4.1.4 Labor plan

(1) Culture schedule

1) Paddy

The culture schedule for paddy is as follows.

Monthly Works of Paddy Rice Culture and Management

Works	Machinery	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Plowing	Disc plow												
Harrowing	Disc harrow												
Land levelling	Land leveller												
Fertilization, seeding	Tractor (seeder)												
Ridging	Ridger												
Top dressing	Aeroplane use												
Weeding													
Control													
Water management													
Harvesting	Harvester												
Transportation	Trailer												

Plowing by disk plows is initiated in August, followed by three rounds of harrowing before land leveling which takes place in September and October. Then, fertilizing and sowing follows begining in the middle of October to end in November. The three month period from September to November represents the most busy season of rice farming. Water management is maintained by means of man power from the end of sowing to February for about five months. Harvesting is executed by the combine, the harvest transported on trailers. Additional fertilizing, weeding and control of insect disease damage are all made by cropdusting techniques.

Table 4-1-5 presents the working hours of these operations for farming of different scales computed on the basis of the foregoing culture schedule.

Table 4-1-5 Working Hours of Wet Paddy Culture and Management

(Unit: Hour)

Month / Item / Scale	Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Total	
	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power
25	-	100	-	100	25 25	175	13 13	88	-	-	-	-	-	-	63	63	100	100	112	287	75	325	-	100	38 388	1,338
50	-	200	-	200	50 50	350	25 25	175	-	-	-	-	-	-	65	65	95	95	110	400	80	440	-	200	75 425	2,125
100	-	400	-	400	100 100	700	50 50	350	-	-	-	-	-	-	130	130	186	186	218	798	158	872	-	400	150 842	4,236
150	-	600	-	600	127 127	945	98 98	630	-	-	-	-	-	-	195	195	286	286	351	1,266	227	1,268	-	600	225 1,284	6,390
250	-	1,000	-	1,000	250 250	1,750	125 125	875	-	-	-	-	-	-	250	250	405	405	470	1,920	340	1,965	-	1,000	375 1,840	10,165
400	-	1,600	-	1,600	400 400	2,800	200 200	1,400	-	-	-	-	-	-	440	440	668	668	796	3,140	560	3,200	-	1,600	600 3,064	16,448
500	-	2,000	-	2,000	500 500	3,500	250 250	1,750	-	-	-	-	-	-	500	500	810	810	940	3,840	680	3,930	-	2,000	750 3,680	20,330

Note: 1. Upper number of machinery column is using hours of combine, and the lower is of tractor.

2. Scale 50 ha Working hours with machinery (tractor) per ha 8.6 hrs.
Working hours with human power per ha 42.5 hrs.

Scale 150 ha Working hours with machinery (tractor) per ha 8.6 hrs.
Working hours with human power per ha 42.6 hrs.

Scale 500 ha Working hours with machinery (tractor) per ha 7.4 hrs.
Working hours with human power per ha. 40.7 hrs.

3. Detail of estimation is accompanied by Appendix.

Use of the tractor reaches the highest peak in October when the operations of harrowing/land grading, land leveling and sowing overlap with themselves and the second highest peak in September and November. Plowing and harrowing/land grading in both August and September are achieved by the operator of a tractor alone without assistance, as might be inferred from the same values of tractor operating hours and manhour. During the October ∿ November period when many operations overlap with themselves along with water management, which is executed by man power begining at the end of sowing, the manhours reaches maximum. After this period, the only operation is water management in the next two months since additional fertilizing, weeding and control of insect disease damage by cropdusting is assigned to an outsider. Most of harvesting and transportation of harvest is performed in May and the rest (some one third of the workload) in April. Loading from the combine to the trailer requires assistants, which explains the large manhours in these months. In the schedules for 150-hectare (medium) and 500-hectare (large) scale farming, the tractor operating hours are 8.6 and 7.4 hours, respectively, and the manhours 42.6 and 40.7 hours, respectively, per hectare.

2) Soybean and wheat farming

The operation schedule of soybean and wheat farming is as follows.

Monthly Works of Soybean and Wheat Culture and Management

Works	Machinery	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Plowing	Disk plow				------					———	———		
Subsoil breaking	Sobsoiler										———		
Harrowing	Disc harrow					.....					———	———	
Fertilization, seeding	Tractor (seeder)					.....						———	
Intertillage	Cultivater											———	———
Weeding	Weeder												———
Control	Speed sprayer	———	———					———		———			———
Harvesting	Combine			———						———			
Transportation	Trailer			———						———			

Note: ——— Soybean, ... Wheat.

The crop rotation of soybean as the export and wheat as the national staple food takes an ideal form in our project from the viewpoint of utilization of machinery and labor allocation; use of tractors is equal every month.

The farming of soybean is started in September, which is the harvesting month of wheat. The operation of plowing starts off following the harvesting of wheat to continues until it is October and November, the busy farming season of soybean farming. Since sowing is made in November, the work centered on the preparations such as subsoil breakup (once in four years) and harrowing/land grading. Then, intertillage and weeding and control of insect disease damage by means of the speed sprayer follow. March is the harvesting month for soybean.

The operation of plowing for wheat starts in April, followed by harrowing (a single round) then by fertilizing and sowing in May. No intertillage by cultivators is executed. In the period from June to August weeding and control of insect disease damage are undertaken by means of the speed sprayer and the month of harvest follows. The transportation of harvesting is completed before September ends.

Table 4-1-6 presents the monthly operation hours schedule of soybean-wheat crop rotation for different farming scales produced on the basis of the foregoing operation schedule.

The peak of tractor work in soybean cultivation is October and November, however, furthermore tractor is used for intertillage, weeding, control of insect disease damage, transportation etc. The peak of man power work is harvest season on March and next is November, however, the difference is few.

The operation of farming the wheat reaches the highest peak in May the seeding time of wheat. The tractor operating hours and manhours for this month can be equated with November when the culture of soybean arrives at its highest peak. The work of subsoil breaking is synchronized with the hours of planting the soybean. The total machine operating time and manhours of wheat culture are slightly less than those of soybean farming since no intertillage and weeding are performed in the former. The tractor operating hours and the manhours per hectare for

50-hectare (medium) scale and 150-hectare (large) scale farming are respectively as follows.

		Total tractor operating hours per hectare (in hours)		Total manhours per hectare	
50-ha scale farming	wheat	9.5	22.2	14.0	32.0
	soybean	12.7		18.0	

Table 4-1-6 Working Hours of Soybean and Wheat Culture and Management

Scale (ha) \ Month / Item	Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Total	
	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power	Machinery	Human power
25 Wheat	-	-	-	-	-	-	66	66	70	103	19	19	37	37	19	19	19 19	75	-	-	-	-	-	-	19 230	319
25 Soybean	37	37	19	19	24 24	94	-	-	-	-	-	-	-	-	-	-	19	19	66	66	70	103	56	56	24 291	394
50 Wheat	-	-	-	-	-	-	94	94	113	169	28	28	56	56	28	28	38 38	150	-	-	-	-	-	-	38 357	525
50 Soybean	56	56	28	28	47 47	188	-	-	-	-	-	-	-	-	-	-	38	38	103	103	122	178	84	84	47 478	675
100 Wheat	-	-	-	-	-	-	220	220	250	371	56	56	113	113	56	56	75 75	300	-	-	-	-	-	-	75 770	1,116
100 Soybean	112	112	56	56	94 94	375	-	-	-	-	-	-	-	-	-	-	90	90	262	262	239	360	177	177	94 1,030	1,432
150 Wheat	-	-	-	-	-	-	193	193	250	383	66	66	135	135	68	68	113 113	450	-	-	-	-	-	-	113 825	1,295
150 Soybean	135	135	68	68	113 113	450	28 28	112	-	-	-	-	-	-	-	-	81	81	228	228	246	379	201	201	141 1,100	1,654
200 Wheat	-	-	-	-	-	-	288	288	363	554	95	95	195	195	90	90	150 150	600	-	-	-	-	-	-	150 1,181	1,822
200 Soybean	191	191	95	95	150 150	600	38 38	150	-	-	-	-	-	-	-	-	135	135	378	378	368	558	290	290	188 1,645	2,397

Note: 1. Upper number of machinery column is using hours of comtine, and the lower is of tractor.

2. Scale 50 ha Wheat / Soybean Working hours with machinery (tractor) per ha ..... 9.5 / 12.7 Total 22.2 hrs.

" Working hours with human power per ha ..... 14.0 / 18.0 Total 32.0 hrs.

Scale 150 ha Wheat / Soybean Working hours with machinery (tractor) per ha ..... 7.3 / 9.8 Total 17.1 hrs.

" Working hours with human power per ha ..... 11.5 / 14.7 Total 26.2 hrs.

3. Detail of estimation is accompanied by appendix.

		Total tractor operating hours per hectare (in hours)		Total manhours per hectare	
150-ha scale farming	wheat	7.3	17.1	11.5	26.2
	soybean	9.8		14.7	

As in the case of paddy culture, greater optimization in both the total mechanical operating hours and manhours is attained in the greater scales of farming. The manhours of soybean and wheat culture are respectively as 1/4 less as the manhours of paddy farming and there is marked evidence of labor saving in the former.

(2) Study of labor demand and supply

1) Family labor hours

It is necessary to determine the standard supply (in hours) of family labor of a farmer in order to study how the demand of the monthly operating hours, as discussed in earlier Sections, is met by the supply of family labor.

The 1982 Censo Nacional de Poblacion y Vivienoas reports set the size of a family in the agricultural zones at six people on the average. Consideration of two persons (male and female of age) out of them as effective labor force draws up a monthly schedule of family labor as shown in Table 4-1-7.

In the area, rainfall occurs almost in the same number of days every month, so that the number of days suited for outdoor works does not vary much from month to month throughout the year. November which has the greatest rainfall than any other month of the year reduces the average working days by two. It follows, therefore, that there are extremely slight monthly fluctuations in the available family labor of a farmer.

2) Study of labor demand and supply

(i) Study of the supply of labor in the area

Since no determination has yet been made on the number of settlers and their family size in the area, it is impossible to estimate the amount of deficiency of supply against the demand of labor.

Table 4-1-7 Holding Labor Capacity

Month	Working persons (laborers)	Work conversion persons	Working days per month	Actual working hours per day	Monthly holding labor capacity	Remarks
Jan.	2	1.8	20.50	7	258	
Feb.	2	1.8	19.15	7	241	
Mar.	2	1.8	19.20	7	242	
Apr.	2	1.8	20.45	7	258	
May	2	1.8	21.10	7	266	
Jun.	2	1.8	20.95	7	264	
Jul.	2	1.8	20.20	7	280	
Aug.	2	1.8	20.65	7	260	
Sep.	2	1.8	20.55	7	259	
Oct.	2	1.8	19.45	7	245	
Nov.	2	1.8	17.75	7	224	
Dec.	2	1.8	18.30	7	231	
Total					3,028	

Note: 1. According to investigation 1982 of Censo Nacional de Poblacion Yvivienoas, a family in rural area consistes of 6 persons. Therefore, it is supposed that working persons in a family are 2, and capable convertion is 1.0 for man and 0.8 for woman.

2. Working days per month is estimated by "Meteorological data of Yacyreta observatory, Meteorological Department, Ministry of National Defence.

Accordingly, the foregoing schedules of operating hours for paddy and soybean-wheat crop rotation farming are compared with the monthly supply of family labor force, as discussed earlier, and data are arranged to determine the balance of demand and supply of labor for each month as shown in Tables 4-1-8 and 4-1-9.

In paddy farming, family labor force can afford to supply the demand of 25-hectare scale except for the seeding period of October and November. In November, particularly, there is a labor shortage up to 101 hours or 15 employees when 101 hours is divided by unit manhours per day and this shortage must be covered by employement. The family labor force of a farmer cannot meet the demand of the 50 hectare scale farming in October, November and March when there is a shortage of labor force equivalent to 70 employees in total. In the case of a 100-hectare scale, the operation of August plowing only is achieved on family labor. In the period from September to April, about 330 employees must be employed. That is, the greater the forming area, the greater the labor shortage. We conclude by saying that the labor demand of 400-hectare paddy farming requires up to 2,000 employees during the cycle.

When farming of paddy is initiated on a large scale in the future, the area will have big labor problems.

In the case of soybean-wheat rotation farming, there is no serious labor shortage problem since the operating hours per hectare is no more than 1/4 of the hours required for paddy culture. As shown in Table 4-1-9, the labor demand of a 50-hectare farmer is fully met by the supply of family labor force without use of outside employers.

Table 4-1-8 Examination of Monthly Overs and Shorts of Labors in Paddy Rice Farmers

(Unit: Hours)

Item \ Month	Jan.	Feb.	Mar.	Arp.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Self holding labor capacity (hours)	258	241	242	258	266	264	280	260	259	245	224	231	3,028
Farmer with managing scale 25 ha	158	141	67	170	-	-	-	197	159	Δ 42	Δ 101	131	1,023 Δ 143
Farmer with managing scale 50 ha	58	41	Δ 108	83	-	-	-	195	164	Δ 155	Δ 216	31	572 Δ 479
Farmer with managing scale 100 ha	Δ 142	Δ 159	Δ 458	Δ 92	-	-	-	130	Δ 73	Δ 553	Δ 648	Δ 169	130 Δ 2,294
Farmer with managing scale 150 ha	Δ 342	Δ 359	Δ 703	Δ 372	-	-	-	65	Δ 27	Δ1,021	Δ1,044	Δ 369	65 Δ 4,237
Farmer with managing scale 250 ha	Δ 742	Δ 759	Δ1,508	Δ 617	-	-	-	10	Δ146	Δ1,675	Δ1,741	Δ 769	0 Δ 7,947
Farmer with managing scale 400 ha	Δ1,342	Δ1,359	Δ2,258	Δ1,142	-	-	-	Δ180	Δ409	Δ2,895	Δ2,976	Δ1,369	0 Δ13,930
Farmer with managing scale 500 ha	Δ1,742	Δ1,759	Δ3,258	Δ1,492	-	-	-	Δ240	Δ551	Δ3,595	Δ3,706	Δ1,769	0 Δ18,112

Note: 1. Δ shorts, overs.

2. Upper number of total column is total of over, Δ is total of shorts.

3. Self holding labor capacity is taken from Table 4-1-7.

Table 4-1-9 Examination of Monthly Overs and Shorts of Labors in Soybean-wheat Farmers

(Unit: Hours)

Item \ Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Self holding labor capacity (hours)	258	241	242	258	266	264	280	260	259	245	224	231	3,028
Farmer with managing scale 25ha	221	222	148	192	163	245	243	241	165	179	121	175	2,315 0
Farmer with managing scale 50 ha	220	213	54	164	97	236	224	232	71	142	46	147	1,828 0
Farmer with managing scale 100 ha	146	185	Δ133	38	Δ105	208	167	204	Δ131	Δ 17	Δ136	54	1,002 Δ 522
Farmer with managing scale 150 ha	123	173	Δ208	Δ 47	Δ117	198	145	192	Δ272	17	Δ155	30	878 Δ 799
Farmer with managing scale 200 ha	67	146	Δ358	Δ180	Δ288	169	85	170	Δ476	Δ133	Δ334	Δ59	637 Δ1,828

Note: Same to Table 4-1-8.

In the case of 100-hectare scale farming, the months of March, May, September and November demand respectively nearly 20 employees in employment, that is, a total of some 75 employees. However, the equivalent scale of paddy farming requires as five times as much or 330 employees. Although the size of labor shortage increases with increasing scale of farming in soybean-wheat crop rotation, the rate of increase is far less compared with paddy farming. It seems that the problem of labor shortage with soybean and wheat farming will not be serious.

(ii) Study of demand and supply of labor

It is apparent that there will be a shortage of labor in the area when the project is initiated. This will be a cause of great problems particularly among those new settlers who are going to manage farming on large scales. As already stated, since the number of new settlers as classified by the scales of farming in the area has not yet been known, it is impossible to determine the quantitative relation of demand and supply of labor there. Accordingly, estimation of this relation is made by studying the status of certain five villages and towns with similar condiitons to determine the supply of labor available from both Itapua and Misiones Departments including these districts and comparing this supply with the prospected demand of labor arising in the area.

Tables 4-1-10 and 4-1-11 shows the labor force of these five villages and towns and Itapua and Misiones tabulated in the same style as Table 4-1-7. The prospected demand of labor in the area is computed on the assumption that the entire area, that is, the 79,880 hectare paddy farming Area B (planting occuring in half the total area in crop rotation with grazing ground) and 25,620 hectare soybean-wheat rotation Area A (excluding the 1,200 hectares of dairy complex), is managed on the 150-hectare farming scale.

The prospected demands of labor by this assumption are shown in Tables 4-1-12 and 4-1-13.

The demand of labor in the area (paddy and soybean-wheat farming combined) is estimated to amount to 2.2 million hours per year,

which is equivalent to 39% of the total labor force of the five villages and towns, i.e., 5.7 million hours. Further, as shown in Table 4-1-12, the demand of labor in the district in May, June, July and August is equal respectively to no more than 13% of the labor force of the five villages and towns. No definite forecast cannot be made of how much of labor these five villages and towns are able to supply, it seems reasonable to think that the area will find recruit in these months as rates of labor shortage are not so high. However, the remaining eight months suffer a high rate of shortage impossible to be covered by a supply of excess labor from the five villages and towns; the demands of labor in October and November, in particular, are each equivalent to 81% and 95% of the total labor force of the five villages and towns. Therefore, it is impossible to make a plan of labor supply to 5 towns and villages concerned.

Table 4-1-10 Labor Capacity Held by 5 Towns and Villages Concerned

Month	Working persons	Work conversion persons	Working days per month	Actual working hours per day	Monthly holding labor capacity	Remarks
Jan.	3,750	3,390	20.50	7	486,465	
Feb.	3,750	3,390	19.15	7	454,430	
Mar.	3,750	3,390	19.20	7	455,616	
Apr.	3,750	3,390	20.45	7	485,279	
May	3,750	3,390	21.10	7	500,703	
Jun.	3,750	3,390	20.95	7	497,144	
Jul.	3,750	3,390	22.20	7	526,806	
Aug.	3,750	3,390	20.65	7	490,025	
Sep.	3,750	3,390	20.55	7	487,652	
Oct.	3,750	3,390	19.45	7	461,549	
Nov.	3,750	3,390	17.75	7	421,208	
Dec.	3,750	3,390	18.30	7	434,259	
Total					5,701,136	

Note: 1. Working persons are calculated by multiplying a population of 20,838 of rural area in a population of 5 towns and villages concerned (1982) of development area by employed population rate of Paraguay (40%, 1980) and Agriculture and stock farming population rate (45%).

Working persons 20,838 persons × 0.4 × 0.45 = 3,750 persons

2. Work conversion persons is estimated by multiplying 3,750 persons by sex ratio (men 52%, women 48%) and capable conversion (man 1.0, woman 0.8).

Formula { Men : 3,750 persons × 0.52 × 1.0 = 1,950 persons
Women: 3,750 persons × 0.48 × 0.8 = 1,440 persons
Total 3,390 persons

Table 4-1-11 Labor Capacity Held by 2 Departments Concerned

Month	Working persons	Work conversion persons	Working days per month	Actual working hours per day	Monthly holding labor capacity	Remarks
Jan.	45,165	40,828	20.50	7	5,858,818	
Feb.	45,165	40,828	19.15	7	5,472,993	
Mar.	45,165	40,828	19.20	7	5,487,283	
Apr.	45,165	40,828	20.45	7	5,844,528	
May	45,165	40,828	21.10	7	6,030,295	
Jun.	45,165	40,828	20.95	7	5,987,426	
Jul.	45,165	40,828	22.20	7	6,344,671	
Aug.	45,165	40,828	20.65	7	5,901,687	
Sep.	45,165	40,828	20.55	7	5,873,107	
Oct.	45,165	40,828	19.45	7	5,558,732	
Nov.	45,165	40,828	17.75	7	5,072,879	
Dec.	45,165	40,828	18.30	7	5,230,066	
Total					68,662,485	

Note: This table is made up in accordance with Table 4-1-10. However, total population of rural areas of both departments (1982) is 250,920.

Working persons: $250,920 \times 0.4 \times 0.45 = 45,165$

Work conversion persons:

Men : $45,165 \times 0.52 \times 1.0 = 23,485$

Women: $45,165 \times 0.48 \times 0.8 = 17,343$

Total 40,828

Table 4-1-12 Labor Demands and Supplys for 5 Towns and Villages Concerned

Item \ Month			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
(1,000 hours) Labor capacity held by towns and villages for development ①			486	454	456	485	501	497	527	490	488	462	421	434	5,701
Required labors	Upland field area	Soybean-wheat roration													
		(hours) Per farming body (a)	135	68	450	305	383	66	135	68	531	228	379	201	2,949
		(1,000 hours) Per area (a) × 171 2 (number of farming bodies)	23	12	77	52	66	11	23	12	91	39	64	34	504
	Paddy rice field area	Paddy rice													
		(hours) Per farming body (b)	600	600	945	630	-	-	-	195	286	1,266	1,268	600	6,390
		(1,000 hours) Per area (b) × 266 3 (number of farming bodies)	160	160	251	168	-	-	-	52	76	337	337	160	1,701
	(1,000 hours) Areal (② + ③) ④		183	172	328	220	66	11	23	64	167	376	401	194	2,205
④ / ① (%)			38	38	72	45	13	2	4	13	34	81	95	44	39

Note: 1. Farming body in paddy rice field and

2. Number of farming bodies per division is calculated as follows.

..... (33,525 ha - 1,500 ha (Dairy farming plot)) ÷ 150 ha/family
= 171 (Farming bodies)

Paddy rice field ..... (79,880 ha × 0.5) ÷ 150 ha/family = 266 (Farming bodies)

3. Labor capacity held by towns and villages for development is taken by Table 4-1-10.

Table 4-1-13 Labor Demands and Supplys for 2 Departments Concerned

Item \ Month			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
(1,000 hours) Labor capacity held by department for development ①			5,859	5,472	5,487	5,845	6,030	5,987	6,345	5,902	5,873	5,559	5,073	5,230	68,662
Required labors	Upland field area	Soybean-wheat rotation													
		(hour) Per farming body (a)	135	68	450	305	383	66	135	68	531	228	379	201	2,949
		(1,000 hours) Per division (a) × 171 (number of farming bodies) ②	23	12	77	52	66	11	23	12	91	39	64	34	504
	Paddy rice field area	Paddy rice													
		(hour) Per farming body (b)	600	600	945	630	-	-	-	195	286	1,266	1,268	600	6,390
		(1,000 hours) Per division (b) × 266 (number of farming bodies) ③	160	160	251	168	-	-	-	52	76	337	337	160	1,701
	(1,000 hours) Areal total (② + ③) ④		183	172	328	220	66	11	23	64	167	376	401	194	2,205
④ / ① (%)			3	3	6	4	1	0	0	1	3	7	8	4	3

Note: Same to Table 4-1-12. However, labor capacity held by departments for development is taken by Table 4-1-11.

As apparent from Table 4-1-13, the annual total of labor force (in hours) available in Itapua and Misiones is 68.66 million hours, only 3% of which, i.e., 2.2 million hours, is the total annual demand of labor force of the area. Moreover, the labor demand of the area for October and November is respectively 7% and 8% of the labor force of the equivalent months of Itapua and Misiones. It is high expected, therefore, that the demand of labor of the area will be fully supplied with extra labor from Itapua and Misiones. Accordingly, it is necessary to include both Itapua and Misiones in the labor project for the area.

(3) Study of the operating hours of machinery

1) The operating hours of machinery

The operating hours of machinery is determined, as follows, in order to study the relation of the operating hours to the actual operating hours of a machinery.

Workable Capacity per Machine

Item \ Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Working days per month (days)	20.50	19.15	19.20	20.45	21.10	20.95	22.20	20.65	20.55	19.45	17.75	18 30
Actual working hours per day (hours)	7	7	7	7	7	7	7	7	7	7	7	7
Monthly workable hours of machine (hours)	144	134	134	143	148	147	155	145	144	136	124	128

Note: Working days is in accordance with Table 4-1-7.

The table given above computes the operating hours for a single piece of machine. The figures, of course, grow much greater when the number of machines increases as in large scale farming.

2) The operating ratio for machinery

The operating ratio for machinery is almost alike between

Table 4-1-14 Operation Conditions of Machinery in Paddy Rice Farming

(hours)

Item \ Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Paddy rice farming scale 50 ha	Machine workable hours ①	144	134	67 134	72 143	148	147	155	145	144	136	124	128	139 1,682
	Machine working hours ②	-	-	50 50	25 25	-	-	-	65	95	110	80	-	75 425
	Operation rate ②/① (%)	0	0	75 37	35 17	0	0	0	45	66	81	65	0	54 25
Paddy rice farming scale 150 ha	Machine workable hours ①	432	402	134 402	143 429	444	441	465	435	432	408	372	384	277 5,046
	Machine working hours ②	-	-	127 127	98 98	-	-	-	195	286	351	227	-	225 1,284
	Operation rate ②/① (%)	0	0	95 32	69 23	0	0	0	45	66	86	61	0	81 25
Paddy rice farming scale 400 ha	Machine workable hours ①	1,008	938	402 938	429 1,001	1,031	1,029	1,085	1,015	1,008	952	868	896	831 11,774
	Machine working hours ②	-	-	400 400	200 200	-	-	-	440	668	796	560	-	600 3,064
	Operation rate ②/① (%)	0	0	100 43	47 20	0	0	0	43	66	84	65	0	72 26

Note: Upper number is combine and lower number is tractor.

Table 4-1-15 Operation Conditions of Machinery in Soybean-wheat Farming

(hours)

Item	Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Soybean-wheat farming scale 50 ha	Machine workable hours ①	144	134	67 134	143	148	147	155	145	72 144	136	124	128	139 1,682
	Machine working hours ②	56	28	47 47	94	113	28	56	28	38 76	103	122	84	85 835
	Operation rate ②/① (%)	39	21	70 35	66	76	19	36	19	53 53	76	98	66	61 50
Soybean-wheat farming scale 150 ha	Machine workable hours ①	288	268	134 268	143 286	296	294	310	290	144 288	272	248	256	421 3,364
	Machine working hours ②	135	68	113 113	28 221	250	66	135	68	113 194	228	246	201	254 1,925
	Operation rate ②/① (%)	47	25	84 42	20 77	84	22	44	23	78 67	84	99	79	61 57

Note: Upper number is combine, lower nuber is tractor.

different scales of farming and is calculated on a monthly basis for three different scales of paddy farming and two scales of soybean-wheat crop rotation farming in Tables 4-1-14 and 4-1-15.

(i) Paddy farming

As already stated in 4-1-3, the number of machines to be introduced and their horsepower are determined on the basis of the estimated workload for October and November when use of the tractors will reach peak. As is shown in Table 4-1-14, the operating ratio for this period is high regardless of the scale of farming.

This operating ratio for March and April is low because these months is the period for transporting harvested crop. There will be no plan for the use of tractors for the paddy growth period of December through February and the fallow period of May through June.

The combine has an extremely high rate of operation in March, the busiest season for harvest, while a low rate in April.

(ii) Soybean-wheat rotation farming

In soybean-wheat rotation farming, as shown in Table 4-1-15, use of tractors is equal throughout the year with an operating ratio of 50 ∿ 55%, twice as high as that for paddy farming. This ratio is relatively low in February, June and July and high during the rest.

(iii) Summarization

The operating ratio for machinery has monthly fluctuations. In paddy-pasture farming patterns, tractors are not used at all for the total period of 6 months in the year. Utilization of the tractors during this periods would result in an increase in income, which would be particularly desirable for small scale farmers. However, there will be little chances for them to earn rent by loaning their unused tractors to neighbors within the area since the basic policy of the development project for this area is such that all settlers will own tractors and combines of their own.

The chances are to find borrowers of a tractor outside the area. This would make it necessary to study the farming patterns and their cycle of use of machinery of those neighboring area.

4.1.5 Economics of farming

(1) Computation of non-farming income

It is expected that 25-hectare and 50-hectare paddy farmers alone will have leisure time to earn non-farming income. As already stated in connection with Table 4-1-8, a farmer on the scale of 100 hectares or more could not manage his own paddy farming within the limit of family labor alone and has to rely on employment. Moreover, 100-hectare farming requires assistance of up to three pieces of large machinery including a combine while 500-hectare farming 12 pieces of it. A large number of machines will have to be maintained and serviced during the fallow period of May through July. Computation of the estimated amount of non-farming income for them was made while taking into account Table 4-1-8 and the following conditions.

(a) It is assumed that 2/3 of the monthly leisure hours represents employment hours for non-farming income when leisure hours exceeds 1/2 of family labor hours in the month.

(b) It is assumed that no job is sought (hence no non-farming income) when leisure hours is smaller than 1/2 of family labor hours in the month.

(c) It is assumed that 20 days represents employment period for non-farming income for each of the three months of May through July of the fallow period.

(d) Female's employment time is equal to 1/2 of male's in either of the above (a) and (c).

25-hectare paddy farming

- o non-farming income during the fallow period (May to July)... condition ©
  @1,000 Gs/day × 20 days/month × 3 months = 60,000 Gs
- o non-farming income during the paddy growth period (Aug., Sept., December, January, February, April; six months)..... condition ⓐ
  @1,000 Gs/day × 956 hours × 2/3 ÷ 7 hours/day = 91,000 Gs

60,000 + 91,000 = 151,000 Gs. Addition to this sum 1/2 of 151,000, the income from a female (his wife)'s employment gives an annual non-farming income of 226,000 Gs.

50-hectare paddy farming

- o non-farming income during the fallow period (May to July)... condition ⓒ
  @1,000 Gs/day × 20 days/month × 3 months = 60,000 Gs
- o non-farming income during the paddy growth period (Aug. and September; two months)
  @1,000 Gs/day × (359 hours × 2/3 ÷ 7 hours/day) ≒ 34,000 Gs

60,000 + 34,000 = 94,000 Gs. Addition to this sum 1/2 of 94,000 Gs, the income from a female (his wife)' employment gives an annual non-farming income of 141,000 Gs.

In addition, computation of the estimated amount of non-farming income for soybean-wheat rotation farming was made on the basis of Table 4-1-9. It is assumed that there is no non-farming income in the 150-hectare scale farmers since they have only two months which fall in conditions (a).

25-hectare soybean-wheat rotation farming

- o non-farming income during the crop growth period (January through December; 12 months) - Condition (a)
  @1,000 Gr/day × (2,315 hours × 2/3 ÷ 7 hours/day) = 220,000 Gs

Addition to this sum 1/2 of 220,000 Gs, the income from a female (his wife)' employement gives an annual non-farming income of 330,000 Gs.

50-hectare soybean-wheat rotation farming

- o non-farming income during crop growth period (January, February, April, June, July, August, September, December; 8 months)..condition ⓐ
  @1,000 Gs/day × (1,560 hours × 2/3 ÷ 7 hours/day) ≒ 150,000 Gs

Addition to this sum 1/2 of 150,000 Gs, the income from a female (his wife)' employment gives an annual non-farming income of 225,000 Gs.

100-hectare soybean-wheat rotation farming

- o non-farming income during the crop growth period (January, February, June, July, August; five months)..... condition ⓐ
  @1,000 Gs/day × (910 hours × 2/3 ÷ 7 hours/day) ≒ 87,000 Gs

Addition to this sum 1/2 of 87,000 Gs, the income from a female (his wife)' employment gives an annual non-farming income of 130,000 Gs.

(2) Disposable income of the farmer

The disposable income of the farmer in the area is shown in Tables 4-1-16-(a) and 4-1-16-(b). The smallest scale of paddy farming (50 hectares; paddy 25 ha and pasture 25 ha) produces a disposable income of 1,184 thousand Gs. The smallest scale (25 hectares) and 50-hectare-scale of soybean-wheat rotation farming produce respectively a disposable income of 0.6 and 1.0 million Gs.

Table 4-1-16-(a) Disposable Income of Farmers...Paddy Rice -- Pasture Rotation System

(1,000 GS)

Farming area(ha)	50	100	200	300	500	800	1,000
Paddy rice / Pasture (ha)	25	50	100	150	250	400	500
Item	25	50	100	150	250	400	500
Family (persons)	6	6	6	6	6	6	6
Persons occupied with farming	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Farmer income	1,221	2,327	4,162	6,876	11,237	17,806	22,138
Farming income	995	2,186	4,162	6,876	11,237	17,806	22,138
Farming gross profit	4,289	8,568	17,137	25,706	42,843	68,548	85,683
{ Paddy rice	3,525	7,050	14,100	21,150	35,250	56,400	70,500
{ Beef cattle	759	1,518	3,037	4,556	7,593	12,148	15,183
Farming expence	3,294	6,382	12,975	18,830	31,606	50,742	63,545
{ Paddy rice	2,708	5,214	10,644	15,333	25,778	41,418	51,890
{ Beef cattle	586	1,168	2,331	3,497	5,828	9,324	11,655
Income outside farming	226	141					
Income outside farming	226	141					
Taxes	37	70	125	206	337	534	664
Disposable income	1,184	2,257	4,037	6,670	10,900	17,272	21,474

Note: 1. For family, average persons of Paraguay 1982 is taken.

2. Income of beef cattle and farming expense are taken from Chapter 3, 3-2-2 Livestock plan.

3. For taxes, 3% of average taxes of Japanese migration area investigated by Encarnacion branch, JICA (Sep. 1981 ∿ Aug. 1982) is taken.

Table 4-1-16-(b) Disposable Income of Farmers Soybean and Wheat Rotation System

(1,000 GS)

Farming area(ha)	25	50	100	150
Soybean / wheat(ha)	25	50	100	150
Item	25	50	100	150
Family (persons)	6	6	6	6
Persons occupied with farming	1.8	1.8	1.8	1.8
Farmer income	619	1,027	1,965	3,247
Farming income	289	802	1,835	3,247
Farming gross profit	2,250	4,500	9,000	13,500
Soybean (ha)	1,050	2,100	4,200	6,300
Wheat (ha)	1,200	2,400	4,800	7,200
Farming expense	1,961	3,698	7,165	10,253
Soybean	934	1,744	3,374	4,818
Wheat	1,027	1,954	3,791	5,435
Income outside farming	330	225	130	-
Income outside farming	330	225	130	-
Taxes	19	31	59	97
Disposable income	600	996	1,906	3,150

4.2 Distribution

As the survey area has natural conditions which are quite favorable for rice cultivation, there is a plan that in the future paddy fields of about 80,000 ha will be developed at the irrigable area in this district and a rice production increase of nearly 200,000 tons will be realized by the rotation system from paddy to other crops (1:1).

However, main foods in Paraguay are manjoca and bread, and the consumption of rice is still at a low level. The domestic demand for rice is sufficiently fulfilled by the domestic production. Furthermore, the excessive production, though not large, is being exported.

The trade volume of rice in the world is extremely small as compared with wheat and other farm products, representing only around 3% of the total production. Most of the trade market is occupied by Thailand and the United States of America. In this connection, we expected various difficulties concerning the marketability of rice which is to be produced in this area after the plan is carried out. Accordingly, we will examine in this chapter the outlook of the domestic demand and the possibility of exports.

In addition to rice, we will also examine various aspects of soybeans and wheat which are expected to be produced at the area of higher altitude in this survey area.

4.2.1 Rice

(1) Outline of production

According to the FAO statistics, the rice production in the world for 1980 totaled 397.60 million tons, accounting for 25% of the total grain production in the world of 1,561.00 million tons for the same year.

The growing area of rice in the world has somewhat changed annually in the last five years, which is shown in Table 4-2-1. However, the change is quite slight; from 143.10 million ha for 1976 to 143.50 million ha for 1980. Meanwhile, the rice production has generally grown; from 350.40 million tons for 1976 to 397.60 million tons for 1980, an increase of 13%.

By continent, the rice production on the Asian continent is

overwhelmingly high, registering 360.90 million tons for 1980, or as much as 91% of the worldwide production. On the Asian continent, the Chinese production is considerably dominant, registering 142.30 million tons for 1980, which is followed by 79.90 million tons of India. The combined rice production of the two countries represented 62% of the total rice production on the Asian continent for 1980.

The South American Continent ranks second, producing 14.40 million tons of rice for 1980, or accounting for 4% of the worldwide production. On this continent, Brazil, which has close relations with Paraguay, is the largest rice producer, producing 9.75 million tons for 1980, or representing 67% of the total rice production on the continent. The annual rice production of Argentina, which is also a neighboring country of Paraguay, is around 300,000 tons, accounting for only 2 ∿ 3% of the total production on the continent.

The average growing area of rice in Paraguay for the last five years is about 30,000 ∿ 38,000 ha, which is extremely small as a rice growing area on this continent. The production is also low; the highest in 1980 at 73,000 tons. The average production for the last five years is 63,000 tons.

During the last five years, the rice production of the South American continent or the above-mentioned two countries neighboring Paraguay has shown little increase.

As is shown in Table 4-2-2, the yield per unit area has seen a tendency for increase. The worldwide average increased by 13.1% from 2,448 kg/ha in 1976 to 2,770 kg/ha in 1980. By continent, the yield per unit area in Asia shows the highest increase of 13.6% from 2,480 kg/ha in 1976 to 2,818 kg/ha in 1980.

The increase rate of the yield per unit area on the South American continent is lower than the world average, showing only 9.5% from 1976 to 1980. In particular, the yield per unit area in Argentina, Brazil and Paraguay has seen little change for the last five years. Among these three countries, the rice cultivation in Argentina centers upon the paddy rice, which is conducted at irrigable areas. Accordingly, the yield per unit area is extremely high. On the contrary, in Brazil, the cultivation of the upland rice culture is mainly conducted, while the cultivation of paddy rice is limited in the southern states, centering on the State of

Table 4-2-1 Growing Area and Production of Rice in the Last 5 Years
(Main Producing Countries)

Continent	Total & country	Harvested area (1,000 ha)					Production (1,000 t)				
		1976	1977	1978	1979	1980	1976	1977	1978	1979	1980
World		143,108	144,092	145,130	141,052	143,534	350,365	370,592	376,448	377,394	397,597
North & Central America	Total	1,813	1,717	2,020	1,876	2,022	7,062	6,431	8,152	7,983	8.614
	U. S. A.	1,004	910	1,238	1,161	1,340	5,246	4,501	6,251	5,935	6,629
Asia	Total	128,107	129,802	130,654	126,607	128,045	317,765	338,993	344,351	343,590	360,876
	China	36,686	37,079	37,290	34,594	33,887	129,054	130,472	131,775	146,959	142,338
	India	38,511	40,001	40,000	39.414	39,773	63,052	79,094	79,010	63,476	79,930
	Thailand	8,463	7,947	8,288	8,651	9.145	15,068	13,910	17,000	15,758	17,366
	Japan	2,779	2,757	2,560	2,497	2,377	15,292	17,000	16,000	14,948	12,189
South America	Total	7,704	7,088	6,781	6,801	7,542	13,471	13,074	11,535	12,414	14,449
	Argentina	87	91	95	102	82	309	320	310	312	266
	Brazil	6,583	5,913	5,552	5,452	6,208	9,560	8,935	7,242	7,595	9,748
	Paraguay	28	34	38	30	38	57	69	75	57	73

Source: FAO Production Yearbook

Table 4-2-2 Rice Yield per Unit Area in the Last 5 Years
(Main Producing Countries)

Continent	Total & country	Yield per unit area (kg/ha)				
Item / Year		1976	1977	1978	1979	1980
World		2,448	2,572	2,594	2,676	2,770
North & Central America	Total	3,896	3,746	4,030	4,255	4,261
	U. S. A.	5,227	4,945	5,049	5,155	4,946
Asia	Total	2,480	2,612	2,636	2,714	2,818
	China	3,518	3,519	3,534	4,248	4,200
	India	1,637	1,977	1,975	1,610	2,010
	Thailand	1,780	1,750	2,051	1,822	1,899
	Japan	5,503	6,166	6,250	5.986	5,128
South America	Total	1,749	1,844	1,701	1,825	1,916
	Argentina	3,541	3,516	3,263	3,047	3,236
	Brazil	1,452	1,511	1,304	1,393	1,570
	Paraguay	2,020	3,044	1,974	1,890	1,901

Source: FAO Production Yearbook

Rio Grande do Sul. The upland rice culture represents about 70% of the rice cultivation in Brazil. Under the circumstances, the production of paddy rice is at a level of 3,500 kg/ha but the yield per unit area for the rice grown in the upland rice is low. As a result, the national average of the yield per unit area is as low as around 1,500 kg/ha.

In Paraguay, the paddy field rice accounts for about 65% of the rice cultivation (on the basis of the areal comparison between paddy rice and upland rice culture for the last five years). Itapua department and Misiones department, which are to be covered by the current plan, play the central role. In 1979, the two departments represented about 70% of the growing area for the paddy rice. The yield per unit area of paddy rice, including that in the two departments, is around 2,300 kg/ha, but the national average of rice production is around 2,000 kg/ha, as is shown in Table 4-2-2.

(2) Trade

Major rice producing countries of the Asian Continent, including China and India, have generally a large population and the rice produced there is almost consumed domestically. As a result, the trade volume of rice in the world is extremely small. As is shown in Table 4-2-3, the worldwide rice exports for 1980 registered 12.70 million tons, representing only 3% of the global production of 397.60 million tons. The export ratio is much lower than 22% for wheat for the same year. However, the rice exports in the world have gradually increased year after year; from 8.99 million tons for 1976 to 12.70 million tons for 1980, an increase of 41%.

As for the South American Continent, the rice exports have shown little change in the last five years partly because of the slow production rise. In 1980, the exports from South America represented only 4% of the total exports in the world. In particular, the exports from Brazil have dropped sharply since 1978 when the country suffered a production drop caused by the drought damage. Paraguay has been exporting, though the volume is very small.

As for the imports, the rice imports to the Asian continent which has an overwhelmingly large production are also the highest since such countries on the continent as Indonesia, Iran, Iraq and Saudi Arabia have

Table 4-2-3 Change of Rice Exports in the Last 5 Years
(Main Producing Countries)

Item / Continent / Total & country / Year		Export volume (1,000 t)				
		1976	1977	1978	1979	1980
World		8,987	10,819	9,686	11,856	12,713
North & Central America	Total	2,116	2,369	2,386	2,367	3,093
	U. S. A.	2,107	2,287	2,279	2,301	3,054
Asia	Total	5,215	6,246	5,316	7,603	7,613
	China	1,436	1,123	1,678	1,459	1,311
	India	38	20	143	375	425
	Thailand	1.925	2,942	1,607	2,797	2,745
	Pakistan	782	945	777	1,015	1,087
	Japan	0.2	0.3	82	603	689
South America	Total	504	939	692	640	481
	Argentina	87	193	129	99	86
	Brazil	76	409	180	0.3	1.5
	Paraguay	0.9	0.8	0.5	0.1	-

Source: FAO Trade Yearbook

been suffering a rice shortage. As is shown in Table 4-2-4, the Asian Continent imported 7.60 million tons of rice in 1980, accounting for 54% of the worldwide imports of 12.70 million tons. It is followed by 18% for the African Continent and 12% for the European continent.

The rice imports to the South American continent were at a low level of 100,000 tons in the past. In 1978, however, the imports to Brazil rose sharply because of the production drop caused by the drought damage. As a result, the imports to the continent for 1979 jumped to 920,000 tons, and, in 1980, also reached 570,000 tons. In Paraguay, the per capita consumption is small and they are self-sufficient in rice. In recent years, the country has not imported rice, except for the drought damage year of 1978.

(3) Study of marketability in connection with rice production increase at the survey area

As mentioned earlier, the volume of the rice trade in the world is extremely small, representing only around 3% of the worldwide production. The major importers are the countries in Asia, Africa and Europe.

The rice imports to South American countries are at an extremely low level, as is seen in Table 4-2-4, except for 1979 and 1980 in Brazil.

Argentina is one of a few nations, except for Asia, which have an excessive power to export rice. As is shown in Table 4-2-5, the country has been exporting rice to many nations, though the volume is small. The volume of the rice imported from Argentina ranges from about 1,000 tons to about 10,000 tons. The annual average of the rice exports from the country for the last five years is about 100,000 tons.

Paraguay has also been exporting rice, though the volume is small. (See Table 4-2-6) Its stable market is Chile. The Paraguayan rice is transported by land to Resistencia in Argentina, and then to Chile by train. The exports are also made to Europe and other regions, which are not stable markets.

Under the circumstances, many problems are expected for the marketability of the rice which will be produced in a larger volume than ever because of the construction of the Yacyreta dam. In this connection, we will examine the domestic demand in Paraguay and the situation in Brazil which has been importing rice for the last few years.

Table 4-2-4 Change of Rice Imports in the Last 5 Years
(Main Importing Countries)

Item / Continent / Total & country / Year		Import volume (1,000 t)				
		1976	1977	1978	1979	1980
World		9,222	10,229	10,128	11,714	13,014
Africa	Total	1,009	1,723	1,943	1,998	2,347
	Ivory Coast	2.3	148	126	198	230
	Madagascar	100	100	125	175	161
	Nigeria	65	450	564	245	387
	Senegal	200	218	238	259	275
	South Africa	89	110	103	137	126
	Total	5,555	5,652	5,364	5,958	7,028
Asia	Bangladesh	396	196	305	59	719
	Hongkong	362	341	344	361	359
	Indonesia	1,301	1,964	1,842	1,922	2,012
	Iran	260	600	367	440	470
	Iraq	194	235	290	320	345
	Malaysia	234	296	409	239	201
	Saudi Arabia	261	121	404	341	356
	Total	1,538	1,569	1,758	1,624	1,602
Europe	France	194	267	282	249	253
	West Germany	180	166	194	160	162
	Italy	58	124	307	178	120
	Netherlands	250	147	145	148	193
	Total	216	120	97	921	574
South America	Argentina	-	6	2	10	-
	Brazil	17	-	29	711	237
	Paraguay	-	-	0.7	-	-
	Chile	26	11	11	8	50
	Colombia	-	75	17	14	11

Source: FAO Trade Yearbook

Table 4-2-5 Rice Exports from Argentina

(Unit: t)

Destination	1975	1976	1977	1978	1979
Netherlands	14,829	18,312	71,966	32,569	12,102
Soviet Union	13,837	-	13,984	-	10,380
Belgium	5,986	6,149	2,318	3,420	4,349
West Germany	3,898	9,362	1,314	2,059	3,135
Israel	3,952	13,488	18,392	5,517	2,710
Italy	-	-	1,914	35,163	1,091
Costa Rica	99	-	-	9,999	-
Dominica	-	-	21,553	-	-
Senegal	-	5,520	17,786	4,645	-
Japan	-	-	-	5,262	-
France	3,069	1,589	1,327	352	817
Chile	1,962	15,269	10,177	-	338
Cuba	-	14,687	18,862	-	-
Singapore	-	-	9,489	-	-
Others	24,188	8,091	3,777	19,667	2,647
Total	71,820	92,467	192,859	118,653	37,569

Source: "Production and Distribution of Agriculture, Livestock, and Forestry in Argentina" JICA

Table 4-2-6-(1) Rice Exports from Paraguay

(Unit: t)

Country \ Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Chile	50	170	72	-	1,250	150	1,450	750	110	120	-	150	-
Brazil	-	60	120	-	-	-	-	-	-	-	-	-	-
France	-	1,090	-	-	-	-	-	-	500	-	-	-	-
South Africa	-	-	-	500	-	-	-	-	-	-	-	-	-
Argentina	-	-	-	62	120	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	445	200	-	-	-	-
Total	50	1,320	192	562	1,370	150	1,450	1,195	810	120	-	150	-

Table 4-2-6-(2) Rice Export from Paraguay

(Unit: US$1,000)

Country \ Year	1975	1976	1977	1978	1979	1980	1981	1982
Chile	63	290	168	22	24	-	57	-
France	-	-	-	90	-	-	-	-
Netherlands	-	-	14	4	-	-	-	-
Total	63	290	182	116	24	-	57	-

Source: Boletin Estadistico

1) Domestic Demand

As was already mentioned in 2.9, the per capita rice consumption in Paraguay still sees a tendency for a slight increase, although the increase has somewhat slowed down. The per capita consumption for the last five years averaged 21.2 kg per annum for the unhulled rice (13.8 kg per annum in terms of brown rice). If the increase in the per capita consumption is not taken into account and the future demand for rice in Paraguay is calculated only on the basis of the population increase, the following Table will be obtained.

Item / Year	Per capita consumption (kg per annum)	Population forecast (in 1,000)	Consumption (1,000 tons)	Increase from the present level (1,000 tons)
Present	21.2	-	63	-
1990	21.2	4,231	90	27
2000	21.2	5,405	115	52

Note: 1. For the "present" column, the average for the last five years.

2. Per capita consumption is indicated in terms of the unhulled rice.

3. Population forecast is made on the basis of the materials supplied by MAG.

This Table indicates that the requirement for rice to be caused by the population increase will be about 52,000 tons for the year of 2000. As the yield per unit area has not increased now, this requirement should be fulfilled through an increase in the planted area.

2) Rice in Brazil

As was mentioned earlier, Brazil is the largest rice producing nation on the South American Continent, and was also a rice exporting nation, though it imported some rice in 1972 and 1975. However, Brazil has become a rice importing nation since 1978 when it was hit by a drought damage.

In the south region of Brazil, a stable production of paddy rice is being made with irrigation facilities, while in the central highland region and north and north-east region most of the rice cultivation is for the upland rice, which means that a stable production is unlikely

because this type of production depends heavily on weather. (See Table 4-2-7 and Fig. 4-2-1) In addition, the Brazilian Government has introduced a minimum price guarantee system for 42 kinds of farm products, including rice, in order to protect producers and maintain the domestic supply-demand balance. The price of respective farm products is determined by the CFP before the start of planting. This mechanism plays an important role that "farmers should analyze respective prices and choose the most advantageous product for the specific year." Accordingly, the farm products a farmer produces generally change year after year; in other words, the upland rice is not always produced for the same area every year. If the prices of soybeans and kidney beans, which are major farm products in Brazil, are higher, the land area for the upland rice is easily used for those products.

Under the circumstances, not only the production of the upland rice depends upon weather, but also the planted area varies year after year, which leads inevitably to an unstable rice production.

As is shown in Table 4-2-8 and Fig. 4-2-2, Brazil has become a importing nation since 1978 when it suffered a drought damage, and partly because of the population increase. For 1983, the country also experienced a trade deficit and is in danger of a permanent shortage of rice. This is closely related to the serious political problems which the country now is faced with.

In the 1970's Brazil maintained an extremely high economic growth thanks to foreign aids of funds: an average of 11% between 1968 and 1973, and 6.5% even after the first oil crisis between 1974 and 1980. Meanwhile, the country's cumulate foreign debts rose sharply, reaching $83.6 billion in 1982. At the end of 1982, Brazil came to a stalemate of the foreign debts, and called on the IMF to take relief measures. This has caused a fundamental change of the economic policy, which is still under way. There is no doubt that the problem of the foreign debts will take a long time to be settled. In addition, the country has a large amount of internal debts ($29.0 billion as of November, 1983). The Government has to work out the future policy under various restrictions caused by those foreign and internal debts. In examining the rice shortage, we must take these political problems into considerations.

Table 4-2-7 Yearly Production of Unhulled Rice in Brazil

Year	Planted area (ha)	Production volume (t)	Yield per unit area (t/ha)	Remarks
1970	4,979,165	7,553,083	1,517	
1971	4,763,998	6,593,179	1,384	
1972	4,821,308	7,824,231	1,623	
1973	4,794,832	7,167,127	1,493	
1974	4,664,883	6,764,038	1,449	
1975	5,306,270	7,781,538	1,446	
1976	6,556,480	9,757,076	1,465	
1977	5,992,090	8,993,696	1,500	
1978	5,623,515	7,296,142	1,297	
1979	5,452,086	7,595,214	1,393	
1980	6,243,138	9,775,720	1,565	
1981	6,065,671	8,260,547	1,362	
1982	6,015,255	9,718,074	1,615	
1983	5,371,180	8,564,695	1,595	
Average	-	-	1,479	

Source: IBGE (Planning Ministry)

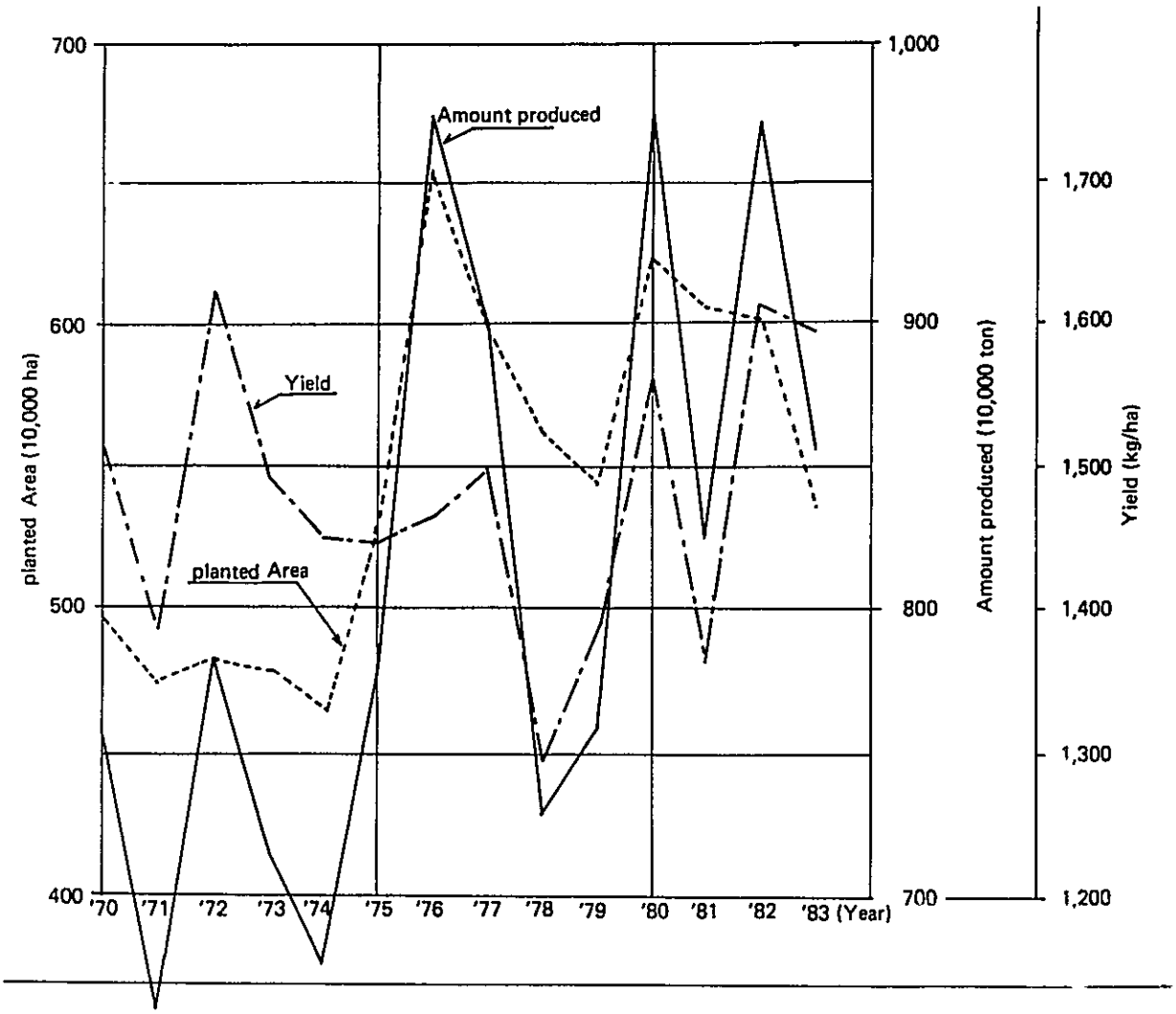


Fig. 4-2-1 Brazilian Rice (Unhulled rice) Production (by year)

On the basis of the present situation of the rice production and the policy in Brazil which have been analyzed so far, we will discuss the future of rice production in Brazil.

(i) Demand Increase to Be Caused by Population Increase

The population of Brazil increased at an average rate of 2.49% between 1972 and 1983. This rate is unlikely to change suddenly.

If this rate of increase is unchanged in the future, the population is projected to increase from 128.20 million in 1983 to 164.00 million 10 years later or in 1993. In other words, the population increase during the period is expected to reach 36.00 million. (See Table 4-2-9) The per capita rice consumption per annum (for the unhulled rice) averaged at 74.6 kg for the last 13 years. (See Table 4-2-10) Therefore, even if the per capita consumption does not increase, the demand for rice will increase about 2,700,000 tons 10 years later.

74.6 kg/person/year × 36.00 million ≒ 2,700,000 tons

It is quite unlikely that, in Brazil where the emphasis is placed on the production of upland rice, an increase in the yield per unit area will be made in order to cope with the above-mentioned demand increase. Accordingly, the planted area should be expanded to cope with the demand increase. However, it is difficult to develop new areas for paddy fields because of the financial problems. Development of paddy fields requires more expenditures as well as more time. As a result, more upland rice should be produced despite the low productivity.

As is shown in Table 4-2-7, the rice yield per unit area in Brazil is about 1,480 kg/ha. However, excluding the States of Rio Grande do Sul and Santa Catarina in the southern Brazil where the production at paddy fields is mainly conducted, the yield per unit area for upland rice is estimated to average around 1,300 kg/ha. Therefore, to make up for the demand increase of 2,700,000 tons, the planted area should be increased by 2.00 million ha (≒ 2,700,000 tons/1,300 kg).

The existing planted area totals about 6.00 million ha. It is extremely difficult to increase the planted area corresponding to

Table 4-2-8 Export-Import Balance of Rice in Brazil

	Exports		Imports CIF		Balance	Remarks
	Volume (t)	$1,000	Volume (t)	$1,000	(1,000 t)	
1970	95,050	6,799	28	9	- 95	
1971	148,829	11,469	1,231	127	-148	According to materials of CACEX(2) and CFP(1)
1972	1,897	153	9,088	1,123	+ 7	
1973	33,431	4,233	10,967	1,555	- 22	
1974	56,781	18,122	368	83	- 56	
1975	2,600	1,236	62,318	23,437	+ 60	
1976	76,349	11,955	16,984	5,219	- 59	
1977	408,434	88,522	824	304	-408	
1978	184,621	38,300	57,180	16,811	-127	CACEX, IBGE(3)
1979	377	145	711,135	245,041	+711	According to materials of CACEX
1980	1,526	463	238,896	99,154	+237	
1981	49,766	19,838	142,524	66,605	+ 93	
1982	12,359	3,835	147,708	47,001	+135	
1983						(1) "Subsidios Para a Fixacao dos Pregos Minimos Safra 78/79" 1979 edition (2) Trade Bureau of the Bank of Brazil (3) Planning Ministry

In the "balance" column, (-) and (+) mean export and import respectively.

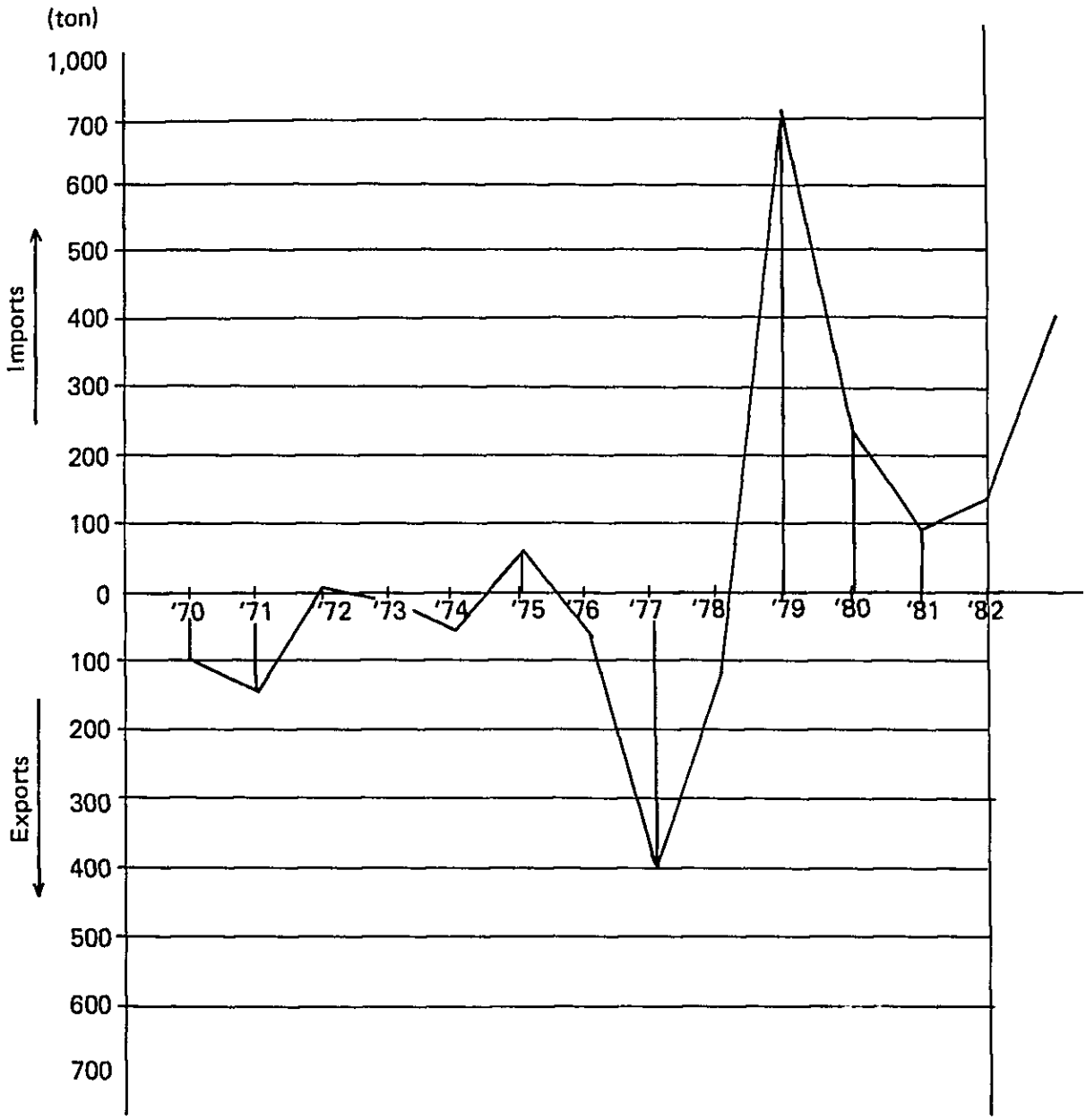


Fig. 4-2-2 Brazilian Rice Imports/Exports Balance

Table 4-2-9 Population Change and Forecast of Brazil

Year	Population (million)	Year	Population (million)	Remarks
1970	93.1	1983	128.2	
1971	95.5	1984	131.4	
1972	97.8	1985	134.7	
1973	100.3	1986	138.0	
1974	102.8	1987	141.5	
1975	105.3	1988	145.0	
1976	107.9	1989	148.6	
1977	110.6	1990	152.3	
1978	113.4	1991	156.1	
1979	116.2	1992	160.0	
1980	119.1	1993	164.0	
1981	122.0	1994	168.1	
1982	125.1	1995	172.3	

Source: IBGE (Planning Ministry)

Note: The average rate of population increase from 1970 to 1984 is 2.492% per annum. This rate is applied to the years after 1985.

Table 4-2-10 Annual per Capita Rice Consumption in Brazil (unhulled rice)

Year	① Harvest (unhulled rice) (1,000 t)	② Export-import balance (cleaned rice) (1,000 t)	③ Conversion to unhulled rice (②÷0.65)	④ Surface consumption (unhulled rice) ①±③ (1,000 t)	⑤ Population (million)	Per capita consumption (④÷⑤) (kg/year)	Remarks
1970	7,553	- 95	- 146	7,407	93.1	79.6	
1971	6,593	-148	- 228	6,365	95.5	66.6	
1972	7,824	+ 7	+ 11	7,835	97.8	80.1	
1973	7,167	- 22	- 34	7,133	100.3	71.1	
1974	6,764	- 56	- 86	6,678	102.8	65.0	
1975	7,782	+ 60	+ 92	7,874	105.3	74.8	
1976	9,560	- 59	- 91	9.469	107.7	87.8	
1977	8.935	-408	- 628	8,307	110.6	75.1	
1978	7,242	-127	- 195	7,047	113.4	62.1	
1979	7,595	+711	+1,094	8,689	116.2	74.8	
1980	9,747	+237	+ 365	10,112	119.1	84.9	
1981	8,261	+ 93	+ 143	8,404	122.0	68.9	
1982	9,681	+135	+ 208	9,889	125.1	79.0	
Average	-	-	-	-	-	74.6	

Note: (-); trade surplus, (+); trade deficit.

one-third of the existing area and then continue an increase in the planted area of more than 200,000 ha every year.

(ii) Specialization of farm products

Because of the foreign debts, Brazil now has to realize a trade surplus. In this connection, the Government is required to produce the farm products which have high marketability overseas. At present, soybeans and corns are possible farm products to be exported, since these quotations are clear in the international market. Therefore, it is apparent that these products will be increasingly specialized in the future. On the other hand, the Government will be unable to introduce a policy emphasizing the rice production. In fact, it is expected that from 1983 to 1984 the planted area for rice will decrease, while that for soybeans and corns will rise.

(iii) Fund shortage in the fiscal policy

In order to increase rice production by the expansion of the planted area, the investments are required for the consolidation of the infrastructure. In particular, it is evident that a large amount of investments are required for the development of paddy fields with irrigation facilities.

It is doubtful that the Government suffering from both foreign and internal debts should spend money for such investments. The Government has difficulties in extending agricultural loans because of the fund shortage. Meanwhile, producers will also find it difficult to carry out the farm management by such loans under a high inflation.

The scale and contents of the 1984 budget of the Federal Government are yet to be seen. We now analyze the draft budget of the State of Sao Paulo for fiscal 1984.

The budget scale is 4,000 billion Crs. down 37% from 1982 in real terms. The investments did not reach 2% of the total budget, registering only 77 billion Crs. or down 76% from 1982 in real terms. This apparently indicates that, even though the State Government of Sao Paulo is willing for consolidation of the infrastructure for agriculture, the possibility of realization is quite dim from the viewpoint of funds. This budget is computed on the premises that the inflation rate for

1983 is 200% and that for 1984 is 87%. If the inflation rate for 1984 is not confined within the projection, the investments will further drop.

Meanwhile, the Federal Government is obliged to see no deficit in public spendings. It is quite probable that its fiscal position will also be extremely difficult like that of the Sao Paulo State. If these negative factors of investment shortage emerge with some time lag, we will not be able to make an optimistic forecast concerning the rice production 10 years later.

(iv) Summary

On the basis of our above-mentioned study of the present situation and future outlook of the rice production in Brazil, it can be summa rized as follows:

a. The demand for rice is certain to increase.

b. It is doubtful that the domestic production could meet the demand increase.

3) Summary of marketability

We have studied the domestic demand for rice in Paraguay and the long-term outlook in Brazil. We now can say, concerning about 200,000 tons of rice to be produced at the survey area, that, if 40,000 tons, which is to be consumed domestically in Paraguay because of the population increase, is deducted, the remaining 160,000 tons should be placed on the foreign market. The volume is about half of the demand increase projected 270,000 tons per year in Brazil.

As mentioned earlier, the rice production in Brazil has many difficulties. Brazil is expected to continue the rice imports, and is very likely to import rice from Paraguay. However, if the Brazilian Government steps up the rice production by effectively making use of the present minimum price guarantee system, the situation will not necessarily be optimistic in view of the potential resources. The possibility of marketability should be examined further for Europe and Africa.

Next, the selling price of rice to be produced at the survey area can be calculated as follows.

The price is $205/t on delivery at Stroessner (for Brazil) and

$225/t on delivery at Paranagua Port (for Europe). As is shown in Table 4-2-11, the average price per ton for the last five years (1977 ∿ 1981) is $378 in Bangkok and $277 in Argentina (1976 ∿ 1980). The prices in Bangkok and Argentina include the export tax and can not simply be compared with the above-mentioned selling price. However, the price of rice to be produced at the area will be substantially competitive in the overseas market.

The following selling price is calculated on the basis of the per unit production cost for the farming pattern determined for this survey.

(i) Study of selling price

a. Production cost $175/t

The production cost per kilogram is 22.6 Gs (for the farmer with managing scale of 150 ha). When it is computed into dollar ($1 = 160 Gs) the cost is $145/t (≒ 22,600 Gs/t ÷ 160 Gs). If the profit, etc. are set at 20%,

$145/t × 1.2 ≒ $175/t

b. Storage fee $7/t

The storage period varies. In this estimate, the period is set at three months. The storage fee of M.A.G. is 350 Gs/t/month. Therefore,

350 Gs ÷ 160 Gs/$ × 3 mo. ≒ $7/t

c. Transportation

Delivery at Stroessner City $23/t

Delivery at Paranagua Port $40/t

Delivery at Stroessner City

(a) The distance for transportation from the district to Stroessner City is 300 km.

(b) The average of transportation fee is 1.2 Gs/kg per 100 km (according to M.A.G.).

Therefore, the transportation fee is:

1,200 Gs/t ÷ 160 Gs/$ × 3 ≒ $23/t

Delivery at Paranagua Port

(a) The transportation route is the district - Stroessner - Paranagua Port.

Table 4-2-11-(1) Rice Price in Bangkok

(Unit: $/ ton FOB)

Year / Price	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Average for last 5 years
FOB Price($)	147.1	350.0	542.0	363.1	254.5	272.2	367.5	331.3	433.9	483.0	378

Source: M.A.G. Rice Promoting Program (Draft) 1983.

Table 4-2-11-(2) Export Volume, Value and Price per Ton of Argentina

Year / Item	1976	1977	1978	1979	1980	Average price for last 5 years
Export volume 1 (1,000 t)	87	193	129	99	86	-
Export value 2 ($1,000)	16,967	40,547	36,592	30,756	33,000	-
Price per ton 2 / 1 ($)	195	210	284	311	384	326

Source: FAO Trade Yearbook

The distance from the area to Stroessner is 300 km.

The distance from Stroessner to Paranagua Port is 800 km.

(b) The average transportation fee in Brazil is 20 Crs/t/km.

When the transportation fee between Stroessner and Paranagua Port is computed at the exchange rate of 900 Crs/$,

20 Crs/t/km ÷ 900 Crs/$ × 800 km ≒ $18/t

(c) When the transportation fee within Paraguay is added, the total transportation fee will be $40/t.

d. Selling price

On the basis of the above-mentioned calculations, the following selling prices will be obtained.

Delivery at Stroessner (for Brazil) $205/t
($175/t + $7/t + $23/t)

Delivery at Paranagua Port (for Europe) $225/t
($175/t + $7/t + $23/t + $18/t)

(ii) Rice import by continent

The rice of Paraguay is expected to be exported to Europe and Africa, in addition to Brazil.

The European continent as a whole imported 1,600,000 tons of rice for 1980. Major importers were France (253,000 tons), the Netherlands (193,000 tons), Belgium (176,000 tons), West Germany and Italy. Paraguay once exported rice to France and the Netherlands. Meanwhile, the African continent as a whole imported 2,350,000 tons of rice for 1980. Major importers were Nigeria (387,000 tons), Senegal (275,000 tons), South Africa (126,000 tons), Madagascar (161,000 tons) and Ivory Coast (230,000 tons).

While European nations generally want high-quality rice, it is said that African nations seek lower-priced rice, even though the quality is low. Rice dealers in Asuncion have already made contact with these countries, which are expected to become the importer of the Paraguayan rice.

4.2.2 Soybean

(1) Outline of production

As the demand of feed and edible oil grows in the world market in the 1970s, soybean production shows a remarkable increase. As shown in Table 4-2-12, the total growing area of soybenas in the world increased by 16% from 44.6 million ha in 1976 to 51.8 million ha in 1980. At the same time the production of soybeans increased by 28% from 63.1 million t in 1976 to 80.9 million t in 1980 in the world.

In viewing production by continent, North and Central America including the United States, top producer of the world is ranked first. In 1980 North and Central America produced 49.8 million t of soybeans which occupied 62% of the total production in the world (80.9 million). South America having shown a remarkable growth is ranked second having produced 19.5 million t in 1980 which exceeds 10.0 million t in Asia.

Such districts of South America Continent as the Middle Western part of Brazil, Central part of Argentina and Eastern part of Paraguay are blessed with the natural conditions for soybean culture and, therefore, the production has remarkably grown in those districts as the world demand is expanded. In comparison with 1976 the production of soybeans in 1980 are increased by 500% in Argentina, 140% in Brazil and 200% in Paraguay. Production increase in such countries is respectively attributable to the increase of planted area and, as indicated in Table 4-2-13, the yield par unit area respectively shows a decline except Argentina in the last 5 years. The yield par unit area of North and Central America is generally high and they are ranked first in producing soybeans as the area is increased.

(2) Foreign trade

While the demand of soybeans will be increasing from now on, most of the producing countries are in the position of self-supporting at best or, what is more, of lacking in the soybeans for domestic use. China, which used to be a top producing country of soybeans, is converting to a importing country of soybeans.

At the present time the supplying countries are in North and Central America and South America. In 1980 these Continents exported the soybeans

Table 4-2-12 Harvested Area and Production of Soybeans in the Last 5 Years ..... Main Producing Countries

By Continent / Total by country	Item / Year	Harvested area (1,000 ha)					Production (1,000 t)				
		1976	1977	1978	1979	1980	1976	1977	1978	1979	1980
World		44,624	49,243	52,859	50,809	51,816	63,064	79,206	80,232	89,010	80,870
North, Central America	Total	20,300	23,832	25,990	29,269	27,900	35,597	48,983	50,949	63,114	49,799
	Canada	153	202	263	283	283	250	527	475	671	713
	Mexico	172	314	231	428	155	302	507	324	719	312
	U.S.A.	19,974	23,314	25,496	28,557	27,461	35,042	47,948	50,149	61,722	48,772
Asia	Total	15,918	15,958	10,473	9,451	9,695	14,081	13,888	10,992	9,598	9,951
	China	14,236	14,230	8,524	7,266	7,515	12,543	12,252	9,041	7,482	7,906
	India	160	170	230	491	560	120	130	200	350	450
	Indonesia	646	646	733	784	726	522	523	617	680	642
U.S.S.R.	Total	762	786	815	838	854	480	540	680	467	525
South America	Total	7,107	8,049	9,213	10,395	12,460	12,338	14,437	12,833	14,755	19,521
	Argentina	434	660	1,100	1,600	2,030	695	1,400	2,500	3,700	3,500
	Brazil	6,416	7,070	7,779	8,256	9,766	11,227	12,513	9,800	10,240	15,153
	Paraguay	173	229	190	360	475	284	377	300	549	575

Source: FAO Production yearbook.

Table 4-2-13 Production Per Hectare of Soybeans in the Last 5 Years

Main producing countries

By Continent / Total by country	Item / Year	Production a hectare (kg/ha)				
		1976	1977	1978	1979	1980
World		1,413	1,608	1,518	1,752	1,561
North, Central America	Total	1,753	2,055	1,960	2,156	1,785
	Canada	1,637	2,606	1,806	2,368	2,517
	Mexico	1,755	1,614	1,405	1,682	2,014
	U.S.A.	1,754	2,057	1,967	2,161	1,776
Asia	Total	885	870	1,050	1,016	1,026
	China	875	861	1,061	1,030	1,052
	India	750	765	870	713	804
	Indonesia	807	809	842	867	885
U.S.S.R.	Total	630	687	834	557	615
South America	Total	1,736	1,794	1,393	1,419	1,567
	Argentina	1,603	2,121	2,273	2,313	1,724
	Brazil	1,750	1,770	1,260	1,240	1,551
	Paraguay	1,635	1,647	1,579	1,524	1,210

Source: FAO Production yearbook

equivalent to 98% of total amount of exported soybeans (26.9 million t). Only the United States occupied the share of 81% of total amount (Refer Table 4-2-14). Those soybeans are exported mainly to the European and Asian countries. Compared with 27.0 million t imported in the world market, Europe imported 16.8 million t and Asia imported 7.3 million t. These figures are equivalent to 62% and 27% of the total amount imported (Table 4-2-15). Japan and such European countries as West Germany, Holland, Spain are major importing countries of soybeans and in those countries imported soybeans are utilized as materials of processed goods like soybean oil. The surplus exceeding the domestic consumption is exported in bulk from Europe.

With regards to the export of soybeans (cake and flour) as shown in Table 4-2-16, North · Central America exported 7.1 million t and South America exported 7.0 million to in 1980. They respectively occupied 40% and 39% of the total amount of exported soybeans (cake and flour) in the same year. In both of the Continents soybeans are exported mostly from the United States and Brazil. As shown in Table 4-2-18, Europe is ranked first in exporting soybeans (oil) with the amount of 1.2 million which is equivalent to 38% of the total amount of exported soybeans (oil). Europe is followed by North · Central America and South America. As pointed out before, the materials of edible oil exported from Europe are mostly the soybeans imported from the United States and Brazil.

Thus, soybeans are dealt with, taking to pieces such as beans, husks, flour and oil. In the United States it is exported in the form of beans. 21.8 million t of soybeans, which are exported from the States in 1980, are equal to 45% of the total production (48.8 million t) in the United States. On the contrary 1.5 million t of exported soybeans occupied 10% of the total amount of production (15.2 million t) in Brazil in the same year because the rate of processed goods is high.

It is considered that oil expressing capacity per annum amounts to 22.0 million t in Brazil. Since 15.2 million t were produced in the peak year of 1980, the surplus of capacity is considerably available even if 10% is occupied by cotton-seed oil and peanut oil. In order to make the best use of these facilities, Brazil imports the soybeans from the neighboring countries such as Paraguay, Argentina and the United States

Table 4-2-14 Exports of Soybeans (Beans) in the Last 5 Years

Main countries

By Continent / Total by country \ Item / Year		Export (1,000 t)				
		1976	1977	1978	1979	1980
World		19,756	20,012	24,051	25,488	26,875
North, Central America	Total	15,361	16,234	20,794	20,956	21,882
	U.S.A.	15,332	16,196	20,710	20,905	21,786
Asia	Total	228	176	175	333	167
	China	190	129	146	306	140
Europe	Total	199	152	243	383	332
	Holland	187	116	218	332	299
South America	Total	3,934	3,442	2,838	3,813	4,493
	Argentina	78	613	1,985	2,834	2,700
	Brazil	3,639	2,587	659	638	1,549
	Paraguay	208	241	192	334	235

Source: FAO Trade yearbook

Table 4-2-15 Imports of Soybeans (Beans) in the Last 5 Years

Main countries

By Continent / Total by country	Item: Year	Import (1,000 t) 1976	1977	1978	1979	1980
World		20,006	19,709	23,165	26,128	26,997
North, Central America	Total	837	908	1,097	1,006	1,129
	Canada	419	318	324	351	477
	Mexico	348	525	681	578	522
Asia	Total	5,280	5,418	6,338	7,066	7,288
	China	829	980	1,071	1,683	1,515
	Japan	3,554	3,602	4,260	4,132	4,401
Europe	Total	12,063	11,827	14,591	15,906	16,800
	Belgium	864	813	1,061	1,004	910
	France	509	549	782	859	868
	West Germany	3,430	3,372	3,613	3,673	3,901
	Italy	1,146	1,180	1,279	1,706	1,393
	Holland	1,759	1,691	2,635	3,288	3,495
	Spain	1,941	1,835	2,179	2,237	3,214
	England	1,106	1,131	1,238	999	1,157
U.S.S.R	Total	1,749	1,384	906	1,765	1,085
South America	Total	48	79	126	294	554

Source: FAO Trade yearbook

Table 4-2-16 Exports of Soybeans (Cake and Flour) in the Last 5 Years

Main countries

By Continent	Total by country	Item / Year	Export (1,000 t) 1976	1977	1978	1979	1980
World			11,383	11,835	14,881	14,953	17,818
North, Central America	Total		4,925	4,252	6,404	6,109	7,103
	Canada		63	45	48	22	78
	U.S.A.		4,862	4,207	6,356	6,087	7,025
Asia	Total		559	783	1,055	252	341
	Israel		27	20	18	39	34
	Singapore		25	106	117	124	111
Europe	Total		1,770	1,764	2,572	2,996	3,359
	Belgium		327	371	515	481	478
	West Germany		559	570	656	733	859
	Holland		637	593	1,145	1,535	1,740
South America	Total		4,625	5,684	5,758	5,567	6,988
	Argentina		210	311	320	347	290
	Brazil		4,374	5,354	5,420	5,177	6,582
	Paraguay		33	17	11	34	73

Source: FAO Trade yearbook

Table 4-2-17 Imports of Soybeans (Cake and Flour) in the Last 5 Years

Main countries

By Continent / Total by country \ Item / Year		Import (1,000 t)				
		1976	1977	1978	1979	1980
World		11,125	11,660	14,448	15,700	17,449
North, Central America	Total	527	549	626	750	775
	Canada	349	351	413	465	404
Asia	Total	559	783	1,055	1,277	1,391
	Japan	193	317	340	283	326
	Singapore	117	150	172	201	208
	Philippines	76	96	130	114	227
Europe	Total	9,850	10,056	12,459	13,152	14,280
	France	1,718	1,704	2,270	2,552	2,764
	East Germany	720	905	827	890	805
	West Germany	938	939	1,693	1,813	1,970
	Holland	897	841	912	839	1,157
	Polland	567	756	772	938	1,144
South America	Total	166	228	225	317	459
	Venezuela	154	213	218	278	341

Source: FAO Trade yearbook

though Brazil is regarded as a big producing country of soybeans. By using the surplus of facilities, Brazil produces soybeans (oil and cake) and exports them finally. The Government of Brazil has set up "Draw back" system which enables the importers of soybeans to import free of tax on the assumption that they must be exported again. Owing to such incentives the soybeans exported from Brazil are decreasing.

(3) Study of Marketability Concerning the Production of Soybeans Being Increased in the Survey Area

As a domestic demand of edible oil is limited in Paraguay, oil expressing factories are small in production scale and the export of processed goods is very scarce. Soybeans have conventionally been exported in unprocessed form to Europe as shown in Table 4-2-20. At present, however, soybeans are only exported in unprocessed form to Brazil. There is nothing to worry about the marketability of soybeans in Paraguay because she is blessed with favourable geographical conditions.

The selling price (in the City of Stroessner) of soybeans produced in the survey area is computed $199 as follows. As the above price has fallen short of the recent average price/t, $204 (1978 ∿ 1982) as shown in Table 4-2-20, and also the average price of soybeans imported from Paraguay to Brazil, $229.9 in 1982, it will be a competitive price even in the future.

1) Farmer's price $169/t

- If the production cost of 24,600 Gs/t (farmer operating 150 ha) is converted with 160 Gs/$,

  24,600 Gs/t ÷ 160 Gs = $154

- Profit of 10% is added

  $154 × 1.1 = $169

2) Storage fee $7/t

- On the assumption that duration of storage is 3 months the computation is made with the storage fee of 350 Gs/t/month (M.A.G. data) as mentioned under.

  350 Gs/t/month ÷ 160 Gs/$ × 3 (month) ≒ $7/t

3) Transportation cost $23/t

a. Transporting distance is 300 km from the district to the city of

Table 4-2-18 Exports of Soybeans (Oil) in the Last 5 Years

Main countries

By Continent / Total by country	Item / Year	Export (1,000 t)				
		1976	1977	1978	1979	1980
World		1,836	2,104	2,596	2,953	3,196
North, Central America	Total	506	768	916	1,110	1,081
	U.S.A.	506	768	914	1,100	1,067
Asia	Total	11	12	17	15	53
	China	0.1	2	6	4	4
	Israel	5	5	4	1	1
	Singapore	2	4	2	5	15
Europe	Total	755	780	1,094	1,218	1,221
	Belgium	101	85	131	118	85
	France	80	82	127	147	132
	West Germany	226	234	216	212	198
	Holland	164	176	291	347	345
	Spain	125	134	273	311	369
South America	Total	562	544	569	609	840
	Argentina	64	40	65	81	92
	Brazil	498	502	504	528	744
	Paraguay	0.2	0.2	0.5	0.2	5

Source: FAO Trade yearbook

Table 4-2-19 Imports of Soybeans (Oil) in the Last 5 Years

Main countries

By Continent / Total by country	Item / Year	Import (1,000 t) 1976	1977	1978	1979	1980
World		1,647	2,158	2,641	2,530	3,143
Africa	Total	160	218	328	362	373
North, Central America	Total	98	108	132	103	168
Asia	Total	609	1,039	1,302	1,044	1,464
Europe	Total	578	569	608	683	775
South America	Total	163	189	237	287	289
	Chile	32	38	49	53	59
	Columbia	32	40	58	76	79
	Peru	63	71	29	14	35

Source: FAO Trade yearbook

Stroessner.

b. As the average transportation cost is 1.2 Gs/kg per 100 m, $/t is as follows.

1,200 Gs/t ÷ 160 Gs/R = $7.5/t/100 km

c. Total transportation cost

$7.5/t × 3 = $23/t

4) Total

(1 + 2 + 3) $199

It is considered that the transportation cost of soybeans in Paraguay will become lower due to the completion of "Paranagua Export Corridor Plan" already discussed in Chapter 2. 2.9.2. Therefore, soybeans production will necessarily become much more profitable than ever in Paraguay.

Table 4-2-20-① Export of Soybeans in Paraguay

(t)

Item \ Year	1974	1975	1976	1977	1978	1979	1980	1981	1982
Soybeans (Bean)	100,651	101,946	208,339	241,202	192,174	334,122	235,307	221,753	467,555
Soybeans (Cake)	27,193	30,610	30,650	17,016	11,400	28,575	72,795	17,886	28,000
Soybeans (Oil)	1,482	93	220	218	460	150	4,600	2,030	56
Soybeans (Flour)	1,300	-	-	-	-	2,550	-	-	-

Source: Boletin Estadistico

Table 4-2-20-② Value of Exported Soybeans in Paraguay

(1,000 $.FOB)

Item \ Year	1974	1975	1976	1977	1978	1979	1980	1981	1982
Soybeans (Bean)	14,975	17,470	32,220	56,209	38,349	78,617	42,096	47,533	89,617
Soybeans (Cake)	3,214	2,651	3,601	2,172	1,536	4,572	12,657	3,467	4,299
Soybeans (Oil)	907	99	133	157	226	113	2,472	1,069	23
Soybeans (Flour)	117	-	-	-	-	308	-	-	-

Source: Boletin Estadistico

Table 4-20-20-③ Export Price of Paraguay

($.FOB)

Item \ Year	1974	1975	1976	1977	1978	1979	1980	1981	1982
Soybeans (Bean)	149	171	155	233	200	235	179	214	192

Source: Boletin Estadistico

(Note) This table is made of Table 4-2-20 ① and 4-2-20 ②.

4.2.3 Wheat

(1) Outline of production

Wheat production of the world amounted to 444.6 million t in 1980 which occupied 28% of the total production of cereals in the world (1,561.0 million t). Asia is ranked first in the production, followed by U.S.S.R., Europe, North Central America. In 1980 the wheat production of these Continents occupied 93% of the total production in the world.

The recent amount of wheat exported in the world is approximately 90.0 million t which is mainly exported from the United States, Canada, Australia, France and Argentina.

In South America Argentina is the top wheat producing country blessed with favourable natural conditions. In 1980 the production of Argentina was 7.8 million t which occupied 65% of the total production (12.0 million t) of South America. It was followed by Brazil. As shown in Table 4-2-21, South America as a whole imports the wheat from the other Continents as the demand can not be met with production in South America.

(2) Wheat in Paraguay

Paraguay imports more than 50% of the domestic demand every year as already discussed in 2-9-3. In recent years wheat has been imported mostly from Argentina as shown in Table 4-2-22.

In 1981 the total value of wheat imported including processed goods amounted to $13.87 million (FOB) which occupied 43% of the total value of food imported ($32.6 million). The total value of foods imported is equivalent to about 6% of the grand total value of Paraguayan imports ($506.11 million). Due to an encouraging policy of wheat production such as the promotion of mechanization by the National Wheat Plan, wheat production has been remarkably increased in recent years. However, the production has not yet reached the level where the domestic demand can be met.

Under such circumstances the production increase of wheat is of great importance to Paraguay. There is nothing to worry about the marketability of wheat produced in the survey area.

Table 4-2-21 Export and Import of Wheat in South America Continent

Item / By country \ Year	Export (1,000 t)					Import (1,000 t)				
	1976	1977	1978	1979	1980	1976	1977	1978	1979	1980
South America	3,183	5,703	1,627	4,279	4,495	6,708	5,346	8,014	6,861	8,653
Argentina	3,155	5,635	1,627	4,279	4,495	-	-	-	-	-
Bolivia	-	-	-	-	-	97	160	207	259	276
Brazil	-	-	-	-	-	3,428	2,624	4,333	3,655	4,755
Chile	-	-	-	-	-	1,129	460	1,050	727	1,020
Columbia	-	-	-	-	-	397	214	446	336	640
Ecuador	-	-	-	-	-	205	241	254	164	198
Ghana	-	-	-	-	-	41	51	41	48	35
Paraguay	-	-	-	-	-	57	44	49	65	75
Peru	-	-	-	-	-	601	832	746	781	800
Surinam	-	-	-	-	-	13	13	12	16	15
Urguay	29	68	-	-	-	0	0	112	92	55
Venezuela	-	-	-	-	-	740	705	764	719	785

Source: FAO Trade yearbook

Table 4-2-22 Amount of Value of Imported Wheats in Paraguay

Item / Year / Exporting country	Amount of export (t)				Value of export ($1,000) FOB			
	1978	1979	1980	1981	1978	1979	1980	1981
Argentina	48,750	64,158	74,591	67,720	4,864	8,086	11,037	13,763
Others	66	624	387	394	15	192	68	108
Total	48,816	64,782	74,978	68,114	4,879	8,278	11,105	13,871

Source: Boletin Estadistico

CHAPTER 5

LAND IMPROVEMENT PLAN

5.1 Irrigation Plan

5.1.1 Basic policy for irrigation plan

The project area is divided into Area A and Area B by the Land Use Plan and it was decided to cultivate upland crops such as wheat, soybeans, etc., in the Area A and to cultivate paddy in the Area B. In order to secure a stabilized production of crops when observing from the conditions of location, it is considered that irrigation to paddy is necessary in the Area B.

The water source of this irrigation plan is the Yacyreta Dam. The intake of irrigation water is naturally performed from the intake work provided on the above-mentioned dam and is conveyed and distributed to the project area. The water-intake altitude shall be the normal full water level of 82.0 m of the Yacyreta Dam and as a rule, the irrigation area shall be the range that can be irrigated by the natural flow from distribution canals. However, water-distribution by partial pump usage will also be planned. The formulation of outline of the irrigation plan for this year shall be based on the abovementioned basic policy and shall be executed upon sufficiently studying the following items.

(1) The irrigated area for this year's plan shall be Area B which occupies the principal part of the project area.

(2) The objective crop shall be paddy which is the main crop of Area B and settings on the benefited area and actual irrigated area shall be made based on the topographic conditions, the Cultivation Plan, etc.

(3) The maintenance or abolition of forests within the benefited area shall be based on the Environmental Conservation Plan and the forest area to be preserved shall be excluded from the irrigated area.

(4) Residential areas, facility sites, slight uplands, small-scaled forests, etc., within the benefited area shall be excluded from the irrigated area and the area percentage excluded shall be 20% of the benefited area.

(5) The irrigation system and irrigation block shall be decided based on the existing roads and rivers and the newly planned system of irrigation canals, drainage canals and roads.

(6) As a rule, the irrigation canal shall be of the open canal system by natural flow and shall be passed through a high part to extents possible.

(7) The route selection of the irrigation canal shall be performed by utilizing a topographic map of 1/50,000 scale.

(8) Areas in which the use of pumps can be considered economical shall be made irrigation areas to be irrigated by pump lift.

(9) With the exception of accessory structures, the irrigation canal shall be an unlined canal.

(10) The use of river waters flowing into the area from hinterland shall be appropriated for future redevelopments and the utilization plan shall be schemed in the following year upon awaiting the results of the presently performed observation.

5.1.2 Irrigated area and principal facilities

The generally determined benefited area based on the basic policy becomes 99,850 ha, the irrigated area becomes 79,880 ha and the actual irrigated area becomes 39,940 ha. These areas are shown in Table 5-1-1.

Irrigation facilities are largely classified into the irrigation canal, aqueduct, diversion works, drop structures, regulating facilities of water level and pump stations and they become as shown in Table 5-1-2 when they are generally determined from the 1/50,000 scale topographic map, and the road and drainage canal system map. Detailed plans of drop structures, regulating facilities of water level and diversion works shall be in accordance with the following year's study. Moreover, it has been arranged under the Agreement between the countries of Paraguay and Argentine that the intake works shall be separately executed in the Yacyreta Dam works.

Furthermore, the designed irrigation system map which indicates the irrigation benefited area and the principal facilities is shown in Fig. 5-1-1 and the designed irrigation system flow chart is shown in Fig. 5-1-2.

Table 5-1-1 Lnad Use Plan in the Project Area

Block No.	Argicultural land			Driving channel, etc.	Grand total	Remarks
	Pasture	Paddy field	Total			
	ha	ha	ha	ha	ha	
1	264	264	528	132	660	
2	580	580	1,160	290	1,450	
3	1,633	1,633	3,266	816	4,082	Main Canal No.1
4	904	904	1,808	452	2,260	
5	1,143	1,143	2,286	571	2,857	
6	1,638	1,638	3,276	819	4,095	
7	1,786	1,786	3,572	893	4,465	
8	1,894	1,894	3,788	947	4,735	
9	563	563	1,126	281	1,407	
10	1,288	1,288	2,576	644	3,220	Main Canal No.2
11	2,341	2,341	4,682	1,170	5,852	
12	1,407	1,407	2,814	703	3,517	P1 Pump use
13	1,644	1,644	3,288	822	4,110	"
14	480	480	960	240	1,200	"
15	1,084	1,084	2,168	542	2,710	"
16	1,194	1,194	2,388	597	2,985	
17	1,344	1,344	2,688	672	3,360	
18	136	136	272	68	340	

Table 5-1-1 Land Use Plan in the Project Area (Continued)

Block No.	Argicultural land			Driving channel, etc.	Grand total	Remarks
	Pasture	Paddy field	Total			
	ha	ha	ha	ha	ha	
19	564	564	1,128	282	1,410	
20	826	826	1,652	413	2,065	P_3 Pump use
21	2,308	2,308	4,616	1,154	5,770	
22	695	695	1,390	348	1,738	
23	460	460	920	230	1,150	
24	480	480	960	240	1,200	
25	728	728	1,456	364	1,820	
26	524	524	1,048	262	1,310	P_4 Pump use
27	1,590	1,590	3,180	795	3,975	"
28	1,309	1,309	2,618	654	3,272	"
29	1,144	1,144	2,288	572	2,860	"
30	202	202	404	101	505	"
31	980	980	1,960	490	2,450	P_2 Main Canal No.3 Pump use
32	588	588	1,176	294	1,470	
33	350	350	700	175	875	Main Canal No.4
34	1,612	1,612	3,224	806	4,030	
35	1,202	1,202	2,404	601	3,005	
36	2,425	2,425	4,850	1,215	6,065	P_5 Pump use
37	630	630	1,260	315	1,575	
Total	39,940	39,940	79,880	19,970	99,850	

Table 5-1-2 Principal Irrigation Facilities

Facility	Total length	Detail
Main Irrigation Canal	92.0 km	Intake works → Northern area → Yabebyry river Q = 103.8 m^3/s ~ 12.4 m^3/s pump station Q = 2.16 m^3/s 1 place H = 2.0 m Turnouts of Main canal 7 place Bridges crossing drainge canal 4 places
Main Irrigation Canal No.1	22.0 km	Q = 9.57 m^3/s ~ 2.97 m^3/s Bridge crossing drainage canal 1 place
No.2	34.4 km	Q = 21.43 m^3/s ~ 4.07 m^3/s Pump station Q = 12.00 m^3/s 1 place H = 2.5 m
No.3	13.7 km	Q = 4.08 m^3/s ~ 1.53 m^3/s Pump Q = 4.08 m^3/s 1 place H = 1.5 Bridge crossing drainage canal 1 place
No.4	23.6 km	Q = 16.17 m^3/s ~ 1.64 m^3/s Bridges crossing drainage canal 2 places Turnouts of main canal 1 place Pump station Q = 6.31 m^3/s 1 place H = 2.5 m
No.5	6.0 km	Q = 4.19 m^3/s ~ 0.62 m^3/s
No.6	10.0 km	Q = 1.20 m^3/S ~ 0.39 m^3/s
No.7	9.0 km	Q = 1.25 m^3/s ~ 0.42 m^3/s
No.8	16.7 km	Q = 12.4 m^3/s ~ 0.53 m^3/s Pump station Q = 12.4 m^3/s 1 place H = 4.0 m
Subtotal	135.4 km	
Total	227.4 km	Turnouts of main canal 8 places Bridges crossing drainage canal 8 places Pump stations 5 places

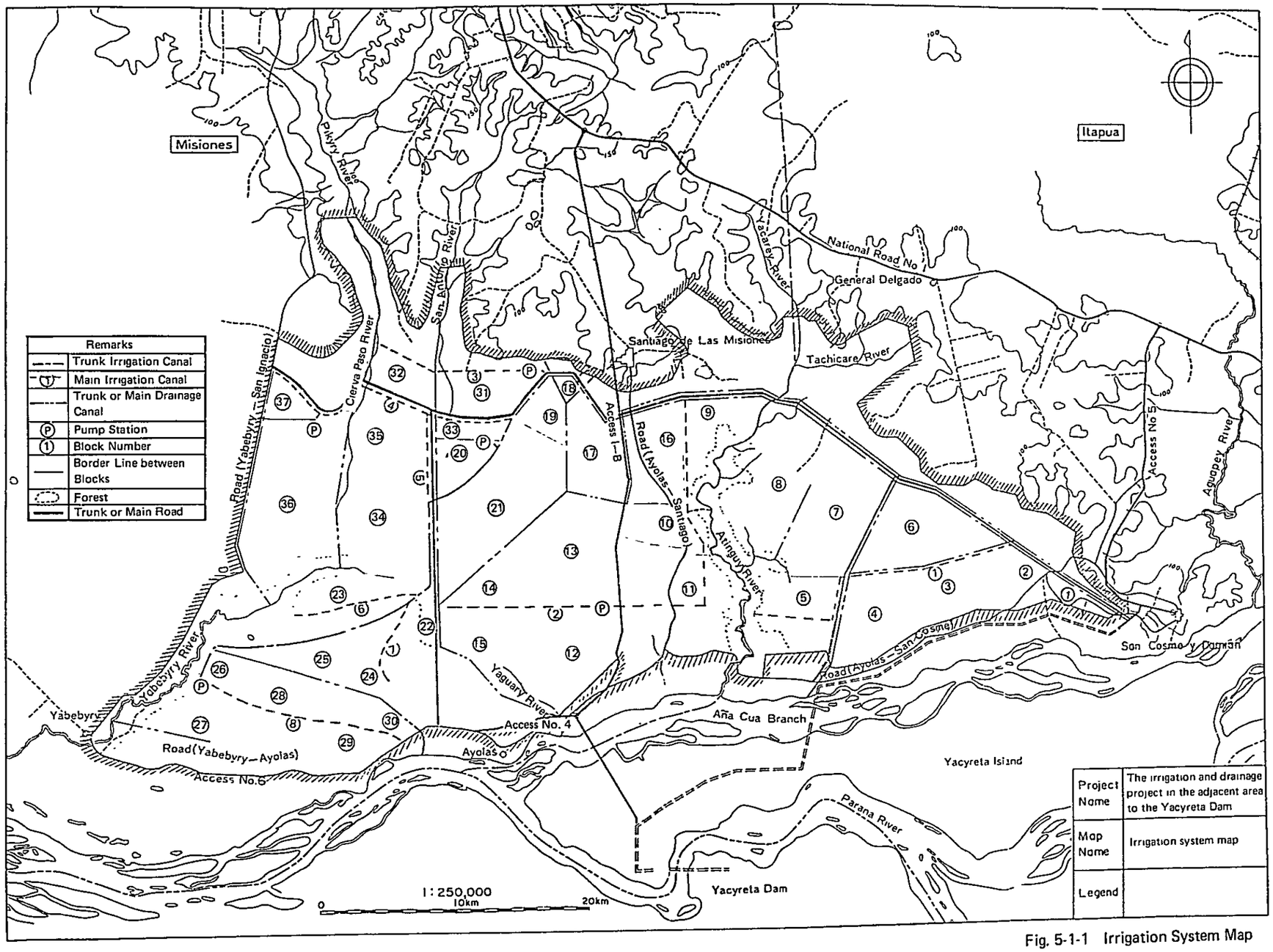
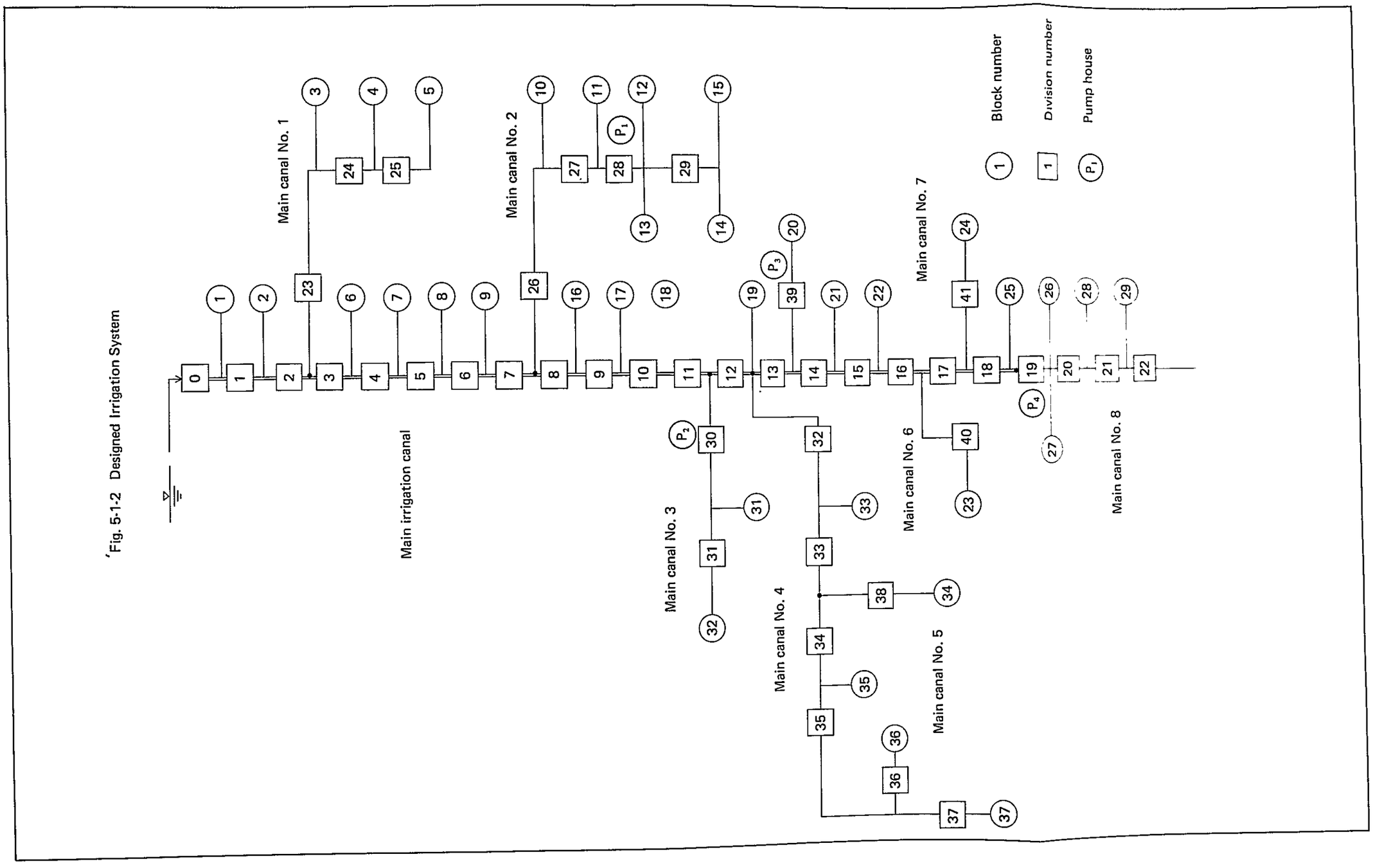


Fig. 5-1-1 Irrigation System Map



'Fig. 5-1-2 Designed Irrigation System

5.1.3 Irrigation plan

(1) Crop water requirement

In the calculation method of potential evapotranspiration, there are the 4 typical examples of the Modified Penman Method, Blaney-Criddle Method, Solar Radiation Quantity Method and Pan Evaporation Method. In this plan, however, it shall be performed by the Modified Penman Method which is said to be the most accurate by FAO.

1) Meteorological data

The meteorological data used in the calculation of the potential evapotranspiration must be the data which represents the meteorology of the project area.

There are 9 meteorological observatories in the periphery of this project area but as the observation period ranges over a long period and the observation places neighbor the project area, the data of the Yacyreta observatory under the jurisdiction of the Ministry of National Defense shall be used this time. (See Table 5-1-3)

Data necessary for calculation under the Modified Penman Method are temperature, humidity, wind speed and duration of sunshine as shown in Table 5-1-4. However, since observation on duration of sunshine is not performed at the Yacyreta observatory, that of the Encarnacion observatory shall be used.

Table 5-1-3 Dimensions of Meteorological Data for Calculate

Item	Observatory	Data used
Daily mean temperature	Yacyrete obserbatory	Average of 10 years 1971 - 1980
Daily mean relative humidity	"	"
Daily mean wind velocity	"	Average of 6 years 1975 - 1980
Daily mean sunshine duration	Encarnacion observatory	"

Table 5-1-4 Meteorological Data for Calculation

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Daily mean temperature °C	26 .3	25 .9	24 .5	20 .8	18 .0	15 .9	16 .2	16 .6	18 .7	21 .2	22 .9	25 .4
Daily mean relative humidity %	74	75	77	76	80	80	77	77	72	73	71	72
Daily mean wind velocity K not		6		5		6		7	7	7	7	
Daily mean sunshine duration hr	7 .9	8 .6	5 .9	7 .1	5 .5	5 .6	5 .5	5 .8	7 .0	5 .8	7 .3	8 .6

Mean maximum relative humidity	Over 90%	Mean wind speed during daytime	2.0

However, there are meterological observatories established by the Yacyreta Public Corporation and this study group in and around planned area, therefore data can be analyzed jointly after collected.

Moreover, there are meteorological observatories established by the Yacyreta Public Corporation and survey mission for the purpose of future study in the project area and its environs and it will become possible to perform joint analysis after data storing.

2) Potential evapotranspiration

The standard potential evapotranspiration calculated by the Modified Penman Method (ETo mm/d) is as shown in Table 5-1-5. (It is said that this value contains an error of ±10% in the summer season.)

Table 5-1-5 The Standard Potential Evapotranspiration

(mm/d)

Mon	J	F	M	A	My	Ju	Jy	A	S	O	N	D
ETo	7.6	7.4	5.2	4.9	3.0	2.5	3.0	3.3	5.0	6.1	7.5	8.3

3) Crop water requirement (ETcrop)

The crop water requirement (ETcrop) is obtained by multiplying the standard potential evapotranspiration (ETo) by the crop coefficient (Kc) and the crop coefficient (Kc) is set up based on the "Irrigation and Drainage paper Volume No. 24 - Crop Water Requirement" of FAO. The planned species of paddy shall be of the CICA variety and the crop water requirement (ETcrop) shall be calculated by making the planting duration for the period of 40 days from October 20th and the cropping period for the period of 140 to 150 days. Moreover, the crop coefficient shall be deducted by 20% during the non-ponding period. The crop coefficient is shown in Fig. 5-1-3.

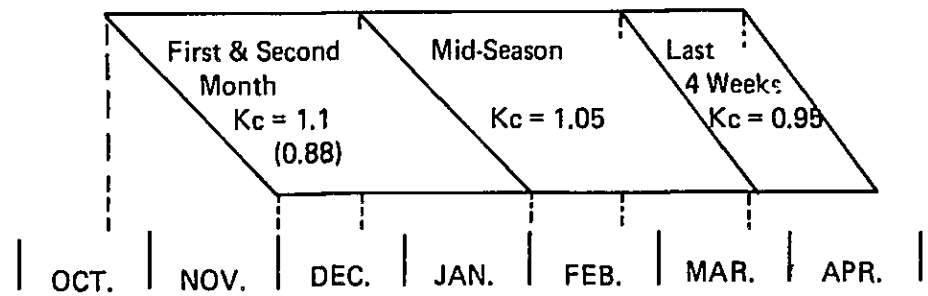


Fig. 5-1-3 Crop Coefficient of Paddy Rice

4) Study of crop water requirement

Upon calculation by utilizing Table 5-1-5 and Fig. 5-1-3, the crop water requirement became as shown in Table 5-1-6.

Table 5-1-6 Crop Water Requirement

Mon.	Nov.	Dec.	Jan.	Feb.	Mar.
mm/d ETo	7.5	8.3	7.6	7.4	5.2
Kc	11/7	1.1(0.88)	1/7 1.05	2/7 0.95	3/6
mm/d ETcrop	8.3 (6.6)	9.1 (7.3)	8.4 8.0	7.8 7.0	4.9

By the way, the mean value of the crop water requirement during the period from December 16th to December 31st was 7.5 mm/day according to the investigation of daily water requirement in depth and it was a value of about 18% lower than the calculated value of 9.1 mm/day.

There lies the possibility of the meteorological conditions changing in the future when the Yacyreta Dam is completed and the land reclaimed to paddy field progresses in the area. However, the calculated value for the planned crop water requirement shall be adopted and checking and study shall be promoted while providing reference to the results of continued investigations and future researches.

(2) Irrigation method

The rice after direct planting of rice-seeds is cultivated in the field without inundation for about 1 month and after this, the inundation is continued up until harvesting. The irrigation method must be one corresponding to the water management method during the growing stage. Moreover, since it is a large-sized rice crop operation, it is prefered that the water management labor force is small.

Since the soil within the area has a small intake rate and the downward loss in surface irrigation is small, it is suitable for storage irrigation. There is a comparatively uniform rainfall during the cropping period and the rainfall can be effectively used by providing a border and storing the rainfall. Since the space of borders can be

widely set as the topographic features within the area is flat and the slope is also small, the water management labor force can be minimized.

From the above-mentioned fact, the irrigation system shall be of the storage irrigation system utilizing the contour levee.

(3) Water management and water requirement

Water management by direct planting of rice-seeds in field without inundation can be classified into the following 3 stages.

a. First stage: Stage from directly after the planting of rice-seeds up until just prior to tillering. The soil moisture is controlled with the wilting point as the lower limit. The rainfall is mainly used and the shortage is supplied by irrigation water.

b. Second stage: Inundation of the paddy field is performed just before tillering. It shall be made of the prescribed inundation depth within the range that it does not become an obstacle to tillering.

c. Third stage: The prescribed inundation depth is maintained up until inundated.

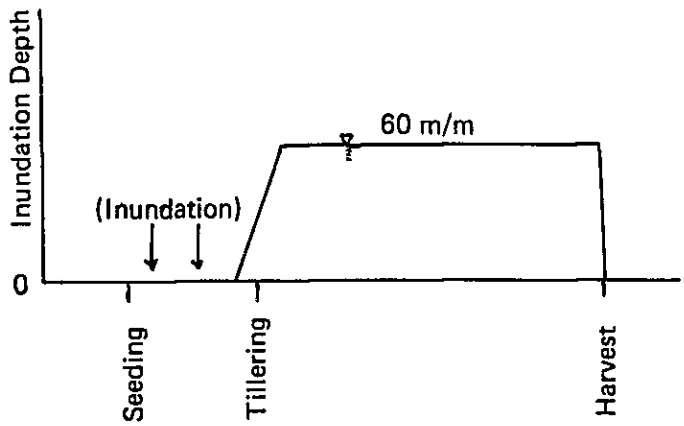


Fig. 5-1-4 Graphical Figure of Water Management

When the above-mentioned stages are represented, they become as shown in Fig. 5-1-4.

The various elements of the irrigation plan are determined as follows from the physical properties of the soil.

a. Designed groundwater level at the time of drained paddy field — GL-700 mm

b. Effective root zone at the time of drained paddy field — 400 mm

c. Volume rate of soil — 60%

d. Total available moisture percentage (At drained paddy field) — 20%

e. Total available moisture (TAM) — 80 mm

f. TRAM (Total readily available moisture) (TRAM/TAM = 0.5) — 40 mm

g. Invalid moisture percentage

Dry side — 10%

Wet side — 10%

h. Necessary moisture amount for making it of saturated condition from the field capacity condition.

$h = 400 \times 0.1 + 300 \times 0.1 \times 1/2 =$ 55 mm

i. Necessary moisture amount for obtaining the prescribed inundation depth (60 mm) from the wilting point condition.

TRAM + h + inundation amount = 40 + 55 + 60 = 155 mm

l) Seasonal water requirement

An intermittent irrigation utilizing the peak water requirement is performed in the first stage. The daily irrigation amount is 40 mm (TRAM) and the number of days of intermittent irrigation shall be for the period of 5 days.

In the second stage, inundation (average 60 mm) shall be completed during the period of the 6 days after 25 days from planting of the rice-seeds. Moreover, the soil moisture shall be saturated by immediately before the starting of inundation.

In the third stage, the daily crop water requirement shall be supplied.

Table 5-1-7 Seasonal Water Requirement

No.	ETo	Kc	ETcrop	P	PUD	TOTAL
	mm/d		mm/d	mm/d	mm/d	
①	6.1	0.88	5.4	-	-	5.4
②	7.5	0.88	6.6	-	-	6.6
③	8.3	0.88	7.3	-	-	7.3
④	7.5	1.1	8.3	3.0	10.0	21.3
⑤	8.3	1.1	9.1	3.0	10.0	22.1
⑥	7.5	1.1	8.3	3.0	-	11.3
⑦	8.3	1.1	9.1	3.0	-	12.1
⑧	7.6	1.1	8.4	3.0	-	11.4
⑨	8.3	1.05	8.7	3.0	-	11.7
⑩	7.6	1.05	8.0	3.0	-	11.0
⑪	7.4	1.05	7.8	3.0	-	10.8
⑫	5.2	1.05	5.5	3.0	-	8.5
⑬	7.4	0.95	7.0	3.0	-	10.0
⑭	5.2	0.95	4.9	3.0		7.9
⑮	4.9	0.95	4.7	3.0		7.7

ETo: Standard potential evapotranspiration

Kc: Crop coefficient

ETcrop: Crop water requirement

P: Percolation

PUD: Water for inundation

The seasonal water requirement according to stages shall include the crop water requirement, percolation quantity and duty of water for initial inundation, and shall be calculated as shown in Table 5-1-9 to Table 5-1-7.

(4) Effective rainfall

1) Initial period of first stage

This is the initial stage of direct planting of rice-seeds in field without inundation and the land is of well drained field condition. Therefore, similarly as in the case of surface irrigation for upland, the effective rainfall is defined as follows:

The value deducting the available moisture amount of the soil at just before the rainfall from TRAM (Total Readily Available Moisture) shall be made the upper limit of the effective rainfall. The daily rainfall of less than 5 mm shall be made invalid and on daily rainfall of more than 5 mm, it shall be considered that 80% of the rainfall is used.

2) After the latter period of first stage

In this stage when the rice plant has grown and the danger of overhead inundation has become small, the effective rainfall is defined as follows:

The daily rainfall of less than 5 mm shall be made invalid and in case of daily rainfall of more than 5 mm and less than 80 mm, 80% of the rainfall shall be made valid. When the daily rainfall exceeds 80 mm, 80% of the rainfall (80 mm $\times$ 0.8 = 64 mm) shall be made valid.

It is necessary to build the structure of levee with sufficient margin for utilizing the rainfall effectively. Moreover, it is necessary that water management reliably copes against rainfall.

The effective rainfall during the cultivation period (From October 20th to April 20th of following year) from the year of 1969 to 1979 are as shown in Table 5-1-8.

The calculation of water balance shall be performed by using the daily rainfall for the years of 1977 to 1978 which is the second in ranking and the probability of continuous drought days during the cultivation period corresponds to 1/5. Moreover, the detailed study of effective rainfall is shown in the Appendix.

Table 5-1-8 Rainfall and effective rainfall

Cropping season	Cropping season							Total	Order
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.		
1969 - 70	(213.2) 122.1	(173.0) 128.4	(74.3) 59.5	(73.0) 58.4	(172.4) 133.2	(314.0) 240.8	(3.2) 0	(1,023.1) 742.4	9
1970 - 71	(96.1) 76.8	(20.8) 13.2	(148.0) 116.0	(41.4) 30.5	(211.3) 76.2	(228.7) 174.4	(61.1) 46.0	(807.4) 533.1	4
1971 - 72	(9.0) 7.2	(42.8) 27.4	(98.9) 74.2	(80.2) 53.2	(63.8) 49.1	(121.2) 96.6	(80.3) 64.3	(496.0) 372.0	1
1972 - 73	(179.2) 133.8	(170.8) 130.0	(196.2) 151.8	(165.8) 119.8	(82.6) 59.3	(268.9) 177.4	(224.0) 177.9	(1,287.5) 950.0	10
1973 - 74	(34.9) 27.9	(58.5) 44.5	(195.9) 152.5	(149.8) 118.3	(125.3) 95.0	(99.7) 75.1	(56.2) 45.0	(720.3) 558.3	5
1974 - 75	(52.6) 40.2	(100.8) 75.7	(204.9) 159.6	(109.8) 87.8	(87.7) 68.2	(188.9) 150.7	(139.8) 107.0	(884.5) 689.2	8
1975 - 76	(228.2) 138.5	(130.2) 101.7	(61.6) 38.4	(189.8) 145.2	(106.8) 83.9	(150.0) 111.0	(44.2) 30.2	(910.8) 648.9	6
1976 - 77	(79.4) 61.8	(104.6) 79.0	(74.6) 55.6	(262.5) 187.8	(44.2) 30.1	(26,8) 11.0	(84.2) 64.0	(676.3) 489.3	3
1977 - 78	(34.0) 27.2	(191.6) 144.0	(145.8) 109.9	(71.2) 51.6	(123.7) 87.3	(51.8) 37.2	(19.8) 15.2	(637.1) 472.4	2
1978 - 79	(111.4) 89.1	(180.8) 143.4	(232.7) 186.2	(25.0) 17.2	(183.5) 140.2	(54.2) 41.1	(80.5) 59.9	(868.1) 677.1	7
Average	(103.8) 72.5	(117.4) 88.7	(143.3) 110.4	(116.8) 87.0	(120.1) 82.3	(150.4) 111.5	(79.3) 60.9	(831.1) 613.3	

( ) Rainfall

0<R<5 ... 0

5<= R <=80 80%

R>80 64 m/m

10/20 - 4/20

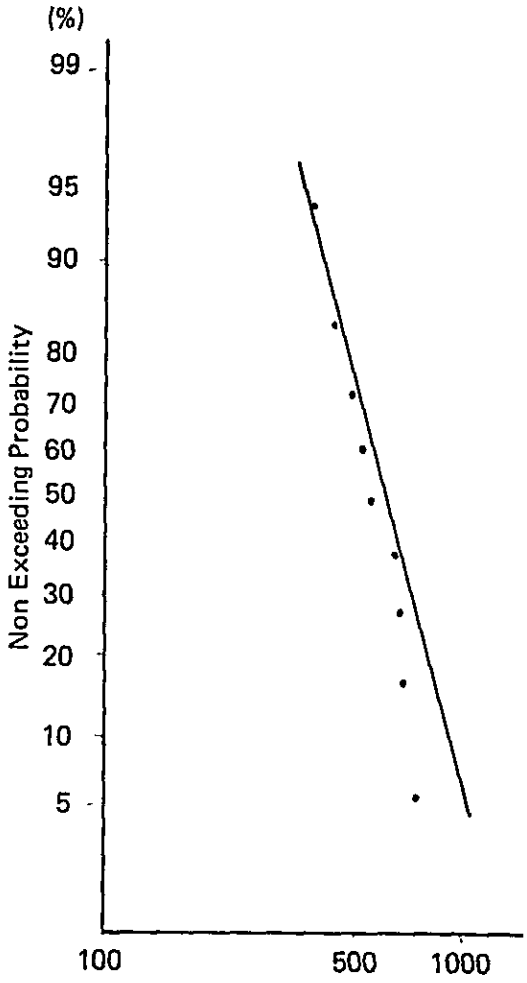


Fig. 5-1-5 Probability Effective Rainfall

(5) Calculation of water requirement

The calculation of net water requirement during the cultivation period is performed under the following conditions.

a.	Cultivation period	Period of 140 to 150 days from October 20th
b.	Planting of rice-seeds period	Period of 40 days from October 20th
c.	Starting of inundation	To be completed in 6 days from the 25th day after planting of rice-seeds.
d.	Calculation year	From October 20, 1977 to April 20, 1978.
e.	Calculation unit	Every 5 days
f.	Cultivation ratio	To be divided into 40 blocks from the 40th day of the planting of rice-seeds period

The results of the calculation performed with Table 5-1-9 are as shown below.

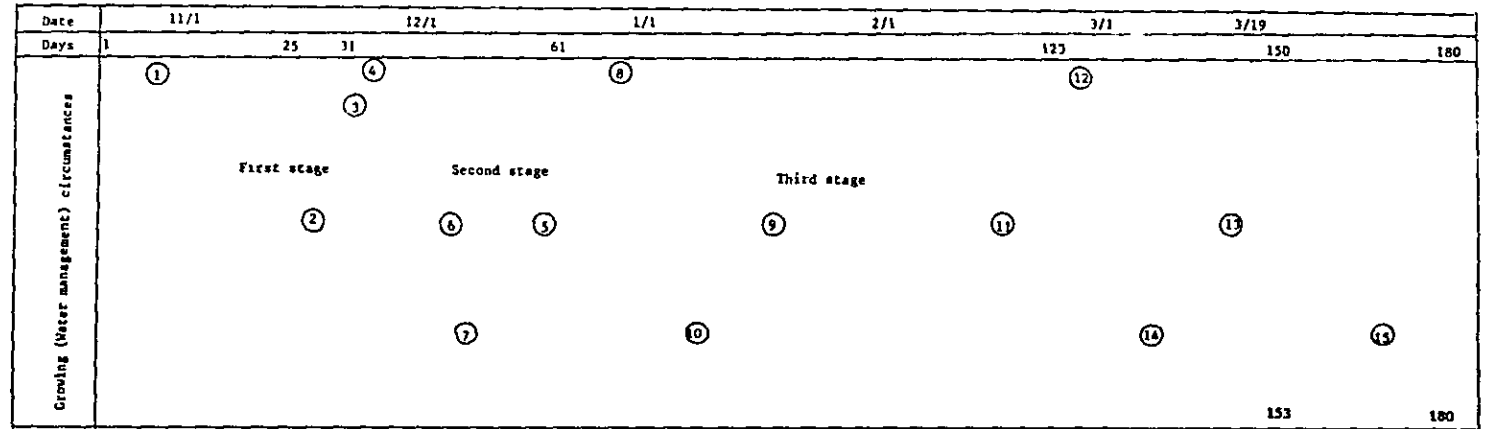
a.	Peak net water requirement	13.4 mm/day
b.	Total net water requirement	1,095.1 mm/cropping season
c.	Effective rainfall	472.4 mm/cropping season

The seasonal water requirement which has been used in the calculation is that which has been calculated based on the results of field investigation and they should be revised in the future by studying the continued observation data. The designed maximum net water requirement in the planning of this year shall be made 13 mm/day (= 1.5 ℓ/sec/ha) ha) from the above-mentioned results.

(6) Irrigation efficiency

Calculation of the design amount of intake water shall be performed by estimating the loss in the net water requirement and this loss percentage shall be set with the irrigation efficiency. The irrigation efficiency shall be determined from many factors such as the size of the field, shape, conditions of irrigation facilities, water management setup, etc. In this program, this efficiency shall be classified into the field efficiency, water-conveyance efficiency and

Table 5-1-9 Calculation of Water Requirement



1	2.0	5.4	10.0	14.9	15.4	30.5	40.0	47.1	53.9	58.4	61.4	64.4	66.9	62.6	57.0	56.1	55.9	55.6	55.4	55.1	54.6	54.0	54.0	54.0	53.9	53.4	43.7	41.0	40.6	40.0	36.5	30.1	22.8	16.4	10.1	3.9
2	15.2	0	19.5	56.4	0	17.1	31.3	31.7	23.5	64.0	0	0	0	0	22.4	21.4	19.0	0	15.8	5.4	64.0	12.3	0	6.0	0	5.0	21.0	0	6.4	0	0	9.8	0	0	0	15.2
3	-	5.4	-	-	15.4	13.4	8.7	15.4	30.4	-	61.4	64.4	66.9	62.6	34.6	44.7	36.9	35.6	39.6	49.7	-	41.7	54.0	48.0	53.9	48.4	22.7	41.0	34.2	40.0	36.5	20.3	22.8	16.4	10.1	-
4	-	1.1	-	-	3.1	2.7	1.7	3.1	6.1	-	12.3	12.9	13.4	12.5	6.9	8.9	7.4	11.1	7.9	9.9	-	8.3	10.8	9.6	10.8	9.7	4.5	8.2	6.8	8.0	7.3	4.1	4.6	3.3	2.0	-

1 Half month requirement (mm)
2 Half month effective rainfall (mm)
3 Short water requirement (mm)
4 Average water requirement
① - ⑮ Seasonal water requirement (Table 3-4-7)

1 Total 1,477 mm/cropping season
2 Total 472.4 mm/cropping season
3 Total 1,095.1 mm/cropping season

management efficiency and each shall be respectively established.

a. Field efficiency

This efficiency has considered the irrigation irregularity, etc., of the field. In case of this area, the topography is comparatively flat and as land grading machineries for farming are also introduced, it can be considered that ponding irregularity does not exist much. On the other hand, inundation continues up until harvesting time and water release is not made intermediately. Moreover, the underground percolation is separately added to the water requirement in depth. From the above-mentioned, the field efficiency shall be based on actual examples of other projects and made 80%.

b. Water-conveyance efficiency

This is the efficiency which concerns water-conveyance by canal from the water source up to the field. The basic irrigation canal, etc., of this plan are unlined canals. The results of leakage survey of existing irrigation canals are few and in places with large leakage, it has been planned to reduce leakages by earth lining. Moreover, the arrangement of facilities, operation methods, etc., are been studied for canal management so that a canal management conforming to the water demand becomes possible. On the other hand, all benefiters are organized as water users and are guided and supervised so that a favorable rotation irrigation is performable.

Upon considering these and the evaporation amount from free water surface, the water-conveyance efficiency with reference to enforcement examples of other projects shall be set at 80%.

c. Management efficiency

This is the efficiency concerning diversion management in canals. In case of this program, the establishment of a management facility and management setup intending the further efficiency of water use is planned and it is considered that an effective management can be made. However, since the canals are big and long and the number of diversion facilities are extremely many, the management efficiency based on actual examples of other projects shall be made 90%.

d. Integrated efficiency

This efficiency is that which has combined the field efficiency, water-conveyance efficiency and the management efficiency and it shall be made 57.6% (80% × 80% × 90%).

(7) Designed unit water requirement

From the overall efficiency of 0.576 obtained in the foregoing item (6) on irrigation efficiency and the maximum net water requirement of 1.5 ℓ/sec/ha obtained in the foregoing item (5) on calculation of water requirement, the design amount of intake water (gross water requirement) becomes 1.5 ℓ/sec/ha/0.576 = 2.6 ℓ/sec/ha.

(8) Total duty of water, maximum amount of intake water

Since the paddy-rice plant cultivation of this area adopts a 3 year crop rotation system with the use as a grazing land, the actual irrigated area is 39,940 ha, that is, one-half of the irrigated area of 79,880 ha.

From the above obtained value, the total duty of water during a cropping season becomes as follows:

39,940 ha × 1,095.1 mm ≒ 437,000,000 m^3/cropping season

The maximum amount of intake water becomes as follows:

39,940 ha × 2.6 ℓ/sec/ha = 103.8 m^3/sec.

5.2 Drainage Plan

5.2.1 Basic policy for drainage plan

The project area for this plan is a flat low swamp of 90 to 60 m in altitude gently sloped from north to south with ever-inundated plate in the middle, and is surrounded by the hilly lands extending in the north and east rolling between 90 and 150 m in altitude where the National Road No. 1 is passing nearly along the ridgeline, flat large Neembucu swamp to the west, and the Parana River to the south.

Drainage from the area is carried by the Atinguy River and the Yabebyry River of large river, and the Yaguary River of small river and artificial drainage canals, into the Parana River, but due to insufficient effect of these, the project area is often or almost always inundated by the water which flows in from the hinterland as well as the water which runoff in the area.

Based on the cultivation plan and the land use plan, this area will be divided into Area A and Area B, where wheat and soybean in the Area A and paddy in the Area B are planned as the primary products, but when seen from the weather and topographical conditions and from the cultivation system, it is said that the essential condition for securing stable production of these is execution of the drainage work which will cover the whole project area.

To outline the drainage plan for such an ever-inundated area in this year, analysis is performed for the inundated condition and the caused, drainage plans are formulated for several cases based on the results obtained from the analysis, and the optimum drainage plan is selected out of such plans, by means of simulation analysis using the mathematical model made for the set conditions.

5.2.2 Rainfall runoff analysis

(1) Methods for rainfall runoff analysis

In the project area, inundates are caused by the rainfall which runoff from the hinterland and the rainfall in the area. This runoff of rainfall can be analyzed by either of the following methods:

1) Method by measured values
   a. Method by measured flow rate
   b. Method by measured water level or by trace of inundates

2) Method by formula for flow rate (Rational method)

3) Method by analysis for measured precipitation and runoff

a. Inundated frequency method

b. Specific flow rate method

c. Coaxial method

d. Unit hydrograph method

e. Tank model method

4) Method by theoretical formula

a. Runoff function method

b. Storage function method

c. Characteristic method

d. Combined characteristics method

These methods have their own features, and as the data are not enough for this area and the topography is quite flat there, the Characteristic method which suit this condition is used for analysis.

(2) Rainfall runoff analysis by Characteristic method

1) Method of analysis Characteristic method

Rainfall in the project area and of hinterland are assumed to flow into rivers or drainage canals in the condition as given in the figure below:

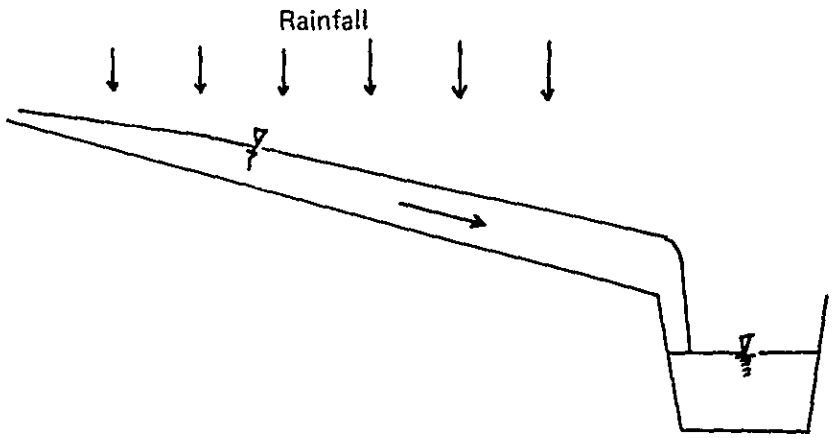


Fig. 5-2-1 Rainfall Runoff Model by Characteristic Curve Method

Based on the assumption that flow on this slope can be approximately equalized by Maning Formula, the inflow condition is analyzed by Characteristic method using a computor. (The formula used and other details are described in the Appendix)

2) Runoff model

Various basic values for the project area and hinterland are required for the runoff analysis. For example, the coefficient of equivalent roughness depends on whether these are to be used as forests, fields or paddy fields, and the slope pitch and slope length will differ by topography. Accordingly, the set conditions are modelled so as the average runoff phenomena of the project area and the hinterland are analyzed, and the analysis is performed using the mathematical model.

a. Estimated design rainfall

(a) Rainfall observatory

The estimated design rainfall is the basis for drainage plan, and the analysis is performed carefully. For details, refer to Chapter 2 General Plan and Survey, 2.1 Meteorology and Hydrology. Around the project area, rainfall observatories are located at 3 places by Department of Meteorology, Ministry of National Defence, 5 places by the Yacyreta Public Corporation, and 3 places by this survey team, totalling 11 observatories. After analyzing suitability of these by Thiessen Method and other methods, data by Yacyreta Observatory, Ministry of National Defence, will be used in formulating the master plan.

(b) Continuous rainy days

To formulate the drainage plan, it is necessary to study which to take, diurnal rainfall, continuous 2-day rainfall or continuous 3-day rainfall, for the design rainfall according to the objective, scale and economy of work. After analyzing the occurrence of continuous rainfall for the past 18 years using the data by Yacyreta Observatory, it is understood that the diurnal rainfall is about 78%, 2-day rainfall is about 16%, indicating the high probability of diurnal rainfall,

and that rainfall of 150 mm, more or less, to be used in the plan is often seen actually as diurnal rainfall. Therefore, this plan will be formulated for diurnal rainfall.

(c) Probability rainfall

As the result of the calculation of Iwai method using the rainfall data of Yacyreta Observatory, the 1/10 year probability diurnal rainfall of 164.4 mm/day is obtained. This rainfall is used to be the design value for simulation.

For details of probability rainfall analysis and the data, refer to 2-1 Meteorology and Hydrology, and to the Appendix.

(d) Rainfall pattern

Using 3 units of auto-pluviometers installed for this survey, the time history analysis of rainfall will be performed, but for this year's plannification it is assumed that the rain would fall uniformly during 12 hours.

(e) Rainfall losses

The rainfall losses is obtained by subtracting the direct run-off from the total precipitation, and it is generally considered to be 50 mm, more or less, for the case of paddy fields. The auto-level gauges and auto-pluviometers were installed in the 2nd year of the survey in this area and is collecting the data at the moment, but for this year's plan the rainfall losses is supposed to be same for both the project area and the hinterland, and the runoff analysis is performed for the cases of 0.0 mm, 50 mm and 80 mm. The relation of rainfall losses and precipitation is described in the Appendix.

b. Base flow

The base flow will be analyzed after the data by auto-level gauges have been complete. Generally, the base flow is small as compared with the peak flow in case of inundate, and the significance of base flow in view of water use is rather negligible. As the rainfall losses is supposed for above 3 cases this time, the base flow is supposed to be 0.0 m^3 on this stage. Also, the subsurface flow is omitted for the same reason.

c. Equivalent roughness

The equivalent roughness is the most important factor in the runoff analysis and is to be determined from the data obtained by the flow observation, but under the situation that the data are being collected at the moment, it is set to be N = 0.5 for slopes and N = 0.05 for rivers and drainage canals based on the another examples.

d. Models for terminal drainage canals and field in the area

The unit runoff from fields to terminal drainage canals in the area is modelled mathematically as given in Fig. 3-3 of the Appendix. Namely, in the unit runoff, the terminal drainage canal is set to be 2,000 m in length and 1/5,000 in inclination, and the field 500 m in slope length and 1/1,000 in inclination.

e. Runoff model for hinterland

The hinterland is divided into 30 blocks based on the category of topographical condition and drainage system, as given in Fig. 5-2-2, and the elements of each of the blocks such as catchment area, mean slope length, mean inclination of slope, extension of river and inclination of river are set based of the 1/50,000 topographic map, as tabulated in Table 5-2-1.

These blocks when modelled are generally classified into 12 drainage systems as given in Fig. 5-2-3.

(3) Results of rainfall runoff analysis

The runoff in the set mathematical models when analyzed by Characteristic method using computors is as tabulated in Table 3-3 of the Appendix.

Also, the results are tabulated in Table 5-2-2 for the peak runoff, peak runoff time and specific peak discharge, from which the peak time is 8 to 16 hours after start of precipitation when seen in the case of rainfall losses of 0.0 mm, 11 to 21 hours in case of rainfall losses of 50 mm, and 12 to 26 hours in case of rainfall losses of 80 mm; the specific peak discharge is 2.14 to 3.81 $m^3/sec/km^2$ in case of rainfall losses of 0.0 mm, 1.19 to 3.61 $m^3/sec/km^2$ in case of rainfall losses of 50 mm, and 0.72 to 2.79 $m^3/sec/km^2$ in case of rainfall losses of 80 mm.

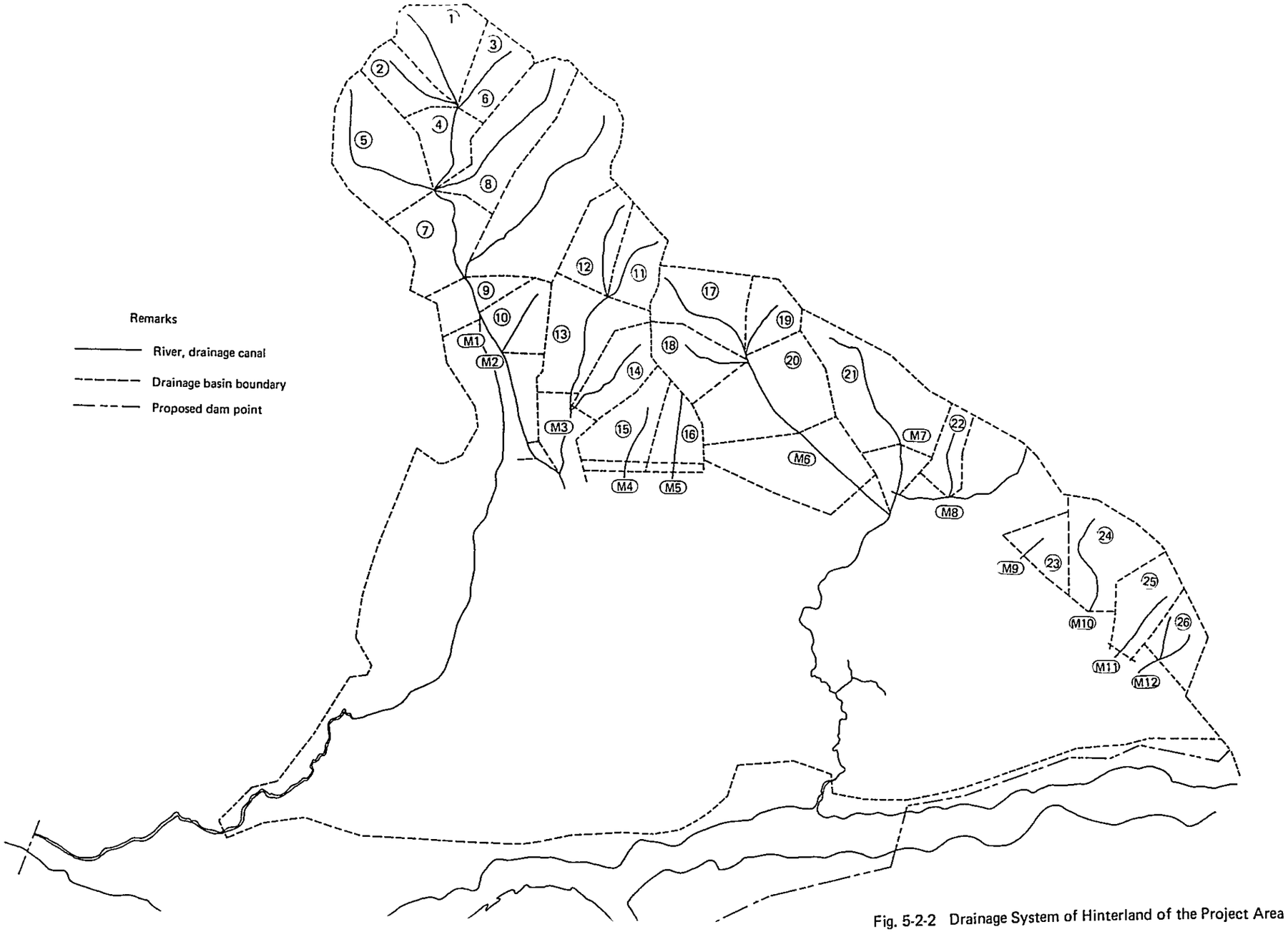


Fig. 5-2-2 Drainage System of Hinterland of the Project Area

Table 5-2-1 Discussion of the Hinterland Block

Block No.	Number	Catch-ment area	Mean slope length	Mean sloping grade	River length	River slope	Remarks
M-1	1	34.0 km^2	3,000 m	1/150	5,700 m	1/220	Verde
"	2	20.0	1,800	1/70	5,700	1/180	
"	3	26.0	1,900	1/70	7,000	1/300	Taihyity
"	4	26.0	2,600	1/100	5,000	1/500	Nangapé
"	5	50.0	1,900	1/70	13,000	1/250	Caje-cue
"	6	45.0	2,100	1/60	10,500	1/260	Cambay
"	7	26.0	1,900	1/100	7,000	1/1100	Pikyry
"	8	104.0	3,200	1/100	16,500	1/300	Gonzalez
"	9	22.0	2,600	1/160	4,300	1/1100	Ciervo Paso MI TOTAL 353.0 km^2
M-2	10	16.0	1,600	1/70	5,000	1/110	
M-3	11	28.0	2,000	1/70	6,800	1/220	Santa Teresa
"	12	26.0	1,700	1/70	7,700	1/190	
"	13	41.0	2,600	1/70	8,000	1/500	Toro-y
"	14	27.0	1,900	1/90	7,000	1/230	Yacare-y MJ TOTAL 122.0 km^2
M-4	15	19.0	2,100	1/110	4,500	1/220	Yacú Guy
M-5	16	23.0	1,900	1/90	6,000	1/300	
M-6	17	36.0	2,300	1/100	7,700	1/320	Ybú
"	18	35.0	2,400	1/120	7,300	1/330	Inguo
"	19	18.0	1,700	1/70	5,400	1/250	Cinbrón
"	20	45.0	4,100	1/120	5,500	1/800	Estero Iyecúa M6 TOTAL 134.0 km^2
M-7	21	83.0	3,000	1/130	14,000	1/400	
M-8	22	13.0	1,700	1/100	3,800	1/130	
M-9	23	33.0	3,400	1/150	4,900	1/330	
M-10	24	47.0	3,900	1/130	6,000	1/500	
M-11	25	13.0	1,400	1/90	4,500	1/300	
M-12	26	17.0	2,800	1/90	3,000	1/300	

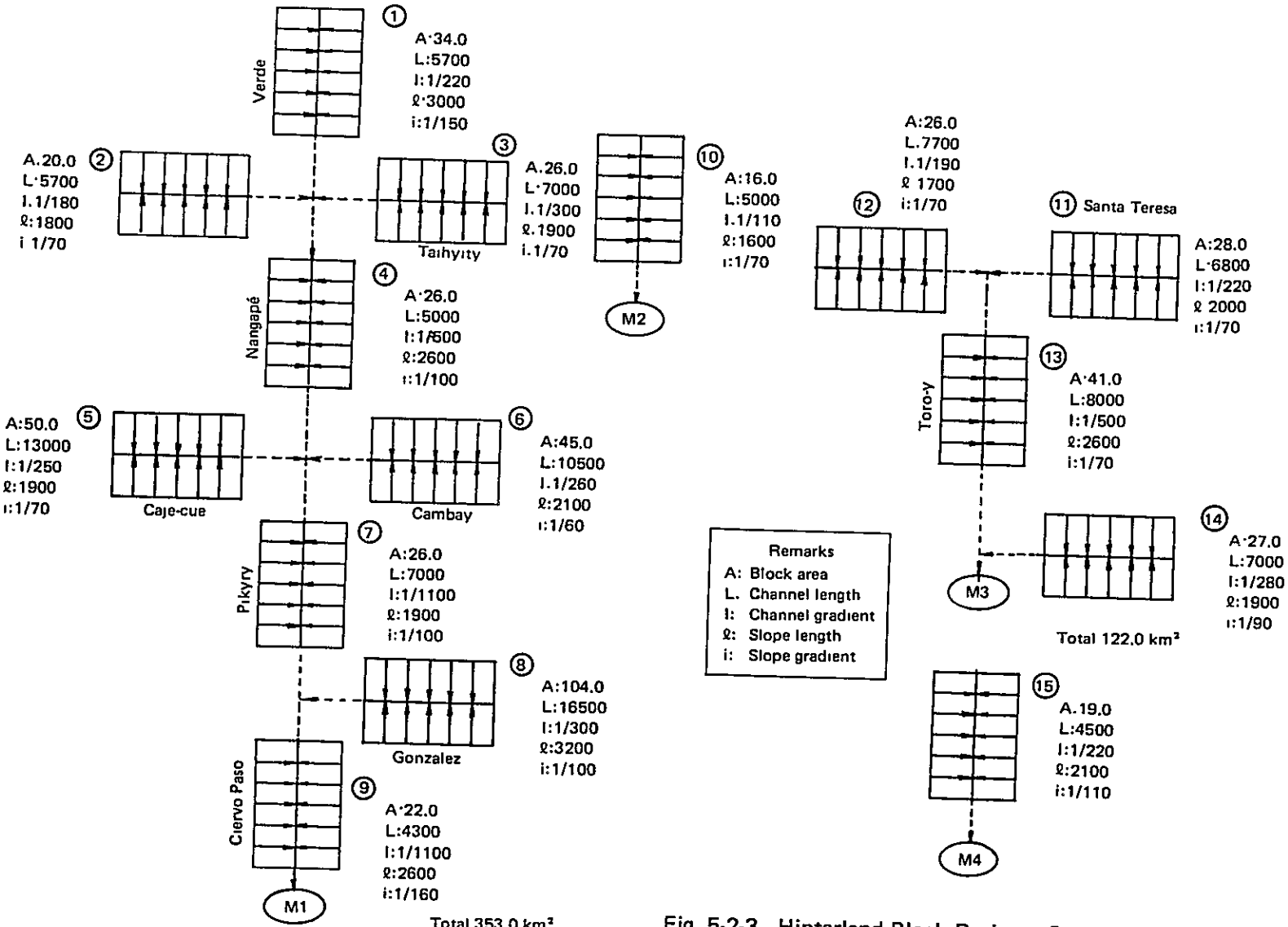


Fig. 5-2-3 Hinterland Block Drainage System Diagram (1)

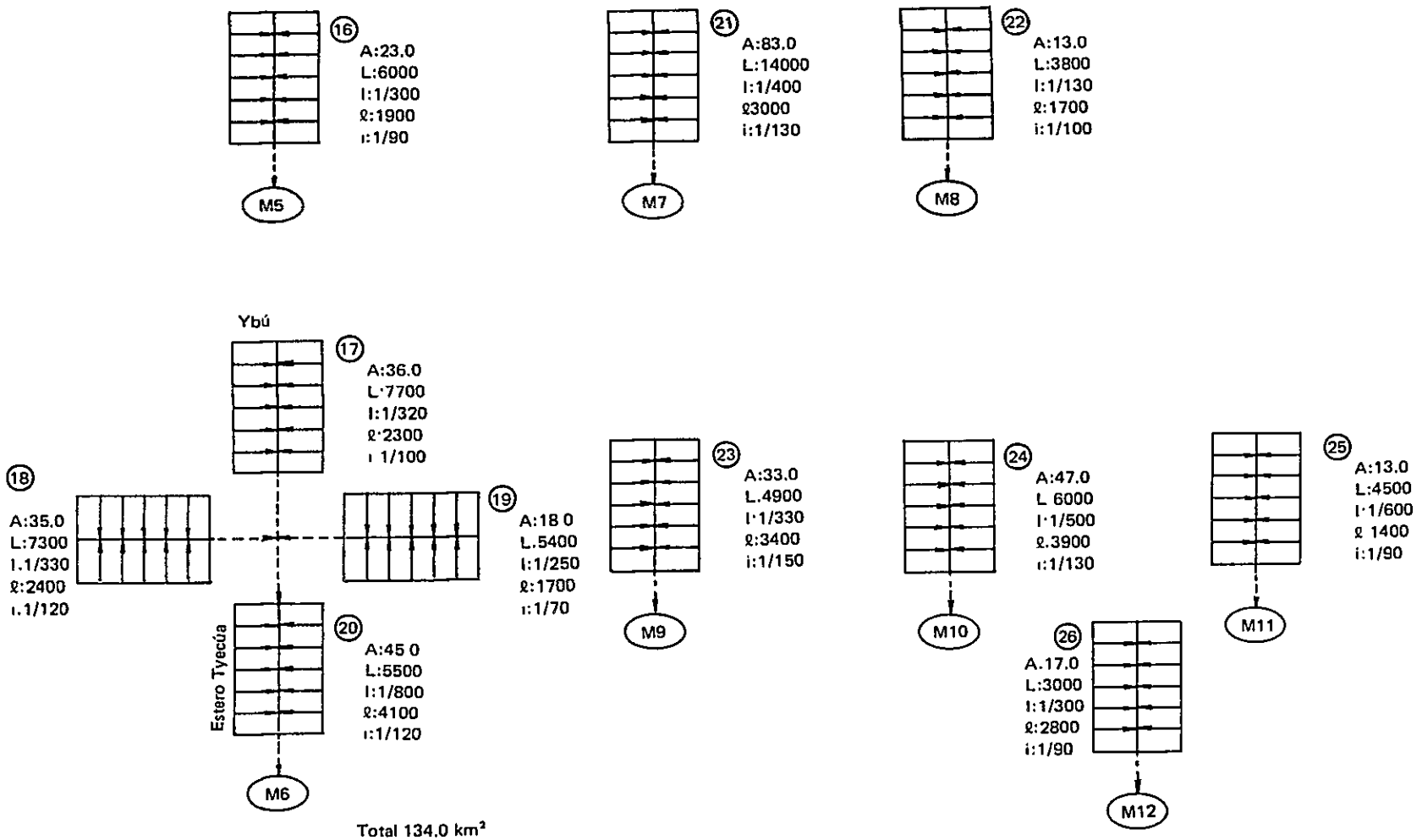


Fig. 5-2-3 Hinterland Block Drainage System Diagram (2)

Table 5-2-2 List of Peak Runoff of the Hinterland Block

Block	Catchment area	Loss of rainfall 0.0m/m			Loss of rainfall 50m/m			Loss of rainfall 80m/m			Remarks
		Peak rainfall discharge	Peak hours	Peak ratio runoff discharge	Peak rainfall discharge	Peak hours	Peak ratio runoff discharge	Peak rainfall discharge	Peak hours	Peak ratio runoff discharge	
	km^2										
M-1	353.0	1,028.3	9	2.91	710.3	11	2.01	464.9	12	1.32	
M-2	16.0	60.7	10	3.79	50.6	12	3.16	35.5	13	2.22	
M-3	122.0	426.7	10	3.50	311.1	12	2.55	201.8	13	1.65	
M-4	19.0	66.3	11	3.49	44.3	13	2.33	27.3	16	1.44	
M-5	23.0	84.9	11	3.69	62.5	12	2.72	39.4	14	1.71	
M-6	134.0	372.5	11	2.78	238.6	12	1.78	146.1	13	1.09	
M-7	83.0	230.0	13	2.77	129.5	17	1.56	78.8	21	0.95	
M-8	13.0	48.2	10	3.71	36.3	12	2.79	23.7	14	1.82	
M-9	33.0	75.9	15	2.30	39.7	12	1.20	25.7	24	0.78	
M-10	47.0	100.6	16	2.14	55.9	21	1.19	33.8	26	0.72	
M-11	13.0	49.3	10	3.79	39.7	12	3.05	29.1	13	2.24	
M-12	18.0	68.5	8	3.81	65.0	11	3.61	50.2	12	2.79	

Fig. 5-2-4

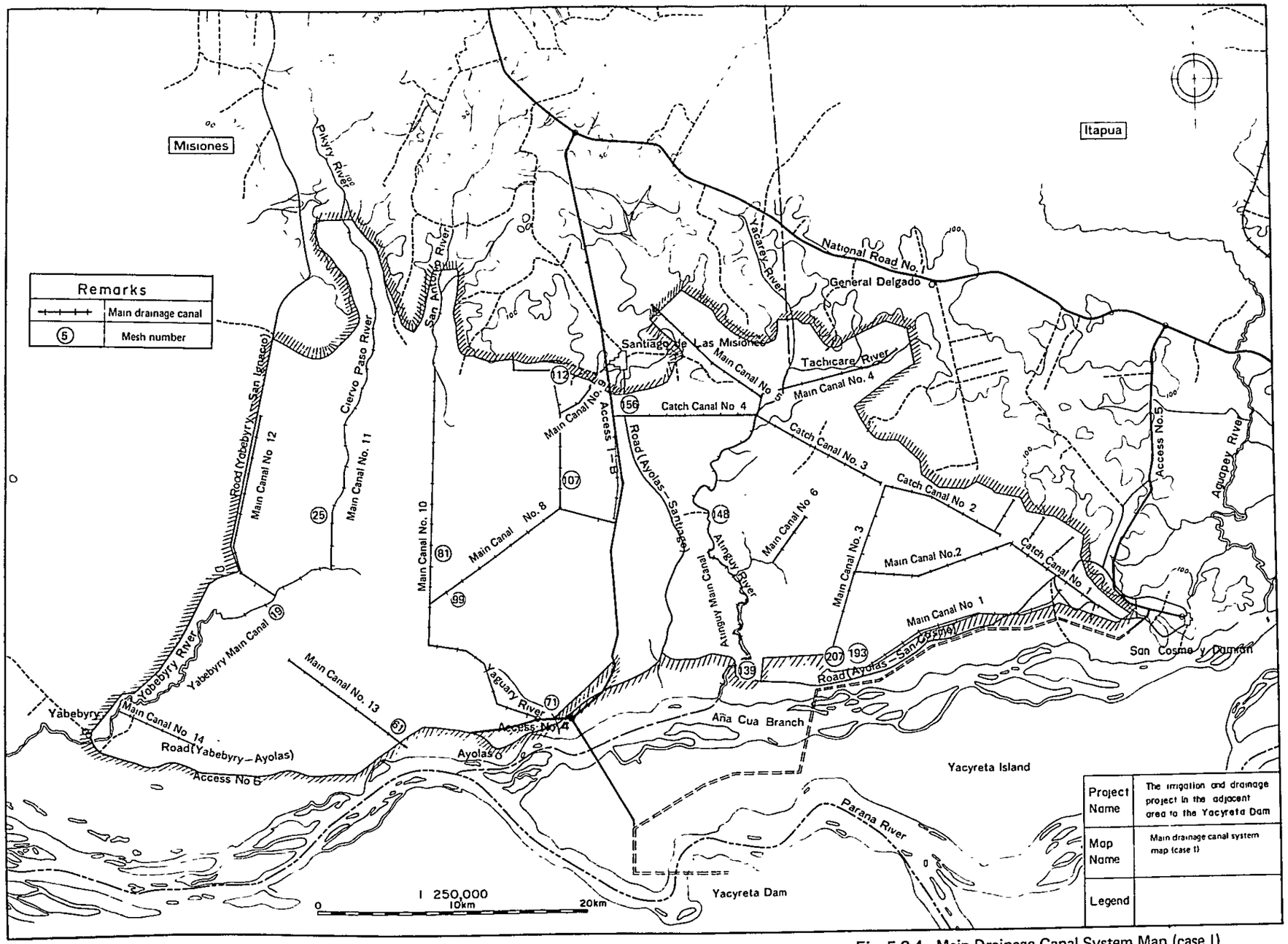


Fig. 5-2-4 Main Drainage Canal System Map (case I)

5.2.3 Flow analysis

(1) Method of flow analysis

As the planned drainage system of this area, system I given in Fig. 5-2-4 and system II in the Appendix Fig. 4-8 are studied. In both of the systems, innumerable number of lateral canals are connected to the Yabebyry River and other rivers and the main drainage canals to be constructed. As these main drainages are connected to the Parana River, flow in the mouths of canals is an unsteady flow which varies depending on the time due to influence from the water level of the Parana River. As it is considered suitable, for the flow analysis on the drainage canals in such area, to simulate the mathematical model in which the hydraulic facilities are used as the software for computation, it is applied to this plan, too.

(2) Flow analysis by mathematical simulation

1) Method of analysis

The method developed by National Research Institute of Agricultural Engineering, Ministry of Agriculture, Forestry and Fisheries, is applied to the flow analysis. The hydraulic calculation of rivers and drainage canals is performed by solving the equation of motion and continuous equation simultaneously for the unsteady flow of open canals. For details of these equation of motion, basic formula for continuous equation, and sequence of calculation, refer to the descriptions in the Appendix.

2) Contents of calculation

To obtain the basic data for preparation of drainage plan by means of this mathematical model simulation, calculations are performed for the drainage systems and other various cases which include the cross section of drainage and so on to be studied in (3) Modelling of the project area in the next section, so as to formulate the optimum drainage plan and to clarify the effects of drainage plan.

(3) Modelling of the project area

1) Setting of conditions for calculation

Preparing the mathematical models of the project area based on each of the cases, the conditions for calculations used in the flow analysis

are set as follows:

2) Data for altitudes of main drainage canals and other data

Data such as the bottom heights, inclination of slopes, height of banquette, of main drainage canals, and altitudes of paddy fields, are determined based on the 1/50,000 topographical map together with the results of surveying performed for the primary portions of the Atinguy River and the Yabebyry River during the 2nd year of the study.

3) Cross section of main drainage canal

The cross section of canal is set for the estimated unit discharges in the following 5 cases:

Case 1: Cross section for 0.25 $m^3/sec/km^2$ of unit discharge (Actual cross sections of the Atinguy River and the Yabebyry River are equivalent to this case.)

Case 2: Cross section for 0.5 $m^3/sec/km^2$ of unit discharge (Cross section which can drain the 1/10 probability diurnal precipitation for 2 days is roughly equivalent to this case.)

Case 3: Cross section for 1.0 $m^3/sec/km^2$ of unit discharge

Case 4: Cross section for 2.0 $m^3/sec/km^2$ of unit discharge

Case 5: Cross section for 3.0 $m^3/sec/km^2$ of unit discharge

The shape of canal's cross section is approximated to the composite trapezoidal cross section to be the standard, as given in Fig. 4-6, based on the results measured and the 1/50,000 topographical map.

For above Cases 2, 3, 4 and 5, the cross sections of which are modelled as the trapezoidal cross sections for symplifying the calculations.

The data for the set cross sections can be referred to in the Table 4-2 of the Appendix.

4) Coefficient of roughness

It is preferable that the coefficient of roughness be determined based on the flow observation and other related measurements to be performed at the site, but under the situation that the data are still being gathered there, the coefficients of the present cross sections of the

Atinguy River and Yabebyry River are set to be 0.05, and the coefficients of other repaired rivers and drainage canals are set to be 0.04.

5) Interval of canal length mesh and time interval for calculation

When calculation is performed with small intervals of canal length mesh and time intervals in simulating the mathematical model, the results can be obtained in detail, but actually, the accuracy is not so improved as expected as compared with time and labor required for analysis using computors. Therefore, meshes and time intervals should be set properly as appropriate. As this plan is still on the stage of master plan to cover such extensive area of nearly 150,000 ha, it would be advisable for obtaining the data in better condition for the planning works when the analysis is first made providing at most 300 of meshes and is further analyzed as necessary in other substitutional plans. Based on this understanding, the mesh is set to be 1,500 m with time intervals of 60 sec.

Additionally, for reducing the meshes in number, the terminal lateral drainage canals are omitted from the model but the flow rates are input as the lateral inflows.

6) Lateral inflow

a. Inflow from the hinterland

Inflow from the hinterland is given as the discharge calculated by Characteristic method.

b. Inflow from fields

For the inflow from the fields, the discharges obtained by multiplying the unit discharge by Characteristic method by control of each mesh is input.

7) Water level of the Parana River (Outer water level)

The water level of the Parana River, outer level, is set to be the level equivalent to 1/10 year probability level (discharge: 30,000 m^3/sec) out of the estimated water level of Ita Ibate Dam.

8) Planned drainage system

Based on the topographical condition and current drainage system in the project area, the following 2 cases are proposed as the planned drainage systems. By performing simulation on these 2 systems, the one which is more effective will be selected.

(System I)

As given in Fig. 5-2-4, it is intended to discharge the water from the area and from the hinterland mostly from the north to the south, by adding 2 of main drainage canals besides existing the Atinguy River and the Yabebyry River.

The model view of the drainage system is given in Fig. 5-2-5.

(System II)

As given in Fig. 4-8 of the Appendix, it is intended to discharge most of the rainfall from the hinterland and the project area into existing the Atinguy River and the Yabebyry River, in which relatively large amount of rainfall is to flow from the east to the west.

The model view of the drainage system is given in Fig. 4-10 and 4-11 of the Appendix.

9) Cases calculated

Based on the study made so far, and by simulation analyses for combinations of various cases, the plan which is optimum for this area will be formulated. Such cases are combined as indicated in Fig. 5-2-3, among which 24 cases connected with full lines are analyzed.

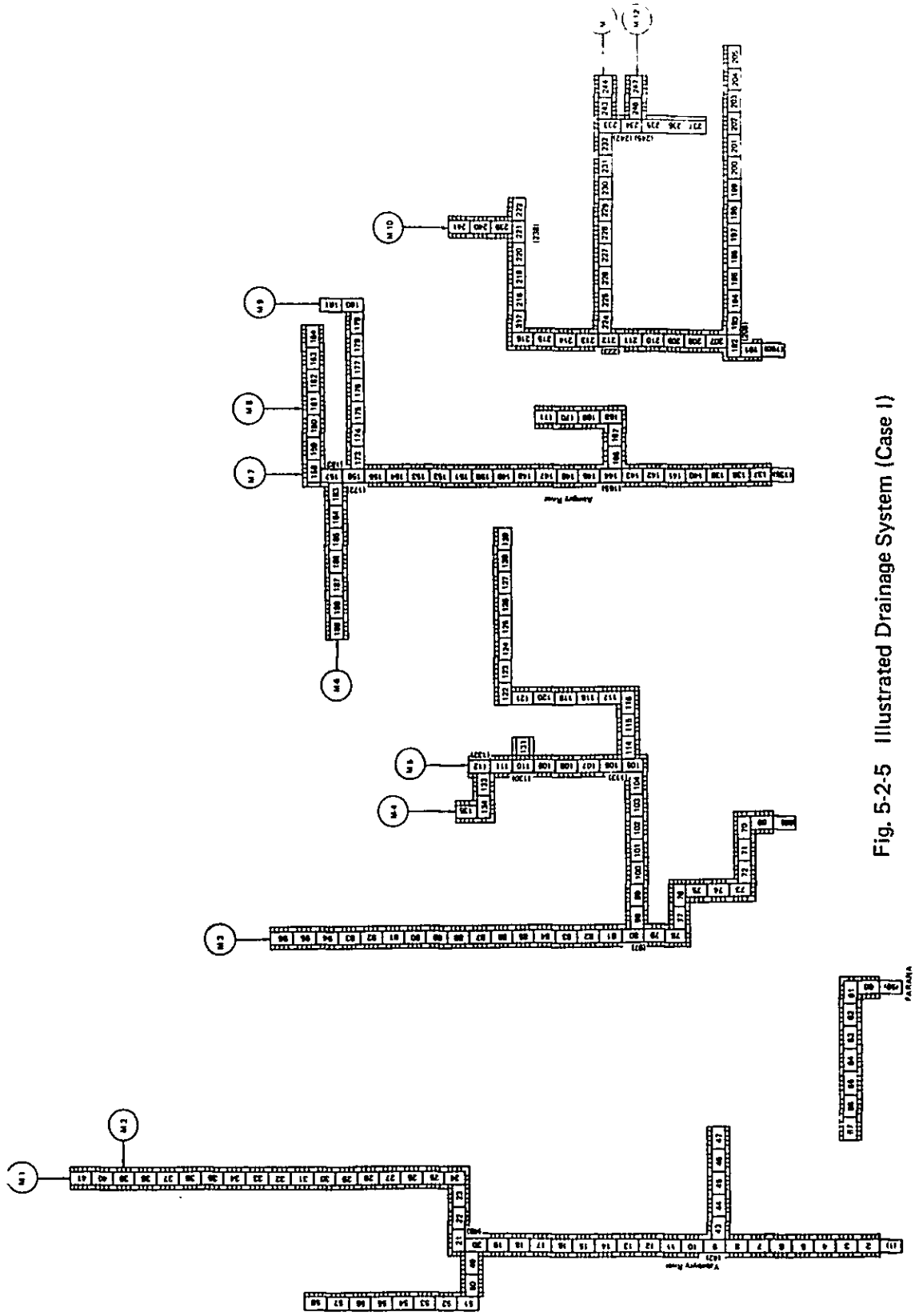
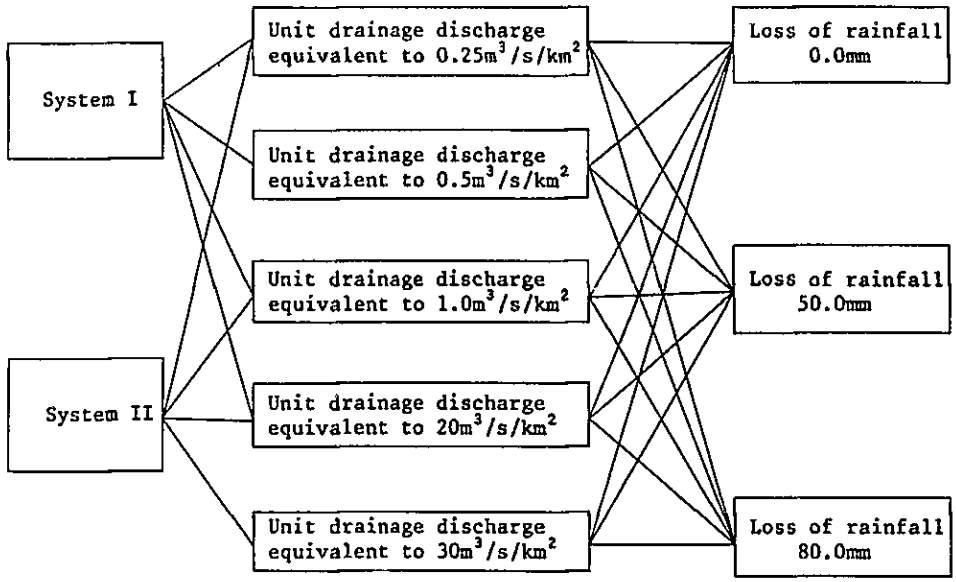


Fig. 5-2-5 Illustrated Drainage System (Case I)

Table 5-2-3 Calculation Cases of the Simulation

Dranage canal system	Canal cross section	Loss of rainfall



5.2.4 Analysis results

Here, the results calculated of the water level, velocity, discharge and lateral inflow of drainage canals, and the depth of inundation and inundated area in the project area are studied, and the drainage system and cross section of drainage canals which are optimum for the project area are studied.

(1) Water level of drainage canal

For the representative points on the drainage canals obtained by simulation, the variation of water level by time is given in Figs. 5-1 and up to 5-24 of the Appendix, and the peak water levels and the timings of occurence (hours after start of rainfall) are given in Table 5-1 and 5-2 of the Appendix.

For system I of drainage water system in which the rainfall losses is supposed to be 50 mm, the cases in which the cross sections of drainage canal is 0.25, 0.5, 1 and 2 $m^3/sec/km^2$, viz., cases 1-2, 2-2, 3-2 and 4-2 are studied mainly. For system II of drainage canal system, details are described in the Appendix.

1) Yabebyry main drainage system

In Figs. 5-2-6 and up to 5-2-8 are given the variations in water level by time for the Mesh No. 7 which is near the boundary with the downstream area and is the primary point in the Yabebyry Main Drainage System, the Mesh No. 19 right after the point the Main Drainage Canal No. 12 flows in, and the Mesh No. 25 located in the midstream. In case 2-2, no inundation occurs at the point of Mesh No. 19, and inundation does not exceed 30 cm in depth at the point of Mesh No. 7, and inundation exceeding 30 cm in depth continues about 40 hrs.

At either of above 3 points, the water level rises and drops as the cross sections of drainage canals are larger. At the point of Mesh No. 25, where runoff is caused in the upstream by inundated water in case of 0.25 $m^3/sec/km^2$ of cross section, a shallow but long continuing inundation is seen.

2) Main Drainage Canal No. 10 System

Figs. 5-2-9 and up to 5-2-14 indicate the variations in water level by time for the Mesh No. 71 located at the downstream of Main

Drainage Canal No. 10, the Mesh Nos. 81 and 99 in its midstream, and the Mesh Nos. 107, 112 and 156 in its upstream.

Inundation does not occur in the downstream and midstream, but occurs in the area between the midstream and upstream.

3) Atinguy Main Drainage Canal System

The variations in water level by time for the Mesh No. 139 located in the estuary of the Parana River of Atinguy Main Drainage Canal and the Mesh No. 148 in its midstream, are given in Figs. 5-2-15 and 5-2-16. The reason why the peak occurs in the later part at the point of Mesh No. 139 is that the discharge from the upstream delays in reaching the point where it meets the discharge form the canals relatively close to the point. It is added that, due to the high water level in the Parana River, inundate occurs also in the case in which the cross section of drainage canal is 2 m^3 /sec/km^2.

4) Main Drainage Canal No. 3 System

For the Mesh Nos. 193 and 207 which located in the downstream of Main Drainage Canal No. 3 system, the variations in water level by time are given in Figs. 5-2-17 and 5-2-18.

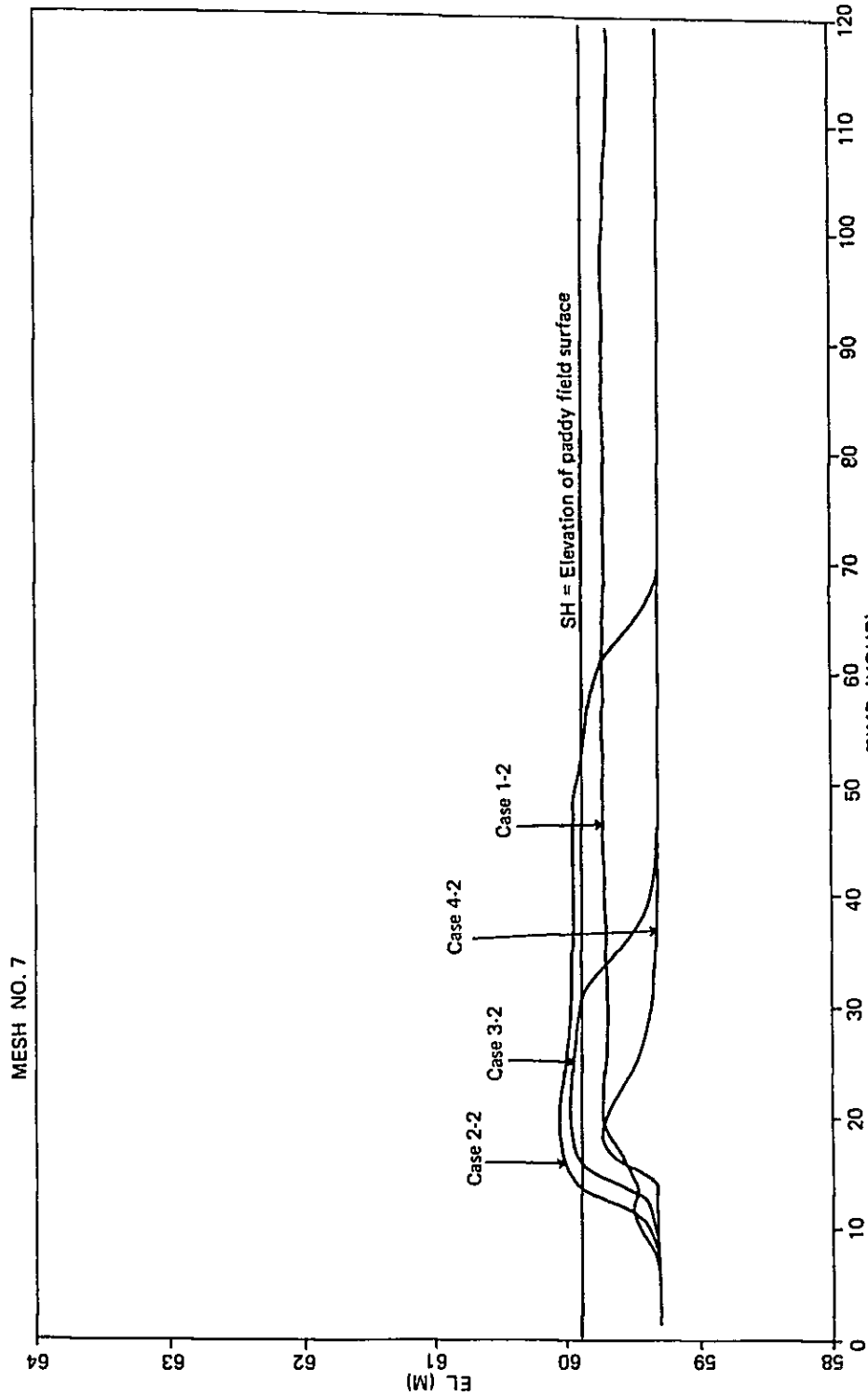


Fig. 5-2-6 Transition Curve of Water Level

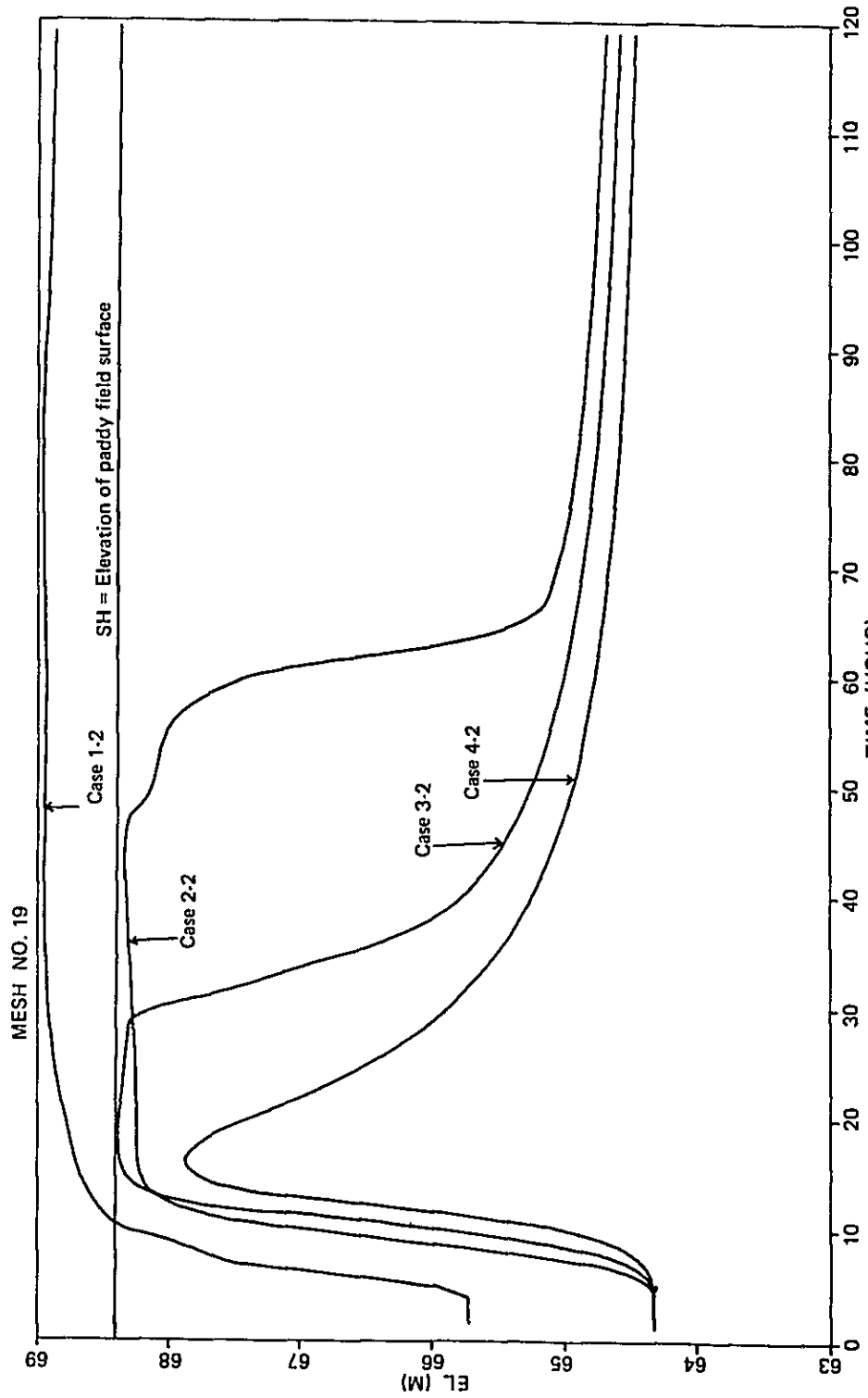


Fig. 5-2-7 Transition Curve of Water Level

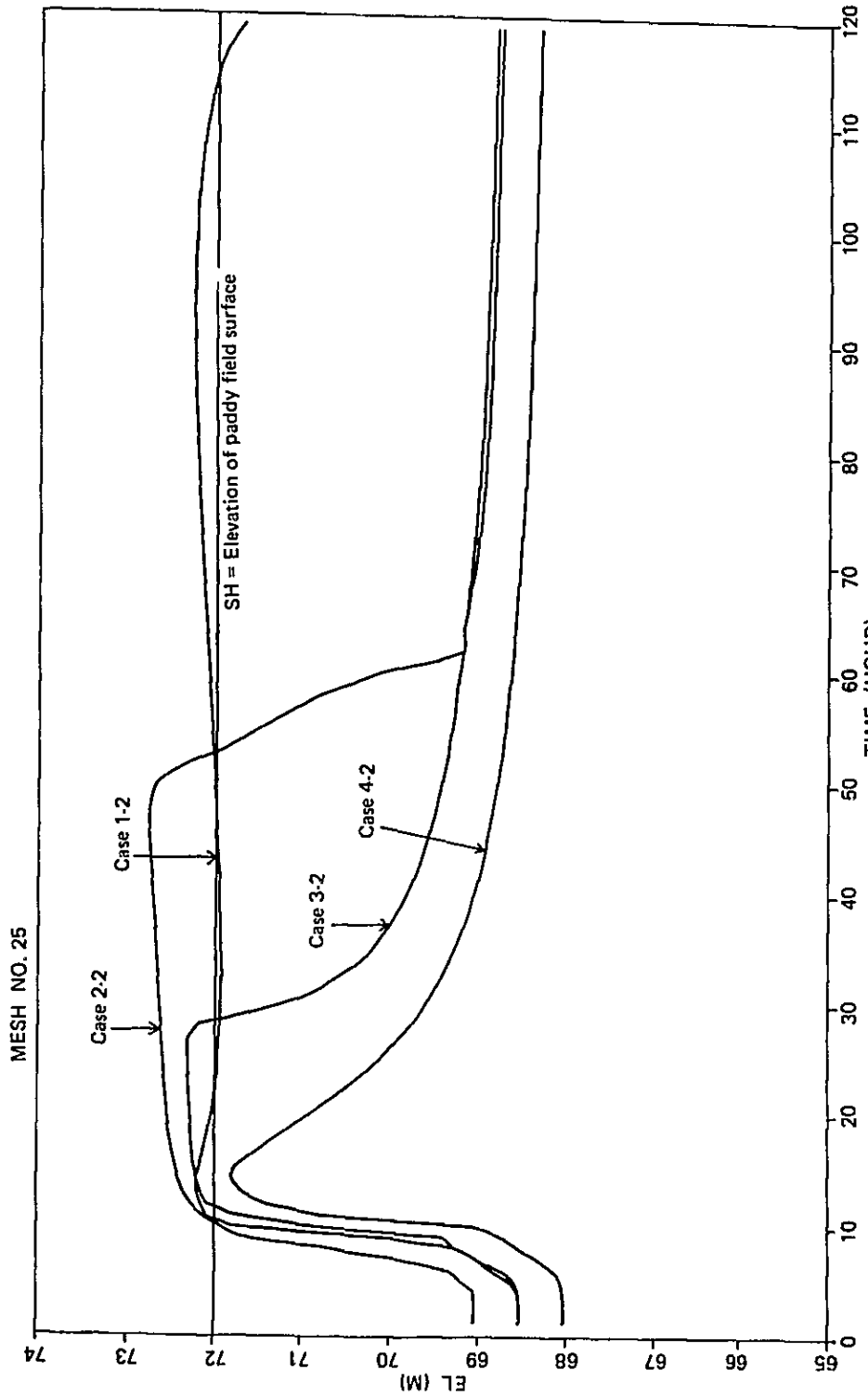


Fig. 5-2-8 Transition Curve of Water Level

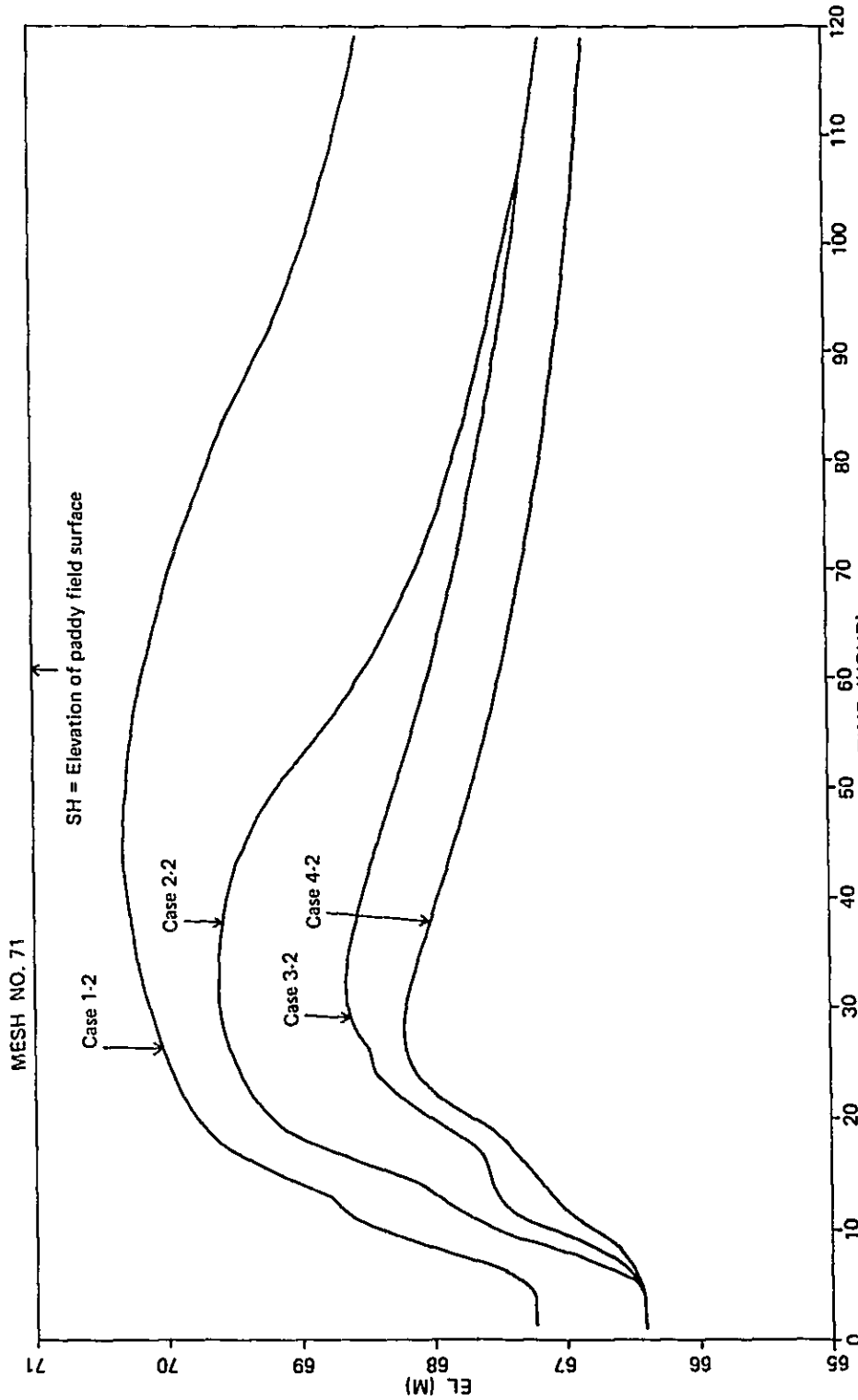


Fig. 5-2-9 Transition Curve of Water Level

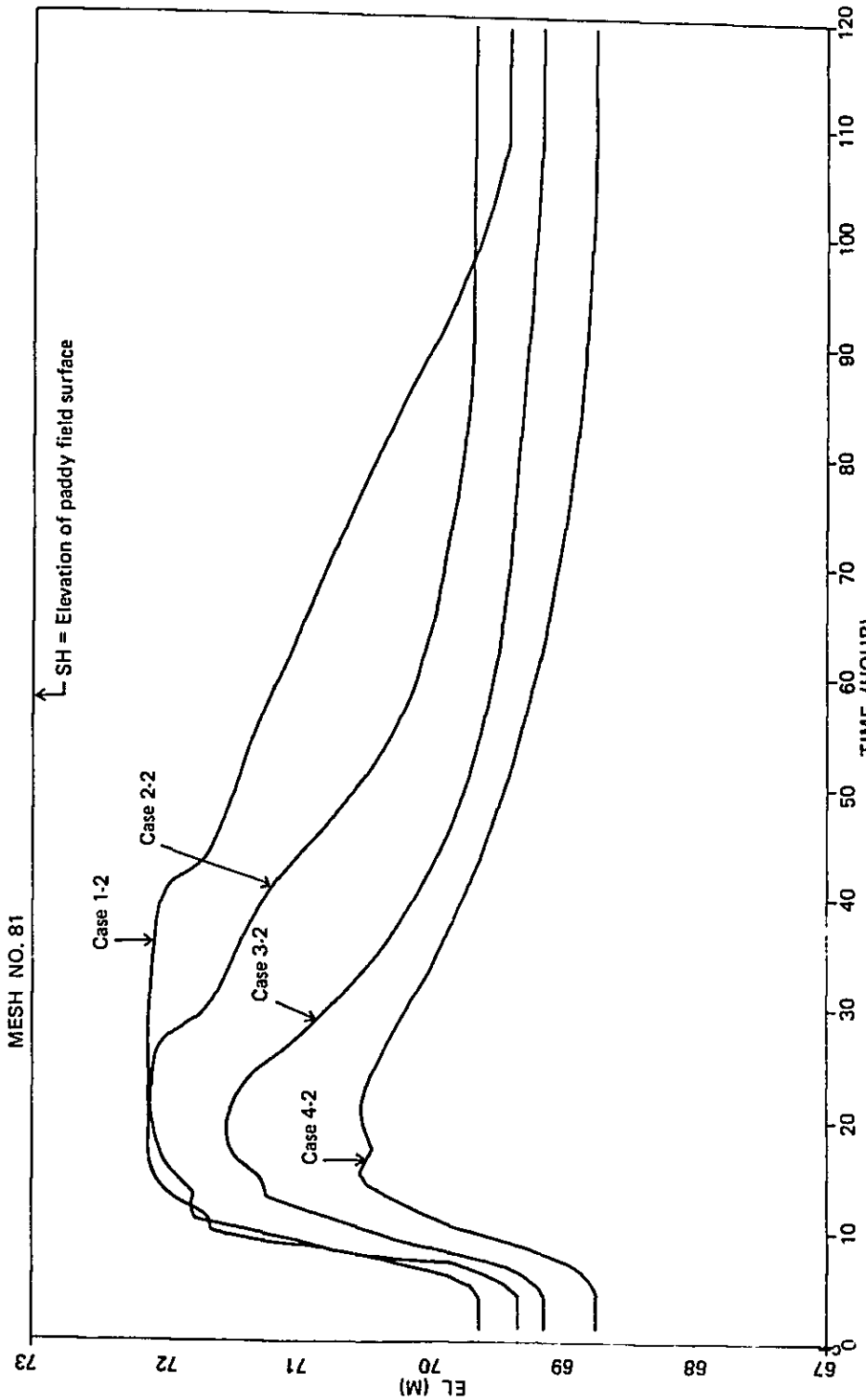


Fig. 5-2-10 Transition Curve of Water Level

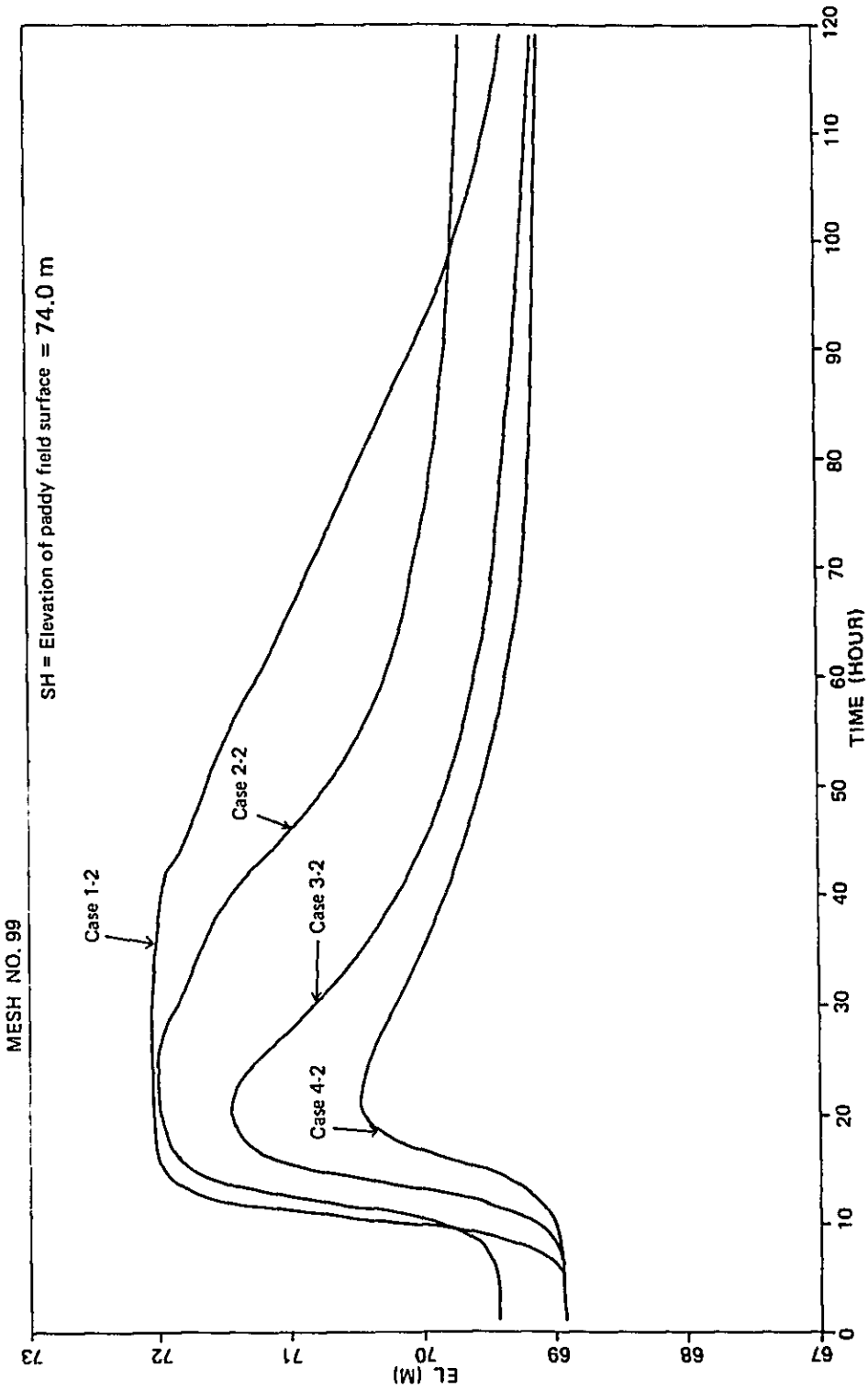


Fig. 5-2-11 Transition Curve of Water Level

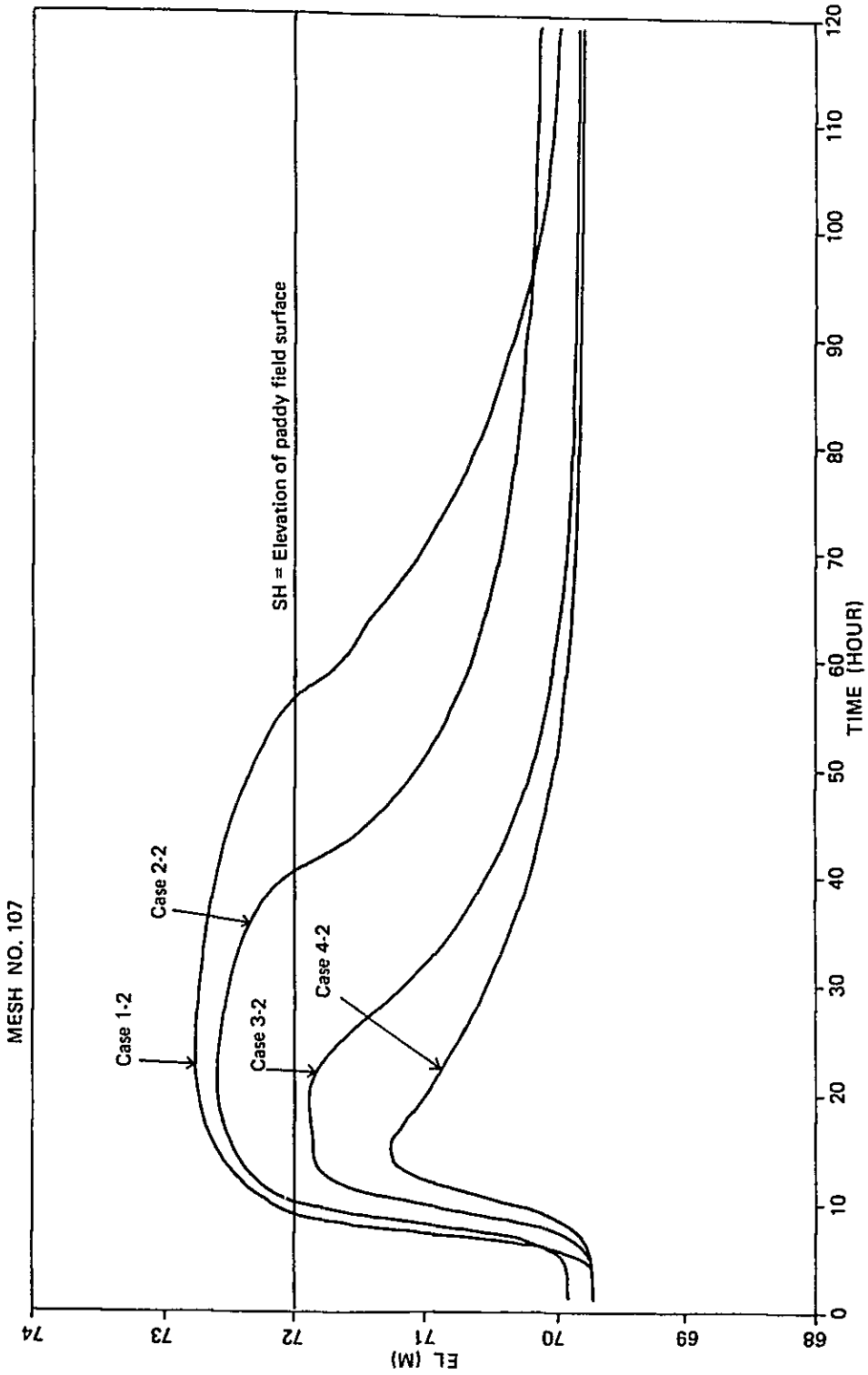


Fig. 5-2-12 Transition Curve of Water Level

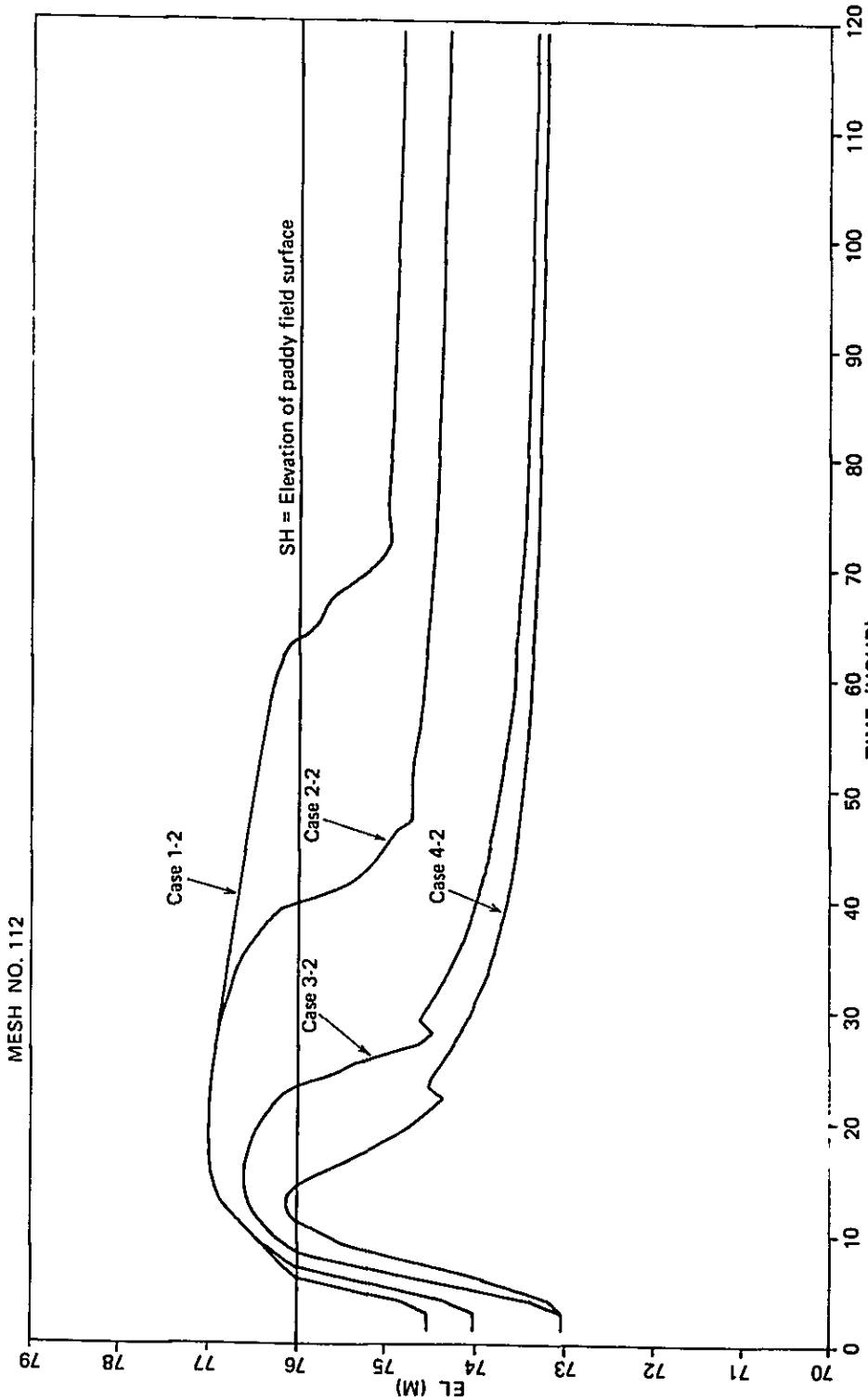


Fig. 5-2-13 Transition Curve of Water Level

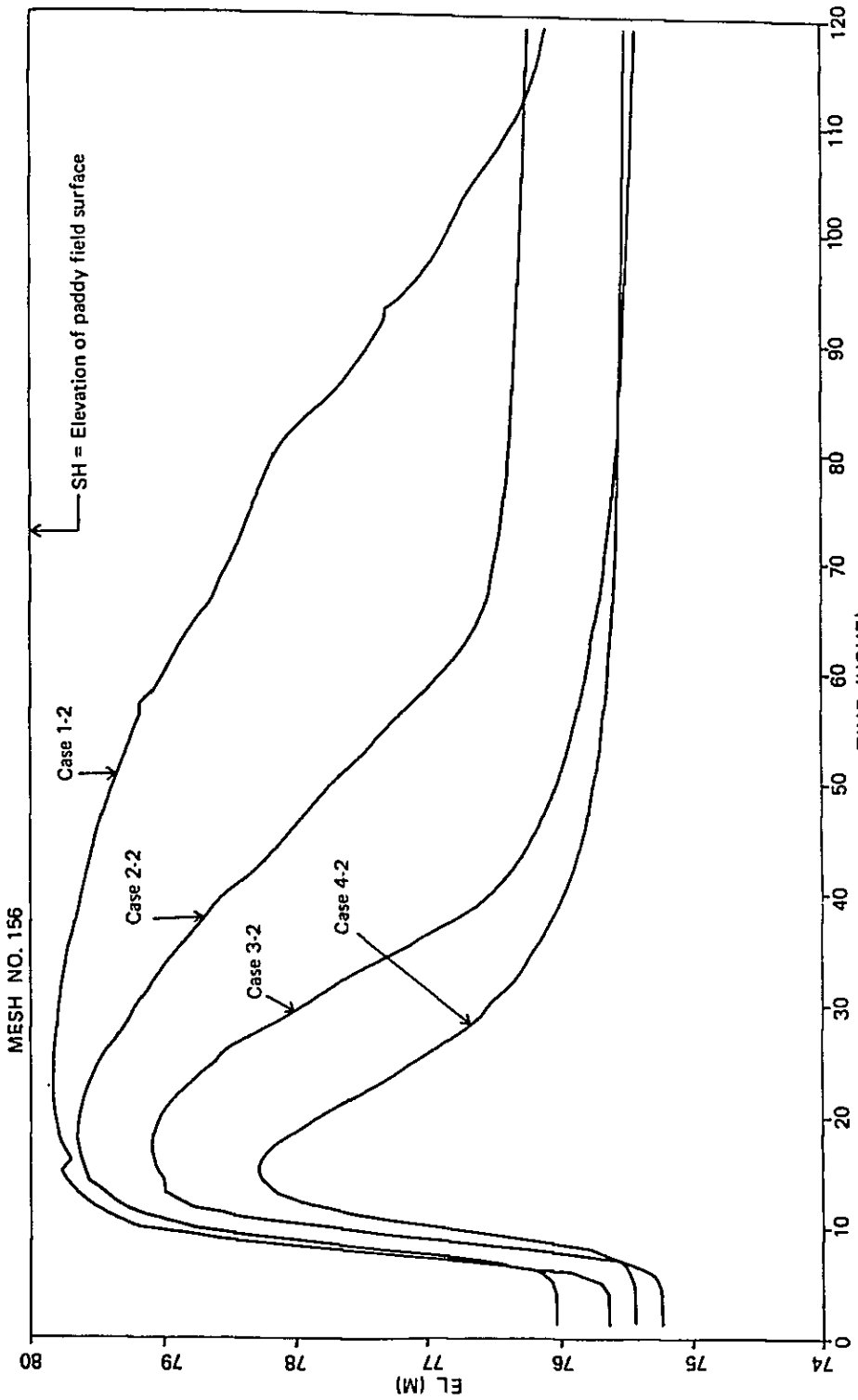


Fig. 5-2-14 Transition Curve of Water Level

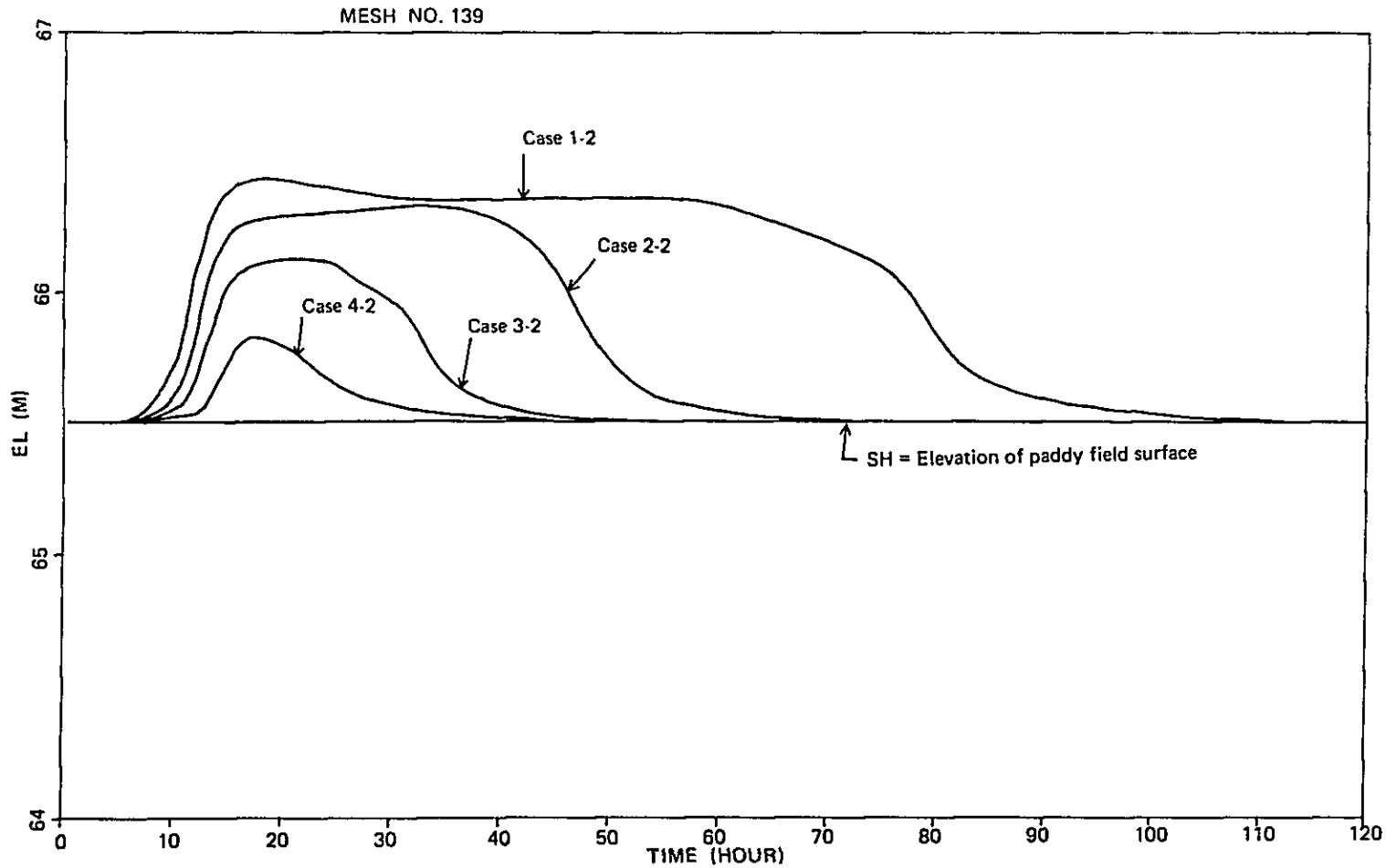


Fig. 5-2-15 Transition Curve of Water Level

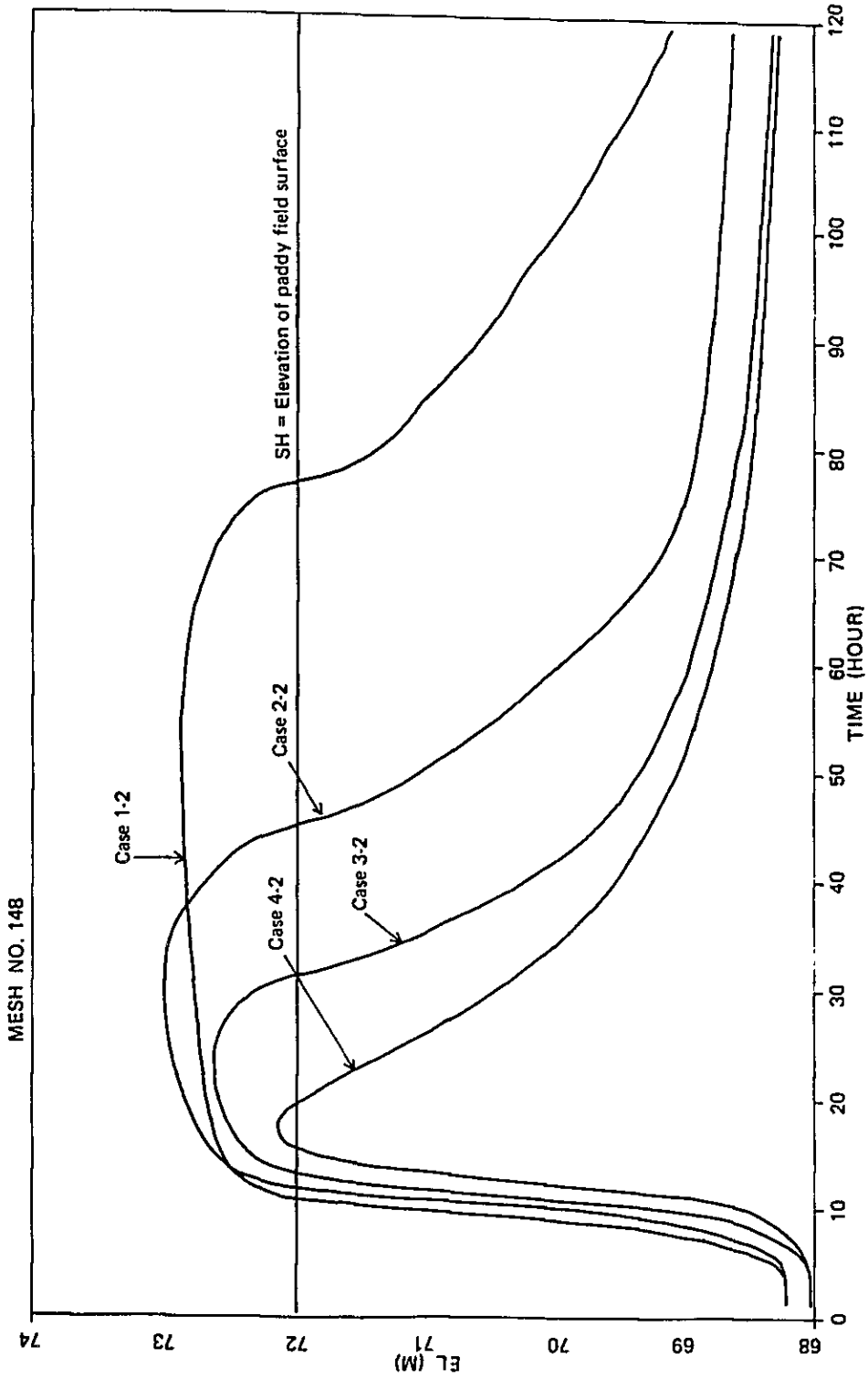


Fig. 5-2-16 Transition Curve of Water Level

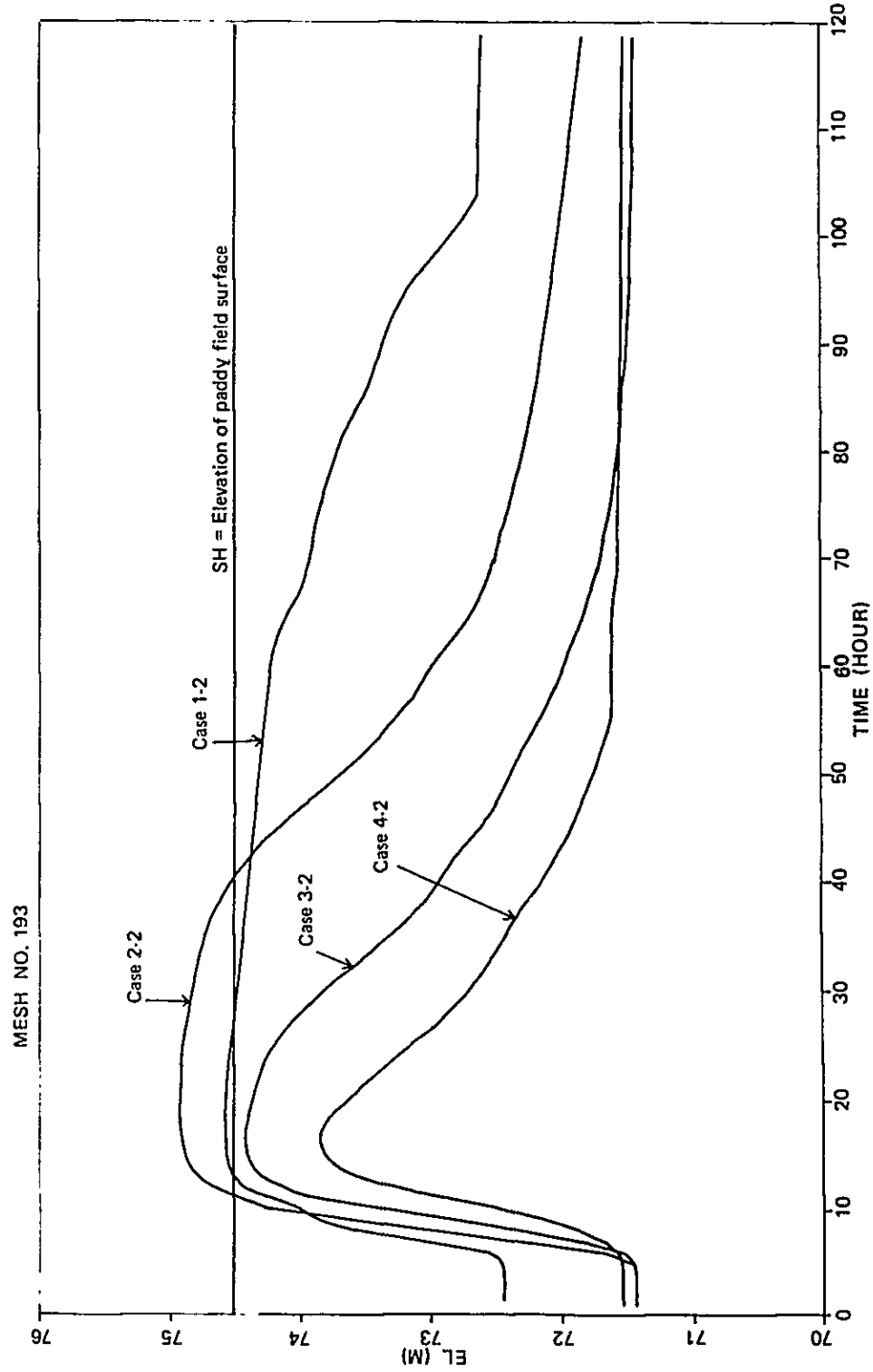


Fig. 5-2-17 Transition Curve of Water Level

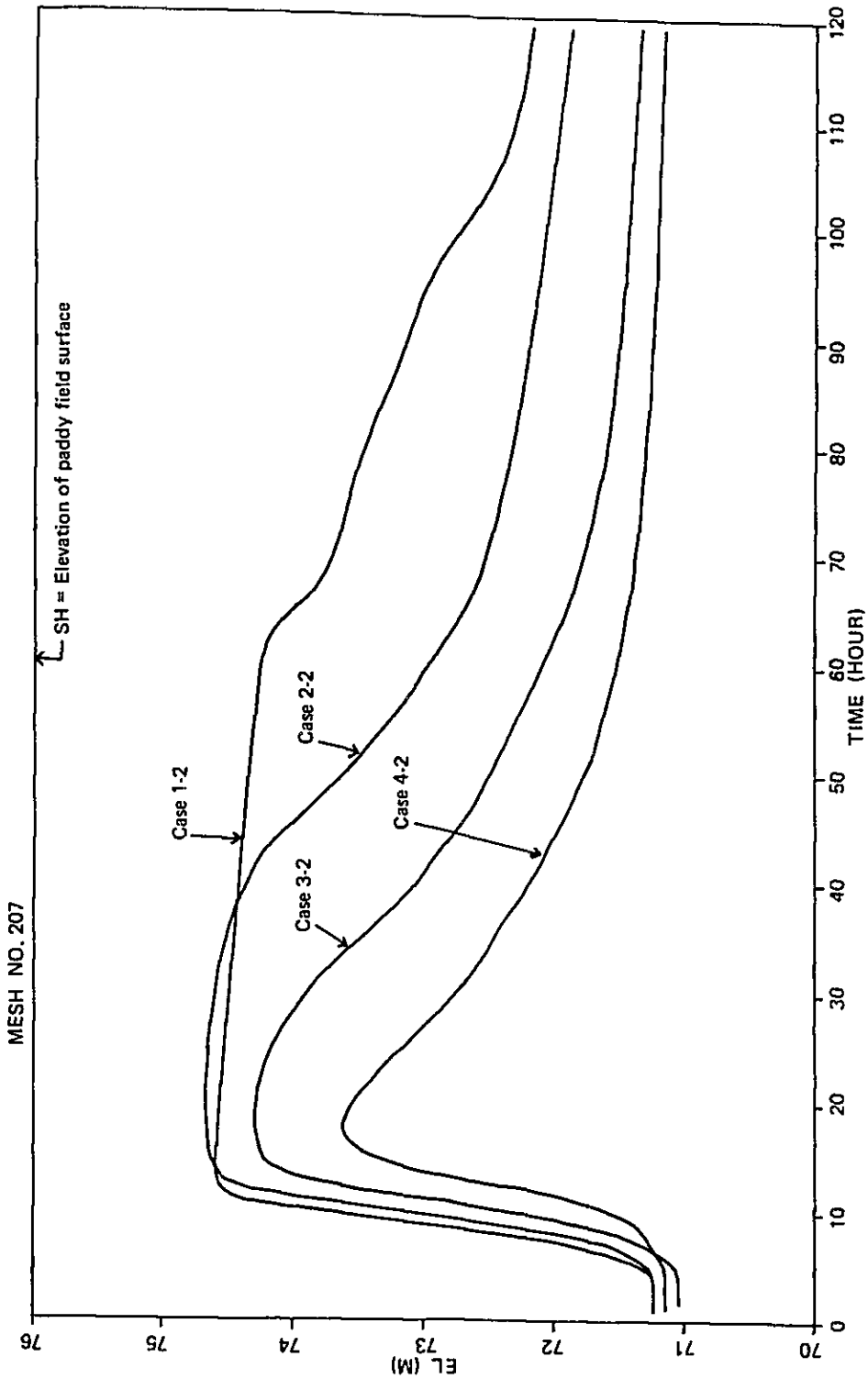


Fig. 5-2-18 Transition Curve of Water Level

(2) Flow rate of drainage canal

For the representative points on the drainage canals obtained by mathematical simulation, the variations in water level by time are given in Figs. 5-67 and up to 5-114 of the Appendix, and the peak water level and the timings of occurence are given in Tables 5-5 and 5-6 of the Appendix. In either of the cases, the peak occurs earlier as the point goes upstream, and it takes longer until the water inundated from the upstream and midstream reduces as the point goes downstream.

When the rainfall losses is 50 mm and cross section of drainage canal is 0.5 $m^3/sec/km^2$ in system I of drainage canal system, viz., case I-2-2, the specific peak flow is 0.526 to 1.575 $m^3/sec/km^2$, and the peak flow is 460.9 m^3/sec in the estuary of the Atinguy River and 468.3 m^3/sec in the estuary of the Yabebyry River.

(3) Condition of inundation

Obtaining the distribution of inundation from the results by the simulation, the maximum depths for each of the cases are figured in Figs. 5-119∿130 and up to 5-152∿163 of the Appendix. To see the variation by time in the distribution of inundation, the condition of inundation in case of rainfall losses of 50 mm observed every 10 hrs. is given in Figs. 5-131 ∿ 5-151 and 5-164 ∿ 5-177 of the Appendix. In order to facilitate understanding of inundated condition, the maximum depths of inundation are indicated for each of the meshes.

In the case of case I-2-2, the distribution of maximum inundation depths is as given in Fig. 5-2-19, from which it is seen that inundation is caused in most of the area. When this is seen in Figs. 5-138 and up to 5-144 of the Appendix in which variations by time are indicated, it is understood that in 10 hrs of rainfall, inundation has started in relatively large area, particularly from the upstream areas, in 20 hrs, inundation proceeds further toward the downstream areas, in 30 hrs, inundation has started reducing in the upstream areas, and in 40 hrs, inundation have disappeared except for the low areas in the midstream. The inundation area and the rate of inundation area are given in Tables 5-8 and up to 5-13. It is understood that the inundation area reduces as the rainfall losses increases or as the cross sections of drainage canals are enlarged.

(4) Study of drainage canal system

Based on the simulations performed for system I and system II to be the drainage canal systems, the systems in the cases are compared in the following:

Fig. 5-2-20 indicates the inundation depths and inundation rates for the case in which the rainfall losses is 50 mm, and the cross section of drainage canal is varied from 0.25 $m^3/sec/km^2$ up to 2 $m^3/sec/km^2$, from which it is understood that the inundation rate is lower in system I than in system II in either of the size of cross section, indicating higher effect of the former.

(5) Study of cross section of drainage canal

To study the optimum size of cross section for drainage canal, the relation of the cross section of drainage canal (size) and the inundation rate is given in Figs. 5-2-21 and 5-2-22 for system I, and in Figs. 5-179 for system II. The relation when the inundation depth is 30 cm is given in Fig. 5-2-22, from which it is seen that, when the rainfall losses is 50 mm, the effect of drainage starts reducing the rate of increase with the cross section of drainage canal of 1 $m^3/sec/km^2$ and over, and that the effect turns downward near the cross section slightly larger than 0.5 $m^3/sec/km^2$. For the rainfall losses, the one suitable for the features of the area will be set in the 3rd year's study based on the water levels and discharge of rivers for which observation has been underway, and it is expected to be set to 50 mm more or less. If so, the rate of inundation area of more than 30 cm in depth is about 9% in case of cross section of 0.5 $m^3/sec/km^2$, and when considering that it satisfies the general requirement for preparation of drainage plan of 10%, it is said that the cross section 0.5 $m^3/sec/km^2$ is appropriate.

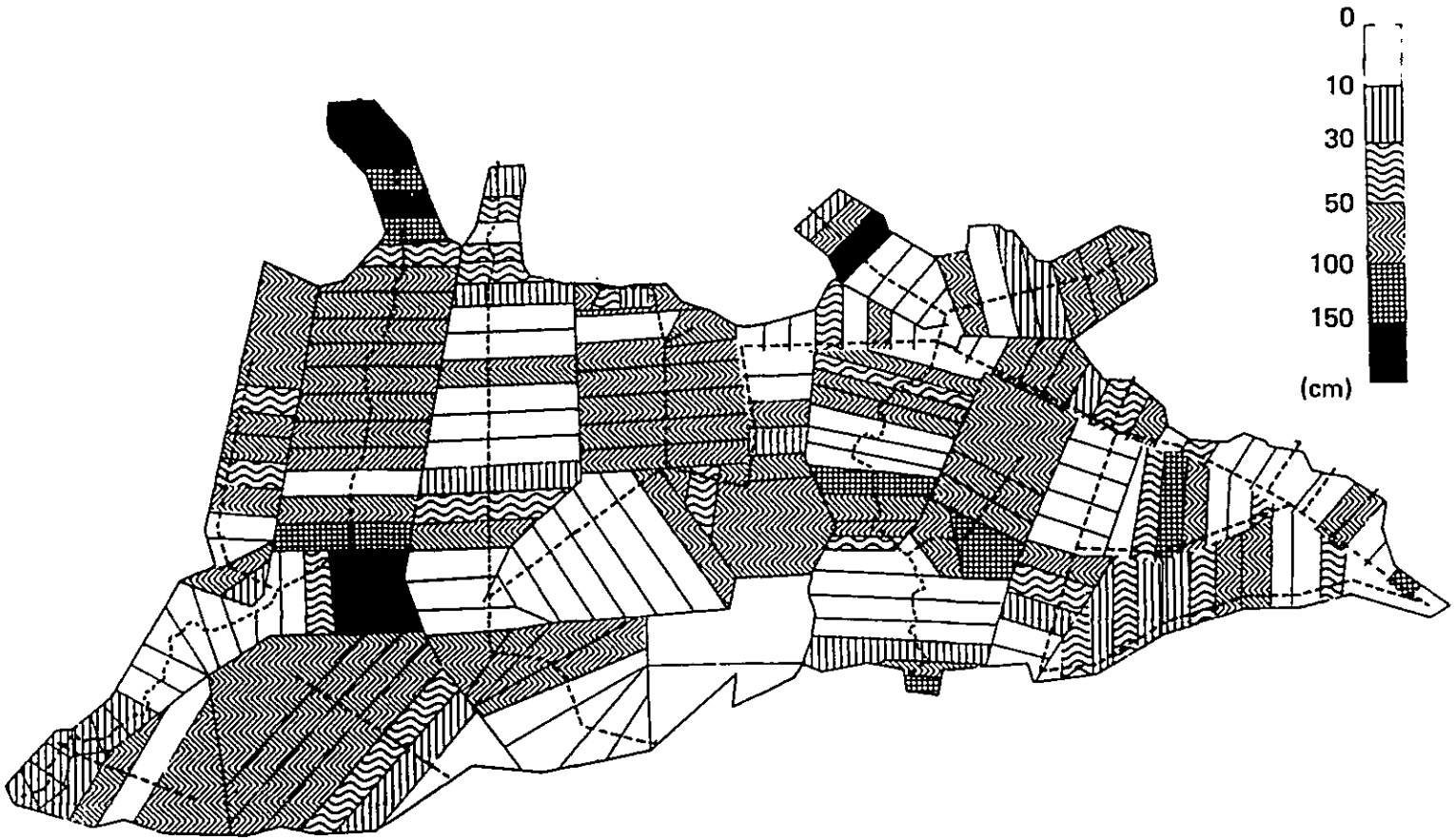


Fig. 5-2-19 Inundation Condition (plan) Case 2-2-MAX. (I)

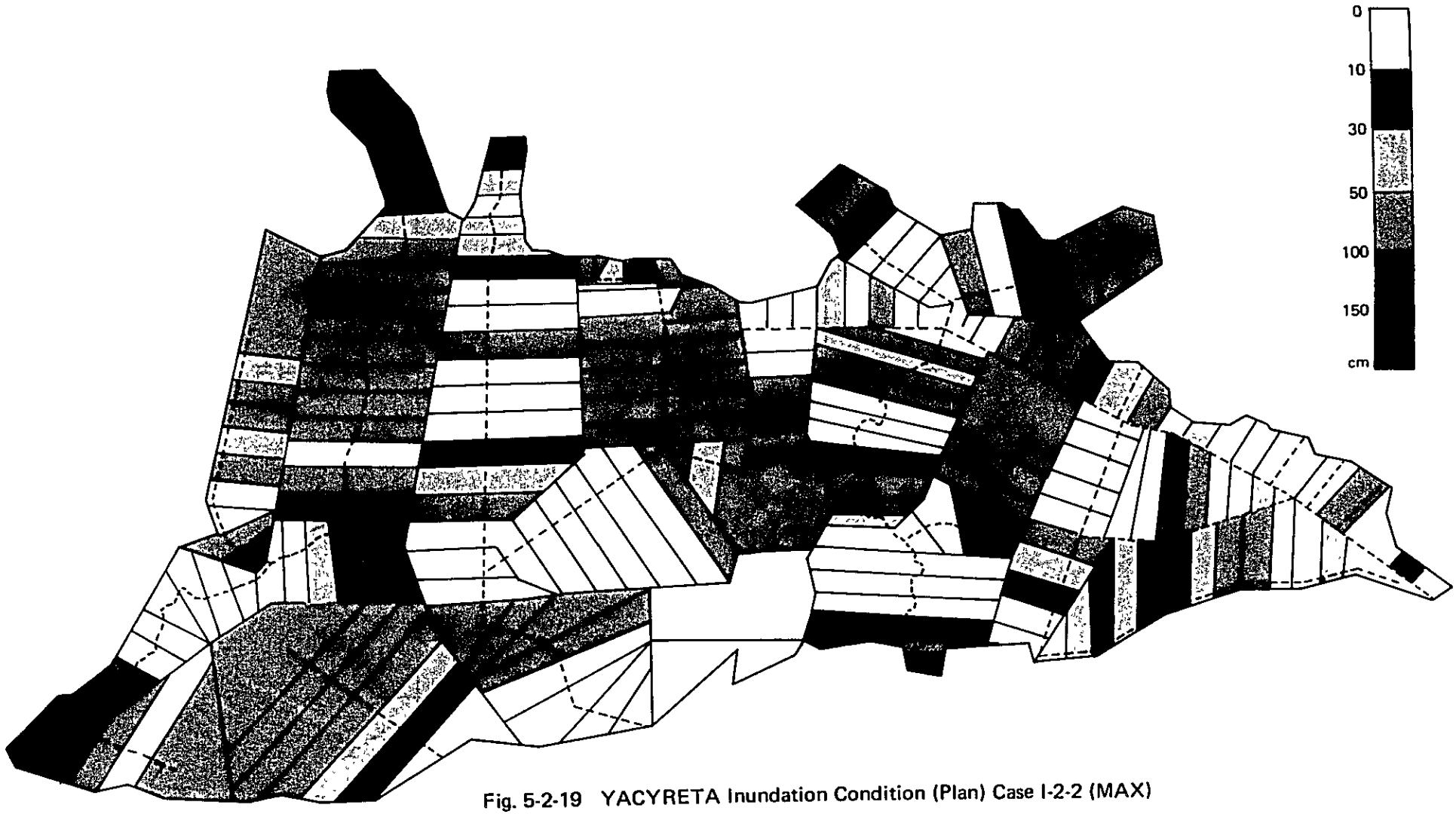


Fig. 5-2-19 YACYRETA Inundation Condition (Plan) Case I-2-2 (MAX)

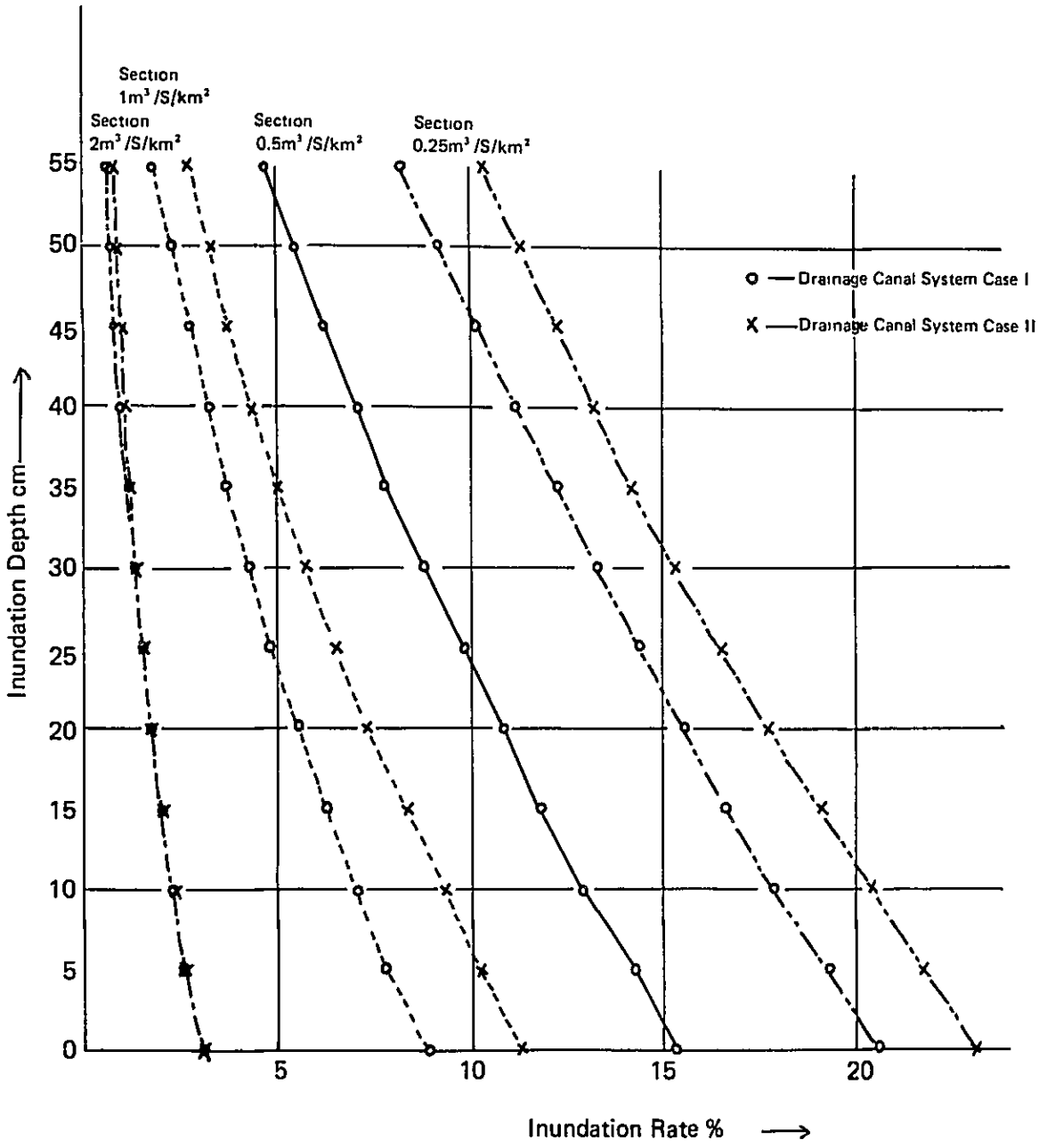


Fig. 5-2-20 Comparison of Inundation Rate by Drainage Section
(Examination of Drainage Canal System)
(For Loss of Rainfall 50 mm)

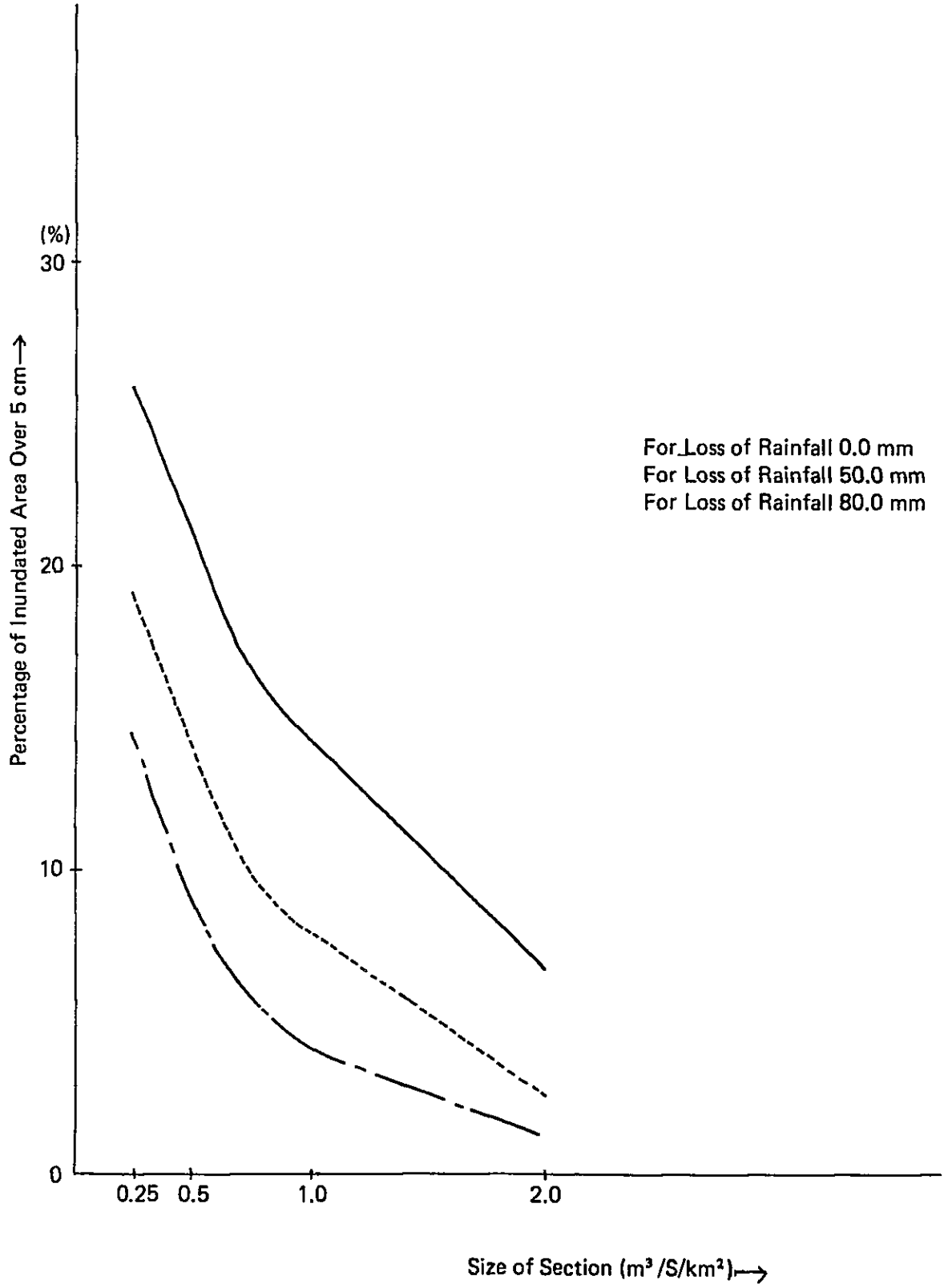


Fig. 5-2-21 Relation between Drainage Canal Section and Inundation Rate (over 5 cm)

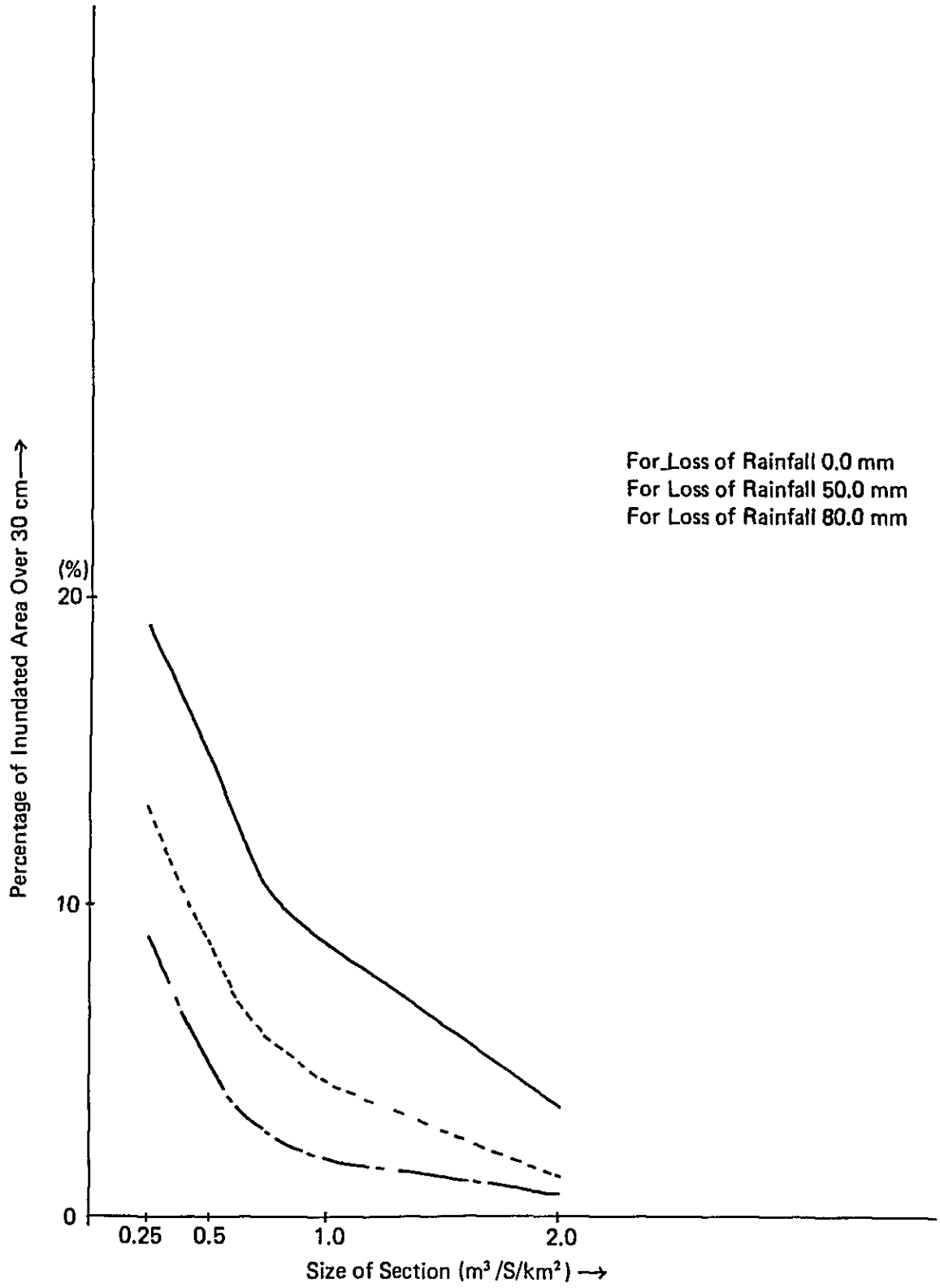


Fig. 5-2-22 Relation between Drainage Canal Section and Inundation Rate (Over 30 cm)

(6) Conclusion

Based on the analysis results obtained so far, system I of the drainage canal system by which effective drainage is expected and the construction work can be proceeded step by step by dividing the project area into sections, is employed.

By system I of drainage canal system, the total length and occupied areas of the main drainage canals are as follows:

Table 5-2-4 Total Length and Occupied Area of Main Drainage Canal

Name of main drainage canal	Total length	Occupied area
Atinguy Main Drainage Canal	33.0km	647.0km^2
Yabebyry Main Drainage Canal	34.5km	830.1km^2
Main Drainage Canal No.1	19.5km	71.0km^2
" No.2	13.5km	114.0km^2
" No.3	19.5km	298.0km^2
" No.4	10.5km	83.0km^2
" No.5	10.5km	200.0km^2
" No.6	9.0km	96.0km^2
" No.7	12.0km	129.0km^2
" No.8	27.0km	352.0km^2
" No.9	1.5km	1.7km^2
" No.10	43.5km	690.0km^2
" No.11	27.0km	541.0km^2
" No.12	15.0km	81.0km^2
" No.13	13.5km	112.0km^2
" No.14	7.5km	39.0km^2
Catch Drainage Canal No.1	13.5km	65.0km^2
" No.2	13.5km	78.7km^2
" No.3	13.5km	64.0km^2
" No.4	12.0km	32.0km^2
Total	349.5km	2,577.1km^2

For the cross section of drainage canal, 0.5 $m^3/sec/km^2$ with which the drainage efficiency is high and the inundation area of more than 30 cm in depth is about 9%, is applied to the plan.

The distribution of inundation areas of more than 30 cm in depth based on the drainage canal system and cross section which are set as above is given in Fig. 5-2-23. It is added that this figure has been modified from Fig. 5-2-19 by picking up the areas of more than 30 cm in depth.

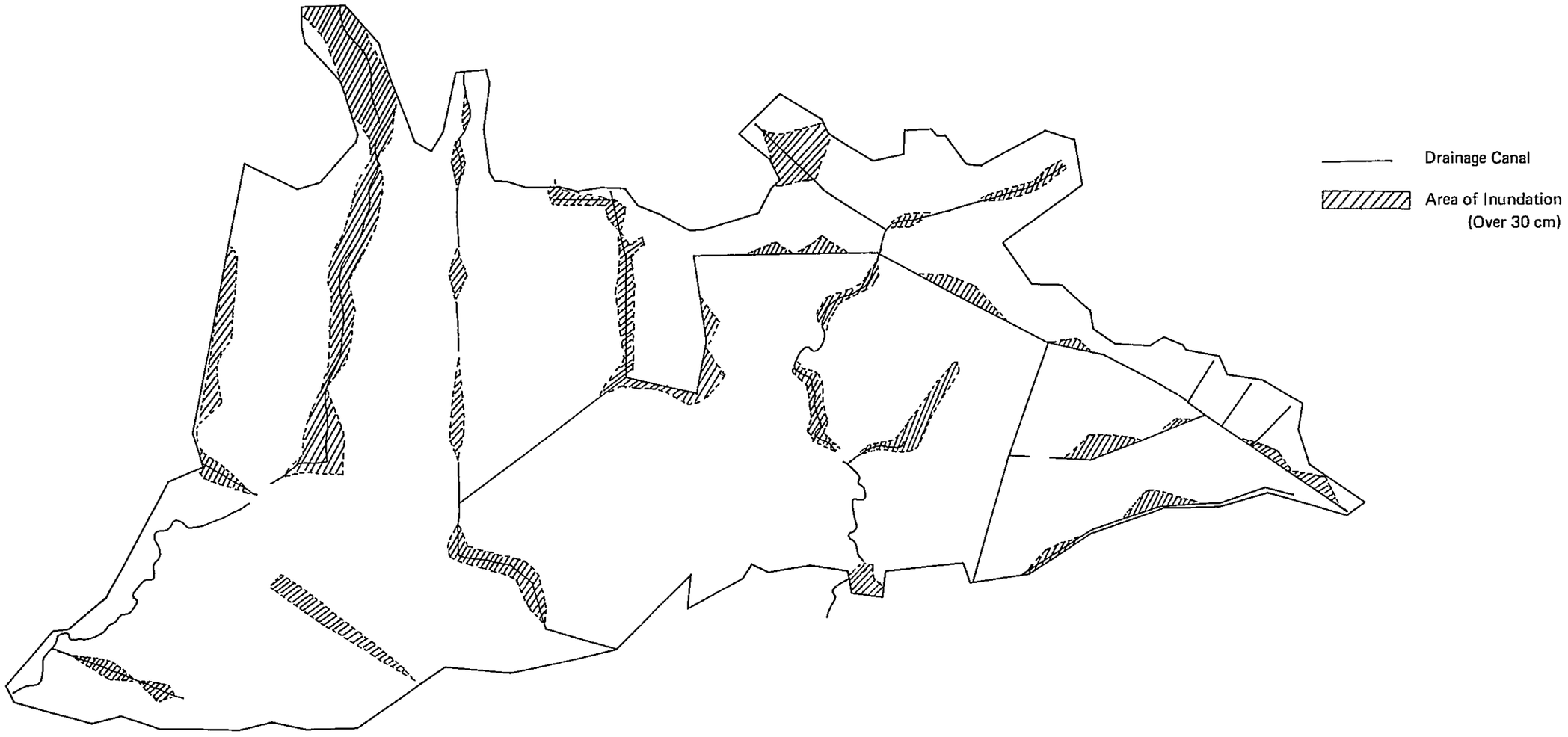


Fig. 5-2-23 Geographical Distribution of Inundation
(Case 1-2-2, Maximum Depth of Inundation Over 30 cm)

5.2.5 Future site survey and analysis

In this year's study of drainage plan, primarily the drainage system was studied based on simulation analyses using the mathematical models, and the drainage canal system and cross section of the drainage canal which are considered to be optimum for the project area were outlined.

Though the conditions for the mathematical models are set according to the results of surveys performed in the 1st and 2nd years, it is preferable that these be verified or adjusted as necessary by the meteorology and hydrology of which observation has been underway for higher accuracy of simulations, and thus the drainage effect is expected to be clarified further.

For this purpose, the following surveys and analyses are required on top of those above in the 3rd year.

(1) Data for rainfall

Though the estimated design rainfall has been set based on the data by Yacyreta Observatory of Department of Meteorology, Ministry of National Defence, it is necessary to cover such extensive project area that the analyses be performed thoroughly using the data obtained by 3 observatories newly located by this survey team as well as the data by the Yacyreta Public Corporation, and that depending on the condition and when required the rainfall characteristics be further clarified for each rainfall runoff block using the data by suitable observatories.

(2) Data for discharge of rivers

Though 3 cases for the rainfall losses, coefficient of roughness, base flow, etc. were set by analyses in the work to outline this plan, it is necessary to analyze the discharge more exactly that collection and analyses of data for water levels of rivers of which collection has been commenced by auto-level gauges newly set by this survey team and the data for discharge being observed by Yacyreta Public Corporation, be proceeded further.

(3) Finalizing of drainage plan and verifying of effect

Based on surveys and analyses as above, the set conditions of mathematical models are verified and adjusted as and when required, and simulations are performed so as to finalize the plan, and particularly, effect of drainage work is clarified by estimated inundation distribution, depth of inundation, and hours of inundation.

5.3 Farm Land Development Plan

5.3.1 On-farm plan

(1) Basic policy on-farm plan

This clause deals with on-farm plan, terminal irrigation and drainage canal, farm-road and pasture-fence.

In cultivation plan of this project area, rotation of wheat and soybean, dairy farming and rotation of paddy rice and pasturing are dealed with as key crops.

Therefore, it is supposed that on-farm plan is divided into 2 types, paddy field requiring irrigation canal, and upland field and grassland requiring no irrigation canal, because paddy rice needs irrigation farming. For upland field cultivation of labor intensive crops, namely irrigation plan is considered, however, it is examined by coordinating farming plan, cultivation plan etc. at the following year.

For farm road, upland field and grassland do not need banking specially, it can be easily determined by individual cultivation plan at actual farming stage.

As especially farm block is the most important in on-farm plan, it is determined considering local farming conditions, the present geographical features, irrigation plan and conditions of farming scale studied afterward, etc.

Soil in farm block is not removed in principle.

Differences among plans for paddy field as rotation area with pasture, for upland field as rotation area of wheat and soybean, and grassland in dairy farming area are described in individual clauses.

(2) Farm land consolidation

1) Farm block

Farm block is examined on the base of circumstances of existing paddy rice farm, local geographical features and plan of irrigation, cultivation, farming and settlement determined in this master plan.

Study on the existing paddy rice farm was made as to the Bolf farm located in this project area and the Pappalardo farm near Asuncion.

The Bolf farm is managed by the standard size of 800 m × 800 m block,

however, farmers tend to reduce size of block for convenience of carrying out of farm products, according to hearing investigation. Moreover, in the Pappalardo farm, block previously 400 m × 2,500 m has been readjusted to 200 m × 2,500 m at present by the reasons of easy water control and carrying out of farm products.

The present topography may not affect the determination of farm block scale, as the present topography is so flat that the slope is mostly under 1/3,000 and partially 1/1,000, also field block and levee block are formed in farm block.

From a viewpoint of irrigation plan, farming block cannot be enlarged extremely because of continuous irrigation method.

On the base of cultivation and settlement plan, farming plan proposes various classes as farming scale per farmer. In the proposal, managing scale doubles by integral number of 25 ha, therefore it is the basic area of a farm block. For the shape of farm block, square is favourable from a viewpoint of field area.

Japanese data indicates that farm irrigation ditch is limited to 600 m long, and longer one causes occurrance of irregular water distribution and interfere with farming. Moreover, the required days for irrigation at peak time is limited to approximately 5 days.

Moreover, in survey on existing paddy rice culture farm, as the Pappalardo farm is far from this project area and its geographical grade is rather steep, it may be possible to irrigate relatively long farm block. Therefore, this plan lays emphasize on data of the Bolf farm existing in the project area.

The standard farm block accordingly is determined to be square 500 m × 500 m as shown in Fig. 5-3-1.

The terminal irrigation and drainage system of paddy field can be corresponded by the terminal irrigation and drainage plan described below.

This farm block shape and size apply upland field and grassland. Farm block is divided into field blocks or lots by levee depending upon cultivating crops, which are made at farming stages every year.

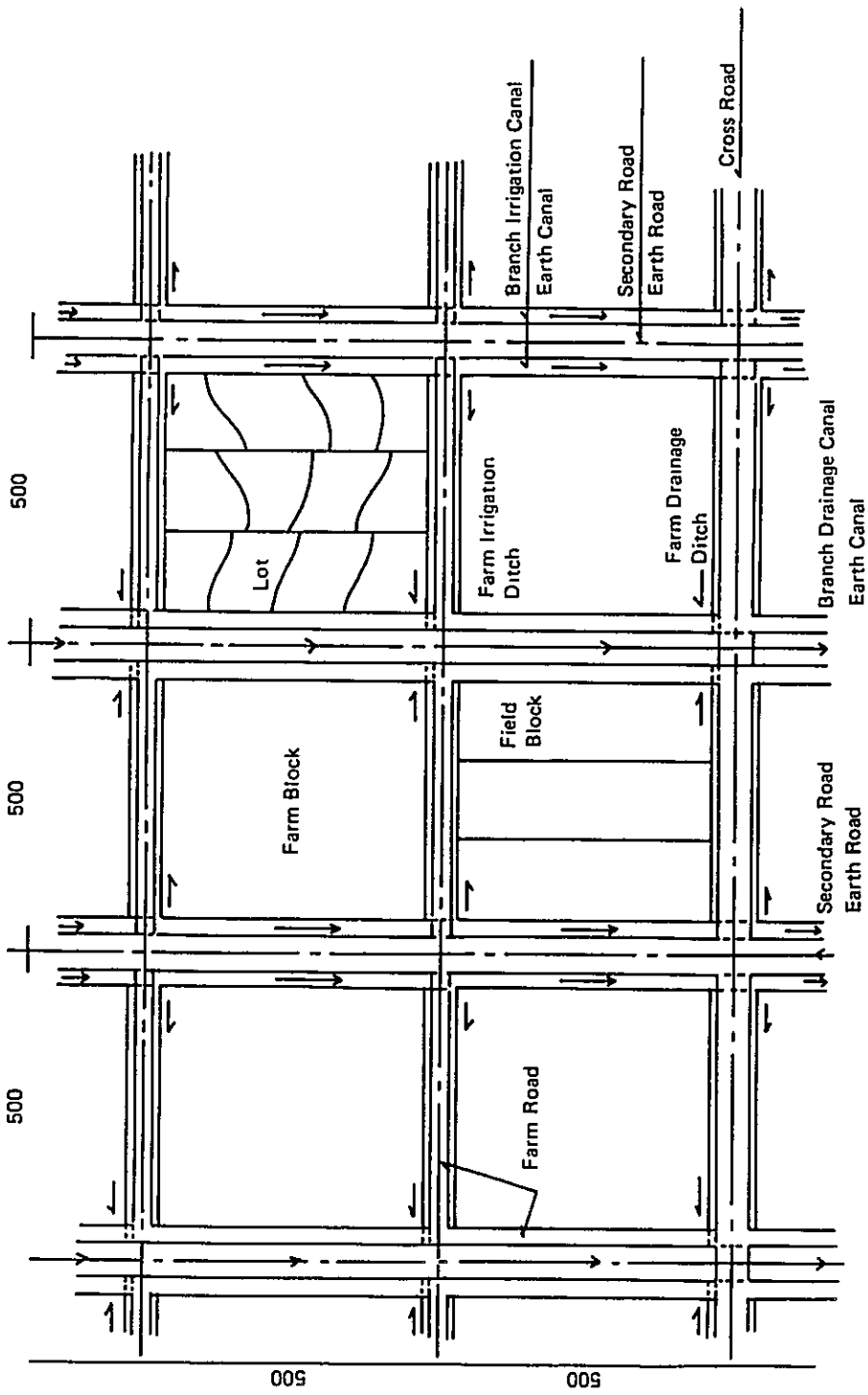


Fig. 5-3-1 Layout of On-farm Plan (Unit: m)

2) Terminal irrigation canal

The terminal irrigation canal should be planned for paddy field, which consists of branch irrigation canals and farm irrigation ditches.

Branch canal takes in water from trunk or main irrigation canal through intake gate, and distribute water to ditches adjacent to farm block through both sides of secondary road laid out beside farm block.

Branch irrigation canal, becoming economical by decreasing cross points with secondary road, should be laid out along both sides of secondary road shown in Fig. 5-3-1, at 2 farm blocks interval, namely 1 km interval parallel each other.

As shown in Fig. 5-3-1, farm irrigation is laid out at upstream side of farm block, and water distributed from branch irrigation canal flows in through inlet of levee of paddy field.

The structure is unlined canal and cross point with road is closed conduit. Terminal irrigation canal, especially farm irrigation ditches are reformed before irrigating every year.

The designed cross section, calculated by initial inundation within 6 days as shown in Table 5-3-1, is 1.5 m in bottom width and 0.3 m in water depth for ditch, and 6.0 m in bottom width and 0.5 m in water depth for branch irrigation canal as shown in Fig. 5-3-2.

Density, site area, control area, etc. of terminal irrigation canal in model block are described in Table 5-3-2.

3) Terminal drainage canal

As terminal drainage canal, branch drainage canal and farm drainage ditch for paddy field are planned.

Farm drainage ditch, as shown in Fig. 5-3-1 is laid out at downstream side of each farm block, and water flowed in from paddy field through outlet of levee flows down to branch drainage canal through this farm drainage ditch.

Branch drainage canal introduces water flowed in from farm drainage ditch to main drainage canal, which is laid out between farm roads at the rate of 1 canal every 2 blocks, namely at intervals of 1 km, as shown in Fig. 5-3-1.

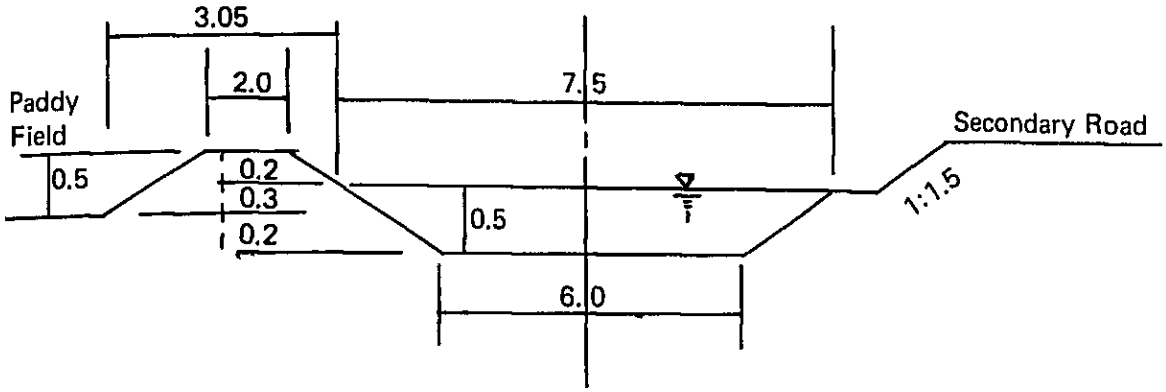
The structure is unlined canal. The cross point with road is

divided into 2 types, cross of secondary road (crossing road) and branch drainage canal, and cross of farm drainage ditch and farm road. For the former, closed conduit or box culvert is laid out depending on scale, and for the later closed conduit or gangplank.

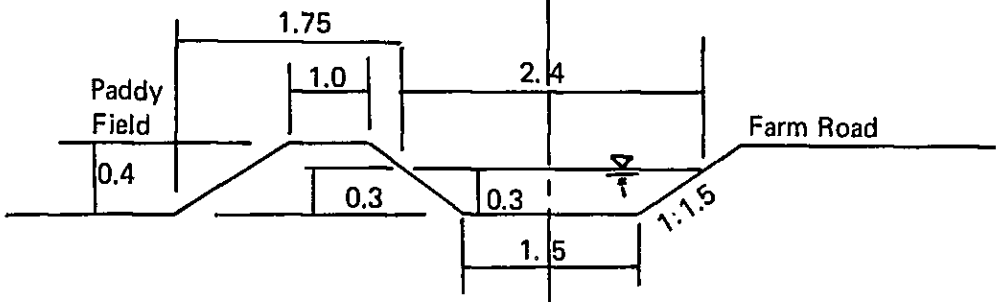
The designed cross section, calculated on the base of 0.5 $m^3/sec/km^2$ given after drainage simulation as shown in Table 5-3-1, is 1.0 m in bottom width and 0.4 m in water depth for farm drainage ditch, and 6.0 m in bottom width and 0.9 m in water depth for branch drainage canal as shown in Fig. 5-3-2.

This cross section is rather wider than the section excluding 2 years probability rainfall within 2 days, and terminal drainage canal for paddy field, upland field and grassland is planned in same idea as it is recognized that upland crop can be introduced to the Area A by results of drainage simulation. The Area A should be examined further by results of detail analysis based on data collected by new investigation on drainage plan at the following year, as it is required to enlarge canal section partially in the Area A.

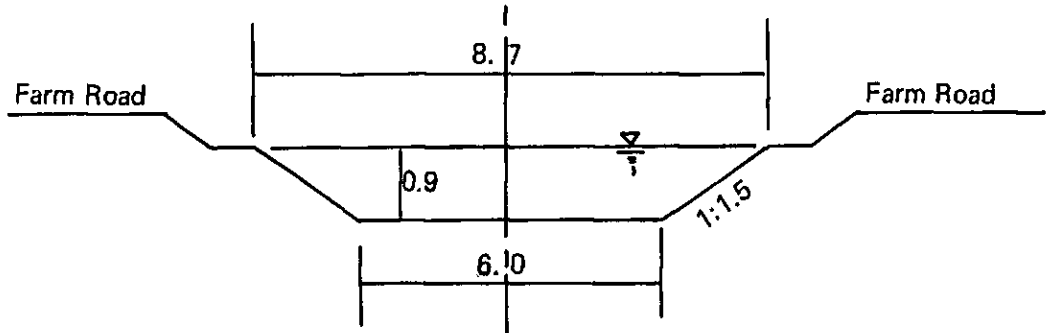
Density, site area, control area etc of terminal drainage canal in model block are described in Table 5-3-2.



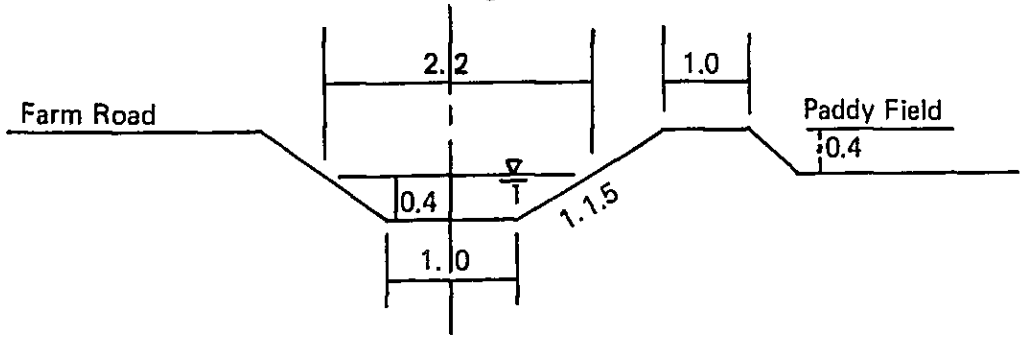
(a) Branch Irrigation Canal



(b) Farm Irrigation Ditch



(c) Branch Drainage Canal



(d) Farm Drainage Ditch

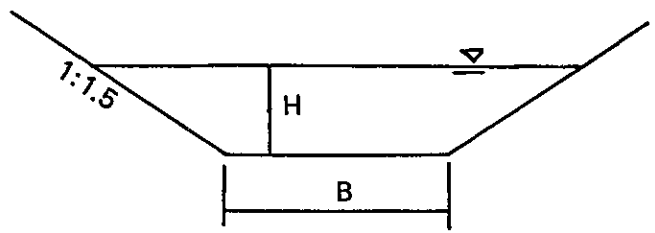
Fig. 5-3-2 Standard Sections (Unit: m)

Table 5-3-1 Calculation of Standard Cross Section of Terminal Irrigation and Drainage Canal

Facilities	Control area (ha)	Unit flow (ℓ/s/ha)	Flow (m^3/s)	Bottom width (m)	Water depth (m)	Flow velosity (m/s)	Allowable flow (m^3/s)
Branch irrigation canal	246.2	3.20	0.79	6.0	0.5	0.27	0.92
Farm irrigation ditch	25.0	3.20	0.08	1.5	0.3	0.18	0.10
Branch drainage canal	554.0	5.00	2.77	6.0	0.9	0.38	2.78
Farm drainage ditch	25.0	5.00	0.13	1.0	0.4	0.20	0.13

Requirement

1. Canal cross section is shown below.
2. Longitudinal slope of channel is 1/3,000 ∿ 1/7,000 based on the present condition.
3. For calculation of discharge, Manning's formula is used.
4. Coefficient of roughness (n) is 0.025 for earth canal.
5. On-farm irrigation water requirement is estimated by peak water requirement of 22.1 mm/day bacing on irrigation plan.
6. On-farm drainage discharge is estimated by 5.0 1/s/ha bacing on drainage plan.



4) Farm road

Farm road, as shown in Fig. 5-3-1 is laid out at 3 sides of farm block boundary except side of branch irrigation canal, namely along farm ditch, branch drainage canal and farm drainage ditch.

This road is used for farming on farm block such as rotary, temporary parking space etc. of large size machine. For paddy field, water level of the adjacent farm ditch and farm block should be considered.

Road section, therefore is earth road with 6.0 m in width and 0.4 m in banking height. For banking, earth excavated from drainage canal etc. is used.

For upland field and grassland, banking is not required and only levelling is performed simultaneously with treatment for prevegetation.

5) Pasture-fence

Pasture-fence is provided to protect cultivating crops from grazing cattle and to prevent cattle from escaping. Particularly rotational paddy field with pasture and pasture is divided into each farm block by pasture-fence.

As shown in Fig. 5-3-3, the structure consists of wooden pile, thin wire and barbed wire. Stake is laid out at 5 m interval, and club is laid out at 2 points (1.67 m interval) between stakes. The height is 1.2 m and totally 4 wires are stretched, middle 2 wires are barbed wire and the top and bottom are thin wires.

For fixture of wires, as shown in Fig. 5-3-3, wire is inserted in a hole of stake or club and wound round fence wire. The gate is simple gate.

Fence is provided at on-farm side of branch canal, downstream side of farm drainage ditch and both sides of branch drainage canal.

Density of field fence is shown in Fig. 5-3-2.

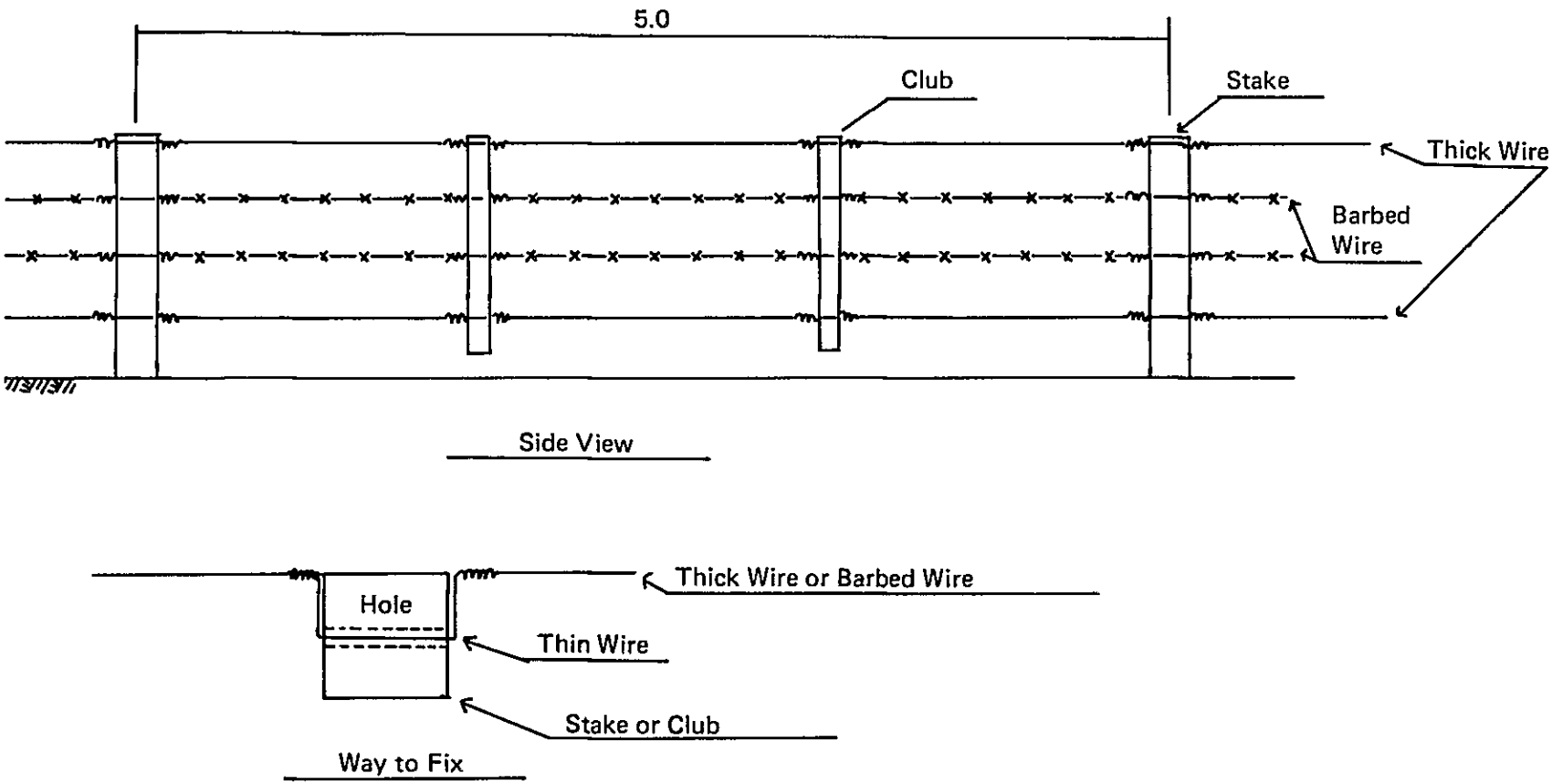


Fig. 5-3-3 Pasture Fence (Unit: m)

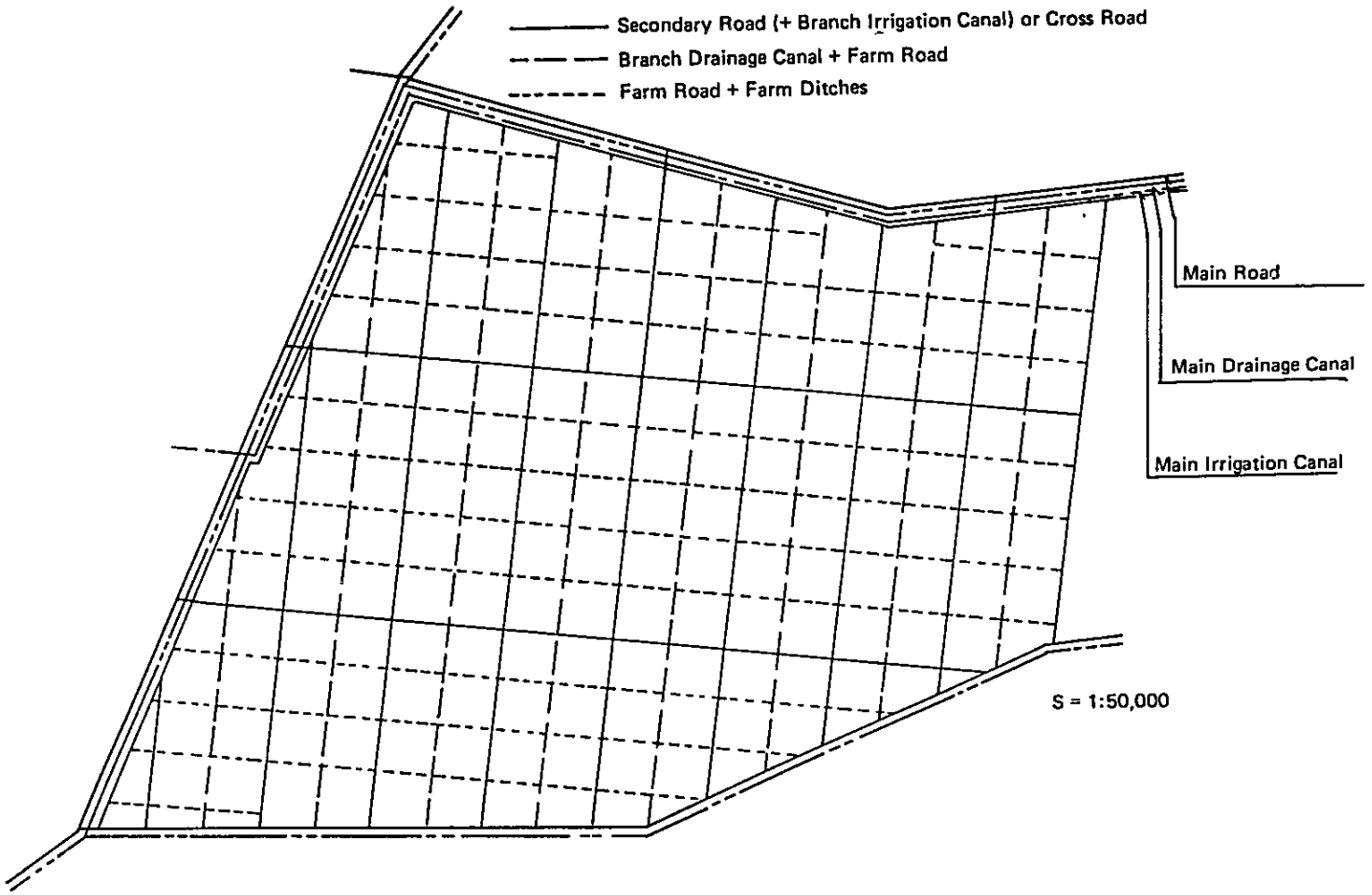


Fig. 5-3-4 Model Block

Table 5-3-2 Density of Terminal Facilities

Area of model block: 4,432 ha

Facility	Quantity (km)	Density (m/ha)	Control area (ha/route)	Site area (m^2/ha)
Secondary road	46.6	10.5	492.4	120.8
Cross road (in on-farm)	14.5	3.3	2,216.0	38.0
Farm road	159.7	36.0	-	295.2
Branch irrigation canal	93.3	21.1	246.2	158.3
Farm irrigation ditch	92.0	20.8	25.0	49.9
Branch drainage canal	41.9	9.5	554.0	82.7
Farm drainage ditch	94.6	21.3	25.0	46.9
Levee (branch irrigation canal)	93.3	21.1	-	64.4
Levee (farm ditches)	186.6	42.1	-	73.7
Pasture-fence	305.0	68.8	-	-
Total				929.9

Occupation area rate of on-farm facilities: 9.3%

Cross facility	Quantity (places)	Density (places/100ha)
Farm road × branch irrigation canal	140	3.16
Cross road × branch irrigation canal	29	0.65
Cross road × branch drainage canal	14	0.32

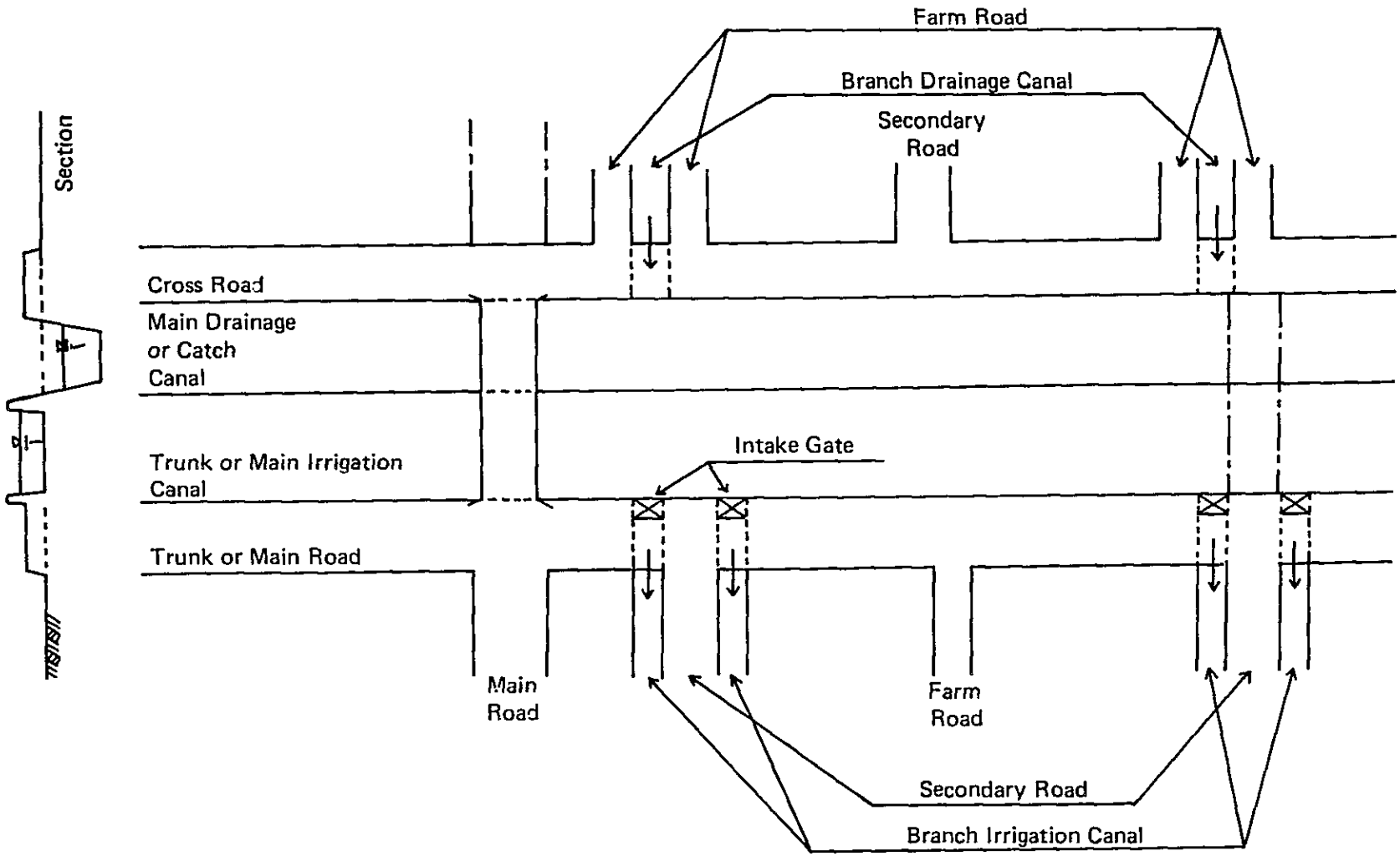


Fig. 5-3-5 Layout of Main and Connecting On-farm Structure

5.3.2 Road plan

(1) Basic policy for road plan

For lay out of road route, in addition to natural conditions of profitable area, layout of national and local roads, utilization possibility, density etc., particularly layout of villages and farming facilities should be considered synthetically, as it forms a link of the chain of the agricultural development. Moreover, it is required to make the most effective plan after defining necessity, propriety and utilization form of the road from a viewpoint of purpose of transportation of material and crops and facility management.

In this plan, road is divided into trunk road, main road, secondary road and operation/maintenance road, and the layout and structure suitable for the function are planned.

Trunk road is connecting the adjacent cities and villages, while secondary road is adjacent to farm block and aimed at transportation of materials and farm products. Main road is connecting these trunk road and secondary road, and supports the function of trunk road.

The structure, particularly width should be planned so that vehicles runs safety and farm work is performed smoothly, considering farm mechanization plan in the light of existing roads.

Propriety of layout of road route from the standpoint of agricultural management is examined further together with plans concerned.

(2) Road consolidation

1) Trunk road

a. Route system

According to the function of trunk road, roads connecting the project area circularly and crossing the area from the south to the north are laid out.

As existing roads of the adjacent area to the project area, local road Ayolas-San Cosme Road and Yabebyry-Ayolas Road along the southern boundary, local road Yabebyry-San Ignacio Road along the western boundary, local road Ayolas-Santiago Road running at the central area from the north to the south and Access Road (1-B) of the Yacyreta Dam are been provided.

Among these roads, Access Road (1-B) is asphalt pavement and still discharge its function.

Ayolas-San Cosme Road, Yabebyry-Ayolas Road and Yabebyry-San Ignicio Road are improved into a trunk road.

Ayolas-San Cosme Road and Yabebyry-Ayolas Road, however will be reconstructed as access road in the Yacyreta Dam Project, and adjusted when the plan is programmed.

As shown in Fig. 5-3-6, trunk roads running at the center of the western part and the eastern part from the south to the north, and at the northern project area from the west to the east are newly provided.

These trunk roads are laid out along trunk irrigation canal or main irrigation or drainage canal, and discharge the function of maintenance of these canals in addition to its original function.

b. Structure and cross section

As shown in Fig. 5-3-7, the road cross section is 15.0 m in total width, 10.0 m in effective width and 1.0 m in banking height so that large size trailer for transportation of materials and farm products can run frequently.

The road is paved with asphalt, gravel and crushed stone.

For banking, earth excavated from the adjacent drainage canal is used, and compacted by bulldozer or tire roller.

The total length, site area and density of trunk road are shown in Table 5-3-3.

At the crossing point of trunk road and trunk or main irrigation or drainage canal, bridge is provided.

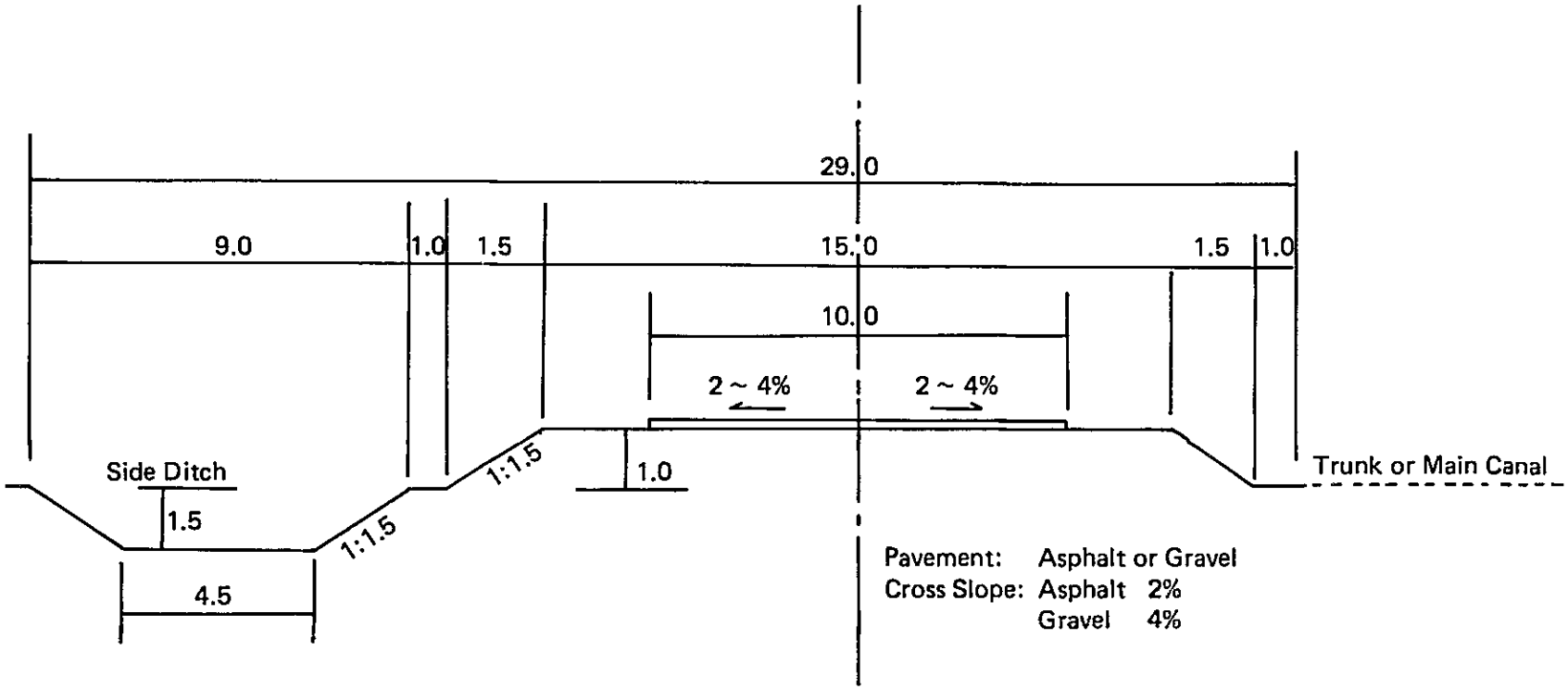


Fig. 5-3-7 Trunk Road Standard Section (Unit: m)

Table 5-3-3 Total Length and Site Area of Trunk Road

Trunk road	Total length (km)	Site area (ha)	Remarks
Trunk Road No. 1	43.0	124.7	
" " No. 2	36.5	105.9	
" " No. 3	43.0	124.7	Trunk Ayolas-San Cosme Road
" " No. 4	30.5	88.5	Trunk Ayolas-Yabebyry Road
" " No. 5	13.3	38.6	
" " No. 6	32.7	94.8	Trunk Access Road
" " No. 7	21.7	62.9	
" " No. 8	34.8	100.9	Trunk San Ignocio-Yabebyry Road
Total	255.5	741.0	1.67 m/ha

* Whole area 152,300 ha

2) Main road

a. Route system

Main road, connecting trunk road to secondary road, is aimed at the supporting function of trunk road.

Moreover, main road is laid out along trunk or main irrigation or drainage canal and discharges the function of maintenance of these irrigation and drainage canal.

Main road is laid out as shown in Fig. 5-3-6 and all are newly provided.

b. Structure and cross section

As shown in Fig. 5-3-8, the structure is 10.0 m in total width 7.0 m in effective width and 1.0 m in banking height so that large farming machine and large size trailer can pass each other.

The road is paved with gravel, crushed stone and sand.

For banking, earth excavated from the adjacent drainage canal is used, and compacted by bulldozer or tire roller.

The total length, site area and density of main road are shown in Table 5-3-4.

Fig 5-36

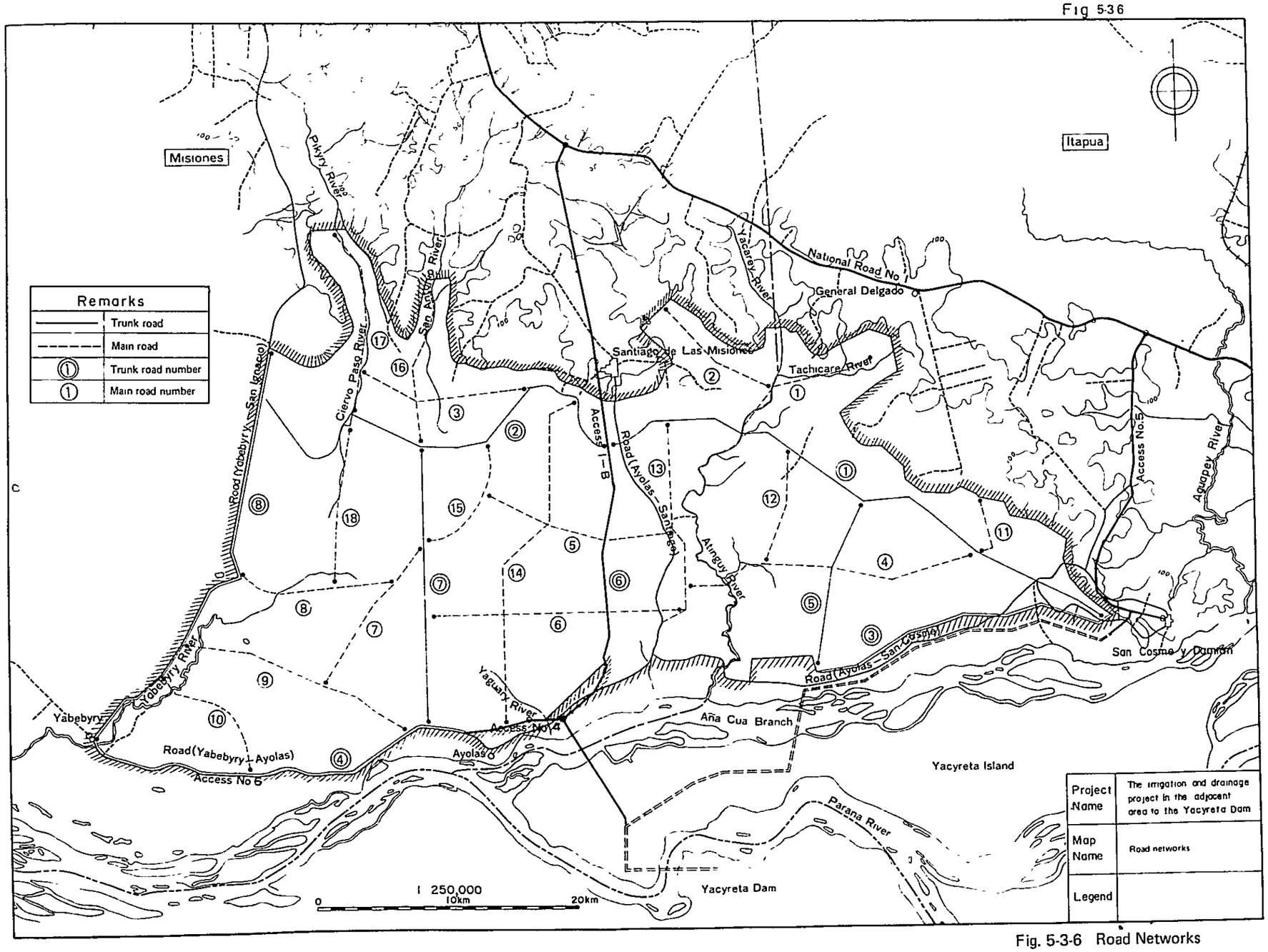


Fig. 5-3-6 Road Networks

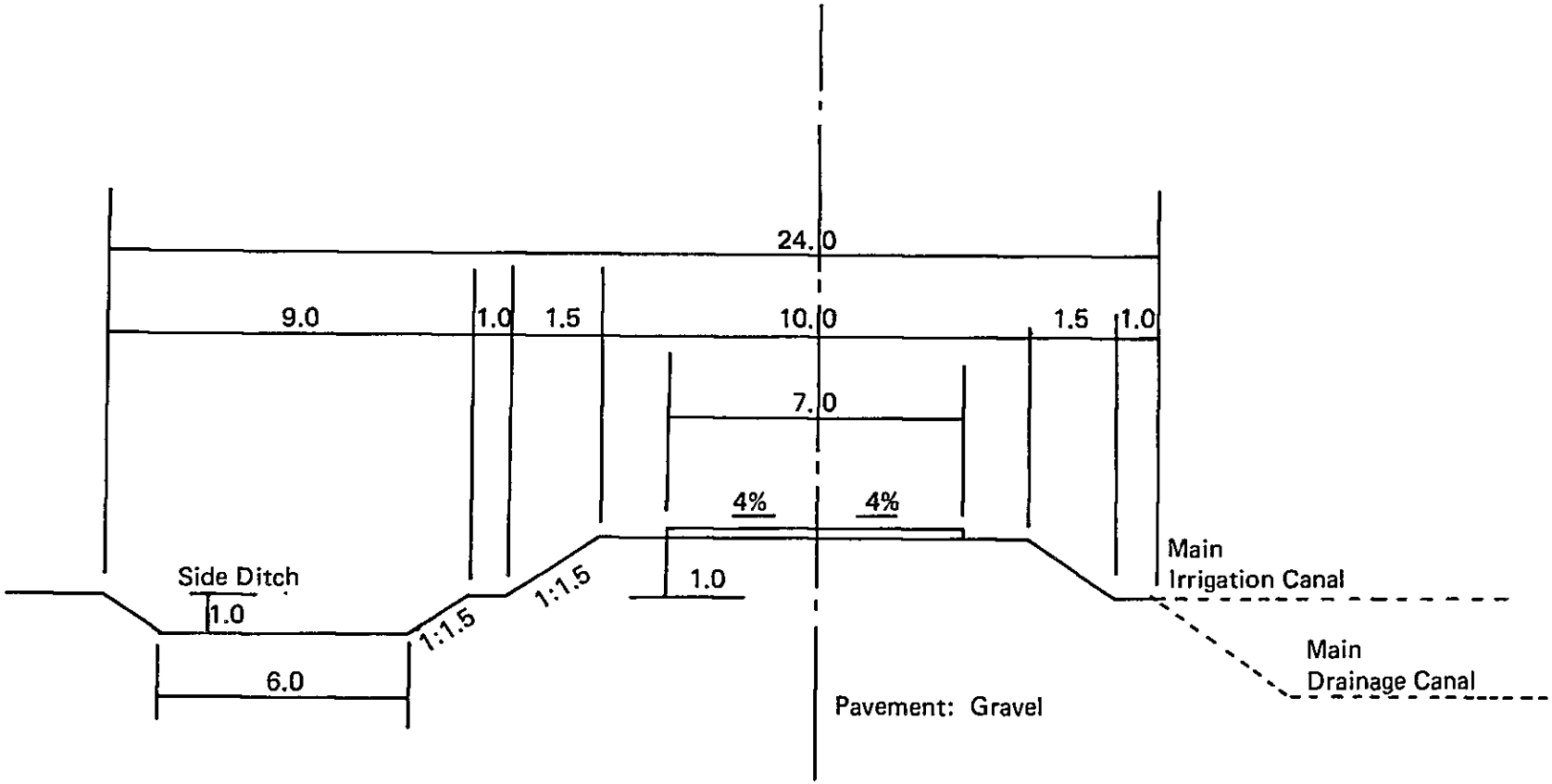


Fig. 5-3-8 Main Road Standard Section (Unit: m)

Table 5-3-4 Total Length and Site Area of Main Road

Main road		Total length (km)	Site area (ha)	Remarks
Main road	Road No. 1	11.8	28.3	
"	" No. 2	10.4	25.0	
"	" No. 3	13.6	32.6	
"	" No. 4	23.5	56.4	
"	" No. 5	14.8	35.5	
"	" No. 6	19.6	47.0	
"	" No. 7	13.3	31.9	
"	" No. 8	12.0	28.8	
"	" No. 9	18.7	44.9	
"	" No. 10	11.0	26.4	
"	" No. 11	5.2	12.5	
"	" No. 12	9.3	22.3	
"	" No. 13	19.4	46.6	
"	" No. 14	27.5	66.0	
"	" No. 15	10.4	25.0	
"	" No. 16	12.3	29.5	
"	" No. 17	13.0	31.2	
"	" No. 18	11.4	27.4	
Total		257.2	617.3	1.69 m/ha

* Whole area 152,300 ha

3) Secondary road and cross road

a. Route system

Secondary road, connecting main road to each farm block, is laid out parallel each other along branch drainage canal at the rate of 1 road every 2 blocks, namely at intervals of 1 km.

Moreover, secondary class road is laid out along trunk or main irrigation or drainage canal at the side which no road is provided and towards the direction crossing secondary road within block at the rate of 1 road every about 3 km.

This secondary class road is specially termed cross road.

b. Structure and cross section

The structure is 8.0 m in total width and 6.0 m in effective width as shown in Fig. 5-3-9 so that large size trailer and large farming machine can pass. The banking height is fixed to be 0.5 m considering approach of farming machine and water level of the adjacent branch irrigation canal, and discharges the function as side bank of the canal.

For banking, earth excavated from the adjacent drainage canal is used, and compacted by bulldozer or tire roller.

The road is paved with gravel where there is a fear of weakening at raining.

The toral length, site area etc. of secondary road and cross road are shown in Table 5-3-2 and Table 5-3-5.

4) Operation and maintenance road

a. Route system

This road, aimed at management of irrigation or drainage canal, is laid out along trunk or main irrigation or drainage canal not running parallel to trunk or main road.

b. Structure and cross section

The structure and cross section are same as secondary road.

The total length and site area of this road are shown in Table 5-3-5.

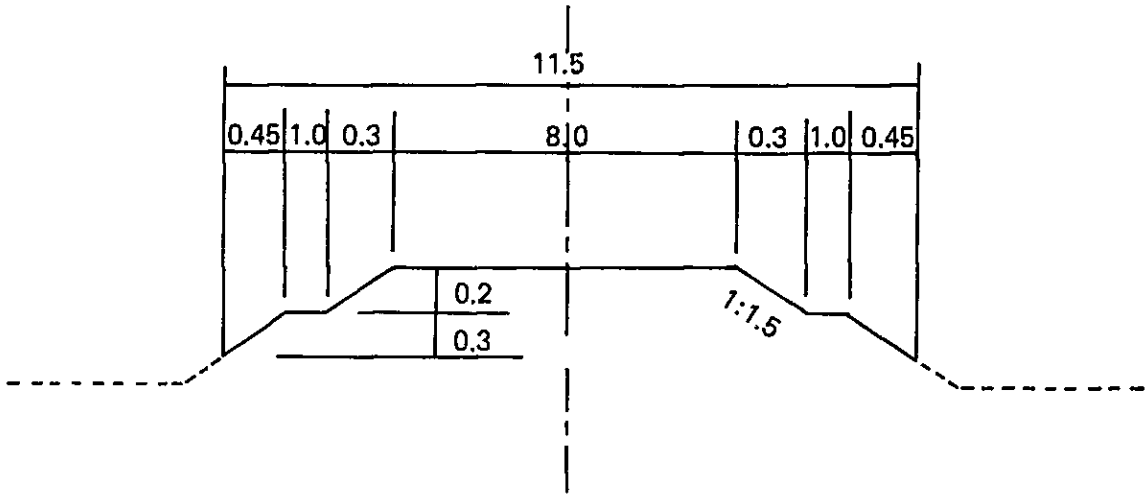


Fig. 5-3-9 Secondary Road Standard Section
(Unit: m)

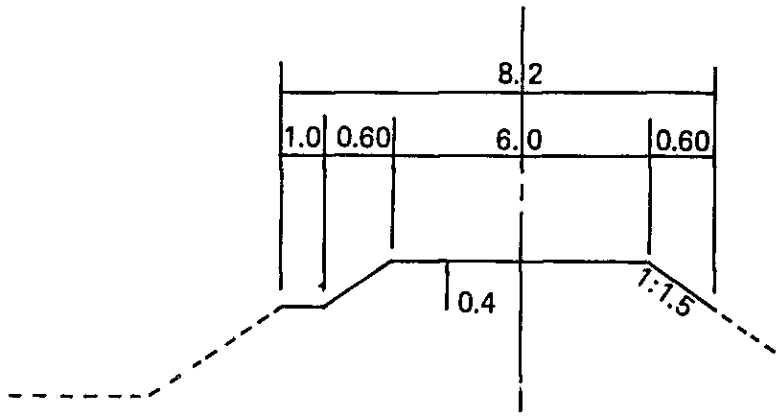


Fig. 5-3-10 Farm Road Standard Section
(Unit: m)

Table 5-3-5 Total Length of Operation and Maintenance Road, and Class Other Secondary Roads

Operation and Maintenance Road, Secondary Road	Total length (km)	Site area (ha)	Remarks
Operation and Maintenance Road No. 1	5.6	6.44	
" " No. 2	6.9	7.94	
" " No. 3	15.0	17.25	
" " No. 4	9.5	10.93	
" " No. 5	17.5	20.13	
" " No. 6	14.0	16.10	
" " No. 7	9.0	10.35	
" " No. 8	1.0	1.15	
" " No. 9	34.5	39.68	
" " No. 10	2.9	3.34	
" " No. 11	2.3	2.65	
" " No. 12	8.5	9.78	
" " No. 13	(54.9) 29.4	(63.14) 33.81	(Whole) within area
" " No. 14	1.2	1.38	
Subtotal	157.3	180.93	
Cross road (along irrigation and drainage canal)	461.3	530.50	
Total		711.43	

CHAPTER 6

LAND USE PLAN AND OTHERS

6.1 Land Utilization Plan

6.1.1 Basic policy for land utilization plan

The main objective of this project is to achieve the integrated agricultural development of a vast extent of unused and unvalued land spreading along the Parana River. As expounded in Chapter 2, this project area is limited in productivity considerably because of undesirable topological features. Accordingly, no increase of productivity would be prospected under present conditions.

Three activities written below will consequently contribute to promoting utilization of the land and, as a result, further development of local economy.

To improve agricultural infrastructure of drainage canal and road and etc.

To improve land productivity by using water which will be available as a result of the construction of the Yacyreta Dam for irrigation.

To increase overall farm production on the principle of raising the right product on the right place.

(1) The existing conditions and problems of the area

1) Natural disaster

① Rainfall and drainage

The project area has a little high annual rainfall of 1,500 mm on the average, the monthly average ranging from 90 to 160 mm, with the average number of from 5 to 8 rainy days in a month. Since rainfall is sufficient in this area, there is no limiting factor of rain shortage on agriculture.

From this fact, it is quite reasonable to say that the idea of constructing an irrigation system in this area is no requisite matter unless certain special farm products are to be raised.

However, natural drainage function is extremely poor at some places in this area. There will occur some inundation or areas locally if rain falls because 10 year's daily probability is 164.4 mm/day.

② Temperature

The area is 21°C in annual average. Average maximum and minimum temperature are 26.8°C, 15.9°C, respectively, which means mild climate very suitable for farming.

③ Effects of wind

In this area, the wind blows at an monthly average velocity ranging from 2.5 to 4 meters/sec, which is below 5 meters/sec, with rare occurrence of frosts. Consequently, it is hardly necessary to have windbreaks forest in this area.

2) Soil conditions

① Farm land conservation

The project area are features a low flat land with a overall gentle gradient, so that rainfall is unlikely to result in water erosion.

Since the soil mixes non-caking earth such as Regosols, care should be exerted in the design of an aqueduct or the like so that erosion will not occur.

② The bearing capacity of the soil

The area shows from 2.2 to 20.1 in the bearing capacity of the solid (with the average of 5.9 as measured by the Yamanaka hardness meter) except for some parts of swamps. With improvement of drainage, the soil will be hard enough for farm machinery to move about on it without sinking.

③ Conservation of soil fertility

The project area is relatively poor in natural fertility as compared with hilly land Furvisols. Because of this, soil fertility conservation measures will have to be maintained. Application of green manure and rotation of paddy field and grazing land are recommended as effective to this aim.

3) Conservation of forest

The forest presently dominates 7% of the total area of the project area and consists of natural forest. There are very few marketable trees. These forests should be left intact for conservation of natural environment.

4) Enhancement of land use

The project area comprises for the most a vast extent of swamp except for paddy fields developed in the gently sloped alluvial fans and small arable land scattered in the natural forests. It can be said that ways of farming in which that sections of land which have good drainage condition are used as grazing land stand contrary to good land use.

5) Land possession and land utilization

As already expounded in Land Possession, ownership of land within the project area is possessed by a very small number of big landowners, the majority of whose land are fenced up. These fenced land contain vast areas of swamps with low land use.

Although settlers have inhabited the south part of the project area, development is slow in progress in those sections for poor-drainage topology in this part. A development plan should be designed such as to treat those swamps according to their particular conditions and size.

(2) Basic policies in the formulation of outline of the land utilization project

In the formulation of outline for land utilization plan, rational use of land resources, farming on the principle of raising the right crop on the right place, farm land preservation, and enhancement of the use of land should be emphasized as the objectives of the plan, and to facilitate the achievement of these objectives, the following policies should be set up.

1) The scope of the project area

The project area is confined to that area of unused and unvalued area which will be able to make use of irrigation water to be made available as a result of the construction of the Yacyreta Dam.

2) Techniques for the plan

The project area is classified by use into land for agriculture (paddy field with irrigation, upland field, grazing land), drainage, traffic, residence, and facilities for agricultural processing by overall coordination of results of land classification, proposed drainage projects, land consolidation plans, and basic policies recommended by the Paraguay government.

6.1.2 Formulation of outline of the scope of the project area

The scope of the project area is generally demarcated as follows according to the policies in the land utilization plan.
(Refer to Fig. 6-1-1 Plan of the project area)

(1) The boundary bordered on the hilly land on the north

Hilly land more than 90 meters in elevation features the land and is highly advanced in effective land use because of good drainage conditions. The project area is demarcated, as a rule, along the elevation line of 90 meters. Where the contour line of 90 meters recedes in protrusion as there are valleys or dales, the area is demarcated within the scope of about 2 km as a result of considered compromise between good natural drainage and the geographical configuration of the area.

(2) The western boundary

From the standpoints of convenience of transportation and water catchment, the demarcation line is drawn along the San Ignacio road on the west.

(3) The southern boundary

1) Between Ayolas and Yabebyry

The area along the Parana River falls here/in this district falls/ within the flood zone of the main stream. The demarcation line follows the existing road running between Ayolas and Yabebyry as a result of consideration of the distribution of urbans and settlements.

2) The settled area

There is a settled area of 3,300 ha along the Ayolas-Yabebyry road. Although this area is being developed, it needs systematic improvement of drainage at places because of its topological condition. It was decided to include settled area within the scope of the present land utilization plan. It was agreed with the Paraguay authorities concerned to treat this settled area as a special district for political reasons which included the problem of allotment of project cost.

3) Between Ayolas and the Yacyreta Dam right bank

The demarcation line is drawn to follow the route Access 1 and the Sanchago-Ayolas road that branches off from it. Along this road