	4	823
1/10 Dry Rainfall													
F.W.R.						5	224	132	95	13			469
1/10 Wet Rainfall	8	7	25	54	205	139	122	143	299	231	73	7	1,313
F.W.R.						5	196	111	30	0			342

TABLE E - 9 (2) FIELD WATER REQUIREMENT (SOYBEAN)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ET _o	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
(mm/day)													
Number of Days	31	28	21										
Crop Factor	0.6	1.05	0.7										
ET crop, Percolation, L.P	71	138	84										293
(mm)													
Pre - Irrigation													60
(mm)													
Huai Sam Ru	5	10	25	39	148	148	157	201	209	111	24	4	1,081
1/10 Dry Rainfall													
F.W.R.	68	130	67										325
1/10 Wet Rainfall	8	15	39	60	228	228	241	309	322	171	38	6	1,665
F.W.R.	65	126	58										309
1/10 Dry Rainfall	5	6	14	30	111	111	97	127	189	105	20	1	816
F.W.R.	68	133	75										336
1/10 Wet Rainfall	8	11	24	55	200	199	175	228	340	188	36	2	1,466
F.W.R.	65	130	68										323
1/10 Dry Rainfall	3	11	13	32	105	98	87	116	174	117	18	2	776
F.W.R.	69	130	75										334
1/10 Wet Rainfall	6	23	26	65	213	199	177	236	354	237	37	3	1,576
F.W.R.	67	120	67										314
1/10 Dry Rainfall	5	5	16	34	128	87	76	90	187	145	46	4	823
F.W.R.	68	134	73										335
1/10 Wet Rainfall	8	7	25	54	205	139	122	143	299	231	73	7	1,313
F.W.R.	65	133	67										325

TABLE E - 9 (3) FIELD WATER REQUIREMENT (MAIZE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ETo	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
(mm/day)													
Number of Days					20	30	31	9					
Crop Factor			0.35		1.15	0.6	0.6	0.6					
ET crop, Percolation, L.P			40		162	84	23						309
(mm)													
Pre - Irrigation													
(mm)													
Huai Sam Ru	5	10	25	39	148	148	157	201	209	111	24	4	1,081
1/10 Dry Rainfall													
F.W.R.					0	40	0	0					40
1/10 Wet Rainfall	8	15	39	60	228	228	241	309	322	171	38	6	1,665
F.W.R.					0	13	0	0					13
Huai Nong Kho	5	6	14	30	111	111	97	127	189	105	20	1	816
1/10 Dry Rainfall													
F.W.R.					0	78	21	0					99
1/10 Wet Rainfall	8	11	24	55	200	199	175	228	340	188	36	2	1,466
F.W.R.					0	26	0	0					26
Khlong Samo Khon	3	11	13	32	105	98	87	116	174	117	18	2	776
1/10 Dry Rainfall													
F.W.R.					0	87	26	0					113
1/10 Wet Rainfall	6	23	26	65	213	199	177	236	354	237	37	3	1,576
F.W.R.					0	26	0	0					26
Khlong Sai	5	5	46	34	128	87	76	90	187	145	46	4	823
1/10 Dry Rainfall													
F.W.R.					0	95	33	4					132
1/10 Wet Rainfall	8	7	25	54	205	139	122	143	299	231	73	7	1,313
F.W.R.					60	18	0						68

TABLE E - 9 (4) FIELD WATER REQUIREMENT (GROUNDNUT)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ET _o	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
Number of Days													
Crop Factor									0.3	1.0	0.69	0.55	
ET crop, Percolation, L.P									37	133	83	39	292
Pre - Irrigation													
Huai Sam Ru	5	10	25	39	148	148	157	201	209	111	24	4	1,081
1/10 Dry Rainfall									0	53	66	37	156
F.W.R.									322	171	38	6	1,665
Huai Nong Kho	5	6	14	30	111	111	97	127	189	105	20	1	816
1/10 Dry Rainfall									0	57	69	39	165
F.W.R.									340	188	36	2	1,466
Khlong Samo Khon	3	11	13	32	105	98	87	116	174	117	18	2	776
1/10 Dry Rainfall									0	49	70	38	157
F.W.R.									354	237	37	3	1,576
Khlong Sai	5	5	46	34	128	87	76	90	187	145	46	4	823
1/10 Dry Rainfall									0	32	51	37	120
F.W.R.									299	231	73	7	1,313
1/10 Wet Rainfall									0	0	34	36	70
F.W.R.													

TABLE E - 9 (5) FIELD WATER REQUIREMENT (VEGETABLE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ETo (mm/day)	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
Number of Days	31	28			20	30	30					21	
Crop Factor	0.99	0.6			0.4	1.0	0.6					0.43	
ET crop, Percolation, L.P (mm)	117	79			46	141	81					33	497
Pre - Irrigation (mm)												60	60
Huai Sam Ru 1/10 Dry Rainfall	5	10	25	39	148	148	157	201	209	111	24	4	1,081
F.W.R.	114	73			0	38	0					91	316
1/10 Wet Rainfall	8	15	39	60	228	228	241	309	322	171	38	6	1,665
F.W.R.	112	69			0	0	0					91	272
Huai Nong Kho 1/10 Dry Rainfall	5	6	14	30	111	111	97	127	189	105	20	1	816
F.W.R.	114	75			0	60	18					93	360
1/10 Wet Rainfall	8	11	24	55	200	199	175	228	340	188	36	2	1,466
F.W.R.	112	72			0	11	0					92	287
Khlong Samo Khon 1/10 Dry Rainfall	3	11	13	32	105	98	87	116	174	117	18	2	776
F.W.R.	115	72			0	69	24					92	372
1/10 Wet Rainfall	6	23	26	65	213	199	177	236	354	237	37	3	1,576
F.W.R.	113	64			0	11	0					92	280
Khlong Sai 1/10 Dry Rainfall	5	5	16	34	128	87	76	90	187	145	46	4	823
F.W.R.	114	76			0	76	30					91	387
1/10 Wet Rainfall	8	7	25	54	205	139	122	143	299	231	73	7	1,313
F.W.R.	112	75			0	43	5					90	325

TABLE E - 9 (6) FIELD WATER REQUIREMENT (PASTURE, SUGERCANE)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ETo	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
Number of Days	31	28	31	30	31	30	31	31	30	31	30	31	-
Crop Factor	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	-
ET crop, Percolation, L.P	82	92	92	124	134	99	98	91	86	93	84	80	1,187
Pre - Irrigation													
Huai Sam Ru	5	10	25	39	148	148	157	201	209	111	24	4	1,081
1/10 Dry Rainfall													
F.W.R.	78	85	106	105	23	5	0	0	0	20	67	77	566
1/10 Wet Rainfall	8	15	39	60	228	228	241	309	322	171	38	6	1,665
F.W.R.	76	81	95	89	0	0	0	0	0	0	56	76	473
1/10 Dry Rainfall	5	6	14	30	111	111	97	127	189	105	20	1	816
F.W.R.	78	88	114	111	45	26	32	10	0	24	69	79	676
1/10 Wet Rainfall	8	11	24	55	200	199	175	228	340	188	36	2	1,466
F.W.R.	76	84	106	94	0	0	0	0	0	0	59	79	198
Khlong Samo Khon	3	11	13	32	105	98	87	116	174	117	18	2	776
1/10 Dry Rainfall													
F.W.R.	80	84	115	110	49	33	39	15	0	17	71	79	692
1/10 Wet Rainfall	6	23	26	65	213	199	177	236	354	237	37	3	1,576
F.W.R.	78	75	105	85	0	0	0	0	0	0	57	78	478
1/10 Dry Rainfall	5	5	46	34	128	87	76	90	187	145	46	4	823
F.W.R.	78	88	112	109	35	39	45	31	0	0	51	77	665
1/10 Wet Rainfall	8	7	25	54	205	139	122	143	299	231	73	7	1,313
F.W.R.	76	87	106	93	0	10	19	1	0	0	34	75	501

TABLE E - 9(7) FIELD WATER REQUIREMENT (TREE CROP)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ETo (mm/day)	3.8	4.7	5.7	6.4	5.7	4.7	4.5	4.2	4.1	4.3	4.0	3.7	-
Number of Days	31	28	31	30	31	30	31	31	30	31	30	31	
Crop Factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
ET crop, Percolation, L.P (mm)	94	105	141	154	141	113	112	104	98	107	96	92	1,357
Pre-Irrigation (mm)													
Huai Sam Ru 1/10 Dry Rainfall	5	10	25	39	148	148	157	201	209	111	24	4	1,081
F.W.R.	90	98	123	124	38	15	10	0	0	31	79	89	697
1/10 Wet Rainfall	8	15	39	60	228	228	241	309	322	171	38	6	1,665
F.W.R.	88	94	113	107	0	0	0	0	0	0	68	88	558
Huai Nong Kho 1/10 Dry Rainfall	5	6	14	30	111	111	97	127	189	105	20	1	816
F.W.R.	90	101	131	131	60	36	44	20	0	35	82	91	821
1/10 Wet Rainfall	8	11	24	55	200	199	175	228	340	188	36	2	1,466
F.W.R.	88	97	123	111	10	0	0	0	0	0	70	91	590
Khlong Samo Khon 1/10 Dry Rainfall	3	11	13	32	105	98	87	116	174	117	18	2	776
F.W.R.	92	97	132	129	64	45	50	26	0	28	83	91	837
1/10 Wet Rainfall	6	23	26	65	213	199	177	236	354	237	37	3	1,576
F.W.R.	90	88	122	104	4	0	0	0	0	0	69	90	567
Khlong Sai 1/10 Dry Rainfall	5	5	46	34	128	87	76	90	187	145	46	4	823
F.W.R.	90	101	129	130	48	51	58	41	0	13	62	89	812
1/10 Wet Rainfall	8	7	25	54	205	139	122	143	299	231	73	7	1,313
F.W.R.	88	100	123	111	8	20	29	11	0	0	45	87	622

TABLE E-10 (1) DIVERSION WATER REQUIREMENT OF HUAI SAM RU

Irrigation Efficiency : 0.58

Month	Filed Irrigation Requirement							Diversion Requirement (1,000 m ²)
	Dice (187 ha) (mm)	Soybean (213 ha) (mm)	Maize (400 ha) (mm)	Groundnut (130 ha) (mm)	Vegetable (10 ha) (mm)	Pasture (107 ha) (mm)	Tree (188 ha) (mm)	
Jan	-	68	-	-	114	78	90	707
Feb	-	130	-	-	73	85	98	964
Mar	-	67	-	-	-	106	123	840
Apr	-	-	-	-	-	105	124	596
May	-	-	0	-	0	23	38	166
Jun	5	-	40	-	38	5	15	356
Jul	196	-	0	-	0	0	10	664
Aug	90	-	0	-	-	0	0	290
Sep	82	-	-	0	-	0	0	264
Oct	27	-	-	53	-	20	31	343
Nov	-	-	-	66	-	67	79	528
Dec	-	60	-	37	91	77	89	750
.....								
Jan	-	65	-	-	112	76	88	683
Feb	-	126	-	-	69	81	94	929
Mar	-	58	-	-	-	95	113	755
Apr	-	-	-	-	-	89	107	349
May	-	-	0	-	0	0	0	0
Jun	5	-	13	-	0	0	0	106
Jul	147	-	0	-	0	0	0	474
Aug	28	-	0	-	-	0	0	90
Sep	16	-	-	0	-	0	0	52
Oct	11	-	-	18	-	0	0	76
Nov	-	-	-	56	-	56	68	449
Dec	-	60	-	37	91	76	88	744
.....								
Total	607	634	53	267	588	1,039	1,255	11,175

TABLE E - 10 (2) DIVERSION WATER REQUIREMENT OF HUAI NONG KHO

Irrigation Efficiency : 0.58

Month	Filed Irrigation Requirement							Diversion Requirement (1,000 m ³)
	Dice (355 ha) (mm)	Soybean (108 ha) (mm)	Maize (37 ha) (mm)	Groundnut (- ha) (mm)	Vegetable (8 ha) (mm)	Pasture (74 ha) (mm)	Tree (100 ha) (mm)	
Jan	-	68	-	-	114	78	90	397
Feb	-	133	-	-	75	88	101	544
Mar	-	75	-	-	-	114	131	511
Apr	-	-	-	-	-	111	131	367
May	-	-	0	-	0	45	60	161
Jun	5	-	78	-	60	26	36	184
Jul	206	-	21	-	18	32	44	1,393
Aug	122	-	0	-	-	10	20	794
Sep	93	-	-	-	-	0	0	569
Oct	31	-	-	-	-	24	35	281
Nov	-	-	-	-	-	69	82	229
Dec	-	60	-	-	93	79	91	382
.....								
Jan	-	65	-	-	112	76	88	385
Feb	-	130	-	-	72	84	97	526
Mar	-	68	-	-	-	106	123	474
Apr	-	-	-	-	-	94	111	311
May	-	-	0	-	0	0	10	17
Jun	5	-	26	-	0	0	0	49
Jul	186	-	0	-	0	0	0	1,138
Aug	77	-	0	-	-	0	0	471
Sep	6	-	-	-	-	0	0	37
Oct	1	-	-	-	-	0	70	6
Nov	-	-	-	-	-	59	91	121
Dec	-	60	125	-	92	79	1,411	382
.....								
Total	732	659			647	1,174	1,411	9,729

TABLE E-10(3) DIVERSION WATER REQUIREMENT OF KHLONG SAMO KOHN

Irrigation Efficiency : 0.58

Month	Filed Irrigation Requirement							Diversion Requirement (1,000 m ²)
	Dice (131 ha) (mm)	Soybean (37 ha) (mm)	Maize (- ha) (mm)	Groundnut (- ha) (mm)	Vegetable (8 ha) (mm)	Pasture (18 ha) (mm)	Tree (22 ha) (mm)	
Jan	-	69			115	80	92	120
Feb	-	130			72	84	97	156
Mar	-	75			-	115	132	134
Apr	-	-			-	110	129	83
May	-	-			0	49	64	39
Jun	5	-			69	33	45	48
Jul	215	-			24	39	50	520
Aug	120	-			-	15	26	286
Sep	102	-			-	0	0	230
Oct	22	-			-	17	28	66
Nov	-	-			-	71	83	54
Dec	-	60			92	79	91	110

Jan	-	67			113	78	90	117
Feb	-	120			64	75	88	142
Mar	-	67			-	105	122	122
Apr	-	-			-	85	104	66
May	-	-			0	0	4	2
Jun	5	-			11	0	0	13
Jul	184	-			0	0	0	416
Aug	70	-			-	0	0	158
Sep	0	-			-	0	0	0
Oct	0	-			-	0	0	0
Nov	-	-			-	57	69	44
Dec	-	60			92	78	90	109

Total	723	648			652	1,170	1,404	3,035

TABLE E - 10 (4) DIVERSION WATER REQUIREMENT OF KHLONG SAI

Irrigation Efficiency : 0.58

Month	Filed Irrigation Requirement							Diversion Requirement (1,000 m ²)
	Dice (103 ha) (mm)	Soybean (40 ha) (mm)	Maize (80 ha) (mm)	Groundnut (- ha) (mm)	Vegetable (7 ha) (mm)	Pasture (56 ha) (mm)	Tree (144 ha) (mm)	
Jan	-	68	-	-	114	78	90	359
Feb	-	134	-	-	76	88	101	437
Mar	-	73	-	-	-	112	129	479
Apr	-	-	-	-	-	109	130	428
May	-	-	0	-	0	35	48	153
Jun	5	-	95	-	76	39	51	304
Jul	224	-	33	-	30	45	58	634
Aug	132	-	4	-	-	31	41	372
Sep	95	-	-	-	-	0	0	169
Oct	13	-	-	-	-	0	13	55
Nov	-	-	-	-	-	51	62	203
Dec	-	60	-	-	91	77	89	348
.....								
Jan	-	65	-	-	112	76	88	350
Feb	-	133	-	-	75	87	100	433
Mar	-	67	-	-	-	106	123	454
Apr	-	-	-	-	-	93	111	365
May	-	-	0	-	0	0	8	20
Jun	5	-	60	-	43	10	20	156
Jul	196	-	8	-	5	19	29	450
Aug	111	-	0	-	-	1	11	225
Sep	30	-	-	-	-	0	0	53
Oct	0	-	-	-	-	0	0	0
Nov	-	-	-	-	-	34	45	145
Dec	-	60	-	-	90	75	87	341
.....								
Total	811	660	200	-	325	1,166	1,434	6,933

E-4 WATER OPERATION

E-4-1 Stage Capacity Relation of Reservoir

The stage capacity curves of the proposed reservoirs have been established based on the topographical maps with scale of 1/5,000 which have been made to order with the survey company by the Study Team after the selection of the model project areas in the Phase I Study. The relations of water stage-water surface area-storage capacity are shown in Table E-11 and the relation curves are illustrated in Figure E-1.

Alternative Damsite of Khlong Samo Khon

The approximate location of the damsite has been selected by the reconnaissance survey with the RTSD topographical map with scale of 1/50,000. However, the detailed survey with the newly prepared topographical map with scale of 1/5,000 reveals several vital disadvantages of the original selection of the damsite as follows :

- (a) A fairly large area of paddy field (approx. 80 ha, 500 rai) would be submerged under the reservoir water.
- (b) A part of the ARD road would also be submerged and about 2 km of road must be relocated.
- (c) Several houses need to be relocated.

The original selection of damsite is abandoned mainly because of the reason (a) and partly because of reason (b).

In order to avoid these disadvantages, the alternative damsite is proposed at about 2 km upstream of the originally propose damsite, although the catchment are becomes smaller, the storage capacity is also smaller and the dam length is much longer than the original damsite in engineering aspect. There is no viable alternative damsite in this area. The further study will be made on this newly proposed damsite.

E-4-2 Dead Storage Capacity

For estimation of the dead storage capacity. It has taken into account of the sediment storage of 100 years with the unit sediment yield of 150 m³/km²/year.

E-4-3 Reservoir Losses

Due to creation of reservoir after completion of dam, runoff characteristic will be changed considerably. When the area is submerged under the stored water, all the rainfall will convert directly into runoff to the reservoir. Whereas, if the area is dried up owing to release of water from the reservoir, the runoff characteristic will be similar to that of bare land in the catchment area. Accordingly the runoff will increase due to creation of reservoir. However, the reservoir area is counted as ordinary catchment area for the estimate of the runoff.

Evaporation loss from the water surface and deep percolation loss through reservoir bed will increase significantly once the reservoir is created. These two losses shall be taken into account in the reservoir operation study.

(a) Evaporation Loss

Evaporation from large open water surface is estimated at 70 percent of the crop reference evapotranspiration (E_{to}) by the modified Penman method.

(b) Percolation loss

Percolation loss is assumed at 0.5 mm/day from the submerge area irrespective of the water depth.

(c) Total Loss

Total reservoir losses are given on monthly basis as follows.

	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Annual</u>
Total Loss	98	106	139	149	139	114	113	107	101	99	96	1,370

unit: mm

E-4-4 Water Balance Simulation

The reservoir water balance simulation study has been carried out on monthly basis for the 1/10 probability dry year and the consecutive 1/10 probability wet year to determine the optimum size of the proposed reservoirs and the related irrigable areas, taking into consideration of the synthesized river inflow to reservoir and the down stream water requirement of irrigable area inclusive of and reservoir water losses. As an initial condition, the storage is set at full capacity in November in due consideration of inflow and requirement patterns. The probable runoff is shown in Table E-12.

The optimum size of the reservoir and related irrigable area have been so determined that the storage in the reservoir decreases to almost empty during the first 1/10 dry year and consecutive dry season of next 1/10 wet year and the storage recovers to the full at the end of October in the 1/10 wet year.

The summary of the water operation study is shown below and the details are shown in Table E-13 and Figure E-2.

<u>Project Name</u>	<u>Effective Storage</u> (MCM)	<u>Irrigable Area</u> (ha)	<u>Inflow</u> (MCM)	<u>Water Requirement</u> (MCM)	<u>Reservoir Loss</u> (MCM)	<u>Spill</u> (MCM)
Huai Sma Ru	3.98	1,022	11.56	5.59	0.61	5.36
Huai Nong Kho	6.79	574	6.08	4.87	1.30	-
Khlong Samo Khon	2.40	179	2.30	1.52	0.79	-
Khlong Sai	2.14	390	20.96	3.47	1.22	16.27

The storage capacity and dam height of Huai Sam Ru and Khong Sai are limited by the topographical conditions rather than the inflow to the reservoirs and have to be decided based on the maximum allowance of the topographic conditions.

TABLE E-11 (1) STAGE CAPACITY OF HUAI SAM RU

<u>Water Stage Elevation</u>	<u>Water Surface Area</u>	<u>Storage Volume</u>	<u>Cumulative Capacity</u>
(m)	(1,000 m ²)	(1,000 m ³)	(1,000 m ³)
290	0	0	0
292	7	7	7
294	46	53	60
296	79	125	185
298	127	206	391
300	207	334	725
302	287	494	1,219
304	379	666	1,885
306	474	853	2,738
308	598	1,072	3,810
310	754	1,352	5,162
312	896	1,650	6,812
314	1,017	1,913	8,725

TABLE E-11 (2) STAGE CAPACITY OF HUAI NONG KHO

<u>Water Stage Elevation</u>	<u>Water Surface Area</u>	<u>Storage Volume</u>	<u>Cumulative Capacity</u>
(m)	(1,000 m ²)	(1,000 m ³)	(1,000 m ³)
124.8	0		
125	1	0.5	1
126	11	6	7
127	27	19	26
128	68	47.5	73
129	128	98	171
130	191	159.5	331
131	282	236.5	567
132	420	351	918
133	561	490.5	1,409
134	756	658.5	2,067
135	952	854	2,921
136	1,211	1,081.5	4,003
137	1,432	1,321.5	5,324
138	1,673	1,552.5	6,877
139	1,899	1,786	8,663
140	2,167	2,033	10,696

TABLE E-11 (3) STAGE CAPACITY OF KHLONG SAMO KHON

<u>Water Stage Elevation</u>	<u>Water Surface Area</u>	<u>Storage Volume</u>	<u>Cumulative Capacity</u>
(m)	(1,000 m ²)	(1,000 m ³)	(1,000 m ³)
133	0	0	0
134	26	13	13
135	80	53	66
136	150	115	181
137	287	219	400
138	515	401	801
139	791	653	1,453
140	1,076	932	2,386
141	1,404	1,239	3,625
142	1,780	1,592	5,217

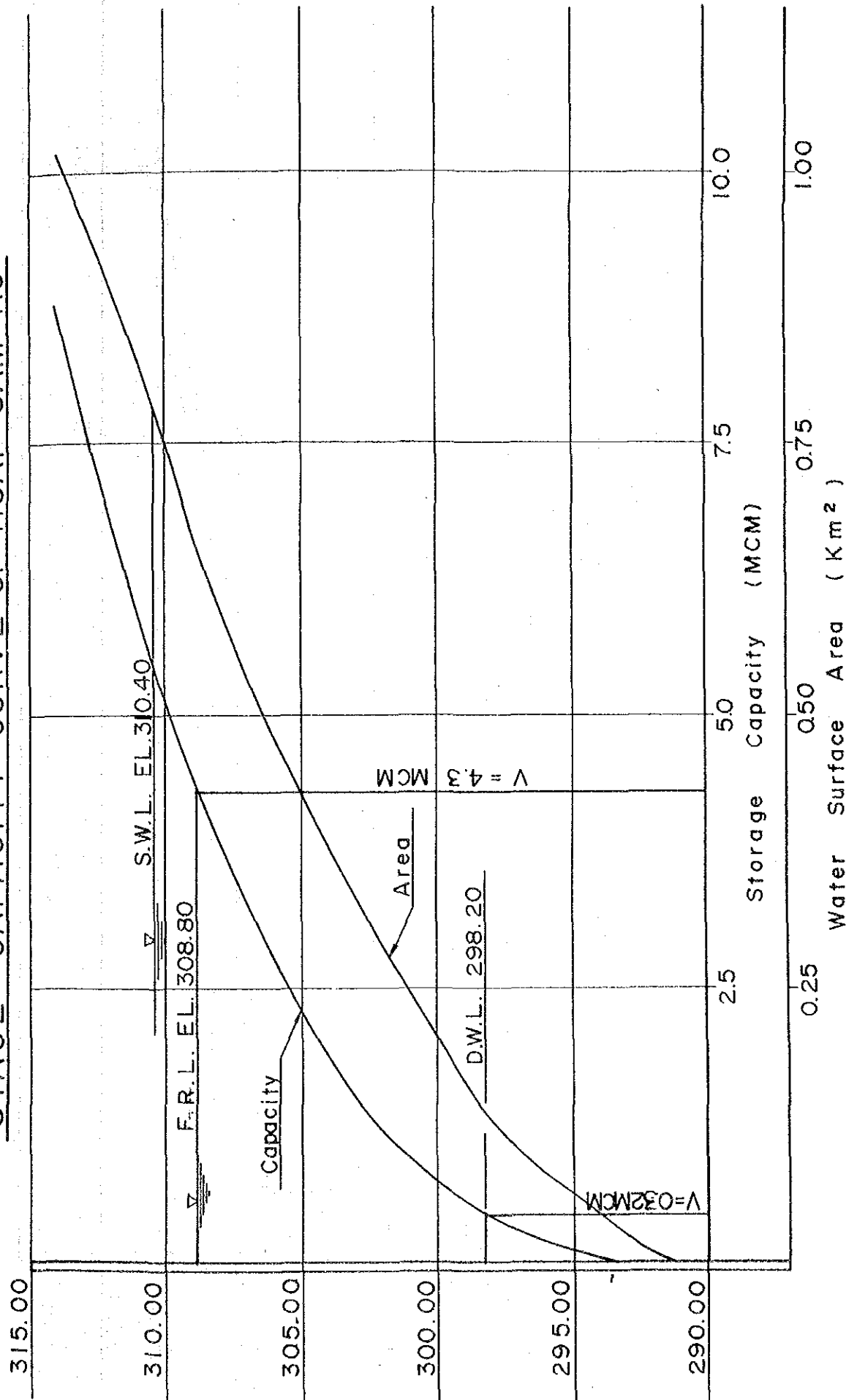
TABLE E-11 (4) STAGE CAPACITY OF KHLONG SAI

<u>Water Stage Elevation</u>	<u>Water Surface Area</u>	<u>Storage Volume</u>	<u>Cumulative Capacity</u>
(m)	(1,000 m ²)	(1,000 m ³)	(1,000 m ³)
162	0	0	0
163	28	14	14
164	92	60	74
165	161	127	201
166	265	213	414
167	436	351	765
168	645	541	1,306
169	855	750	2,056
170	1,135	995	3,051
171	1,409	1,272	4,323

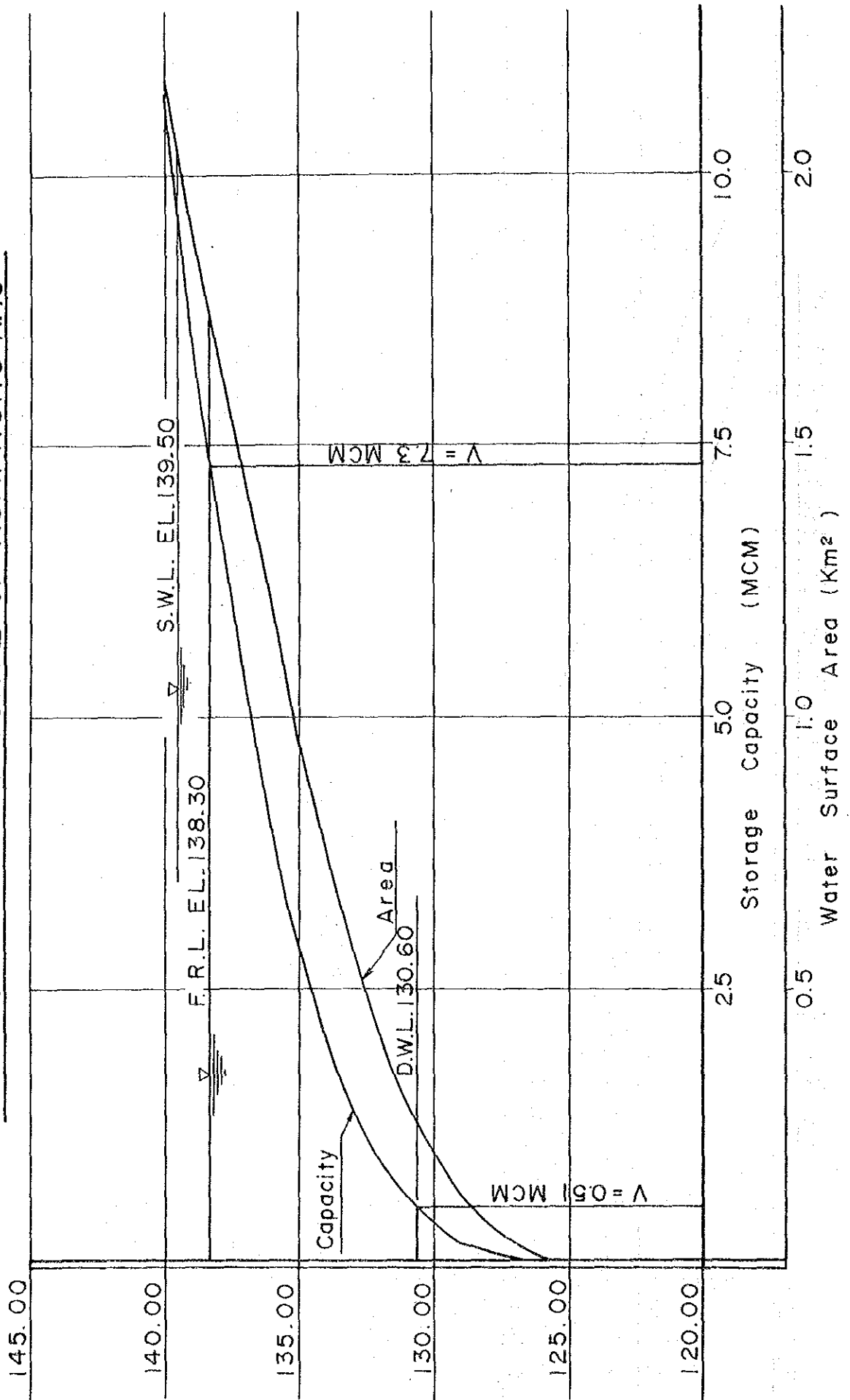
TABLE E-12 PROBABLE MONTHLY RUNOFF

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Huai Sam Ru CA = 28 km ² (Station N-36 Khue Noi)													
Average (1/sec/km ²)	1.97	4.43	9.60	19.20	33.50	42.61	23.02	7.94	3.87	2.73	2.20	1.77	12.37
Average (MCM)	0.15	0.33	0.70	1.21	2.51	3.09	1.73	0.58	0.29	0.20	0.15	0.13	11.07
1/10 Dry Year (MCM)	0.09	0.20	0.43	0.75	1.56	1.92	1.07	0.36	0.18	0.12	0.09	0.08	6.85
1/10 Wet Year (MCM)	0.22	0.49	1.03	1.78	3.69	4.54	2.54	0.85	0.43	0.29	0.22	0.19	16.27
Huai Nong kHo CA = 34 km ² (Station Y-26 Nam Mae Mok)													
Average (1/sec/km ²)	0.02	3.22	7.75	2.62	3.86	14.59	19.20	5.02	0.93	0.31	0.13	0.01	4.81
Average (MCM)	0.00	0.29	0.68	0.24	0.35	1.29	1.75	0.44	0.08	0.03	0.01	0.00	5.16
1/10 Dry Year (MCM)	0.00	0.13	0.31	0.11	0.16	0.58	0.79	0.20	0.04	0.01	0.00	0.00	2.33
1/10 Wet Year (MCM)	0.00	0.55	1.29	0.46	0.67	2.45	3.33	0.84	0.15	0.06	0.02	0.00	9.82
Khlong Samo Khon CA = 13 km ² (Station Y-26 Nam Mae Mok)													
Average (1/sec/km ²)	0.02	3.22	7.75	2.62	3.86	14.59	19.20	5.02	0.93	0.31	0.13	0.01	4.81
Average (MCM)	0.00	0.11	0.26	0.09	0.13	0.49	0.67	0.17	0.03	0.01	0.00	0.00	1.96
1/10 Dry Year (MCM)	0.00	0.05	0.12	0.04	0.06	0.22	0.30	0.08	0.01	0.00	0.00	0.00	0.88
1/10 Wet Year (MCM)	0.00	0.21	0.49	0.17	0.25	0.93	1.27	0.32	0.06	0.02	0.00	0.00	3.72
Khlong Sai CA = 47 km ² (Station P-26a Khlong Suan Mak)													
Average (1/sec/km ²)	1.17	4.42	8.53	9.29	11.23	33.54	47.81	25.71	6.23	2.54	1.18	0.87	13.04
Average (MCM)	0.14	0.62	1.04	1.17	1.41	4.09	6.02	3.13	0.78	0.32	0.13	0.11	18.96
1/10 Dry Year (MCM)	0.06	0.27	0.46	0.51	0.62	1.80	2.65	1.38	0.34	0.14	0.06	0.05	8.34
1/10 Wet Year (MCM)	0.25	1.10	1.84	2.07	2.50	7.24	10.66	5.54	1.38	0.57	0.23	0.19	33.57

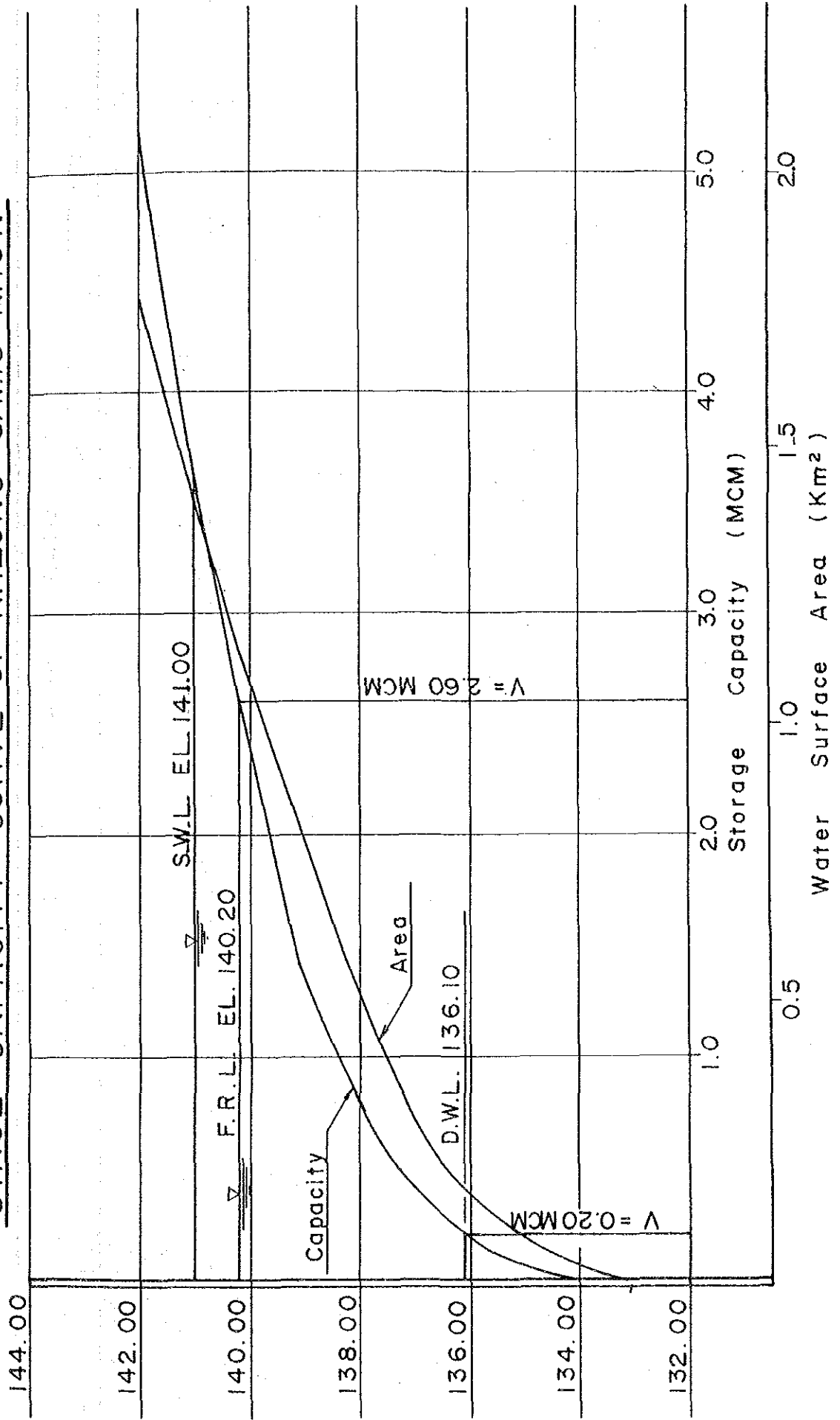
STAGE CAPACITY CURVE OF HUAI SAM RU



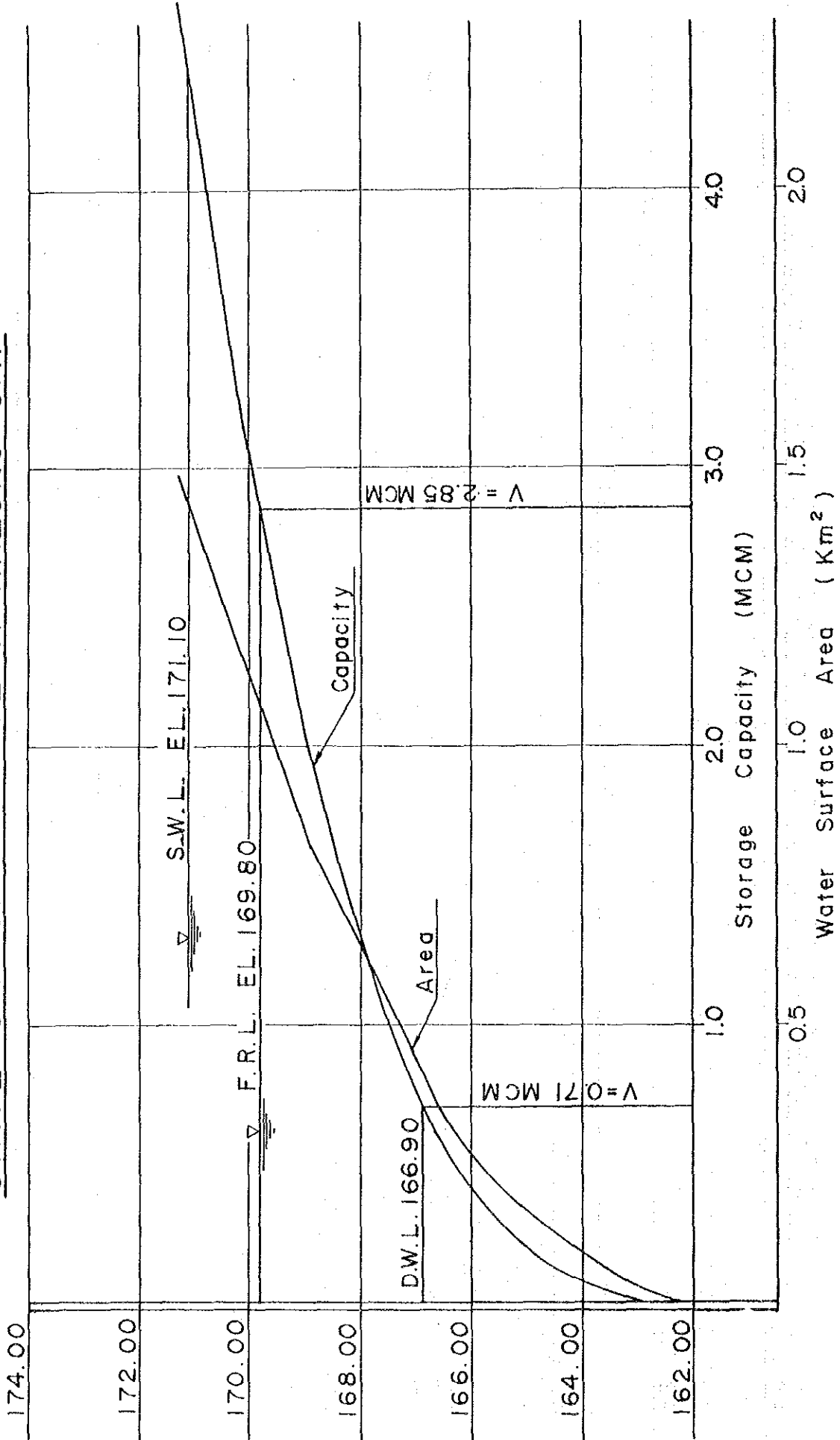
STAGE CAPACITY CURVE OF HUAI NONG KHO



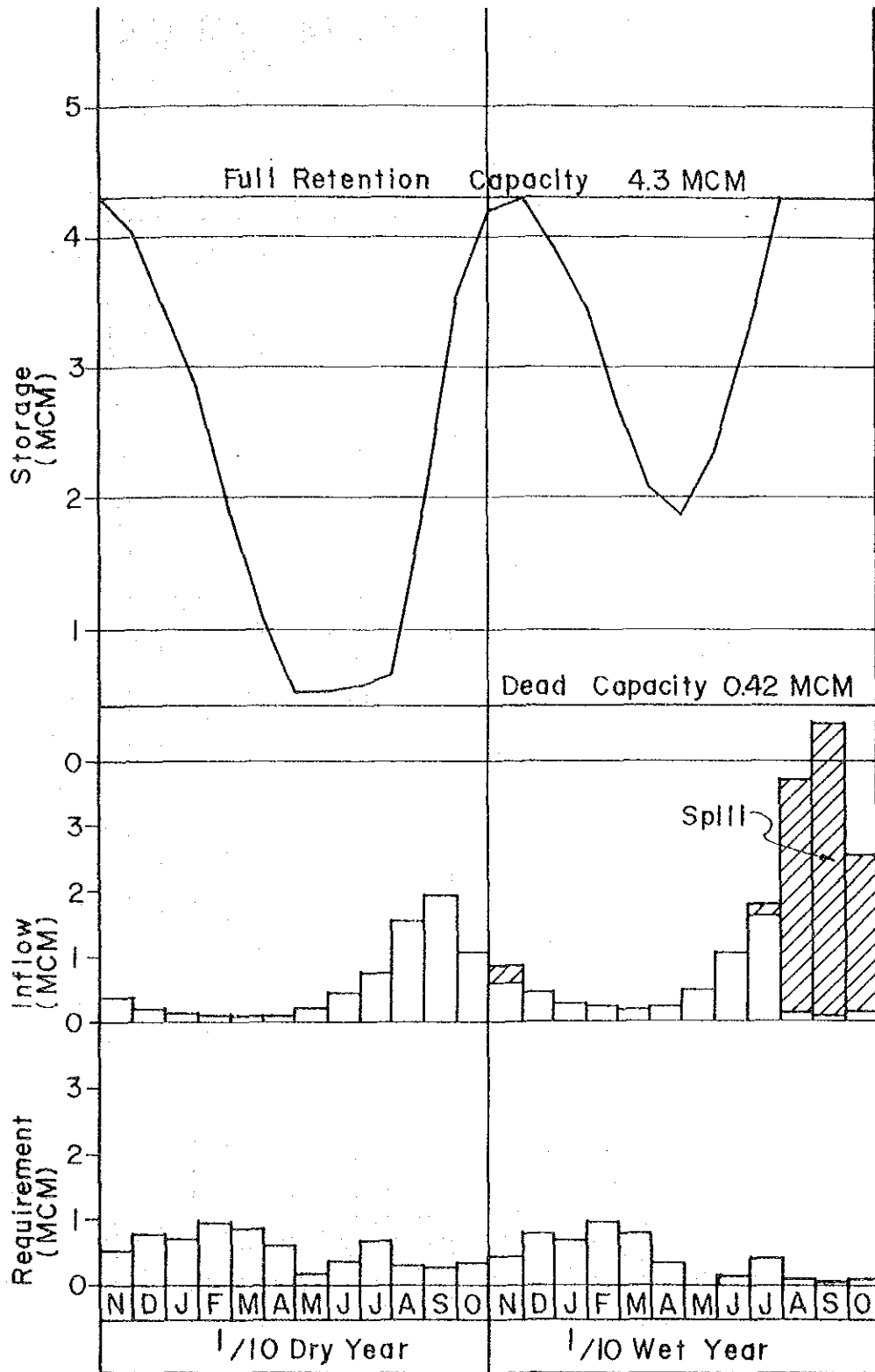
STAGE CAPACITY CURVE OF KHLONG SAMO KHON



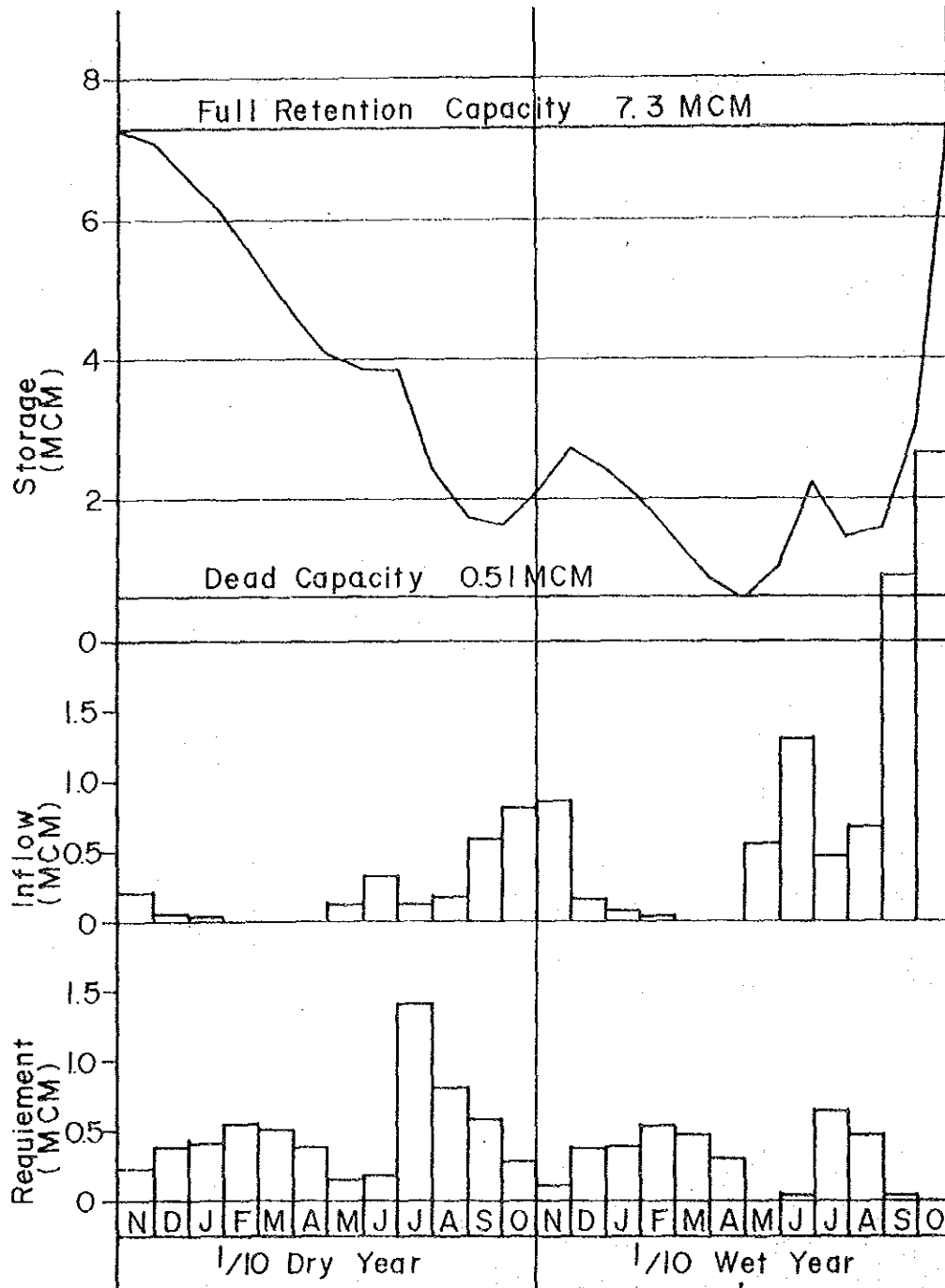
STAGE CAPACITY CURVE OF KHLONG SAI



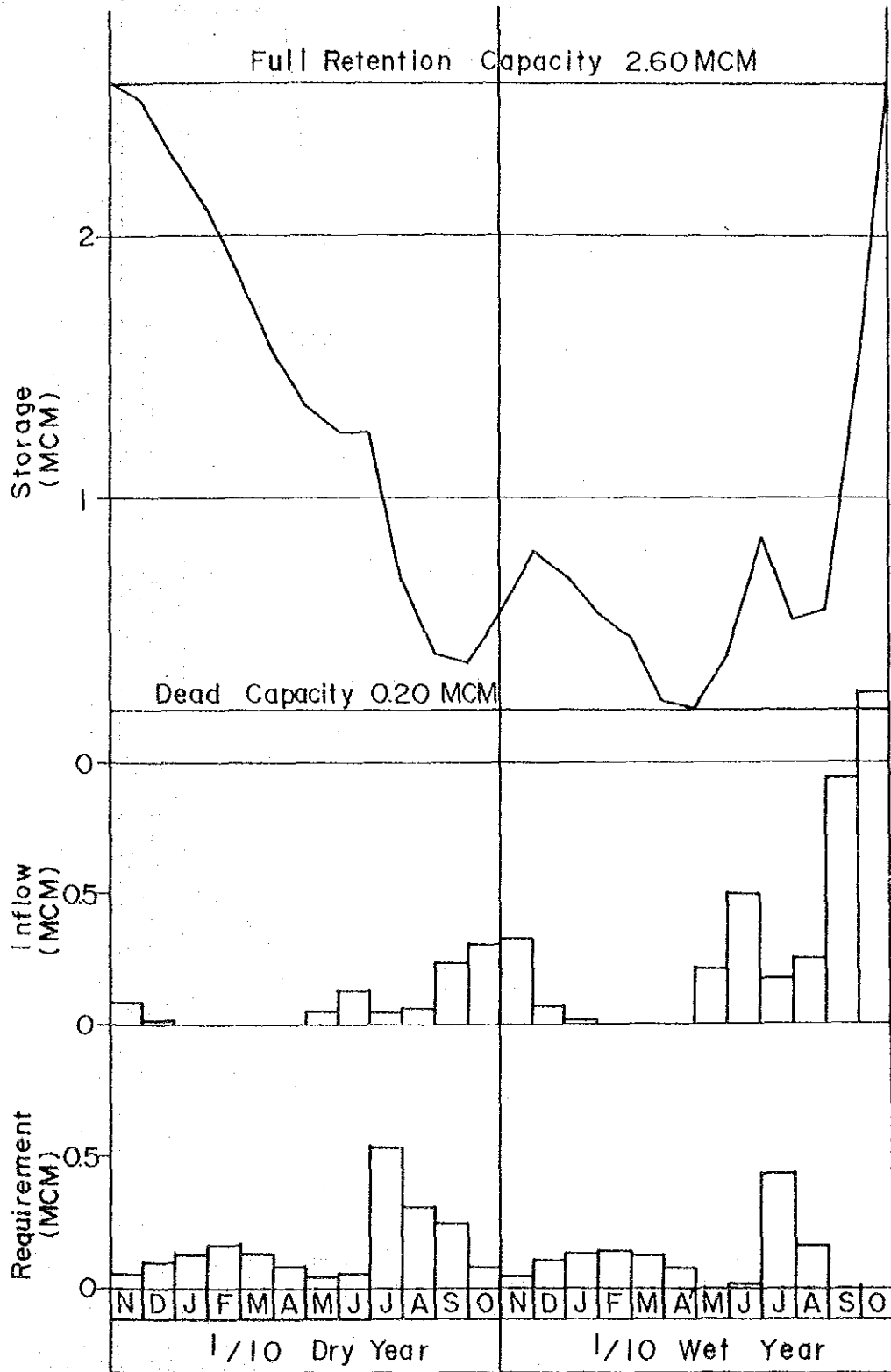
HUAL SAM RU RESERVOIR OPERATION



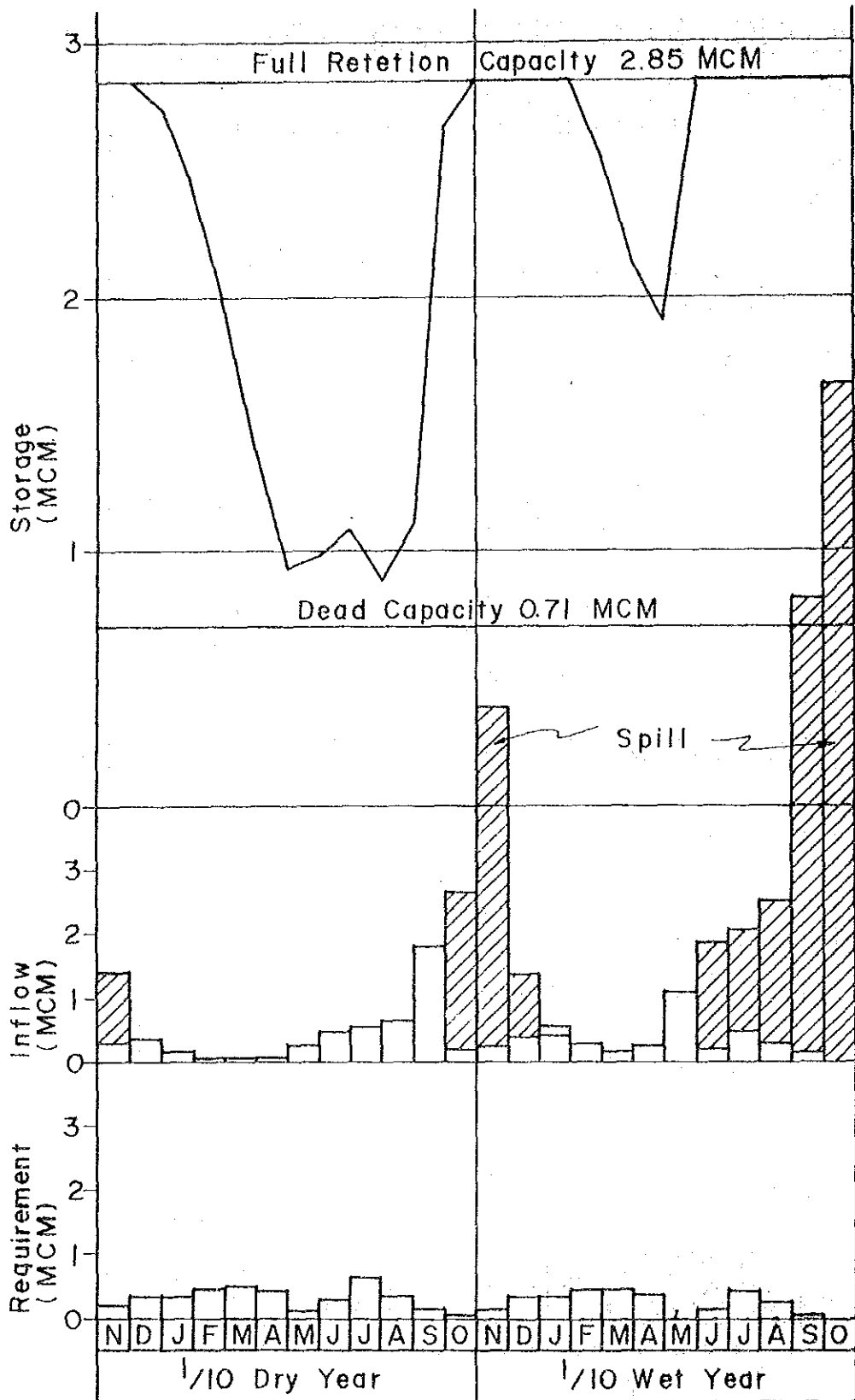
HUAI NONG KHO RESERVOIR OPERATION



KHLONG SAMO KHON RESERVOIR OPERATION



KHLONG SAI RESERVOIR OPERATION



APPENDIX F. ENGINEERING WORKS

APPENDIX F. ENGINEERING WORKS

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F-1 Field Survey in Model Project Area

F-1-1 Huai Sam Ru (PSU)

(1) General

The model project area is located 15 km the southwest of Amphoe Nahkon Thai. The topography of the area is very complicated. There are intervening steep hills and deep valleys along the river. The main river in the project area is named Huai Sam Ru flowing from the west the east and/or the southeast and has 6 branch rivers. There are 2 villages, named Ban Kaeng Wa and Ban Kaeng Hai, Located on the left bank of the main river at elevations of 282 to 295 m above the mean sea level, and both of them area backward villages.

(2) Road

Ban Kaeng Wa and Ban Kaeng Hai are located along the laterite road which is connected with Route 2013 (Provincial Highway) at 3 km northeast of Ban Kaeng Wa. This rod form the provincial highway to Ban Kaeng Wa is 6 m width and between Ban Kaeng Wa and Ban Kaeng Hai is 4 m width. There is a wooden bridge in Ban Kaeng Hai, the length is 7.5 m and the width 2.0 m, it shall be replaced.

The condition of road surfaces area very bed because it had not been maintained after rainy seasons. During a rainy season, most of vehicles can not drive on these after raining.

The other roads around these villages are about 2 m width and ordinary vehicles can not pass through during a rainy season except tractors.

(3) Water Use

Even in the end of a dry season, Huai Sam Ru has water flows but the l flow is in deep valleys and so it can not avail for villager without in-take facilities.

Ban Kaeng Wa has the water supply system for domestic water use to each household by the pipeline. The in-take facilities are located on the upstream of Huai Sam Ru and the water is conveyed to Ban Kaeng Wa school by the pipeline with gravity flow, and then it's pumped up to elevated tanks.

Ban Kaeng Hai dose not have water supply system, therefore, the villagers have to gather domestic water from the river, ponds and/or rainfall stocked in rain jars.

There area 3 reservoirs as irrigation facilities and/or domestic water use in the model project area. The following table shows purpose, dimensions and capacities of these ponds.

THE EXISTING RESERVIREES

Village Name or Code No.	Dimensions W×L×H (m)	Capacity (cu-m)	Purpose	Constructed
29 - 3	-	44,000	Irrigation	RID
Ban Kaeng Wa	-	-	Domestic	ARD
Ban Kaeng Wa	26×106×3.5	9,600	Domestic	-

There are also some small ponds and shallow wells for domestic water in the village, For drinking water, every households use rainfall water and install rain jars to gather rainfalls.

However, these villagers face to the shortage of irrigation and domestic water through the year and the quality of drinking water in dry season.

F-1-2 Huai Nong Kho (SUK)

(1) General

The model project area is located on 25 km the northwest of Amphoe Ban Dan Lan Hoi and can be divided into the upstream area and the downstream area. The upstream area is surrounded by mountains on three sides and located on the pivot of fan. There are 2 villages, named Ban Huai Khrai(1) and Ban Huai Khrai(2), and large cultivated lands among these

villages at elevations of 100 to 120 m above the mean sea level with the ground slope of 1 : 150. The name of main river is Huai Nong Kho in this area.

The downstream area is on the flat plain. The main river in this area, named Huai Khrai (Downstream of Huai Nong Kho), flows from the west to the east, then turning to the southeast at the 2 isolated mountains. There area composed of 4 villages, Ban Lan Thong, Ban Nong Krathum, Ban Wang Phong and Ban Khok Kwai Yai Long, and last 2 of them are backward villages. The cultivated land near Ban Wang Phong is located on the left bank of Huai Khrai at elevations of 65 to 75 m with the ground slope of 1 : 500.

(2) Road

The ARD road (ST 11012) connects with Ban Hui Khrai(2) from Route 12 (National Highway) in Amphoe Ban Dan Lan Hoi. The road was paved by asphalt as far as 0.5 km from Route 12 and ARD completed to construct another 2.55 km of them as ARD Standard Road which was 6.0 m width and paved by laterite in 1990. There is a wooden bridge at the end of ARD Standard Road, it is going to be replaced by ARD in 1991. The remaining road as for as Ban Huai Khrai(2), a distance of 22 km, will replace with ARD Standard Road including a wooden bridge (L = 10.3 m) in future.

There is a road along Huai Nong Kho connecting the northeast of Ban Huai Khrai(1) to ARD Road (ST 11012) in Ban Huai Khrai(2). The width of road is about 4 m and the condition of road surfaces in very bad, even in dry seasons, only pick-up and/or tractors can pass through.

On the right bank of Huai Khrai (Down stream of Huai Nong Kho), there is a road connected Ban Huai Khrai(2) to Route 12 in 2 km the east of Amphoe Ban Dan Lan Hoi. It's 24 km long and 4 m wide, by way of Ban Khao Khwang, Ban Nong Krathum, Ban Khok Kwai Yai Long, Ban Wang Daet and Ban Dan. The condition of road surface is the same as above.

On the left bank of Huai Khrai, there is the road along Huai Khrai, with 4 m width, by way of Ban Lan Thong and Ban Wang Phong and the surface condition is fair because of having been maintained recently. Even in rainy seasons, the road is available for vehicles passing through.

There is no bridges connect for these 2 roads described above in the model project area.

(3) Water Use

There is many shallow wells, having been set each 5 to 10 households, for domestic water in the these villages. The quantity of the water is not enough in dry seasons. There is a natural swamp on the north of Ban Khok Kwai Yai Long and is used for the irrigation and domestic water.

For the drinking water, every households use rainfall water and have rain jars to gather rainfalls.

In the upstream of the model project area, there is the weir with a canal constructed by RID in SSIP near by proposed dam sight. But the scale of the weir is too small to control the flood, and so the water can not be led to the canal even after a flood coming. There is the reservoir which is caused by the small dam at the west end of Ban Huai Khrai(2) in Huai Nong Kho. The reservoir was available for the multiple purposes, irrigation, domestic water use, fishery and others.

There area some reservoir and in-take facilities in the downstream of the project area. The west end of Ban Lan Thong, there is the in-take facilities installing the box without gates in Huai Lan Phum to make the water level higher elevation. The irrigation water is led to Ban Lan Thong by the canal along the road.

There area 2 existing weirs on Huai Khrai, one is at 1.0 km downstream of Ban Lan Thong but it had been destroyed long time ago. The existing gut is at the right bank of the weir and excavated more than 2.0 m from previous river bed. The weir shall be taken away.

The other weir is at 2.0 km upstream of Ban Wang Pong and it is providing the irrigation water by the connecting canal. The function of the weir has no problems at present but it will be necessary to replace in near future.

The existing facilities for domestic used, irrigation and fisheries in model project area area shown as the following table.

THE EXISTING RESERVOIRS

<u>Village Name or Code No.</u>	<u>Dimensions W×L×H (m)</u>	<u>Capacity (cu-m)</u>	<u>Purpose</u>	<u>Constructed by</u>
Ban Kaeng Khrai	-	-	Multiple	-
Ban Kaeng Thong	30×100×3.5	14,028	Irrigation	ARD
Ban Kaeng Thong	-	-	Fishery	DOF
Ban Kaeng Thong	-	-	Irrigation	-

THE EXISTING IN-TAKE FACILITIES

<u>Village Name or Code No.</u>	<u>Dimensions W×H (m)</u>	<u>Irrigable Area (ha)</u>	<u>Type</u>	<u>Constructed by</u>
25 - 3	-	480	Weir	RID
27 - 1	10 × 2.0	480	Weir	RID
Ban Wan Phong	15 × 1.7	-	Weir	-
Ban Lan Thong	1.8 × 1.8	-	Box	-

F-1-3 Khong Samo Khon (KPP)

(1) General

The model project area is located 20 km the northwest of Amphoe Phran Kratai, The topography of the area is surrounded by mountains on three sides and shallow flats area along Khlong Samo Khon. There are 2 villages, named Ban Nam Deb Ma Phroam and Ban Sa Mokon, located on the left bank of Huai Samo Khon at elevations of 115 to 135 m above the mean sea level, and both of them area backward villages. The river gradient is about 1 : 600.

There is low and flat hills along Huai Samo Khon on the tight bank, and the elevation of hills top is about 5 m higher than the river.

(2) Road

ARD Standard Road (KP 11002) is connected 2.5 km the north of Ban Nam Deb Ma Phroam to Route 1132 (Provincial Highway) at 17 km the northwest of Amphoe Pharan Kratai, by way of those 2 backward villages, was completed in 1990.

The other roads around these villages are about 2 m width and ordinary vehicles can not pass through during rainy seasons.

(3) Water Use

There area shallow wells for domestic water in these villages, and many small ponds in the hill on the right bank of Huai Samo Khon for irrigations and domestic water. For drinking water, every households install rain jars.

The existing weir constructed by ARD is in Ban Nam Deb Ma Phroam on Huai Samo Khon, but the connecting irrigation canal terminates 50 m from the weir and so it can not irrigate any cultivated land, because the elevation of weir crest is too low. There is a reservoir constructed by ARD 2 km the south of Ban Sa Mokon beside the ARD road.

The table of existing facilities are shown as follows.

THE EXISTING RESERVOIRS

<u>Village Name or Code No.</u>	<u>Dimensions W×L×H (m)</u>	<u>Capacity (cu-m)</u>	<u>Purpose</u>	<u>Constructed by</u>
Ban Sa Mokon	-	-	Irrigation	ARD

THE EXISTING IN-TAKE FACILITIES

<u>Village Name or Code No.</u>	<u>Dimensions W×H (m)</u>	<u>Irrigable Area (ha)</u>	<u>Type</u>	<u>Constructed by</u>
KP 21003	19 × 1.5	334	Weir	ARD

F-1-4 Klong Sai (TAK)

(1) General

The model project area is located 20 km the south of Amphoe Muang. The topography of the area is surrounded by gentle mountains and the river named Klong Pra Dang (Downstream of Klong Sai) flows from the southwest to the northeast.

There are 4 villages, named Ban Na Bot and Ban Wang Tam Lung, Ban Lat Yao and Ban Takhian Duan. Ban Na Bot is located on the confluence of Klong Pra Dang and Klong Sai where is the most upstream in these villages. The other villages are located on the right bank of Klong Pra Dang. Among these villages, only Ban Wang Tam Lung is regarded as backward. The elevations of these villages area 135 to 165 m above the mean sea level, and the river gradient is about 1 : 300.

(2) Road

There are 2 provincial highways, Route 1110 and Route 1108. All of villages it the project area face Route 1110, and there is the junction of Route 1110 and 1108 in Ban Na Bot. Route 1110 is connected with Route 1 (National Highway), and Route 1108 is connected with Route 105 (National Highway) from the junction.

The other roads around these villages area about 2 m width and ordinary vehicles can not pass through during rainy seasons.

(3) Water Use

Klong Sai and Klong Pra Dang have water flows even in the end of a dry season, but there is no existing facilities for domestic water, irrigation and/or other purpose. For drinking water, every household install rain jars.

F-2 Planning Concept

F-2-1 Irrigation

(1) Reservoir

Dimension of each reservoir and dam were Planned as shown in Table F-1, in consideration of the following conditions.

- Reservoir capacity was estimated by the toposurvey maps scaled 1 : 5,000
- The sediment volumes in the reservoirs were estimated by the following equation.
$$\text{Sediment volume} = 150 (\text{m}^3/\text{km}^2/\text{year}) \times \text{catchment area} (\text{km}^2) \times 100(\text{years})$$
- L.W.L of four reservoir were established corresponding to the surface of sediment.

(2) Dam

(a) Dam Type

Selection of suitable dam type shall be made basing on such overall view as the scale of dam, site's topography and geology, quality and quantity of available construction materials, etc.

In case of four sites, the earth fill type dam shall be applicable taking account of the following conditions :

- The sites are gentle slope,
- Obtaining construction materials especially impervious materials for fill dam nearby the sites (Average distance is 400 m) is possible in quantity and quality.
Dispersive soils which area to be avoided for the fill dam embankment were not found in the borrow areas except only a few area along Lam Se.
- Earth fill type dam is the most economical one among the various dam types.
- Easiness of construction works

(b) Dam Foundation Treatment

The damsite in the Lower North basin lies generally on the flat topography and on the foundation consisting of well-compacted overburden and well-consolidated rock formation. Therefore, the dam foundation except cut-off trench is prepared only by stripping one to 0.5 meter in depth to remove the loose overburden covered with vegetation.

A cut-off trench should be provided at the center of dam body in order to attend the pass length of seepage line through the dam foundation.

Huai Nong Kho Dam, Khlong Samo Khon Dam and Khlong Sai Dam, the dam height of which area less than 20 m will not require foundation treatment by grouting. However, Huai Sam Ru Dam with dam height of 25 m shall be provided grouting works to improve the permeability of the foundation. Curtain grouting is planned to have a half of the water depth at the river bed and 5 m at the both abutments. Since the rock formation consists of well consolidated sedimentary rock, the cement of grouting milk to be injected will be less than 50 kg per linear meter of the grout hole.

(c) Dam Body

The dam shall be provide with vertical and horizontal drain to draw down the phreatic surface and to prevent the piping through dam body and foundation, The riprap is designed at the upstream slope higher than the dead water level to protect the dam slope from erosion due to waves in the reservoir. A filter zone is also provided under the riprap to prevent squeezing of the embankment material by the drawdown of the water level in the reservoir.

As the semi-pervious materials of silt and fine sand with uniform grain size distribution area apt to bring about piping, those materials cannot be used in the upstream zone and they area only allowed to be used for the downstream zone behind the vertical drain in the dam body.

Dry freeboard of the dams shall stand wave creeping height depending on the wind velocity and reservoir fetch. The wind speed of 30 m/sed and the largest fetch of the Huai Nong Kho requires only 0.8 m of dry

freeboard, however, the minimum freeboard of 1.5 m is given to all the dams.

(d) Spillway

i) Design Rainfall

For the design of spillway of medium scale dam, 50 years return period is adopted as the design flood. The hydrograph is required to estimate the effect of reservoir surcharge by means of flood routing analysis. As there are no reliable hourly flood discharge data sufficient for estimating the 50 years probable flood hydrograph, the hydrograph has been theoretically developed by observed rainfall data.

Hyetgraph (rainfall pattern) has been so assume as to increase with time and get to the maximum intensity in the last one hour. The 70 percent of daily rainfall concentrates in the last one hour and it is taken as effective rainfall.

ii) Unit hydrograph

synthesis hydrograph developed by Snyder would be applied for the estimation of probable flood.

Unit hydrograph is obtainable by,

$$QP = 0.275 C_p A/T_p$$

where Q_p = Peak discharge of unit hydrograph (cu.m/s/mm)

C_p = Snyder's coefficient ($C_p = 0.56$ to 0.69)

A = Drainage area (sq. km.)

T_p = Time lag from midpoint of effective rainfall duration t_r to the peak of a unit hydrograph

For the sake of simplicity, the pattern of hydrograph was assumed to be a triangle. The assumption scarcely affects the accuracy of the peak out flow estimation in flood routing analysis, but affects the duration of flood outflow which is out of the discussion. The duration of unit hydrograph of a triangle is given as follows.

$$T_b = 2A/3.6/q_p$$

where T_b = Duration of unit hydrograph (hr)
 A = Drainage area (km²)
 q_p = Unit peak discharge (m²/s/mm)

The dimensions of the unit hydrograph is shown in TABLE F-10.

Spillway design capacity is determined in order to safely discharge the flood inflow of the reservoir. The peak discharge of the inflow can be decreased due to surcharge effect above the full water surface level. This effect is significant if the water surface area is wide as compared with the inflow volume. The flood routing analysis has been carried out and the detail is shown in FIGURE F-2.

The overflow section of spillway should be designed based noncontrolled overflow type without gate due to inconvenient operation.

The main features of the spillways are shown below :

Project	Catchment Area (km ²)	1/50 Rainfall (mm)	Peak Inflow (m ³ /sec)	Crest Length (m)	Overflow Depth (m)	Overflow Depth (m ³ /sec)
Huai Sam Ru	28	246.7	178	40	1.60	157
Huai Nong Kho	34	142.1	127	20	1.20	54
Khlong Samo Khon	13	187.3	82	30	0.80	45
Khlong Sai	47	167.3	222	60	1.30	186

(4) Weir

In 5 Year plan, there area 55 weirs to be suitable for construction based on 1 : 50,000 map. Weirs are planned as ARD standard type.

(5) Canal

(a) Main and Lateral Canal

The layout of the canal system is made based on the topographic maps with scale of 1 : 5,000. The alignment of canals is planned to enable the paddy and crop field to be irrigated by gravity, running in parallel with contour lines as far as it can be so that appurtenant structures like drops and the quantity of earth work area reduced to a certain extent. Main canals area designed to be trapezoid channels with concrete lining or pipeline made of concrete pipes depended on topographic conditions and lateral canals are adopted trapezoidal channels without concrete lining, having a conveyance capacity of 1.62 ℓ /sec/ha. Canals will be constructed to command a project area down to a terminal irrigation block of 16 ha (100 rai).

Irrigation canal with a bottom width of more than 0.3 m is designed with concrete lining taking into consideration that the soil in the service area consists of previous sandy materials.

(b) Related Structures of Canals

The following related structures of canals area planned :

- Head regulators area provided to divert irrigation water from the main to lateral canal or from the lateral to sub-lateral. Distributors area also installed as measuring devices at the head of the structure to keep accurate water diversion.
- Farm turnouts area placed at the head of service units and designed by a pipe barrel of 400 mm in diameter with a steel slide gate as measuring devices.
- Check structures area provided at the down stream of the head regulator and turnout, and used to control diversion water and maintain a certain water level of canal. The check structures area designed with overflow weir overflow weir of duckbill type.
- Check/drop structures are designed at the place where dissipation of surplus energy is required due to different elevation of canal water level. One check/drop structure is employed for 1.00 m different