APPENDIX 4

DRAINAGE

DRAINAGE

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4-1. Drainage Systems and Problems

(1) Drainage System

The Kamphaeng Saen area can be subdivided into three drainage systems for the discussion of drainage conditions - Tha Sarn, Tha Rua and Nakhon Chaisi drainage systems (Figs. 4-1 and 4-2), as follows:

Tha Sarn Drainage System

The Tha Sarn main drainage canal, which is originally one of the natural branches of the Mae Klong river, had been used for dual purposes of irrigation and drainage before completion of the Greater Mae Klong Irrigation in first stage. The total length of the Tha Sarn River is approximately 65.7 km. The length of the main drainage canal and three laterals are 27.6 km and 10.1 km in the area, respectively. The Tha Sarn main canal, covering a drainage area of about 7,100 ha in the Project Area, meets the Nakhon Chaisi River at Bang Pla. It also has a function as floodway to spill a part of the Mae Klong floods and has a capacity of 53.96 m^3/s including the flood discharge allocated to this river. Although the Tha Sarn has been recently reconstructed as a main drainage canal by RID, it is still in use for irrigation purpose for the Malaiman area (Mae Klong Irrigation Project-Stage II Left Bank area), which is situated on the left bank and outside of the Project Area. The water surface in the river is dammed up by four control structures including the two structures which were constructed in 1972. These structures cause drainage problems in the area alongside Tha Sarn River. The profile of this river is shown in Fig. 4-3.

Tha Rua Drainage System

The Klong Tha Rua flowing into the Nakhon Chaisi River is linked with Tha Sarn River through an RID drainage canal (IL). It was also reconstructed as a main drainage canal by RID in the same way as the Tha Sarn. The drainage system covers a drainage area of about 22,700 ha

including outside Project Area of about 5,600 ha and is equipped with Tha Rua River and 8 drainage canals with a total length of about 116.0 km and a tail regulator.

Flood water in Mae Klong River is diverted into the Tha Rua River, which convey the water to the Nakhon Chaisi, to prevent the downstreams of Mae Klong River from flood damages. In the course between the Mae Klong and the Nakhon Chaisi, Tha Rua River, having a function as dual-irrigation/drainage canal, has several canals branching off in the southward (outside Project Area) and join the main drainage canal (1L) of the Kamphaeng Saen and Rang Yao creek near the conjunction of Nakhon Chaisi River. The designed drainage capacity of the Tha Rua is 53.96 m^3/s, the same as that of the Tha Sarn. The profile is shown in Fig. 4-4.

Nakhon Chaisi Drainage System

This is the area where excess water is drained into the Nakhon Chaisi via three major drainage canals. The drainage area amounts to about 3,800 ha and are subject to inundation from the Nakhon Chaisi River. Several small drainage canals other than major ones play a role for drainage of the area. All of these canals function dually as irrigation/drainage canals both in the dry and wet seasons.

(2) Drainage Problems

The cause of the drainage problems envisaged in the area could be summarized as follows:

- Floods from the Mae Klong and the Nakhon Chaisi Rivers

The floods in recent years in the Mae Klong River occurred in 1969, 1972 and 1974. It is reported that several hundred hectares of farm land around the Malaiman highway have inundated for two days from the overflows of the Tha Sarn river which has a function to spill some flood water from the Mae Klong River. The Sri Nagarind

dam on the Khwae Yai River is under construction, and the plan of the Khao Laem multi-purpose dam on the Khwae Noi river is also undertaken by EGAT. After completion of these dams, the frequency and magnitude of Mae Klong floods will be reduced to a considerable extent so that spillage through the Tha Sarn River will be no longer necessary.

No serious flood from the Nakhon Chaisi River has been recorded since the Bumibol and the Sirikit dams were constructed. The Nakhon Chaisi River, however, rises to EL 2.0-2.1 m at Bang Pla and to EL 1.5-1.7 at Bang Phra frequently, and it continues for about one month (Exhibit-8). Consequently, in the low-lying area along the river, shallow inundation occurs due to the contraflow through the canals where no regulator is installed.

- Check-up of the Water Level in the Tha Sarn River

Four control structures in the Tha Sarn River, lying on the northern project boundary, are operated to check up the water level so high as to irrigate the areas on both sides of the river. According to the water level records, the Kamphaeng Saen regulator checked up water levels some two meters high, which is a water level difference between the upstream and downstream of the structure (Exhibit-9). So the left bank area (second stage area of the Greater Mae Klong project) has not yet been equipped with irrigation systems, and the Tha Sarn River would still be used for dual purpose of irrigation and drainage. Inasmuch as the control structures cannot be removed at present, the construction of new drainage systems and/or provision of flood protection dikes will be required for drainage improvement of the right bank area.

- Inundation in the Depressions

In the Tha Sarn drainage system, there are three swamps: Nong Know, Nong Thung Kaolan Thong and Langrang, all of which are connected with the Tha Sarn river through drainage canals. Even in the dry season, however, they form about 80 ha swampy areas due to low elevation. Moreover, there are several small-scaled swamps without drains to connect with main and lateral drainage canals in the Tha Rua drainage system area. These areas amount to about 2,250 ha, of which about 1,340 ha would enable to reclaim with provision of adequate drainage facilities. Drainage area for each system by ground elevation is shown in Table 4-1.

- Inadequate Drainage Facilities

Besides the flood, inadequate control structures and topographical conditions, poor drainage problems prevailed in the Project Area. Due to lack of drains at farm level, unlinked channels to the depressions and inadequate regulation facilities for drainage, most of paddy field in low-lying land are distressed with abundant excess water. These conditions put difficulty in undertaking efficient water use, introduction of HYV, improvement of soil properties, etc. The density of present drainage channels in the area is about 6 m/ha. List of drainage channels in the area is shown in Table 4-2.

4-2. General Planning

(1) Plan Formulation

The major causes of the drainage difficulties have been roughly specified into four as mentioned previously. The countermeasures to be taken in view of engineering are to prevent the external water from intruding, to drain the excess water out of the Area, and to provide the on-farm drainage facilities. The construction of the on-farm facilities will be discussed in the paragraph on the on-farm development scheme (Appendix V).

(2) Flood Control

- Flood from the Mae Klong river: There will be little probability of flooding from the Mae Klong river to the Project Area with development the Mae Klong River Flood Control Program.

- Flood from the Nakhon Chaisi river: Frequency of serious flooding from the Nakhon Chaisi river to the Project Area will be reduced to the considerable extent with development of the Chao Phya River Flood Control Program. However, some protective measure should be taken for floods occurring once several years so that introduction of HYV and paddy double cropping can be ensured in the areas along the river. In terms of engineering, the construction of flood control embankments and gates is possible measures for the purpose. The inundation would not exceed 0.5 meter in depth.

The proposed routes of the embankments are the existing roads along the rivers (about 13 km) and the route connecting the terminal of 8L-1R-1L-5L with the terminal of 2L-5L, in utilizing their embankments (about 7 km).

Under the present conditions of the Nakhon Chaisi river, the construction of the flood control embankment requires further detailed study with prudence in view of those effects of economy as well as insufficient river capacity for flood discharge.

- Flood from the Tha Sarn drainage canal: The regulators on the Tha Sarn canal could not be taken away before completion of the irrigation system in the left bank area. It is proposed, therefore, to provide dikes by utilizing existing roads and new construction for flood protection in the right bank of the canal. The new dikes will extend about 25 km with crest to be used as road. The borrow pits for construction will be used for drainage canals to lead the water to the downstream of the regulator. The drainage canals joining the Tha Sarn will provide the flood protection gate.

(3) Inland Drainage

- Drainage improvement in swamp areas: Construction, upgrading or installation of gates will be implemented for the drainage canals to link the main drainage canals and swamps.

Essentially, the complete development of swamps requires pumping drainage, which may be experientially unjustifiable from the economic standpoint. The drainage canals with adequate capacity will accelerate the drainage of farm lands around the swamps in lower outer water level, so that paddy cropping can be stabilized and better working condition for mechanized farming can be secured.

(4) Proposed Drainage System

According to the Plan mentioned previously, the total Project Area of 28,000 ha will be provided with new sub-drainage system in utilizing the existing main drainage canals besides flood protection dikes and drainage improvement in the swamp area (see Figs. 4-5). The layout in this line will be closely related with the on-farm development scheme.

4-3. Design Drainage Capacity

(1) Rainfall Analysis

The drainage plan for paddy fields should be established based on the designed rainfall of successive rainfall basis, because paddy plants originally have some deep water resistance, which is different in growing stages. Moreover, paddy fields can serve in the flood control function to some extent. The record and probability of maximum daily rainfall and successive rainfall are illustrated below, covering 16 years from 1952 to 1977 observed at Kamphaeng Saen Station, the representative area in the Project.

Record and Probability of Maximum Daily and Successive Rainfall

(Unit: mm)

	1 day	2 days	3 days	4 days	5 days	10 days
(Recorded maximum rainfall)						
First	132.6 (Sep.'72)	198.0 (Sep.'72)	233.6 (Sep.'72)	240.4 (Sep.'72)	244.6 (Oct.'72)	380.2 (Oct.'72)
Second	127.3 (Oct.'67)	158.6 (Nov.'69)	230.3 (Oct.'57)	239.1 (Oct.'57)	240.4 (Sep.'72)	294.1 (Oct.'60)
Third	125.8 (Oct.'69)	150.2 (Oct.'57)	188.0 (Sep.'69)	225.6 (Sep.'69)	233.5 (Sep.'69)	277.7 (Sep.'63)
Fourth	124.2 (Oct.'60)	139.4 (Oct.'60)	166.1 (Jun.'75)	213.1 (Oct.'60)	221.5 (Oct.'60)	272.6 (Sep.'72)
Fifth	112.3 (Jun.'58)	133.0 (Oct.'67)	162.0 (Sep.'55)	197.3 (Jun.'75)	197.3 (Jun.'75)	271.6 (Sep.'69)
(Probability of maximum rainfall)						
1/5 years	107	134	158	175	187	252
1/10 years	118	148	183	204	216	285
1/20 years	128	161	206	232	243	316

Note: ( ) shows the month and year when recorded

(2) Water Level of Nakhon Chaisi River

Records available

Water level of the Nakhon Chaisi River is recorded at two stations; one is Bang Pla and the other in Bang Phra, the upperstream end of the project area and the lowerstream end, respectively. The measurements are carried out five times on the hour of 6, 9, 12, 15, 18 hour every day.

Records of river water level so far collected covers 8-year period (71 - 78) for Bang Pla and 7 years (70 - 74 and 77 - 78) for Bang Phra including some lackings.

The Nakhon Chaisi river flows about 100 km from Bang Phra to the estuary. In the Project Area, the water level of the Nakhon Chaisi fluctuates by tidal effect. The records at Bang Phra reveals that the hourly water level below EL 1.4 m is affected by the tidal movement; particularly the lower water level was considerably affected to fluctuate in a range of some ten centimeters, while the water level over EL 1.4 m was little affected.

The Nakhon Chaisi river extends about 35 km between Bang Phra and Bang Pla, having little inflow within this course. The daily mean water levels recorded at both stations show a considerably favorable correlation-ship at elevation over 0.7 m.

Hydrograph

From the records available for recent seven (7) years, the water level fluctuation of the Nakhon Chaisi river can be summarized as follows:

- Water level rises gradually from August to September.
- There is a rapid water level rise observed in October and it reaches maximum on and around the end of October and/or early November.
- Water level is lowered gradually from November to February.
- For the period of March - July, water level is steadily maintained low.

Flood occurrences of the Nakhon Chaisi River are recorded at Bang Pla (the lowest plot elevation at 1.0 m) as follows.

Year	Flood higher than EL 1.0 m Period	Days	Maximum flood Water level	Date occurred
1970	Mid. Sep. - Mid. Jan.	120	1.96	November 18
1971	Later Sep. - Later Dec.	120	1.68	November 3
1972	Early Sep. - Later Jan.	150	1.54	December 23
1973	Later Sep. - Later Jan.	110	1.42	October 30
1974	Early Oct. - Mid. Jan.	100	2.07	November 4
1977	Early Oct. - Later Oct.	10	1.11	November 3
1978	Early Oct. - Mid. Dec.	80	1.86	November 4

The Nakhon Chaisi river is downstream portion of the Suphan river, one of the branches of the Chao Phya river, the most part of its catchment area is occupied by the Chao Phya river basin.

Water level fluctuation pattern as mentioned above is derived from the fact that the water level is not affected by the rainfall in the Kamphaeng Saen area as the most of catchment area of the Nakhon Chaisi belongs to the Greater Chao Phya River Basin. Therefore, peak water level in the Nakhon Chaisi usually happens in November though the maximum rainfall in the Kamphaeng Saen area is mostly recorded during the period of September - October.

The Bumiphol dam and the Sirikit dam on the Chao Phya river, which were constructed in 1964 and 1972 respectively, and water control at the Chi Nat barrage are reported to have succeeded in improvement of flow conditions of the Nakhon Chaisi river and in reducing frequency of severe floods in the Kamphaeng Saen Area.

(3) Run-off Analysis

Introduction

Excess water from the most part of the Kamphaeng Saen area flows directly into the Nakhon Chaisi River and poor drainage and/or adverse flow from the river to the area have taken place when water level is high in the Nakhon Chaisi. Under the circumstances, run-off in the area will be divided into two: - one from the upper part where drainage is not affected by the river water level and the other

where drainage is much affected by the river water level. Run-off analysis was made in accordance with the above concept as follows;

Upper Part: ΔS, stored water in paddy field after completion of land consolidation work can be computed by the following formula.

$$\Delta S = R' - (E + P) - Dc$$

Where, R' = Rainfall in paddy field

E = Evaporation

P = Percolation

Dc = Drained water from paddy field

Rain water outside the paddy fields flows to downstream through drainage canals. Drainage discharge can be estimated at about 70 percent of the total rainfall in taking into account percolation and partial storage on the way. Furthermore, in the flat area of the Project Area, percolated water may be mostly leaked into drainage canals therearound. This study takes all percolation to be drained to the drainage canals.

The irrigation water supply will be stopped, when the sucessive rainfall allows the paddy fields to store sufficient water for irrigation. However, it will be little expected that the extremely long-extending Mae Klong Irrigation System can be so properly operated as to meet the requirement of the Mae Klong Area which is situated at the east end of the long irrigation system. And sometimes, excessive irrigation water may be discharged from the upstream to flow down into the most downstream through the canals in the Project Area. The drainage from the upstream to the downstream can be estimated by the following formula.

$$Do = Dc + 0.7R'' + P + Dir + Di$$

Where, Do = Ourflow from the upstream

Dir = Irrigation water

Di = Inflow

R'' = Rainfall in area other than paddy field

Lower Part: In the lower part, inundation would be caused by high water level in the Nakhon Chaisi river. ΔS, inundation is given by the following formula

$$\Delta S = (R + Di) - (E + P) - Do$$

Where, Di = Inflow from upperstream

Do = Outflow to river

Outflow to the river would be determined by the difference between the river water level and the inundated water level in the lower area.

In case of August transplanting

- For recent 26 years, the maximum monthly rainfall (275.2 mm) occurred in 1976, when the maximum daily rainfall was measured by 36.3 mm in generally low intensity but with many rainy days. These values fall under the prudent side for Drainage scheme.

- The year of 1963 had the second largest monthly rainfall (245.6 mm) with five successive rainy days for 113.0 mm which was smaller than the third largest in 1975.

- The third largest monthly rainfall (214.3 mm) took place in 1975, when five successive rainy days brought about the largest rainfall of 159.7 mm, and the maximum daily rainfall was measured by 70.5 mm (the second largest). The rainfalls in August of the year was found most critical to drainage planning.

The field inundation (ΔS) can be given by the following formula.

$$\Delta S = R - (ET + Per) - Dc$$

Where, $(E_T + Per)$ = Field loss; Per = 1.0 mm, E_T = 3.7

Dc = Drainage Capacity; Dc-1 = 37.5 mm (proposed)
Dc-2 = 22.5 mm (present)

Estimate of ΔS in 1975 (mm/day)

Month	Date	R	(ET + Per)	Dc Max. /* 37.5	Dc Max. /* 22.5	ΔS 37.5	ΔS 22.5
Aug.	27	70.5	4.7	36.5	21.5	29.3	44.3
	28	15.3	"	36.5	21.5	3.4	33.4
	29	7.4	"	6.1	21.5	0	14.6
	30	5.2	"	0.5	15.1	0	0
	31	61.3	"	36.5	21.5	20.1	35.1
Sep.	1	16.7	"	32.1	21.5	0	25.6
	2	5.3	"	0.6	21.5	0	4.7
	3	7.5	"	2.8	7.5	0	0
	4	25.5	"	20.8	20.8	0	0
	5	17.7	"	13.0	13.0	0	0
	6	12.2	"	7.5	7.5	0	0
	7	5.5	"	0.8	0.8	0	0

/* Dc max is 37.5 mm and 22.5 mm but 1.0 mm of percolation, which is field loss, is considered as re-discharge to the drainage canals; therefore, the surface water to flow down is measured by 36.7 mm and 21.5 mm in deducting 1 mm from 37.5 mm.

Five-day successive rainfall with 5-year return period

- Designed rainfall is 187.5 mm. Actual rainfall near to this value was 187.7 mm is 1958. The inundation in the fields was obtained as follows:

Estimate of ΔS in 1958 (mm/day)

Day	R	ET + Per	Dc Max. 37.5	Dc Max. 22.5	ΔS 37.5	ΔS 22.5
1	112.2	4.5(*)	36.5	21.5	71.2	86.2
2	-	"	36.5	21.5	30.2	60.2
3	38.5	"	36.5	21.5	27.7	70.7
4	-	"	23.2	21.5	0	46.7
5	36.9	"	32.4	21.5	0	57.6
6	-	"	0	21.5	0	31.6
7	-	"	0	21.5	0	5.6
8	-	"	0	1.1	0	0

(*) Average on 10 September ET = 3.5, Perco. = 1.0) 4.5

- The inundation water level rises up to 71.2 mm at maximum with 3-day duration in case of 37.5 mm/day and 86.2 mm at maximum with 8-day duration in case of 22.5 mm/day, respectively.

- The value of the probable five days successive rainfall includes the probable maximum daily rainfall (106.9 mm) and the rainfall distribution was obtained based on the above.

Estimate of ΔS in Design Rainfall Distribution (mm/day)

Day	R	ET + Per	Dc Max.		ΔS	
			37.5	22.5	37.5	22.5
1	106.9	4.5	36.5	21.5	65.9	80.9
2	26.5	"	36.5	21.5	51.4	81.4
3	25.0	"	36.5	21.5	35.4	80.4
4	18.1	"	36.5	21.5	12.5	72.5
5	11.3	"	19.3	21.5	0	57.8
6	-	"	0	21.5	0	31.8
7	-	"	0	21.5	0	5.8
8	-	"	0	1.3	0	0

- In the same rainfall condition, runoff analysis in the low land which suffers excess water from the upstreams has been made as follows:

Estimate of ΔS in Design Rainfall Distribution (mm/day)

Day	R	ET + Per	Inflow from Upstream /1	Dc Max.		ΔS /2	
				37.5	22.5	37.5	22.5
1	106.9	4.5	41.9	36.5	21.5	187.5	202.8
2	26.5	"	10.4	"	"	183.7	213.7
3	25.0	"	9.8	"	"	177.5	222.5
4	18.1	"	7.1	"	"	161.7	221.7
5	11.3	"	4.4	"	"	136.4	211.4
6	0	"	0	"	"	95.4	185.4
7	0	"	0	"	"	54.4	159.4
8	0	"	0	"	"	49.5	133.4
9	0	"	0	"	"	45.1	107.4
10	0	"	0	"	"	40.6	81.4

/1 -- ratio of paddy field and others was assumed to be 54:46 (Refer to proposed land use) and runoff coefficient was assumed at 70%.
/2 -- initial water depth in the paddy field of 80 mm was given.

As a result of the above estimates, water depth inundated in the paddy field was over 20 cm with 5-day duration in case of 22.5 mm/day of drainage capacity, while the water depth do not exceed 20 cm in any date in the case of 37.6 mm/day.

(4) Unit Drainage Discharge

The allowable water depth to paddy plants, which differs in its growing stage, is critical in the stage immediately after transplanting. In the cropping schedule in the Project, the wet season paddy would be transplanted in a period from May to early August. On the other hand, high intensity rainfalls have frequently taken place in September and October.

The records on the successive rainfalls show that most of the rainfall has taken place in 3 to 5-successive rainy days. Therefore, in this study, the design rainfalls for drainage of the paddy fields was taken by 187.5 mm of the 5-day successive rainfall with 5-year return period, and it was planned to drain the above rainfalls for five days. The daily drainage capacity was proposed at 37.5 mm/day or 4.34 ℓ/s/ha which is the unit drainage discharge in the Project, taking into account the frequency of successive rainy days and inundation conditions in the low land.

The drainage from the sugarcane fields and other upland fields than paddy fields would have to be carried out at a higher level than the drainage from the paddy fields in consideration of the fact that one of the major problems on water use in the Project Area exists in the conflict between irrigation to paddy fields and drainage from sugarcane fields. To meet the conditions, the plan was made to drain daily the amount of 70 percent of 106.9 mm, the maximum daily rainfalls with 5-year return period, and the unit drainage discharge was determined at 74.8 mm/day or 8.66 ℓ/s/ha.

(5) Runoff Analysis for the Kamphaeng Saen Drainage Areas

Drainage Area

The gross acreage of the Kamphaeng Saen drainage areas is 18,149 ha, which is divided into two areas by the ends of EL 1.8 m; the upstream area and the downstream area. The Project Area has received the drainage water from 2,500 ha area extending west of the Malaiman road. The total drainage area of the Kamphaeng Saen Area is 23,749 ha, and specified as follows:

(Unit: ha)

	Paddy Field	Other	Total
Outside Project Area	3,100	2,500	5,600
Upstream Area	8,700	6,949	15,649
Downstream Area	2,300	200	2,500
Total	14,100	9,649	23,749

Design Rainfall

The actual rainfalls in 1969 were adopted for carrying out the drainage simulation for the Kamphaeng Saen drainage areas. The total rainfalls in the year were 1,235 mm (25-year average: 1,096 mm) and the return period was assumed by five years. The high intensity rainfalls, however, were recorded in a period from September to November; rainfalls for the respective 3-, 4-, and 5-successive days are recorded at the third largest in 25 years, and those for 10-day successive rainfall at the fifth largest in 25 years.

The records of the rainfalls in 1969 were shown in Table 4-3.

The design rainfall for runoff analysis for the Kamphaeng Saen drainage area was adopted by the rainfalls in 1969, which provide the annual rainfalls with 5-year return period. The designed outer water level was taken by the actual value at maximum flood water level in 1974, the largest value observed in these seven years at Bang Pla. (Table 4-4).

Results of Analysis

The maximum inundation water level was EL 2.07 m in "Without Project", when the inundated acreage was about 6,650 ha. On the other hand, the Project would decrease the inundation water level to EL 1.89 m at maximum and reduce the inundated acreage to about 4,790 ha; hence, about 1,860 ha of the fields would be saved from inundation. In other words, the acreage of non-inundated paddy fields would total about 93,360 ha (18,150 ha - 4,790 ha). (See Fig. 4-6).

4-4. Drainage Improvement Plan

The total Kamphaeng Saen Area of 28,000 ha was divided into four by the drainage systems, and the general descriptions and the measures to be required for drainage improvement are shown below.

(1) Tha Sarn Drainage System

The gross area of 6,385 ha is covered by this system as bounded by Tha Sarn drainage canal, 1R-1L-5L and 8L-1R-1L-5L irrigation canals. Water level at the Tha Sarn drainage canal is maintained high with regulator since the water in this drainage canal is utilized as an irrigation water source for the Malaiman area. To protect the water intrusion from the canal to the Project Area, a protection dike (about 24 km) as a farm-to-market road will be constructed along the Tha Sarn canal. Excess water in the area will be discharged to lower stream of regulator through the main drainage canal (borrow area for embankment material) along the embankment.

(2) Kamphaeng Saen Drainage System

This system covers 18,149 ha of gross area which is bounded by the Malaiman highway, irrigation canals of 1R-1L-5L, 8L-1R-1L-5L and 2L-5L and the proposed flood protection dike (6.7 km connecting the terminal points of 8L-1R-1L-5L and 2L-5L) along the Nakhon Chaisi River. When water level is high at the Nakhon Chaisi River, drainage cannot be functioned, but there would be no serious inundation in the

area as it was confirmed that there was not much rainfall in the area during the period of highest high water level.

(3) Nakhon Chaisi Drainage System

Flat low land of 1,768 ha along the Nakhon Chaisi River is the area covered by this system. Affected by high water level in the Nakhon Chaisi River the area has frequently suffered from poor drainage and inundation by river water. For the improvement, polder dikes and pumping facilities for drainage purpose are required though such measures would not be economically justified. For this system, therefore, no provision of facilities other than farm drains will be available under the present on-farm development.

(4) Tha Rua Drainage System

This system covers 1,698 ha area in strip as bounded by the Tha Rua drainage canal and 2L-5L canal, for which no other provision than drainage ditches will be considered for the same reason as the Nakhon Chaisi drainage system.

4-5. Project Works

Major project works are as follows and summarized in Table 4-5.

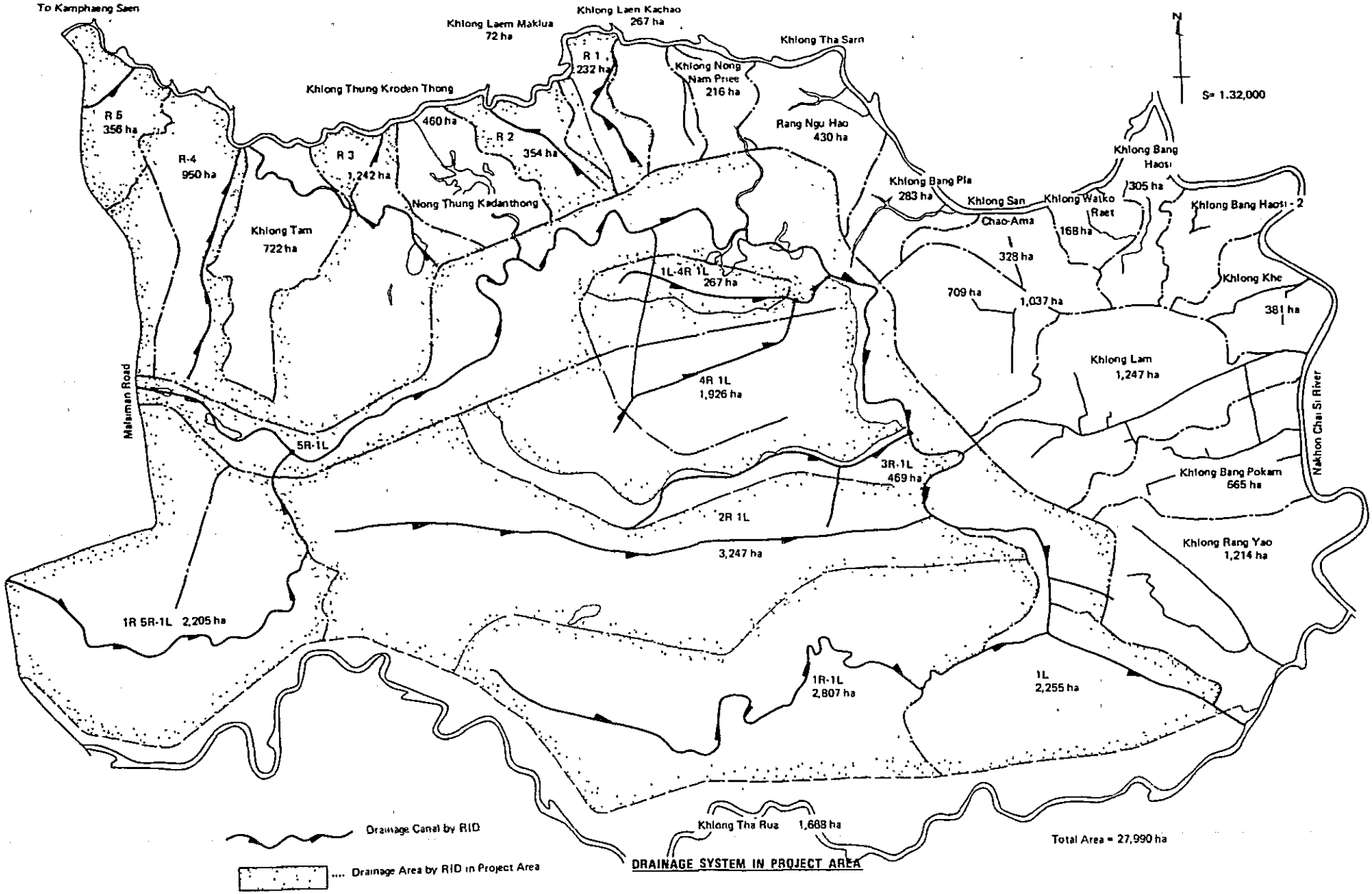
i) Channel works, which consist of improvement of existing drainage canals and construction of drainage lateral/sub-laterals

ii) Appurtenant works, which compose of construction of bridges for O & M and local transportation, sluices to prevent from river flood and foot bridges for farmings.

iii) Embankment for flood protection. (See Fig. 4-7 and 4-8)

iv) Improvement of drainage culverts to block the excess water comming from outside area.

Figure 4 - 1 Present Drainage System Map



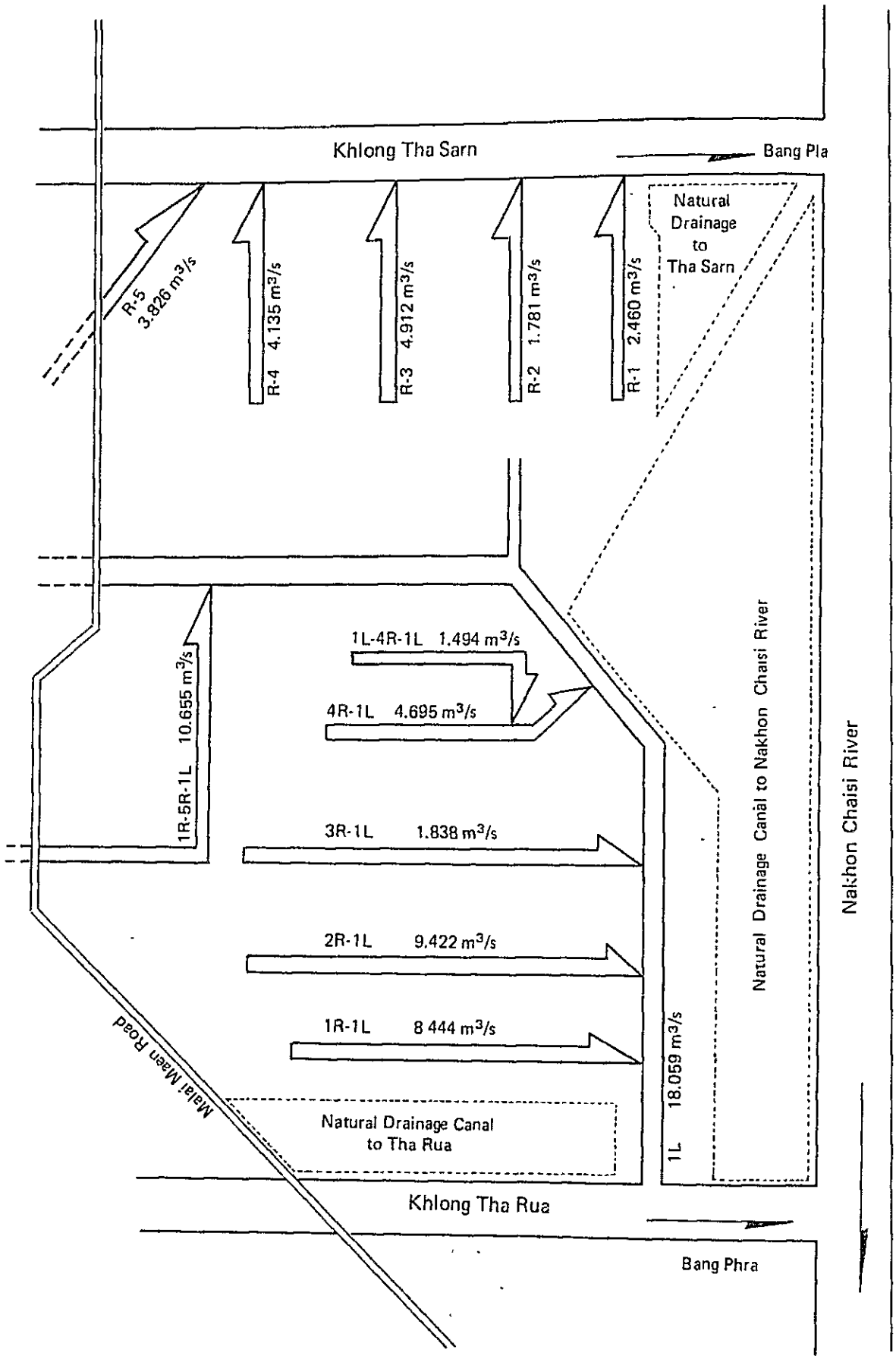


Figure 4 - 2 Systematic Diagram of Present Drainage System

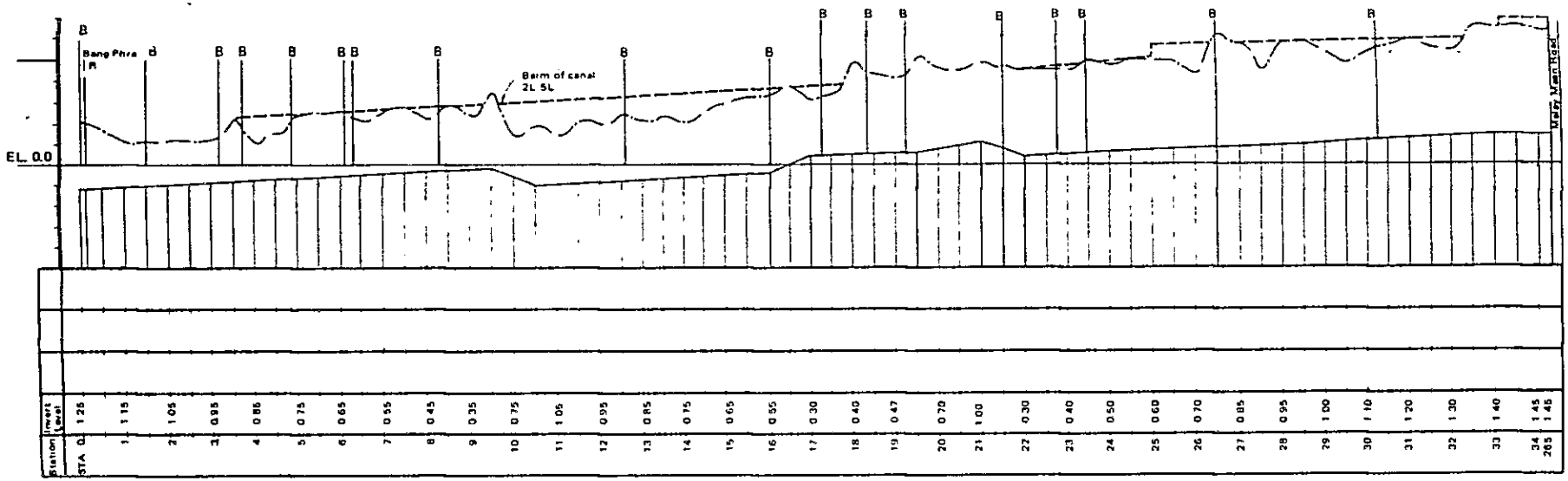


Figure 4 - 4 PROFILE OF KLONG THA RUA

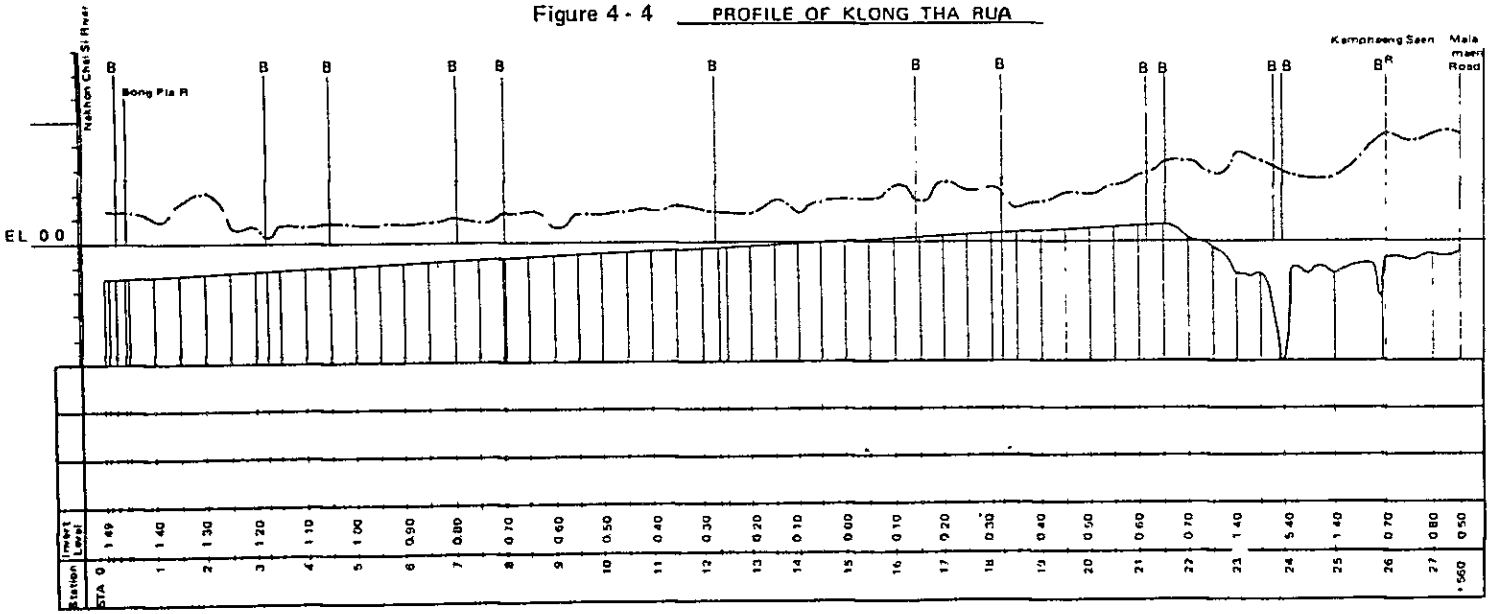


Figure 4 - 3 PROFILE OF KLONG THA SARN

LEGEND

R Regulator of Stop Log

B Bridge

VERTICAL SCALE 0 5 m

HORIZONTAL SCALE 0 1 2 2.5 km

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Table 4-1 Drainage Area for Each System and Channel by Ground Elevation

(Unit: ha)

CANAL NAME	SWAMP	< 1.5 m	< 2.0	< 3.0	< 4.0	< 5.0	< 6.0	< 7.0	8 <		Total
° Tha Sarn by IRD											
R-5	0	0	1	29	266	60	0	0	0		356
R-4	0	0	3	38	235	358	225	79	12		950
R-3	17	0	16	630	265	233	65	16	0		1,242
R-2	0	3	79	176	83	13	0	0	0		354
R-1	0	18	120	82	12	0	0	0	0		232
Total											3,134
° Natural Drainage Canal along Tha Sarn.											
K. Tam	0	0	4	184	251	145	115	23	0		722
K. Thug Karden Thong	33	1	81	302	35	8	0	0	0		460
K. Lam Maklem	0	0	28	38	6	0	0	0	0		72
K. Lam Kacho	0	43	159	60	5	0	0	0	0		267
K. Nong Prieo Nam	0	60	130	25	1	0	0	0	0		216
K. Nguhao	0	88	328	14	0	0	0	0	0		430
K. Bang Pla	0	57	195	31	0	0	0	0	0		283
K. Sam Chao Ama	0	578	388	71	0	0	0	0	0		1,037
K. Watko Raet	0	92	76	0	0	0	0	0	0		168
K. Bang Phasi	0	78	209	18	0	0	0	0	0		305
Total											3,960
° Natural Drainage Canal along Nakhon Chaisi River											
K. Bang Haosi	0	196	127	3	0	0	0	0	0		326
K. Khe	0	255	126	0	0	0	0	0	0		381
K. Lam	0	780	467	0	0	0	0	0	0		1,247
K. Bay Rakam	0	569	95	0	1	0	0	0	0		665
K. Rang Yao	0	1,100	113	0	1	0	0	0	0		1,214
Total											3,833
° Central Drainage Canal by IRD											
1R-5R-1L	2	0	0	10	570	1,011	535	75	2		2,205
5R-1L	28	69	320	520	432	298	367	148	27		2,209
1L-4R-1L	0	10	158	91	8	0	0	0	0		267
4R-1L	0	72	1,076	429	192	104	50	3	0		1,926
3R-1L	0	0	1	126	176	112	50	4	0		469
2R-1L	12	16	409	1,219	965	449	165	12	0		3,247
1R-1L	1	52	605	1,634	414	101	0	0	0		2,807
1L	0	593	903	688	71	0	0	0	0		2,255
Total											15,375
° Natural Drainage Canal by Tha Rua											
Tha Rua	0	132	357	505	189	225	107	119	54		1,688
Grand Total	93	4,852	6,574	6,923	4,178	3,117	1,679	479	95		28,000

Remarks; K: Khlong

Table 4-2 Drainage canal Demension in Project area

CANAL NAME	Length	Bottom Width	Depth	Side Slope	Capacity	Discharge area	Canal Slope	Invert elevation		Remarks	
	m	m	m		cum/s	sqm		m			
° Tha Sarn by IRD											
R-5	3,500	6.00	1.15	1 : 2.0	3.8263	9.545	1:10,000	1.949	Executed length = 0		
R-4	4,500	5.00	1.30	"	4.1345	9.880	"	1.700	Executed length = 0		
R-3	4,340	8.00	1.15	"	4.9119	11.875	"	0.600	Finished		
R-2	2,700	6.00	0.75	"	1.7811	5.625	"	0.250		"	
R-1	3,080	6.00	0.90	"	2.4603	7.020	"	-0.100		"	
Total											
° Natural Drainage Canal along Tha Sarn											
K. Tam	3,760										
K. Thug Karden Tho	1,000										
K. Lam Maklem	2,400										
K. Lam Kacho	2,000										
K. Nong Prieo Nam	2,880										
K. Nguhao	2,160										
K. Bang Pla	4,400										
K. Sam Chao Ama	4,160										
K. Watko Raet	2,400										
K. Bang Phasi	6,880										
Total											
° Natural Drainage Canal along Nakhon Chaisi River											
K. Bang Haosi	4,640										
K. Khe	5,200										
K. Lam	16,024										
K. Bay Rakam	4,832										
K. Rang Yao	16,416										
Total											
° Central Drainage Canal by IRD											
1R-5R-1L	10,500	12.00	1.45	1 : 2.0	10.6545	21,605	1:10,000	2.450	Finished		
5R-1L	16,140	15.00		"			"	0.050		"	
1L-4R-1L	3,600	2.50	1.00	"	1.4937	4.500	"	1.000	Executed length = 0		
4R-1L	4,950	4.50	1.45	"	4.6949	10.730	"	-0.635		"	
3R-1L	6,000	2.00	0.95	"	1.8376	3,705	1:2,600	1.025	Executed length = 1,500m		
2R-1L	10,200	8.00	1.65	"	9.4218	18.645	1:10,000	-0.450	Finished		
1R-1L	15,250	7.00	1.65	"	8.4437	16,995	"	-0.500		"	
1L	19,832	5.00	2.75	"	18.0586	28.875	"	-0.900		"	
Total											
° Natural Drainage Canal by Tha Rua											
Tha Rua	2,000										
Grand Total	185,744										

Remarks; K: Khlong

Tha Sarn	34,265	20.00	2.800	1 : 2.0	53.9607	71.680	1:10,000	-1.490	Spillway		
Tha Rua	27,560	20.00	2.400	1 : 2.0	53.9607	"	1:10,000	-1.250	Spillway		

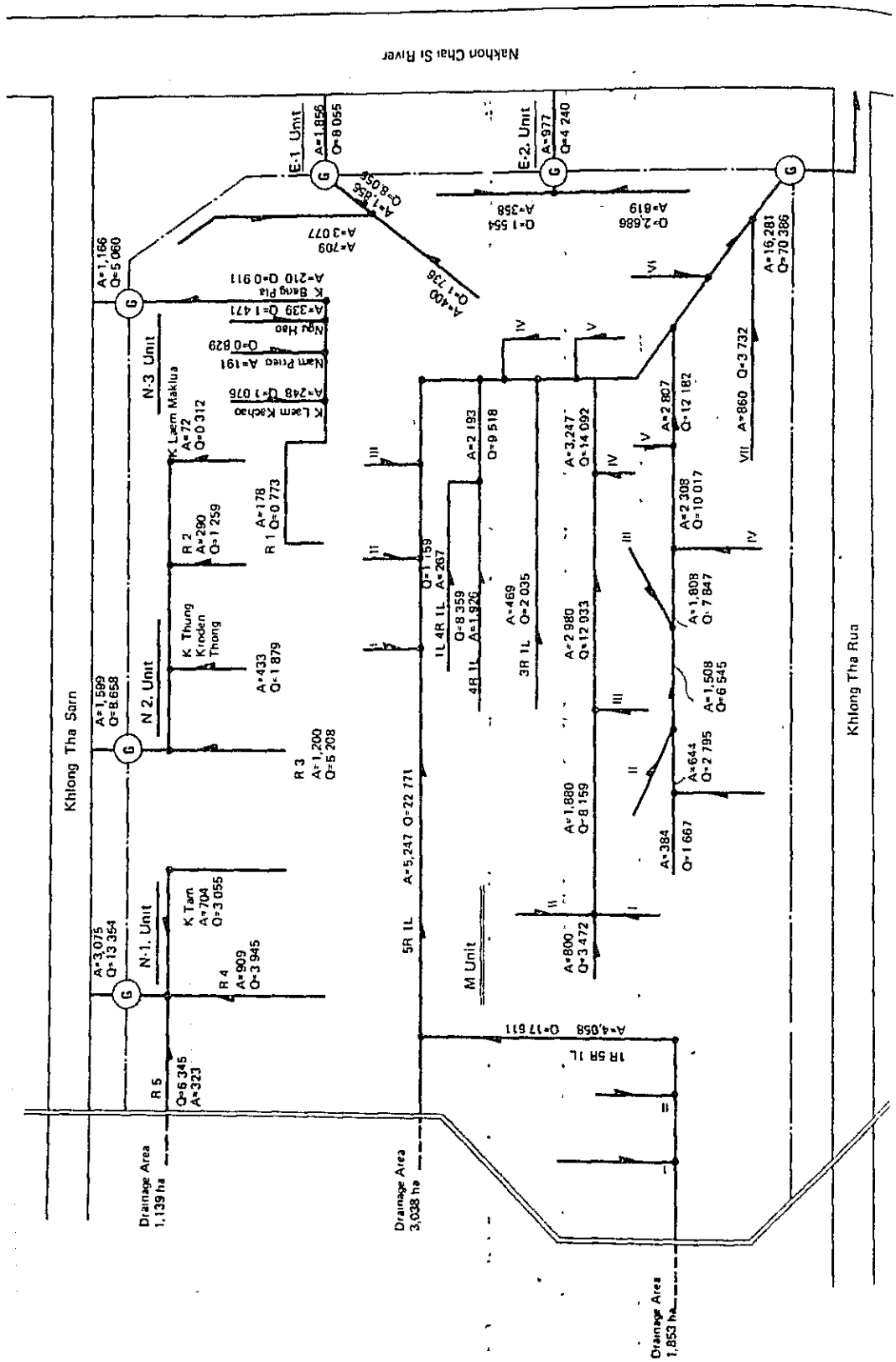


Figure 4 - 5 Systematic Diagram of Proposed Drainage System

Table 4-3 Daily Rainfall Record, Kamphaeng Saen, 1969

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	10.4	37.4	59.7	0.0
2	0.0	0.0	0.0	0.0	0.0	8.6	17.1	0.0	0.0	0.0	98.9	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.0	2.3	15.3	14.3	0.0
4	0.0	0.0	0.0	15.8	0.0	0.0	0.0	1.6	17.2	10.6	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	9.5	0.0	12.7	46.2	30.1	0.0	0.0
6	4.1	0.0	0.0	0.0	43.3	13.8	0.0	0.0	2.3	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	1.5	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	10.7	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	22.1	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	9.3	18.7	35.2	2.1	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	12.1	1.8	7.2	1.3	20.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	3.4	2.2	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	26.1	7.4	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	21.9	0.0	0.0	0.0	7.9	0.0	0.0	0.0
17	7.1	0.0	0.0	0.0	0.0	0.0	0.0	19.3	98.8	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9	55.3	0.0	0.0	0.0
19	2.3	0.0	0.0	0.0	0.0	0.0	2.6	0.0	33.9	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	3.2	18.6	37.6	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	8.0	0.0	0.0	14.6	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	1.1	14.1	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	2.1	12.5	0.0	18.2	0.0	0.0
27	0.0	0.0	0.0	0.0	9.6	0.0	0.0	0.0	0.0	9.9	0.0	4.8
28	0.0	0.0	0.0	9.2	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0
30	0.0		0.0	0.0	16.2	0.0	0.0	18.3	32.8	0.0	0.0	0.0
31	0.0		0.0		0.0		0.0	0.0		0.0		0.0
TOTAL	13.5	0.0	0.0	25.0	107.2	91.1	78.2	206.3	384.3	152.0	172.9	4.8

Annual Total 1,235.3

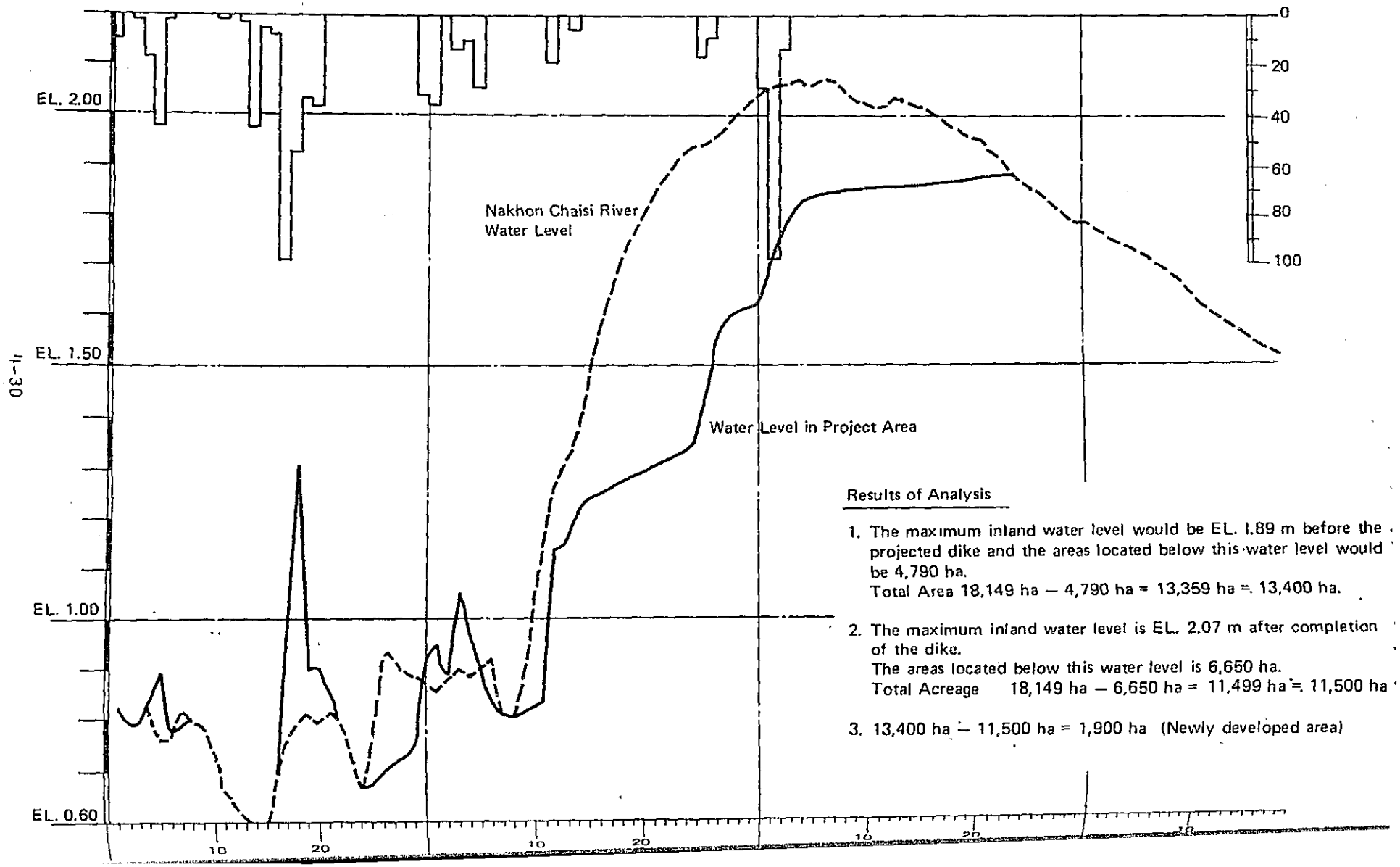
Table 4-4 Average Water Level of the Nakhon Chaisi at Bong Phra
- 1974 -

(Unit El. m)

Month / Date	6	7	8	9	10	11	12	1
1	0.13	0.24	0.45	0.82	0.85	2.05	1.78	1.29
2	0.13	0.18	0.40	0.79	0.88	2.06	1.76	1.25
3	-0.08	0.06	0.27	0.78	0.90	2.06	1.75	1.22
4	-0.02	0.07	0.27	0.82	0.88	2.07	1.74	1.18
5	-0.04	0.08	0.55	0.76	0.90	2.06	1.73	1.14
6	-0.10	0.05	0.49	0.76	0.91	2.07	1.72	1.09
7	-0.11	-0.04	0.64	0.81	0.80	2.07	1.70	1.05
8	-0.13	0.02	0.63	0.79	0.80	2.05	1.69	1.06
9	-0.05	-0.01	0.58	0.79	0.89	2.03	1.68	1.05
10	0.05	-0.14	0.52	0.75	1.04	2.02	1.65	1.01
11	-0.08	-0.20	0.39	0.66	1.15	2.02	1.63	0.99
12	-0.30	-0.10	0.18	0.64	1.27	2.02	1.63	0.96
13	-0.28	-0.23	0.11	0.61	1.33	2.04	1.61	0.92
14	-0.22	-0.19	0.002	0.50	1.37	2.03	1.60	0.88
15	-0.12	-0.01	-0.14	0.51	1.46	2.02	1.58	0.84
16	0.05	0.05	-0.26	0.67	1.56	2.01	1.57	0.77
17	0.08	-0.06	0.04	0.76	1.63	2.00	1.56	0.77
18	0.22	-0.02	0.23	0.79	1.70	1.98	1.54	0.82
19	-0.03	-0.11	0.28	0.81	1.75	1.97	1.52	0.82
20	0.15	-0.14	0.26	0.79	1.80	1.06	1.51	0.78
21	0.11	-0.16	0.34	0.81	1.83	1.96	1.49	0.76
22	1.25	0.71	0.38	0.80	1.26	1.93	1.47	0.79
23	0.23	1.25	0.50	0.74	1.89	1.91	1.44	0.77
24	0.25	0.12	0.48	0.66	1.92	1.88	1.42	0.83
25	0.23	0.64	0.47	0.73	1.93	1.86	1.38	0.91
26	0.20	0.68	0.38	0.92	1.95	1.84	1.38	0.77
27	0.27	0.67	0.37	0.93	1.95	1.83	1.38	0.71
28	0.62	0.61	0.44	0.89	1.98	1.81	1.35	0.61
29	0.13	0.51	0.48	0.83	2.00	1.79	1.32	0.58
30	0.36	0.54	0.74	0.87	2.02	1.79	1.32	0.63
31	-	0.68	0.69	-	0.23	-	1.32	0.58

Indicates the estimated value based on the corelationship with the level at Bong Pla

Figure 4 - 6 Analysis of Drainage Conditions on Kamphaeng Saen Drainage Area



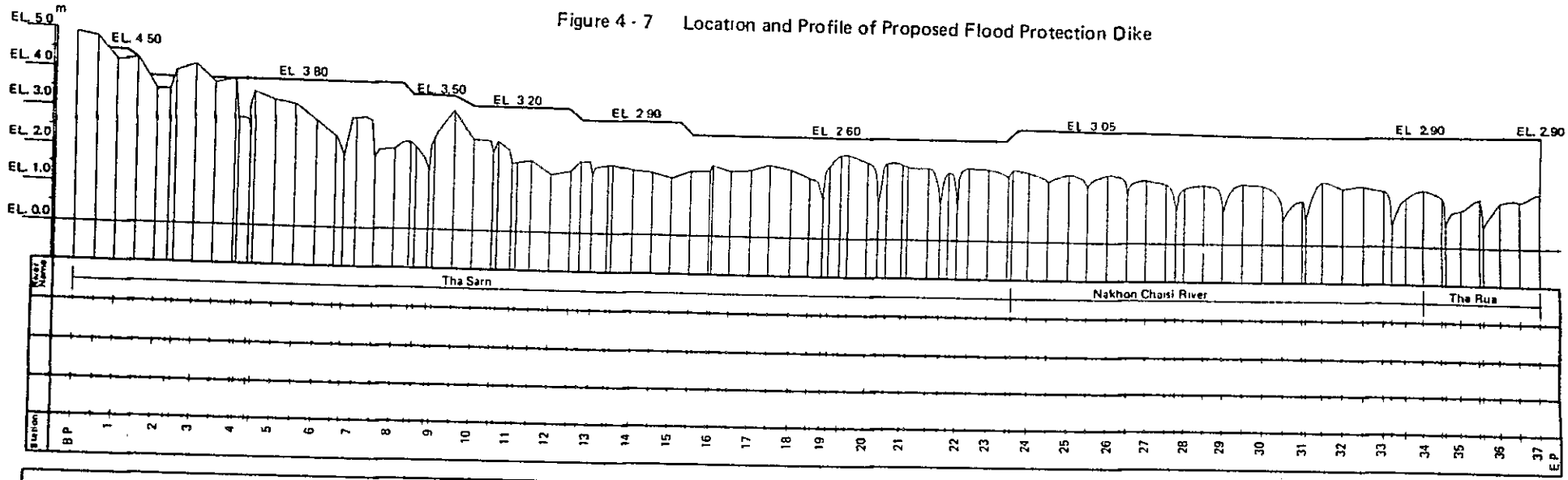
Results of Analysis

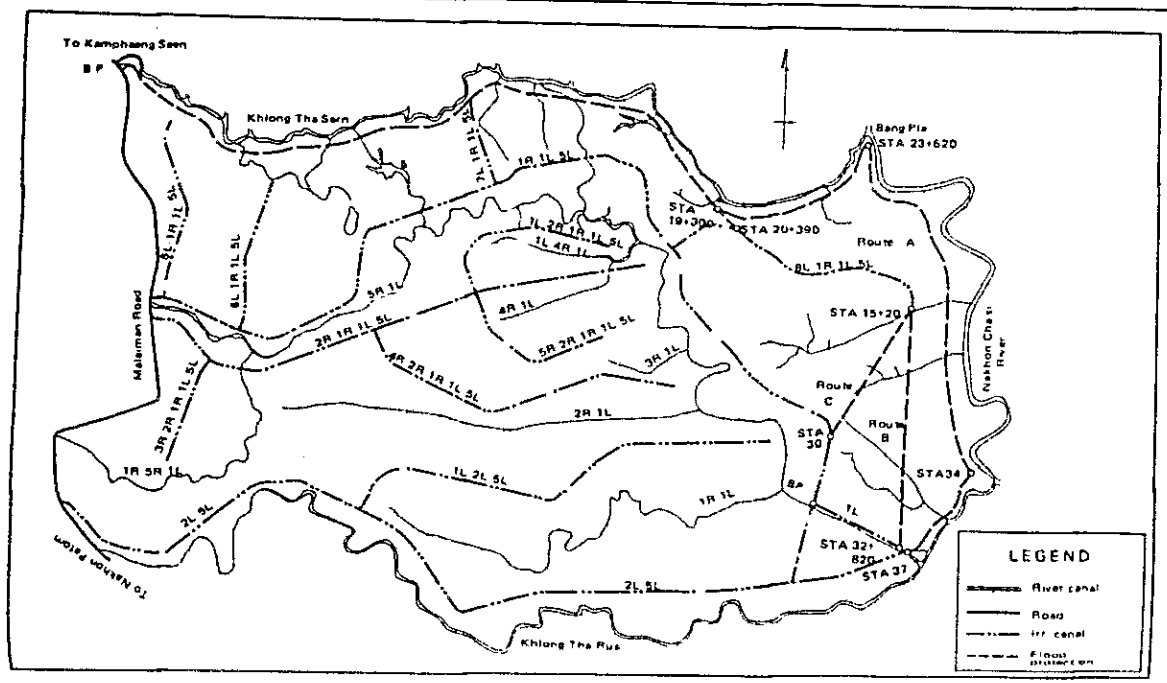
1. The maximum inland water level would be EL. 1.89 m before the projected dike and the areas located below this water level would be 4,790 ha.
   Total Area 18,149 ha — 4,790 ha = 13,359 ha ≒ 13,400 ha.
2. The maximum inland water level is EL. 2.07 m after completion of the dike.
   The areas located below this water level is 6,650 ha.
   Total Acreage 18,149 ha — 6,650 ha = 11,499 ha ≒ 11,500 ha
3. 13,400 ha — 11,500 ha = 1,900 ha (Newly developed area)

Table 4-5. List of Proposed Works For Drainage System Improvement

Work Items	Channels' works		Appurtenent works constructed			Embankment	Closed Culverts
	Improved	Constructed	Bridges	Sluices	F.Bridges		
Channel improvement	(m)	(m)	(Nos.)	(Nos.)	(Nos.)	(m)	(Nos.)
N-1	12,312	2,240	1	1	19	-	-
N-2	7,300	3,560	-	1	14	-	-
N-3	5,600	4,240	-	1	13	-	-
1R-5R-1L	10,500	4,100	-	-	19	-	-
5R-1L	16,140	2,400	2	-	22	-	-
4R-1L	8,710	-	-	-	11	-	-
3R-1L	-	6,000	-	-	8	-	-
2R-1L	12,880	5,050	2	-	21	-	-
1R-1L	15,250	9,700	2	-	30	-	-
1L	19,634	6,450	-	1	-	-	-
E-1	-	9,130	-	1	12	-	-
E-2	-	15,400	2	1	15	-	-
sub-total	108,326	68,270	9	6	184	-	-
Flood protection works	-	-	-	1	-	32,820	15
Total	108,326	68,270	9	7	184	32,820	15

Figure 4 - 7 Location and Profile of Proposed Flood Protection Dike





PROFILE OF ROUTE "A"

VERTICAL SCALE 0 1 2 3 4 5 m

HORIZONTAL SCALE 0 1 2 3 4 5 km

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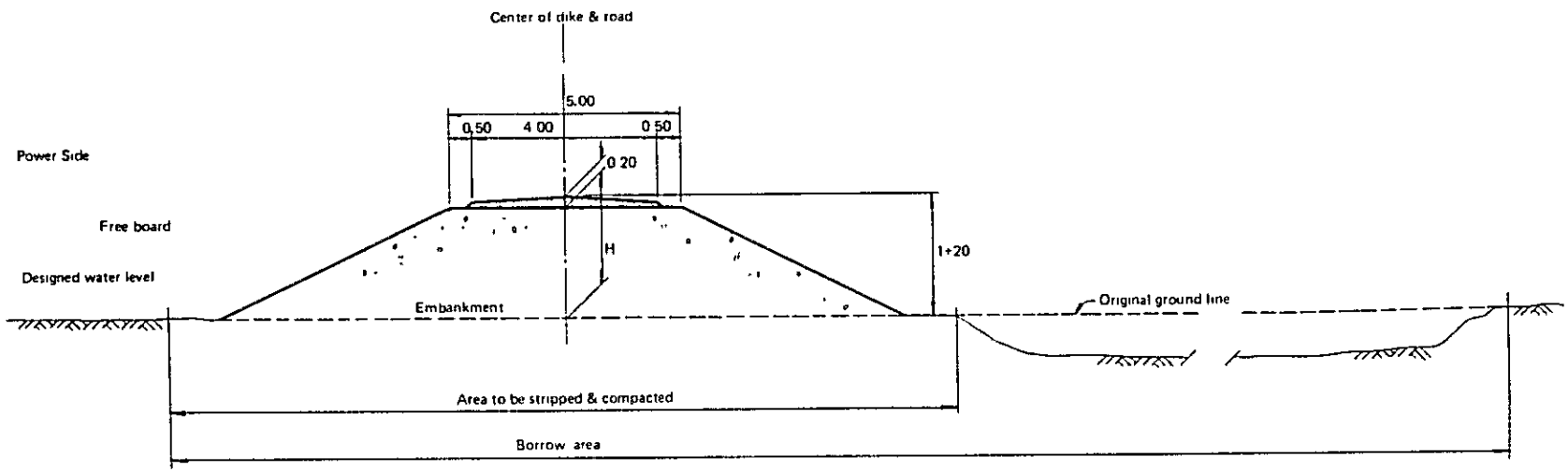
Figure 4 - 8 Typical Cross Section of Proposed Dike

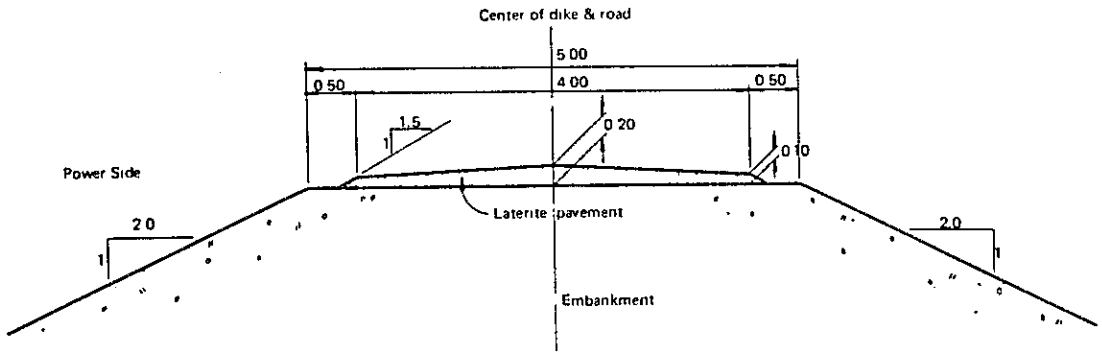


Typical Section

SCALE

M

0 1 2 3 4 5



Detail of Dike Crown

SCALE

0 1 2 3

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APPENDIX 5

ON-FARM FACILITIES

ON-FARM FACILITIES

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ON-FARM FACILITIES

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ON-FARM FACILITIES

5-1. Existing On-Farm Facilities

(1) Farm Ditch

The Ditches and Dikes Project was initiated in the Area in 1969 and farm ditches with a total length of 304 km were constructed. The farm ditches were provided as a measure to expand irrigation water distribution to a large area at lower cost, and have had effect on the area to a certain extent. However, in order to ensure an improved agriculture in the area by HYV cropping, double paddy cropping etc., the major improvement required are listed as below.

- Sparsity of farm ditches (average 10.9 m/ha), consequently, most farm plots to be irrigated by the plot-to-plot method.
- Unsuitable alignments that left some areas uncommandable, and caused irregular distribution of water, resulting in floods in some fields and water shortage in others in the same unit.
- Inaccurate zoning of service units due to lack of detailed potographic information, simpleness in layout of ditches in straight at 300 - 400 m intervals as well as unfirmly established commandable area by respective service units, and inadequacy in the ditch section to the commanding areas.
- Improper O & M which has resulted in many collapses on the ditches; particularly on the ditches crossing borrow areas along the canals.
- Difficulty in effective water control in some farm ditches that are longer than 2 km, and in proper water distribution by branching minor ditches without control facilities.

(2) Drainage Facilities and Farm Roads

Drainage on farm level has been provided with few facilities available, which might resulted from the fact that efforts had been

made by farmers only to store the water for irrigation. Under such conditions, the low-lying areas is obliged to be cropped with broadcasting paddy. The main drainage canals have been constructed by RID, but additional construction of laterals and farm drains is needed to connect with the main canals for improvement of water management.

The Area provides no access to the farms. The farmers use as farm roads only the O & M roads along the irrigation canals and the district roads connecting hamlets each other. The construction of farm roads along the farm ditches is necessary to improve the accessibility for farming works (Table 5-3).

(3) Farm-size and Shape

The survey of the Sample Area selected for this study revealed that the size of farm plot is mostly 2 - 3 ha, being found 0.4 ha at minimum, and that most farm plots were shaped in rectangle with varying in length of run from 250 to 350 m. In general the farm plot is composed of several sub-plots of which the area varies between 0.06 ha and 1.6 ha. These sub-plots are the units for farming practice and water management (Table 5-1 and Fig. 5-1).

(4) Existing facilities in Sample Areas

Items surveyed

During the course of field survey, though cadastral data and survey period are rather limited, sample areas for on-farm development were selected so as to determine the standard for development, method and the construction cost required. The results derived from the sample area survey shall be fully referred in estimating the total construction cost for implementing the on-farm development in the Project Area (Table 5-2).

Conditions which is deemed important in studying the Sample Areas are as follows.

- Topography: Elevation, slope and undulation

- Irrigation and Drainage: Locational conditions on main irrigation/ drainage systems, diversion water level of main system and affect by external water

- Land Use: Paddy fields, sugarcane fields, dry season cropping, wet season cropping and double cropping

- Land tenure and plot size: Owner/operator, tenant and plot size/shape

During the field survey, the Project Area was divided into three parts of lower (L), middle (M) and higher (H), and ten (10) sample areas were selected for study (Fig. 5-3).

General description

- Sample areas L-1, L-2, and L-3

  Topography: flat low land, slope - 1/1,000 - 1/5,000. Elevation - lower than 2.0 m (mostly lower than 1.5 m)

  Land Use: Paddy field mainly for dry season cropping

  Irrigation/ drainage: L-1 & L-3 areas are directly covered with main system but L-2 is not. Inundated by flood water from the Nakhon Chaisi river.

- Sample Areas M-1, M-2, M-3, M-4

  Topography: comparatively complicated with undulation, slope - more than 1/1,000. Elevation - 2.0 - 3.0 m Swamps are scattered.

  Land Use: mainly paddy fields with some sugarcane fields. Wet season paddy cropping and dry season paddy cropping are mixed up.

  Irrigation/ drainage: directly covered with main system. Inundation is observed in lower parts.

- Sample areas H-1, H-2, H-3

Topography:	complicated with considerable undulation/ rolling, slope - more than 1/1,000 elevation - 2.0 - 5.0 m, Swamps are scattered.
Land Use:	mainly sugarcane fields with some paddy fields
Irrigation/ drainage:	directly connected with main system. No problem in drainage.

Land tenure and plot size

Conditions on land tenure and plot size/shape are different from one Sample Area to another. As for the land tenure, owner/operator is more in the higher areas and less in the lower areas. Plot size (land property) is larger in the flat low land area and getting smaller as it goes to higher part (Fig. 5-2).

5-2. On-farm Development

(1) General

For upgrading agricultural productivity through introducting of HYV varieties, enlargement of double cropping area, crop diversification and improvement of technical infrastructures at on-farm level is vitally important. To this end, technical countermeasures at on-farm level should be planned and implemented in conformity with the close relation-ship with the farming practices projected, but not independently.

In the Project Area, main irrigation and drainage systems have been completed and irrigation water for dry season cropping would be released from the Sri Ngarind reservoir in the near future. In view of the agriculture in the area, several developments have been observed recently, i.e. expansion of dry season transplanting paddy farming instead of wet season broadcasting paddy farming, considerable extension of double cropping of paddy where is favored

with better irrigation and drainage conditions and mechanized plowing and harrowing.

On-farm development work differs from the other type of public works in the point that farm lands owned by particular individuals are to be improved by the public works. Therefore, there would be a variety of beneficiaries related with the project. In some cases, there might be some conflicts between the upperstream area and the lowerstream area and also between paddy planters and sugarcane planters. As is the case, better understandings by farmers on the project to be implemented should be fully secured, and necessary guidances and trainings for farmers are to be duly accomplished for this purpose. In this connection, it is considered that any planning and implementation of on-farm developments should be further progressed based on the well-coordinated program by the agencies concerned with the initiative by the government, but reflecting the farmers' opinion as much as possible.

(2) Technical measures

Improvement of physical infrastructures at on-farm level consists of the parts or all of the followings.

i) construction of minor irrigation and drainage systems which can be controlled in accordance with the necessity in water management

ii) Construction of roads for the purposes of O & M and efficient farming practices

iii) Land levelling aiming at improvement of water control capability

iv) Reparcelling of farm plots for higher water management practices and more efficient farming practices

(3) Types of on-farm development

In referring to the present conditions prevailed in the Project

Area, past experiences in on-farm development in other areas in Thailand and the current government's policy, the following three (3) types of on-farm development have been worked out during this term of field works. (ref. Fig. 5-6, 5-7, 5-8)

Type	Description

A: At least 70 percent of the area, for which this type of development will be applied, will be directly connected with farm ditches and drains. While at the maximum, 30 percent of the area is obliged to be supplied with irrigation water by so-called plot-to-plot irrigation. Farm ditches, drains and farm roads will be provided along the existing boundaries. No land levelling is needed in this type of development.

B: Every farm plot will be connected directly with farm ditches, drains and farm roads though plot rearrangement is to be undertaken only when required. Farm ditches, drains and farm roads will be in principle located along the existing boundaries and in some cases such facilities would cross the existing farm plots when required, in which plot rearrangement will be necessary. Land levelling is to be carried out just for aiming at easier water control at farm level.

C: Technically, this type provides the highest standard of on-farm facilities. Every farm plot will be provided with farm ditches, drains and farm roads. Plot will be rearranged to be in rectangular shape through land levelling and replotting.

Criteria for development planning

On-farm development plans complying the above-mentioned three (3) types of improvement will be implemented in accordance with the following criteria.

Type A

i) Production target: HYV can be introduced for 50 percent of the area. Target yield is 3.3 ton/ha.

ii) Plot arrangement: No replotting is carried out.

iii) Farm ditches: Located on the existing boundary lines, in principle farm drains will be extended to command four (4) plots at the terminal point. Interval between farm ditch and drain will be 400 m at the maximum. There might be some plots situated higher than FSL of farm ditches. (Pumping irrigation may be required.)

iv) Farm drains: Located on the existing boundary lines, in principle, farm drains will be extended to cover four (4) plots at the terminal point.

v) Farm roads: To be located along farm ditches with the width of 3.0 m.

vi) Land levelling: No levelling will be undertaken.

Type B

i) Production target: HYV will be introduced to 80 percent of the area for target yield at 4.3 ton/ha.

ii) Plot arrangement: Replotting will be made only when necessary. In case the plot is crossed by ditches, replotting is required.

iii) Farm ditches: To be located, in principle, on the existing boundary lines. Interval of farm ditch with farm drains shall be 200 m at the maximum. FSL will be at least 10 cm higher than plot elevation.

iv) Farm drains: In principle, located along the existing boundary lines. Designed high water level be same with that of plot elevation.

v) Farm roads: Located along the existing boundary lines. The width will be 3.0 m and the road surface will be 30 - 50 cm higher than plot elevation.

iv) Land levelling: No levelling for replotting purpose. Levelling can be made just for betterment of water control at farm level. When earth moving volume is much, a plot will be divided into several sub-plots.

Type C

i) Production target: HYV will be introduced to 100 percent of the area for target yield at 4.8 ton/ha.

ii) plot arrangement: Standard size is 160 m x 50 m (5 rai). Farm ditches and drains will be located alternately for every 160 m distance. Replotting will be necessary.

iii) Farm ditches: Located along the shorter side of plot. The maximum length is 750 m. FSL will be 25 cm higher than plot elevation.

iv) Farm drains: Located along the shorter side of plot. Designed high water level be same with that of plot elevation.

v) Farm roads: To be located along farm ditches. The width will be 3.0 m and the road surface will be 30 - 50 cm higher than plot elevation.

vi) Land levelling: Plot elevation will be so designed that downstream areas are lower than upper

stream areas along farm ditches. In case earth moving volume is rather big due to complicated topography, a plot is divided into several sub-plots (40m x 50m). Accuracy for land levelling will be ± 10cm or less. (Through land preparation by using hand tractors, accuracy can be improved to ± 2.5 cm level.

Design of Sample Areas

-- General descriptions

Ten (10) sample areas were selected in totaling 2,619 ha in gross, which contain;

Low-lying flat lands	(3 areas)	L-1, -2, -3
Medium elevated lands	(4 areas)	M-1, -2, -3, -4
High elevated lands	(3 areas)	H-1, -2, -3

The above 10 sample areas were studied on their topography, land tenure, land use, plot conditions, to be classified into three (3) types by design criteria, Type-A, -B and -C, and grading for land consolidation, construction method and the costs were decided therefrom.

-- Designed area and land consolidation method

The designed area for land consolidation is 2,399 ha by deducting about 220 ha of residential areas and others from the gross area of 2,619 ha. (See Table 5-2)

The ten sample areas were classified into three as above types for grading of land consolidation and the costs required; they were respectively applied as Type-A for low-lying flat lands, Type-B for medium elevated lands, and Type-C for high elevated lands.
(See Figure 5-6, 5-7, 5-8)

-- Density of road/canal networks and deduction rate

The captioned rates in the Sample areas are shown in the following table.

Density of Road/Canal Networks (See Table 5-3)

	Road (m/ha)	Irri. Canal (m/ha)	Drain. Canal (m/ha)	Lost Land Rate (%)
Type A	42	52	29	3.7
Type B	75	89	48	6.9
Type C	76	85	46	6.2

Note: The values quoted above indicate those at maximum in designing for the respective sample areas.

-- Design of section for farm ditches

The necessary farm ditch capacity is determined by the following formula to meet the requirement of the commanding areas.

$$Q = \frac{A^{ha}}{N} \times \frac{d_1{}^{mm/day} \times 10^{-3} \times 10^4}{86{,}400 \times \alpha} + \frac{N\text{-}1^{ha}}{N} \times \frac{d_2{}^{mm/day} \times 10^{-3} \times 10^4}{86{,}400 \times \alpha} \quad (m^3/sec/ha)$$

Where; A: Commanded areas by farm ditches (ha)

d_1: Water for land preparation

d_2: Water requirements during land preparation (mm/day)

α: Field loss (0.70)

N: No. of Days for land preparation

- Number of Days for land preparation and unit water requirement.

The following table shows the standard of the days for paddling and unit water requirements.

Irrigation Area (ha)	No. of days for Land Prep. (days)	Unit Water Requirement (m^3/sec)
under 50	20	q = 0.002633 A
51 - 100	30	q = 0.002098 A
101 - 150	40	q = 0.001831 A
over 151	60	q = 0.001564 A

-- The design of section for farm drains

The unit drainage discharges are decided at 37.5 mm/day for paddy fields (4.14 l/s/ha) and 74.8 mm/day (8.66 l/s/ha) for others, respectively.

(4) On-farm development plan

The gross project area of 28,000 ha can be divided into the following four (4) zones in accordance with the topographic condiions, present land use, land tenure and so forth. (ref. Fig. 5-3, 5-4)

i) Higher part-sugar cane zone:	EL 3.0 - 7.0 m Higher rate of owner/operator
ii) Higher part-paddy/sugar cane mixed zone:	EL 3.0 - 5.0 Higher rate of owner/operator (80 - 100%) Averaged plot size at 1.4 - 1.7 ha
iii) Middle part-paddy zone:	EL 2.0 - 3.0 m Rate of owner/operator at 70 - 80%, Sugarcane is cultivated only partially. Averaged plot size at 1.5 - 1.7 ha
iv) Lower part-paddy zone:	EL 1.0 - 2.0 m Flat low land. Lower rate of owner/operator at less than 50%. Regularly inundated by flood water from the Nakhon Chaisi river.

For the above four (4) zones, development plan shall be finally worked out based on the following basic concepts.

ZONE i) Type A will be applied for sugarcane area. The road is to be designed width enough for traffic of stake trucks for transporting harvested sugarcane.

ZONE ii) Separated irrigation/drainage system will be provided for sugarcane area and paddy field area. Type A is applied for sugarcane area is the same way as the zone i). For the paddy field areas which are not affected by flood water from the rivers, type C will be applied. For those affected by flood water type A is considered.

ZONE iii) For the areas not affected by flood water from the rivers, type C or type B will be applied. For the areas affected by flood water, type A will be applied.

ZONE iv) For the areas which can be protected from flood water after construction of protection dike, type B will be applied. For the areas flood water form the river brings about inundation, type A will be applied.

5-3. Implementation Program and Costs

(1) Components of On-Farm Works

The on-farm development includes the following components.

Pegging and surveying
Land clearing
Construction of farm roads and ditches
Construction of farm drains
Land levelling
Construction of structures
Site clearing

(2) Major Construction Equipment

The major construction works and the necessary machinery for their implementation for tabulated as follows:

Land cleaning ------- Bulldozers 140 Hp (15 ton) Earth Moving

Construction of farm road & ditches
- Scrape-dozers 6.4 m^3 Earth Moving
- Bulldozers 140 Hp (15 ton) Embankment
- Roadrollers 69 Hp (8-10 ton) Compaction

Construction of farm drains ------ Power-shovels 87 hP - 143 Hp Excavation

Land levelling
- Bulldozers 140 Hp
- " 140 Hp (Marsh-type)
- " 183 Hp
- Motor-graders 110 HP

(3) On-Farm Development Area

The areas of each on-farm development were worked out taking into account topographical conditions, land tenure, farmers' willingness on the land development, economic analysis (see Table 5-5), etc., as follows:

Category	Type	Development Area Present (ha)	Development Area After Project (ha)	Remarks
Paddy Fields	A	2,655	2,560	Deduction rate 3.6% (95 ha)
	B	11,675	11,070	" " 5.2% (605 ha)
	C	1,650	1,550	" " 6% (100 ha)
Sub-total		15,980	15,180	" " 5% (800 ha)
Sugarcane Field	A	1,220	1,200	" " 1.5% (20 ha)
Total		17,200	16,380	" " 4.8% (820 ha)

(4) Costs for Each Type of Development Level

The costs for each type of development level by construction mode, force account and contract bases, are shown as follows:

Cost for Each Development Level Type

(Unit: ฿/ha)

Type	Construction Method	COST				
		Earth Works	Facilities	Levelling	Others[1]	Total
For Paddy Field						
A	Force account	4,983	3,284	-	-	8,267
	Contract	6,265	3,284	-	1,031	10,580
B	Force account	6,719	4,047	-	-	10,766
	Contract	8,484	4,047	-	1,359	13,890
C	Force account	7,527	4,598	8,374	-	20,499
	Contract	9,577	4,598	11,654	2,841	28,670
For Sugar-cane Field						
A	Force account	4,253	2,044	-	-	6,297
	Contract	5,460	2,044	-		8,320

/1 --- This costs compose of additional management fee, profit and taxes for contractor which are not included in unit costs.

(5) Disposition for Substitute Plots in Case of Type C Development

A farm plot would be rearranged into the standard size of 50m x 160m (5 rai) in case of type C on-farm development plan. This standard size is a reasonable size for farming as well as minimized land levelling costs. Therefore, land owner would have some of standard size plots in case that his owned land is more than 5 rai. This standard size would be rearranged shorter side into a certain length based on area of land owner. These procedure are shown in Figure A-10. Table 4-6 and 4-7 are shown relationship of owned land between before and after land consolidation works.

Table 5-1 Present Land Use and Land Owner-Ship in Sample Areas

Sample Area	Farm Elevation MSL (m)	Sample Area Gross ha	Sample Area Net ha	Present Land Use (%) W.R.	D.R.	D.C.R.	SUG	G.L.	W.L.	Land Owner-Ship Number of Persons	Component (%) OF	LO	T	PT	OFLO	Component of Land (%) Owned	Leased	Available Water Level of Irrigation MSL (m)
L-1	2.40-1.10	287.8	284.2	98.6	-	-	-	1.3	0.1	136	48.5	22.1	25.7	0.7	2.9	59.1	40.9	2.40
L-2		283.7	272.9	-	88.0	-	-	8.7	3.3	179	48.0	31.3	16.8	2.8	1.1	53.9	46.1	-
L-3		248.0	241.5	-	87.6	-	-	-	12.4	118	36.5	31.4	23.7	5.9	2.5	54.5	45.5	
		819.5	798.6	32.9	58.5	-	-	3.3	5.3	433	44.3	28.3	22.1	3.1	2.2	55.8	44.2	
M-1	2.75-1.70	247.2	176.2	31.8	16.5	44.4	3.7	1.4	2.2	116	79.3	8.6	6.9	2.6	2.6	86.3	13.7	3.63-1.75
M-2		377.1	313.7	8.9	75.0	7.2	0.6	6.2	2.1	230	59.1	16.5	17.4	3.5	3.5	68.5	31.5	
M-3		393.4	366.7	6.3	4.8	70.4	9.7	3.3	5.5	239	67.8	13.8	11.7	5.4	1.3	77.5	22.5	
		1,122.4	958.3	12.1	24.1	45.0	13.1	2.7	3.0	648	62.7	16.1	14.1	3.7	3.4	75.7	24.4	
H-1	6.65-2.10	220.7	212.3	0.1	-	36.2	61.8	1.7	0.1	153	79.1	9.1	9.8	1.3	-	84.4	15.6	4.39
H-2	6.10-3.00	115.3	102.5	-	-	63.9	36.1	-	-	54	100	-	-	-	-	100	-	5.61
H-3		341.0	327.0	5.0	-	43.3	46.6	4.8	0.3	152	61.8	15.1	16.5	4.6	2.0	75.8	24.2	
		677.0	641.8	1.7	-	47.8	48.2	2.2	0.1	359	80.3	8.2	8.8	2.0	0.7	86.7	13.3	
		2,618.9	2,398.7							1,440								

Note: W.R. Wet Season Rice
D.R. Dry Season Rice
D.C.R. Double Cropping Rice
SUG Sugarcane
G.L. Grass Land
W.L. Waste Land

OF Owner Farmer
LO Land Owner
T Tenant
PT Partial Tenant
OFLO Owner Farmer/Land Owner

FIG. 5-1 PRESENT LAND USE AND LAND OWNERSHIP IN SAMPLE AREAS

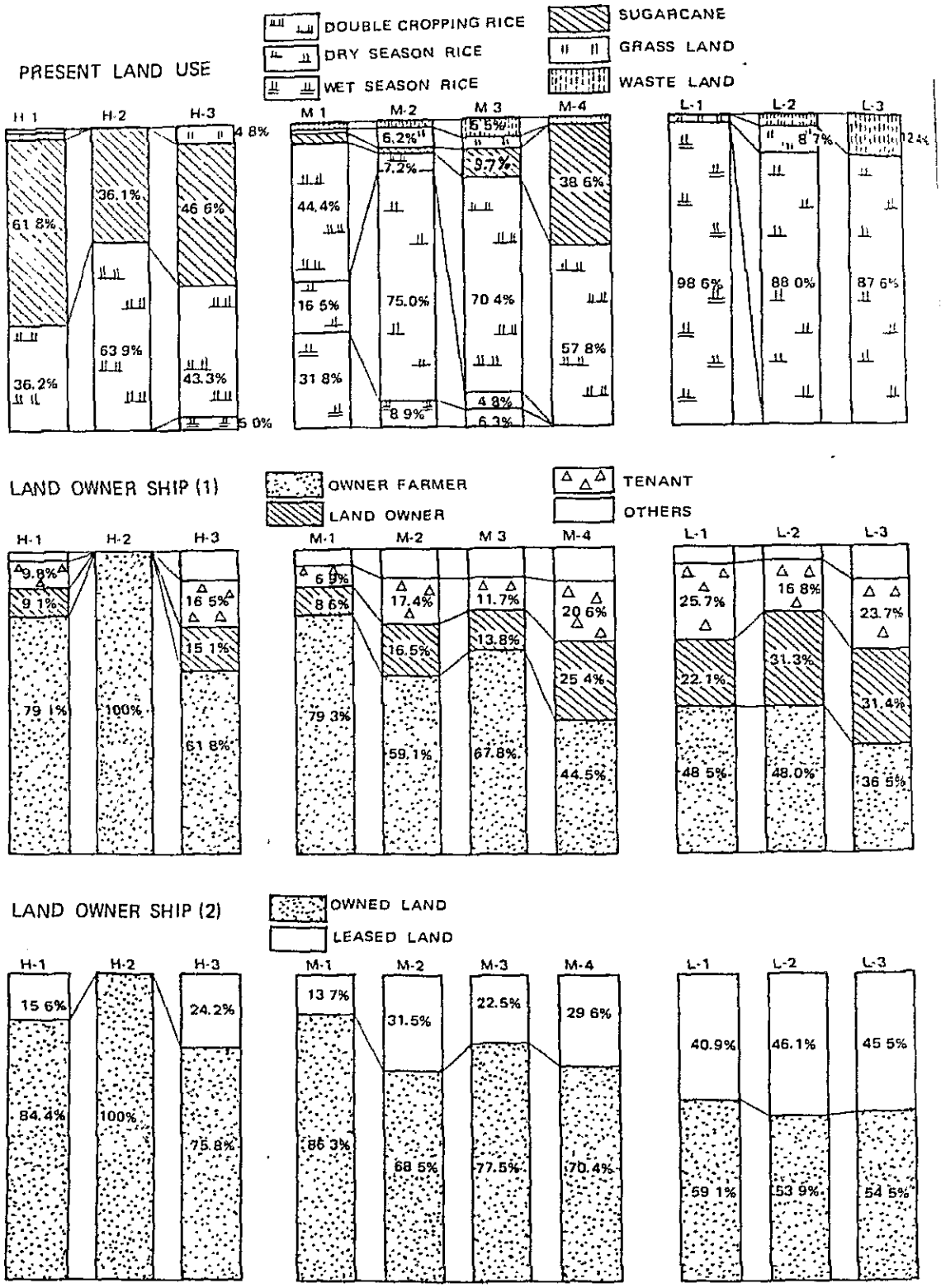
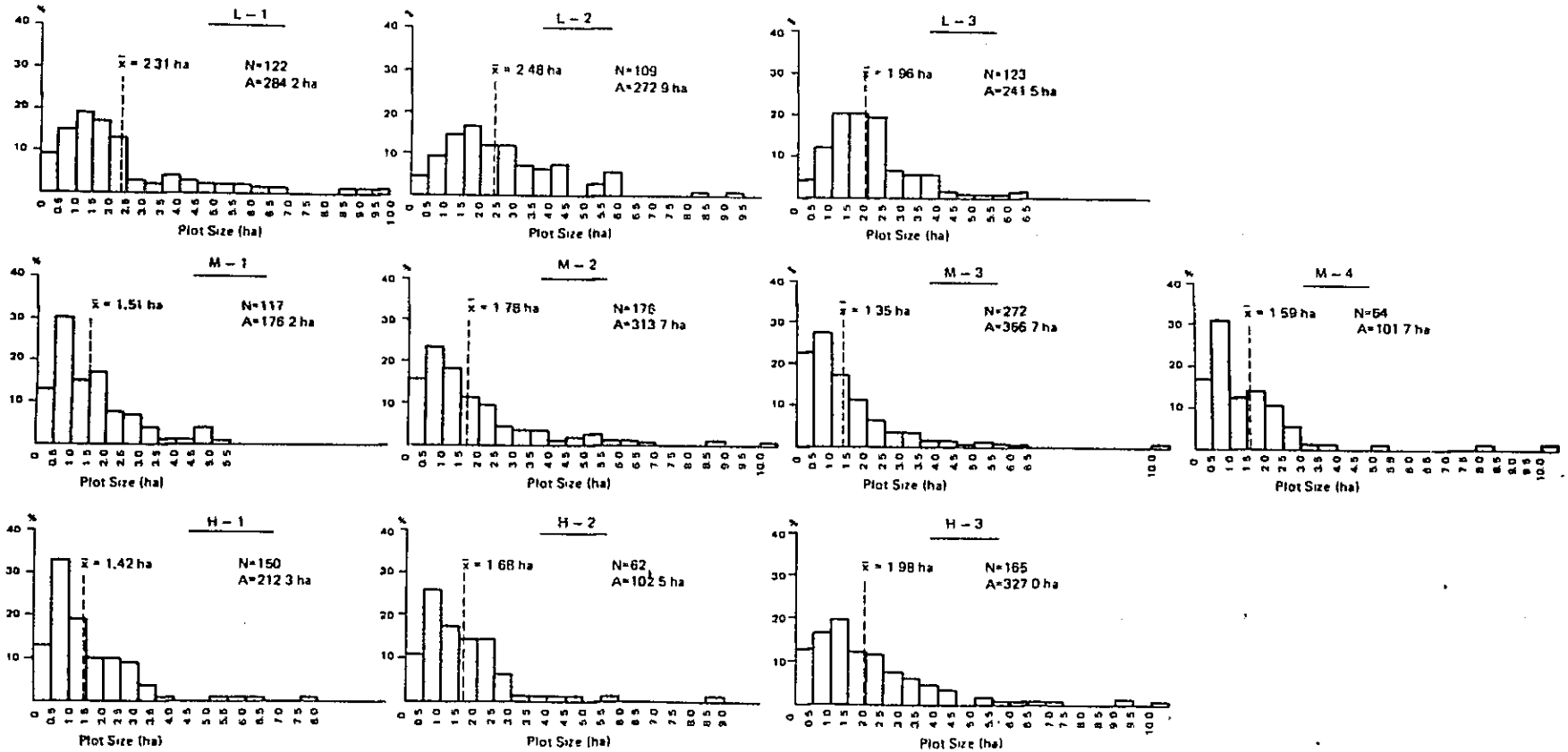


Table 5-2 Areal Survey for Sample Areas

Sample Areas	Acreage (ha)	Farm Land (ha)	Others (Residential Lots & Others) (ha)	Components of Fram Lands: Paddy Fields (ha)	Components of Fram Lands: Sugarcane Fields (ha)
H-1	220.7	212.3	8.4	81.1	131.2
H-2	115.3	102.5	12.8	65/5	37.0
H-3	341.0	327.0	14.0	174.8	152.2
M-1	247.2	176.2	71.0	169.7	6.5
M-2	377.1	313.7	63.4	311.7	2.0
M-3	393.4	366.7	26.7	331.1	35.6
M-4	104.7	101.7	3.0	62.4	39.3
L-1	287.8	284.2	3.6	284.2	-
L-2	283.7	272.9	10.8	272.9	-
L-3	248.0	241.5	6.5	241.5*	-
Total	2,618.9	2,398.7	220.2	1,994.9	403.8

*241.5 - 167 = 74.5

Figure 5-2 Histogram of Farm Plot Size by Ownership



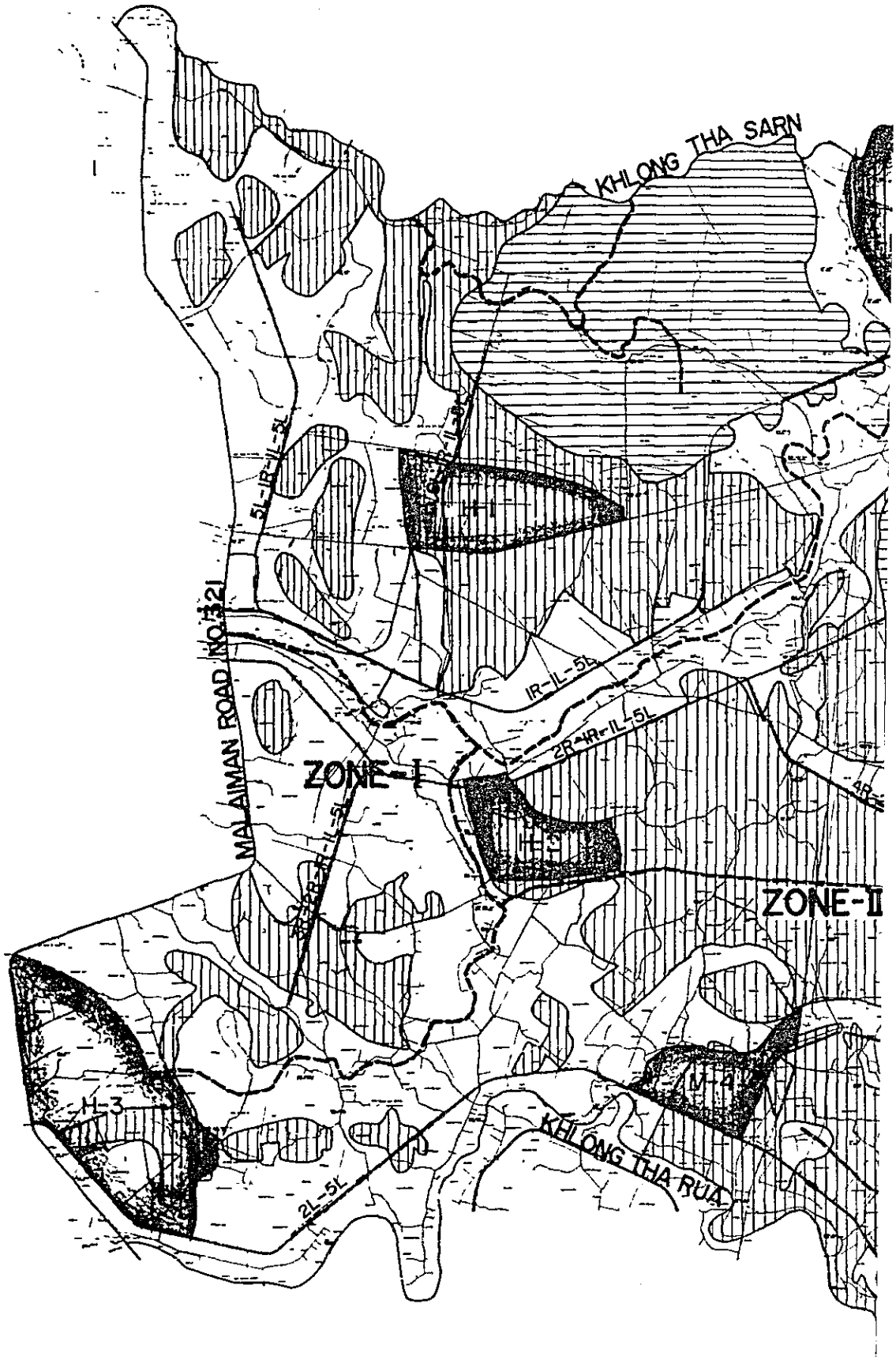
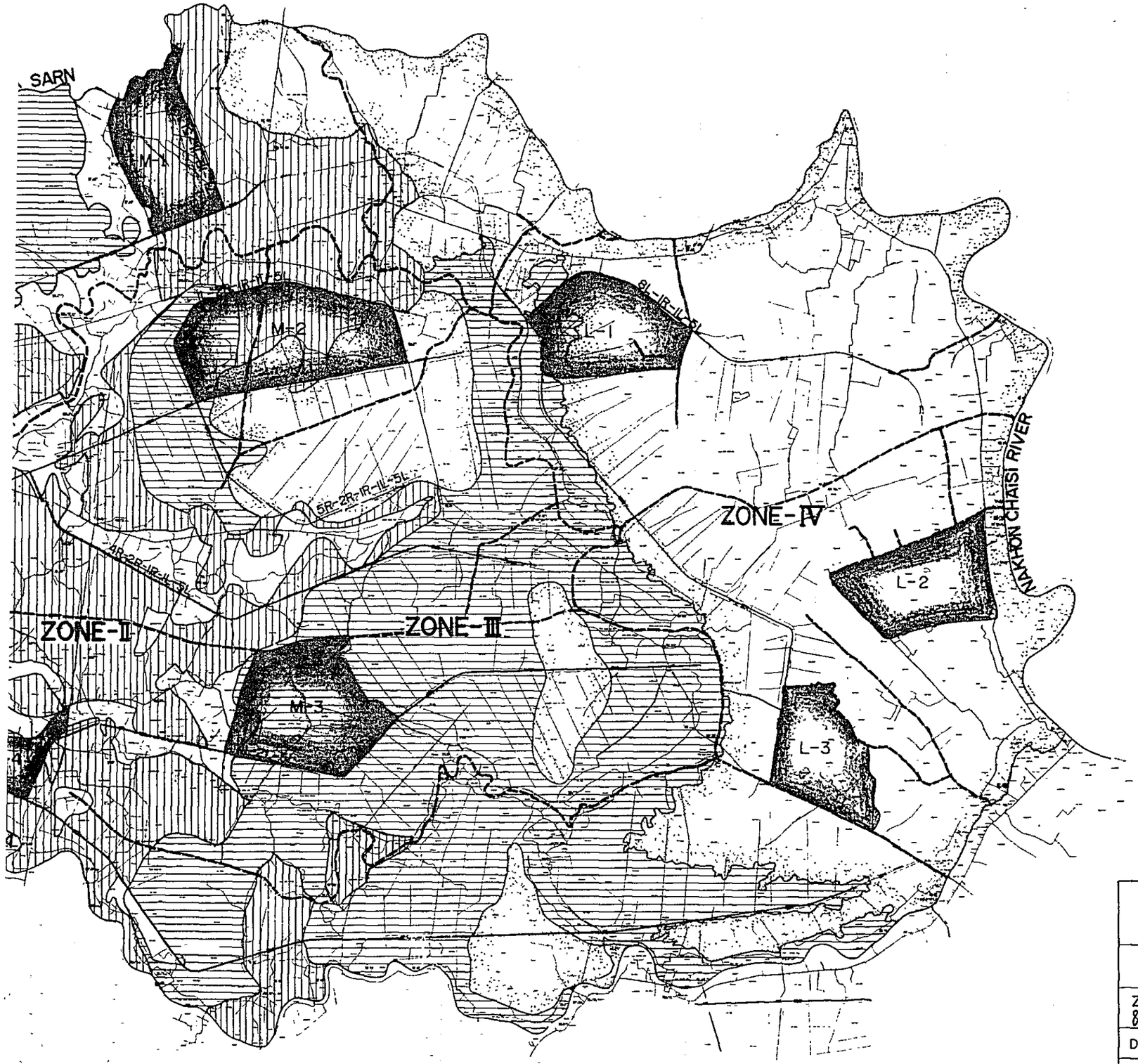

KHLONG THA SARN
MALAIMAN ROAD (NO.321)
5L-1R-1L-5L
1R-1L-5L
2R-1R-1L-5L
ZONE-I
ZONE-II
H-1
H-2
H-3
M-1
KHLONG THA RUA
2L-5L

FIG 5.3



KINGDOM OF THAILAND MINISTRY OF AGRGULTURE AND COOPERATIVES ROYAL IRRIGATION DEPARTMENT			
F/S FOR THE KAMPHAENG SAEN IRRIGATED AGRICVLTURE DEVELOPMENT			
ZONING MAP FOR LAND CONSOLIDATION & LOCATION MAP OF SAMPLE AREA			
DATE	AUG – 1979	D.W.G.	5003
JAPAN INTERNATIONAL COOPERATION AGENCY			

FIG 5.4

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ROYAL IRRIGATION DEPARTMENT

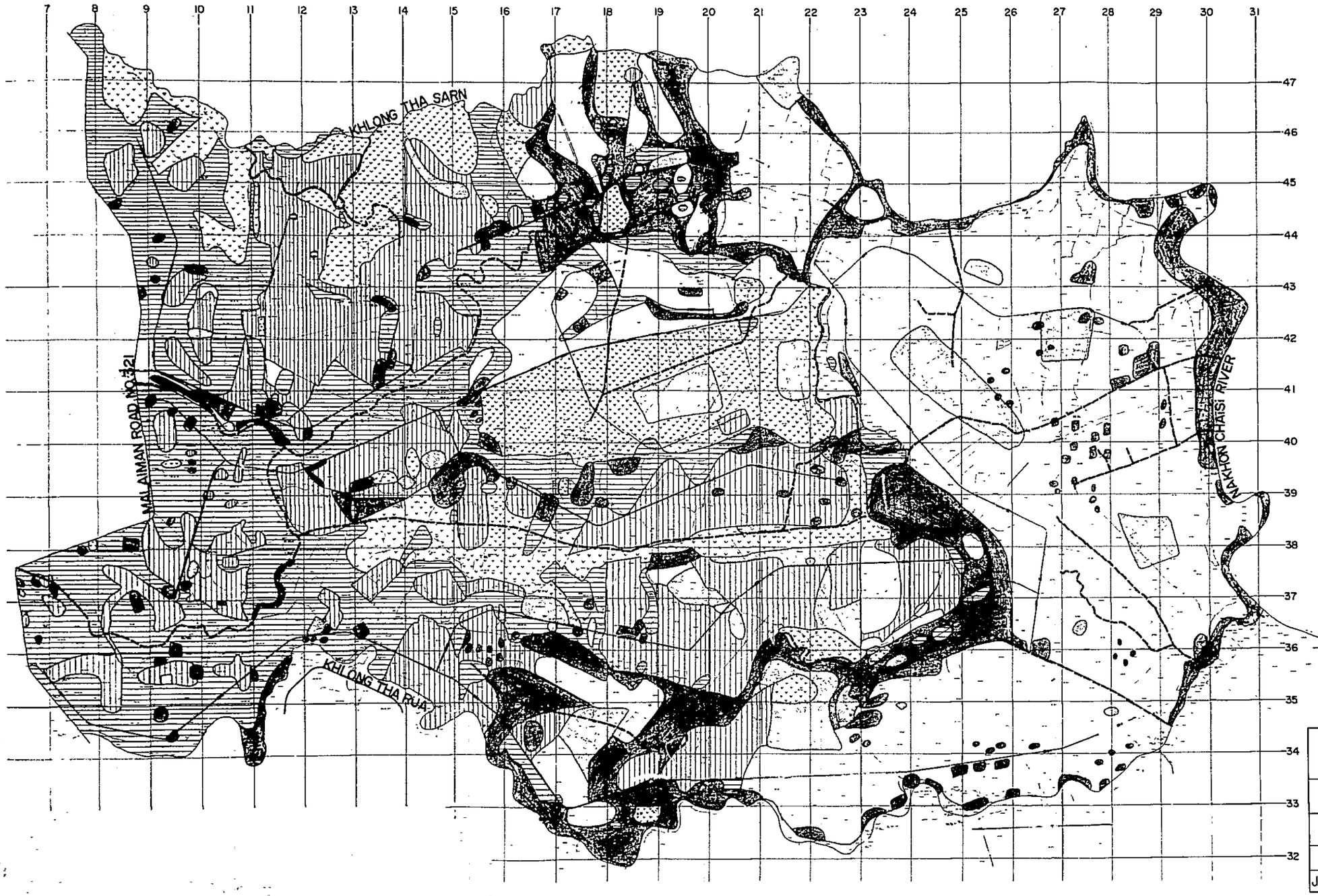
F/S FOR THE KAMPHAENG SAEN
IRRIGATED AGRICVLTURE DEVELOPMENT

ON-FARM DEVELOPEMENT MAP

DATE	AUG – 1979	D.W G	5004

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG 5.5



N

LEGEND

	FIRST RICE
	SECOND RICE
	FIRST RICE & SECOND RICE
	WASTE LAND
	SUGAR CANE LAND
	UP-LAND (VEGITABLE&TREE)
	DRAINAGE CANAL

SCALE 1:32,000

0 500m

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IRRIGATED AGRICVLTURE DEVELOPMENT

LAND USE MAP

DATE	AUG – 1979	D.W.G.	5005

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG 5.6

LEGEND

- HOME STEAD
- ORCHARDS TREES
- RICE LAND
- SUGAR CANE
- WASTE LAND BUT CULTIVABLE
- ANNUAL DIVERSIFIED UP-LAND CRUPS
- INTAKE
- DIVERSION BOX
- FARM ROADS FARM DITCH
- DRAINAGE DITCH
- CROSS CULVERT
- INLET
- FARM INLET

SCALE S = 1/ 8000

0 500m

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ROYAL IRRIGATION DEPARTMENT

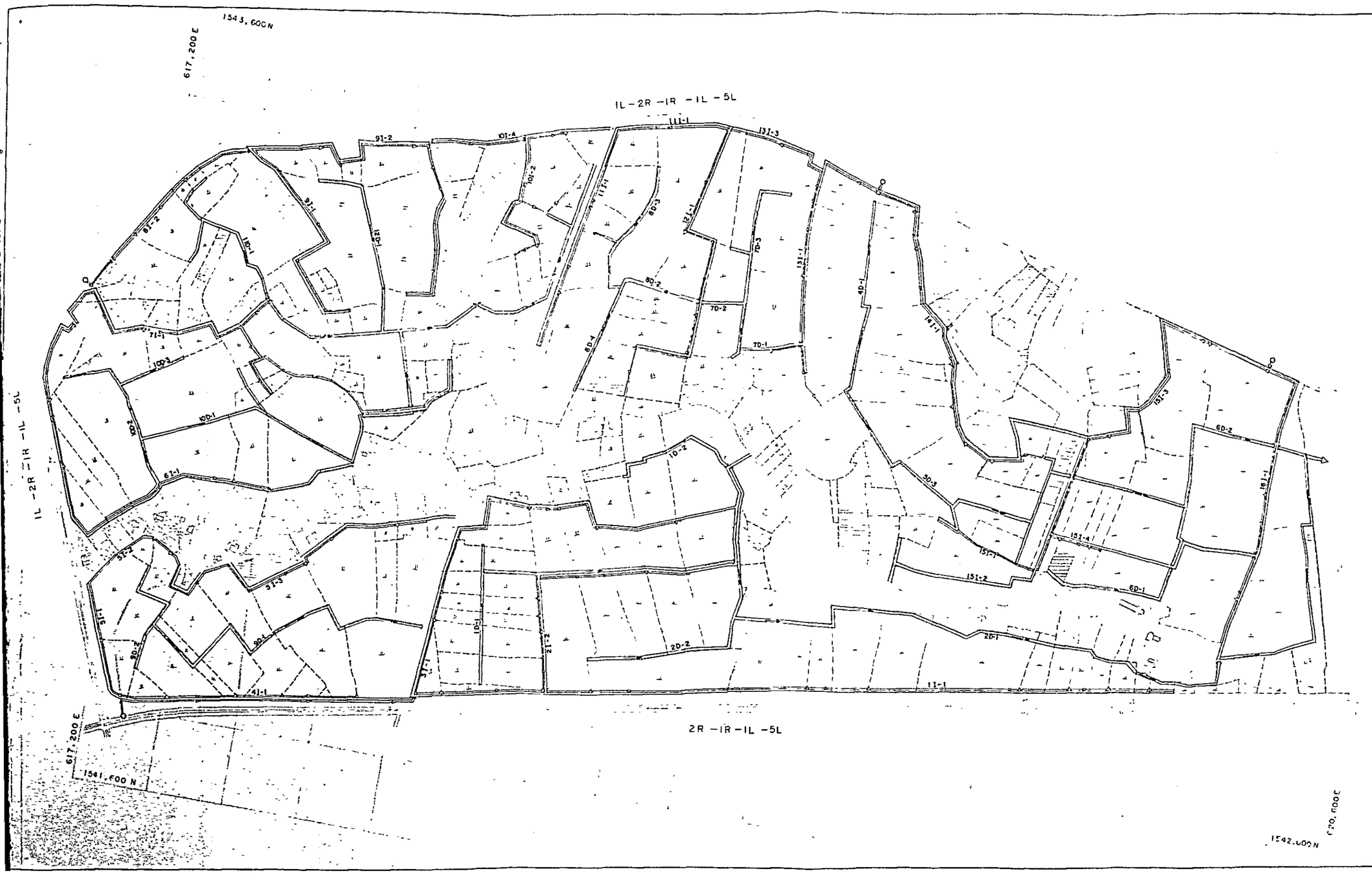
F/S FOR THE KAMPHAENG SAEN IRRIGATED AGRICULTURE DEVELOPMENT

ON-FARM DEVELOPEMENT
SAMPLE AREA L-2 (TYPE-A)

DATE AUG-1979 DWG 5006

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG 5.7



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ROYAL IRRIGATION DEPARTMENT

F/S FOR THE KAMPHAENG SAEN IRRIGATED AGRICULTURE DEVELOPMENT

ON-FARM DEVELOPEMENT
SAMPLE AREA M-2 (TYPE-B)

DATE AUG-1979 DWG 5007

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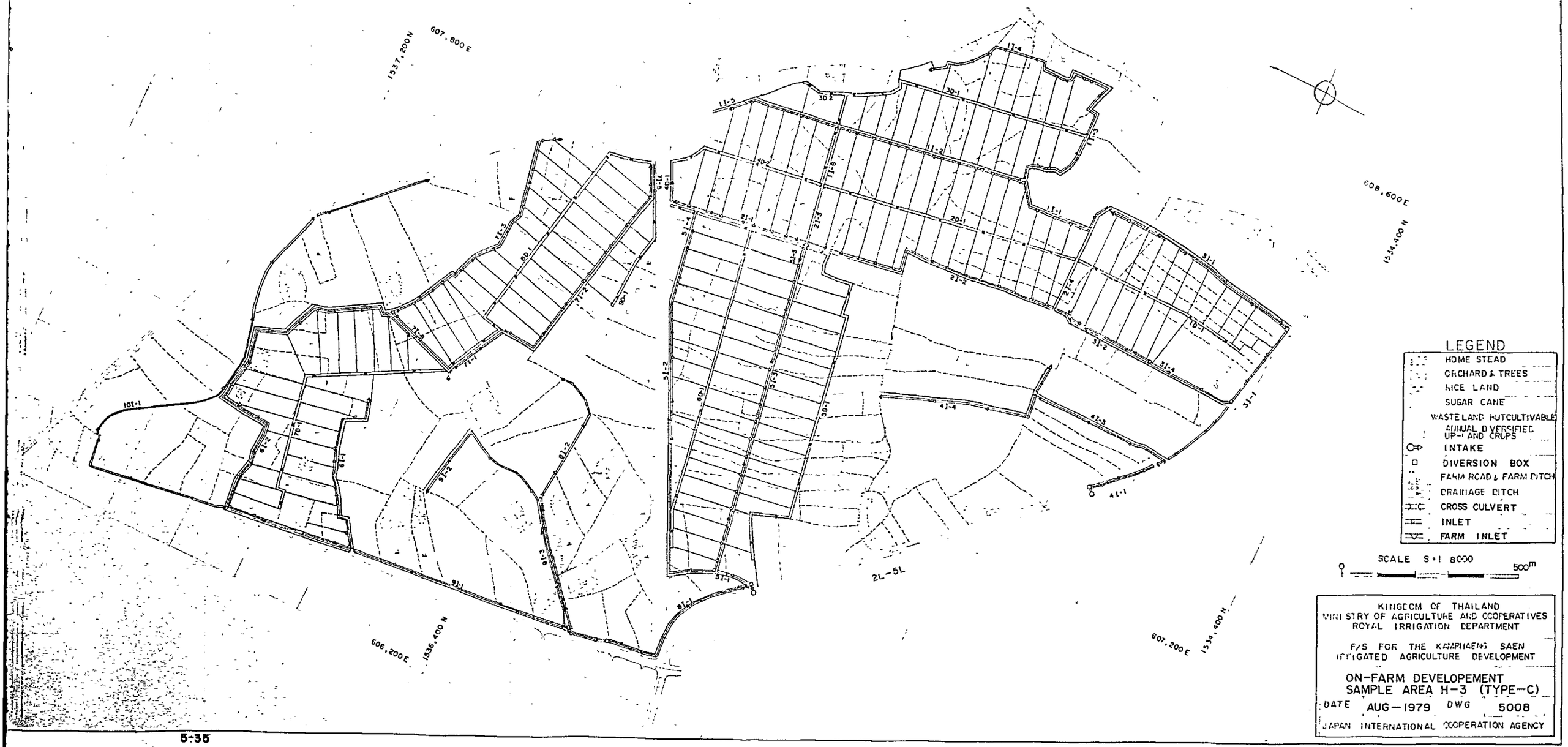
FIG 5.8



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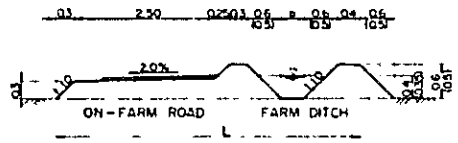
F/S FOR THE KAMPHAENG SAEN
IRRIGATED AGRICULTURE DEVELOPMENT

ON-FARM DEVELOPEMENT
SAMPLE AREA H-3 (TYPE-C)

DATE AUG-1979 DWG 5008

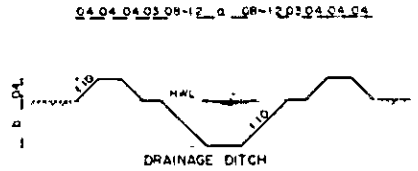
JAPAN INTERNATIONAL COOPERATION AGENCY



TYPE-A & B

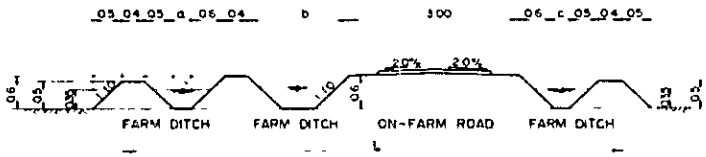
TYPE	b	L
A - 1	05~06	545~555
A - 2	07~10	565~595
A - 3	04	535
A - 4	15	645
A - 5	20	695
A - 6	12	615
B	03~04	545~555

NOTE ( ) TYPE-B



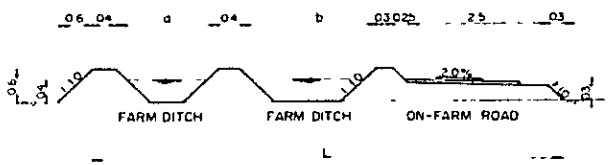
TYPE-N.O.P

TYPE	a	b	L
N - 1	04 ~ 05	08	42~43
N - 2	06 ~ 08	08	44~46
O	05 ~ 08	10	47~50
P	06 ~ 08	12	52~54



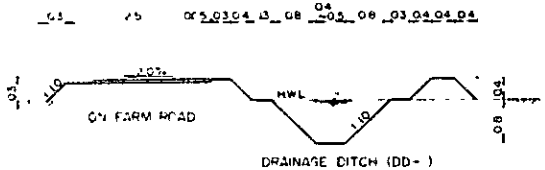
TYPE-C & J

TYPE	a	b	c	L
C - 1	-	05~06	03~04	700
C - 2	03~04	07~10	03~04	915
C - 3	03~04	04	03~04	870
J - 1	07~10	27	04	1045
J - 2	-	27	07~10	855

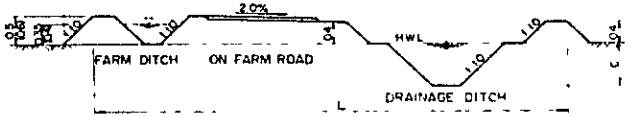


TYPE-G H

TYPE	a	b	L
G - 1	16	32	895
G - 2	17 ~ 18	16	750
G - 3	17 ~ 18	19~22	795
G - 4	17 ~ 18	32	910
G - 5	19 ~ 22	27	890
H - 1	15 ~ 16	27	830
H - 2	15 ~ 16	16	720



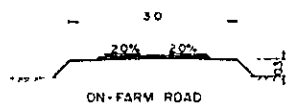
TYPE-M



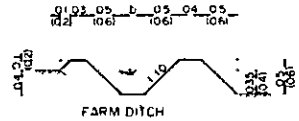
TYPE-D & I

TYPE	a	b	c	L
D - 1	13~14	25~28	10	905
D - 2	13~14	22~24	08	870
D - 3	13~14	20~21	08	845
D - 4	13~14	30~32	12	950
I - 1	16	25~28	10	940
I - 2	27	20~21	08	990
I - 3	32	20~21	08	960

NOTE ( ) TYPE-I



TYPE-L



TYPE-E.F.K.

TYPE	b	L
E	03 ~ 04	15 ~ 16
F	03 ~ 04	21~22
K - 1	24	20
K - 2	05 ~ 06	215
K - 3	15	310
K - 4	07 ~ 10	245
K - 5	20	360

NOTE ( ) TYPE-K

ALL DIMENSIONS AREA GIVEN IN METERS

KINGDOM OF THAILAND
MINI STRY OF AGRICUL TURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT
F/S FOR THE KAMPHAENG SAEN
IRRIGATED AGRICULTURE DEVELOPMENT

TYPICAL SECTIONS OF ROAD AND CANAL

DATE AUG — 1979 D W G 5009

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 5-3 Length of Roads/Canals and Their Density

Sample Areas	Items / Type	Roads Total Length (m)	Roads Density (m/ha)	Irr. Canals Total Length (m)	Irr. Canals Density (m/ha)	Drain. Canals Total Length (m)	Drain. Canals Density (m/ha)
H-1 (81.1ha)	C	*1 6,180	76	5,360	66	3,725	46
H-2 (65.5ha)	C	4,160	63	5,595	85	3,060	46
H-3 (174.8ha)	C	10,835	62	13,030	75	7,590	43
M-1 (169.7ha)	B	9,130	54	9,800	58	8,000	47
M-2 (311.7ha)	B	19,620	63	18,805	60	14,870	48
M-3 (331.1ha)	B	21,000	63	24,905	75	15,595	47
M-4 (62.4ha)	B	4,710	75	5,565	89	2,965	48
L-1 (284.2ha)	A	11,430	40	12,600	44	7,660	27
L-2 (272.9ha)	A	8,766	32	9,894	36	7,990	29
L-3 *2(167.0ha)	A	6,635	42	8,195	52	4,095	26

Note: *1 Total road length includes that of the existing ones.

*2 The acreage of 167 ha excludes the acreage to be irrigated by pumping.

Table 5-4 Deduction Rate

Sample Area		Acreage ha	Farm loss m^2	Deduction Rate %	Remarks
Paddy Fields	H-1	81.8	44,948	5.5	Net Area 76.6 ha
	H-2	65.5	35,334	5.4	-ditto- 62.0
	H-3	174.8	108.668	6.2	-ditto- 163.9
	M-1	169.7	84.027	5.0	-ditto- 161.3
	M-2	311.7	172,115	5.5	-ditto- 294.5
	M-3	311.1	156,157	4.7	-ditto- 315.5
	M-4	62.4	43,398	6.9	-ditto- 58.1
	L-1	284.2	103,168	3.6	
	L-2	272.9	98.634	3.6	
	L-3	167.0	61,570	3.7	Excluding the area to be irrigated by pumping
Sugar cane Fields	H-1	131.2	15,180	1.2	
	H-2	37.0	9,615	2.6	
	H-3	152.2	19,034	1.3	

Notes: Typewise Deduction Rate

A - Type	3.62%
B - Type	5.20
C - Type	5.86
Sugar cane	1.41

Table 5-5 Alternative Study on Area Development by Type of On-farm Development Level

Item	Unit	Case 1	Case 2	Case 3
Development Area				
Type A 1/	(ha)	3,875	3,875	3,875
Type B	(ha)	13,325	11,675	9,755
Type C	(ha)	-	1,650	3,570
Total	(ha)	17,200	17,200	17,200
Field Costs for on-farm development				
Total	(Bmillion)	233.80	250.72	284.55
per ha 2/	(B/ha)	14,265	15,306	17,393
Total Costs excluding price increase				
Total	(Bmillion)	484.58	501.50	535.33
per ha 2/	(B/ha)	29,566	30,612	23,722
Expected Benefits 3/				
Incremental B.	(Bmillion)	239.59	248.85	258.67
per ha		14.618	15,192	15,811
B/C		0.494	0.496	0.483
IRR		26.3%	26.5%	26.3%
Project charge	(B/ha) 4/	1044	1520	2838
Rent recovery index		23	38	65

Note 1/ area consist of 2,655 ha for paddy firld and 1,220 ha for sugarcane field

2/ Field costs per benefited area with project ; case 1, 16,390 ha ; case 2, 16,380 ha ; and case 3, 16,360 ha

3/ Expected yield and net value of production with project were assumed as follows

Type	Yield (ton/ha) Wet	Yield (ton/ha) Dry	N.Y.P (B/ha) Wet	N.Y.P (B/ha) Dry
A (Sugarcane)	80		29,040	
A (Paddy)	3.3	4.3	12,280	16,090
B (Paddy)	4.1	4.5	15,400	16,905
C (Paddy)	4.8	5.3	18,100	19,990

4/ Total project charges only for on-farm development works, 10% of common facilities and 100% of leveling works with 12% of interest, 3-year grace period and 15-year payment.

Table 5-6 Areas of Plot Before Land Consolidation

(Unit: ha)

Plot No.	Gross Area	Paddy	Other	Plot No.	Gross Area	Paddy	Other
5	1.1	0.7	0.4	83	1.9	1.9	
6	0.7	0.7	-	84	2.5	1.6	0.9
7	1.7	1.7	-	87	2.0	2.0	
12-1	3.2	3.2	-	88	1.2	1.2	
17	4.7	4.7	-	89	2.2	2.2	
18	2.9	2.2	0.7	90	2.3	2.3	
21	2.7	1.0	1.7	90-1	0.8	0.8	
27	2.2	1.9	0.3	90-2	0.9	0.9	
28	2.3	1.9	0.4	91	1.0	1.0	
29	2.3	1.7	0.6	91-1	0.9	0.9	
30	2.4	1.7	0.7	92	0.9	0.9	
31	2.0	0.8	1.2	113-1	0.1	0.1	
32	1.0	1.0	-	116-1	-	-	
33	2.4	2.4	-	117-1	0.1	0.1	
35	2.3	1.9	0.4	118-2	0.1	0.1	
38	1.8	1.8	-				
38-1	1.7	1.7	-				
39	2.1	1.3	0.8				
45	0.5	0.5					
46	2.8	2.8					
47	1.8	1.8					
48	2.0	2.0					
49	1.7	1.7					
50	3.6	3.6					
57-1	2.9	2.9					
58	4.6	4.6					
80	1.5	1.5					
80-1	2.3	2.3					
81	2.9	2.9					
82	0.7	0.7		Total	83.7	75.6	8.1

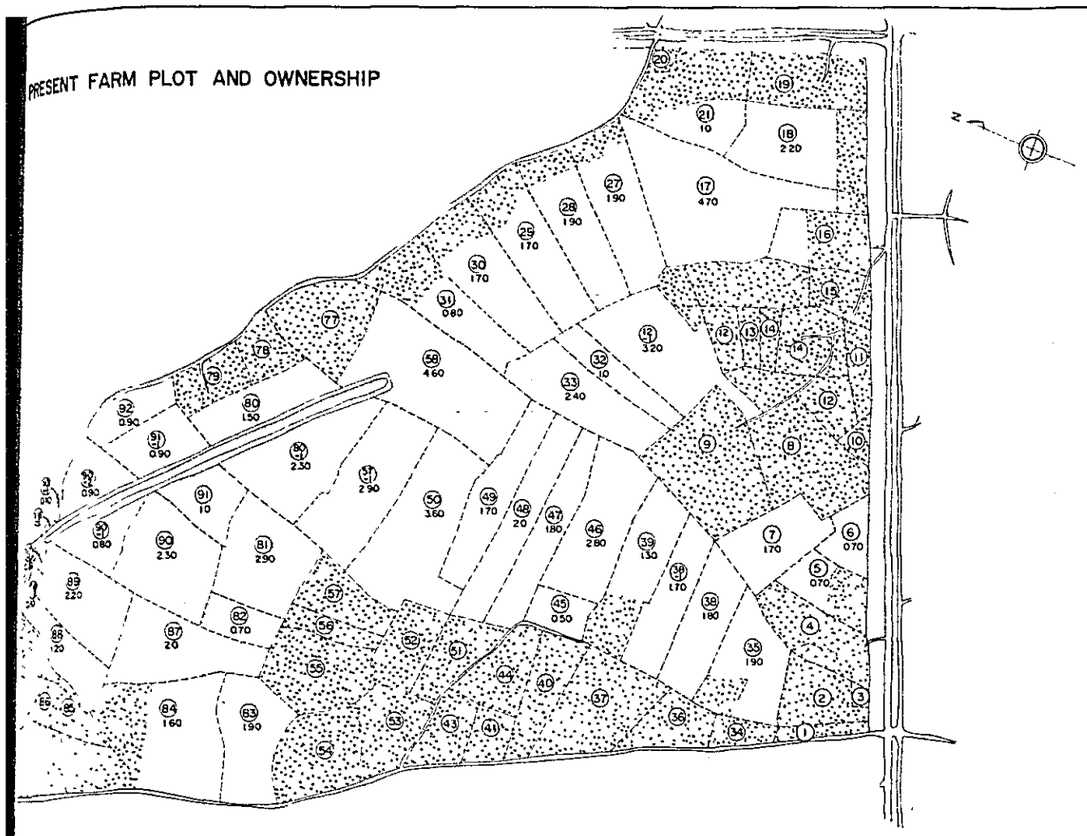
Table 5-7 Distribution of Land Ownership

(Unit: ha)

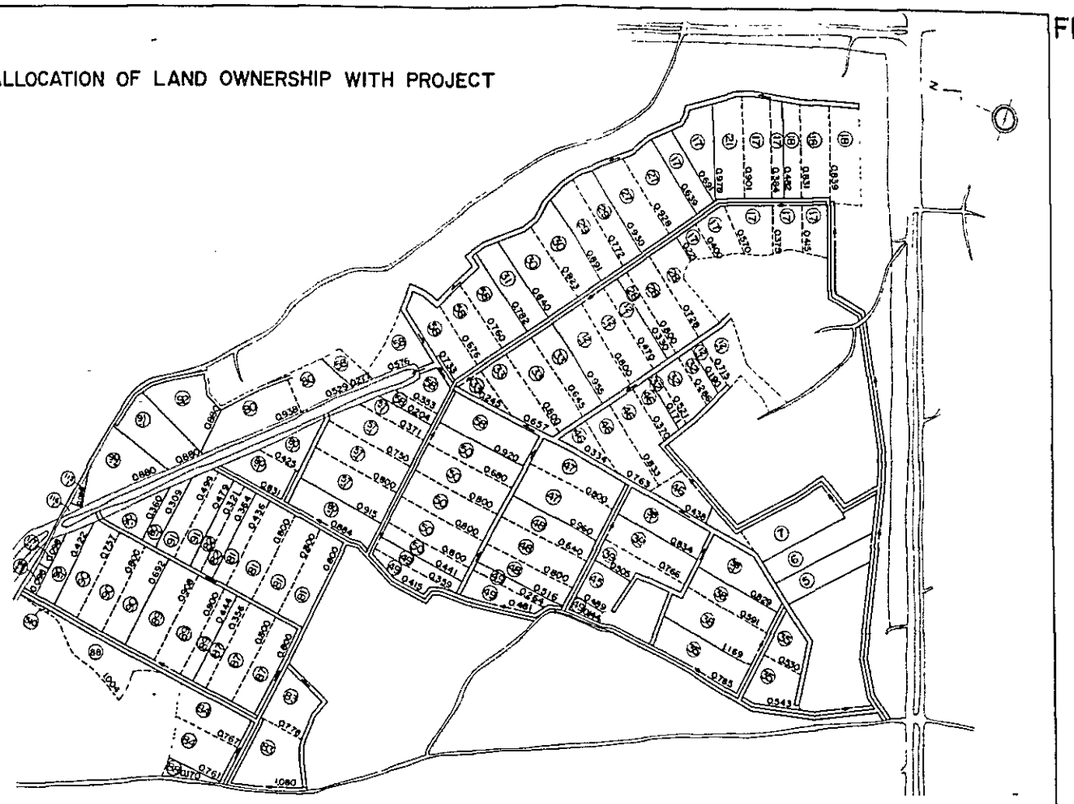
Plot No.	Before Land cons.	After Land cons.	Plot No.	Before Land cons.	After Land cons.
5	0.7	0.685	83	1.9	1.858
6	0.7	0.685	84	1.6	1.565
7	1.7	1.663	87	2.0	1.956
12-1	3.2	3.130	88	1.2	1.174
17	4.7	4.596	89	2.2	2.152
18	2.2	2.152	90	2.3	2.249
21	1.0	0.978	90-1	0.8	0.782
27	1.9	1.858	90-2	0.9	0.880
28	1.9	1.858	91	1.0	0.978
29	1.7	1.663	91-1	0.9	0.880
30	1.7	1.663	92	0.9	0.880
31	0.8	0.782	113-1	0.1	0.098
32	1.0	0.978	116-1	-	
33	2.4	2.347	117-1	0.1	0.098
35	1.9	1.858			
38	1.8	1.760			
38-1	1.7	1.663			
39	1.3	1.271	Reduction rate of Area:		2.2%
45	0.5	0.489			
46	2.8	2.738			
47	1.8	1.760			
48	2.0	1.956			
49	1.7	1.663			
50	3.6	3.521			
57-1	2.9	2.836			
58	4.6	4.499			
80	1.5	1.467			
80-1	2.3	2.249			
81	2.9	2.836			
82	0.7	0.685	Total	75.6	73.937

FIG 5.1C

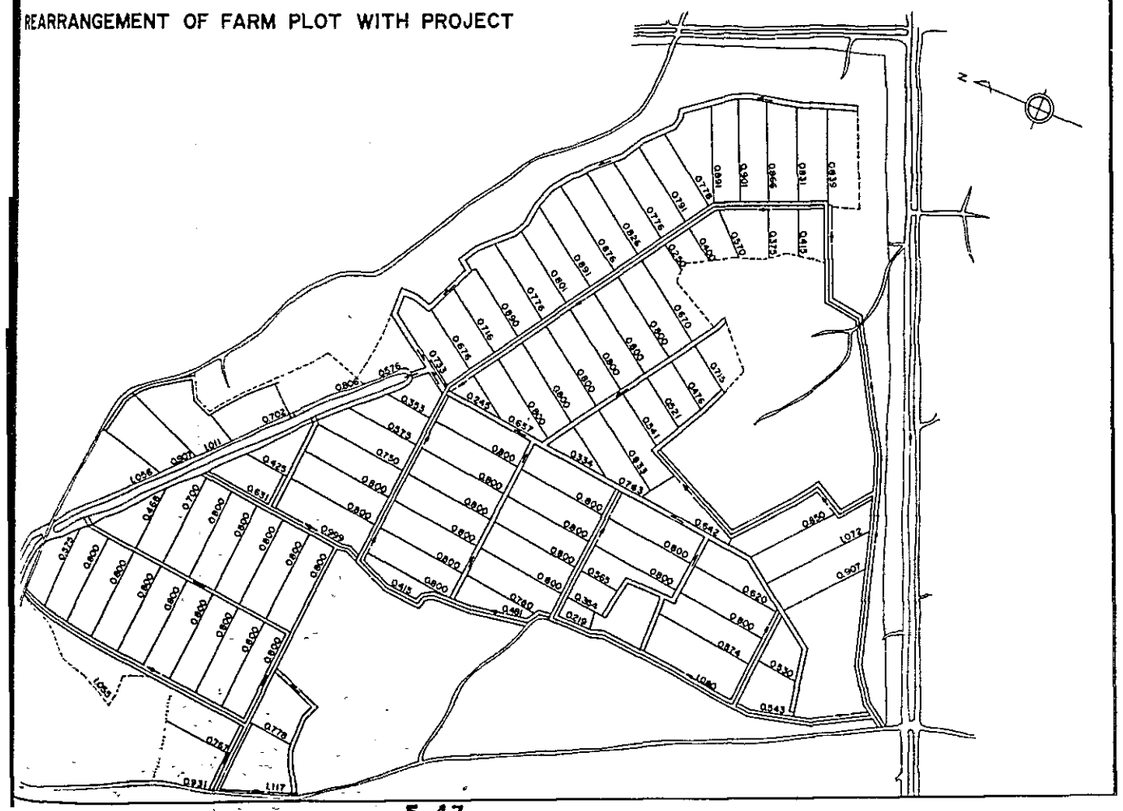
PRESENT FARM PLOT AND OWNERSHIP



REALLOCATION OF LAND OWNERSHIP WITH PROJECT



REARRANGEMENT OF FARM PLOT WITH PROJECT



SCALE 1:10,000

REPLOTTING MAP