4. PLANNING AND DESIGN OF PROJECT FACILITIES

4.1 General

The general features of the Project is to irrigate the area of 28,190 rai in the Huai Khon Kaen sub-project area, 11,250 rai in the Huai Yai sub-project area and 7,500 rai in the Khlong Chaliang Lab sub-project area. The facilities required for the Project are irrigation canals which convey water from each dam to its command area and their related structures.

The basis for planning and design of the project facilities are the most effective use of water and economical layout of irrigation canal system. On the basis of these requirements,the following planning and preliminary design of the Project facilities are made. The general features of the project facilities thus designed are summarized in Table VIII.3. and their layouts are shown in DWG. NOS.202, 203 and 204.

4.2 Irrigation Canal System

4.2.1 Function and Requirement of Canal

Irrigation canal systems in each sub-project includes main canals, lateral canals and sub-lateral canals. The layout planning of these canals is done after understanding their respective functions and requirements mentioned below.

(1) Main canal

The function of main canal is to convey irrigation water from each dam to development area in the most economical way. The Huai Khon Kaen sub-project area has two main canals i.e. right main canal (RMC) and left main canal (LMC). The Huai Yai and the Khlong Chaliang Lab sub-project areas have one main canal respectively. The main canals have concrete lined trapezoidal sections.

(2) Lateral and sub-lateral canal

The functions of lateral and sub-lateral canals are to deliver irrigation water from main canals to the head portions of tertiary units. The sizes of lateral units vary from 50 to 500 ha consisting of 2 to 18 tertiary units. The lateral and sub-lateral canals are of unlined earth canal and have trapezoidal sections.

(3) Tertiary unit

The tertiary units are so demarcated as to have the maximum area of 40 ha.

4.2.2 Layout Planning of Canal

(1) Layout planning on map

Prior to the field survey, a layout planning of canals is made on the map. For this work, the map on a scale of 1/10,000 prepared by RID is used. In the planning the following matters are taken into consideration.

(a) Canal alignment should be straight and short as much as possible.

(b) The alignment should be planned so as not to pass through village yards and not to give damages to public facilities.

(c) If there are existing irrigation canals, these canals are to be incorporated to the project canal network as much as possible.

(d) Embankment portion should be minimized as much as possible.

(e) Canal water level should be kept as high as possible for easy operation of canal system.

(f) Canal construction cost should be minimized by selecting the proper alignment.

(2) Field survey

(a) Based on the layout planning prepared on the map, the detailed field reconnaissance is made along the canal alignments to grasp micro-topography, hydrological conditions and soil conditions.

(b) The topographic survey including route survey and cross-section survey along the main and lateral canals at the average interval of 200 m are carried out in collaboration with RID staff.

(c) The construction material survey is made for their availabilities and prices.

(d) For the layout planning, agricultural and socio-economical data are also collected.

4.2.3 Design of Irrigation Canal

(1) Design discharge

Based on the unit irrigation water requirement of 1.0 ℓ/sec/ha for both Lom Sak and Phetchabun areas, the design discharges for the canals over the three sub-project areas are obtained as shown in Fig. VIII.6.

(2) Velocity

The maximum and minimum permissible velocity is determined so as not to give the erosion and deterioration and not to allow the sedimentation and the growth of aquaplant and moss in canals. Considering the above basic requirements, the canal water velocities are determined as follows:

	maximum velocity (m/s)	minimum velocity (m/s)
- concrete-lined canal	1.2	0.8
- earth canal	0.7	0.5

(3) Roughness coefficient

The Manning formula is used for determination of hydraulic properties of canals. The Manning's roughness coefficient "n" is determined as follows:

	Manning's "n"
- concrete-lined canal	0.015
- earth canal	0.025

(4) Freeboard and waste bank

The freeboard in canals is normally governed by considerations of the canal size and location, velocity, storm-water inflow, water surface fluctuations caused by checks, wind action, soil characteristics, etc. The freeboard is determined by the following formula:

$$Fb = 0.05 \times d + hv + (0.05 - 0.15)$$

where

Fb : minimum freeboard (m),

d : water depth for maximum design discharge (m), and

hv : velocity head (m).

The height of waste bank is determined to be 0.2 to 0.3 m for concrete-lined canal and 0.2 m for earth canal, while their width is 2.0 m for concrete-lined canal and 1.0 m for earth canal.

(5) Canal base width/water depth (B/h) ratio

The ratio of canal base width and water depth is determined as follows:

	B/h
- concrete-lined canal	1.0 - 1.5
- earth canal	1.0 - 2.0

(6) Side slope

The side slope of 1:1.5 is adopted for the design of both concrete-lined and earth canals taking into account the results of soil mechanical investigations.

(7) Lining of canal

All the main canals are lined with 6 cm thick plain concrete to check seepage from the canal banks and bottom and to protect the canal section against erosion.

(8) Canal cross-section

Considering above mentioned items, canal types and their typical cross-sections are designed as shown in DWG. NO. 401.

4.2.4 Design of Related Structures

A number of related structures are required in conjunction with irrigation canals for conveyance, regulation and measurement of irrigation water and protection of canal system.

The required numbers of the canal related structures are summarized in Table VIII-4, and proposed plan of irrigation canal system including its related structures is shown in DWG. NOS. 202, 203 and 204. . The general characteristics and design criteria of those structures are briefed as follows:

(1) Culvert

Culverts are constructed to convey canal water under roads. The culverts in the proposed canal system are classified into four types for main canal and two types for lateral canal depending on their discharges. The two types for main canal have box barrels and the others have pipe barrels. Design water depth in the barrel is taken to be about 80 % of barrel height, and design velocity is to be 110 % to 130 % of canal water velocity.

(2) Inverted siphon

Inverted siphons are constructed to convey canal water under rivers and drainage channels. These structures are classified into four types depending on the canal discharge. The three types have design capacities of more than 1.0 m^3/sec and are provided with box barrels. Another type has a design capacity of less than 1.0 m^3/sec and provided with pipe barrel. The maximum velocity is taken to be 1.5 to 2.0 m/sec.

(3) Drop structure

The function of drop structure is to dissipate excess energy. The structures are classified into four types depending on canal water discharge. Particularly for the lateral canals, inlet and outlet transitions are provided with stone masonry to prevent canal from scouring.

(4) Check gate

A check gate is provided at the just downstream of turnout and a spillway to maintain the required water level during the period of partial flow in the canal. In case a drop structure is needed closely to a check gate, a check cum drop structure is provided. These structures are classified into four types for main canal and two types for lateral canal depending on their discharges.

(5) Turnout

Turnouts are constructed to divert irrigation water from one canal to others. There are two types of turnout; (1) for diversion of water from main canal to lateral or sub-lateral canals or lateral canal to sub-lateral canal (simply called "turnout"), (2) for diversion from main canal, or lateral canal or sub-lateral canal to tertiary unit (called "farm turnout"). The turnouts are provided with one line of pipe barrel with a diameter of 300 mm - 800 mm and concrete-made outlet structure. All the farm turnouts have a pipe barrel with 300 mm diameter, and the upstream and downstream of the farm turnouts are protected by stone masonry against erosion.

(6) Spillway

Over-flow type spillways are constructed along the canals for the purpose of flushing off all the excess water in the canals. These structures are classified into four types depending on the canal discharge. The design discharge of the spillway is taken to be 25 % of the canal discharge.

(7) Water measuring device

Cipoletti weirs are installed at the head of lateral and sub-lateral canals for the purpose of canal water measurement. The weirs are classified into four types depending on the canal discharge.

(8) Cross drain

Cross drains are constructed across the irrigation canals at the places where the canals run across depressed lands or natural streams. Cross drains are classified into two types depending on the design discharge. One has a pipe barrel and the other has a rectangular-shaped concrete barrel. The former is adopted for the design discharge of less than 2.5 m^3/sec and the later is for the discharge of 2.5 m^3/sec or more.

(9) Bridge

Concrete bridges are provided on operation and maintenance roads to cross over rivers and drainage channels at the points where the construction of siphons is planned.

Concrete bridges are also provided over irrigation canals at the points where canal crossings are needed for villagers along the irrigation canals.

4.3 Drainage Canal System

4.3.1 General

The functions of drainage canals are to drain out water in fields and to lower or control the subsurface water level, and to lead the water to outlets or disposal points. The layout of the irrigation system and topography are the main factors for determining the location of the drainage canal. Existing natural streams or depressed areas are used for location of the drainage canal as much as possible.

4.3.2 Layout Planning of Drainage Canal

Through the field investigation, following items are checked and studied.

- Field damage due to floods and mal-drainage is surveyed for its extent and magnitude.
- Present drainage mechanism is observed in its vicinal areas.
- Rainfall data is calculated for the analysis of the intensity and duration of rainfall and estimation of drainage requirements.
- Present land use in the areas is surveyed for the use of analysis on drainage requirements.

Based on the results of field investigation mentioned above, drainage canal systems are planned (DWG. NOS. 202, 203 and 204).

4.3.3 Design of Drainage Canal and Its Related Structures

According to the drainage water requirement calculated in Section 3.2 hereof, the unit design discharge is determined to be 4.5 ℓ/sec/ha in both Lom Sak area and Phetchabun area. Design discharges of respective drainage canals are calculated on the basis of the unit design discharge. Existing natural streams and drainage canals are incorporated into the proposed drainage canal network as much as possible.

The related structures to the drainage canals include cross drains and culverts. They are planned and designed with the same principles as those of the related structures for the irrigation canals.

4.4 Inspection Road

For the proper operation and maintenance of project facilities, well arranged inspection roads are of vital importance. Since these roads will be used as village roads and farm roads after the project implementation, the arrangement of the inspection raods should be made considering the existing road networks.

(1) Main inspection road

The main inspection roads are required for inspection, operation and maintenance of main canals. Considering the future increase of vehicles for the inspection and operation and heavy construction equipment to be required for the canal maintenance and repair, all the main inspection roads are so designed as to have an effective width of 5 meters and to be laterite-paved. These roads are also used for the movement of agricultural products and equipment and for the day-to-day services between villages and from them to the highway.

(2) Lateral inspection road

The lateral inspection road is mainly provided alongside the lateral canal. All these roads have an effective width of 3 meters. These roads are also used for the purpose of farm operation, particularly for harvesting.

TABLE VIII-1 (1)

IRRIGATION WATER REQUIREMENT FOR WATER BALANCE STUDY
-LOM SAK AREA, CROP INTENSITY : 135%-

Unit : m^3/month/ha

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1964	45	29	915	876	247	0	273	794	561	753	607	464
1965	54	48	597	1933	179	172	986	807	561	725	579	344
1966	63	55	1101	2060	120	1075	682	751	493	629	737	497
1967	40	65	958	1373	771	0	964	736	561	753	672	420
1968	37	30	626	783	920	1117	829	823	561	622	693	501
1969	53	55	1070	1581	1184	0	908	743	561	753	737	260
1970	59	57	466	2173	179	228	724	814	479	753	633	402
1971	68	48	615	1580	198	488	765	824	552	753	606	406
1972	52	64	634	1704	204	324	766	748	540	753	737	376
1973	59	54	739	1027	1154	570	1163	787	561	753	731	373
1974	47	45	739	1124	263	873	751	640	561	520	477	410
1975	70	60	760	876	239	268	648	576	561	753	444	490
1976	55	43	744	683	191	241	583	794	561	753	737	373
1977	49	54	1070	1171	792	355	964	814	352	749	626	486
1978	201	39	1038	470	865	0	1132	817	561	695	438	501
1979	41	49	550	1124	372	884	1200	824	559	753	626	199
1980	59	39	508	848	390	0	758	774	561	504	416	413

TABLE VIII-1 (2)

IRRIGATION WATER REQUIREMENT FOR WATER BALANCE STUDY
-PHETCHABUN AREA, CROP INTENSITY : 135%-

Unit : m^3/month/ha

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1964	54	32	657	716	160	0	474	773	553	753	632	318
1965	49	64	497	1467	209	1	1004	737	545	709	685	472
1966	55	40	1065	574	170	733	659	701	515	753	718	501
1967	25	43	1044	922	522	8	1126	749	561	753	698	460
1968	38	45	751	695	1713	336	874	743	561	462	536	358
1969	51	62	703	1408	301	0	408	824	561	753	737	366
1970	45	51	417	688	175	1	927	814	500	753	640	475
1971	39	41	1018	1283	263	682	1070	816	553	753	623	460
1972	51	69	500	816	220	815	653	721	545	753	718	358
1973	58	55	727	901	469	0	1023	824	561	753	620	497
1974	52	65	1037	1079	451	803	557	771	561	491	562	271
1975	70	49	975	1267	202	215	662	794	561	753	579	417
1976	58	39	861	644	150	0	403	749	561	753	737	493
1977	58	49	870	736	358	200	737	824	479	753	731	413
1978	44	60	777	496	576	0	862	807	561	659	363	501
1979	47	51	618	2500	649	803	1038	824	561	753	718	402
1980	60	51	449	886	1081	186	702	824	561	753	731	472

TABLE VIII-1 (3)

IRRIGATION WATER REQUIREMENT FOR WATER BALANCE STUDY
-LOM SAK AREA, CROP INTENSITY : 150%-

Unit : m^3/month/ha

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1964	68	29	915	876	247	0	315	997	807	1088	875	696
1965	80	48	597	1933	179	172	1034	1014	807	1048	845	515
1966	94	55	1101	2060	120	1075	724	942	712	911	1062	746
1967	61	65	958	1373	771	0	1012	923	807	1088	969	631
1968	56	30	626	783	920	1117	874	1034	807	901	1002	751
1969	80	55	1070	1581	1184	0	954	931	807	1088	1062	390
1970	88	57	466	2173	179	228	766	1023	681	1088	912	603
1971	102	48	615	1580	198	488	808	1034	796	1088	875	609
1972	78	64	634	1704	204	324	809	938	765	1088	1062	565
1973	74	54	739	1027	1154	570	1217	988	807	1088	1053	560
1974	71	45	739	1124	263	872	793	800	807	755	688	614
1975	104	60	760	876	239	268	690	717	807	1088	641	734
1976	83	43	744	683	191	241	625	997	807	1088	1062	559
1977	74	54	1070	1171	792	355	1012	1023	501	1078	903	729
1978	301	39	1038	470	865	0	1185	1025	807	1005	631	751
1979	61	49	550	824	372	884	1255	1034	805	1088	903	299
1980	88	39	508	848	390	0	804	971	807	1088	922	620

IRRIGATION WATER REQUIREMENT FOR WATER BALANCE STUDY
-PHETCHABUN AREA, CROP INTENSITY : 150%-

Unit : m^3/month/ha

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1964	81	32	657	716	160	0	516	971	797	1088	912	477
1965	74	64	497	1467	209	1	1053	924	786	1026	988	708
1966	83	40	1065	574	170	733	701	876	754	1088	1035	751
1967	37	43	1034	922	522	8	1179	940	807	1088	1006	691
1968	57	45	751	695	1713	336	920	931	807	671	761	538
1969	83	62	703	1408	301	0	450	1034	807	1088	1062	549
1970	68	51	417	688	175	1	974	1028	721	1088	922	713
1971	58	41	1018	1283	263	692	1121	1025	797	1088	885	691
1972	76	69	500	816	220	815	695	903	786	1088	835	538
1973	86	55	727	901	469	0	1073	1031	807	1088	894	746
1974	78	65	1037	1079	451	803	599	968	807	713	810	407
1975	105	49	975	1267	202	215	704	997	807	1088	843	625
1976	87	39	861	644	150	0	445	940	807	1088	1062	740
1977	87	49	870	736	358	200	779	1034	691	1088	1053	620
1978	66	60	777	496	576	0	906	1014	807	953	531	751
1979	71	51	618	2500	649	803	1187	1034	807	1088	1035	603
1980	90	51	449	886	1081	186	744	1034	807	1088	1053	708

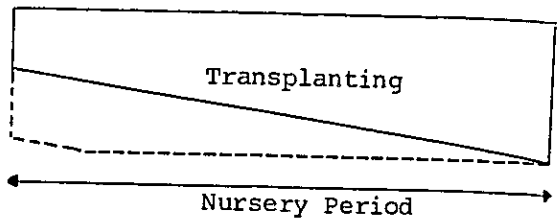
TABLE VIII-2
(1)

SUMMARY OF UNIT IRRIGATION WATER REQUIREMENT

	July		
A. Lom Sak Area	1st 10-day	2nd 10-day	3rd 10-day
High Yield Variety of Paddy			
- Farm Water Requirement (mm)	44.8	46.8	44.3
- Diversion Water Requirement (mm)	80.0	83.6	79.1
Improved Local Variety of Paddy			
- Farm Water Requirement (mm)	29.0	32.1	32.0
- Diversion Water Requirement (mm)	51.8	57.3	57.1
Combined Water Requirement (HYV : 70%, ILV : 30%)			
- Farm Water Requirement (mm)	40.1	42.4	40.6
- Diversion Water Requirement (mm)	71.5	75.7	72.5
- Unit Water Requirement (ℓ/sec/ha)	0.83	0.88	0.84
B. Phetchabun Area			
High Yield Variety of Paddy			
- Farm Water Requirement (mm)	48.7	44.8	40.7
- Diversion Water Requirement (mm)	87.0	80.0	72.7
Improved Local Variety of Paddy			
- Farm Water Requirement (mm)	30.6	31.5	30.4
- Diversion Water Requirement (mm)	54.6	56.3	54.3
Combined Water Requirement (HYV : 70%, ILV : 30%)			
- Farm Water Requirement (mm)	43.3	40.8	37.6
- Diversion Water Requirement (mm)	77.3	72.9	67.1
- Unit Water Requirement (ℓ/sec/ha)	0.89	0.84	0.77

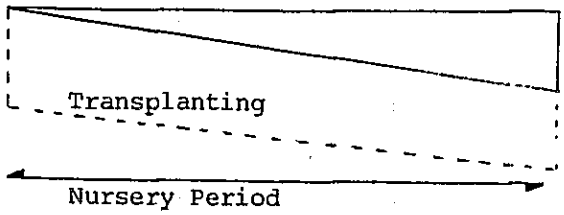
CALCULATION FACTORS OF UNIT IRRIGATION WATER REQUIREMENT
(PLANTED AREA, CROP COEFFICIENT, ET_p, L_p)

High Yield Variety of Paddy

	July		
	1st 10-day	2nd 10-day	3rd 10-day
1. Cropping Pattern			
2. Nursery Period			
- Nursery Bed Area	$\frac{19}{48}$	$\frac{1}{4}$	$\frac{1}{12}$
- Nursery Bed Area out of Main Paddy Field (6%)	$\frac{19}{800}$	$\frac{3}{200}$	$\frac{1}{200}$
3. Puddling Period			
- Puddling Area	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$
4. Post-transplanting Period			
- Cropping Area			
Early Crop	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
Middle Crop	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{3}$
Late Crop	-	$\frac{1}{12}$	$\frac{1}{4}$
Tatal Area	$\frac{7}{12}$	$\frac{3}{4}$	$\frac{11}{12}$
- Crop Coefficient			
Early Crop	1.05	1.15	1.25
Middle Crop	0.94	1.00	1.05
Late Crop	-	0.90	0.94
Weighting Average	1.0	1.06	1.09
5. Potential Evapotranspiration (mm)	31.9	31.9	35.2
6. Percolation Loss (mm)	10.0	10.0	11.0

CALCULATION FACTORS OF UNIT IRRIGATION WATER REQUIREMENT
(PLANTED AREA, CROP COEFFICIENT, ET_p, L_p)

Improved Local Variety of Paddy

	July		
	1st 10-day	2nd 10-day	3rd 10-day
1. Cropping Pattern			
2. Nursery Period			
- Nursery Bed Area	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
- Nursery Bed Area out of Main Paddy Field (6%)	$\frac{3}{100}$	$\frac{3}{100}$	$\frac{3}{100}$
3. Puddling Period			
- Puddling Area	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$
4. Post-transplanting Period			
- Cropping Area			
Early Crop	$\frac{1}{12}$	$\frac{1}{4}$	$\frac{1}{3}$
Middle Crop	-	-	$\frac{1}{12}$
Late Crop	-	-	-
Tatal Area	$\frac{1}{12}$	$\frac{1}{4}$	$\frac{5}{12}$
- Crop Coefficient			
Early Crop	0.90	0.93	1.00
Middle Crop	-	-	0.90
Late Crop	-	-	-
Weighting Average	0.90	0.93	0.98
5. Potential Evapotranspiration (mm)	31.9	31.9	35.2
6. Percolation Loss (mm)	10.0	10.0	11.0

UNIT IRRIGATION WATER REQUIREMENT OF H.Y.V.
(LOM SAK AREA)

Unit : mm

	July		
	1st 10-day	2nd 10-day	3rd 10-day
1. Nursery Period			
- Nursery Bed Area out of Main Paddy Field	$\frac{19}{800}$	$\frac{3}{200}$	$\frac{1}{200}$
- Effective Rainfall (Re)	8.9	15.0	23.6
- Water Req. in Nursery Period (Wfn)	1.3	0.7	0.2
- Puddling Water Req. in Nursery Bed (Wpn)	0.7	-	-
- Nursery Water Req. (Wn)	2.0	0.7	0.2
2. Puddling Period			
- Puddling Area out of Main Paddy Field	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$
- Effective Rainfall (Re)	8.9	15.0	23.6
- Puddling Water Req. (Wp)	23.5	22.5	20.4
3. Post-transplanting Period			
- Cropping Area	$\frac{7}{12}$	$\frac{3}{4}$	$\frac{11}{12}$
- Crop Coefficient (Kc)	1.00	1.06	1.09
- Consumptive Use (Cu)	31.9	33.8	38.4
- Effective Rainfall (Re)	8.9	15.0	23.6
- Water Requirement after Transplanting	19.3	23.6	23.7
4. Farm Water Requirement			
- Total Farm Water Req. (Wf)	44.8	46.8	44.3

UNIT IRRIGATION WATER REQUIREMENT OF I.L.V.
(LOM SAK AREA)

Unit : mm

	July		
	1st 10-day	2nd 10-day	3rd 10-day
1. Nursery Period			
- Nursery Bed Area out of Main Paddy Field	3/100	3/100	3/100
- Effective Rainfall (Re)	8.9	15.0	23.6
- Water Req. in Nursery Period (Wfn)	1.6	1.4	1.3
- Puddling Water Req. in Nursery Bed (Wpn)	1.4	1.4	1.2
- Nursery Water Req. (Wn)	3.0	2.8	2.5
2. Puddling Period			
- Puddling Area out of Main Paddy Field	1/6	1/6	1/6
- Effective Rainfall (Re)	8.9	15.0	23.6
- Puddling Water Req. (Wp)	23.5	22.5	20.4
3. Post-transplanting Period			
- Cropping Area	1/12	1/4	5/12
- Crop Coefficient (Kc)	0.90	0.93	0.98
- Consumptive Use (Cu)	28.7	29.7	34.5
- Effective Rainfall (Re)	8.9	15.0	23.6
- Water Requirement after Transplanting	2.5	6.8	9.1
4. Farm Water Requirement			
- Total Farm Water Req. (Wf)	29.0	32.1	32.0

UNIT IRRIGATION WATER REQUIREMENT OF H.Y.V.
(PHETCHABUN AREA)

Unit : mm

	July		
	1st 10-day	2nd 10-day	3rd 10-day
1. Nursery Period			
- Nursery Bed Area out of Main Paddy Field	$\frac{19}{800}$	$\frac{3}{200}$	$\frac{1}{200}$
- Effective Rainfall (Re)	3.8	15.0	27.5
- Water Req. in Nursery Period (Wfn)	1.4	0.7	0.2
- Puddling Water Req. in Nursery Bed (Wpn)	0.7	-	-
- Nursery Water Req. (Wn)	2.1	0.7	0.2
2. Puddling Period			
- Puddling Area out of Main Paddy Field	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$
- Effective Rainfall (Re)	3.8	15.0	27.5
- Puddling Water Req. (Wp)	24.4	22.5	20.4
3. Post-transplanting Period			
- Cropping Area	$\frac{7}{12}$	$\frac{3}{4}$	$\frac{11}{12}$
- Crop Coefficient (Kc)	1.00	1.06	1.09
- Consumptive Use (Cu)	31.9	33.8	38.4
- Effective Rainfall (Re)	3.8	15.0	27.5
- Water Requirement after Transplanting	22.2	21.6	20.1
4. Farm Water Requirement			
- Total Farm Water Req. (Wf)	48.7	44.8	40.7

UNIT IRRIGATION WATER REQUIREMENT OF I.L.V.
(PHETCHABUN AREA)

Unit : mm

	July		
	1st 10-day	2nd 10-day	3rd 10-day
1. Nursery Period			
- Nursery Bed Area out of Main Paddy Field	3/100	3/100	3/100
- Effective Rainfall (Re)	3.8	15.0	27.5
- Water Req. in Nursery Period (Wfn)	1.8	1.4	1.3
- Puddling Water Req. in Nursery Bed (Wpn)	1.5	1.4	1.2
- Nursery Water Req. (Wn)	3.3	2.8	2.5
2. Puddling Period			
- Puddling Area out of Main Paddy Field	1/6	1/6	1/6
- Effective Rainfall (Re)	3.8	15.0	27.5
- Puddling Water Req. (Wp)	24.4	22.5	20.4
3. Post-transplanting Period			
- Cropping Area	1/12	1/4	5/12
- Crop Coefficient (Kc)	0.90	0.93	0.98
- Consumptive Use (Cu)	28.7	29.7	34.5
- Effective Rainfall (Re)	3.8	15.0	27.5
- Water Requirement after Transplanting	2.9	6.2	7.5
4. Farm Water Requirement			
- Total Farm Water Req. (Wf)	30.6	31.5	30.4

GENERAL FEATURES OF PROJECT FACILITIES

-HUAI KHON KAEN SUB-PROJECT-

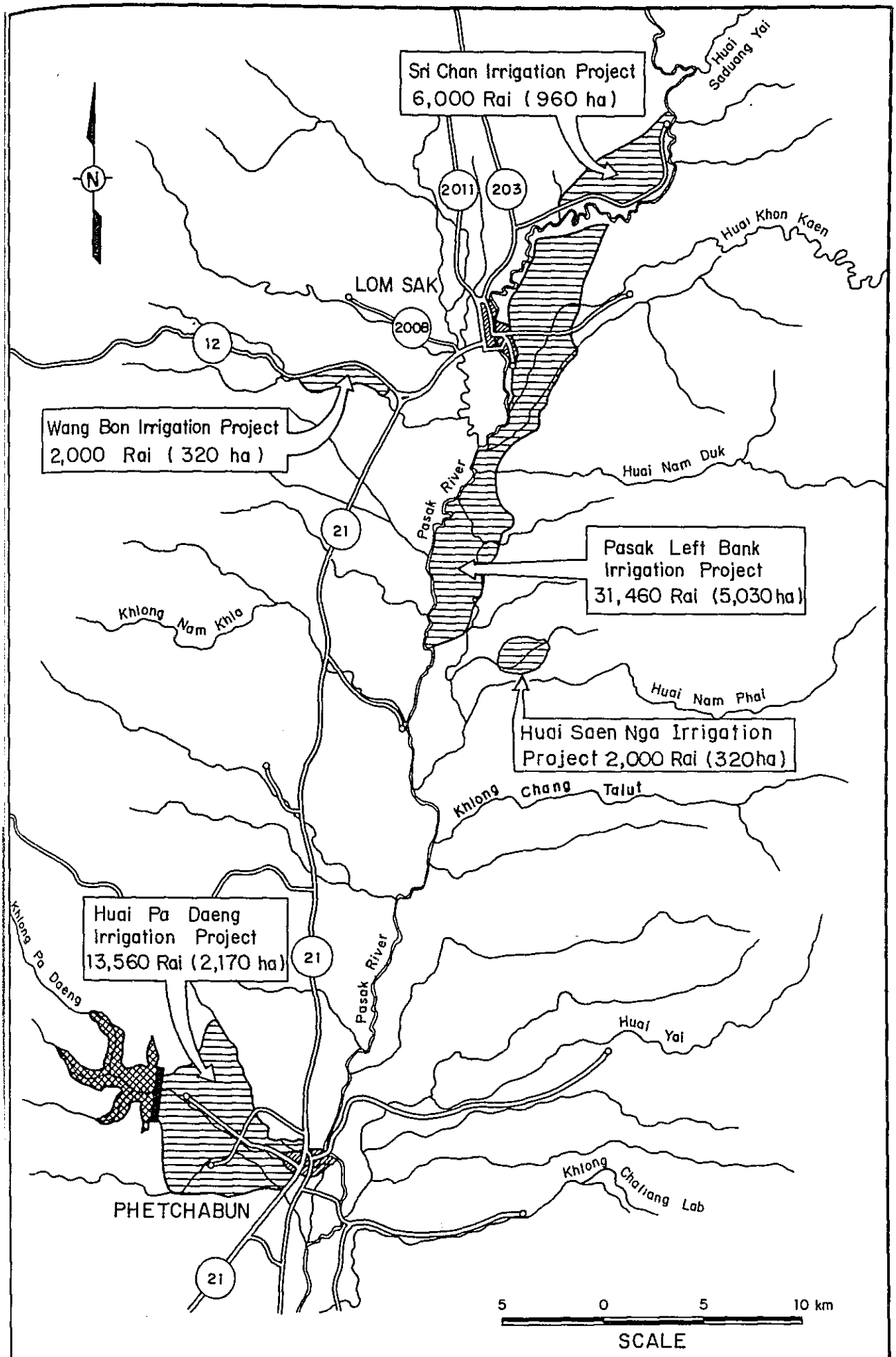
1.	Source of irrigation water	:	Huai Khon Kaen Reservoir
2.	Net irrigation area	:	5,100 ha
3.	Maximum diversion water requirement	:	5.1 m^3/sec
4.	Irrigation facilities		
	Main Canal	:	2 Nos.
	- Type of canal	:	trapezoidal concrete lined
	- Side slope of canal	:	1 : 1.5
	- Length	:	53.5 Km
	- Width of inspection road	:	6.0 m (effective width : 5.0 m)
	Laternal and sub-lateral canal	:	22 Nos.
	- Type of canal	:	trapezoidal unlined
	- Side slope of canal	:	1 : 1.5
	- Length	:	52.2 Km
	- Width of inspection road	:	4.0 m (effective width : 3.0 m)
	Related structures		
	- Culvert	:	40 Nos.
	- Inverted siphon	:	17 Nos.
	- Drop structure	:	38 Nos.
	- Check structure	:	86 Nos.
	- Check cum drop structure	:	38 Nos.
	- Turnout	:	21 Nos.
	- Farm turnout	:	132 Nos.
	- Spillway	:	19 Nos.
	- Measuring divice	:	22 Nos.
	- Cross drain	:	21 Nos.
	- Bridge	:	18 Nos.
5.	Drainage facilities		
	- Length of canal	:	72.3 Km
	- Related structure (culvert & cross drain)	:	7 Nos.

GENERAL FEATURES OF PROJECT FACILITIES
-HUAI YAI SUB-PROJECT-

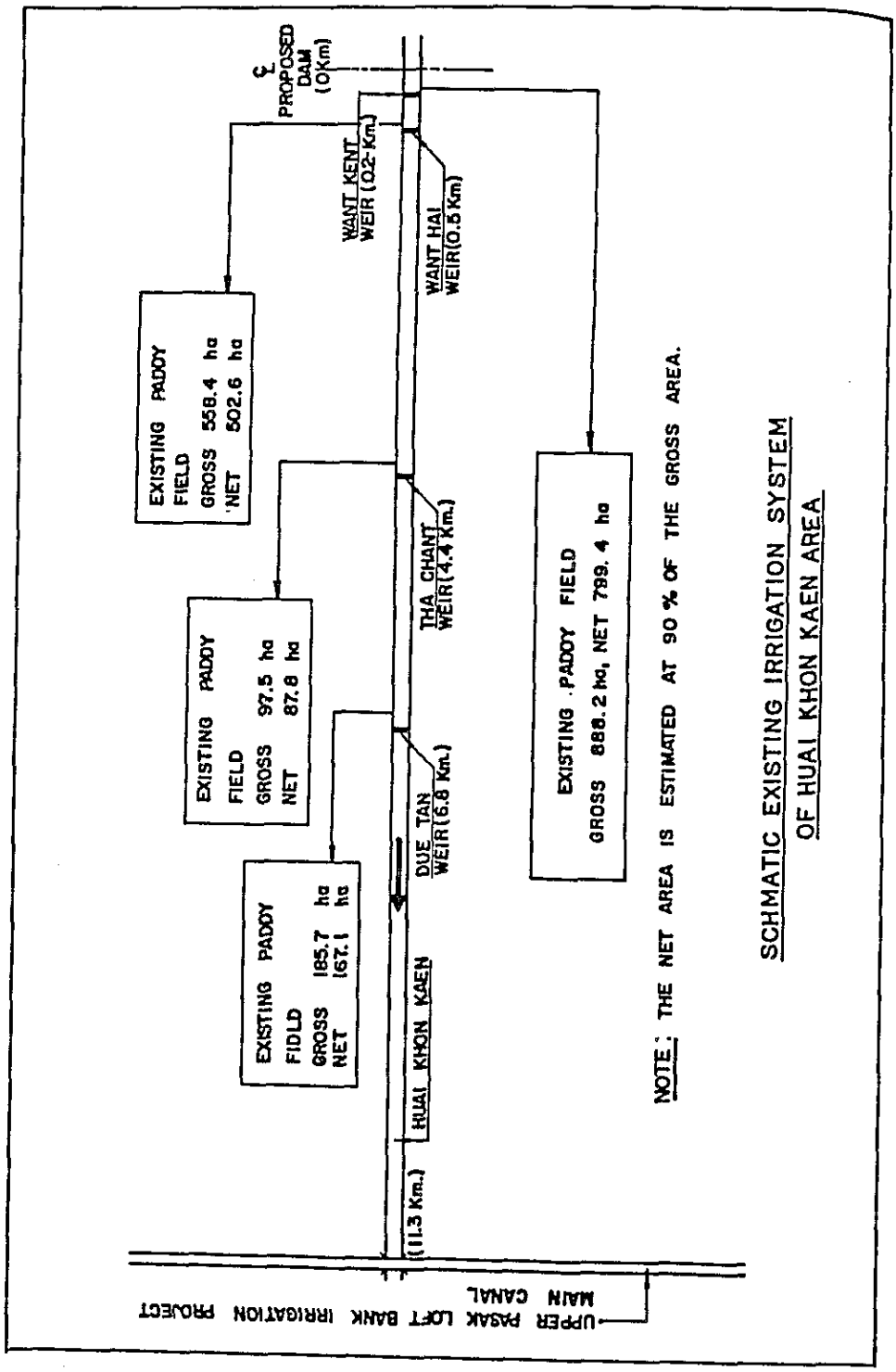
1.	Source of irrigation water	: Huai Yai Reservoir
2.	Net irrigation area	: 1,800 ha
3.	Maximum diversion water requirement	: 1.8 m^3/sec
4.	Irrigation facilities	
	Main Canal	: 1 No.
	- Type of canal	: trapezoidal concrete lined
	- Side slope of canal	: 1 : 1.5
	- Length	: 8.9 Km
	- Width of inspection road	: 6.0 m (effective width : 5.0 m)
	Laternal canal	: 3 Nos.
	- Type of canal	: trapezoidal unlined
	- Side slope of canal	: 1 : 1.5
	- Length	: 17.7 Km
	- Width of inspection road	: 4.0 m (effective width : 3.0 m)
	Related structures	
	- Culvert	: 11 Nos.
	- Inverted siphon	: 5 Nos.
	- Drop structure	: 41 Nos.
	- Check structure	: 21 Nos.
	- Check cum drop structure	: 23 Nos.
	- Turnout	: 2 Nos.
	- Farm turnout	: 52 Nos.
	- Spillway	: 8 Nos.
	- Measuring divice	: 3 Nos.
	- Cross drain	: 5 Nos.
	- Bridge	: 21 Nos.
5.	Drainage facilities	
	- Length of canal	: 36.7 Km
	- Related structure (culvert & cross drain)	: 2 Nos.

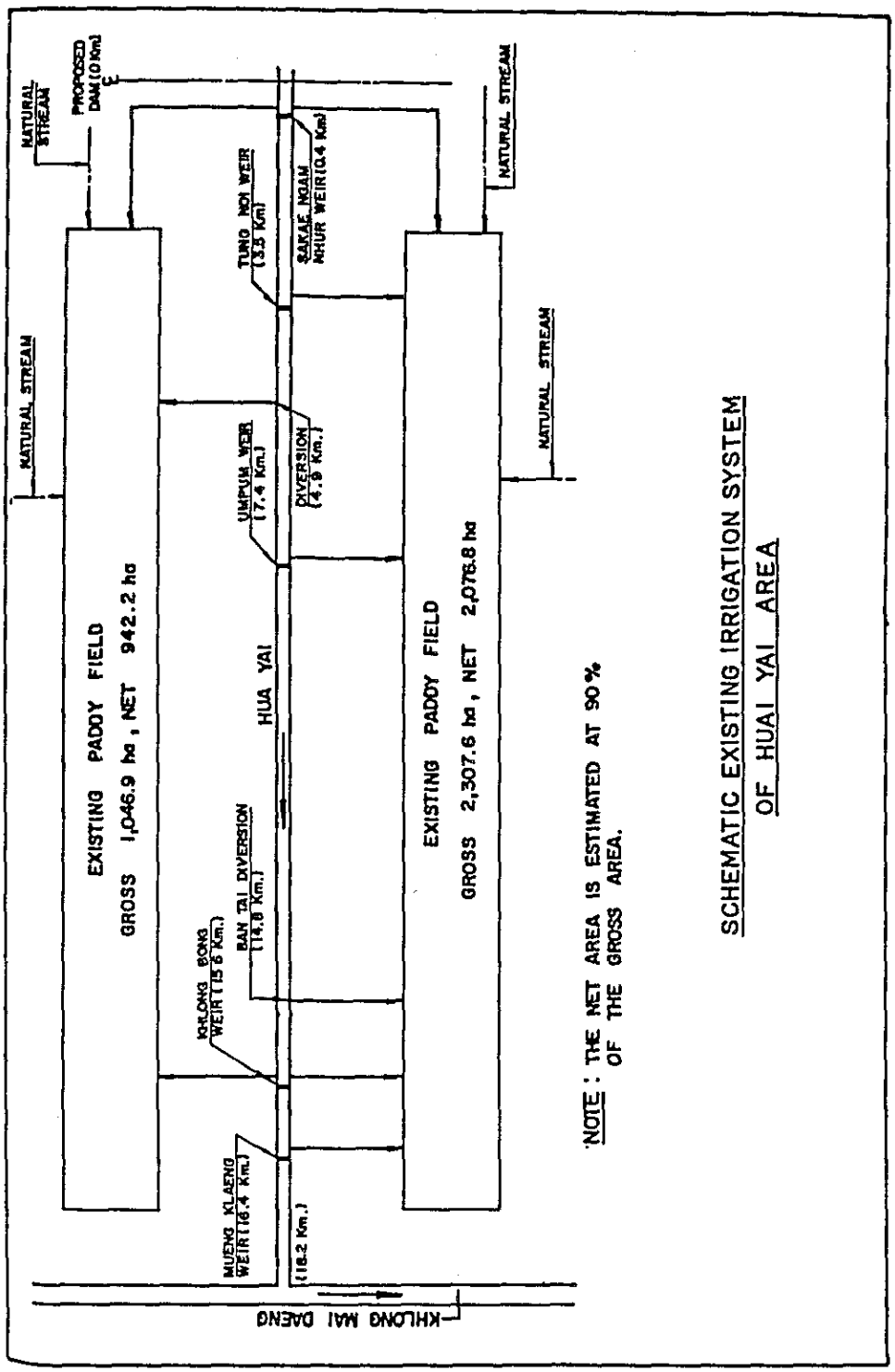
GENERAL FEATURES OF PROJECT FACILITIES
-KHLONG CHALIANG LAB SUB-PROJECT-

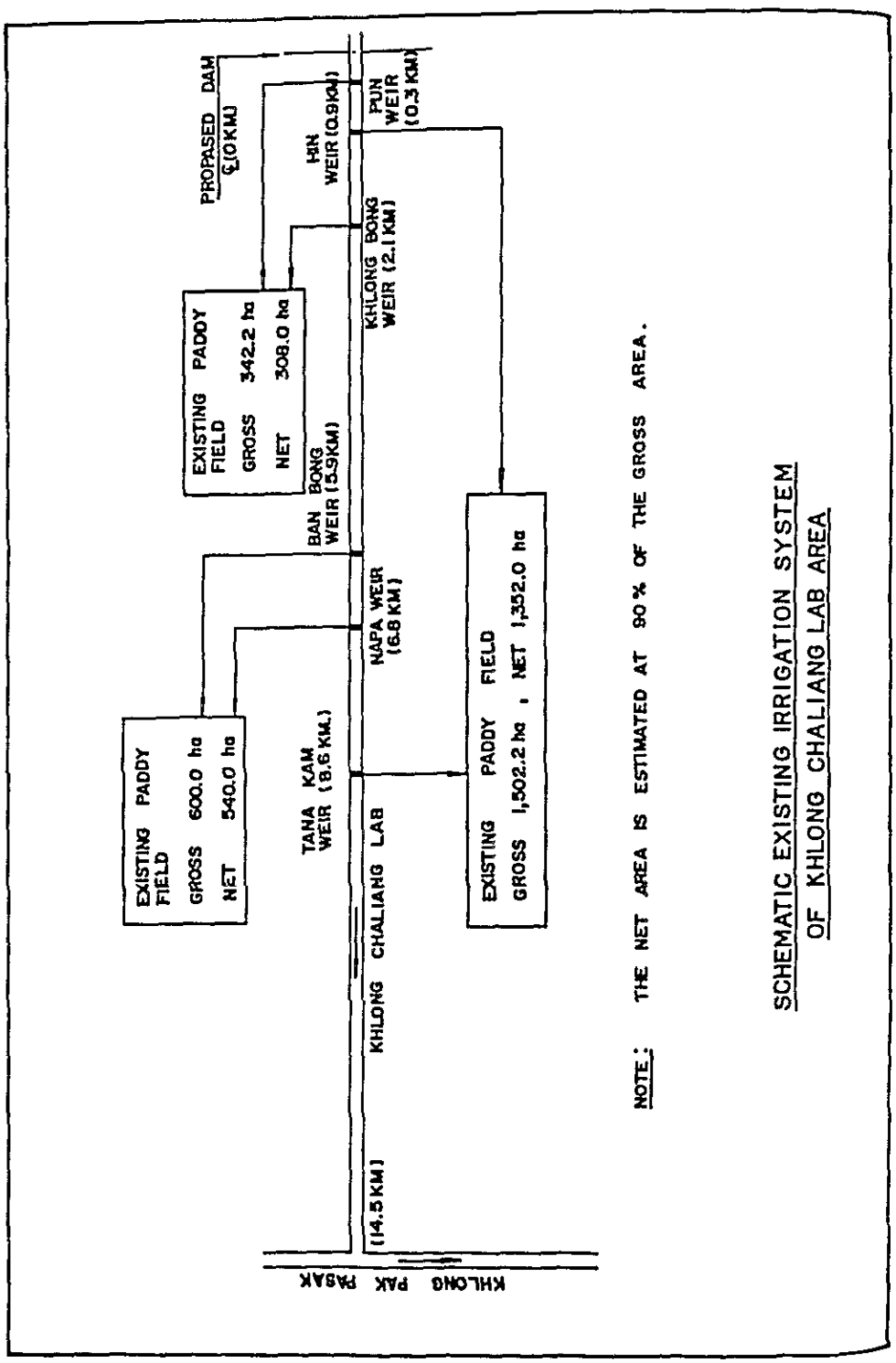
1.	Source of irrigation water	: Khlong Chaliang Lab Reservoir
2.	Net irrigation area	: 1,200 ha
3.	Maximum diversion water requirement	: 1.2 m^3/sec
4.	Irrigation facilities	
	Main Canal	: 1 No.
	- Type of canal	: trapezoidal concrete lined
	- Side slope of canal	: 1 : 1.5
	- Length	: 7.4 Km
	- Width of inspection road	: 6.0 m (effective width : 5.0 m)
	Laternal canal	: 4 Nos.
	- Type of canal	: trapezoidal unlined
	- Side slope of canal	: 1 : 1.5
	- Length	: 13.8 Km
	- Width of inspection road	: 4.0 m (effective width : 3.0 m)
	Related structures	
	- Culvert	: 5 Nos.
	- Inverted siphon	: 3 Nos.
	- Drop structure	: 48 Nos.
	- Check structure	: 19 Nos.
	- Check cum drop structure	: 16 Nos.
	- Turnout	: 3 Nos.
	- Farm turnout	: 34 Nos.
	- Spillway	: 4 Nos.
	- Measuring divice	: 4 Nos.
	- Cross drain	: 2 Nos.
	- Bridge	: 2 Nos.
5.	Drainage facilities	
	- Length of canal	: 20.0 Km
	- Related structure (culvert & cross drain)	: 1 No.



LOCATION OF EXISTING IRRIGATION PROJECTS

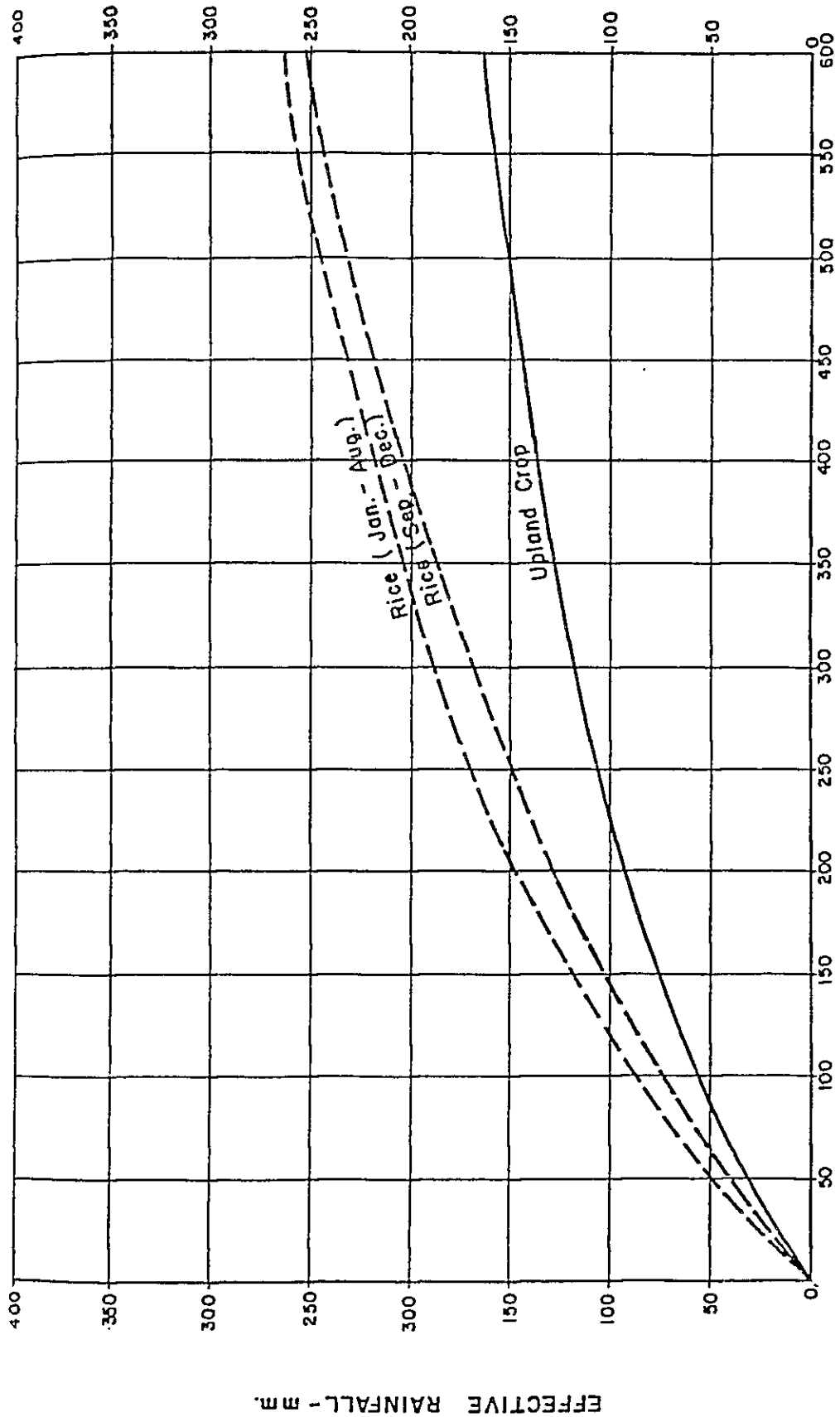

℄ PROPOSED DAM (0Km)
WANT KENT WEIR (0.2 Km.)
WANT HAI WEIR (0.5 Km)
THA CHANT WEIR (4.4 Km.)
DUE TAN WEIR (6.8 Km.)
EXISTING PADDY FIELD GROSS 558.4 ha NET 502.6 ha
EXISTING PADDY FIELD GROSS 97.5 ha NET 87.8 ha
EXISTING PADDY FIDLD GROSS 185.7 ha NET 167.1 ha
EXISTING PADDY FIELD GROSS 888.2 ha, NET 799.4 ha
HUAI KHON KAEN
(11.3 Km.)
UPPER PASAK LOFT BANK IRRIGATION PROJECT
MAIN CANAL
NOTE; THE NET AREA IS ESTIMATED AT 90 % OF THE GROSS AREA.
SCHMATIC EXISTING IRRIGATION SYSTEM
OF HUAI KHON KAEN AREA


NATURAL STREAM
PROPOSED DAM (0 Km)
NATURAL STREAM
TUNG NOI WEIR (3.5 Km)
SAKAE NGAM KHUR WEIR (10.4 Km)
NATURAL STREAM
NATURAL STREAM
UMPUM WEIR (7.4 Km.)
DIVERSION (4.6 Km.)
EXISTING PADDY FIELD
GROSS 1,046.9 ha, NET 942.2 ha
HUA YAI
EXISTING PADDY FIELD
GROSS 2,307.6 ha, NET 2,076.8 ha
KHLONG BONG WEIR (15.6 Km.)
BAN TAI DIVERSION (14.8 Km.)
MUENG KLAENG WEIR (18.4 Km.)
(18.2 Km.)
KHLONG MAI DAENG
NOTE : THE NET AREA IS ESTIMATED AT 90 % OF THE GROSS AREA.
SCHEMATIC EXISTING IRRIGATION SYSTEM
OF HUAI YAI AREA



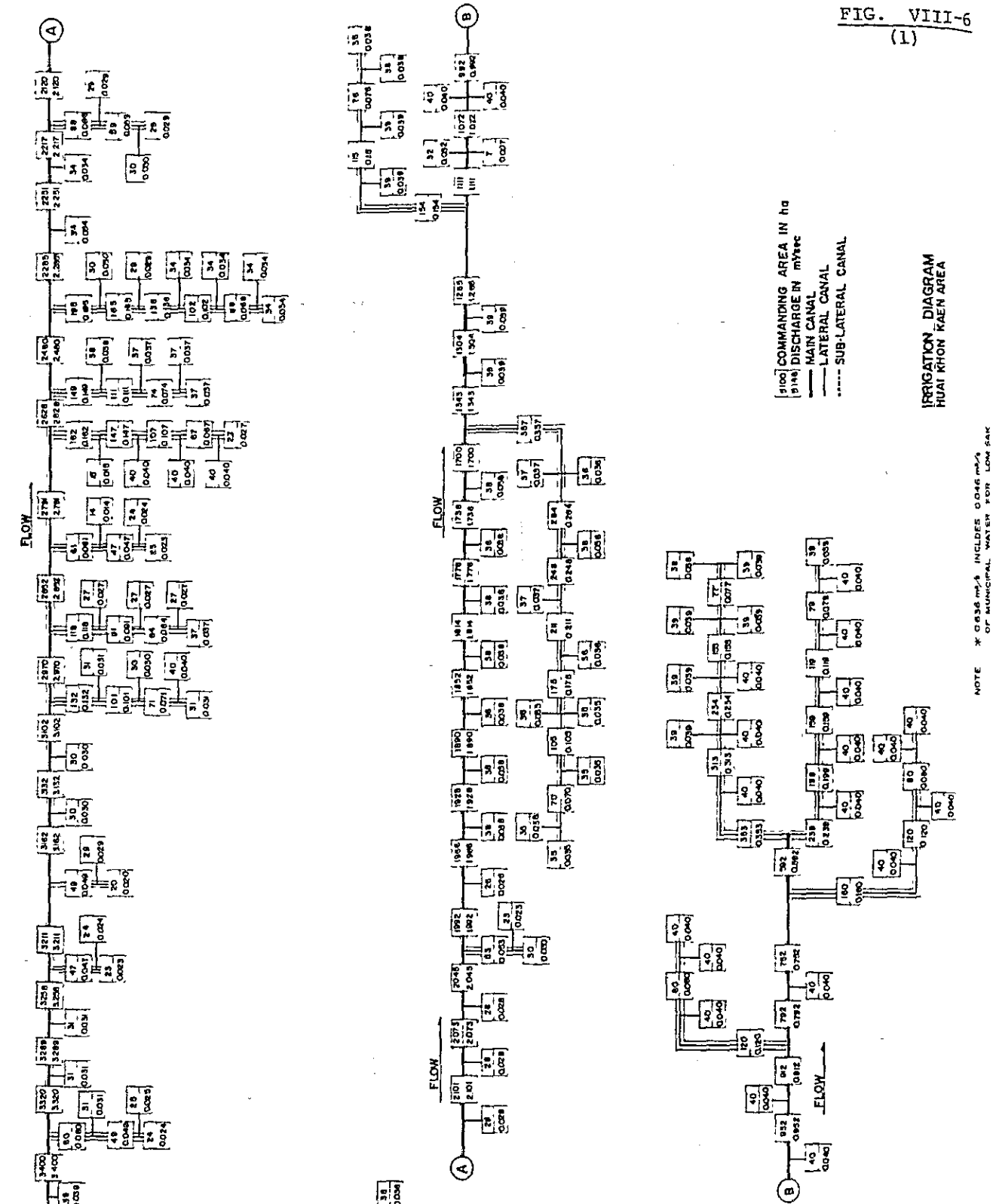
NOTE: THE NET AREA IS ESTIMATED AT 90 % OF THE GROSS AREA.

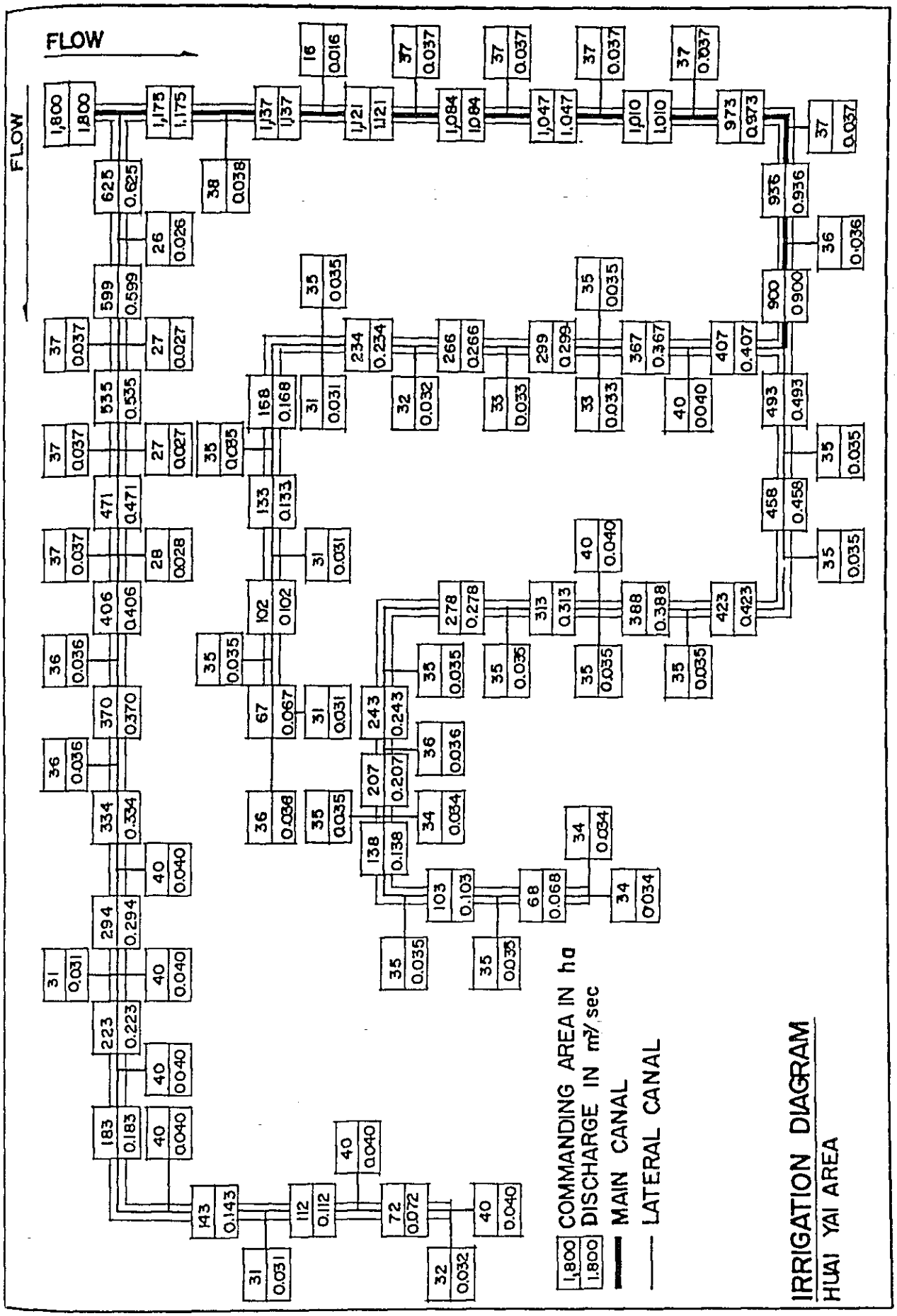
SCHEMATIC EXISTING IRRIGATION SYSTEM
OF KHLONG CHALIANG LAB AREA

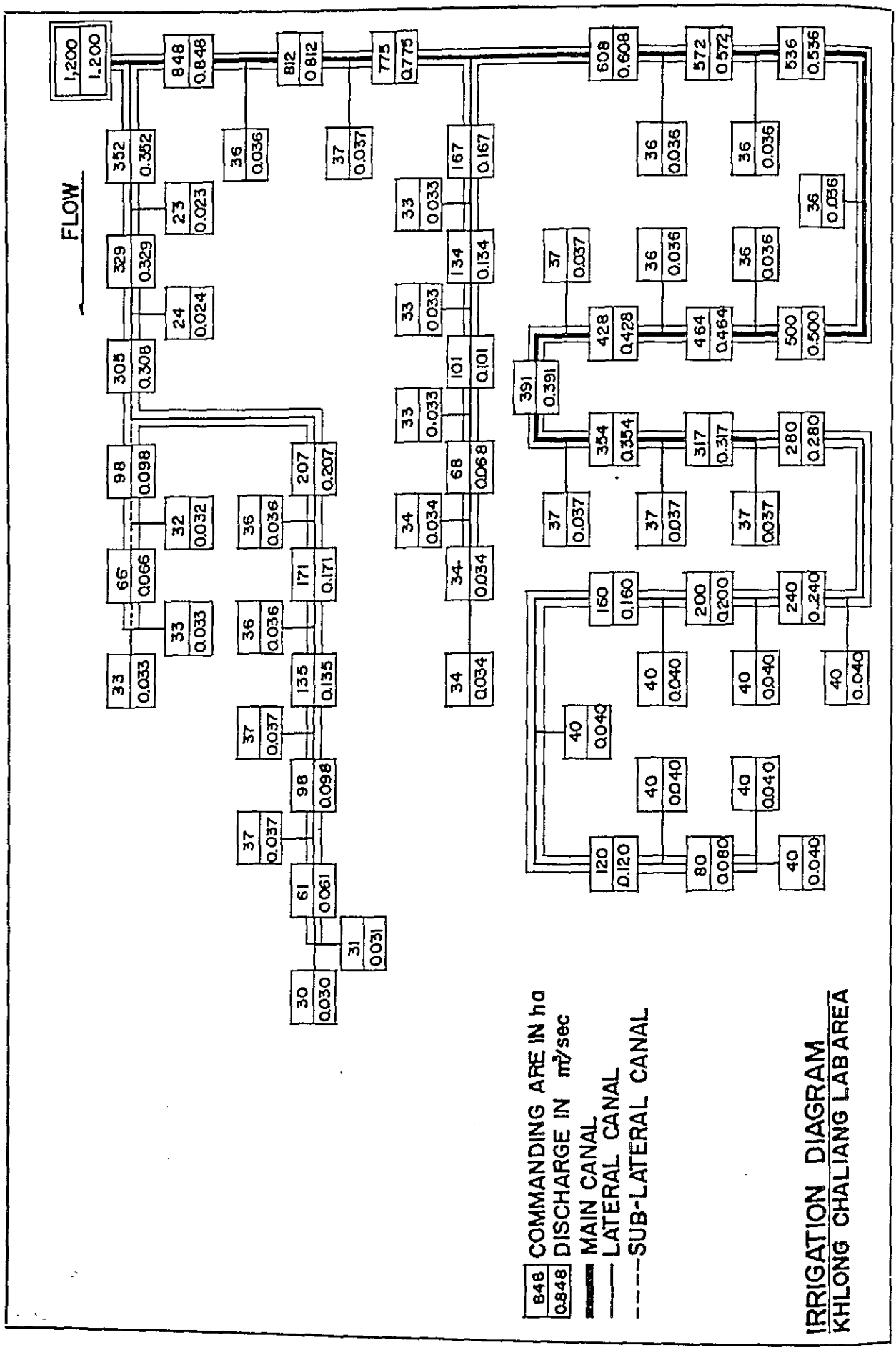


EFFECTIVE RAINFALL CHART

FIG. VIII-6
(1)


IRRIGATION DIAGRAM
HUAI KHON KAEN AREA
(100) COMMANDING AREA IN ha
(0.46) DISCHARGE IN m³/sec
MAIN CANAL
LATERAL CANAL
SUB-LATERAL CANAL
NOTE * 0.838 m³/s INCLUDES 0.046 m³/s OF MUNICIPAL WATER FOR LOM SAK
FLOW
PASAK RIVER


FLOW
FLOW
IRRIGATION DIAGRAM
HUAI YAI AREA
COMMANDING AREA IN ha
DISCHARGE IN m³/sec
MAIN CANAL
LATERAL CANAL


FLOW
1,200 1.200
848 0.848
812 0.812
775 0.775
608 0.608
572 0.572
536 0.536
352 0.352
329 0.329
305 0.308
98 0.098
66 0.066
33 0.033
32 0.032
33 0.033
36 0.036
207 0.207
171 0.171
135 0.135
98 0.098
61 0.061
31 0.031
30 0.030
37 0.037
36 0.036
37 0.037
36 0.036
37 0.037
23 0.023
24 0.024
167 0.167
134 0.134
101 0.101
68 0.068
34 0.034
34 0.034
33 0.033
33 0.033
33 0.033
34 0.034
391 0.391
428 0.428
464 0.464
500 0.500
354 0.354
317 0.317
280 0.280
160 0.160
200 0.200
240 0.240
120 0.120
80 0.080
40 0.040
848 COMMANDING ARE IN ha
0.848 DISCHARGE IN m³/sec
MAIN CANAL
LATERAL CANAL
SUB-LATERAL CANAL
IRRIGATION DIAGRAM
KHLONG CHALIANG LAB AREA

ANNEX IX

ORGANIZATION AND MANAGEMENT

ANNEX - IX

ORGANIZATION AND MANAGEMENT

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ANNEX - IX

ORGANIZATION AND MANAGEMENT

1. PRESENT ORGANIZATION FOR IRRIGATION DEVELOPMENT

1.1 Royal Irrigation Department (RID)

The Roayl Irrigation Department (RID) in the MOAC is given responsibilities for planning, developing, operating and manging for most of all national and provincial level irrigation systems. The RID was formed in 1904 and since then has constructed not only irrigation systems, but also flood control and navigation systems, and has expanded benefited area for nearly 12.5 million rai (2 million ha).

The RID has 22 Divisions and 12 Regional Offices under a Director General with assistance of three Deputy Director Generals and two Chief Engineers (FIG. IX-1).

1.2 Project Execution

For smooth and effective execution of the development schemes, all irrigation development projects are divided into three scales; small, medium and large scales, by the amount of construction cost as shown below:

Small Scale Irrigation Project	:	below ฿ 4 million
Medium Scale Irrigation Project	:	below ฿ 200 million
Large Scale Irrigation Project	:	over ฿ 200 million

There are some differences between small scale and medium and large scales on their procedure of the project implementation. The responsibilities for the implementation of the small scale project are mainly taken by the Regional Office and for the operation and maintenance (O & M) after completion of the project are taken by farmers themselves under assistance of the Provincial Irrigation Staff (RID Staff) in the Provincial Administration Office. The imlementation of the medium and large scale projects is handled directly by the headquarters of RID, and the O & M Office of the specific project is in charge of O & M of the project under control of the Regional Office.

For the execution of medium and large scale projects, RID designates the Project Manager under the Deputy Director General who serves as the Project Director responsible for overall direction. The Project Manager is directly responsible for day-by-day management, coordination of the other functional division and other governmental agencies. After completion of the medium and large scale irrigation projects, operation and management of the projects are undertaken by the Regional Office under the administrative assistance of the Operation and Maintenance Division in RID headquaters.

On the field level, the Project Engineer is designated as a chief of the O & M office and responsible for operation and management of the project. In general, operation of the irrigation system is carried out through the channel of operation staffs such as water master, zone man and common irrigator.

1.3 O & M Office in the Phetchabun Province

In the Phetchabun Province, which belongs to the Region III, there exist 20 small scale irrigation projects and three medium scale irrigation projects; the Pasak Left Bank Project, Huai Pa Daeng Project and Sri Chan Project which are under construction.

The responsibilities for operation and management of the Huai Pa Daeng and Pasak Left Bank Project are taken by one Project Engineer in the Phetchabun Irrigation Project Office. The Project Engineer also surves concurrently as the Provincial Irrigation Engineer. All the small scale irrigation projects in the province were established under assistance of the Provincial Irrigation Engineer especially on the stage of the planning. The Phetchabun Irrigation Project Office consists of five sections; engineering, mechanical, water management, secretary and administrative sections. The organization chart of the Phetchabun Irrigation Project Office is as shown in FIG. IX-2.

All the problems existing in the present operation and management of the said office are derived from the point of insufficient budget. The Project Engineer is burdened by administrative and regulatory function related to the small scale irrigation projects. Repair and mainteance are not carried out timely because budgetary arrangement takes time, even it is needed urgently. Insufficient staffing makes difficulty in giving enough support to farmers, especially on agricultural services. TABLE IX-1 shows the recent distribution of O & M cost for the O & M offices in Region III. Although the O & M cost for the Pasak Left Bank Project is rather high at ฿ 248/rai (฿ 1,550/ha), the Huai Pa Daeng Irrigation Project shows only ฿ 54/rai (฿ 335/ha).

1.4 Water Users' Association (WUA)

The Government has made much efforts to organize farmers in the irrigated area into the Water Users' Association (WUA). As a results, 187 WUAs have been established over the country as of August 1982. These WUAs are organized under the assistance of the RID for introduction of modern water management to farmers. WUA consists of several Water Users' Groups (WUG) which take responsibility for control of terminal irrigation units.

There is no WUA in and around the project area, though there exist two medium scale irrigation projects. There are about 10 WUGs in the Pasak Left Bnnk Project area and 6 WUGs in the Huai Pa Daeng Project area, but they were mostly organized for the minority of the group members and might have difficulty in accepting water management under the present system.

2. PROPOSED ORGANIZATION FOR THE PROJECT

2.1 Project Execution

RID will become the execution agency for the Upper Pasak Medium Scale Irrigation Project. It will be responsible for design and construction of project works and supervision for the project operation.

The Project Director will be appointed for project implementation on the same level as Deputy Director General and responsible for overall execution of the proposed project, who will coordinate activities of all relevant governmental agencies in connection with implementation of the project.

2.2 Organization for Construction Stage

The Project Manager will be directly responsible for the execution of the project as a chief of the Project Construction Office under the Project Director. The proposed organization structure is shown in FIG. IX-3. Main functions of the Project Construction Office are as follows, and required number of staff is as shown in TABLE IX-2.

(1) Financial arrangement needed for construction of irrigation, drainage and road system,

(2) Design and construction supervision of all the construction activities down to secondary system,

(3) Assistance to farmers in construction of tertiary system, and

(4) Accounting and management of construction works.

The Project Construction Office will consist of one main office and four branch offices. The Main Office will have four sections, engineering, construction, operation and administrative section, and major works done by each section will be summarized as follows:

(1) The engineering section will prepare plan and schedule of the Project execution including budgetary and disbursement schedule, carry out detail survey for the design and construction works, and report and record the project progress and implementation.

(2) The construction section will prepare detailed monthly construction plan and schedule based on the project construction schedule, and supervise project construction work. And, it will also prepare documents for procurement of equipment and materials, management and operate workshop, prepare equipment working plan, maintain equipment, etc.

(3) The operation section will give advice to farmers on-farm consolidation of terminal units taken by farmers themselves, obtain the written consent for the project implementation and organize farmers into WUA after completion of planning and design of irrigation systems under the assistance of the Water Users' Center in O & M Division, RID.

(4) The administrative section will take responsibilities for accounting, financing, administrative affairs and procurement for the implementation, operation and maintenance of the project.

2.3 Organization for O & M Stage

2.3.1 Organization and Management

After completion of the construction works, the Project Construction Office will be re-organized into the Project O & M Office under the Region III Office. Since this re-organization would require two years or more, the Project Construction Office will successively be responsible for the operation and maintenance of the project facilities during the transfer period.

The Project Engineer will be assigned as a chief of the O & M Office and responsible for operation and maintenance of the irrigation, drainage and road networks down to inlets of tertiary blocks. The operation and maintenance of the tertiary blocks down to the terminal facilities will be entrusted to WUAs and farmers themselves. The proposed organization chart is as shown in FIG. IX-4. Staff necessary for the office is listed in TABLE IX-3.

The Office will consist of one main office, two branch offices and six field offices. The Main O & M Office will be established in the Phetchabun city, and two branch offices will be established under the main office: one is in the Phetchabun city and the other is in the Lom Sak city. The field O & M Offices will be established or re-organized for every proposed and existing medium scale irrigation projects. The Phetchabun Branch Office will be responsible for control of the medium scale irrigation projects in the Phetchabun District such as the Huai Yai, Khlong Chaliang Lab sub-projects and existing Huai Pa Daeng Project, and the Lom Sak Branch Office will be for the Huai Khon Kaen sub-project, existing Pasak Left Bank Project and Sri Chan Project in the Lom Sak District. All the main, branch and field offices established in the construction stage will be used as the Project O & M Office except two branch offices. The Phetchabun Branch Office will be organized in the main office, and the Lom Sak Branch Office will be established in the late stage of construction for control of the above-mentioned field offices.

The Main Office will be responsible for the overall activities necessary for proper operation and maintenance of all the project facilities including preparation of overall O & M program, design and construction/ supervision of maintenance and repairing works, budgeting, training of staff etc. The Office will consist of five sections, engineering, O & M, workshop, agricultural service and administrative section. The following are the proposed major roles to be taken by each section.

(1) The engineering section will prepare plan and design of the maintenance and repair works, assist and advise to farmers through WUAs in design of maintenance works within the tertiary command area, and collect and analize data on the river discharge.

(2) The O & M section will work for estimation of water requirement and preparation of water supply schedule based on the cropping schedule obtained from WUA through the branch and field offices, regular contact with the Field Offices regarding water supply schedule, and information supply to the field offices on water management.

(3) The workshop section will manage workshop and O & M equipment, prepare operation schedule of O & M equipment, repair and maintain metal works of the project facilities.

(4) The agricultural service section will assist and advise the farmers for promoting advanced technics for irrigated agriculture and collect and compile agricultural data.

(5) The administrative section will work mostly the same as that of the construction office, for accounting, financing, administrative affairs, etc.

The Branch Offices will be established in both districts; Phetchabun and Lom Sak, for control of the Field Offices as mentioned before. The supervisor will be appointed as a chief of the Branch Office for supervising the activity of Water Master in the Field Offices, and responsible for all O & M works of the related Field Offices. The main duties taken by the Branch Offices are as follows:

(1) Collection of information of cropping schedule from the field offices and transfer it to the main office,

(2) Supply of information on water distribution schedule to WUA through the field offices,

(3) Maintenance of the project facilities in the commanding area, and

(4) Providing periodical consultation to WUA on operation and maintenance within the terminal irrigation units.

2.3.2 Water Management

Water management up to the farm turnouts of each sub-project will be mainly carried out under the responsibility of the field office. For efficient operation of the proposed irrigation systems, each irrigation system will be divided into several zones. Each zone of about 7,000 rai (1,120 ha) will be further divided into about seven irrigation units called Chaeks. Each chaek of about 1,000 rai (160 ha) will consist of four terminal irrigation units. The covering area of each terminal irrigation unit is planned to be less than 250 rai (40 ha).

The systematic staffing channels will be adopted for management of each irrigation system and the above-mentioned zone and chaek.

Water master will be appointed as a chief of the field office and directly responsible for water delivery to the irrigation system, and also supervise one to four zone men. Major works to be taken by the water master are;

(1) Preparation of the suitable cropping pattern for the area based on water availability and control of water supply from canals to each irrigation unit according to the cropping pattern,

(2) Statistical study of actual consumption of irrigation water in the canal and at the terminal,

(3) Supervision and arrangement of staffs in the field office for efficient water management and adequate maintenance of the canals and facilities, and

(4) Preparation of monthly report on the water operation for the branch office and main office.

Zone man will be responsible for water management within the zone. He will supervise four common irrigators and support water master on estimating and reporting of irrigated area, quantity of water delivered and delivery schedule and perform the maintenance works of the laterals as well as drainage canals in the zone assigned to him.

Common irrigator will manage the water distribution at the farm turnout which will cover terminal irrigation unit of 250 rai (40 ha). Four irrigation units (one chaek) will be handled by one common irrigator who will be hired on the contract base with the project engineer. Besides the water operation works, common irrigator will report to zone man on water quantity required from Water Users' Group, maintain the main ditches and perform the necesaary works for water management. Common irrigator will be elected among the members of water user's group and given the role concurrently with a chaek leader.

2.4 Water Users' Association Set-up

For the management, operation and maintenance of the irrigation and drainage systems in terminal irrigation unit, beneficiaries will organize themselves into the Water Users' Group (WUG) in each chaek of about 940 rai (150 ha) consisting of about 100 farm families on an average in the irrigation development area. For good coordination and cooperation, federation of WUGs, called Water Users' Association (WUA) will be established in each irrigation system of the sub-project through affiliation of WUGs. The following table shows the numbers of WUGs and WUAs to be established in the project area.

Name & No. of WUA	Command Area of WUA	No. Of WUG
Huai Khon Kaen	31,875 rai (5,100 ha)	34
Pasak Left Bank	27,750 rai (4,440 ha)	30
Sri Chan	6,000 rai (960 ha)	6
Huai Yai	11,250 rai (1,800 ha)	12
Khlong Chaliang Lab	7,500 rai (1,200 ha)	8
Huai Pa Daeng	13,560 rai (2,170 ha)	20
TOTAL 6	97,935 rai (15,670 ha)	110

2.4.1 Water Users' Group (WUG)

WUG will be organized in each chaek consisting of four terminal irrigation units on the initiative of related village and sub-district (Tambon) chief and with quidance and consultation of the Water Users' Center in O & M Division, RID and O & M Office, before completion of the construction work of the project.

After establishment of WUG, group leader (chaek leader) will be elected among the members as a representative of the group. The chaek leader and members will take responsible for operation and management within the terminal irrigation units under mutual cooperation. The major works taken by the chaek leader will be as follows:

(1) Preparation of register of members and collection of data on expected cropping pattern, water use of members and report it to O & M Office through regulation work of WUA.

(2) Regulation and control of water distribution according to the program decided by the O & M Office.

(3) Preparation of maintenance schedule and stimulation of members into the works.

(4) Solution of all kinds of problems related to the water management.

All the works mentioned above will be done under the guidance and support of zone man and agronomist in the O & M Office.

2.4.2 Water Users' Association (WUA)

WUA will be established in each irrigation system of sub-project as a federation of WUGs as mentioned bofore. Further, it is strongly proposed to establish the committee of WUA for efficient management of each WUA. The committee will be organized by about 25 representatives elected from chaek leaders and take responsibilities not only for water management of the terminal irrigation units, but also for support of farm management of members according to the created condition of the committee. Through the committee, the WUA will be given strong support from all the agricultural supporting agencies in the province such as RID, DAE, BAAC, etc.

The followings are the major duties to be taken by WUA and its committee.

(1) Preparation of register of association on the basis of submitted ones from the chaek leaders,

(2) Regulation of sub-project wide water distribution and O & M program on the basis of the submitted cropping pattern and program from the chaek leaders and reporting it to O & M Office,

(3) Regulation of water distribution to zone areas through contact with the water master in the field office, and

(4) Supply of farm inputs and marketing of products with better conditions than private sectors and supplying credit from BAAC.

All the works mentioned above will be done on the condition of close inter-linkage between WUA and all kind of institutional agencies mentioned before.