7. PROJECT BENEFITS

7.1 Economic Benefits

The economic benefits attributable to the Project consist of increment in agricultural production less incremental costs, both of which are worked out on the basis of economic value from the viewpoint of the national economy.

The increase in agricultural production would be due mainly to (1) the newly irrigated area of 3,500ha; (2) more intensive use of land; and (3) heigher yield of rice.

The crop production gradually increases after commencement of the partial operation of the Project. The build-up period for full development of rice production is assumed to be 5 years after completion of the construction works.

The Project will, when fully developed, generate net benefits amounting about US$2.0 million per year, which is the difference between the annual production values under future "with" and "without" Project conditions.

7.2 Farmers' Income

The main beneficiaries of the Project will be the farmers in the Project area. At present, there are about 9,067 farm households in the Project area with rice fields under rainfed condition.

Without the Project, the net average income from crop production for a farmer who cultivates about 0.4ha of rainfed farmland is estimated at Rp.223,400/year based on a yield of 3.2 tons of paddy/ha/year and 0.8 tons of Groundnuts/ha. With the Project, the average net crop income of the farmer would be increased to Rp.714,200/year based on a yield of 10.0 tons of paddy/ha during both the wet seson and dry season and 1.2 tons of Groundnuts/ha.

7.3 Savings in Foreign Exchange

As a net importer of rice, the Government of Indonesia determined self-sufficiency in foodcrops as one of the principal goals. The Project will, after completion of the Project works, contribute each year an added amount of about

22,840 metric tons of paddy or 15,500 metric tons of milled rice, which will contribute considerably to savings in foreign exchange.

The details of the Project benefits will be discussed in ANNEX-XI.

Table VI-1 AREAS AND POPULATION BY ISLAND IN INDONESIA

	AREA		POPULATION		
	km^2	(%)	1971	1980	(%)
JAVA	132,187	(6.89)	76,086,327	91,269,528	(61.88)
Jakarta	590	(0.03)	4,579,303	6,503,449	(4.41)
West Java	46,300	(2.41)	21,623,529	27,453,525	(18.61)
Central Java	34,206	(1.78)	21,877,136	25,372,889	(17.20)
Yogyakarta	3,169	(0.17)	2,489,360	2,750,813	(1.87)
East Java	47,922	(2.50)	25,516,999	29,188,852	(19.79)
SUMATRA	473,606	(24.67)	20,808,148	28,016,160	(19.00)
KALIMANTAN	539,460	(28.11)	5,154,704	6,723,086	(4.56)
SULAWESI	189,216	(9.85)	8,526,901	10,409,533	(7.05)
NUSA TENGGARA	88,488	(4.61)	6,610,074	8,487,110	(5.76)
MALUKU & I. JAYA	496,486	(25.87)	2,013,005	2,584,881	(1.75)
INDONESIA	1,919,443	(100.00)	119,208,229	147,490,298	(100.00)

Source: Population Census 1980, BPS

Table VI-2

POPULATION AND POPULATION GROWTH RATE BETWEEN 1971-1980

	1971	1980	Average Annual Growth Rate (%)
Indonesia	119,208,229	147,490,298	2.32*
West Java Province	21,623,529	27,453,525	2.66
Banten Region	1,978,359	2,486,813	2.57
Kabupaten Serang	859,467	1,109,186	2.85

Note: * excluding East Timor

Source: Sensus Penduduk 1980, BPS

Table VI-3

POPULATION DENSITY

	Area (km^2)	Density (person/km^2)
Indonesia	1,919,443	77
West Java Province	46,300	593
Banten Region	7,632	326
Kabupaten Serang	1,876	591

Source: Statistik Indonesia 1980/81, BPS and Statistic Data in Serang

Table VI-4 **GROSS DOMESTIC PRODUCT BY SECTOR OF ORIGIN AT CONSTANT 1973 PRICES, 1978-1981**

(Rp billion)

	1978	1979	1980	1981
Agriculture	3,134.8 (33%)	3,255.6 (32%)	3,424.9 (31%)	3,545.5 (30%)
Mining	1,048.8	1,046.9	1,034.6	1,069.1
Manufacturing	1,235.6	1,395.3	1,704.6	1,909.4
Electricity, Gas, Water	56.9	68.6	77.9	89.9
Construction	528.9	562.8	639.3	700.6
Transport	514.2	559.8	609.4	652.5
Trade	1,530.3	1,681.1	1,851.9	2,067.9
Other Services	1,517.0	1,594.8	1,826.6	1,982.5
Total	9,566.5	10,164.9	11,169.2	12,017.4

Source: National Income of Indonesia, 1978-1981, BPS

Table VI-5 **PERCENTAGE OF EMPLOYED PERSONS BY INDUSTRY IN INDONESIA**

Industry	1961	1971	1980
Agriculture	71.9	64.2	54.8
Mining & Quarrying	0.3	0.2	0.7
Manufacturing	5.7	6.5	8.5
Electricity, Gas and Water	0.1	0.1	0.2
Construction	1.8	1.6	3.1
Trade	6.7	10.3	12.9
Transport and Communication	2.1	2.3	2.9
Finance	-	0.2	0.4
Services	9.5	10.0	15.1
Others	1.9	-	0.1
Not Stated	-	4.6	1.3
	100.0	100.0	100.0

Source: Welfare Indicator, 1980, BPS

Table VI-6 **GROSS DOMESTIC PRODUCT IN INDONESIA AND GROSS REGIONAL DOMESTIC PRODUCT IN WEST JAVA AT CURRENT MARKET PRICES IN 1978**

(Rp billion)

	Indonesia	West Java	Share of West Java (%)
Agriculture	6,706.0	947.7	14.1
(Food Crops)	(3,991.4)	(676.2)	
(Other)	(2,714.6)	(271.5)	
Mining	4,357.6	311.5	7.2
Manufacturing	2,420.4	311.1	12.9
Electricity, gas, water	119.3	23.8	20.1
Construction	1,242.1	130.2	10.5
Trade	3,450.2	713.1	20.7
Other service	4,451.4	556.6	12.5
Total	22,746.0	2,994.0	13.2

Source: Regional Income by Province in Indonesia, 1981, BPS

Table VI-7

BALANCE OF TRADE

(Million US$)

	1975	1976	1977	1978	1979	1980
EXPORT	7,102	8,547	10,853	11,644	15,590	21,910
Oil/Products	5,311	6,004	7,298	7,439	8,871	12,859
Group A*	813	1,158	1,747	1,828	2,270	2,727
Group B**	978	1,385	1,808	2,377	4,449	6,324
IMPORT	4,770	5,673	6,230	6,690	7,202	10,834
BALANCE	2,334	2,874	4,623	4,954	8,388	11,076

* Group A including Rubber, Copra, Coffee, Plam kernel, Palm oil, Tobacco, Pepper and Tin

** Group B including Tea, Copra cake, Fibre, Copal and Damar, Wood and Others

Source: Indikator Ekonomi, Mei 1982, BPS

Table VI-8 EXPORT OF SELECTED COMMODITIES IN INDONESIA
(FOB Amount in Million US$)

	1975	1976	1977	1978	1979	1980
Petroleum & Products	5,311	6,004	7,298	7,439	8,870	12,859
Wood	500	780	954	995	1,796	1,852
Rubber	258	530	588	716	936	1,165
Coffee	100	238	599	491	614	658
Palm oil	152	136	184	208	204	254
Tin	140	165	250	286	404	510

Source: Indikator Ekonomi, Mei 1982, BPS

Table VI-9

IMPORT OF RICE IN INDONESIA

(including glutinous rice)

Year	Volume 1,000 ton	Value US$ Million
1975	692.6	326.5
1976	1,301.2	450.1
1977	1,973.4	678.0
1978	1,841.6	591.5
1979	1,922.0	596.3
1980	2,011.7	690.4
1981	538.3	206.4

Source: Indikator Ekonomi, Mei 1982, BPS

Table VI-10 **LENGTH OF ROAD AND ITS CONDITION IN INDONESIA AND WEST JAVA**

	Total (km)	Good	Moderate	Damage	Heavy Damage	Un-specified
Indonesia	142,314	28,642 (20%)	50,447 (35%)	24,502 (17%)	34,052 (24%)	4,671 (4%)
West Java	11,533	3,513 (31%)	3,888 (34%)	2,009 (17%)	2,003 (17%)	90 (1%)

Source: Statistik Indonesia, 1980/1981, BPS

Table VI-11 **LENGTH OF ROAD AND ITS CONDITION IN KABUPATEN SERANG**

	Length (km)	Damaged (%)
State Road	59.43	0
Provincial Road	61.03	0
Kabupaten Road	569.50	57
Desa Road	1,895.35	100

Source: Laporan Tahunan, 1980, Dinas Pertanian Kabupaten Serang

Table VI-12 **PRESENT GENERAL CONDITION IN AND AROUND THE K-C-C AREA (IN 1980)**

	Kec. KOPO	Kec. PAMARAYAN	Kec. CIKANDE	Kec. CARENANG
Total population	43,440	41,085	52,365	40,666
Total household	8,723	9,924	10,453	8,133
Average number per family	4.98	4.14	5.00	5.00
Farm household	8,592	9,733	8,339	6,504
Total administrative area (ha)	8,518	7,344	8,268	5,493
Rice field (ha)	2,880	3,185	4,817	4,196
Upland, orchard & homeyard	4,261	3,466	2,533	1,148
No. of Village	15	15	12	11
No. of BUUD/KUD	2	1	2	3
BRI Unit Desa	1	1	2	2
No. of Huller	17	17	39	38

Source: Agriculture office in Serang, Kecamatan offices and BPP offices in the area

Table VI-12A

POPULATION BY AGE GROUP IN AND AROUND THE K-C-C AREA (1980)

Age	Group	Kec. Kopo	Kec. Pamarayan	Kec. Cikande	Kec. Carenang
0-4	M	3,852	3,684	4,533	3,219
	F	3,629	3,588	4,475	3,146
5-9	M	3,573	3,565	4,520	3,286
	F	3,523	3,353	4,270	3,118
10-14	M	2,792	2,558	3,179	2,362
	F	2,255	1,950	2,541	1,753
15-24	M	3,196	2,750	3,688	2,415
	F	4,050	3,548	4,615	3,419
25-49	M	6,083	5,810	7,342	5,889
	F	6,168	6,253	8,080	6,824
50 up	M	2,166	1,982	2,536	2,550
	F	2,153	2,044	2,486	2,613
Total		43,440	41,085	52,265	40,666

Source: Statistic Office, Serang

Table VI-13

PRESENT GENERAL CONDITIONS OF THE STUDY AREA (1980)

Kecamatan	Desa	Population	Household	Average Family Size	Farm Household	Rice Field (ha)
Kopo	Cemplang	2,362	464	5.09	455	130
	Nanggung	2,922	652	4.48	646	204
	Pagintungan	2,285	576	3.97	573	147
	Jawilan	3,566	670	5.32	664	262
	Pasirbuyut	2,947	472	6.25	466	261
	Parakan	2,466	436	5.66	432	364
	Maja	2,276	636	3.58	630	177
	Junti	4,976	829	6.00	803	472
	Gabus	3,830	958	4.00	819	270
Pamarayan	Pamarayan	2,729	686	3.98	652	238
	Damping	2,294	459	5.00	459	129
	Wirana	2,660	528	5.04	527	214
	Keboncau	2,220	733	3.03	720	205
	Pudar	2,372	589	4.03	587	234
	Binong	3,318	840	3.95	834	279
	Pasirlimus	2,955	731	4.04	723	281
	Pangawinan	2,122	528	4.02	521	150
	Bandung	3,487	695	5.02	687	278
	Mander	4,022	803	5.01	796	340
Cikande	Cikande	3,975	795	5.00	636	242
	Total	59,784	13,080	4.57	12,630	4,877

Source: Agriculture Office in Serang, BPP offices and Desa offices

Table VI-14

LAND HOLDING SIZE OF FARMERS IN INDONESIA (1973)

	Farm Family	Area	Ha/Family
Java	8,664,446	5,505,215	0.64
Sumatra	2,847,068	3,802,749	1.34
Kalimantan	689,195	1,868,144	2.71
Sulawesi	1,101,187	1,523,485	1.38
Bali	305,154	266,605	0.87
Nusa Tenggara	646,678	942,121	1.46
Maluku	119,814	259,862	2.17
Total	14,373,542	14,168,181	0.99

Source: 1973 Agricultural Census, BPS

Table VI-15

FARM FAMILIES BY LAND HOLDING SIZE IN INDONESIA (1973)

	0.5ha	0.5-1.0ha	1.0-5.0ha	5.0ha	Total	Average size
Indonesia	6,560,758	3,554,297	3,951,119	307,368	14,373,542	0.99
West Java	1,498,475	538,178	419,584	12,044	2,468,281	0.62

Source: 1973 Agricultural Census, BPS

Table VI-16

PRICES OF MAJOR FOOD CROPS IN THE RURAL MARKETS OF JAVA

Year & Month		Milled Rice (kg)	Maize mixed (kg)	Soy-beans (kg)	Peanuts shelled (kg)	Cassava (kg)	Sweet potatoes (kg)
1975	Average	98	59	164	252	17	20
1976	"	141	77	176	294	28	30
1977	"	152	71	197	344	29	32
1978	"	165	77	218	370	28	32
1979	"	210	103	292	480	33	38
1980	"	246	111	329	577	42	45
	Jan.	282	114	378	605	44	48
	Feb.	283	112	389	613	45	48
	Mar.	273	112	395	625	46	49
	Apr.	266	113	399	659	46	50
	May	264	116	400	672	46	51
	Jun.	265	119	388	675	47	51
	Jul.	266	122	382	687	47	52
	Aug.	268	125	383	691	47	52
	Sep.	274	126	382	679	46	52
	Oct.	284	132	382	665	45	52
	Nov.	290	133	387	664	45	51
	Dec.	294	131	383	663	45	51

Source: Indikator Ekonomi, Mei 1982, BPS

Table VI-17

CALCULATION OF 1990 ECONOMIC FARM GATE PRICE OF PADDY
(Import Substitution Price)

	US$/ton	Rp/ton
Milled rice 5% broken, F.O.B. Bangkok	425	293,250
Quality discount (x0.9)	383	264,270
Ocean freight to Jakarta	20	13,800
Port handling and Storage	7	4,830
Wholesale price, Jakarta	410	282,900
Inland transportation	11	7,500
Wholesale price, Project area	399	275,300
Conversion to dry paddy (x0.68)	271	186,900
Milling, local transportation, etc.	10	6,900
Economic farm gate price of dry paddy	261	180,000

Source: Commodity Prices and Price Projections in 1981 Constant Price, World Bank
Conversion rate: US$1=Rp.690

Table VI-18

CALCULATION OF 1990 ECONOMIC FARM Gate PRICES OF MAIZE, GROUNDNUTS AND SOYBEANS

(Import Substitution Price)

	Maize		Groundnuts		Soybeans	
	US$/ton	Rp/ton	US$/ton	Rp/ton	US$/ton	Rp/ton
1. International price	142	97,900	598	412,600	365	251,800
2. Freight and insurance	20	13,800	20	13,800	20	13,800
3. Storage, handling, etc.	7	4,800	7	4,800	7	4,800
4. Inland transportation	7	4,800	7	4,800	7	4,800
5. Marketing costs	10	6,900	10	6,900	10	6,900
6. Farm gate price	152	104,800 (Rp.105/kg)	608	419,500 (Rp.420/kg)	375	258,700 (Rp.259/kg)

Source: Commodity Prices and Price Projections in 1981 Constant Dollar, World Bank

Table VI-19

CALCULATION OF 1990 ECONOMIC FARM GATE PRICES OF FARM INPUTS

	US$/ton	Rp/ton
1. Fertilizer		
(1) Urea		
World market price	265	182,800
Freight and insurance	15	10,300
Storage, handling, etc.	10	6,900
Inland transportation	10	6,900
Marketing costs	10	6,900
Farm gate price	310	213,900 (Rp.214/kg)
(2) TSP		
World market price	195	134,500
Freight and insurance	15	10,300
Storage, handling, etc.	10	6,900
Inland transportation	10	6,900
Marketing costs	10	6,900
Farm gate price	240	165,600 (Rp.166/kg)
(3) KCL		
Farm gate price	155	106,950 (Rp.107/kg)
2. Agro-chemicals		
(1) Pesticide, Fungicide		
Farm gate price		6,000,000 (Rp.6,000/lit)
(2) Rodenticide		
Farm gate price		2,100,000 (Rp.2,100/lit)

Source: Commodity Prices and Price Projection in 1981 Constant Dollar, World Bank, 1982

Conversion rate: US$1=Rp.690

Table VI-20 ECONOMIC AND FINANCIAL PRICES OF FARM PRODUCTS AND FARM INPUTS AT FARM GATE

		Unit	Financial Price (Rp/kg)	Economic Price (Rp/kg)
1. Inputs				
Seed	Rice	kg	250	250
	Maize	"	600	600
	Peanut	"	350	350
	Soybean	"	800	800
	Chili	"	100	100
Fertilizer	Urea	"	70	214
	TSP	"	"	166
	KCL	"	"	107
Agro-chemicals				
	Pesticide/Fungicide	kg/lit	1,230	6,000
	Rodenticide (Klerat)	kg	500	2,100
Farm Labour				
	Hard Worker	man/day	1,200	720
	Light Worker	"	1,000	600
2. Outputs				
Milled rice		kg	250	275
Unhusked rice		"	135	180
Soybean		"	300	259
Groundnut		"	450	420
Maize		"	150	105
Chili		"	600	600
Cassava		"	45	45

Source: 1. Commodity Prices and Price Projection in 1981 Constant Dollar, World Bank, 1982

2. Farm Economy Survey, Statistic Office, 1982, Serang

Table VI-21

TYPICAL FARM BUDGET
(0.4ha Farm)

	Without Project (Rp)	With Project (Rp)
1. Gross Income	223,400	756,000
Farm Income	186,200	756,000
Rainy season paddy	(172,800)	(270,000)
Dry season paddy	(0)	(270,000)
Palawija crops (Groundnut)	(13,400)	(216,000)
Other Income	37,200	0*
2. Expenditures	199,200	579,100
Farming expenditures	38,000	143,400
Rainy season paddy	(36,400)	(44,500)
Dry season paddy	(0)	(44,500)
Palawija crops (Groundnut)	(1,600)	(54,400)
Taxes and interest	11,200	35,700
Living expenses	150,000	400,000
3. Net Income (Capacity to pay)	24,200	176,900

* Present condition of a rice a year will be changed into two rice croppings plus one palawija cropping a year with the project and farmers' net income will be increased by more than seven (7) times compared with the present condition even if other income will be zero. It is also considered that there will be very little chance for farmers to do other business than farming under with project condition.

ANNEX - VII

IRRIGATION AND DRAINAGE

ANNEX-VII IRRIGATION AND DRAINAGE

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ANNEX - VII

IRRIGATION AND DRAINAGE

1. THE PROJECT AREA

1.1 General

The K-C-C area is located at the eastern part of the District (Kabupaten) of Serang, having a gross land area of about 22,000ha. The study area with a gross land area of about 11,500ha which occupies the southern part of the K-C-C area, has been selected for the delineation of the potential irrigable area of the Project. The study area is bounded by the Cibeureum/Cidurian rivers to the east, by the Ciujung Project area to the west, by District road connecting Cikande and Babakan to the north and by District boundary to the south. There exist about 5,000ha of rice field and about 1,000ha of upland field in this study area, out of which about 3,800ha in gross of rice field has been selected as the Project area, i.e. the irrigatin development area, taking into consideration the economic, engineering and other aspects.

1.2 Present Situation of the Study Area

Rice cultivation is very common in the study area, but most of the rice cultivation is made under rainfed condition due to lack of irrigation facilities and dependable water supply. The cultivation patterns are much affected by seasonal distribution of rainfall and therefore most of rice cultivation is concentrated in the wet season. In the wet season, road condition becomes muddy because of poor maintenance and drainage, which sometimes hampers agricultural activities in this area.

1.3 Basic Concept for Irrigation Development

The proposed Project aims at achieving the increase of agricultural production and thereby improvement of the farmers' living standard in the Project area through the provision of irrigation systems using water resources from the Cibeurem river basin. With this view, the major concept for the irrigation development would be: 1) to stabilize and improve the production of rice in both wet and dry season; 2) to stablize and increase the production of palawija crops such as groundnut, soybean, etc.; and 3) to raise the living standard of the farmers in the Project area through the increase of farm products.

1.4 Water Resources

For the establishment of the new irrigation network in the Project area, the diversion works which consist of dam, intake structure, spillway and gates are to be constructed at the proposed dam site of Gadeg on Cibeureum river, about 5km south of the boundary of the Project area. The catchment area of the Cibeureum river up to Gadeg site is about 117 km^2. Water level record at Gadeg site is available for about two years but it cannot be used because some data are not stated. Accordingly, the estimation of the discharge of the river at Gadeg site has been made using the discharge data at Kopomaja gauging station on the Cidurian river which has the same watershed with the Cibeureum and has the reliable discharge data for the long period. The estimation of the discharge at Gadeg has been made paying full attention to the characteristics of the river basin, rainfall and discharge of Kopomaja site. Based on the estimated discharge for 1963 - 1976 at Kopomaja, the discharge at Gadeg site is estimated as 0.24 m^3/s at the minimum and 27.68 m^3/s at the maximum. The dependable water calculation based on 80% of available water is shown in Table VII-16.

1.5 Comparative Study for Basic Irrigation Development Plan

Discharge of the Cibeureum river at Gadeg site fluctuates considerably throughout the year. As indicated in Table VII-16, discharge of Gadeg increases steadily at the beginning of each growing season. However, from the middle of December until the beginning of January, discharge drops sharply. Discharge is relatively plentiful from Janauary until May, after which it decreases with the period of minimum discharge lasting from June to August.

The proposed cropping pattern has been devised taking into consideration the discharge characteristic of the Cibeureum river, and is formulated to maximize (i) divertible water resources, (ii) irrigable area and (iii) Project benefits.

The diversion requirement from the Cibeureum river has been calculated with consideration for the maintenance flow of the downstream portion of the river, and the daily domestic water needs of residents in the downstream area of the river.

The relationship between divertible discharge amount and irrigation requirement has been calculated for the 13 cropping years from 1963 to 1976. Findings have been tabulated as Table VII-16.

2. IRRIGATION AND DRAINAGE PLAN

2.1 Irrigation Water Requirements

2.1.1 General

In planning of an irrigation project, a full knowledge of irrigation water requirements of crops from the time of seeding until harvest is needed. It is also necessary to know the total amount of water required in each season to produce optimum yields for the climate and soils involved. Peak water requirement by crop must be known in order to determine the capacity of irrigation system. It is also important to check whether the peak use periods for different crops in the study area occur at the same time or at different months. This may be a very important consideration where water resources are limited compared with the magnitude of the irrigable area.

Since the field measurement of consumptive use of water by crops was not carried out in the study period because of shortage of time, the study was mainly depending on the field measurement results obtained in the similar nature projects and recommendations by FAO/UNDP. The empirical and theoretical formulas developed in the past by various experts were also used in this study.

The calculation of irrigation water requirement for the proposed cropping patterns has been made on 10-day basis from 1963 to 1976 as shown in Table VII-16.

2.1.2 Consumptive Use of Water

The consumptive use of water is the sum of the volumes of water used by vegetative growth in a given area in the transpiration or building of plant tissue, and that evaporated from adjacent soil or intercepted precipitation on the area in any specified time. Practically, the consumptive use of water is obtained by multiplying the class-A pan evaporation or potential evapotranspiration by the crop coefficient.

(1) Potential evapotranspiration

In the study area, the evaporation data are available at Serang (1971 - 1979), but these data are not used in this study, because there found some disturbances in these data, i.e. extremely high and low values and many blanks in daily data. Instead, the potential evapotranspiration calculated using the Modified

Penman Formula has been used in the study. In the selection of formula among the various empirical and theoretical formulas, the latitudinal and altitudinal location of the study area and availability of meteorological data are fully taken into consideration. The meteorological data and calculation methods used in the water requirements study are summarized as follows:

(A) Meteorological Data Used

a) Mean Monthly Air Temperature (t)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
26.3	26.7	26.6	27.0	27.1	26.6	26.4	26.6	26.8	27.2	27.1	26.6

(°C)

b) Mean Monthly Relative Humidity (Hm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
84	82	84	82	81	80	80	78	77	77	78	82

(%)

c) Mean Monthly Sunshine Duration (h)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
96.1	92.4	117.8	120.0	130.2	132.0	161.2	164.3	156.0	136.4	120.0	93.0
3.1	3.3	3.8	4.0	4.2	4.4	5.2	5.3	5.2	4.4	4.0	3.0

(hr/month and hr/day)

d) Mean Monthly Wind Velocity (U_2)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
126.1	141.1	126.1	116.0	126.1	126.1	123.6	136.7	132.4	117.7	123.6	146.3

(km/day)

e) Mean Monthly Pan Evaporation (by class-A pan)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
80.6	109.2	117.8	123	136.4	135.0	139.5	145.7	126.0	130.2	129.0	105.4
2.6	3.9	3.8	4.1	4.4	4.5	4.5	4.7	4.2	4.	4.3	3.4

(mm/month and mm/day)

(B) Calculation Methods

The calculations have been made using the following two empirical formulas.

i) Modified Penman Method

This method presents the complete theoretical approach to the calculation of potential evapotraspiration showing the consumptive use inseparably connected with the solar energy. The formula representing the potential evapotranspiration is as follows:

$$Egr = \frac{\Delta(H_{nt}^{sh} - H_{nt}^{lo})/L + Ea}{\Delta + \gamma a}$$

In which,

- Egr : the Evaporation Index representing the Potential evapotranspiration of short-cut grass (mm per 24 hrs)
- H_{nt}^{sh}: the net short-wave radiation (Langleys per 24 hrs)
- H_{nt}^{lo}: the net long-wave radiation (Langleys per 24 hrs)
- Ea : the evaporation computed from the aerodynamic equation, assuming the surface temperature to be equal to the air temperature (mm per 24 hrs)
- L : the latent heat of vaporization (Langleys per mm)
- Δ : the slope of the saturated vapour pressure (V), temperature curve at temperature of the air (mmHg per ^{0}C)
- a : a factor representing the stomatal diffusion resistance. A valve of 0.7 has been used in the computation of the Evaporation Index.
- γ : a factor, called the psychrometer constant, which is defined by Bowen's dimentionaless ratio (0.49mm Hg per $0^{0}C$)

If no radiation data are available, the net short-wave radiation can be calculated by means of the following formula:

$H_{nt}^{sh} = (1-\gamma)\, H_A\, (0.29 \cos \phi + 0.52\, n/N)$

In which,

- γ : the reflectivity of the surface for incident short-wave radiation: for grass a value of 0.25 has been selected
- H_A : the theoretical maximum short-wave radiation received if no atmosphere were present (Angot value: Langleys per 24 hrs)
- ϕ : the latitude (degrees)
- n/N : the relative duration of bright sunshine

The formula for calculating the net long-wave radiation is:

$H = 0.97\, \sigma T_K^4\, (0.47 - 0.077\, \sqrt{ea})\, (0.2 + 0.8\, n/N)$

In which,

- σ : the Stefan-Bolzmann constant equal to 0.8132×10^{-10} Langlays min - 1.0k-4
- T_K^4 : the average daily air temperature at 2 meters above ground level (degree Kelvin)
- e_a : the average daily saturated vapour pressure at dew-point temperature of the air at 2 m ground level (mmHg)
- Ea : calculated by means of the following formula:
  $Ea = 0.35\, (0.5 + 0.54u)\, (e_s - e_a)$

In which,

- u : wind velocity at 2 m above ground level (m/sec)
- $e_s - e_a$: the average daily water vapour pressure deficit of the air at 2m above ground level (mmHg)

The process of the calculations is shown in Table VII-1 (1)

ii) Christiensen-Hargreaves Method

The Christiensen-Hargreaves method is a modification of the Hargreaves formula in terms of wind, sunshine, and elevation factors. The method is explained as follows.

$ETo = 17.4 \cdot D \cdot Tc\, (Fh \cdot Fw \cdot Fe)$

$Fh = 0.59 - 0.55 \cdot Hn^2$

$Fw = 0.75 + 0.0255 \cdot Wkd$

$Fs = 0.478 + 0.58 \cdot S$

$Fe = 0.950 + 0.0001 \cdot E$

Where,

ETo : Potential evapotranspiration (mm/day)

D : Day-time coeffecient (See Table VII-7)

Tc : Temperature (°C)

Hn : Noon humidity (%)

$Hn = 0.4\ Hm + 0.6\ Hm^2$

Hm : Relative humidity (%) (See Data Book)

Wkd : Wind velocity at 2 m above the field (km/day)

S : Sunshine hour ratio

$S = n/N$

n : Sundhine hours (hr/day)

N : Maximum possible sunshine hours (hr/day) (See Table VII-4)

E : Elevation above the sea level (m)

The calculations of evapotranspiration based on each formula are given in Tables VII-1 (1) and VII-1 (2) respectively.

(C) Results of Calculation

Potential evapotranspiration has been calculated by the above two empirical formulas as tabulated below. The values obtained would be applied to estimate of water requirement. The maximum and minimum values of potential evapotranspiration are 4.67 mm/day in September and 3.78 mm/day in January respectively according to the modified Penman method.

(mm/day)

Method	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
M. Penman	3.78	4.00	4.06	4.03	3.93	3.84	4.15	4.46	4.67	4.45	4.30	3.83
C-Hargreaves	2.79	3.28	2.89	3.23	3.50	3.85	4.07	4.33	4.42	4.09	3.97	3.14

Judging from the above results, the Modified Penman Method is adopted in the estimation of the potential evapotranspiration.

(2) Crop Coefficient (Kc)

The crop coefficients used for paddy are the same as recommended by PROSIDA but adjusted with the aid of the Table below. The crop coefficient (Kc) curve for paddy is shown in Fig. VII-1 (1), (2)

The Kc-Curve for palawija (Peanuts, etc.), shown in the Technical Release No. 21 published by USDA in 1967 is used in the calculation, this curve is shown in Fig. VII-1 (3)

Growing Season %	The crop coefficient
10	1.08
20	1.18
30	1.27
40	1.37
50	1.40
60	1.33
70	1.23
80	1.13
90	1.02
100	0.92

2.1.3 Determination of the Basic Year for Planning

Return period of each year is calculated based on the annual rainfall in the Project area and discharge at Gadeg dam site, using data for 13 years (1964~1976) as shown in the following table.

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Annual Rainfall at Parigi	1054	1765	1691	1815	2407	1718	2637	2298	1562	2383	2471	1992	1481
	1	6	4	7	11	5	13	9	3	10	12	8	2
	125	2.4	3.3	2.3	1.2	2.8	1.1	1.3	5.0	1.2	1.1	1.7	6.7
Annual Effiectve Rainfall at Parigi	879	1182	1091	1174	1560	1095	1646	1412	1070	1609	1468	1326	981
	1	7	4	6	11	5	13	9	3	12	10	8	2
	26	2.3	3.7	2.5	1.1	3.6	1.1	1.3	4.5	1.1	1.2	1.5	8.7
Annual Rainfall at Gadeg	3090	2227	2096	1988	2659	2197	1953	2003	2110	2823	2678	2357	2131
	13	8	4	2	10	7	1	3	5	12	11	9	6
	1.1	2.9	7	12	2.0	.32	15	10	5.5	1.1	1.2	2.9	4.2

Upper figure: rainfall (mm)
Middle figure: Ranking
Lower figure: Return period (year)

The above table shows that the year of 1972 corresponds to the return period of 1/5. Therefore, the year of 1972 has been selected as the basic year for the planning of the Project.

Water balance calculation has been made to figure out the irrigable area and the results are:

The first crop (rice)	3,519ha
The second crop (rice)	3,593ha
Palawija crop (s)	3,750ha

Based on the calculation above, the net irrigable area of the Project is determined as 3,500ha.

2.1.4 Unit Irrigation Water Requirement

After knowing the consumptive use of water, the unit irrigation water requirements for each crop are calculated using the daily water balance method. For this method, the following equations are employed:

Equation for Paddy:

$IWD = (CU + PL + NW + PW - ER)/Ei$

Equation for Upland Crop:

$IWS = (CU + FA - ER)/Ei$

Where,

IWD, IWS:		unit irrigation water requirements	(l/s/h)
Cu	:	consumptive use of water = Kc · ETo	(mm/10-day basis)
PL	:	percolation loss (for paddy field only)	(mm/10-day basis)
NW	:	nursery water requirement (for paddy field only)	(mm/10-day basis)
PW	:	puddling water requirement (for paddy field only)	(mm/10-day basis)
ER	:	daily effective rainfall	(mm/10-day basis)
FA	:	farm application losses	
Ei	:	combined irrigation efficiencies	

(1) Percolation loss (PL)

Referring to the percolation rates observed at several sites in the project area as presented in Table VII-10, the percolation rates for irrigation planning in this project area are suggested as follows. The percolation loss of 2 mm/day, however, is only incorporated in the calculation of the irrigation water requirement for the captioned project.

	Percolation Rate (mm)	
	dry season	rainy season
Elevated paddy field	2	2
Lowland paddy field	1	1

(2) Effective Rainfall (Re)

Paddy

The daily rainfall data have been collected from the station as shown Fig. I-8. Among them, the data at the PR33 are used for the estimation of effective rainfall in the project area.

Effective rainfall (Re) during a growing period of paddy is estimated by the daily water depth balance method based on the rainfall records of the stations from 1963 to 1976 shown on Table I-7. The following assumptions are made prior to the calculation;

-rainfall less than 5 mm/day is ineffective,
-excess beyond 50 mm/day is also ineffective, and
-70% of the rainfall which is greater than 5 mm/day and less than 50 mm/day is effective.

The effective rainfall is estimated by every 10 day period through 13 years from 1963 to 1976, and its calculation results are shown in Table VII-11.

Palawija

The calculation is made in the same condition as paddy

-70% of the rainfall which is greater than 5 mm/day and less than 50 mm/day is effective.

(3) Farm Water Requirement (Fw)

Paddy

The farm water requirement (Fw) for paddy is expressed by the following formula.

$$Fw = Wp + (Wn + Wd)$$

Where,

- Fw : Farm water requirement for paddy field (mm/10 day basis)
- Wp : Water requirement for main paddy field after transplanting (mm/10 day basis)
- Wn : Nursery water requirement (mm/10 day basis)
- Wd : Puddling water requirement (mm/10 day basis)

The Water requirement for main paddy field (Wp) is expressed by the following formula.

$$Wp = (Cu + Pc - Re) \times Ic$$

Where,

- Cu : Water requirement for main paddy field (mm/10 day basis)
- Pc : Percolation loss in paddy field (mm/10 day bassis)
- Re : Effective rainfall for paddy (mm/10 day basis)
- Ic : Crop intensity

The nursery water requirement (Wn) is given by the following formula. The calculation is made by 10 day basis through the nursery period of 20 day.

$$Wn = Sn + Pwn$$

$$Sn = (1.5 \cdot n \cdot d - Re) \times \frac{Au}{20}$$

$$Pwn = (Pwo - Re) \times \frac{Au}{20}$$

Where,

- Wn : Nusery water requirement (mm/10 day basis)
- d : Potential evapotranspiration (ETo) + Percolation loss (Pc) (mm/10 day basis)

$\frac{Au}{20}$: Ratio of transplanting area to total paddy field area

Pw ; Puddling water (mm)

(puddling water of 120 mm is applied on reference to the following paragraph)

The puddling water requirement (Wd) is presented by the following formula.

$$Wd = (Pw - Re) \times Ap$$

Where,

Wd : Puddling water requirement (mm/10 day basis)

Pw : Puddling water in mm (mentioned below)

Re : Effective rainfall (mm/10 day basis)

Ap : Ratio of puddling area in 10-day period to total puddling area

The puddling water quantity (Pw) is theoretically assessed by soil to be saturated and porosity, and presented by the following formula.

Where,

Pw : Puddling water quantity (mm)

Ds : Water depth above soil surface after puddling (mm)

Ws : Difference of soil moisture before and afer puddling (mm)

Following assumptions are applied in the calculation and the results of soil physical analysis made in the period of field work are also adopted.

-Water depth above soil surface after puddling (Ds) is 50mm.

-Polosity (Po) is 50 % both in surface soil (d_1) with depth of 200 mm and sub-soil (d_2) with depth of 100 mm.

-Soil moisture (Ms) before water supply is 20 % in volume.

-Vapour phase (Vp) in soils after puddling is 5 %.

Then, the puddling water quantity (Pw) is calculated as follows.

$$\begin{aligned} Pw &= Ds + Ws \\ &= Ds + (d_1 + d_2) \times (Po - Ms - Vp) \\ &= 140 \text{ (mm)} \end{aligned}$$

The farm water requirement (Fw) for Palawija is presented by the following formula.

$$Fw = (Cu - Re) \times Ic$$

Where,

Fw : Farm water requirement for Palawija (mm/ 10 day basis)

Re : Effective rainfall (mm/10 day basis)

Ic : Crop intensity

The calculated results of nursery and puddling water requirement are as shown Table VII-14, VII-15.

(4) Irrigation Efficiency (E)

The irrigation Efficiency (E) is usually defined as follows;

$$E = \frac{Ea}{100} \times \frac{Eco}{100} \times 100 \ (\%)$$

Where,

Ea : Water application efficiency (%)

Eco : Water conveyance and operation efficiency (%)

i) Water Application Effeciency (Ea)

The water application efficiencies for paddy and Palawija are assumed as 80% and 75% respectively.

ii) Water Conveyance and Operation Efficiency (Eco)

The water conveyancy and operation efficiency (Eco) depend upon the condition of the irrigation system and the operation skill of the irrigation facilities. The common value of the efficiency is usable for irrigation of both paddy and Palawija. Taking into account the size of the project and the technical level of water management in the project area, the water conveyance and operation efficiency (Eco) for the Project is assumed as 80 %.

iii) Irrigation Efficiency (E)

The irrigation efficiencies (E) for both paddy and Palawija are calculated based on the above mentioned assumptions. The results are summarized as follows.

Crop	Irrigation Efficiency (E)
Paddy	64 %
Palawija	60 %

(5) Diversion Water Requirement (Dw)

The diversion water requirement (Dw) is calculated by the following formula.

$$Dw = Fw \times \frac{100}{E}$$

Where,

Dw : Diversion water requirement (mm/10 day basis)

Fw : Farm water requirement (mm/10 day basis)

E : Irrigation efficiency (%)

The calculations are shown in Table VII-16.

(6) Unit Diversion Water Requirement

i) The calculations for the unit diversion water requirement for the proposed cropping pattern have been made for the years from 1963 to 1976. The calculations have been made by the continuous simulation method for 13 years. The results of the calculations are presented in Table VII-13. The results show that the maximum unit diversion water requirement is Q=1.637 ℓ/sec/ha for the first paddy occurs at the end of December 1963, and the second maximum unit diversion water requirement is Q=1.446 ℓ/sec/ha for the same occurs at the middle of December 1974.

For the second paddy, the maximum unit diversion water requirement of Q=1.506 ℓ/sec/ha at the end of April 1972 and the second maximum unit diversion water requirement is Q=1.433 ℓ/sec/ha at end of April 1971.

Regarding the Palawija, the maximum unit diversion water requirement is Q=0.847 ℓ/sec/ha at the beginning of September 1964 and the second maximum unit diversion water requirement is Q=0.843 ℓ/sec/ha at the end of August 1970 and 1972.

ii) Maximum unit diversion water requirements of the basic year of the planning (1972) are as follows:

The first crop (rice)	1.360 lit/s/ha	Mid-Dec.
The second crop (rice)	1.506 lit/s/ha	End-Apr.
Palawija crop (s)	0.843 lit/s/ha	End-Aug.

Design diversion water requirement has been worked out considering the probability of the effective rainfall's unavailability at the time when water requirement reaches its peak. The results of calculation are as follows:

The first crop (rice)	1.637 lit/s/ha	Mid-Dec.
The second crop (rice)	1.506 lit/s/ha	End-Apr.
Palawija crops (s)	0.843 lit/s/ha	End-Sep.

Based on the above figures, the design discharge has been calculated.

2.1.5 Design Diversion Water Requirement

The design diversion water requirement which can be used for the proposed farming practice is assumed at 80% of the total dependable water available from the Cibeureum river, in due consideration of the domestic water requirement for the inhabitnts downstream of Gadeg and the river maintenance flow. Taking into consideration the above, the water balance calculations between the dependable water and the seasonal diversion water requirement have been made on the ten day basis for the years of 1963 to 1976 and its results are presented in Table VII-9. Through this study, it has been worked out that the paddy and Palawija proposed in the Project may be cropped with the area shown below.

1. First paddy 3,500ha
2. Second paddy 3,500ha
3. Palawija 3,500ha

As to the Palawija, it may not be irrigated continuously judging from the availability of water, so it is recommended to irrigate Palawija with the interval of every 6 days, then the Palawija of 3,500ha may be irigated fully.

2.1.6 Irrigation Method

(A) Irrigation Method for Rice

The intermittent irrigation method is usually recommended for the projects, considering the situation of dependable water dischage. However, this method is quite hard to manage because most of the rice fields in the Project area lie in the Terrace, which makes the intermittent irrigation difficult. The continuous irrigation method, therefore, is recommended for rice cultivation in the Project.

(B) <u>Irrigation Method for Palawija</u>

(a) Recommendable Irrigation Method

The palawija cropping in the Project would be introduced during only three months of dry season. Considering the land preparation for upland crops in which the paddy field would be reformed, it is uneconomical to apply such typical field irrigation method as furrow irrigation. So, it is recommended that small in-field ditches would be dug by every season in order to take the irrigation water quickly into the field and supply it equally to the field. The ditches would be made in checkerboard pattern with an inteval of 10m or so. The field surface would be flooded by the water overflowed from the ditches.

(b) Irrigation Interval

i) Available Moisture (AM)

Available moisture (AM) on the field irrigation has been defined as moisture difference in effective root zone between the field capacity (pF 1.5 - 2.0) and the first wilting point (pF 3.5 - 3.8). While, it is defined as moisture difference in effective soil layer between the water holding capacity after 24 hours of soil saturation and the moisture equivalent (pF 3.0) to depletion of moisture content optimum growth. No data on the effective soil layer of the project area is available. Hence, these definitions would be applied to the calculation.

ii) Effective Root Zone Depth (D)

The effective root zone of palawija crops is determined considering that the paddy field after harvest is used for palawija cropping. The effective root zone depth (D) would be limited to 30cm of plowing depth.

iii) Soil Moisture Extraction Pattern (SMEP)

The soil moisture extraction patterns of palawija crops are determined in accordance with the "Basic Moisture Extraction Pattern" <u>/1</u> established by Shockley (U.S.A).

iv) Total Readily Available Moisture (TRAM)

The calculation of total readily available moisture (TRAM) is carried out in the following procedures. The available moisture (AMi) in a soil layer is calculated by the use of following formula.

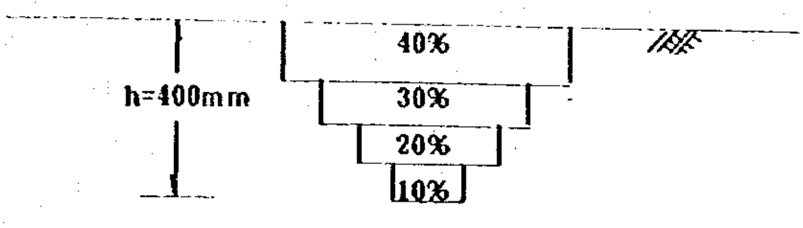
$$AMi = \frac{1}{100} \cdot (Fc - Wpf) \cdot h$$

Where,
- AMi: Availabl moisture in a soil layer (mm)
- Fc: Soil moisture at field capacity (volume %)
- Wpf: Soil moisture at first wilting point (volume %)
- h: Thickness of a soil layer (mm)

The soil moistures at both the field capacity and the first wilting point are determined based on the result of actual soil investigation in the project area as shown below:

Soil Type: Clay	Soil Moisture (volume %)
Field Capacity, Fc (pF 1.5)	43.9%
First Wilting Point, Wfp (pF 3.2)	31.9%

The thickness (h) of a soil layer in effective root zone is 400mm, and soil moisture extraction pattern (SMEP) is as shown in the following figure and limited layer is 1st layer.



$$WDI = AMi \times \frac{100}{RBMI}$$

Where, WDI: Soil moisture extraction based on each soil layer's characteristics (mm)
RMBI: Moisture extraction ratio in each soil layer (%)

Soil Layer	Total Soil Moisture Extraction in Effective Root Zone (mm)
1st Layer	30

The total readily available moisture (TRAM) is defined as the minimum value of total soil moisture extraction in effective root zone.

v) Irrigation Interval

The maximum irrigation interval is given by the following formula.

$$\text{Max. Irrigation Interval (day)} = \frac{(\text{TRAM, mm})}{(\text{Peak Consumptive Use, mm/day})}$$

The TRAM of 30mm is estimated as shown in the above table and the peak consumptive use is estimated at 4.37 mm/day. Then, the maximum irrigation interval is calculated at six days.

Finally, to meet the irrigation interval for paddy mentioned hereinbefore, the design irrigation interval for Palawija would be also proposed at six days.

2.2 Drainage

Systematized drainage systems are not at all established in the Project area. At present, excess water in this area is naturally drained through the exisiting small rivers which are usually meandering in every direction.

Some of the Project area are presently put under poor drainage condition due to shortage of adequate drainage facilities and lack of the river training for the existing river which will play very important roles for the drainability of the Project area. According to the field investigations and soil investigations, the area under poor drainage condition amounts to 250ha.

This area consists of marshy low-lying valley bottoms and saddled parts of hilly paddy area, where excess water from the surrounding terraces is collected. The poor drainage condition mentioned above is hard to be improved unless such facilities as pumping stations, embankments and other related drainage facilities, which will require a considerable amount of investment, are provided. As such it is recommended that the area under extremely poor drainage condition is to be excluded from the Project area.

Out of the remaining drainage area of 3,800ha, the area of 2,450ha which is deemed as imperfectly drained area will need the introduction of the improved drainage system.

But, this improved drainage system to be introduced will also require the improvement of the natural rivers in the proejct area, otherwise the drainage system to be introduced will not function fully.

Especially, since the rivers which run the existing paddy fields located in the western part of the project area are connected to the Ciudjung river, it is also very important to pay the attention to these rivers. But, the improvement of these rivers will also requre a considerable time and investment. As such, drainage plan considering the whole project area should be taken up in the future plan to be executed.

3 PROJECT FACILITIES

3.1 General

The general feature of the K-C-C Irrigation Development Project is to supply irrigation water of 6.0 m^3/sec at the maximum to the area of 3,500 ha from the Cibeureum river. The facilities required for the Project mainly comprise diversion dam, headrace, canals and related structures. The basis for planning and design of the project facilities is the most effective use of the water resources. The followings are brief descriptions of the comparative studies, design criteria and design of the project facilities.

3.2 Diversion Works

3.2.1 Alternative Study on the Function of the Diversion Dam

(1) General

At the early stage of the feasibility study, two proposals for the diversion work were made, i.e. Proposal-I and Proposal-II. Proposal-I is to give the function of reservoir to the diversion work that can regulate the water flowing into the diversion work and Proposal-II is to give the function to the diversion work aiming only at raising the water level for the purpose of irrigating the Project area. These two proposals may be considered as "with and without reservoir planning" for the diversion work. Detailed studies were made on these two proposals taking into consideration the study results obtained by the master plan team (M/P team).

In the detailed studies, it has been worked out that Proposal-I would not provide any significant merit for the purpose of irrigation as well as regulating the water due mainly to the following reasons:

(a) The location of diversion tunnel which diverts the water from the Karian dam to the Cibeureum river has been lowered during the studies by M/P Team. Due to this, the water level to be kept in the diversion work has to be reduced to avoid the bad effect to the diversion tunnel, thus causing the reduction of storage capacity of the diversion work.

(b) In due consideration of the elevations of the project area to be irrigated, the maximum storage capacity of the diversion work must be reduced thus

the expected maximum storage capacity would satisfy only one day's amount of water required for the irrigation of Project area.
Reflecting the above, the diversion work without the function of storage capacity has been proposed for the Project.

(2) Consideration on the Future Development of the Project

A multi-purpose dam has been planned in the Karian area as to be taken up in the future plan. An irrigation plan to irrigate the whole K-C-C area utilizing the water from the Karian dam is also considered as the future plan to be taken up. In establishing the irrigation plan for the K-C-C area in the feasibility stage, attention has been paid especially to the location of the intake facility and its elevation, location of main canal, etc. so as to maintain well-functioned relationships between the F/S and the M/P. As such, the dimensions such as the height of the diversion work, intake water level, etc. will satisfy the requirements to be considered in the future plan.

But as for the main irrigation canal, since it has been designed based on the maximum discharge of 6.0 m^3/sec which can irrigate the area of 3,500ha under the Project, it will be necessary to enlarge the sections of the main canal and to extend the length of main canal in the future when irrigation study for the whole K-C-C area will be taken up.

3.2.2 Alternative Study on the Location of the Diversion Dam

(1) General

A dam planning for the K-C-C Irrigation Development Project was once proposed near Gadeg in the survey report prepared by the Government of Indonesia. After that, further investigations such as geological and soil mechanical surveys were made at the said point. In addition to this, a comprehensive study on the same was made by JICA M/P Team in 1982. Gadeg dam site is located about 20km upstream the junction of the Cibeureum and Cidurian rivers where the river terrace formed by the Cibeureum river begins to spread. The width of the river terrace ranges between 50 and 150m and the terrace is developed on the both banks of the Cibeureum river. The width of the Cibeureum river ranges from 15 to 30m and its river bed elevation is around EL 25.0m above the mean sea level. Rock foundation is observed 3.0 to 3.5m below the river bed. Rock foundation is also observed 8 to 10.0m below the surface of the said river terrace.

The longitudinal river bed slope of the Cibeureum river is around 1/250 and the outcroppings of the rock foundations are sometimes observed. The river course, upstream of Gadeg, is meandering and its cross-sectional area is also very complicated. It may be mentioned that a water releasing structure (may be defined as a spillway) for the Karian dam is planned about 3.5km upstream the Gadeg intake site as a future plan. The elevation of the structure is tentatively fixed at EL 39.00m above the mean sea level.

Reflecting these backgrounds, following three alternative studies for the intake site for the K-C-C Irrigation Development Project have been made.

Alternative - I:	Proposed by JICA M/P Team in 1982
Alternative - II:	About 3.5km upstream of the proposed dam site by JICA M/P Team
Alternative - III:	Proposed by JICA F/S Team which is about 100m downstream of Alternative-I.

(2) Location

Alternative-I has been proposed considering that the elevation of the top of the proposed dam is to be maintained at EL 50.0m. Judging from this point of view only, the intake site proposed in Alternative-I would be the best one. However, considering the future plan for Karian Dam, it is necessary to fix the elevation of the top of the proposed diversion dam for the K-C-C Irrigation Development Project at around EL 40.00m so that no bad influence will be given on the water releasing structure for the Karian dam to be constructed in the future. On the other hand, Alternative-II is located at the place where the river bed of the Cibeureum river is about 10.0m higher in elevation compared with that of Alternative-I and the site proposed in Alternative-II consists of steep slope developed on the both river banks of the Cibeureum river. Alternative-II will require a headrace of 3.5km and due to this, it is anticipated that the required water level of the proposed diversion dam will become higher due to the head loss to be considered in the said headrace.

Furthermore, if the elevation of the water releasing structure for the Karian Dam is kept at EL 39.00m as proposed, the elevations of the areas to be irrigated by the proposed diversion dam will be lowered due to the head loss to be considered in the said headrace. Anyway, Alternative-III will require the least facilities compared with Alternative-I and Alternative-II. Alternative-III is located in the downstream of Alternative-I, i.e. at the coffer dam site to be planned in the case of Alternative-I, but there are no significant differences between Alternatives I and III. If no consideration for the Karian Dam is necessary and a diversion tunnel is allowed to be constructed, Alternative-III will be the best one among the three Alternatives, as it does not require large scaled facilities, and submergible houses after the completion of the dam will be less compared with other two Alternatives. Each Alternative introduced in the above is summarized as follows:

SUMMARY OF ALTERNATIVE STUDIES

	Items	Alternative-I	Alternative-II	Alternative-III
(a)	Planned intake water level	EL 38.50m	EL 38.50m+X_1, /1	EL 38.50m
(b)	Elevation which can be irrigated	EL 34.00m-X_2 /2	EL 33.0 32.5m-X_2	EL 34.00m-X_2
(c)	River bed elevation	EL 25.50m	EL 35.00m	EL 25.00m
(d)	Height of dam	H = 15.50m	H = 3.5 - 4.0m	H = 16.00m
(e)	Length of dam	L = 190.0m	L = 45.0m	L = 160.0m
(f)	Spillway	large-scaled	small-scaled	large-scaled
(g)	Intake facilities and headrace	easy to construct	difficult to construct	easy to construct
(h)	Submergible houses due to construction of the dam	some	none	some

Notes: /1 X_1 = 0.50m
/2 X_2 = 0 - 1.0m

Judging from the above listed conditions, Alternatives-I and III are considered worth proposing on the conditions that the first priority is to be given to the Karlan future plan. As there are no significant differences in the construction works of Alternatives-I and III, Alternative-III may be proposed as the best one because of its easiness of design and construction.

(3) Type of Dam

Usually following three types of dam are considered, i.e., concrete type dam, rockfill type dam and earth type dam (homogeneous type). The selection of dam type depends on the topographic, soil-mechanical and meteorological conditions at the proposed dam site and availability of construction materials of the dam. In addition to this, it is important to pay attention to the purpose of the dam, scale of the dam and required construction period of the dam also.

Generally speaking, a fill-type dam is economically recommended when a formation coefficient is big which is defined as the ratio of dam length (L) and its height (H), i.e. L/H although the volume of the dam is usually increased. It is also widely understood that a fill-type dam usually gives less pressure to the foundation compared with a concrete type dam, thus achieving the wide response to the foundation conditions at the dam site. In addition to this, it is necessary to notice that a fill-type dam usually requires a large scaled spillway which increases the total construction cost of the dam. Judging from these discussions, it may be concluded that a fill-type dam should be recommended for the K-C-C Irrigation Development Project, considering that the fill-type dam which has been planned, has a formation coefficient of about 8.0 and the excavation work for the planned dam is relatively less and in addition to this, the availability of construction material for the dam is high compared with other types of dams. The fill-type dam thus selected may be further divided into a rock-fill type dam and an earth fill-type dam. In case of a rock-fill type dam, the quality control of the dam is relatively easy and the reliability of the dam is high and this will allow to adopt steeper slopes both for upstream and downstream portions of the dam, thus achieving the economy in the construction work, although it depends on the distance between the borrow site and construction site of the dam and availability of its construction material.

In case of an earth fill dam, it is not so easy to control the construction material as it usually contains various size of grains and is composed of soils which have different permeabilities. Based upon above discussions it may be concluded that a zoned rock fill type dam with center core may be recommended for the Project as the excavated materials to be borne by the foundation excavation of the dam may be used as the material for random zone of the dam and also due to easy quality control of the dam during its construction. Please refer to Table VII-20 and Fig. VII-8 concerning comparative study of dam types.

3.2.3 Material for the Diversion Dam

A center-cored fill type dam as shown in the Drawings has been proposed considering the geologic conditions of the dam site, construction cost, etc. In this section, some detailed discussions will be made on the design of the dam using limited data obtained mainly from the Government of Indonesia. In the design of the dam, the upstream and downstream slopes of each zone have been decided as follows.

Zone	Upstream slope	Downstream slope
impervious zone	1:0.2	1:0.2
filter	1:0.3	1:0.3
transition	1:1.2	1:1.0
rock	1:3.0	1:2.5

The material required for these zones must have the following properties.

(a) Impervious zone

The material used for the impervious zone shall have the high impermeability of about $k=10^{-5}$ cm/sec and shall be composed of fine grain of soils. The soils shall have the properties of $C=1.0$ kg/cm^2, $\phi=0°$ or $C=0.4$ kg/cm^2, $\phi=10$ to $20°$ and the dry density of 1.0 to 1.4 t/m^3. The grain size distribution curve shown in Fig. IV-3 presents the ranges of the grains which can be used for the fill type dam. As for the grain size distribution of the soils obtained from several soil surveys, they have shown the similarity with the said distribution curve. So it may be judged that the soils considered for the dam should be compacted under the condition that the moisture content of the soil is maintained at a little bit higher than the most optimum moisture content, and the compaction ratio should be maintained at around 90 to 95%. The soils to be used for the dam shall be spread with the thickness of 20cm and after that the soils shall be compacted by roller making the compaction ratio mentioned above.

(b) Filter zone

Filter zone shall be provided between the materials whose permeabilities are different each other to avoid the flowing-out of the impervious materials in the dam due to seepage flow. The filter zone must have the function of draining the seepage flow completely as well as the function to avoid piping action which may collapse the dam. Usually, sand, gravels and artificially crashed stones are used for the filter zone. These materials are composed of cohesionless ones. The material used for the filter zone is usually composed of fine grain size of less than 0.074mm and the total percentage of the fine grain is less than 5%, and the permeability of the material is 10 to 100 times bigger than that of the core material to be protected. These materials are obtainable from the Cibeureum and Ciberang rivers.

(c) Transition zone

The transition materials are provided between the pervious and impervious zones to avoid the sudden change in grain size of the material. The required conditions for the grains to be used for the transition zone are not so severe compared with those for the filter zone. Sands, gravels and mucks are usually used for the transition zone. But, these materials are generally not obtainable in natural condition. So it is recommended to use sand stones, andesites and agglomerates which belong to Miocene Epoch Age for the transition zone. These materials are available in Bedengantjol which is located between the national road connecting Bogor to Rangkasbitung and the railway. These materials shall be crashed into pieces prior to its use as the transition materials.

(d) Rock zone

Rock materials used for rock zone shall have the required shear strength and the permeability of about $k=10^{-3}$ cm/sec or more and shall be chemically stable as well as hard and durable. The materials suitable for rock zone may be produced from the crashed sand stones, andesites and agglomerates. Adopting these materials as the rock zone, it is expected that they have the cohesion of $C=0.2$ kg/cm^2, angle of internal friction of $\phi=35^o$ and dry density of d=1.6 t/m^3 or $C=0$, $\phi=40^o$ and d=1.6 t/m^3. It is expected that further detailed study on the decision of each section of the dam will be made in the future paying attention to the above mentioned figures.

3.2.4 Specification of the Diversion Dam

Through the above discussions, a center core rockfill type dam having the following specifications have been proposed for the Project.

- (a) Height: 16m (EL 41.00m)
- (b) Width of the Crest: 10m
- (c) Length: 160m
- (d) Type: Zoned rock fill type with center core

3.2.5 Related Facilities

(a) Intake Gate

As the project area spreads on the left bank of the Cibeureum river, it is advantageous to provide the intake facility on the left bank of the proposed dam. This is also justified from the topographic conditions around the dam site and intake site. Maximum water of 6.0 m^3/sec will be diverted through the intake facility which is composed of two bays of concrete structure with regulating gates. The intake water level is fixed at EL 38.50m and the intake velocity is taken at around 0.7 m/sec and the invert of the intake is fixed at EL 37.20m.

The design intake water velocity at the intake gate is 0.7 m/sec. Net width of intake structure is calculated using the following fomula:

$B = Q/h_f \cdot V_f = 3.23m < 3.50m$

Where

- B : Required net width of intake structure
- Q : Design intake dischange 6 m^3/sec
- h_f : Intake water depth 1.30m
- V_f : Intake water velocity 0.7 m/s

The operation of gates is done combinedly by motor and manual.

Design discharge	6.0 m^3/s
Intake level	EL 38.50m
Intake sill elevation	EL 37.20m
Width of intake	3.50m
Numbers	2 nos.
Gate type	Roller gate
Size of gate	3.50(B)x1.50(H)x2(N)

(b) Spillway

A spillway which has the function of releasing the maintenance flow of the Cibeureum river, daily surplus water and the flood water will be constructed on the right bank of the Cibeureum river being about 1.5km upstream of the diversion dam. The location of the spillway is shown on the Drawings. The proposed location for the spillway will be most suitable one for the Project considering the following technical points of view:

(i) the location selected for the spillway also well facilitates the function of temporary diversion work required for releasing surplus water during the construction of the dam.

(ii) judging from the topographic conditions around the proposed spillway site, the location of the proposed spillway will minimize the construction cost of the leading canal to be connected after the spillway.

The proposed spillway will function as the temporary diversion work to release excess water during the construction of the dam and after that it will be facilitated to have the full function as the spillway by the time of the completion of the dam. The spillway is finally designed as three bays structure with regulating gates. The type of the gates will be radial and roller. For the emergency of flood, the radial type gate will have two bays; one for the emergency case. Roller type gate is used for maintenance flow. The spillway is also designed to have the capacity of releasing the water of Q=320 m^3/sec which may occur once in 500 years. Brief calculations for the hydraulic design of the spillway are introduced below.
The spillway is designed as an overflow type spillway.

The overflow discharge of water under complete overflowing condition can be calculated by the following equation:

$$Qd = C.B\ H^{3/2}$$

Where,
- Q: Discharge (m^3/sec)
- B: Width of spillway (m)
- H: Upstream water depth above crest (m)
- C: Coefficient of discharge

The results obtained from the above calculations are summarized as below.

Item	No. 1 Spillway	No. 2 Spillway
Design discharge	320 m^3/sec	Max 10 m^3/sec
Water level	EL 38.50m	EL 38.50m
Crest level	EL 30.60m	EL 36.40m
Design Head (H)	7.90m	2.10m
Width (B)	7.00m	2.00m
Coefficient (c)	2.00	2.00
Type of gate	Radial gate	Roller gate
Size of gate	8.40m(H) x 7.00m(B)	2.40m(H) x 2.00m(B)
Number of gate	2	1

(c) Summary and conclusion

So as to make the above discussions clear, the summaries of the function of the discussed structures and conditions considered are summarized as below.

(1) Intake facility

site: Gadeg site

diversion head water level: EL 38.50m

height: 16.0m from river bed

length: 160.0m

(2) Spillway

site: on the right bank of the Cibeureum river, about 1.2km upstream of the proposed dam where topographically saddled portions are dominant.

type: three bays with regulating gates

discharge: $Qmax = 320\ m^3/sec$

(3) Headrace

canal type: earth canal

slope of canal: 1/5,000

shape of canal section: trapezoid

maximum discharge: $Qmax = 6.0\ m^3/sec$

maximum velocity: $Vmax = 0.7$ m/sec

The intake facility proposed has been discussed from the various technical points of view and some alternative plans for the captioned structure have also been taken into account as discussed in the previous sections. As such the summary of the captioned facilities will give the most suitable features for the Project.

3.3 Design of Canal System

3.3.1 General

The canal system of the Project consists of headrace, main canal, secondary canals, tertiary canals and quaternary canals. The headrace is the trunk canal which conveys water from the intake site to the Project area. The main canal is the trunk canal which conveys water to the entrance of the secondary blocks. The route of the headrace is selected at the skirt of the western high ranges. The design discharge of the irrigation water conveyed through the headrace would be from 6.0 m^3/sec to 0.50 m^3/sec. The total length of the headrace is about 9.6 km including a siphon of about 430 m. The main canal is constructed along the road connecting Cikande and Rangkasbitung which passes through the raised portions of the Project area. The main canal will carry the water of 6.0 m^3/sec to 0.5 m^3/sec and the total length will be about 13.0 km. The canals is basically unlined and trapezodial. The raised portion is lined with concrete. The secondary canal is defined as the canal which conveys the water diverted at the diversion work to the integrated tertiary blocks. The design water discharge of the secondary canal would range from 0.213 m^3/sec to 0.941 m^3/sec.

The tertiary canal is defined as the canal which conveys water diverted from the secondary canal to distribute the irrigation water to the quaternary blocks. The total length of each canal to be provided in the Project area is summarized as follows.

Canals	Total length (m)
1 Headrace	9,622
2 Main canal	13,043
3 Secondary canal	32,430
4 Tertiary canal	63,600

The canal system of the Project and general layout of the canals are shown in Fig. VII-7 (see also Volume-5).

3.3.2 Comparative Study on the Headrace Route

The topographic condition in the reach of the main canal between the head work and S-1 turnout is sharply undulating and steep. The average slope in the reach is estimated as 1 to 2.0 and the canal crosses the concaved rice field which stretches more than 1.0 km along the canal and also crosses rivers and the railway.

Judging from the above-mentioned topographic conditions, the location and type of the canal should be carefully planned and decided. If the canal is planned to pass through the said rice field, the canal system would require a inverted siphon which is fairly long. On the other hand, if the main canal is planned to avoid the said siphon, the route of main canal would have to be located following the existing topographic condition which seems to be suitable for the construction of the canal, in this case the length of the canal will become longer compared with the case that the said siphon is adopted in the canal system. These two alternative routes are shown in Fig. VII-7. To estimate the quantity of earth works and number and kinds of required structures for each alternative, profile of each alternative route has been prepared as shown in Table VII-17 based on the results of the route survey and the contoured map with the scale of 1/5000.

The canal route which passes through the concaved rice field will be called hereinafter as "Alternative-I" and the other one a- "Alternative-II". Based on the studies, the main features in each alternative are tabulated as shown below.

Main features	Alternative-I	Alternative-II
1. Canal length (m)	1760	4110
2. Length of siphon (m)	1700	430 (2 Nos.)
3. Construction Cost of earth works and siphon		
(1) Excavation (Rp)	90,219,000	126,618,000
(2) Embankment (Rp)	486,197,000	449,929,000
(3) Siphon (Rp)	561,357,000	180,072,000 (2 Nos.)
Total (Rp)	1,137,773,000	756,619,000
4. Head loss in the Headrace system	5,050mm	2,900mm

As is seen from the above, the total length of the canal is longer in the case of Alternative-II compared with Alternative-I. On the other hand, the head loss in the canal is much less in the case of Alternative-II compared with Alternative-I.

This means that the Alternative-II has much potential for the irrigation of the Project area.

In addition, Alternative-I would involve more difficult problems in construction as well as in arrangement of required construction material of the canal system compared with Alternative-II. It is also anticipated that Alternative-I which needs the construction of a long siphon would make the drainage condition of the Project area bad.

Thus it may be judged that Alternative-II is technically and economically more eligible than Alternative-I and would be recommendable as the most optimum plan.

3.3.3 Design of Irrigation Canal

(1) Design Discharge

Based on the irrigation water requirement calculated in Section 2.1 hereof, the design discharges for the headreach and the main canals are obtained as shown in Fig. VII-4. As for the secondary and the tertiary canals, the design discharge for respective canal is calculated as follows:

(a) The design discharge for the secondary canal is calculated based on the unit irrigation water requirements for each cropping pattern obtained in Section 2.1.4 hereof.

(b) The design discharge for the tertiary canal is calculated by using the following formula.

$$Q = 5.32 \times a \times A^{2/3}$$

where,
- Q : design discharge (lit/sec)
- a : unit irrigation water requirement (lit/sec/ha)
- A : commanding area (ha)

From the economical and technical points of view, all the canals mentioned above are designed as unlined canals. But raised portion is lined with asphalt pitch.

(2) Velocity

The maximum permissible velocity in the unlined canals is determined so as not to give the erosion, on the other hand, the minimum permissible velocity is determined so as not to induce the growth of aquatic plant and moss. The maximum and minimum permissible velocities are determined as follows by use of Manning's formula.

- Maximum velocity: 0.7 m/sec
- Minimum velocity: 0.3 m/sec

(3) Roughness coefficient

The roughness coefficients of the canals for the determination of their hydraulic properties are as follows:

		Mannings "n"
- Barth canal & asphalt lined portion		
$Q \geq 3$ m^3/sec	:	0.0225
$Q < 3$ m^3/sec	:	0.025
- Concrete lined portion	:	0.015

(4) Freeboard

The freeboard height is normally subject to canal size and location, velocity, water surface fluctuations caused by check gates and wind action and availability of materials for embankment. The minimum freeboard for the respective canal discharge is determined as follows:

Discharge (m^3/sec)	Freeboard (m)
$Q \leq 0.3$	0.3
$0.3 < Q \leq 1.0$	0.3 - 0.5
$1.0 < Q \leq 7.5$	0.5 - 0.6
$7.5 < Q \leq 25.0$	0.6 - 0.9
$25.0 < Q \leq 44.1$	0.9 - 1.2

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

Ratio of canal base width and water depth is determined with reference to the criteria of L.P.M.A. of Indonesia. For the headrace design, however, more hydraulically economical section, i.e. the smaller ratio than the criteria, is adopted in order to reduce the canal excavation volume.

(6) Side slope

The side slope of 1:1.5 is adopted for the design of both earth and lined canals and 1:1.0 for the design of tertiary and quarternary taking into account the results of soil mechanical investigations.

3.4 Descriptions of main related structures provided in the canal system

(i) Turnout

Turnout structure is constructed to distribute the required water from a parent canal to a branching canal. A Romijn or slide gate is provided for a staff gauge and a weir is provided in outlet side as a measuring device. A Romijn gate is provided for the tertiary intake. In case that the no release structure and/or wasteway is combined, a reinforced concrete pipe is laid under canal embankment to distribute irrigation water. The details are shown in the Drawings (Volume-5).

(ii) Check structure

Check structure is provided just downstream of a turnout and/or a spillway to raise the water surface to the required level during the period of small discharge. The check structure would regulate the water supply and aid to drain out the excess water which flows out through a spillway. The check structures are divided into two types depending on the discharge in the canal.

The transition of 5m long is provided both up-and down-streams of the structure respectively to minimize the head loss. A slide gate is installed to regulate water surface in the upstream of canal. The details are shown in the Drawings.

(iii) Culvert

Culverts are provided for the road crossing. The culverts in the proposed canal system are made of reinforced concrete and the types of culverts are divided into two types, i.e., rectangular and circular types. Design water depth in the culverts is taken to be about 80% of culvert height and the crown of culvert is designed to be equal to road surface.

(iv) Bridge

Bridges are constructed where a road crosses over the main canal. The bridges on the main canal are of concrete T-beam type and divided into two types depending on the classification of load, i.e. the one which will be provided where the main road crosses over the main canal (Type-I) and the other (Type-II) provided where the branch roads cross over the main canal.

The span length and width of Type-I bridge are 12.0m and 8.0m and those of Type-II bridges are 12.0m and 6.0m respectively. The required numbers of the bridges will be 1 for Type-I and 5 for Type-II respectively.

(v) Spillway

A spillway is constructed in the canal system for the purpose of flushing off all the water in the canals or spilling out excess flow in case of emergency and clearing and repairing the canals. This structure is provided in the mid-course of respective main canal and at the end of secondary canal. All the spillways are equipped with slide gates (waste-way) and connected to the nearby natural streams.

(vi) Crossdrain

A number of cross drains are provided to drain excess runoff from hill sides extending along canal route. Cross drains are divided into two types depending on the design discharge, one has a wet stone masonry barrel with a rectangular section and another has a reinforced concrete barrel with a circular section. The former is adopted in the case of the design discharge of more than $2.5m^3/sec$ and the latter in the case of less than $2.5m^3/sec$. Slab of the barrel is of reinforced concrete. The inlet and outlet of the structure are protected by wet stone masonry. The bottom and side slopes of canal above a cross drain structure are protected by wet stone masonry. The details are shown in the Drawings.

(vii) Siphon

Inverted siphons are provided in the proposed canal system for river and railway crossings. Usually the siphon is superior to the aqueduct in view of the structural stability for being free from seismic load and passage of the river flood, but requires high head losses and complicated maintenance. The siphon has a barrel with a rectangular section. The siphon is adopted in case the design discharge is less than 6.0m^3/sec. The transitions are provided up and down streams of the siphon to minimize the head loss. The design velocity in the siphon is decided to be about 1.5 times of the velocity in the upstream canal. The earth cover over the barrel is greater than two (2) meters. Detailed informations regarding the siphon are available in the Drawings.

(viii) Drop

Drop structures are divided into three types depending on the design discharge. A drop structure consists of inlet transition, steep portion with a rectangular section, stilling pool and outlet transition. The inlet transition is protected by wet stone masonry to prevent canal from scouring.

3.5 Inspection Road

3.5.1 General

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

3.5.2 Main inspection road

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

3.5.3 Secondary inspection road

The secondary inspection roads are mainly provided along the secondary canals. All these roads have an effective width of 5m and are paved with gravel. These roads link the cultivable areas to populated centers in the area and are used for the purpose of farm operation, particularly for harvesting.

3.5.4 Tertiary inspection road

For the same purpose as that of the secondary farm roads, the tertiary farm roads are constructed along one side of all the tertiary canals. These roads have an effective width of 3m and are of earth without any metalling.

3.6 Tertiary Development

3.6.1 General

Tertiary development program aims at efficient water management by establishing the well organized tertiary system and through refined rotational irrigation program. For this subject, the Directorate of Irrigation of DPU has prepared the report titled as "Guideline Manual for Planning of Tertiary Network". For the details of criteria and standards for the design and operational programming, this guideline manual is referred to.

3.6.2 Definition and Recommended Size of Irrigation Block

The tertiary development program is prepared for every tertiary block. This tertiary block is further divided into several subordinate blocks like sub-tertiary blocks and quaternary blocks. The definition and recommended size of each irrigation block is briefed as follows:

(1) Tertiary block

The tertiary block is covered by one tertiary canal. The distribution of irrigation water in the tertiary block is managed by farmers themselves. In some cases, however, it is difficult for the farmers to manage the distribution of water to vast lands and large number of farmers equally. The past experiences in Indonesia have shown that the suitable size to be covered by one tertiary canal would be in the order of 50 ha. Considering the appropriate organization of water users' group in future, the maximum size of tertiary block is proposed to be 50ha.

(2) Sub-tertiary block

In case that the tertiary block can not be formed within one village (for example, the boundary of tertiary block crosses the administrative boundaries of villages), a sub-tertiary block is formed in each village to simplify the organization of water users' group.

(3) Quaternary block

In order to distribute irrigation water equally and efficiently to all parts of the fields through more intensive water control, it is advisable to sub-divide the tertiary block into several subordinate blocks and the quaternary blocks. The recommended size of one quaternary block is 10 to 15 ha. The rotational irrigation is practiced on the quaternary basis.

3.6.3 Irrigation Canal System

(1) Canalization system

The tertiary system consists of tertiary canal, sub-tertiary canals and quaternary canals which respectively cover the tertiary block, sub-tertiary blocks and quaternary blocks as mentioned above. In layout planning of these canals, the following respective function and design principle are taken into consideration.

(a) Tertiary canal

The tertiary canal delivers irrigation water from secondary irrigation canal or sometimes directly from main canal to the sub-tertiary canals and/or quaternary canals. The irrigation water should not be taken directly from the tertiary canal into fields.

(b) Sub-tertiary canal

The sub-tertiary canal leads irrigation water from the tertiary canal to the quaternary canals. In this case also, irrigation water should not be taken directly from this canal to fields. In principle, the alignment of this canal is made in the same manner as that of the tertiary canal.

(c) Quaternary canal

The quaternary canal is terminal system. Irrigation water to be carried by this canal flows in fields directly or through sub-quaternary canals (branch of quaternary canal). The end of quaternary canal is connected to nearby drainage canal so as to drain off excess water in the canal. Especially in steep-slope area, more than 1% of land slope, the canal should be aligned in parallel to the contour line (contour type). In order to avoid irrigation water from spilling-out from one paddy field to the next field, the width of one plot of quaternary sector should be limited to 200 m at maximum. All the quaternary canals except the canal to be constructed in the highest position in the respective area are so designed as to have dual functions; irrigation and drainage functions, where possible.

(2) Related structures

In order to attain its primary objective, the canalization system thus aligned requires the following structures.

(a) Tertiary division box

Many division boxes are constructed on the tertiary canals and all of them are equipped with gates to regulate irrigation water in accordance with the rotational irrigation program.

(b) Quaternary division box

All the division boxes to be constructed on the quaternary canal are not equipped with gates.

(c) Measuring device

The measuring device such as Romijn gate is installed at the head of tertiary block.

(d) Drop structure

A drop structure is provided where the ground surface slope is steeper than the required canal system as an independent structure but as a supplementary structure of division box. Especially for the fall height of less than 30 cm, in case of the quaternary canal, the drop structure is not constructed independently.

(e) Culvert

A culvert is constructed at the crossing point of canal with road. This structure is of combined type with the division box as far as possible.

(f) Crossdrain

A crossdrain is provided at the site where the irrigation canal has to cross over the drainage canal.

3.6.4 Farm Road Networks

For the purpose of canal inspection and farm operation, two types of road; tertiary inspection road and farm road, are required in the tertiary block. The respective function and design principle are mentioned below:

(a) Tertiary inspection road

A tertiary inspection road is required alongside the tertiary canal and the sub-tertiary canal. This road is used only for the inspection of canals and farm operation.

(b) Farm operation road

This road suitable for trucks and tractor is required throughout the tertiary block for the purpose of farm operation particularly for harvesting. This road is also provided for the connection of tertiary inspection road to other roads.

(c) Related structures

Farm approaches are provided at the entrances from the tertiary road into the field plots.

Table VII-1 Calculation of Potential Evapotranspiration (by Modified Penman Method) (1)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ⓐ Temperature (°C)	26.3	26.7	26.6	27.0	27.1	26.6	26.4	26.6	26.8	27.2	27.1	26.6
Ⓑ Humidity (%)	84	82	84	82	81	80	80	78	77	77	78	82
Ⓒ Sunshine (hr)	3.1	3.3	3.8	4.0	4.2	4.4	5.2	5.3	5.2	4.4	4.0	3.0
Ⓓ Wind Velocity at 10m (km/day)	158.6	177.5	158.6	145.9	158.6	158.6	155.5	172.0	166.5	148.0	155.5	184.0
Ⓔ Wind Velocity at 2m (km/day)	126.1	141.1	126.1	116.0	126.1	126.1	123.6	136.7	132.4	117.7	123.6	146.3
Ⓕ Wind Velocity at 2m (km/sec)	1.46	1.63	1.46	1.34	1.46	1.46	1.43	1.58	1.53	1.36	1.43	1.69
① f (Tal) x 10^{-2}	9.12	9.17	9.15	9.20	9.21	9.15	9.13	9.15	9.18	9.22	9.21	9.15
② $\Delta L^{-1} \times 10^{-2}$	2.60	2.66	2.64	2.70	2.71	2.64	2.62	2.64	2.67	2.73	2.71	2.64
③ $P_z W_a/sa$	25.74	26.32	26.18	26.74	26.90	26.18	25.89	26.18	26.46	27.05	26.90	26.18
④ $r + \Delta$	2.01	2.04	2.03	2.06	2.07	2.03	2.01	2.03	2.04	2.08	2.07	2.03
⑤ $P_z W_a$ Ⓑ×③	21.62	21.58	21.99	21.93	21.79	20.94	20.71	20.42	20.37	20.83	20.98	21.47
⑥ f (Tdp)	0.112	0.112	0.109	0.109	0.110	0.117	0.120	0.122	0.123	0.119	0.117	0.113
⑦ $P_z W_a/sa - P_z W_a$ ③-⑤	4.12	4.74	4.19	4.81	5.11	5.24	5.18	5.76	6.09	6.22	5.92	4.71
⑧ $r \times f(U_2)$	0.221	0.237	0.221	0.210	0.221	0.221	0.218	0.232	0.228	0.211	0.218	0.244
⑨ $r E_q$ ⑦×⑧	0.911	1.123	0.926	1.010	1.129	1.158	1.129	1.336	1.389	1.312	1.291	1.149
⑩ $O_a H_{sh} \times 10^{-2}$	9.04	9.12	8.91	8.37	7.72	7.35	7.47	8.01	8.62	8.97	9.01	8.97
⑪ r Ⓒ/⑩	0.343	0.362	0.426	0.478	0.544	0.599	0.696	0.662	0.603	0.490	0.444	0.334
⑫ a sh · f (r)	0.350	0.357	0.382	0.402	0.428	0.450	0.487	0.474	0.451	0.407	0.389	0.346
⑬ H^{ne}_{sh} ⑫×⑩	3.164	3.256	3.404	3.365	3.304	3.308	3.638	3.797	3.888	3.651	3.505	3.104
⑭ m 8①-Ⓒ	5.256	5.104	4.592	4.176	3.648	3.208	2.432	2.704	3.176	4.080	4.448	5.328
⑮ f (m)	0.580	0.592	0.633	0.666	0.708	0.743	0.805	0.784	0.746	0.674	0.644	0.574
⑯ H^{ne}_{ea} ①×⑥×⑮	0.592	0.608	0.631	0.668	0.717	0.795	0.882	0.875	0.842	0.739	0.694	0.593
⑰ $H^{ne}_{sh} - H^{ne}_{ea} = H^{ne}_{ra}$ ⑬-⑯	2.572	2.648	2.773	2.697	2.587	2.513	2.756	2.922	3.046	2.912	2.811	2.511
⑱ $\Delta(L^{-1} \times 10^{-2}) \times H^{ne}_{ra}$ ②×⑰	6.687	7.044	7.321	7.282	7.011	6.634	7.221	7.714	8.133	7.950	7.618	6.629
⑲ $rE_q + \Delta(L^{-1} \times 10^{-2}) \cdot H^{ne}_{ra}$ ⑨+⑱	7.598	8.167	8.247	8.292	8.140	7.792	8.350	9.050	9.522	9.262	8.909	7.778
⑳ Eo (mm/day) ⑲/④	3.780	4.003	4.063	4.025	3.932	3.838	4.154	4.458	4.668	4.453	4.304	3.832

Eo: Evapotranspiration
= [illegible]

Table VII-1 Calculation of Potential Evapotranspiration (ETO) (Christiansen - Hargreaves Method) (2)

	Christiansen-Hargreaves Method ETo = 17.4. D.TC·(Fh·Fw·Fc)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	Monthly day-time Coefficient: D	1.05	0.94	1.02	0.97	1.00	0.96	0.98	1.00	0.98	1.03	1.01	1.05
2	Mean Monthly Temperature: Tc (°C)	26.3	26.7	26.6	27.0	27.1	26.6	26.4	26.6	26.8	27.2	27.1	26.6
3	Mean daily relative humidity Hon	0.84	0.82	0.84	0.82	0.81	0.80	0.80	0.78	0.77	0.77	0.78	0.82
4	Mean Unit Velocity WKD km/day	126.1	141.1	126.1	118.0	126.1	126.1	123.6	136.7	132.4	117.7	123.6	146.3
5	Mean Monthly Sunshine hour S	0.343	0.362	0.426	0.478	0.544	0.599	0.696	0.662	0.603	0.490	0.444	0.334
6	Elevation above the Sea level E 25m												
7	Mean Noon humidity Hn %=0.4Hm+0.6Hm2	0.76	0.73	0.76	0.73	0.72	0.70	0.70	0.68	0.66	0.66	0.68	0.73
8	Fh = 0.59-0.55 Hn2	0.27	0.30	0.27	0.30	0.30	0.32	0.32	0.34	0.35	0.35	0.34	0.30
9	Fw = 0.75+0.0255 /Wkd	1.04	1.05	1.04	1.02	1.04	1.04	1.03	1.05	1.04	1.03	1.03	1.06
10	Fs = (0.478+0.58S)	0.68	0.69	0.73	0.76	0.79	0.83	0.88	0.86	0.83	0.76	0.74	0.67
11	Fc = (0.95+0.0001E)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
12	Fh·Fw·Fc= (8 9 x 10 x 11)	0.18	0.21	0.19	0.22	0.23	0.26	0.28	0.29	0.29	0.26	0.25	0.20
13	17.4·D·TC·(Fh·Fw·Fs·Fc) = 17.4 x 1 x 2 x 12 = ETO	86.49	91.71	89.70	100.26	108.45	115.52	126.05	134.22	132.53	126.74	119.06	97.20
14	Evapotranspiration (mm/day)	2.79	3.28	2.83	3.23	3.50	3.85	4.07	4.33	4.42	4.09	3.97	3.14

Table VII- 2 EXTRA TERRESTRIAL RADIATION (Ra)

(mm/H20/day)

Latitude	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Northern Hemisphere							
10°	13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9
8	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3
6	13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7
4	14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1
2	14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4
0	15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8

(mm/H20/day)

Latitude	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Southern Hemisphere							
10°	16.4	16.3	15.5	14.2	12.8	12.0	12.4	13.5	14.8	15.9	16.2	16.2
8	16.1	16.1	15.5	14.4	13.1	12.4	12.7	13.7	14.9	15.8	16.0	16.0
6	15.8	16.0	15.6	14.7	13.4	12.8	13.1	14.0	15.0	15.7	15.8	15.7
4	15.5	15.8	15.6	14.9	13.8	13.2	13.4	14.3	15.1	15.6	15.5	15.4
2	15.3	15.7	15.7	15.1	14.1	13.5	13.7	14.5	15.2	15.5	15.3	15.1
0	15.0	15.5	15.7	15.3	4.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8

Table VII-3 EXPERIMENTALLY DETERMINED CONSTANTS FOR THE RADIATION EQUATION

Rs = (a + b.n/N)/Ra

Source		Location or Range of Locations	Constants a	b	Latitude (o)
As listed by Linacre	(1967)				
Fitzpatrick	(1965)	Kimberley, S. Africa	0.33	0.43	16 S
Cockett et al.	(1964)	Centrl Africa	0.32	0.47	15 S
Page	(1961)	Dakar, Snegal	0.10	0.70	15 N
Yadov	(1965)	Madras, India	0.31	0.49	13 N
Davies	(1965)	Kano, Nigeria	0.26	0.54	12 N
Smith	(1960)	Trinidad	0.27	0.49	11 N
Stanhill	(1963)	Benin City, Nigeria	0.26	0.38	7 N
		Mean	0.26	0.50	13°
Davies	(1965)	Accra, Ghana	0.30	0.37	6 N
Black et al.	(1954)	Batavia (Jakarta)	0.29	0.59/1	6 S
Page	(1961)	Kinshasa, Zaire	0.21	0.52	4 S
Page	(1961)	Singapore	0.21	0.48	1 N
Glover et al.	(1958b)	Kabete, Kenya	0.24	0.59	1 S
Page	(1961)	Kisangani, Zaire	0.28	0.40	1 S
Rijks et al.	(1964)	Kampala, Uganda	0.24	0.46	0
		Mean	0.25	0.49/2	3°

/1: Table by Linacre (1967) indicated 0.29 for Batavia, a likely error since Chidley and Pile (1970) give 0.59 for Jakarta, the same location

/2: Based on revised figure for Batavia

Table VII-4 **MAXIMUM POSSIBLE SUNSHINE HOURS (N) FOR DIFFERENT MONTHS AND LATITUDES**

Northern Lats	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Southern Lats	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
50°	8.5	10.1	11.8	13.8	15.4	16.3	15.9	14.5	12.7	10.8	9.1	8.1
48	8.8	10.2	11.8	13.6	15.2	16.0	15.6	14.3	12.6	10.9	9.3	8.3
46	9.1	10.4	11.9	13.5	14.9	15.7	15.4	14.2	12.6	10.9	9.5	8.7
44	9.3	10.5	11.9	13.4	14.7	15.4	15.2	14.0	12.6	11.0	9.7	8.9
42	9.4	10.6	11.9	13.4	14.6	15.2	14.9	13.9	12.6	11.1	9.8	9.1
40	9.6	10.7	11.9	13.3	14.4	15.0	14.7	13.7	12.5	11.2	10.0	9.3
35	10.1	11.0	11.9	13.1	14.0	14.5	14.3	13.5	12.4	11.3	10.3	9.8
30	10.4	11.1	12.0	12.9	13.6	14.0	13.9	13.2	12.4	11.5	10.6	10.2
25	10.7	11.3	12.0	12.7	13.3	13.7	13.5	13.0	12.3	11.6	10.9	10.6
20	11.0	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
15	11.3	11.6	12.0	12.5	12.8	13.0	12.9	12.6	12.2	11.8	11.4	11.2
10	11.6	11.8	12.0	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
5	11.8	11.9	12.0	12.2	12.3	12.4	12.3	12.3	12.1	12.0	11.9	11.8
0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0

Table VII-5 **REFLECTION COEFFICIENT (r)**

Water Surface	Surface covered with Crops
0.05 - 0.07	0.15 - 0.25

Table VII-6

VALUES OF σTK^4 FOR VARIOUS TEMPERATURES FOR THE PENMAN METHOD

Temperature, Tk	σTk^4	Temperature, Tk^4	σTk^4
K (°Abs)	mm H_2O/day	°F	mm H_2O/day
270	10.73	35	11.48
275	11.51	40	11.96
280	12.40	45	12.45
285	13.20	50	12.94
290	14.26	55	13.45
295	15.30	60	13.96
300	16.34	65	14.52
305	17.46	70	15.10
310	18.60	75	15.65
315	19.85	80	16.25
320	21.15	85	16.85
325	22.50	90	17.46
		95	18.10
		100	18.90

Table VII- 7 **MONTHLY DAY-TIME COEFFICIENT, D**

(only for use with Hargreaves equations)

Latitude degree	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
North												
10	0.97	0.89	1.01	1.01	1.06	1.03	1.06	1.05	0.99	0.99	0.95	0.97
8	0.98	0.89	1.01	1.01	1.05	1.02	1.05	1.04	0.99	0.99	0.95	0.97
6	0.98	0.90	1.01	1.01	1.05	1.02	1.05	1.04	0.99	1.01	0.95	0.98
4	0.98	0.91	1.02	1.00	1.04	1.01	1.04	1.04	0.99	1.01	0.95	0.98
2	1.01	0.91	1.02	0.99	1.02	0.99	1.02	1.02	0.98	1.02	0.98	1.01
0	1.02	0.92	1.02	1.00	1.02	0.99	1.02	1.02	0.98	1.02	0.99	1.02
South												
2	1.02	0.93	1.02	0.98	1.01	0.98	1.01	1.01	0.98	1.02	0.99	1.03
4	1.04	0.93	1.3	0.98	1.01	0.97	0.98	1.01	0.98	1.03	1.00	1.04
6	1.05	0.94	1.02	0.97	1.00	0.96	0.98	1.00	0.98	1.03	1.01	1.05
8	1.05	0.94	1.02	0.97	0.99	0.95	0.98	1.00	0.98	1.02	1.02	1.06
10	1.06	0.94	1.02	0.97	0.98	0.94	0.97	0.99	0.98	1.04	1.02	1.07

Table VII-8

WEIGHTING FACTOR (W) AT DIFFERENT TEMPERATURES AND ALTITUDE

Temperature °C	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
W at altitude (m)																
0	.55	.58	.61	.64	.66	.68	.71	.73	.75	.77	.78	.80	.82	.83	.84	.85
500	.57	.60	.62	.65	.67	.70	.72	.74	.76	.78	.79	.81	.82	.84	.85	.86
1000	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.80	.82	.83	.85	.86	.87
2000	.61	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.87	.88
3000	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.88	.88	.89
4000	.66	.69	.71	.73	.76	.78	.79	.81	.83	.84	.85	.86	.88	.89	.90	.90

Table VII-9

CORRECTION FACTOR (K) OF WIND VELOCITY

U day/ U night Ratio	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Correction Factor (K)	1.0	1.2	1.3	1.43	1.5	1.56	1.6

Table VII-10 Representative Results of Percolation Rate Measurement

No.	Observed date	Observed site	Phisiography /Soil Condition	Percolation Rate (mm/day)
1	Nov. 14	Kolelet	flat valley /Gleysols	1.43
2	Nov. 14	Sabrang	flat valley /Gleysols	0
3	Nov. 14	Pauamping	flat valley /Gleysols	0
4	Nov. 15	Cikalang	hillyland /Actisols	6.82
5	Nov. 15	Kejos	hillyland /Actisols	5.21
6	Nov. 15	Lengkd	hillyland /Actisols	2.50
7	Nov. 16	Gabu	hillyland /Actisols	1.88
8	Nov. 17	Kandang	hillyland /Nitosols	2.21
9	Nov. 17	Kouar	flat valley /Nitosols	2.11
10	Nov. 17	Njompok	flat valley /Gleysols	1.57

Table VII-11 Estimated Effective Rainfall

	Wet season rice								Dry season rice							
Year	R (mm)	Re_{70} (mm)	Re_{80} (mm)	Rae_{70} (mm)	Rae_{80} (mm)	$\frac{Re_{70}}{R}$ (%)	$\frac{Re_{80}}{R}$ (%)	$\frac{Rae_{70}+Rae_{80}}{R}$ (%)	R (mm)	Re_{70} (mm)	Re_{80} (mm)	Rae_{70} (mm)	Rae_{80} (mm)	$\frac{Re_{70}}{R}$ (%)	$\frac{Re_{80}}{R}$ (%)	$\frac{Rae_{70}+Rae_{80}}{R}$ (%)
1961-62	769	460	113	302	12	59.8	14.7	40.9	847	453	266	186	34	53.5	31.4	26.0
62-63	—	702	261	472	32	—	—	—	—	76	118	67	8	—	—	—
63-64	551	291	176	146	25	52.8	31.9	31.1	657	461	326	216	46	70.2	49.6	40.1
64-65	1134	572	269	338	29	50.4	23.7	32.4	943	556	436	270	57	59.0	40.2	34.8
65-66	1019	611	302	373	40	60.0	29.6	40.6	734	349	290	200	39	47.5	39.5	32.8
66-67	1555	830	315	531	40	53.4	20.3	36.7	765	383	400	226	56	50.1	52.3	36.9
67-68	1256	838	179	556	19	66.7	14.3	45.8	1039	527	450	248	48	50.7	43.3	28.5
68-69	1153	554	177	334	23	48.0	15.4	31.0	862	430	543	258	48	49.9	63.0	35.5
69-70	1204	778	261	468	33	64.6	21.7	41.6	962	480	301	280	33	49.9	31.3	32.5
70-71	1942	1041	509	576	72	53.6	20.3	33.4	1253	486	432	254	48	38.8	34.5	24.1
71-72	1827	834	194	514	25	45.6	10.6	29.5	899	324	375	205	46	36.0	41.7	27.9
72-73	1132	723	82	458	10	63.9	7.2	41.4	1081	644	412	381	54	59.6	38.0	40.3
73-74	1332	802	293	435	38	60.2	22.0	35.6	1068	468	420	234	56	43.8	39.3	27.2
74-75	1265	741	257	487	36	58.6	20.3	41.4	664	337	355	174	43	50.8	53.5	32.7
75-76	1284	706	343	444	44	55.0	26.7	38.1	576	327	267	173	38	56.8	46.4	36.8
mean						56.6	20.6	37.1						51.2	43.6	32.6

Note
(1) R: Rainfall during cropping period
(2) Re_{70}: Effective Rainfall (70%)
(3) Re_{80}: Effective Rainfall (80%)
(4) Rae_{70}: Actual Effective Rainfall used for crops (Re_{70} x Crop Intensity)
(5) Rae_{80}: Actual Effective Rainfall used for crops (Re_{80} x Crop Intensity)
(6) Blanks in the Table show no calculations have been made due to lack of rainfall data

Table VII-11

Year	Palawija R (mm)	Palawija Re70 (mm)	Palawija Re80 (mm)	Palawija Rae70 (mm)	Palawija Rae80 (mm)	Palawija Re70/R (%)	Palawija Re80/R (%)	Palawija (Rae70+Rae80)/R (%)	Total R (mm)	Total Re70 (mm)	Total Re80 (mm)	Total Rae70 (mm)	Total Rae80 (mm)	Total Re70/R (%)	Total Re80/R (%)	Total (Rae70+Rae80)/R (%)
1961-62	490	335	—	138	—	68.4	—	28.3	1479	977	652	618	46	66.1	42.3	44.9
62-63	65	46	—	8	—	70.8	—	12.9	—	810	379	549	40	—	—	—
63-64	406	286	—	164	—	70.4	—	40.6	1175	795	502	498	72	67.7	42.7	48.6
64-65	211	146	—	36	—	69.2	—	17.5	1724	1094	705	650	86	63.0	41.0	42.8
65-66	276	190	—	73	—	68.8	—	26.7	1582	998	592	637	79	63.0	37.0	45.0
66-67	81	56	—	30	—	69.1	—	37.0	2050	1222	715	779	118	59.6	34.9	43.8
67-68	538	385	—	224	—	71.6	—	41.6	2147	1476	629	1030	67	68.7	29.3	51.1
68-69	378	252	—	122	—	66.7	—	32.3	1926	1071	720	710	71	55.6	67.2	40.9
69-70	496	341	—	133	—	68.8	—	26.8	2038	1324	562	872	66	65.0	27.6	46.0
70-71	585	202	—	108	—	34.5	—	18.5	2788	1573	1001	949	120	56.4	35.9	38.3
71-72	62	44	—	36	—	71.0	—	58.8	2233	1136	569	759	71	50.9	25.5	37.2
72-73	641	437	—	205	—	68.2	—	32.0	2174	1463	494	1027	65	67.3	22.8	50.2
73-74	725	393	—	262	—	54.2	—	36.2	2462	1469	713	940	95	59.7	29.0	42.1
74-75	494	347	—	199	—	70.2	—	40.5	1853	1251	611	841	79	67.5	33.0	49.7
75-76									1652	1102	670	649	83	66.7	40.6	44.4
mean						65.9	—	32.1	1949	1184	634	768	77	62.7	36.3	44.6

Table VII-12 The Factors for Calculation of Unit Irrigation Water Requirements (except Rainfall)

Item	Crop	Oct. (31)			Nov. (30)			Dec. (31)			Jan. (31)			Feb. (28)			Mar. (31)		
Days	R-I			11	10	10	10	10	10	11	10	10	11	10	10	8	10	4	
	R-II																5	10	11
	Pal	10	10	10															
Kc	R-I			1.15	1.17	1.21	1.28	1.33	1.39	1.385	1.31	1.27	1.175	1.13	1.08	1.06	1.05	1.05	
	R-II																1.17	1.18	1.24
	Pal	0.63	0.57	0.55															
ETo (mm)	R-I			48.95	43.0	43.0	43.0	38.3	38.3	42.13	37.8	37.8	41.58	40.0	40.0	32.0	40.6	16.24	
	R-II																20.3	40.60	44.66
	Pal	46.5	44.5	44.5															
Cu (mm)	R-I			56.29	50.31	52.03	55.04	40.94	53.23	58.35	49.52	47.86	48.86	45.2	43.2	33.92	42.63	17.05	
	R-II																23.75	47.91	55.38
	Pal	28.03	25.37	24.48															
Pc	R-I			22	20	20	20	20	20	22	20	20	22	20	20	16	20	8	
	R-II																10	20	22
	Pal																		
Sub Total (Cu + Pc)	R-I																		
	R-II																		
	Pal																		
Ic	R-I			0.092	0.267	0.433	0.6	0.767	0.963	1	1	0.971	0.792	0.617	0.45	0.3	0.13	0.033	
	R-II																0.042	0.104	0.338
	Pal	0.417	0.25	0.083															

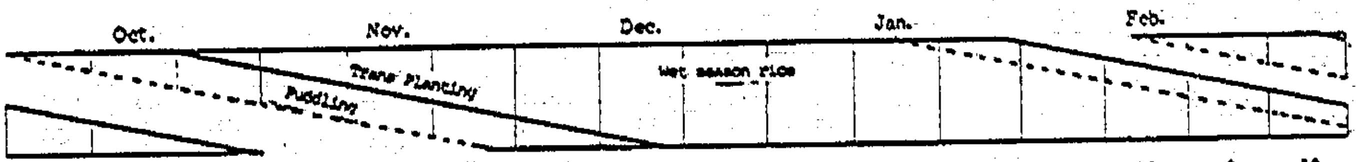
R-I : Wet season rice
R-II : Dry season rice
Pal : Palawija

Kc : Crop Factor
ETo : Evapotranspiration
Cu : Consumtive Use
Po : Percolation
Ic : Intercity

Table VII-12

	Apr. (30)			May (31)			Jun. (30)			Jul. (31)			Aug. (31)			Sep. (130)	
10	10	10	10	10	11	10	10 8	10 10	10 10	3 10	11	10	10	11	10	10	10
1.33	1.40	1.35	1.30	1.225	1.095	0.99	0.98 0.29	0.98 0.205	0.98 0.316	0.98 0.372	0.39	0.65	0.765	0.98	0.93	0.84	0.73
40.3	40.3	40.3	39.3	39.3	43.23	38.4	38.4 30.72	38.4 38.4	41.5 41.5	12.45 41.5	45.65	44.6	44.6	49.06	46.7	46.7	46.7
53.60	56.42	54.41	50.86	57.95	47.58	38.02	37.63 8.91	37.63 11.33	40.67 13.11	12.20 15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
20	20	20	20	20	22	20	20	20	20	6							
0.517	0.683	0.850	0.9835	0.975	0.779	0.663	0.467 0.067	0.300 0.217	0.133 0.383	0.025 0.55	0.725	0.9	0.996	1	0.917	0.75	0.583

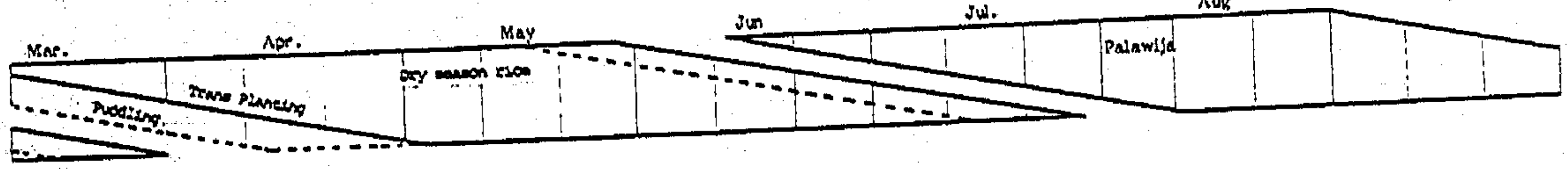
Table VII-13 Diversion Unit Water Requirement (1)



1961-1962 Wet season rice	Period of 10-day	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			0	25	12	14	0	44	52	35	14	41	70	55	57	13
	Wp	l/sec/ha			0.119	0.219	0.470	0.662	0.984	0.493	0.486	0.263	0.935	0.389	0	0.067	0	0.135
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																13
	Wp	l/sec/ha																0.023
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	0	4	0													
	Wp	l/sec/ha	0.225	0.103	0.039													
1962-1963 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			30	77	13	24	0	53	75	43	50	164	69	53	51	0
	Wp	l/sec/ha			0.073	0	0.462	0.554	0.984	0.341	0.088	0.480	0.310	0	0	0.083	0	0.170
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																0
	Wp	l/sec/ha																0.51
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	0	32	30													
	Wp	l/sec/ha	0.225	0	0													
1963-1964 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			19	35	9	56	9	0	35	18	0	11	35	0	0	43
	Wp	l/sec/ha			0.099	0.154	0.495	0.207	0.859	1.275	0.820	0.846	1.190	0.857	0.306	0.514	0.339	0.53
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																40
	Wp	l/sec/ha																0.046
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	0	27	19													
	Wp	l/sec/ha	0.225	0	0.009													

ET: Evapotranspiration, P: Percolation, Re: Effective Rainfall, Wp: Water Requirement for Paddy Field Pal: Palawija

Table VII-13 (1)



4 25.05 8 0.026																			
10 67.91 8 0.113	11 77.38 51 0.147	10 73.60 27 0.436	10 76.42 0 0.944	10 74.41 57 0.268	10 70.86 16 0.979	10 67.95 25 0.754	11 69.58 0 0.925	10 58.02 42 0.183	10 57.63 0 0.487	10 57.63 114 0	10 60.67 16 0.069	3 18.20 84 0							
									8 8.91 0 0.015	10 11.33 114 0	10 13.11 16 0	10 15.44 84 0	11 17.80 5 0.163	10 28.99 7 0.382	10 38.22 26 0.235	11 48.08 4 0.772	10 43.43 0 0.768	10 39.23 8 0.432	10 34.09 9 0.282

4 25.05 0 0.037																			
10 67.91 0 0.128	11 77.38 0 0.430	10 73.60 0 0.688	10 76.42 0 0.944	10 74.41 0 1.144	10 70.86 0 1.264	10 67.95 53 0.268	11 69.58 4 0.871	10 58.02 17 0.470	10 57.63 0 0.487	10 57.63 0 0.313	10 60.67 0 0.146	3 18.20 0 0.027							
									8 8.91 0 0.014	10 11.33 0 0.047	10 13.11 0 0.097	10 15.44 0 0.164	11 17.80 0 0.226	10 28.99 0 0.503	10 38.22 0 0.737	11 48.08 0 0.843	10 43.43 0 0.768	10 39.23 0 0.568	10 34.09 0 0.383

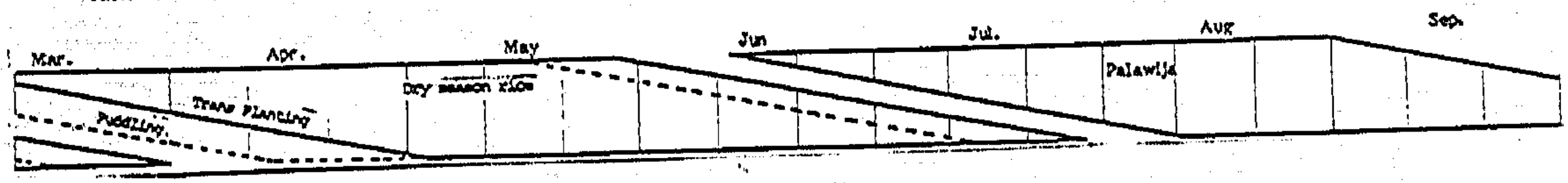
4 25.05 21 0.19																			
10 67.91 48 0.88	11 77.38 19 0.324	10 73.60 70 0.034	10 76.42 25 0.635	10 74.41 74 0.006	10 70.86 41 0.331	10 67.95 20 0.854	11 69.58 25 0.586	10 58.02 0 0.664	10 57.63 0 0.487	10 57.63 18 0.215	10 60.67 6 0.131	3 18.20 18 0							
									8 8.91 0 0.115	10 11.33 18 0	10 13.11 6 0.083	10 15.44 72 0	11 17.80 0 0.226	10 28.99 0 0.503	10 38.22 23 0.733	11 48.08 46 0.842	10 43.43 4 0.847	10 39.23 0 0.367	10 34.09 5 0.327

Table VII-13 Diversion Unit Water Requirement (2)

			Oct.			Nov.			Dec.			Jan.			Feb.			
1964-1965 Wet season rice	Period of 10-day	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			15	60	4	25	0	36	39	39	48	98	35	60	32	60
	Wp	l/sec/ha			0.105	0.450	0.534	0.543	0.984	0.648	0.748	0.501	0.348	0	0.306	0.026	0.112	0.007
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																35
	Wp	l/sec/ha																0.018
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	74	21	15													
	Wp	l/sec/ha	0	0.021	0.015													
1965-1966 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.20	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			0	29	18	136	50	21	21	53	13	42	50	113	39	26
	Wp	l/sec/ha			0.130	0.282	0.425	0	0.290	0.909	1.073	0.271	0.962	0.413	0.154	0	0.741	0.100
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																13
	Wp	l/sec/ha																0.032
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	10	0	0													
	Wp	l/sec/ha	0.145	0.122	0.039													
1966-1967 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.37	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			37	42	36	48	94	42	23	46	151	75	85	81	35	69
	Wp	l/sec/ha			0.062	0.137	0.282	0.293	0	0.544	0.943	0.425	0	0	0	0	0.101	0
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																69
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	18	17	37													
	Wp	l/sec/ha	0.081	0.040	0													

ET: Evapotranspiration, P: Percolation, Re: Effective Rainfall, Wp: Water Requirement for Paddy Field Pal: Palawija

Table VII-13 (2)

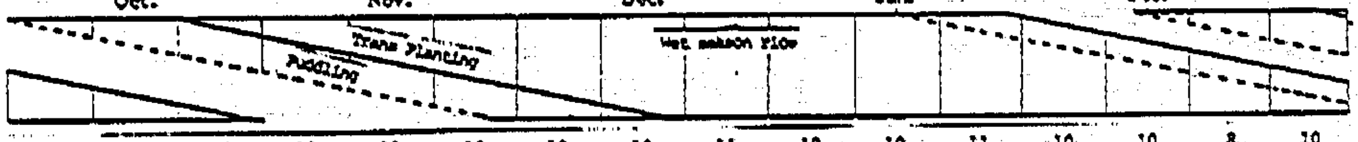


4 25.05 21 0.019																			
10 67.91 36 0.088	11 77.38 36 0.064	10 73.60 60 0.127	10 76.42 60 0.203	10 74.41 16 0.898	10 70.86 34 0.656	10 67.95 12 0.997	11 69.58 95 0	10 58.02 0 0.664	10 57.63 38 0.166	10 57.63 59 0	10 60.67 35 0.062	3 18.20 0 0.007							
									8 8.91 38 0	10 11.33 59 0	10 13.11 35 0	10 15.44 0 0.163	11 17.80 0 0.226	10 28.99 0 0.503	10 38.22 4 0.657	11 48.08 0 0.842	10 43.43 0 0.366	10 39.23 0 0.567	10 34.09 0 0.613

4 25.05 20 0.118																			
10 67.91 20 0.127	11 77.38 48 0.109	10 73.60 6 0.632	10 76.42 39 0.462	10 74.41 53 0.329	10 70.86 34 0.656	10 67.95 12 0.997	11 69.58 33 0.481	10 58.02 35 0.263	10 57.63 21 0.309	10 57.63 0 0.313	10 60.67 35 0.062	3 18.20 21 0.013							
									8 8.91 21 0	10 11.33 0 0.048	10 13.11 35 0	10 15.44 21 0	11 17.80 0 0.226	10 28.99 0 0.503	10 38.22 0 0.733	11 48.08 0 0.842	10 43.43 11 0.574	10 39.23 30 0.133	10 34.09 0 0.613

4 25.05 0 0.037																			
10 67.91 0 0.128	11 77.38 88 0	10 73.60 31 0.398	10 76.42 48 0.351	10 74.41 69 0.083	10 70.86 63 0.140	10 67.95 25 0.757	11 69.58 0 0.891	10 58.02 0 0.644	10 57.63 0 0.487	10 57.63 0 0.313	10 60.67 13 0.115	3 18.20 7 0.017							
									8 8.91 0 0.015	10 11.33 0 0.047	10 13.11 13 0.001	10 15.44 7 0.090	11 17.80 0 0.226	10 28.99 0 0.503	10 38.22 0 0.734	11 48.08 7 0.720	10 43.43 6 0.620	10 39.23 0 0.568	10 34.09 0 0.359

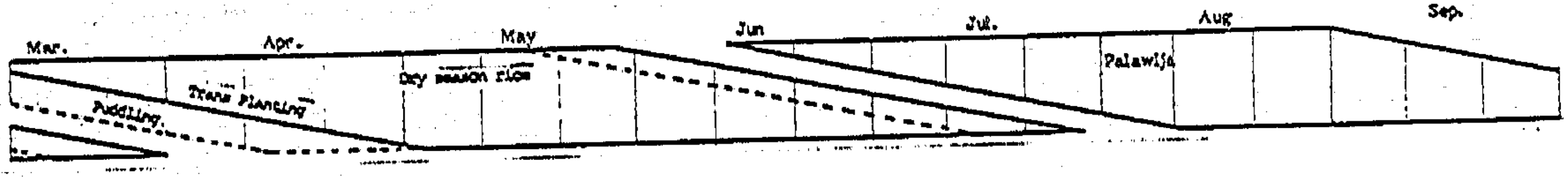
Tabel VII-13 Diversion Unit Water Requirement (3)



				Oct.			Nov.			Dec.			Jan.			Feb.	
1967–1968 Wet season rice	Period of 10-day	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			0	26	24	11	40	43	108	73	131	68	54	84	70	52
	Wp	l/sec/ha			0.118	0.214	0.376	0.694	0.429	0.526	0	0	0	0.037	0.125	0	0	0.190
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																52
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	23	0	0													
	Wp	l/sec/ha	0.004	0.122	0.040													
1968–1969 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			20	27	27	2	46	13	151	15	27	15	36	114	12	34
	Wp	l/sec/ha			0.088	0.209	0.353	1.335	0.346	1.049	0	0.986	0.717	0.731	0.377	0	0.257	0.078
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																34
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	12	7	20													
	Wp	l/sec/ha	0.129	0.009	0.007													
1969–1970 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			54	90	37	0	0	43	18	61	111	81	135	72	23	37
	Wp	l/sec/ha			0.037	0	0.274	0.814	0.984	0.526	1.025	0.154	0	0	0	0	0.363	0.070
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																37
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	4	0	54													
	Wp	l/sec/ha	0.193	0.122	0													

ET: Evapotranspiration, P: Percolation, Re: Effective Rainfall, Wp: Water Requirement for Paddy Field Pal: Palawija

Table VII-13 (3)

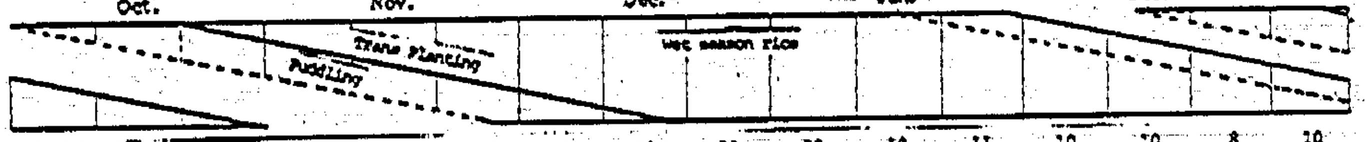


4 25.05 55 0																			
10 67.91 55 0.024	11 77.38 36 0.230	10 73.60 32 0.389	10 76.42 42 0.425	10 74.41 2 1.113	10 70.86 33 0.673	10 67.95 48 0.352	11 69.58 22 0.609	10 58.02 58 0.001	10 57.63 45 -0.107	10 57.63 43 0.079	10 60.67 0 0.146	3 18.20 40 0							
									8 8.91 48 0	10 11.33 43 0	10 13.11 0 0.097	10 15.44 40 0	11 17.80 62 0	10 28.99 35 0	10 38.22 23 0.292	11 48.08 42 0.107	10 43.43 22 0.279	10 39.23 0 0.568	10 34.09 34 0.001

4 25.05 16 0.014																			
10 67.91 16 0.098	11 77.38 44 0.485	10 73.60 58 0.146	10 76.42 55 0.265	10 74.41 5 1.067	10 70.86 92 0	10 67.95 17 0	11 69.58 6 0	10 58.02 0 0.664	10 57.63 28 0.250	10 57.63 7 0.275	10 60.67 20 0.098	3 18.20 2 0.024							
									8 8.91 28 0	10 11.33 7 0.018	10 13.12 20 0	10 15.44 2 0.143	11 17.80 0 0.226	10 28.99 0 0.503	10 38.22 0 0.735	11 48.08 0 0.773	10 43.43 20 0.308	10 39.23 92 0	10 34.09 19 0.169

4 25.05 16 0.014																			
10 67.91 16 0.098	11 77.38 7 0.391	10 73.60 41 0.305	10 76.42 35 0.512	10 74.41 33 0.637	10 70.86 50 0.373	10 67.95 37 0.546	11 69.58 62 0.097	10 58.02 37 0.241	10 57.63 91 0	10 57.63 0 0.313	10 60.67 19 0.100	3 18.20 15 0.005							
									8 8.91 91 0	10 11.33 0 0.005	10 13.11 19 0	10 15.44 15 0.005	11 17.80 3 0.188	10 28.99 6 0.503	10 38.22 35 0.062	11 48.08 0 0.843	10 43.13 17 0.407	10 39.23 56 0	10 34.09 4 0.338

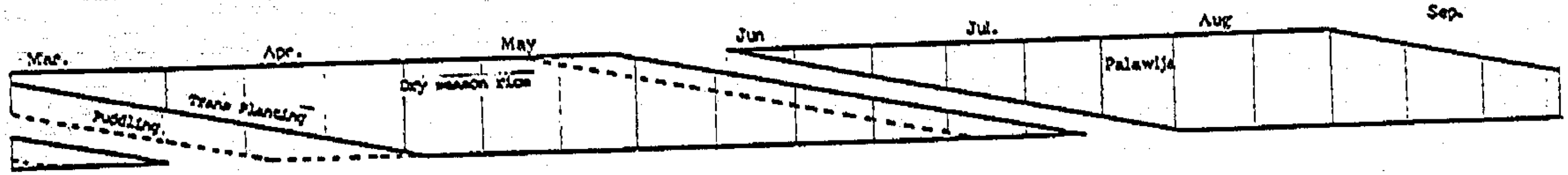
Table VII-13 Diversion Unit Water Requirement (4)



			Oct.			Nov.			Dec.			Jan.			Feb.			
1970-1971 Wet season rice	Period of 10-day	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			80	92	143	44	27	92	69	46	56	55	116	72	70	34
	Wp	l/sec/ha			0	0	0	0.337	0.609	0	0.187	0.425	0.209	0.207	0	0	0	0.023
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																54
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	16	5	80													
	Wp	l/sec/ha	0.097	0.098	0													
1971-1972 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			28	17	57	5	30	25	31	119	133	70	0	142	81	70
	Wp	l/sec/ha			0.076	0.257	0.118	0.760	0.568	0.842	0.811	0	0	0.012	0.728	0	0	0
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																70
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	0	8	28													
	Wp	l/sec/ha	0.225	0.084	0													
1972-1973 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			0	7	22	11	16	15	67	75	43	72	209	56	42	29
	Wp	l/sec/ha			0.118	0.299	0.392	0.095	0.702	1.014	0.219	0	0.437	0	0	0.063	0.034	0.091
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																29
	Wp	l/sec/ha																0.007
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	0	0	0													
	Wp	l/sec/ha	0.220	0.122	0.039													

ET: Evapotranspiration, P: Percolation, Re: Effective Rainfall, Wp: Water Requirement for Paddy Field Pal: Palawija

Table VII-13 (4)

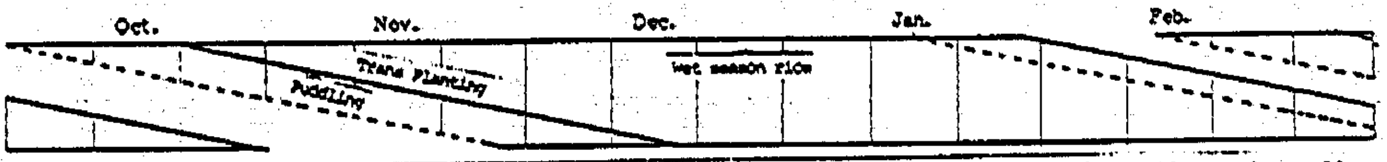


4																			
25.05																			
25																			
0.001																			
10	11	10	10	10	10	10	11	10	10	10	10	3							
67.91	77.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02	57.63	57.63	60.67	18.20							
25	81	36	19	4	16	94	12	83	21	27	0	14							
0.081	0	0.352	0.709	1.082	1.261	0	0.832	0	0.309	0.166	0.146	0.006							
									8	10	10	10	11	10	10	11	10	10	10
									8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
									21	27	0	14	0	4	16	20	25	26	13
									0	0	0.097	0.015	0.274	0.433	0.427	0.808	0.306	0.191	0.222

4																			
25.05																			
46																			
0																			
10	11	10	10	10	10	10	11	10	10	10	10	3							
67.91	72.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02	57.63	57.63	60.67	18.20							
46	35	53	6	0	91	64	0	8	0	0	0	0							
0.041	0.235	0.193	0.870	1.144	0	0.070	0.891	0.373	0.487	0.313	0.146	0.027							
									8	10	10	10	11	10	10	11	10	10	10
									8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
									0	0	0	0	18	26	0	0	0	0	0
									0.014	0.047	0.097	0.164	0	0.050	0.688	0.843	0.768	0.568	0.383

4																			
25.05																			
59																			
0.051																			
10	11	10	10	10	10	10	11	10	10	10	10	3							
67.91	77.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02	57.63	57.63	60.67	18.20							
59	34	13	40	89	53	69	81	45	41	51	5	35							
0.017	0.241	0.567	0.450	0	0.318	0	0	0.149	0.140	0.036	0.134	0							
									8	10	10	10	11	10	10	11	10	10	10
									8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
									41	51	5	35	33	53	29	23	7	0	39
									0	0	0.060	0	0	0	0.177	0.440	0.644	0.568	0

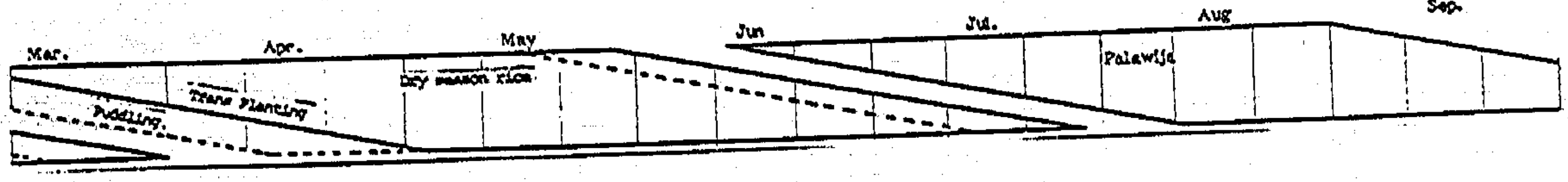
Table VII-13 Diversion Unit Water Requirement (5)



				Oct.			Nov.			Dec.			Jan.			Feb.	
1973–1974 Wet season rice	Period of 10-day	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			97	5	0	83	15	29	27	153	57	12	29	120	46	77
	Wp	l/sec/ha			0	0.315	0.564	0	0.776	0.770	0.877	0	0.191	0.766	0.404	0	0.027	0
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																42
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	18	10	93													
	Wp	l/sec/ha	0.081	0.074	0													
1974–1975 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			0	39	65	0	78	11	55	78	44	111	127	74	6	0
	Wp	l/sec/ha			0.118	0.151	0.055	0.814	0	1.084	0.417	0	0.419	0	0	0	0.298	0.170
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																0
	Wp	l/sec/ha																0.051
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	0	35	0													
	Wp	l/sec/ha	0.226	0	0.039													
1975–1976 Wet season rice	Period	days			11	10	10	10	10	10	11	10	10	11	10	10	8	10
	Pw=ET+P	mm			78.29	70.31	72.03	75.04	70.94	73.23	80.35	69.52	67.56	70.86	65.20	63.20	49.92	62.63
	Re	mm			69	51	20	0	45	34	57	71	102	118	16	0	0	119
	Wp	l/sec/ha			0.014	0.093	0.407	0.814	0.380	0.685	0.384	0	0	0	0.549	0.514	0.271	0
Dry season rice	Period	days																5
	Pw=ET+P	mm																33.75
	Re	mm																60
	Wp	l/sec/ha																0
Palawija	Period	days	10	10	10													
	Pw=ET+P	mm	28.03	25.37	24.48													
	Re	mm	25	57	56													
	Wp	l/sec/ha	0.024	0	0													

ET: Evapotranspiration, P: Percolation, Re: Effective Rainfall, Wp: Water Requirement for Paddy Field Pal: Palawija

Table VII-13 (5)



4
25.05
32
0

10	11	10	10	10	10	10	11	10	10	10	10	3
67.91	77.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02	57.63	57.63	60.67	18.20
58	36	35	62	18	18	64	42	0	8	70	7	8
0.019	0.230	0.361	0.178	0.898	0.940	0.070	0.353	0.664	0.419	0	0.129	0.016

8	10	10	10	11	10	10	11	10	10	10
8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
8	70	7	8	14	0	98	53	17	35	43
0.001	0	0.045	0.079	0.048	0.503	0	0	0.408	0.060	0

4
25.05
53
0

10	11	10	10	10	10	10	11	10	10	10	10	3
67.91	77.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02	57.63	57.63	60.67	18.20
90	31	54	36	32	35	41	0	0	0	0	0	18
0	0.258	0.183	0.499	0.683	0.638	0.475	0.891	0.664	0.487	0.373	0.146	0.001

8	10	10	10	11	10	10	11	10	10	10
8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
0	0	0	26	34	0	41	46	18	16	28
0.014	0.047	0.097	0	0	0.503	0	0.036	0.450	0.336	0.064

4
25.05
4
0.031

10	11	10	10	10	10	10	11	10	10	10	10	3
67.91	77.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02	57.63	57.63	60.67	18.20
41	19	20	0	35	80	5	0	56	0	0	11	0
0.051	0.324	0.501	0.882	0.637	0	1.109	0.891	0.023	0.487	0.312	0.119	0.027

8	10	10	10	11	10	10	11	10	10	10
8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09
0	0	11	0	0	0	0	4	25	0	22
0.013	0.044	0.015	0.154	0.212	0.472	0.688	0.725	0.306	0.532	0.127

Table VII-14 Nursery Water Requirements

	Wet season rice								Dry season rice								
	Oct.			Nov.			Dec.		Feb.		Mar.			Apr.			May
	I	II	III	I	II	III	I	II	II	III	I	II	III	I	II	III	I
n (days)	10	10	11	10	10	10	10	9	7	8	10	10	11	10	10	10	4
Index	0.002	0.006	0.009	0.008	0.008	0.008	0.006	0.002	0.003	0.009	0.016	0.017	0.017	0.017	0.015	0.007	0.002
Nu (l/s/ha)																	
1963 - 64	0.010	0.021	0.03	0.023	0.033	0.014	0.011	0.010	0.016	0.043	0.038	0.037	0.055	0.022	0.047	0.017	0.015
64 - 65	0.057	0.023	0.033	0.015	0.035	0.024	0.026	0.007	0.010	0.029	0.028	0.032	0.031	0.027	0.027	0.025	0.015
65 - 66	0.010	0.027	0.037	0.025	0.030	0	0.014	0.005	0.014	0.024	0.050	0.037	0.037	0.063	0.039	0.062	0.013
66 - 67	0.008	0.023	0.026	0.021	0.023	0.016	0.016	0.006	0.016	0.027	0.023	0.071	0.012	0.049	0.043	0.028	0.015
67 - 68	0.007	0.027	0.038	0.027	0.027	0.031	0.016	0.006	0.003	0.012	0.035	0.033	0.044	0.049	0.035	0.029	0.009
68 - 69	0.008	0.012	0.032	0.027	0.028	0.030	0.008	0.009	0.001	0.038	0.046	0.061	0.039	0.031	0.029	0.015	0.003
69 - 70	0.010	0.013	0.013	0.006	0.023	0.031	0.026	0.006	0.004	0.138	0.045	0.061	0.063	0.043	0.041	0.020	0.007
70 - 71	0.008	0.027	0.011	0.006	0	0.015	0.020	0.002	0.004	0.012	0.033	0.053	0.015	0.046	0.051	0.028	0.033
71 - 72	0.010	0.025	0.030	0.030	0.070	0.030	0.018	0.007	0	0.010	0.022	0.037	0.015	0.035	0.059	0.025	0.003
72 - 73	0.010	0.027	0.037	0.033	0.028	0.028	0.022	0.008	0.013	0.024	0.048	0.030	0.046	0.063	0.037	0.005	0.009
73 - 74	0.005	0.026	0.005	0.034	0.036	0.007	0.022	0.008	0.013	0.021	0.027	0.031	0.044	0.047	0.025	0.024	0.013
74 - 75	0.010	0.019	0.037	0.023	0.013	0.031	0.006	0.010	0.015	0.163	0.068	0.011	0.048	0.033	0.041	0.080	0.017
75 - 76	0.009	0.013	0.015	0.019	0.029	0.031	0.014	0.006	0.016	0.043	0.001	0.043	0.055	0.037	0.063	0.020	0.017

Table VII-15 Puddling Water Requirements

Wet season rice

period	Oct. I	Oct. II	Oct. III	Nov. I	Nov. II	Nov. III	Dec. I	Dec. II
n (days)	5	10	11	10	10	10	10	4
Index	1/14	2/14	2.2/14	2/14	2/14	2/14	2/14	0.8/14
Pd (l/s/ha)								
1963-64	0.455	0.389	0.305	0.238	0.336	0.196	0.336	0.362
64-65	0.280	0.466	0.315	0.186	0.186	0.261	0.362	0.284
65-66	0.445	0.528	0.362	0.274	0.310	0	0.212	0.362
66-67	0.394	0.479	0.253	0.228	0.253	0.220	0.119	0.253
67-68	0.377	0.528	0.362	0.285	0.251	0.329	0.244	0.233
68-69	0.410	0.508	0.302	0.302	0.282	0.305	0.226	0.323
69-70	0.433	0.528	0.202	0.096	0.252	0.362	0.362	0.233
70-71	0.400	0.513	0.127	0.090	0	0.233	0.284	0.090
71-72	0.445	0.505	0.279	0.313	0.019	0.346	0.274	0.305
72-73	0.445	0.528	0.362	0.341	0.295	0.328	0.313	0.346
73-74	0.443	0.526	0.080	0.346	0.362	0.119	0.318	0.274
74-75	0.445	0.425	0.362	0.243	0.171	0.362	0.129	0.362
75-76	0.445	0.354	0.160	0.212	0.302	0.362	0.230	0.326

Dry season rice

period	Feb. II	Feb. III	Mar. I	Mar. II	Mar. III	Apr. I	Apr. II	Apr. III
n (days)	2	8	10	10	11	10	10	9
Index	0.4/14	1.6/14	2/14	2/14	2.2/14	2/14	2/14	1.8/14
Pd (l/s/ha)								
1963-64	0.393	0.486	0.181	0.220	0.279	0.155	0.289	0.142
64-65	0.289	0.393	0.186	0.196	0.196	0.186	0.186	0.315
65-66	0.390	0.367	0.284	0.302	0.220	0.346	0.258	0.207
66-67	0.393	0.382	0.158	0.362	0.103	0.271	0.349	0.158
67-68	0.145	0.279	0.208	0.199	0.255	0.060	0.232	0.300
68-69	0.056	0.431	0.261	0.314	0.232	0.190	0.199	0.211
69-70	0.180	0.418	0.252	0.314	0.341	0.241	0.254	0.264
70-71	0.187	0.279	0.204	0.289	0.124	0.256	0.307	0.331
71-72	0	0.248	0.155	0.217	0.258	0.207	0.346	0.362
72-73	0.331	0.362	0.276	0.189	0.264	0.326	0.243	0.098
73-74	0.341	0.349	0.341	0.191	0.253	0.258	0.181	0.307
74-75	0.344	0.399	0.362	0.096	0.271	0.202	0.253	0.269
75-76	0.393	0.486	0.010	0.243	0.305	0.302	0.362	0.258

Table VII-16 Summary of Balance Calculation Between Diversion Water Requirement and Dependable Discharge

No.	Year	Item	Oct. I	Oct. II	Oct. III	Nov. I	Nov. II	Nov. III	Dec. I	Dec. II	Dec. III	Jan. I	Jan. II	Jan. III	Feb. I	Feb. II	Feb. III	Mar. I	Mar. II	Mar. III
1	1963	Disc	6.47	2.94	4.09	9.55	7.12	9.39	9.49	7.61	5.11	11.27	8.63	10.19	9.47	17.82	9.75	19.97	3.64	7.02
	|	Wu	0.670	0.389	0.413	0.412	0.831	0.403	0.421	1.637	0.820	0.846	1.190	0.857	0.306	0.907	0.825	0.757	0.327	0.603
	1964	Wr	1.689	1.362	1.419	1.442	2.909	1.411	4.183	5.730	2.870	2.961	4.165	3.000	1.071	3.175	2.888	2.650	1.743	2.110
2	1964	Disc	11.27	11.43	10.24	4.70	9.02	9.10	8.16	11.30	5.72	15.32	5.91	6.98	5.58	14.66	13.34	6.39	18.67	2.09
	|	Wu	0.280	0.487	0.435	0.636	0.720	0.804	1.346	0.932	0.748	0.501	0.348	0	0.306	0.315	0.505	0.211	0.303	0.260
	1965	Wr	0.980	1.643	1.479	2.226	2.520	2.814	4.711	3.262	2.618	1.754	1.218	0	1.071	1.103	1.768	0.739	1.061	0.910
3	1965	Disc	6.96	1.09	3.58	4.07	7.28	6.90	3.20	2.89	4.02	11.08	6.98	4.71	7.06	7.34	8.20	8.11	9.76	5.54
	|	Wu	0.590	0.650	0.531	0.456	0.735	0	0.502	1.271	1.073	0.271	0.962	0.413	0.154	0.390	1.108	0.416	0.448	0.329
	1966	Wr	1.643	1.919	1.745	1.596	2.573	0	1.757	4.449	3.756	0.949	3.367	1.446	0.539	1.365	3.878	1.456	1.915	1.152
4	1966	Disc	10.33	4.90	10.88	7.04	6.64	2.38	8.46	3.77	2.11	4.59	6.02	8.11	12.68	3.35	6.45	11.14	1.56	12.70
	|	Wu	0.475	0.519	0.315	0.375	0.535	0.513	0.119	0.797	0.943	0.425	0	0	0	0.393	0.483	0.158	0.527	0.103
	1967	Wr	1.426	1.700	1.103	1.313	1.873	1.796	0.417	2.790	3.301	1.488	0	0	0	1.376	1.691	0.553	1.845	0.361
5	1967	Disc	13.61	6.37	6.13	6.24	9.81	6.33	5.46	10.03	5.78	12.05	5.93	9.59	4.15	9.32	5.58	4.22	13.19	5.98
	|	Wu	0.381	0.650	0.520	0.499	0.667	1.023	0.673	0.761	0	0	0	0.037	0.125	0.145	0.279	0.398	0.223	0.485
	1968	Wr	1.322	1.919	1.703	1.747	2.335	3.581	2.356	2.664	0	0	0	0.130	0.438	0.508	0.977	1.393	0.781	1.698
6	1968	Disc	9.68	4.78	9.87	8.80	7.61	6.96	14.72	6.58	9.82	2.07	11.78	8.26	4.50	7.15	2.32	1.57	12.53	7.60
	|	Wu	0.539	0.517	0.397	0.511	0.635	1.098	0.572	1.372	0	0.986	0.717	0.732	0.337	0.056	0.708	0.339	0.426	0.470
	1969	Wr	1.510	1.743	1.369	1.789	2.223	3.843	2.002	4.802	0	3.451	2.510	2.559	1.180	0.196	2.478	1.187	1.491	1.460
7	1969	Disc	2.14	5.29	4.95	8.63	4.14	4.83	4.74	2.98	2.76	3.25	8.16	7.03	13.98	8.02	7.39	6.83	6.87	4.87
	|	Wu	0.626	0.650	0.239	0.096	0.526	1.176	1.346	0.761	1.025	0.154	0	0	0	0.180	0.783	0.322	0.426	0.732
	1970	Wr	1.629	1.919	0.839	0.336	1.841	4.116	4.711	2.664	3.588	0.539	0	0	0	0.630	2.742	1.127	1.491	2.562
8	1970	Disc	2.00	1.63	2.47	5.96	9.91	8.21	2.50	1.84	7.10	4.14	8.76	4.74	15.02	19.03	4.63	3.46	10.15	6.36
	|	Wu	0.497	0.611	0.127	0.090	0	0.570	0.893	0.090	0.187	0.425	0.209	0.207	0	0.181	0.279	0.227	0.371	0.124
	1971	Wr	1.457	1.853	0.445	0.315	0	1.995	3.126	0.315	0.655	1.488	7.315	0.725	0	0.664	0.977	0.795	1.299	0.434
9	1971	Disc	2.47	4.37	14.91	3.44	4.74	3.30	6.47	3.67	5.61	12.96	18.34	19.18	12.44	8.28	4.70	16.26	13.35	10.40
	|	Wu	0.670	0.589	0.355	0.570	0.137	1.106	0.842	1.147	0.811	0	0	0.012	0.728	0	0.248	0.155	0.259	0.493
	1972	Wr	1.689	1.817	1.243	1.995	0.480	3.871	2.947	4.015	2.839	0	0	0.042	2.548	0	0.868	0.543	0.388	1.726
10	1972	Disc	0.24	0.46	2.94	2.38	4.16	3.60	4.83	7.65	8.57	10.00	5.30	7.46	16.85	10.91	10.79	8.64	9.49	7.27
	|	Wu	0.665	0.650	0.519	0.640	0.687	1.023	1.077	1.360	0.219	0	0.439	0	0	0.394	0.416	0.374	0.257	0.505
	1973	Wr	2.328	2.275	1.817	2.240	2.405	3.581	3.770	4.760	0.767	0	1.330	0	0	1.379	1.456	1.309	0.900	1.768
11	1973	Disc	7.92	4.45	9.74	7.18	2.38	5.86	7.16	4.56	7.34	22.16	15.13	3.94	8.00	10.36	7.87	10.48	3.42	5.28
	|	Wu	0.524	0.600	0.080	0.661	0.926	0.119	1.094	1.044	0.877	0	0.191	0.766	0.404	0.341	0.376	0.341	0.210	0.483
	1974	Wr	1.598	1.884	0.280	2.314	3.242	0.416	3.829	3.654	3.070	0	0.669	2.681	1.414	1.194	1.316	1.194	0.735	1.516
12	1974	Disc	7.71	7.23	5.61	3.00	10.88	2.81	3.66	1.72	3.82	4.06	4.44	11.43	6.93	10.85	9.12	7.82	3.18	5.59
	|	Wu	0.671	0.425	0.519	0.396	0.226	1.176	0.129	1.446	0.417	0	0.419	0	0	0.344	0.697	0.583	0.096	0.529
	1975	Wr	1.690	1.488	1.703	1.386	0.791	4.116	0.452	5.061	1.460	0	1.467	0	0	1.204	2.440	2.041	0.336	1.852
13	1975	Disc	6.33	6.40	4.80	5.48	9.28	3.34	3.24	5.44	3.49	14.96	24.96	27.68	12.29	4.53	6.83	14.93	3.77	5.12
	|	Wu	0.469	0.356	0.174	0.305	0.709	1.176	0.590	1.011	0.384	0	0	0	0.549	0.907	0.757	0.010	0.325	0.629
	1976	Wr	1.572	1.246	0.609	1.068	2.482	4.116	2.065	3.539	1.344	0	0	0	1.922	3.175	2.650	0.035	1.138	2.202

Notes:
1) Disc - - Dependable water at Gadeg (m^3/sec)
2) Wu - - - Unit diversion Water requirement (ℓ/sec/ha)
3) Wr - - - Diversion Water requirement (m^3/sec)

Table VII-16

Apr.			May			Jun.			Jul.			Aug.			Sep.		
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
20.72	13.14	11.52	16.36	3.12	7.27	4.67	9.95	5.72	4.76	4.06	6.73	9.26	12.59	9.29	11.44	9.87	10.32
0.189	0.924	0.148	0.531	0.854	0.586	0.664	0.602	0.215	0.214	0	0.226	0.503	0.733	0.842	0.847	0.567	0.327
0.662	3.234	0.518	1.859	2.989	2.051	2.324	1.772	0.752	0.507	0	0.131	0.293	0.427	0.491	0.494	0.330	0.190
9.61	4.73	4.42	15.92	9.31	12.74	11.76	6.23	10.74	7.18	2.22	2.29	2.07	3.98	1.43	0.84	4.07	1.72
0.659	0.387	1.213	0.656	0.997	0	0.664	0.166	0	0.062	0.170	0.226	0.503	0.657	0.842	0.366	0.567	0.613
2.307	1.355	4.246	2.296	3.490	0	2.324	0.581	0	0.217	0.120	0.131	0.293	0.383	0.491	0.213	0.330	0.357
6.68	9.74	6.82	7.75	3.80	7.82	8.86	4.15	1.40	2.31	0.72	2.35	0.75	3.20	5.11	7.69	7.98	3.86
0.978	0.720	0.536	0.656	0.997	0.481	0.263	0.309	0.361	0.062	0.013	0.226	0.503	0.733	0.842	0.574	0.133	0.613
3.423	2.520	1.876	2.296	3.490	1.684	0.921	1.082	1.124	0.217	0.046	0.131	0.293	0.427	0.491	0.334	0.078	0.357
6.75	15.78	8.28	5.06	8.86	3.64	1.40	0.76	3.96	0.73	0.80	1.43	0.57	2.43	0.63	0.66	0.51	6.26
0.669	0.700	0.241	0.140	0.757	0.891	0.664	0.502	0.360	0.116	0.107	0.226	0.503	0.734	0.720	0.620	0.368	0.359
2.342	2.450	0.844	0.490	2.650	3.119	2.324	1.713	1.123	0.403	0.112	0.132	0.293	0.428	0.420	0.361	0.331	0.209
4.13	16.76	5.02	5.03	4.94	4.87	5.14	6.54	6.58	7.08	9.64	5.84	2.71	2.96	11.82	4.46	11.46	10.75
0.449	0.657	1.413	0.673	0.352	0.609	0.001	0.107	0.079	0.243	0	0	0	0.292	0.107	0.379	0.568	0.001
1.572	2.300	4.946	2.356	1.232	2.132	0.004	0.375	0.277	0.568	0	0	0	0.170	0.062	0.221	0.331	0.001
14.60	9.42	9.83	14.59	12.20	6.00	6.24	2.41	1.71	12.42	3.98	1.64	0.75	2.72	2.71	7.98	10.39	3.44
0.336	0.467	1.278	0	0	0	0.664	0.250	0.293	0.098	0.167	0.226	0.503	0.735	0.773	0.308	0	0.169
1.176	1.635	4.473	0	0	0	2.324	0.873	0.973	0.343	0.167	0.131	0.293	0.428	0.450	0.179	0	0.098
7.39	5.02	4.58	9.85	16.20	6.76	5.23	7.71	2.79	1.55	1.45	3.08	1.42	2.31	2.12	1.63	7.49	5.44
0.546	0.770	0.901	0.373	0.546	0.097	0.24	0	0.317	0.100	0.010	0.188	0.503	0.062	0.843	0.467	0	0.338
1.911	2.695	3.154	1.306	1.911	0.340	0.844	0	1.098	0.350	0.020	0.110	0.293	0.036	0.491	0.272	0	0.197
7.52	8.13	7.90	5.67	3.71	4.20	4.07	4.96	4.22	4.17	5.23	1.78	3.00	5.08	3.37	2.34	1.14	1.66
0.608	1.016	1.433	1.261	0	0.832	0	0.309	0.166	0.243	0.021	0.274	0.433	0.427	0.808	0.306	0.191	0.222
2.128	3.556	5.016	4.414	0	2.912	0	1.082	0.581	0.568	0.029	0.159	0.252	0.249	0.471	0.179	0.111	-0.130
5.20	7.88	9.30	10.70	7.71	8.37	5.02	1.75	1.14	0.76	0.60	0.52	2.79	2.29	1.33	0.48	0.38	0.47
0.400	1.216	1.506	0	0.070	0.891	0.373	0.501	0.360	0.243	0.191	0	0.050	0.688	0.843	0.768	0.368	0.383
1.400	4.256	5.271	0	0.245	3.199	2.006	1.713	1.123	0.567	0.190	0	0.029	0.401	0.491	0.448	0.331	0.223
10.24	15.55	16.14	8.93	9.37	8.64	9.16	3.37	6.63	4.02	5.88	2.96	4.21	5.18	5.90	11.92	7.51	15.72
0.893	0.693	0.098	0.318	0	0	0.149	0.140	0.036	0.194	0	0	0	0.177	0.440	0.644	0.568	0
3.126	2.426	0.343	1.113	0	0	0.522	0.490	0.126	0.504	0	0	0	0.103	0.256	0.375	0.331	0
5.91	13.27	4.92	8.93	13.94	6.37	4.30	3.22	6.37	4.54	5.11	3.13	5.90	7.45	5.52	13.14	16.28	16.20
0.619	0.339	1.205	0.940	0.070	0.353	0.664	0.420	0	0.174	0.095	0.048	0.503	0	0	0.468	0.060	0
2.167	1.257	4.218	3.290	0.245	1.236	2.324	1.467	0	0.477	0.102	0.028	0.293	0	0	0.273	0.035	0
7.18	9.62	10.01	10.49	10.31	10.24	8.80	2.41	1.64	2.74	2.69	6.54	12.42	4.13	4.39	9.66	6.95	10.20
0.385	0.752	0.952	0.638	0.475	0.891	0.664	0.501	0.300	0.243	0.001	0	0.503	0	0.036	0.450	0.335	0.064
1.348	2.632	3.332	2.233	1.663	3.119	2.324	1.713	1.122	0.567	0.004	0	0.293	0	0.021	0.262	0.196	0.037
6.26	5.51	8.86	9.88	4.44	1.64	4.97	2.72	1.02	1.81	0.67	1.02	2.90	0.98	3.09	2.59	0.85	1.59
0.803	1.244	0.895	0	1.109	0.892	0.023	0.500	0.356	0.134	0.181	0.212	0.472	0.688	0.725	0.306	0.532	0.127
2.811	4.354	3.133	0	3.882	3.119	0.081	1.712	1.118	0.425	0.184	0.123	0.275	0.401	0.422	0.178	0.310	0.74

Table VII-17 General Features of the Project Facilities

1. Name of Project	:	K-C-C Area Irrigation Development Project
2. Source of irrigation water	:	Cibeureum River
3. Net irrigation area	:	3,500ha
4. Maximum diversion warer requirement	:	5,730 m^3/sec
5. Irrigation facilities		
(1) Diversion works		
Location	:	Gadeg
Catchment area	:	117km^2
Riverbed EL.	:	25.0m
Geology	:	tuff
Design flood	:	Q=320 m^3/sec
Dam type	:	Center core rockfill
Crest EL.	:	41.00m
Dam height at maximum	:	16m
Crest length	:	160m
Embankment	:	83,000m^3
Excavation	:	11,600m^3
Spillway type	:	Radial type gate - - - 2 bays
	:	Roller type gate - - - 1 bay
Spillway scale	:	No. 1 gate 7.00m x 8.40m
		No. 2 gate 2.00m x 2.40m
Intake gate type	:	Roller type gate - - - 2 bays
Intake gate scale	:	3.50m x 1.5m - - - 2 bays
(2) Main irrigation canal with related structures		
Canal type	:	Trapezoidal earth canal Siphon (No.1, No.2)
Length total	:	22,665m
(Siphon)		430m (No.1 300, No.2 130m)
Discharge	:	max. 5,730 m^3/sec

(3) Secondary Irrigation canal with related structures

Canal type	:	Trapezoidal earth canal
Length	:	25,250m
Number	:	9

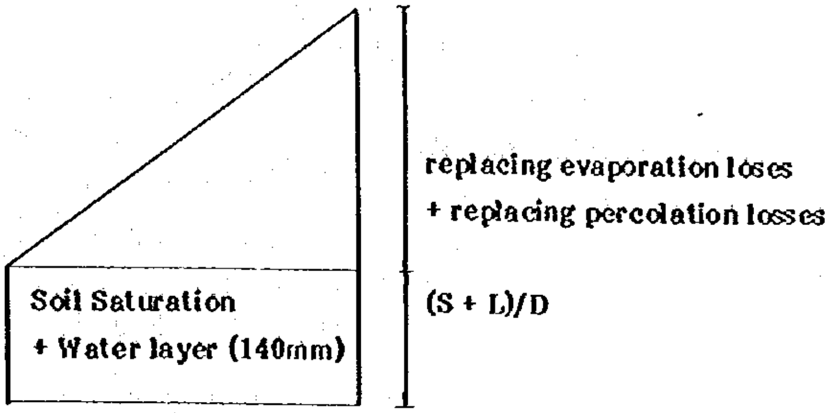
6. Tertiary system

Area to be served	:	3,500ha
Tertiary Unit	:	Average 50ha
Facilities	:	Tertiary and quaternary canal

7. Farm road Network

Main road length	:	14,800m
width	:	3.50m
Secondary road length	:	25,250m
Width	:	3.0m
Gravel pavement	:	127.550m^2

Table VII-18 **Calculation Sheet of Puddling Area in Oct.**
Ist 10-day to 2nd 10-day



Q = S + L + 1/2 (B + P) x D x A x 10 (m^3)

Where: D = Duration of the time (days) = 75 days

B = (4.45 x 26 + 4.3 x 30 + 3.83 x 19) = 317.47

P = (2 x 75) = 150

Q = 140 + (317.47 + 150) 1/2 x 1 x 10

= 3737.4 m^3/ha

Q/75days = q = 49.832 m^3/day/ha

= 0.000576 m^3/sec/ha

= 0.576 l/sec/ha ——> 0.9 l/sec/ha

qmin = 140/75 = 18.67 m^3/day

= 0.000216 l/sec/ha

= 0.216 l/sec/ha ——> 0.338 l/sec/ha

qmax = (140/75 + 4.45 + 2) x 10

= 0.985 l/day/ha

In case of perod of puddling --- 20days

Q = (140 + (4.45 + 2.0) x 20 x 1/2) x 10

= 2045m^3

= 102.25 m^3/day = 0.00118 m^3/sec

= 1.18 l/sec

Diversion requirement

= 1.85 l/sec

qmin = 140/20 x 10

= 70m^3

= 0.00081 m^3/sec/ha

= 0.81 l/sec/ha ——> 1.266 l/sec/ha

Available use water for the puddling (Dependable Water of Water resource —Nursery Water)

Oct. Ist 0.24m3

240 - 35 = 200 ℓ/sec

2nd 0.46m3

460 - 88 = 370 ℓ/sec

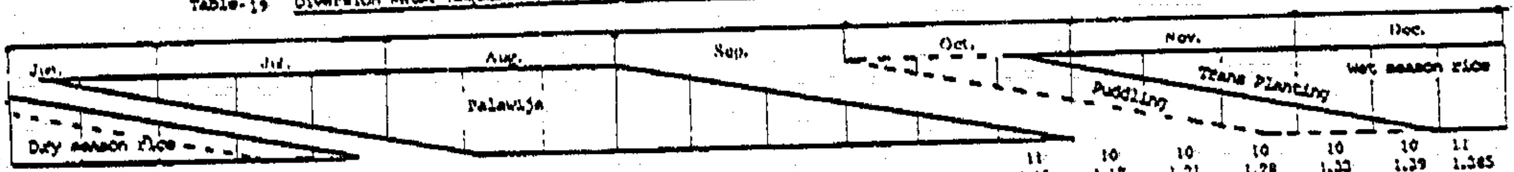
	Oct Ist	Oct IInd
Available Water	200 ℓ/sec	370 ℓ/sec
Available Water / Unit Water Requirement	$\frac{200}{0.9}$ = 222ha	$\frac{370}{0.9}$ = 411ha
	$\frac{200}{0.34}$ = 588ha	$\frac{370}{0.34}$ = 1088ha
	$\frac{200}{0.445}$ = 449ha	$\frac{370}{0.528}$ = 700ha
	$\frac{200}{1.266}$ = 158ha	$\frac{370}{1.266}$ = 292ha

Table-15 Diversion Water Requirement and Dependable Water (Basic Year for Planning,1972) (1)

1972

Crop	No.	Item	Jan.			Feb.			Mar.			Apr.			May		
			Wet season rice						Puddling		Trans planting			Dry season rice			
Wet season rice	①	n-days	10	10	11	10	10	8	10	4								
	②	Kc	1.31	1.27	1.175	1.13	1.08	1.06	1.05	1.05								
	③	ETo (mm)	37.8	37.8	41.58	40.0	40.0	32.0	40.6	16.24								
	④	Cu (mm)	49.52	47.86	48.86	45.20	43.20	33.92	42.63	17.05								
	⑤	Pe (mm)	20	20	22	20	20	16	20	8								
	⑥	Wp (mm)	69.52	67.86	70.86	65.20	63.20	49.92	62.63	25.05								
	⑦	Re (mm)	119	133	70	0	142	81	70	46								
	⑧	Wp - Re	0	0	0.86	65.20	0	0	0	0								
	⑨	Ic	1.000	0.971	0.792	0.617	0.450	0.300	0.150	0.033								
	⑩	⑧x⑨/①x 8.64	0	0	0.008	0.466	0	0	0	0								
	⑪	Wu⑩/0.64	0	0	0.012	0.728	0	0	0	0								
Dry season rice	①	n-days							5	10	11	10	10	10	10	10	11	10
	②	Kc							1.17	1.18	1.24	1.33	1.40	1.35	1.275	1.225	1.095	0.99
	③	ETo							20.3	40.60	44.66	40.30	40.30	40.30	39.30	39.20	43.23	38.4
	④	Cu							23.75	47.91	55.38	53.60	56.42	54.41	50.86	48.00	47.58	38.02
	⑤	Pe							10	20	22	20	20	20	20	20	22	20
	⑥	Wp							33.75	67.91	77.38	73.60	76.42	74.41	70.86	67.95	69.58	58.02
	⑦	Re							70	46	35	53	6	0	91	64	0	8
	⑧	Wp - Re							0	21.91	42.38	20.60	70.42	74.41	0	3.95	69.58	50.02
	⑨	Ic							0.042	0.104	0.338	0.517	0.683	0.850	0.984	0.975	0.779	0.633
	⑩	⑧x⑨/①x 8.64							0	0.026	0.151	0.123	0.557	0.732	0	0.045	0.570	0.366
	⑪	Wu⑩/0.64							0	0.041	0.235	0.193	0.870	1.144	0	0.070	0.891	0.573
Palawija	①	n-days																
	②	Kc																
	③	ETo																
	④	Cu																
	⑤	Pe																
	⑥	Wp																
	⑦	Re																
	⑧	Wp - Re																
	⑨	Ic																
	⑩	⑧x⑨/①x 8.64																
	⑪	Wu⑩/0.64																
Puddling Wetseason rice	①	n-days																
	②	Ic																
	③	(ETo - Pe)·Ic																
	④	Re																
	⑤	(140 - Re)·Ic/n																
	⑥	③+⑤																
	⑦	Wu⑥/8.64 x 0.64																
Puddling Dry season rice	①	n-days					2	8	10	10	11	10	10	9				
	②	Ic					0.4/14	1.6/14	2/14	2/14	2.2/14	2/14	2/14	1.8/14				
	③	(ETo - Pe)·Ic					0.171	0.686	0	0	0	0	0	0				
	④	Re					160	92	80	56	40	60	6	0				
	⑤	(140 - Re)·Ic/n					0	0.686	0.857	1.200	1.429	1.143	1.914	2				
	⑥	③+⑤					0	1.372	0.857	1.200	1.429	1.143	1.914	2				
	⑦	Wu⑥/8.64 x 0.64					0	0.248	0.155	0.217	0.258	0.207	0.346	0.362				
		Wu Total (l/sec/ha)	0	0	0.012	0.728	0	0.248	0.155	0.259	0.493	0.400	1.216	1.306	0	0.070	0.891	0.573
		Dependable water at Cadeg (m^3/sec)	12.96	18.34	19.18	12.44	8.28	4.70	16.16	13.35	10.40	5.20	7.88	9.30	10.70	7.71	8.37	5.02

Table-19 Diversion Water Requirement and Dependable Water (Basic Year for Planning,1972) (2)



													11	10	10	10	10	10	11
													1.15	1.17	1.21	1.28	1.33	1.39	1.385
													48.95	43.0	43.0	43.0	38.3	38.3	42.13
													56.29	50.31	52.03	55.04	50.94	53.23	58.35
													22	20	20	20	20	20	22
													78.29	70.31	72.03	75.04	7094	73.23	80.35
													0	7	22	11	16	15	67
													78.29	63.31	50.03	64.04	54.94	58.23	13.35
													0.092	0.267	0.433	0.600	0.767	0.963	1.000
													0.076	0.191	0.251	0.445	0.488	0.649	0.140
													0.118	0.299	0.392	0.695	0.762	1.014	0.219
10	10	10	3																
0.98	0.98	0.98	0.98																
38.4	38.4	41.5	12.45																
37.63	37.63	40.67	12.20																
20	20	20	6																
57.63	57.63	60.67	18.20																
0	0	0	0																
57.63	57.63	60.67	18.20																
0.467	0.300	0.133	0.025																
0.311	0.200	0.093	0.018																
0.487	0.313	0.146	0.027																
8	10	10	10	11	10	10	11	10	10	10	10	10	10						
0.290	0.295	0.316	0.372	0.39	0.650	0.765	0.980	0.930	0.840	0.730	0.630	0.570	0.550						
30.72	38.4	41.5	41.5	45.65	44.60	44.60	49.06	46.70	46.70	46.70	44.50	44.50	44.50						
8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09	28.03	25.37	24.48						
—	—	—	—	—	—	—	—	—	—	—	—	—	—						
8.91	11.33	13.11	15.44	17.80	28.99	38.22	48.08	43.43	39.23	34.09	28.03	25.37	24.48						
0	0	0	0	18	26	0	0	0	0	0	0	0	0						
8.91	11.33	13.11	15.44	0	2.99	38.33	48.08	43.43	39.23	34.09	28.03	25.37	24.48						
0.067	0.227	0.383	0.550	0.725	0.900	0.996	1.000	0.917	0.750	0.583	0.417	0.250	0.083						
0.009	0.028	0.058	0.098	0	0.030	0.441	0.506	0.461	0.341	0.230	0.132	0.073	0.024						
0.014	0.047	0.097	0.164	0	0.050	0.688	0.843	0.768	0.568	0.383	0.220	0.122	0.039						
											5	10	11	10	10	10	10	4	
											1/14	2/14	2.2/14	2/14	2/14	2/14	2/14	0.8/14	
											0.461	0.921	0	0	0	0	0	0	
											0	0	0	8	26	13	18	6	
											2	2	2	1.886	1.629	1.814	1.743	1.914	
											2.461	2.921	2	1.886	1.629	1.814	1.743	1.914	
											0.445	0.528	0.362	0.341	0.295	0.326	0.315	0.346	
0.301	0.360	0.243	0.191	0	0.050	0.688	0.843	0.768	0.568	0.383	0.665	0.650	0.519	0.640	0.687	1.023	1.077	1.360	0.219
1.75	1.14	0.76	0.60	0.52	2.79	2.29	1.33	0.48	0.38	0.47	0.24	0.46	2.94	2.38	4.16	3.60	4.83	7.63	8.57

Note: Kc Crop Factor; ETo Evapotranspiration; Cu Kc x ETo; Pe Percolation; ... ; Re Effective Rainfall (mm); Wu Unit Water Requirement (l/sec/ha); Wu Total: Unit diversion Water Requirement (l/sec/ha); Ie Crop Intensity

Table VII-20 Comparison of Dam Types

A diversion dam is planned to be constructed at Gadeg dam site and a comparative study has been undertaken to make a choice of the dam type. As a result, a rock fill dam is recommended as the most suitable type for this feasibility study for the following reasons.

1. Economical: The construction costs of each dam type are as follows:
   a) rock fill dam Rp. 2,057 million
   b) concrete gravity dam Rp. 2,715 miliion
   c) combined dam Rp. 2,453 million

2. Safety: According to soil-mechanical data available, the soil layer with low bearing capacity lies very deep at both banks of the dam site. Therefore, the construction of rock fill dam will be safer than that of other type dam.

3. Advantage: The excavated soils can be used again for the construction of rock fill dam.

4. Disadvantages of other type dam: a) the jointed part between concrete and fill is insecure in the case of a combined dam. b) Sheathing will not be secured in the case of concrete dam due to its heavy load. c) A large scale of river bank protection works will be necessary downstream the dam site in the case of equipping a spillway in dam body.

Comparative Study of Dam Cost
(Rp. million)

	Item	Fill Dam	Combined Dam	Concrete Gravity Dam
1.	River Diversion			
	1.1 Diversion channel	(included	60.7	60.7
	1.2 Coffer dam	in 2.4)	26.1	26.1
2.	Dam Body			
	2.1 Earth work	507.8	274.2	146.0
	2.2 Concrete work	0	867.7	1,040.2
	2.3 Foundation Grouting	197.4	404.7	614.3
	2.4 Spillway	1,198.0	570.0	674.1
	2.5 Water stop	0	96.2	0
3.	Access Road	91.2	91.2	91.2
4.	Intake	62.2	62.2	62.2
	Total	2,056.6	2,453.0	2,714.8

Fig. VII-1 Crop Coefficient Curve (1)
(Rice) case of 120 days

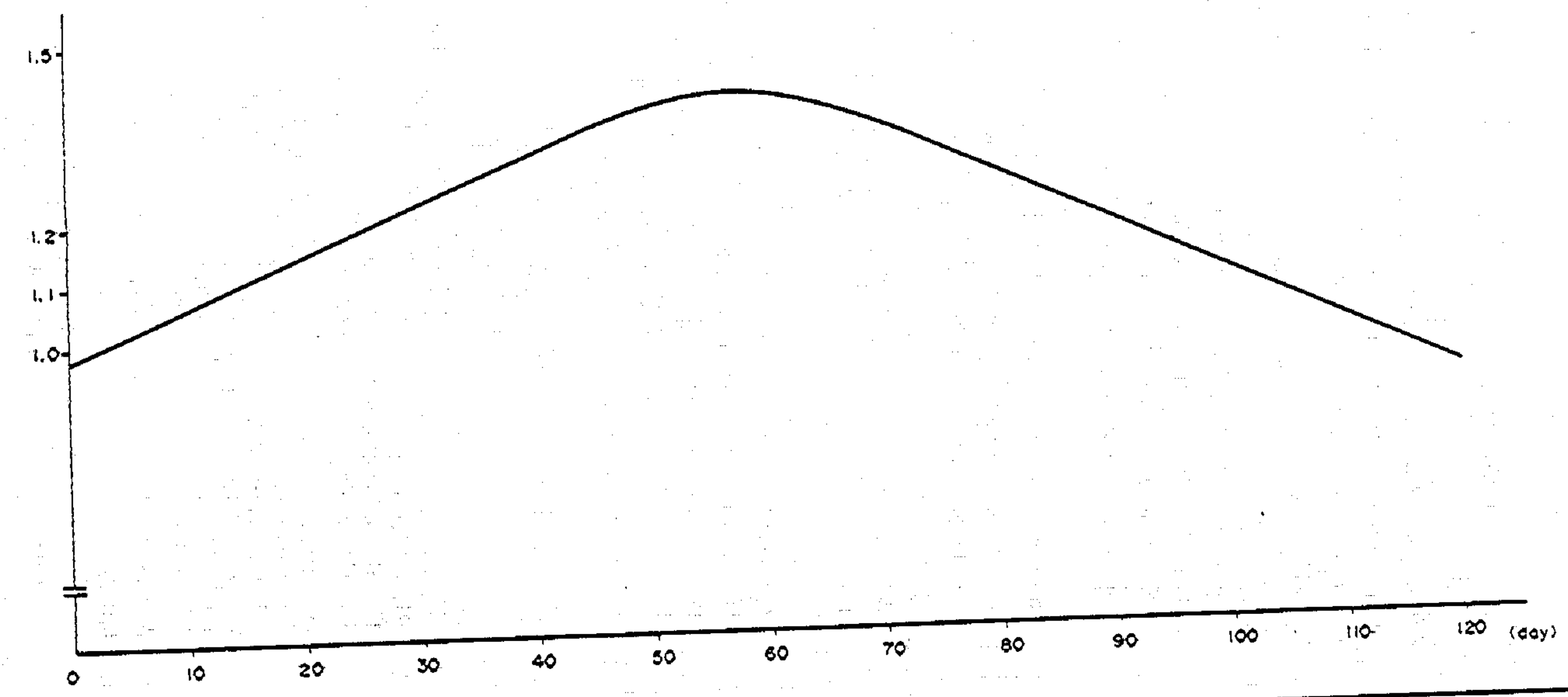


Fig. VII-1 Crop Coefficient Curve (2)
(Rice) case of 105 days

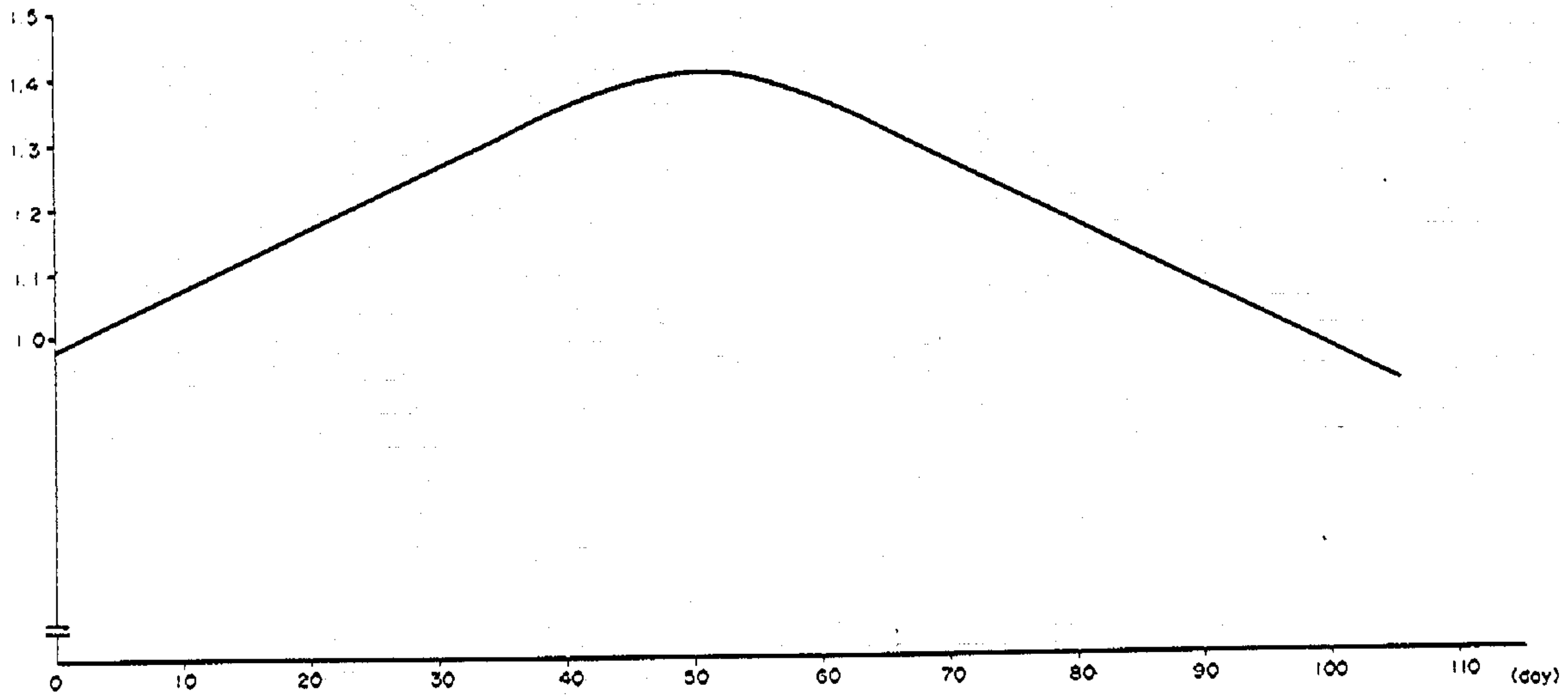
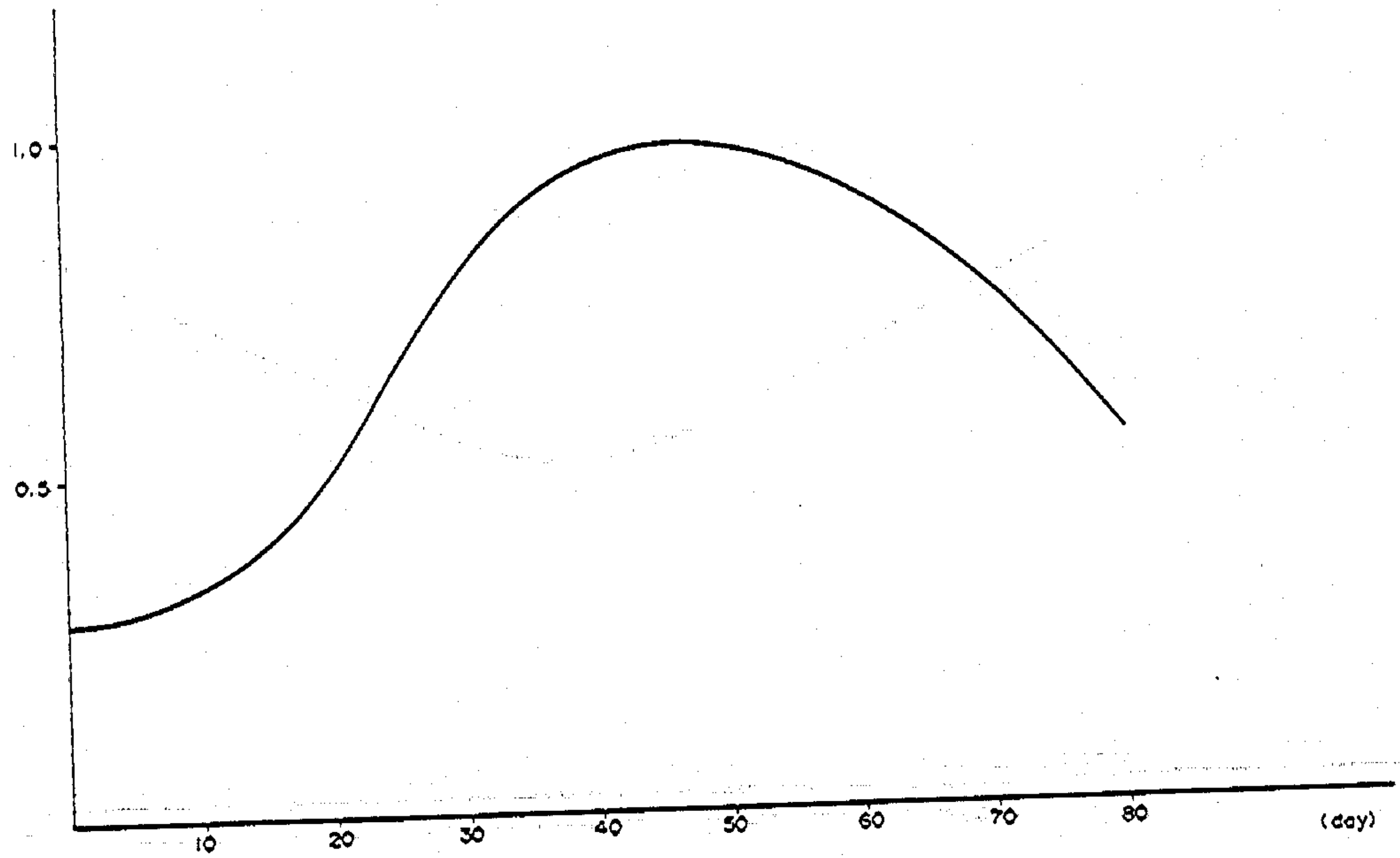


Fig. VII-1 Crop Coefficient Curve (3)
(Palawija) case of 80days



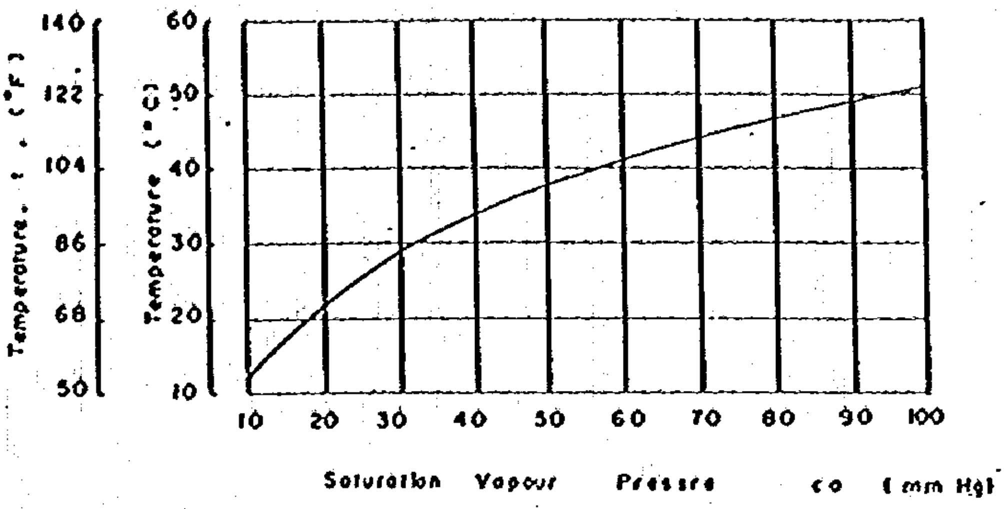


Fig. VII-2 SATURATION VAPOUR PRESSURE CURVE

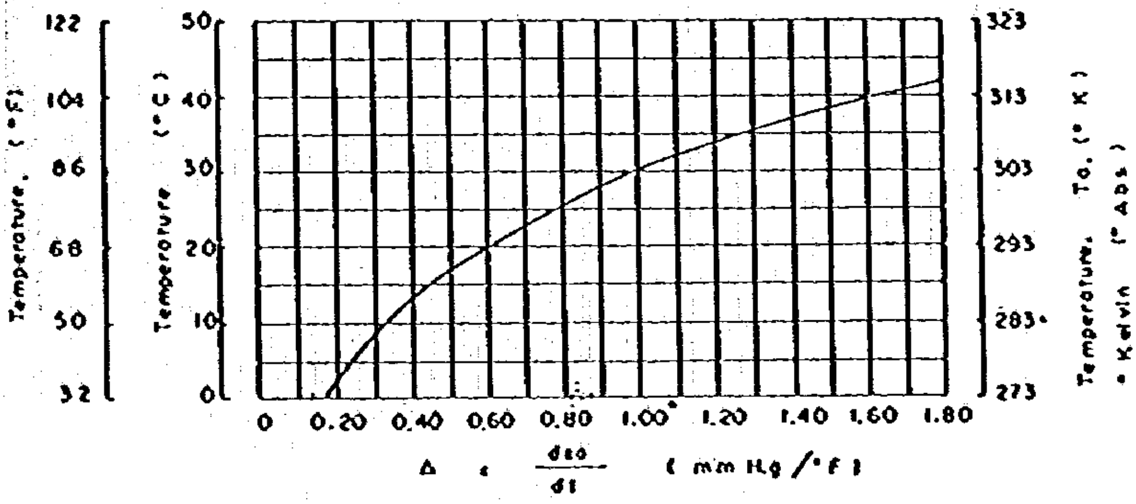


Fig. VII-3 SLOPE OF SATURATION VAPOUR PRESSURE CURVE

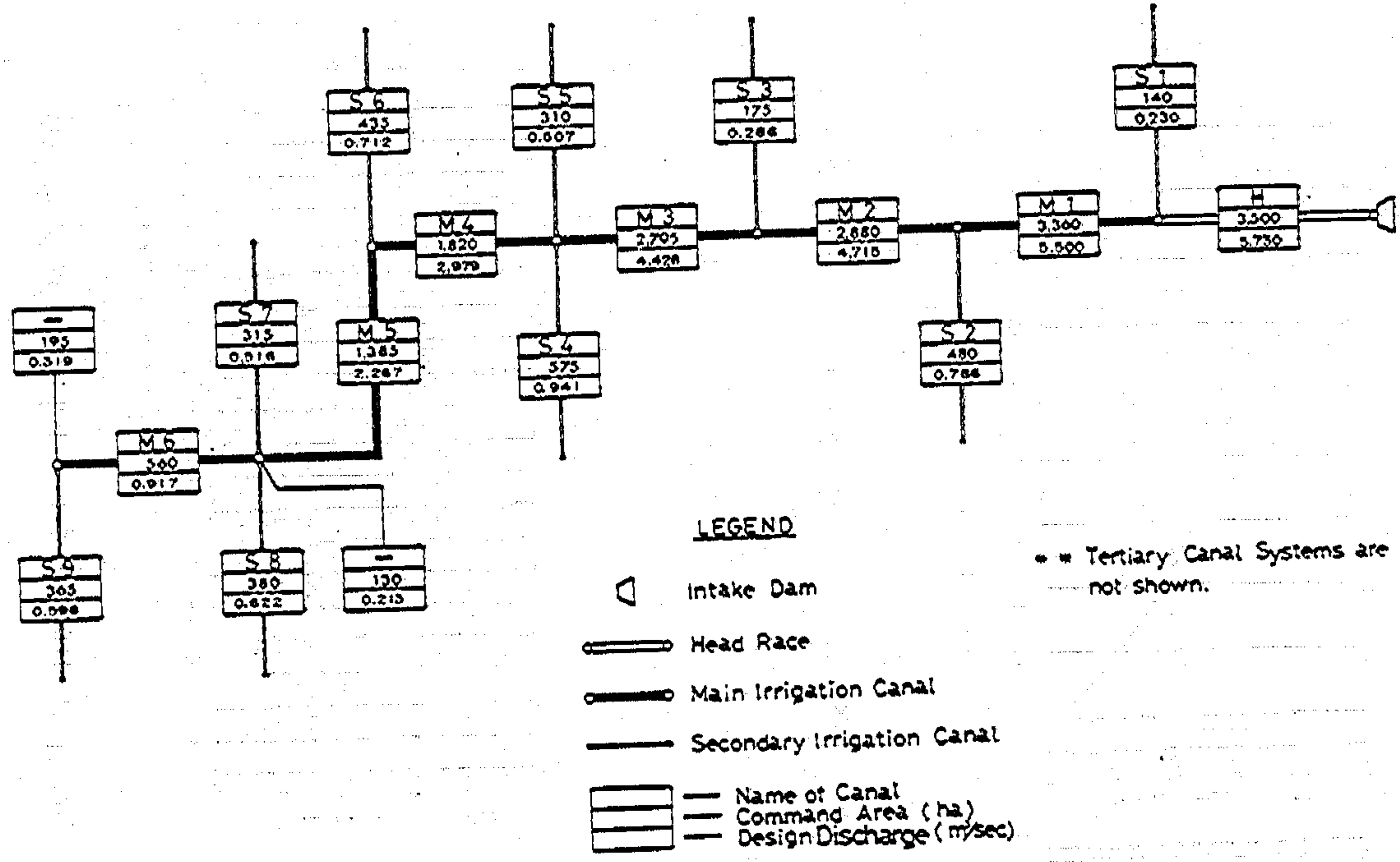
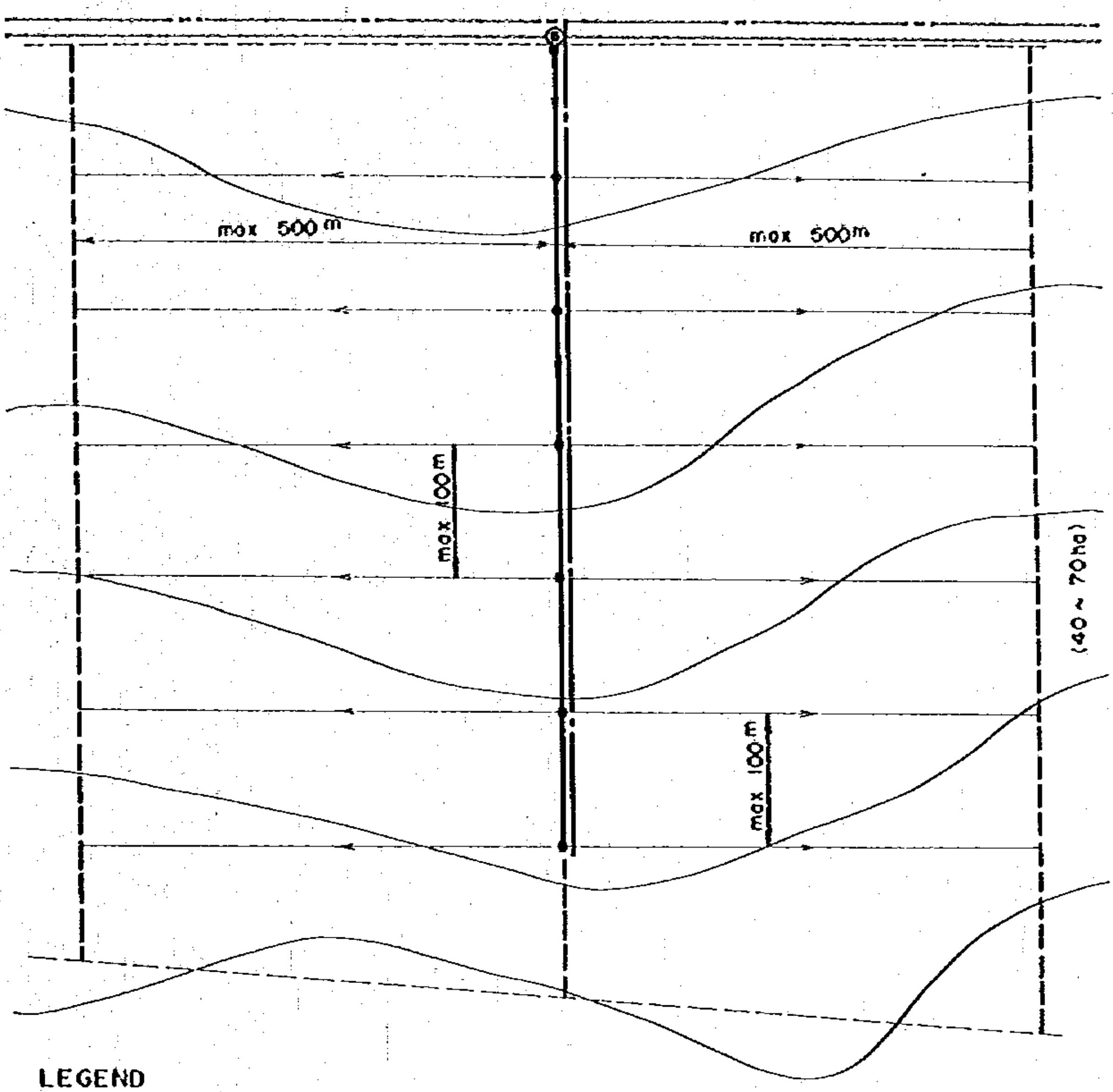


FIG.VII-4 GENERAL IRRIGATION CANAL DIAGRAM

FIG. VII - 5

TYPICAL LAYOUT OF TERTIARY SYSTEM



LEGEND

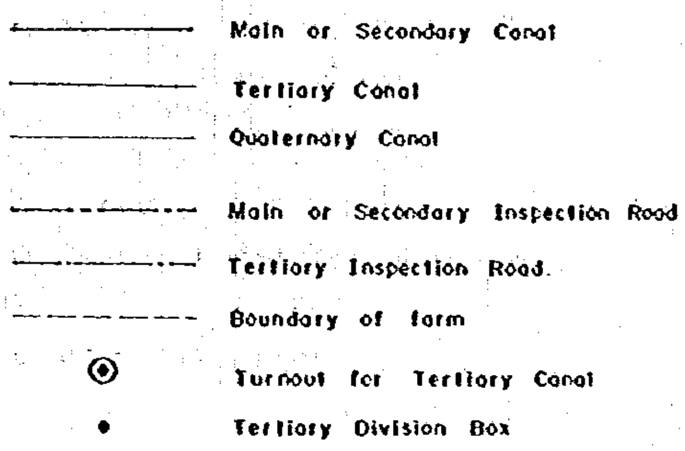


FIG. VII - 6
SAMPLE LAYOUT OF TERTIARY SYSTEM (I)

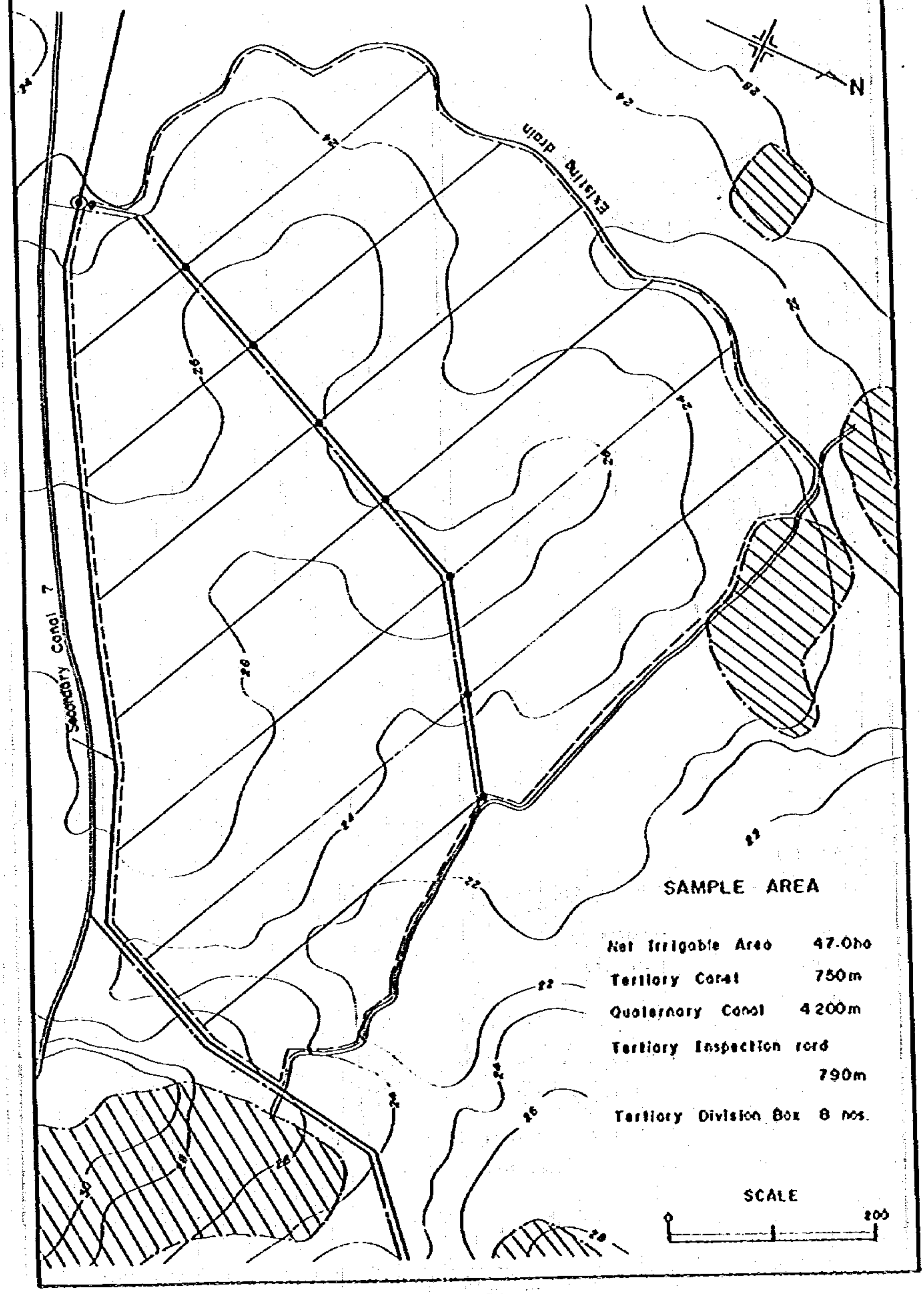
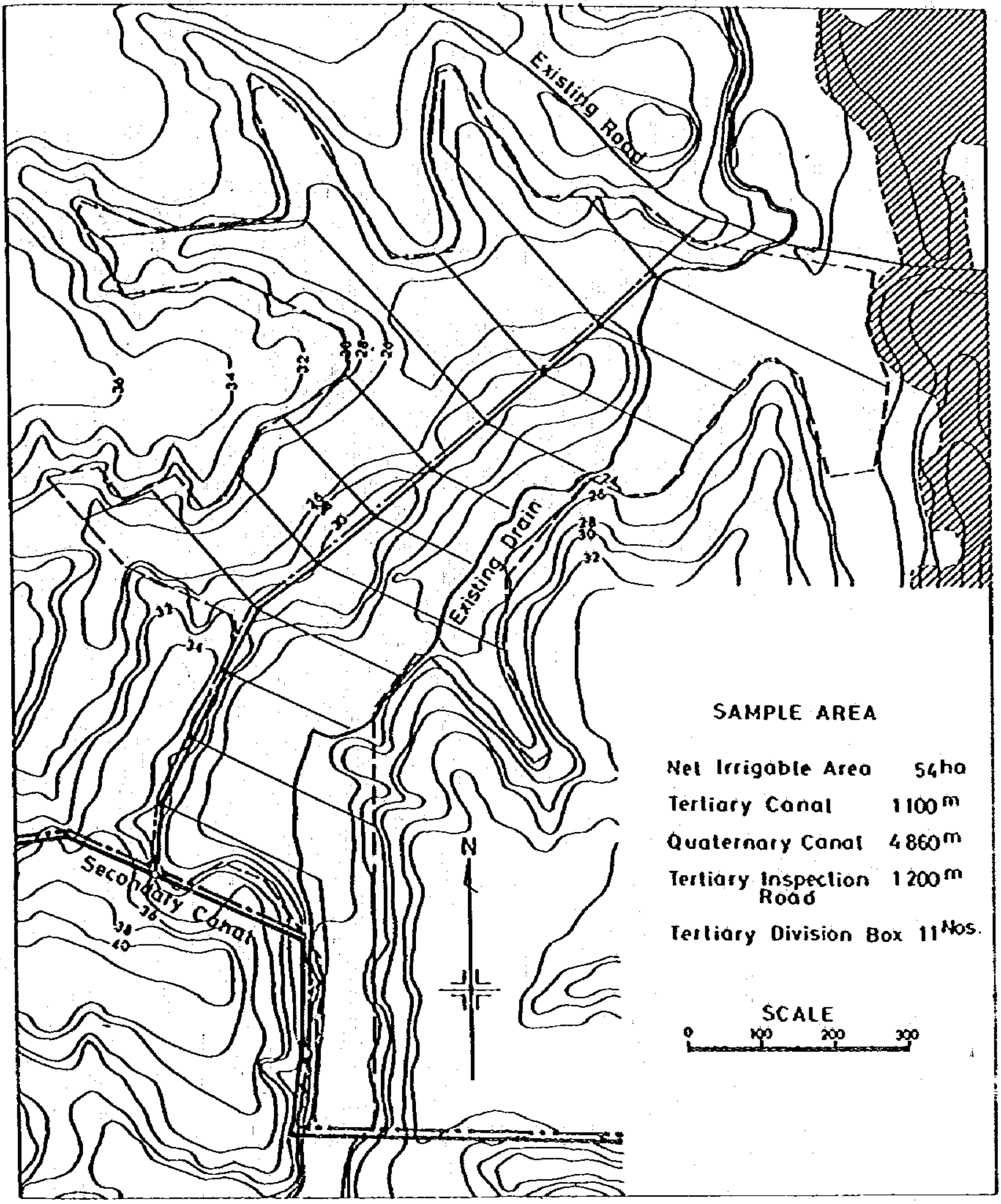


Fig. VII-6

SAMPLE LAYOUT OF TERTIARY SYSTEM (2)



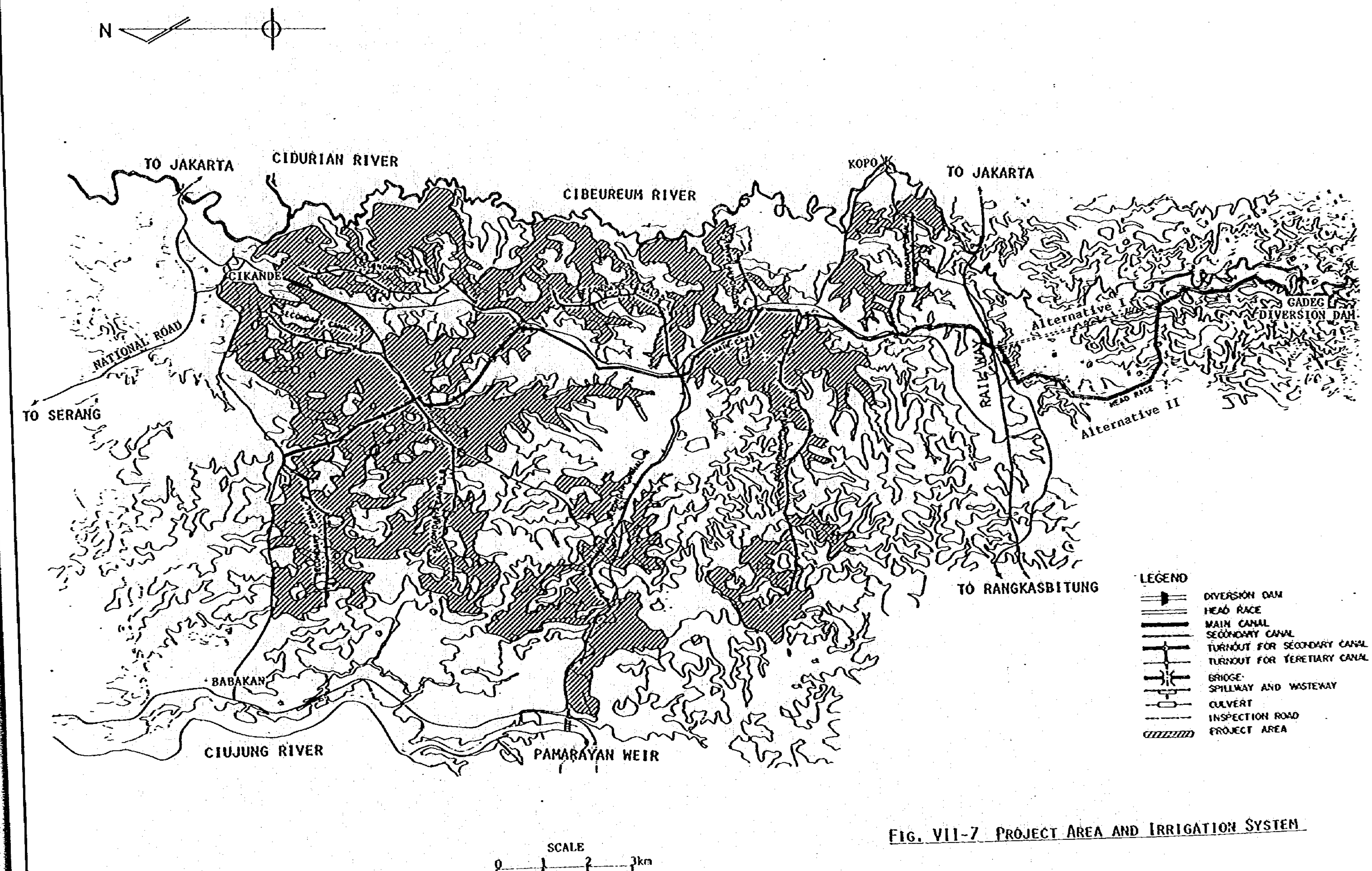
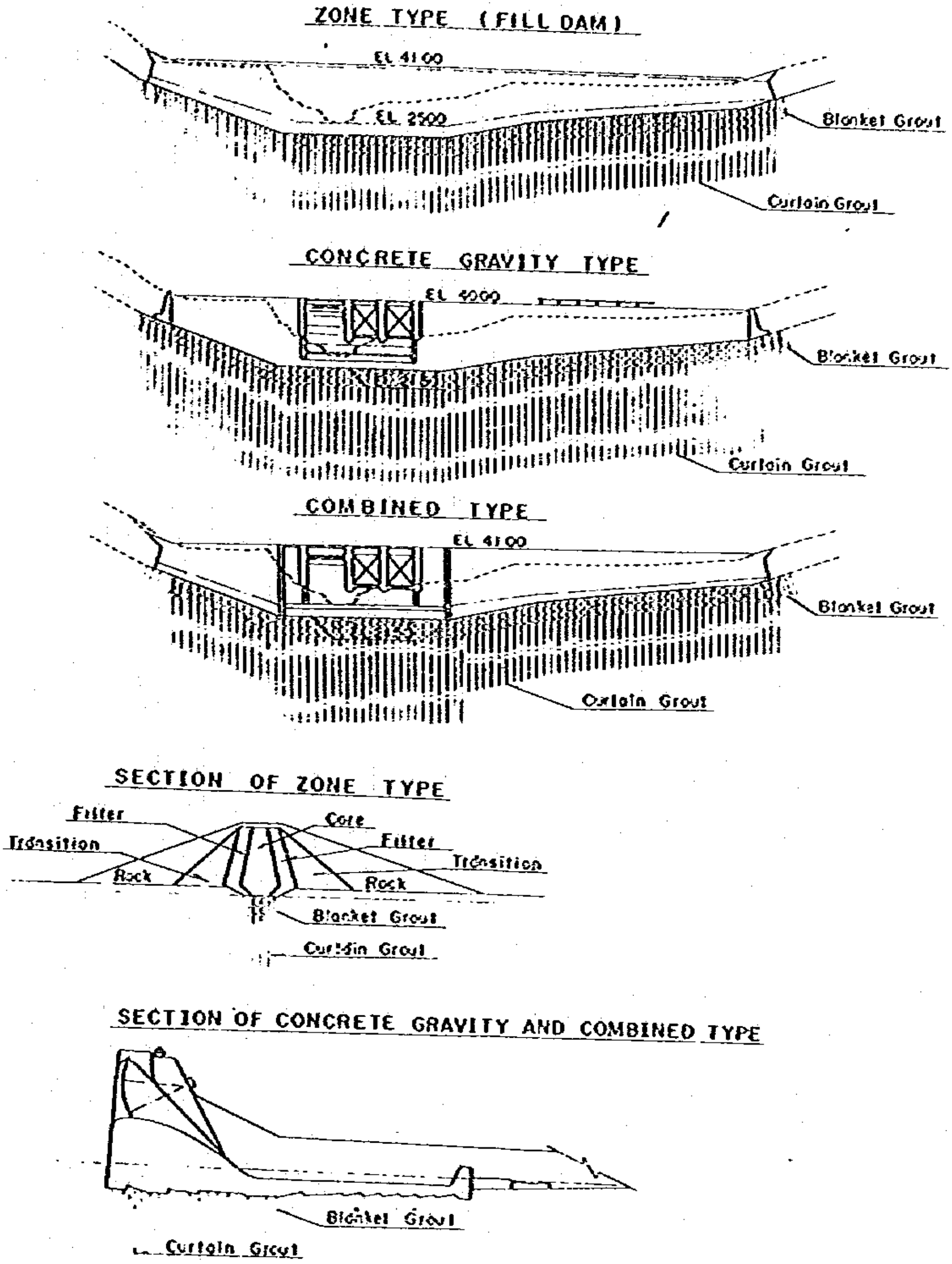


FIG. VII-7 PROJECT AREA AND IRRIGATION SYSTEM

Fig-8 COMPARATIVE STUDY OF DAM TYPE



ANNEX - VIII

PROJECT IMPLEMENTATION SCHEDULE

ANNEX - VIII PROJECT IMPLEMENTATION SCHEDULE

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ANNEX - VIII

PROJECT IMPLEMENTTION SCHEDULE

1. BASIC CONSIDERATIONS

The Project Implementation schedule is prepared based on the following considerations:

(1) The Project mobilization which includes financing, legalization, establishment of the Project organization will be completed by the end of March, 1984.

(2) Considering the scale of this Project, the construction of diversion works, main to tirtiary canals and the related structures will be carried out concurrently so that the all irrigation network can be completed by the end of September, 1987.

(3) Annual workable days for construction equipment are estimated to be 240 days based on the rainfall records in the past 13 years.

(4) Taking into account the scale of this Project, the mechanized construction will principally be introduced in the main construction works. In order to maximize the employment opportunity in and around the Project area, however, man power construction will be adopted as much as possible.

In this context, large-scale civil works such as diversion dam, intake facility, spillway, and headrace will be carried out mainly by heavy construction machinery. The minor civil works for secondary canal system and tertiary development will be carried out mainly by man-power with minor construction equipment.

2. IMPLEMENTATION SCHEDULE

2.1 Preparatory Works

10 months' time will be required for the preparatory works such as topographic and land use mapping, the construction of offices/quarters, etc. as shown in Fig.VIII-1.

Topographic map on a scale of 1/5,000 with a contour interval of 0.5m has not been completed yet. This mapping work should be completed by the end of June 1984, before the start of the detailed design of the secondary canal. The project office and quarters will be completed prior to the major construction works. This work will be started from August 1984 and completed by the end of March, 1985.

The detailed design works for the diversion works and intake gate, headrace, main canal, secondary canal and related facilities will be carried out from April 1984 to March 1985, including the time necessary for survey and investigation on the detailed design.

2.2 Diversion Works

The deversion works consist of various components such as diversion dam, intake gate, spillway, coffering and dewatering works. The time required for the construction of diversion works will be about two years from June 1985 to August 1987 taking two dry seasons.

The coffering and dewatering works would carefully be carried out and maintained until the dam is completed. The construction of concrete structures such as spillway and intake will be completed by the end of 1987 dry season.

2.3 Canals and Inspection Road

The construction of headrace, main canal and inspection road will be carried out in parallel with that of the diversion works. The construction of canal will first be started from the dry season of 1986 and completed by the end of 1987 dry season after spending two dry seasons.

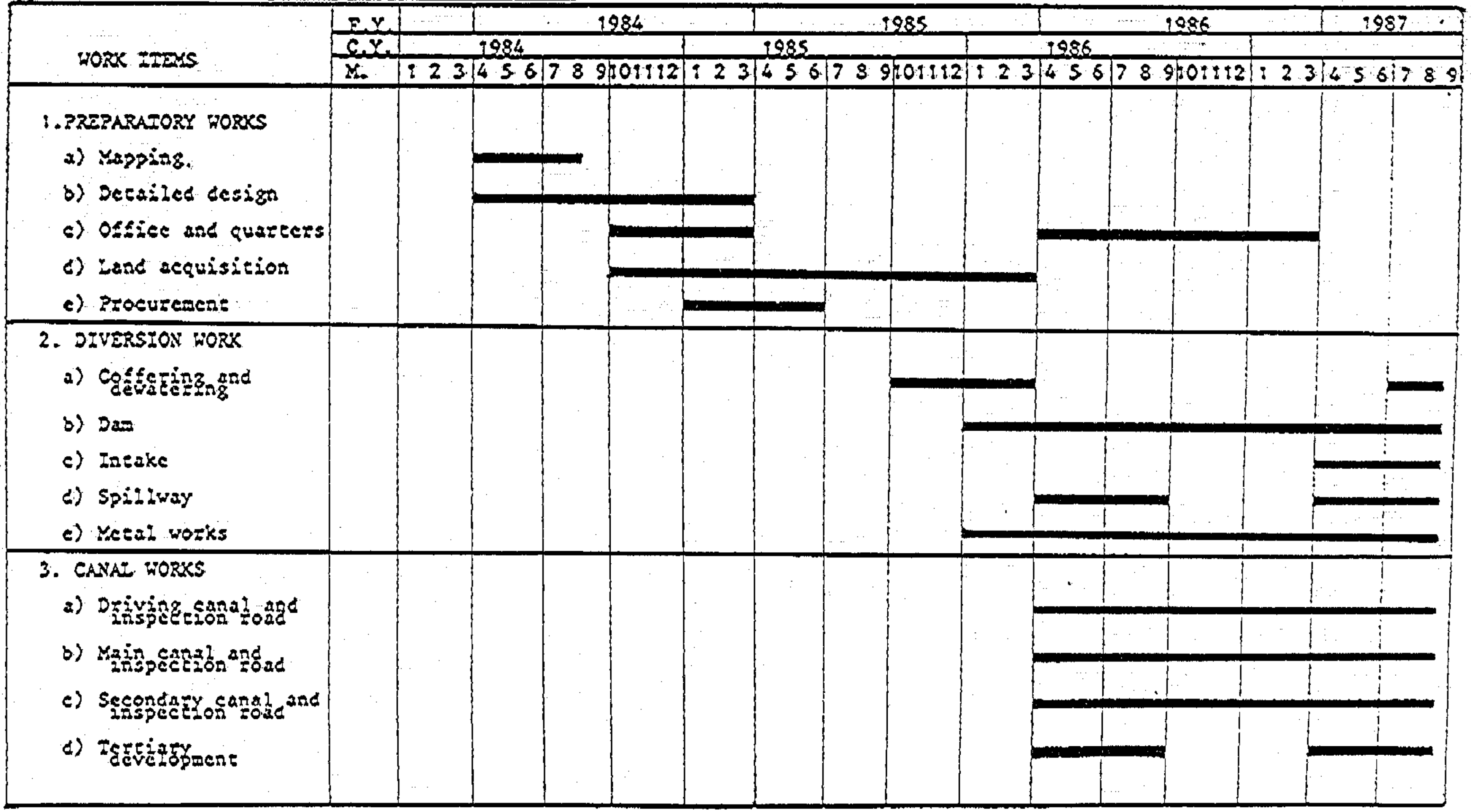
In the rainy season, the excavation work will be stopped and the main effort will be paid to the construction of related structures such as check gates, bridges, culverts turnouts, division boxes, drops, cross drains, and inverted siphons. The excavated soils in the canal construction will be utilized as much as possible for canal, and road embankment if the soils are suitable. Since the inspection roads can also be used for the access in the construciton canal. The construction of the secondary canal including secondary road will be carried out in parallel with that of the main canal.

The asphalt pavement on the main and secondary inspection road, however, will be carried out after the completion of canals alongside the roads. The tertiary development includes the construction of tertiary canal and tertiary inspection road and related structures. The tertiary development will be started from April 1986 and completed by the end of September 1987. The quarternary canals will be constructed by farmers themselves as soon as irrigation water is available to thier farmlands.

3. CONSTRUCTION MACHINERY

Major civil works of the Project would principally be carried out by heavy construction machinery. The type and number of construction machinery to be required for the major civil works are estimated based on the work quantity, construction time schedule and the natural condition in the Project area. Table VIII-I shows the required type and number of construction machinery.

Table VIII-1 PROJECT IMPLEMENTATION SCHEDULE



Tabel VIII-2 REQUIRED MAJOR CONSTRUCTION MACHINERY

No.	Machinery	Specification	Required Number
	Crawler drill	5t	3
	Jack hammer	20kg	8
	Submergible pump	6"ø	15
	Engine centrifugal pump	6"ø	15
	Engine centrifugal pump	4"ø	5
	Concrete pump truck	$20m^3$/hr	2
	Engine concrete mixer	$0.2m^3$	10
	Concrete mixing plant	$10m^3$/hr	1
	Concrete vibrator	5"ø	3
	Concrete vibrator	2"ø	5
	Concrete slope form	20m-gantry	1
	Aggregate screen plant	150t/hr	1
	Aggregate screen plant	30t/hr	1
	Diesel generator	200KVA	2
	Diesel generator	50KVA	5
	Engine compressor	$10m^3$/min	3
	Grease car	6t	2
	Repair shop car	6t	1
	Engine beltconveyor	7m	20
	Repair shop	L.S.	1
	Water supply system	L.S.	1
	Work shop	L.S.	1