GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART 1

VOL. 4
ANNEX
D. IRRIGATION DEVELOPMENT

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JAPAN INTERNATIONAL COOPERATION AGENCY

NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART 1

LIST OF VOLUMES

ABBREVIATIONS

(1) Organization/Plan

4MP	:	Fourth Malaysia Plan
DID (JPT)	:	Drainage and Irrigation Department
EPU	:	Economic Planning Unit
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
GSD	:	Geological Survey Department
JICA	:	Japan International Cooperation Agency
MADA	:	Muda Agricultural Development Authority
NEB (LIN)	:	National Electricity Board
NWRS	:	National Water Resources Study
PWD (JKR)	:	Public Works Department
RISDA	:	Rubber Industry Small-Holders Development Authority
WHO	:	World Health Organization

(2) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
COD	:	Chemical Oxygen Demand
D&I	:	Domestic and Industrial
dia.	:	Diameter
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation Above Mean Sea Level
Eq.	:	Equation
Fig.	:	Figure
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
NHWL	:	Normal High Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SS	:	Suspended Solid

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot
yd = yard

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cubic meter
gal. = gallon

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton
lb = pound

Time

s = second
min = minute
h = hour
d = day
y = year

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree in centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

Derived Measures

m^3/s = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere
BTU = British thermal unit
psi = pound per square inch

Money

M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch 1 m = 3.28 ft = 1.094 yd 1 km = 0.621 mile	1 inch = 2.54 cm 1 ft = 30.48 cm 1 yd = 91.44 cm 1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in 1 m^2 = 10.76 sq.ft 1 ha = 2.471 acres k km^2 = 0.386 sq.mile	1 sq.ft = 0.0929 m^2 1 sq.yd = 0.835 m^2 1 acre = 0.4047 ha 1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in 1 lit = 0.220 gal.(imp.) 1 kl = 6.29 barrels 1 m^3 = 35.3 cu.ft 10^6 m^3 = 811 acre-ft	1 cu.ft = 28.32 lit 1 cu.yd = 0.765 m^3 1 gal.(imp.) = 4.55 lit 1 gal.(US) = 3.79 lit 1 acre-ft = 1,233.5 m^3
Weight	1 g = 0.0353 ounce 1 kg = 2.20 lb 1 ton = 0.984 long ton = 1.102 short ton	1 ounce = 28.35 g 1 lb = 0.4536 kg 1 long ton = 1.016 ton 1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F - 32)·5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec 1 kg/cm^2 = 14.2 psi 1 ton/ha = 891 lb/acre 10^6 m^3 = 810.7 acre-ft 1 m^3/s = 19.0 mgd	1 cusec = 0.0283 m^3/s 1 psi = 0.703 kg/cm^2 1 lb/acre = 1.12 kg/ha 1 acre-ft = 1,233.5 m^3 1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang 1 kg = 1.65 kati 1 ton = 16.5 pikul	1 gantang = 4.55 lit 1 kati = 0.606 kg 1 pikul = 60.6 kg

ANNEX D

IRRIGATION DEVELOPMENT

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1. INTRODUCTION

This ANNEX presents the irrigation development plan and the projection of irrigation water demand in the Region for the years 1982, 1985, 1990 and 2000 based on information and data collected in Malaysia from January to March 1983.

Chapter 2 of this ANNEX deals with the present condition of existing irrigation schemes in the Region. In Chapter 3, the present water utilization by existing irrigation schemes is analyzed. Chapter 4 presents the future irrigation development area and development schedule assuming that the all irrigable area where economically being feasible will be developed up to the year 2000. Chapter 5 explains the methodology, assumptions and estimated results of irrigation water demand in the Region based on the development schedule assumed in Chapter 4. Finally, Chapter 6 presents the investment and O&M costs for new development of irrigation area in the Region for reference.

2. PRESENT CONDITION OF IRRIGATION SCHEMES

2.1 Muda Irrigation Project

The Muda irrigation project of 95,800 ha is located in the States of Kedah and Perlis in northwestern Peninsular Malaysia. The irrigation area occupies flat alluvial coastal plain of about 20 km wide and 65 km long between the foothills of the Central Range and the Straits of Malacca. Although the plain is flat on a macro-level, the micro-topography is variable. Most of the Muda soils are heavy, poorly drained and slightly acidic silty clays, which is suitable for rice production.

The Muda irrigation project was implemented during the period 1965 - 1970 and was aimed at introducing double-cropping of paddy over an area of 96,000 ha, previously devoted to a single paddy cultivation. The principal project components were:

(a) the construction of the Pedu Dam with an active storage capacity of 1,049 x 10^6 m^3, the Muda Dam with an active storage capacity of 160 x 10^6 m^3, and the 7 km long Saiong connecting tunnel between the two dams with a maximum discharge capacity of 70 m^3/s;

(b) a conveyance system comprising an existing river channel, headworks and 115 km of main canals;

(c) an internal reticulation system with some 970 km of secondary canals from 1,200 - 2,000 m apart (canal density 10 m/ha), 870 km of drains (drain density 9 m/ha), some 2,000 structures, 24 pumping stations and about 780 km of laterite surfaced farm roads; and

(d) some 100 km of coastal bund with 25 tidal gates.

The source of water supply for the Muda irrigation project are the controlled flow from the Pedu and the Muda reservoirs and the uncontrolled flow from the tributaries of the Kedah river. The former supplies 67% of the average annual irrigation water demand and the latter supplies the remainder.

The present Muda system relies on plot-to-plot flooding over distances ranging from 1,200 to over 2,000 m, averaging about 1,600 m. Water must be moved across numerous parcels of land, each of which is surrounded by small field bunds required for water level control within the parcel. The drainage system is equally rudimentary, and difficulties in supplying and removing water on a plot-to-plot basis are compounded by the variations in micro-topography. Only about 10% of the parcels have direct access to either a canal or a drain, and associated roads. This situation results in lags of more than 40 days in farming activities within each block, which causes serious agricultural problems because of varying water requirements over the growing stages of the paddy crop.

To improve such problems, the tertiary irrigation and drainage development in the existing Muda irrigation area is on-going as the Muda II irrigation project with a financial assistance from IBRD since 1979 (Ref. 1). The plan is to provide tertiary canals, drains and access roads to about 24,800 ha (38 Blocks) of paddy area, or 26% of the whole irrigation area of 95,800 ha. This project is regarded as the first phase of the overall 15-year program for tertiary development covering the whole Muda irrigation area. After the completion of the tertiary irrigation and drainage development, the canal density will be augmented from the present 10 m/ha to 30 m/ha and better water management can be expected. By the end of 1982, tertiary development for 6 irrigation blocks (3,360 ha) has been completed.

The co-operation research program between MADA and Tropical Agricultural Research Center (TARC), Japan, has been carried out in MADA area since 1978. The purpose of this research is to establish recommendable measures for the implementation of on-going tertiary development. The research area is ACRBD 4 irrigation block (761 ha in gross) in Irrigation District II in the MADA area. Through the field observation on actual farming practices, water balance, etc. during 1979 - 1982, the following problems were revealed concerning irrigation water supply (Ref. 2).

(a) Average presaturation period for off season paddy was 57 days which was 2.7 times of the planned period of 3 weeks. Irrigation supply in this period was 590 mm which was 1.7 times of the planned demand of 350 mm (Table 1);

(b) Actual yearly irrigation supply into the ACRBD 4 block was 1,858 mm comprizing 960 mm for off season paddy and 898 mm for main season paddy (Table 15), which is nearly double of irrigation water demand in the original plan of 967 mm;

(c) Yearly irrigation water supply from the Pedu dam was 1,168 mm comprizing 648 mm for off season paddy and 520 mm for main season paddy, which was also nearly double of demand in the original plan of 509 mm/y; and

(d) Due to shortage of irrigation water, farming practices of paddy cultivation has usually been delayed 1.6 to 2.8 months for off season paddy and 1.3 to 1.8 months for main season paddy. Fallow period between harvest of off season paddy and presaturation of main season paddy was as long as 2.2 months on an average. This delay of farming schedule resulted in shift of the latter period of main season paddy into dry season and consequently caused much irrigation requirements than the planned value.

Present irrigation water supply to the Muda irrigation project area is obviously very high compared with the original plan as revealed in the ACRBD 4 irrigation block and analyzed in Chapter 4 based on data from MADA. Under the present plot-to-plot irrigation, much irrigation losses and water shortage are unavoidable. To improve these problems, implementation of the tertiary development and development of additional water source are indispensable in the MADA area.

2.2 Minor Irrigation Schemes in the Region

Minor irrigation schemes in the Region have been developed steadily by DID since early 1950s. In parallel with the implementation of the Muda irrigation project (1965 - 1970), the irrigation development of minor schemes in the Region has been accelerated, and from 1965 to 1975, 29 minor irrigation schemes covering 11,390 ha were completed as shown in Table 2. In 1982, there are 63 minor irrigation schemes covering 26,020 ha in the Region. Location of these schemes are shown in Plates 1 and 2.

Existing minor irrigation schemes can be classified by size as shown in Table 3. Irrigation schemes smaller than 500 ha share 86% in number, but only 31% in area, of total positive irrigation area of 26,020 ha (63 schemes). The average size of positive irrigation schemes is 248 ha/scheme for Perlis, 205 ha/scheme for Kedah and 1,179 ha/scheme for Pulau Pinang. Table 4 shows the calssification of schemes by type. Of the total positive irrigation schemes, about half of them are irrigated by pumping. In the Perlis and Kedah river basin, gravity irrigation is dominant. On the other hand, pumping irrigation is the major type in the Muda river basin.

The present situation of minor irrigation schemes is described by state hereunder.

(1) State of Perlis

Minor irrigation schemes in Perlis are characterized by serious shortage of water source during dry season. Off season paddy can hardly be cultivated in Perlis except for any future development of water source such as storage facilities and inter-basin diversion. At present, 22 minor irrigation schemes (7,354 ha in total) comprizing 15 gravity irrigation schemes (3,717 ha) and 7 control drainage schemes (3,637 ha) are located in the state mainly along the Perlis river and its tributaries as listed in Table 5. Most facilities in the existing irrigation schemes have been built within the past 15 years by DID.

Poor water management is common to all the schemes in Perlis and, while this is partly attributable to poor operation of the existing facilities on most schemes, shortcomings in the infrastructure make correct operation impossible. Poor water control is caused by lack of gated diversion structures and uncontrolled pipe offtakes. There is a complete absence of any form of water measurement. The canal density on some schemes, especially the control drainage schemes, is extremely low, reflecting the lack of adequate on-farm facilities. The present canal density of gravity irrigation schemes is 21 m/ha on an average ranging between 5 m/ha and 45 m/ha.

To improve existing irrigation schemes in the States of Perlis and Kedah, the Study on the Intensification of Irrigated Agriculture in Kedah and Perlis was carried out in 1981 (Ref. 3). This study covered 16 existing minor schemes in Perlis. The proposed measure for improvement of these schemes were as follows:

(a) remodeling of 18.7 km of canals and 6.6 km of drains;

(b) provision of 41.2 km of new canals, 6.5 km of new drains and 89.2 km of new farm road; and

(c) rehabilitation/provision of 574 nos. of related structures.

In 1983, the Feasibility Study of Timah Tasoh and Arau Dams Project is in progress (Ref. 4). These dams are multipurpose consisting of irrigation, flood control and domestic water supply. By the creation of these dams, all minor irrigation schemes being located on the down-stream of each dam are expected to be fully irrigated during dry season.

(2) State of Kedah

Minor irrigation schemes in Kedah (excluding the Kerian river basin and Pulau Langkawi) are located mainly along the tributaries of the Kedah and Muda rivers as shown in Plates 1 and 2. In 1982, 37 minor irrigation schemes (10,158 ha in total) exist in Kedah as shown in Table 4. Inventory of all schemes is summarized in Tables 6 and 7. In the Kedah river basin, the water source is insufficient for full development of irrigation. By 1982, only 4 irrigation schemes covering 1,608 ha have been developed by DID in the tributaries of the Kedah river although more than 13,000 ha of rainfed paddy area are scattered in the basin. On the other hand, the Muda river basin has higher possibility of irrigation development. About 5,600 ha (21 in number) of minor irrigation schemes have been developed by 1982. More than half of these irrigation area are irrigated by pump.

The grade of irrigation facilities in Kedah is better than that in Perlis. The present canal density of irrigation schemes is 45 m/ha on an average ranging between 17 m/ha and 94 m/ha which is more than double of average canal density in Perlis. However, the same water management problems as found in Perlis are common in most existing schemes in Kedah. Insufficient maintenance, unequal water distribution and lack of measuring devices have made the water control difficult.

Improvement of existing facilities in 38 minor irrigation schemes covering 8,850 ha in the State of Kedah is in progress as a component of the Kedah Valleys Agricultural Development Project with a financial assistance from the World Bank (Ref. 5). The irrigation development works would include the following items:

(a) rehabilitation of about 200 km of main, secondary and tertiary canals;

(b) provision of 7 km of new main canals;

(c) rehabilitation of canal structures and pumps;

(d) provision or improvement of about 400 km of field and tertiary drains; and

(e) upgrading of about 380 km of farm roads.

The rehabilitation works would be implemented over five years (1983 - 1987). Total cost for irrigation development would be M$52.8 x 10^6 excluding physical contingencies, or M$6,000/ha. After the completion of the project, canal densities in all schemes are to be raised to about 45 m/ha. Weighted average of cropping intensities in the project schemes are expected to improve from current 140% to about 160%.

(3) State of Pulau Pinang

The history of irrigation development in Pulau Pinang is relatively old compared with other states. Before the completion of the Muda irrigation project of 96,000 ha, the Sungai Muda pumping irrigation scheme of 7,115 ha was the largest and most important irrigation scheme in the Region. The most irrigation schemes in the state have developed by early 1970. In 1982, 13 irrigation schemes covering 15,128 ha are located in Pulau Pinang consisting of 11 schemes (14,002 ha) in Seberang Perai (Peninsular side) and 2 schemes (1,126 ha) in Balik Pulau (island) as listed in Table 8. Due to urbanization and industrialization, the irrigation area in the state is obliged to be decreased gradually.

Poor distribution of irrigation water and poor drainage are generally found in the schemes in P. Pinang. The present canal density of schemes is 25 m/ha on an average ranging between 10 m/ha and 62 m/ha. The lack of sufficient tertiary and quaternary canals and control structures prevents adequate control of water. Insufficient maintenance of facilities is commonly found in P. Pinang, which is mainly due to limitation of funds (Ref. 6). However, water shortage is not so serious in irrigation schemes in Pulau Pinang.

3. PRESENT WATER UTILIZATION

3.1 General

In order to assess the present water utilization in the Muda irrigation project and minor irrigation schemes in the Region, available data were collected from MADA and state DID of Kedah and Pulau Pinang. Analyses were made as described hereunder.

3.2 MADA Area

3.2.1 Existing irrigation supply system

The principal source of irrigation water for the MADA area is the Padang Terap river, the main stream of the Kedah river. It supplies uncontrolled river flow supplemented by releases from Pedu reservoir to make up the irrigation requirements. The water is diverted by Pelubang barrage into a canal leading to Pelubang head regulators. These regulators divide the supplied water between the Northern canal and the Central canal. The latter bifurcates at Guar Kepayang regulator, 26 km downstream of Pelubang regulators, into the Tokai branch and the Southern branch canals. The layout is shown in Fig. 1.

In the Muda irrigation canal system, the uncontrolled flow from 2 tributaries joins with the existing canal and can be used for irrigation purpose. The Tanjong Pauh river with a catchment area of 453 km^2, a tributary of the Kedah river, joins with the Northern canal at 6 km downstream of Pelubang regulators. The Arau river with a catchment area of 97 km^2, a tributary of the Perlis river, also joins with the Northern canal at its end point.

In order to control the distribution of irrigation water, 243 control structures comprizing 12 regulators, 221 offtakes and 10 control drops presently exist in the MADA area as shown in Fig. 1.

3.2.2 Available data

Irrigation water supply for the Muda irrigation project has been controlled by the Muda Agricultural Development Authority (MADA) since 1971. Among 243 control structures, 17 structures as listed in Table 9 are regarded as key structures for water management by MADA. The periodical water level measurement (3 times a day) at these structures and calculation of daily mean discharge by electric computer have been carried out since 1976. In the present study, all available discharge data calculated by computer were collected and analyzed to grasp the actual irrigation supply to the MADA area. The calculated monthly total flow at each control structure is summarized in Tables 10 to 12.

3.2.3 Present water utilization

The standard amount of irrigation supply to the MADA area currently adopted by MADA is 1.75 lit/s/ha (40 acres/cusec) for presaturation and 1.17 - 0.58 lit/s/ha (60 - 120 acres/cusec) for the supplemental irrigation during growing season. To compensate the conveyance loss in the canal, the unit amount of 53 lit/km (3 cusecs/mile) is generally added to the above figure. However, actual irrigation supply can only be assessed through the analysis of discharge data observed at control structures.

Discharge records obtained at Pelubang regulators cannot be regarded as the actual total irrigation supply to the whole MADA area because of uncontrolled flow into the Northern canal from tributaries. In order to estimate the actual irrigation supply to the MADA area, the following procedure is taken into account:

(a) estimation of the net irrigation supply using discharge records at representative control structures in each irrigation district;

(b) estimation of conveyance efficiency in the main canals; and

(c) estimation of the gross irrigation water supply based on the above figure ((a)/(b)).

The representative control structures in each irrigation district are selected among 17 control structures taking the location into account as follows:

District	Control Structure No.	Control Structure Name	Irrigation Area (ha) Main	Irrigation Area (ha) Off
I	7	Arau	14,771	13,279
II	3	ACX	16,954	16,679
II	5	LBX	10,599	10,599
III	8	CCRBX1	3,657	3,119
III	13	CCRBX10	2,181	1,860
IV	14	Tokai	8,986	8,585
IV	17	Guau Chempedak	10,936	8,953
Total			68,084	63,074

These representative offtakes cover 71% of the total irrigation area of 95,800 ha. The estimated actual irrigation supply at each representative structures is shown in Tables 13 and 14 in volume (10^6 m^3) and in Tables 15 and 16 in depth (mm). The net irrigation supply by season by irrigation district is estimated as a weighted averaged figure as shown in Table 17. The main season supply observed at the representative structures in the irrigation district I and II cannot use for the present analysis because the excess water from the

Tanjong Pauh and Arau rivers usually drains away through the offtakes. Assuming that the main season supply to the irrigation district I and II is the same as that to the irrigation district III and IV, the average net irrigation supply for the whole MADA area is estimated to be 795 mm for off season paddy and 468 mm for main season paddy. Annual total amount is estimated at 1,281 mm.

The conveyance efficiency can be estimated by the inflow-outflow balance method on the selected portion in the existing main canals. Calculations are made between Jitra regulator and Lana Bulu regulator for the Northern canal and between Pelubang regulators and Jabi regulator for the Central canal. The irrigation water diverted into small areas through offtakes on the main canal is assumed to be the same depth as the contiguous large area covered by the offtake with discharge records. The annual total flow at 17 control structures and estimated supply between control structures from 1977 to 1981 is illustrated in Figs. 2 to 6. The average conveyance loss at the portions above-mentioned is estimated to be 14.9% in the Northern canal and 5.5% in the Central canal as shown in Table 18. These losses are equivalent to 0.93% per km in the Northern canal and 0.63% per km in the Central canal. In the present study, the conveyance loss of 0.8% per km is used as an averaged figure for the whole main and branch canals. The weighted average flow distance from Pelubang regulators in the main and branch canals is estimated to be 30 km. Hence, the average conveyance loss in the main and branch canals is estimated at 24%, which is equivalent to 76% conveyance efficiency.

The gross irrigation water supply is, therefore, estimated to be 1,046 mm for off season paddy and 639 mm for main season paddy. Annual total amount is estimated at 1,685 mm, or $1,556 \times 10^6$ m^3/y.

3.3 Minor Irrigation Schemes

In order to evaluate the actual irrigation water supply to the minor irrigation schemes, operation records of pump for recent 5 years (1978 - 1982) are collected from state DID of Kedah and Pulau Pinang. Average annual supply to the typical 5 pumping irrigation schemes is estimated at 1,931 mm/y in gross as shown in Table 19. In case of gravity irrigation schemes, no discharge records are available. However, the total supply for the gravity schemes seems to be more than that for pumping irrigation schemes because of poorer water management.

4. FUTURE IRRIGATION DEVELOPMENT

4.1 General

Among 3 states covered by the present study, the State of Kedah has highest possibility for irrigation development in the future. In order to assess the area of future irrigation development, a study was carried out based on available maps and information collected from the federal and state DIDs. The whole areas regarded as suitable for irrigation development are assumed to be developed by the year 2000.

4.2 Identification of New Irrigation Schemes

The state DID of Kedah has been steadily identified new irrigation schemes among major rainfed paddy areas in the tributaries of the Kedah and Muda rivers. However, much rainfed paddy areas still remain without identification for irrigation development. Based on the available maps and information, possible areas for irrigation development are identified by the following procedure:

(a) demarcation of existing rainfed paddy area;

(b) calculation of maximum irrigable area per unit catchment area in the Region;

(c) determination of minimum cropping intensity required to attain economic feasibility of schemes; and

(d) selection and determination of new irrigation schemes.

(1) Demarcation of existing rainfed paddy area

Demarcation of existing rainfed paddy area is carried out based on the 1/63,360 scale topographic map, land use map and soil map. The rainfed paddy area excluding on-going irrigation schemes is estimated at 32,500 ha in the study area comprizing 6,600 ha in the Perlis river basin, 13,200 ha in the Kedah river basin and 12,700 ha in the Muda river basin.

(2) Maximum irrigable area per unit catchment area in the Region

In the hydrological study (Annex E), the study area is divided into 19 sub-basins based on annual isohyet, catchment loss and topography as shown in Fig. 7. Runoff in each sub-basin is calculated using a conversion ratio from the runoff at key stations as shown in Table 20. The water deficit in the study area normally appear between March and July. In order to estimate the available discharge for irrigation with 80% dependability, the fourth smallest natural runoff in March to July among study period from 1961 to 1980 is selected for each key station as shown below.

River Basin	Nos. of Sub-Basin	Key Station	1/5 Drought Year
Perlis	3	Timah-Tasoh	1968
Kedah	6	Lengkuas	1977
Muda	7	Jeniang	1974
Perai	3	Ara Kuda	1965

Estimated 5-day mean discharge for the selected year is as shown in Table 21 in terms of specific runoff (m^3/s per 100 km^2). Available 5-day mean discharge with 80% dependability for each sub-basin can, therefore, be calculated by multiplying the conversion ratio (Table 20) by the discharge at the key stations (Table 21).

In order to evaluate the maximum size of irrigation area per unit catchment area, it is necessary to estimate the irrigation water demand for minor irrigation schemes and to compare the demand with the available 5-day mean discharge. The irrigation water demand (10-day mean value) is estimated in Chapter 5 of this ANNEX. The result of estimation by rainfall zone identified in the Region is shown in Table 59. Assuming that the period of water deficit does not exceed 10 consecutive days, the maximum size of irrigation area per unit catchment area is estimated as shown in Table 22.

(3) Determination of minimum cropping intensity

If the irrigable area during dry season is small, feasibility of an irrigation development will be low. To set a criteria of minimum cropping intensity to attain economic feasibility of irrigation schemes, a simplified study with the following assumptions is carried out:

(a) Unit construction cost of irrigation development (economic cost) is M$9,200/ha;

(b) Construftion period of a scheme is 3 years;

(c) Disbursement of construction cost is 30%, 40% and 30% for the 1st, 2nd and 3rd year, respectively;

(d) O&M cost is of 1.5% of total construction cost;

(e) Project life is 50 years;

(f) Target yield of paddy with project is 3.4 ton/ha for main season paddy and 3.5 ton/ha for off season paddy;

(g) Net incremental benefit of irrigated paddy cultivation is M$762/ha for main season paddy and M$1,212/ha for off season paddy; and

(h) Target yield can be achieved in 4 years progressively from 2.8 ton/ha to 3.4 ton/ha for main season paddy and from 2.9 ton/ha to 3.5 ton/ha for off season paddy.

The present worth of benefit is calculated in 3 cases, i.e. 120%, 140% and 160% of cropping intensity. Assuming that the interest rate is 12%, the present worth of cost and benefit and B/C ratio are obtained as shown below.

Cropping Intensity (%)	Present Worth ($M\$10^3$/ha) Benefit	Cost	B/C Ratio
120	8.7	10.6	0.82
140	9.8	10.6	0.92
160	11.5	10.6	1.08

From these results, it is found that the cropping intensity of 150% is necessary in order to attain economic feasibility of irrigation schemes.

(4) Selection and determination of new irrigation schemes

Existing rainfed paddy areas are mostly located along tributaries of Perlis, Kedah and Muda rivers in a shape of narrow strip. Large-scale irrigation development in the Region is no longer possible. After discussing about the size of development with DID officials and based on our judgement, the minimum possible size of new irrigation development is decided to be 20 ha. The minimum size of irrigable area for off season paddy is, therefore, to be 10 ha. In order to secure the water source for the minimum irrigation development, certain size of catchment area at proposed intake sites is necessary as shown in Table 23.

Based on the minimum catchment area by sub-basin (Table 23) and demarcated existing rainfed paddy in the Region, the possible area for future irrigation development is selected as shown in Plates 1 and 2.

4.3 Area for Future Irrigation Development

All minor irrigation schemes identified by DID Kedah are fully taken into consideration in this study. The irrigation areas newly selected for future development in this study based on the above-mentioned procedure are 1,463 ha (9 schemes) in Perlis and 5,374 ha (128 schemes) in Kedah. New irrigation development is not considered in the State of Pulau Pinang. Improvement plans for existing minor irrigation schemes proposed in the previous studies (Refs. 3 and 6) are fully considered. Detailed list of existing, on-going and identified minor irrigation schemes is shown in Tables 24 to 31. Area and number of irrigation schemes by river basin is summarized in Tables 32 to 34. Location of proposed intake site for irrigation schemes is shown in Plates 3 and 4.

Due to tertiary development in the Muda irrigation project area, irrigation area for main season paddy of 95,800 ha in 1982 is assumed to be reduced by 2,000 ha by the year 2000. In addition, 800 ha of paddy area in the Muda area is assumed to be converted into residential area due to urbanization of Alor Setar and other small towns. Hence, the Muda

irrigation project area is reduced to 93,000 ha by 2000. Irrigation area of the Muda irrigation project for the years 1982, 1985, 1990 and 2000 by irrigation district is summarized as shown in Table 35.

As a summary, projected irrigation areas by state/MADA and by river basin are shown in Tables 36 and 37 respectively. Minor irrigation schemes proposed to take irrigation water from the existing Muda main canal are listed in Table 38.

5. IRRIGATION WATER DEMAND

5.1 General

The role of irrigation in the Region has been devoted mostly to wet paddy, particularly for the double-cropping of paddy. Irrigation for paddy in the Region is totally dependent on surface water sources because of the relatively high costs of groundwater development, and the high consumption of water in paddy production relative to the value of the crop. In this Chapter irrigation water demand is projected only for irrigated paddy area.

Estimation of irrigation water demand for the years 1980, 1985, 1990 and 2000 is conducted on 10-day basis applying the newly developed plot-to-plot irrigation model. Cropping patterns recommended in the agricultural study (ANNEX C) are used for the estimation. It is assumed that the tertiary development for the whole Muda irrigation project of 95,800 ha will be completed by 2000. New minor irrigation schemes are assumed to have the canal density of 45 m/ha. Due to insufficiency of field measurement data for evapotranspiration, percolation rate, effective rainfall and irrigation loss, many simplified assumptions are set in the present study. Details of calculation and background of the assumptions are described in the succeeding section.

5.2 Previous Studies on Irrigation Water Demand in the Region

In the last 5 years, many studies on irrigation development and/or water resources development in the Region have been carried out under EPU or MOA/DID. In the course of these studies, irrigation water demand was estimated by using their own methodology and assumptions as summarized in Tables 39 and 40. Among many factors, disparity in the previous studies is found most in evapotranspiration, effective rainfall and irrigation efficiency.

Crop evapotranspiration can be calculated by multiplying the potential evapotranspiration by crop coefficient. Figure 8 shows the comparison of crop coefficient used in the previous studies. The curve used in the National Water Resources Study is made based on the actual measurement records in the paddy field and hence, it will be the most reliable curve at present.

Calculation method of effective rainfall is also quite different among previous studies. Some studies have made the opposite assumption for effective rainfall: The study for P. Pinang (Ref. 6) assumed that effectiveness of rainfall during presaturation was higher than that during crop growing season, but the study for Perlis (Ref. 7) made the opposite assumption which was seemed to be incorrect. The study for Kedah/Perlis (Ref. 3) adopted the USDA method for the estimation of effective rainfall, which was applicable only for upland crops. The study for Pulau Langkawi (Ref. 8) assumed the effectiveness of monthly rainfall to be 70%, which was considered as optimistic taking the

current water management into account. Many studies carried out both in Japan and Taiwan show that the achievable effectiveness of rainfall in paddy fields through a growing season is about 65% under better water management. Hence effective rainfall in the Region is assumed to be in the order of 60% of monthly actual rainfall or less as an achievable level in the Region.

Irrigation efficiency also affects the amount of irrigation demand very much. Without any actual observation records on irrigation efficiency, determination of the efficiency is not an easy task. Irrigation efficiency assumed for similar irrigation schemes in Indonesia is mostly from 60 to 64% for planning purpose but some actual measurement records show the overall efficiency between 40% to 55%. Actual observation of the overall irrigation efficiency in Japan and Taiwan is mostly between 45% and 55% under better water management. In the Kemubu irrigation project in Kelantan, it is reported that the overall irrigation efficiency at the initial stage of the project was estimated at 30 - 40% (Ref. 9). The overall irrigation efficiency of 55% for minor irrigation schemes which was assumed in the National Water Resources Study is considered to be more realistic figure than the others.

5.3 Calculation Basis of Irrigation Water Demand in the Region

5.3.1 Methodology of calculation

The calculation of the irrigation water demand consists of two components, i.e. (1) field irrigation requirement at offtakes on tertiary or secondary (in case of no tertiary canals) irrigation canals and (2) irrigation losses between the offtakes and the intake at headworks or pumping station. The irrigation water demand for paddy is commonly defined by the following equation.

$$IDR = FIR/Ea \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$FIR = (ET + P + PS - ER)/Eb \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where, IDR: Irrigation diversion requirement
FIR: Field irrigation requirement
Ea : Conveyance efficiency
ET : Crop evapotranspiration
P : Percolation rate
PS : Presaturation
ER : Effective rainfall
Eb : Field irrigation efficiency

At present, this equation is widely used in most countries in Asia. However, in the case of plot-to-plot irrigation which is the common type in Malaysia, assessment of the effective rainfall and the field irrigation efficiency in the above equation is not well known yet although previous project studies set their own assumptions as typically shown in Tables 39 and 40.

In order to make clear these points and to estimate the field irrigation requirement more realistically, a computer simulation model on the plot-to-plot irrigation method is newly developed and used in the present study. The model is the daily balance model based on the following basic equation (see Fig. 9).

$$R + Ii = Oi + ET + P + h \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where, R : Rainfall
Ii: Irrigation supply to i-plot (= Outflow from (i-1)plot)
Oi: Outflow from i-plot (= Inflow to (i+1)plot)
ET: Crop evapotranspiration
P : Percolation rate
h : Water level change in i-plot

Calculation is made from the first plot up to the terminal plot. If the number of the continuous plot is "n", outflow from n-plot is regarded as the total loss from the series of plots. In the above equation, irrigation supply to the first plot is equivalent to the field irrigation requirement in Eq. (2). By using this simulation model, integrated assessment of the field water balance under plot-to-plot irrigation can be made. Detail of this simulation model is described in the succeeding section.

5.3.2 Rainfall zone in the Region

Among many meteorological factors, rainfall distribution influences foremost on the required amount of irrigation. For the study purpose, the Region can be divided into 9 rainfall zones based on annual isohyet and monthly rainfall distribution pattern as shown in Fig. 10. For each rainfall zone, representative rainfall stations with daily rainfall records for 20 years are selected as shown in Table 41. The boundary of rainfall zones is arranged so as to correspond to the sub-basin boundary in Fig. 7.

5.3.3 Irrigation schedule

The cropping schedule proposed in ANNEX C is rearranged into 7 types of irrigation schedule for the Muda irrigation project and 2 types for minor irrigation schemes based on planting method, growth period, growing season, and tertiary development as summarized in Table 42. Each type of irrigation schedule is subdivided into several different cropping period staggering 10-day each as shown in Fig. 11. Irrigation area by type of irrigation schedule for the Muda irrigation project area (MADA area) in the years 1982, 1985, 1990 and 2000 by irrigation district are shown in Tables 43 to 46, respectively, and that for minor irrigation schemes are summarized in Table 47.

5.4 Calculation of Irrigation Water Demand by Paddy

5.4.1 Plot-to-plot irrigation model

Input data and output of the computer model for the plot-to-plot irrigation are as follows:

Input data

R	:	Daily rainfall in mm (saved in file in the computer system)
Io	:	Irrigation supply in m^3/s (10-day mean discharge)
ET	:	Crop evapotranspiration in mm/d
P	:	Percolation rate in mm/d
A	:	Average size of paddy plot in ha
n	:	Number of continuous plot
S	:	Water depth for soil saturation in mm
H	:	Height of spillway of each plot in mm
Hmax	:	Maximum water depth on the terminal plot in mm
Hmin	:	Minimum water depth on the terminal plot in mm

Output

Daily water depth on the terminal plot in mm
Daily irrigation supply in m^3/s
Daily outflow from the terminal plot in mm
Monthly rainfall in m^3/month
Monthly irrigation supply in m^3/month
Monthly outflow from the terminal plot in m^3/month
Monthly water loss in m^3/month (ET + P)

Among the input data, the Irrigation supply (Io) is the changeable factor correlating with the allowable water shortage appearing in the terminal plot. If the amount of irrigation is too small compared with the total irrigation area (A x n), irrigation water cannot reach the terminal plot and certain period of water shortage will be appeared. On the other hand, too much irrigation supply cause low irrigation efficiency and low effectiveness of rainfall. If the paddy field does not receive any form of water for certain period, crop yield will be reduced. According to the experience in Japan, the water shortage (no standing water condition) for the period of less than 10 days generally does not cause any significant damage to paddy yield (Ref. 17). Therefore, in the present study, continuous water shortage for 10 days is assumed to be allowable in the terminal plot in the plot-to-plot irrigation model. Based on this assumption, reasonable amount of irrigation supply (10-day mean discharge) for each cropping pattern and for each rainfall zone can be determined by using the simulation model.

Details of the irrigation method and each input data are explained in the succeeding section.

5.4.2 Irrigation method in the computer model

Two types of irrigation method, i.e. controlled irrigation and scheduled irrigation methods, can be calculated by the proposed simulation model. The former is a method of irrigation controlled through periodical check of the water depth in the terminal plot. For example, if the water depth in the terminal plot is lower than the allowable minimum depth (Hmin), the irrigation supply is started. When the water depth in the terminal plot becomes higher than the spillway (Hmax) due to rainfall, irrigation supply should be stopped. Such daily control of irrigation supply can be simulated by putting the figures Hmax and Hmin in the computer model. In practice, the controlled irrigation method can be achieved successfully on condition that the water management organization functions well and control structures in schemes are maintained in good condition. Under the present situation of minor irrigation schemes, the controlled irrigation method is not easy to follow except for some pumping schemes. In the case of the Muda irrigation project, the controlled irrigation method using VHF radio sets with transmission of data by voice have been practiced since 1976. However, actual discharge records at offtakes show that the reduction of irrigation supply depending on the amount of rainfall is not carried out well.

On the other hand, scheduled irrigation is defined as a type of irrigation supplying fixed (scheduled) amount of water for certain period without irregular change in supply amount depending on rainfall. The scheduled amount of irrigation can be determined by simulating the daily water balance in the plot-to-plot irrigation model using daily rainfall data for 20 years obtained from the selected rainfall stations. If the supply amount by scheduled irrigation is determined on the reasonable level, the water control is much easier than the controlled irrigation and risk of over irrigation becomes less. In the present study, the irrigation water demands for the Muda and minor irrigation schemes are estimated on condition that the scheduled irrigation is practiced.

5.4.3 Evapotranspiration

The evapotranspiration (ET), or consumptive use, by paddy varies seasonally correlating with the growing stage of paddy and meteorological factors. The evapotranspiration can generally be calculated by the following equation:

$$ET = ETo \times kc \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where, ET : Evapotranspiration by crop
ETo: Reference crop evapotranspiration
kc : Crop coefficient

If the crop coefficients are obtained from actual measurement in the field by reliable measures, this equation gives ET values with reasonable accuracy. Fortunately, such field measurement records on

evapotranspiration are available in Muda project area. In 1967 - 1969, Sugimoto (Ref. 10) carried out the field measurement of evapotranspiration by paddy and evaporation from open water by using tanks placed inside the paddy field in the Muda area. In addition, Yashima (Refs. 11 and 12) carried out the same measurement by the same equipment as Sugimoto's in 1979 - 1980. Among these measurement, the growing period of paddy planted for the measurement is not equal. In order to obtain a standardized correlation figure between kc (Crop evapotranspiration/ Open water evaporation) and time in days after transplanting, adjustment of growing period - kc relationship is made. Figure 12 shows the adjusted correlation between kc and time as a case of mid-term variety of paddy (135-day variety). To use Fig. 12 for the estimation of evapotranspiration for short-term or long-term variety of paddy, adjusted curve should be used by expanding or shortening the middle part (30 - 90 days after transplanting) of the curve proportionally so as to correspond to the growing period of paddy. The 10-day kc value is calculated for 135-day and 145-day variety as shown in Table 48.

The reference crop evapotranspiration (ETo) can be calculated by the modified Penman method proposed by FAO (Ref. 14). For the estimation of ET in the Region, the open water evaporation summarized in the DID Water Resources Publication No. 5 (Ref. 13) can be used as ETo in Eq. (3) because of the following reasons. In this Publication, the 120 cm pan evaporation was converted into open water evaporation using conversion factor of 0.9. In addition, Yashima (Ref. 11) observed the evaporation (EW) from the tank placed in the paddy field and the 120 cm pan evaporation (EP), and obtained the EW/EP ratio of about 0.9 varying from 0.89 to 1.0, which was equivalent to the above-mentioned ratio of 0.9. Hence, the open water evaporation can be used for the estimation of ET value in Eq. (3) . For present study purpose, the open water evaporation at 5 representative station is selected in the Region as shown in Table 49. The difference of values among these stations is small and, therefore, the averaged figure of them is calculated and considered to be applicable for the whole Region. The averaged monthly figure in Table 49 is sub-divided into 10-day value as shown in Table 50, which is used for the study. Crop evapotranspiration for each irrigation schedule is calculated as shown in Tables 51 to 54 based on Tables 48 and 50. These figures are used as input data for the plot-to-plot irrigation model by computer.

5.4.4 Percolation rate

In calculating the irrigation water demand, assessment of percolation rate is important. Vertical percolation rate in paddy fields can be measured by bottomless cylinder without difficulty. However, the average percolation rate for the whole scheme area is not easy to assess because the groundwater level which varies locally and seasonally, and the water level in the drainage canal also affects on the percolation rate as well as permeability of the soil.

Some data on percolation rate measured in paddy fields are available only in the Muda project area. It was reported that the percolation rate

measured in the Muda project area was 1 mm/d or less and the percolation rate of 1 mm/d was used for the calculation of irrigation water demand in the feasibility study carried out by MADA (Ref. 15). In 1980, Yamashita T. and Nagaishi Y. (Ref. 16) reported that the permeability of the soil measured in Muda area after puddling work is the order from 8×10^{-6} to 5×10^{-7} cm/s which is equivalent to 0.7 to 0.04 mm/d. In this study, the percolation rate in the Muda project area is assumed to be 1 mm/d for off season paddy and to be negligible for main season paddy.

For minor irrigation schemes, no observation records of percolation rate are available. In the previous reports, percolation rate assumed for minor schemes is mostly from 1 to 3 mm/d. In general, minor schemes are scattered along the tributaries of the Perlis, Kedah, Muda and Perai river and soils are more permeable than the Muda area. Therefore, percolation rate in minor schemes can be assumed slightly higher than that in Muda. In this study, the percolation rate of 2 mm/d is assumed for minor irrigation schemes in the Region.

5.4.5 Average size and continuous number of paddy plots

The model for the Muda irrigation project area without tertiary development condition is determined by analyzing present condition of the ACRBD 4 irrigation block of 761 ha in irrigation district II, where TARC (Japan) has carried out field research for tertiary development. The ACRBD 4 irrigation block consists of about 360 farm lots. Most farm lots are subdivided into plots by small levee. The total number of plot in the ACRBD 4 irrigation block is estimated at 1,150. The size of plot is 0.64 ha on an average ranging between 0.39 and 1.22 ha. Irrigation water for the block is supplied from secondary canal by 45 feeder pipes of 0.15 m in diameter. The number of continuous plot is estimated to be 26. Therefore, the input data of the model for the Muda area without tertiary development condition is assumed to be A = 0.64 ha and n = 26 nos.

After the completion of tertiary development, the distance from terminal offtake to the terminal plot is reduced by the provision of new tertiary canals. The ACRBD 4 irrigation block is planned to be divided into 48 irrigation service units (ISU). The average size of ISU is estimated at 15.2 ha. The number of continuous plot is estimated to be 6 on an average by the map study. Therefore, the input data of the model for the Muda area with tertiary development condition is assumed to be A = 0.64 ha and n = 6 nos.

Minor irrigation schemes in the Region have different field conditions compared with the Muda area. The size and number of continuous plot is different from scheme to scheme. The plot-to-plot irrigation model for the Sungai Muda irrigation scheme which is the largest minor scheme in the Region is determined by the map study carried out on the sample area of 790 ha locating in the northeastern part of the scheme area (Ref. 6). The input data for the Sungai Muda scheme is assumed to be A = 0.6 ha and n = 4 nos. Similar studies are carried out for typical irrigation schemes in the Region and the plot-to-plot irrigation model is determined by state. For minor irrigation schemes in the states of

Perlis and Kedah, the input data are assumed to be A = 0.5 ha and n = 3 nos. On the other hand, the input data for minor schemes in the State of P. Pinang are assumed to be A = 0.8 ha and n = 4 nos.

5.4.6 Water depth in the field

The water depth required for soil saturation (S mm) and the height of spillway of each paddy plot (H mm) affect on the amount of irrigation supply. The former is determined by soil texture and soil depth to be saturated. In the Muda area, Yashima et al (Ref. 18) has estimated the recommendable irrigation water demand for the Muda area. They assumed the soil saturation depth for off season paddy as 90 mm. In this study, this figure is used in the plot-to-plot irrigation model. The height of spillway is assumed to be 10 cm on an average based on the information from the ACRBD 4 irrigation block. For minor irrigation schemes, the same depth for soil saturation and standing water is assumed.

5.4.7 Field irrigation requirement

The field irrigation requirement is calculated by applying input data and assumptions to the proposed plot-to-plot irrigation model as mentioned in the previous sections. In practice, the field irrigation requirement (= input data of Io) can be determined by trial and error method so as to minimize the irrigation supply (Io) as long as the continuous water shortage in the terminal plot does not exceed the allowable period of 10 days.

The procedure for the above determination is as follows:

(1) Determination of required 10-day irrigation requirement under rainfall condition from 1961 to 1980 based on the controlled irrigation condition (H_{max} = 100 mm, H_{min} = 30 mm), which is equivalent to the theoretically minimum amount for irrigation supply;

(2) Selection of fourth largest 10-day irrigation requirement among 20-year simulation results (1961 - 1980) as an initial input condition into the scheduled irrigation model;

(3) Calculation of daily water level in the terminal plot based on 10-day irrigation supply amount calculated in item (2);

(4) Check the number of continuous days of water shortage in the calculation results in item (3);

(5) Increase in 10-day irrigation supply amount immediately before the period of water shortage exceeded continuous 10 days;

(6) Recalculation of daily water level in the terminal plot based on revised 10-day irrigation supply amount in item (5); and

(7) Trial and error calculation between the above items (4) and (6) until the all water shortage exceeded continuous 10-day period are disappeared.

The finally determined figures are shown in Tables 55 to 58 for the Muda irrigation project and Tables 59 and 60 for minor irrigation schemes.

5.4.8 Irrigation efficiency

The present irrigation efficiency (conveyance efficiency) in the Muda irrigation canal system is presumed to be 76% as mentioned in Section 3.2 in Chapter 3. In the case of minor irrigation schemes, the present irrigation efficiency is poorly investigated. In the present study, the irrigation efficiency for minor schemes is presumed by using the data on the Sungai Muda irrigation scheme where information on both field condition and actual pumping records is available. The estimated actual annual supply to the Sungai Muda scheme is 2,314 mm as shown in Table 19. On the other hand, field irrigation requirement for this scheme is estimated to be 1,426 mm based on Table 59. The irrigation efficiency between pumping station and terminal offtake is, therefore, presumed to be 62%. This irrigation efficiency includes not only conveyance loss but also operation loss. The operation loss can be reduced if the water management practice is improved in future.

Expecting the improvement on water management and canal in near future, the irrigation efficiency between intake and the terminal offtake is assumed to be 80% for the Muda irrigation project and 70% for minor irrigation schemes from the year 1990 onward.

5.4.9 Irrigation diversion requirement

The irrigation diversion requirement is calculated by dividing field irrigation requirement by irrigation efficiency. The results of calculation is shown in Tables 61 to 66 in terms of annual total volume by scheme by year. These figures are summed up by river basin as shown in Tables 67 to 70. Summary of irrigation diversion requirement by river system by state is shown in Table 71.

5.5 Return Flow

Irrigation water demand comprises many kinds of irrigation losses which are unavoidable in process of conveyance and distribution of irrigation water to paddy fields. A certain percentage of irrigation losses such as conveyance, application, percolation and operational losses is considered to return to the river through drainage networks or underground permeable layer. Such return flow has never been measured in Malaysia and there is no evaluation basis for it.

For the basin-wide water demand and supply balance study, the amount of return flow should be considered as an usable water source. Since there is no evaluation basis for the return flow in Malaysia, it is assumed that 20% of diverted water for irrigation schemes locating upstream of the water balance study point may return to the river with little time lag, which is the same basis generally used in Japan based on long-term experience in water balance study.

6. PLANNING MATERIALS

6.1 Investment Cost

6.1.1 Unit construction cost

Construction cost for irrigation development varies widely depending on the location and topography of the project area, component of development, type of irrigation system and so on. In this study, standardized unit construction costs are assumed for projection of future development cost based on information obtained from DID Kedah.

Table 72 shows the typical construction cost by type of scheme. The unit construction cost is estimated to be about M$10,100 - 11,300/ha.

Construction cost for irrigation development is estimated in four categories, i.e. (1) direct construction cost, (2) engineering service & administration, (3) land acquisition, and (4) physical contingency. Engineering service and administration costs are assumed to be 10% of the direct cost. Physical contingency is assumed to be 30% of the total of the above (1) to (3). The direct construction cost for gravity and/or pumping irrigation scheme is assumed at M$8,200/ha based on the typical cost for intake facilities, canal facilities and others as shown in Table 73. In the case of CHO scheme, the direct construction cost is assumed to be M$6,300/ha owing to the cheaper cost for intake facilities (M$400/ha). The total construction cost including land acquisition and physical contingency is, therefore, assumed to be M$11,500/ha for pumping/gravity scheme and M$9,000/ha for CHO scheme as shown in Table 73.

The total project cost for tertiary development for the Muda irrigation project is M$153 x 10^6, or M$6,120/ha (Ref. 19). According to the information from the Muda II project office, the total project cost is presumed to be increased to about M$230 x 10^6, or M$9,200/ha. After discussing this matter with DID officials and based on our judgement, the unit construction cost for tertiary development for the whole of the MADA area including physical contingency is assumed to be M$9,000/ha at 1982 price level.

6.1.2 Investment cost

Investment costs for each minor irrigation schemes are estimated based on the projected irrigation area by scheme and the unit construction cost. Results of estimation is shown in Tables 74 to 78 by scheme by Malaysia plan. Summary of investment costs is shown in Table 79.

6.2 Operation and Maintenance Cost

O&M cost necessary for irrigation schemes varies widely depending on local conditions and type of scheme. Actual O&M cost for each minor irrigation scheme in the States of Kedah and Pulau Pinang is shown in Tables 80 and 81. The O&M cost in Kedah is M$149/ha on an average. The O&M cost in Pulau Pinang is M$208/ha which is higher than Kedah.

In case of newly identified schemes in this study, type of scheme is now known. In order to evaluate economic feasibility of the new schemes in the States of Kedah and Perlis, standard O&M cost is assumed to be 1.5% of the total investment cost. Annual O&M cost is, therefore, M$173/ha for gravity/pumping scheme and M$138/ha for CHO scheme, which is slightly higher than the present value.

6.3 Mnapower Requirement

Manpower (or staff) of DID can broadly be classified into 4 grades, i.e. (A) engineer, (B) technical assistant, (C) technician and (D) others as listed in Table 82. According to the information collected from MADA and state DIDs of Perlis, Kedah and Pulau Pinang, the existing manpower is counted as shown in Table 83. Especially in Perlis and Kedah, existing manpower seems to be not enough to operate and maintain irrigation schemes well.

In order to calculate the required manpower up to 2000, the calculation standard of manpower requirement for irrigation development is determined as shown in Table 84 through discussion this matter with state DIDs of Perlis and Kedah. Based on the development schedule of irrigation area (Tables 24 to 30), manpower requirement by Malaysia Plan is calculated as shown in Table 85 for Perlis and Table 86 for Kedah. It is assumed that no manpower will be increased in MADA and the state DID of Pulau Pinang from the year 1985 onward.

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TABLES

Table 1 WATER BALANCE IN ACRBD 4 IRRIGATION BLOCK IN MUDA IRRIGATION PROJECT (1979 - 1981 AVERAGE)

Unit: mm

	Off Season			Main Season			Annual
	PS	NI	Total	PS	NI	Total	Total
Irrigation Period (day)	73	109	182	74	99	173	355
Supply							
Irrigation	590	370	960	274	624	898	1,858
Rainfall	384	553	937	435	205	640	1,577
Total	974	923	1,897	898	829	1,538	3,435
Water Level Change	180	-83	97	76	-104	-28	69
Demand and Loss							
Evapotranspiration	396	604	1,000	370	700	1,070	2,070
Percolation and Seepage	399	402	801	263	233	496	1,297
Total	795	1,006	1,801	633	933	1,566	3,367

Source; Ref. 2

Table 2 HISTORICAL TREND OF MINOR IRRIGATION AREA IN THE REGION

Unit: ha (Nos.)

Year	Perlis	Kedah*	P.Pinang	Total
1960	0 (0)	28 (1)	7,515 (4)	7,543 (5)
1965	557 (2)	1,041 (10)	10,350 (9)	11,948 (21)
1970	2,093 (5)	3,927 (16)	11,465 (12)	17,485 (33)
1975	2,996 (12)	5,214 (25)	15,128 (13)	23,338 (50)
1980	2,996 (12)	7,175 (35)	15,128 (13)	25,299 (60)
1982	3,717 (15)	7,175 (35)	15,128 (13)	26,020 (63)

Remarks; *: Excluding the Kerian river basin and Langkawi island

Table 3 CLASSIFICATION OF MINOR IRRIGATION SCHEMES BY SIZE IN 1982

Unit: ha (nos.)

Area	Perlis	Kedah*	P. Pinang	Total
Positive Irrigation Scheme				
Smaller than 50 ha	38 (1)	335 (10)	38 (2)	411 (13)
51 - 100 ha	224 (3)	589 (7)	0 (0)	813 (10)
101 - 500 ha	2,404 (10)	3,540 (16)	901 (5)	6,845 (31)
501 - 1,000 ha	0 (0)	931 (1)	1,915 (3)	2,846 (4)
Larger than 1,000 ha	1,051 (1)	1,780 (1)	12,274 (3)	15,105 (5)
Sub-total	3,717 (15)	7,175 (35)	15,128 (13)	26,020 (63)
Control Drainage Scheme	3,637 (7)	2,983 (2)	0 (0)	6,620 (9)
Total	7,354 (22)	10,158 (37)	15,128 (13)	32,640 (72)

Remarks; *: Excluding the Kerian river basin and Langkawi island

Table 4 CLASSIFICATION OF MINOR IRRIGATION SCHEMES BY TYPE IN 1982

Unit: ha (nos.)

Type	Perlis	Kedah*	P. Pinang	Total
Positive Irrigation Scheme				
Gravity	3,717 (15)	3,057 (25)	5,140 (6)	11,914 (46)
Pumping	0 (0)	3,078 (8)	9,199 (6)	12,277 (14)
Gravity + Pumping	0 (0)	1,040 (2)	789 (1)	1,829 (3)
Sub-total	3,717 (15)	7,175 (35)	15,128 (13)	26,020 (63)
Control Drainage Scheme	3,637 (7)	2,983 (2)	0 (0)	6,620 (9)
Total	7,354 (22)	10,158 (37)	15,128 (13)	32,640 (72)

Remarks; *: Excluding the Kerian river basin and Langkawi island

Table 5 INVENTORY OF MINOR IRRIGATION SCHEMES MAINTAINED BY DID IN PERLIS IN 1982

No.	Name of Scheme	Water Source	Scheme Area (ha)	Type of Scheme	Pump Capacity or Gate Size	Length of Irrigation Canal (km)	Length of Drainage Canal (km)	Length of Bund (km)	Construction Period	Construction Cost (M$10^3)
1	Sungai Siran	Sg. Siran	175	G	—	0.6	-	-	1972-1975	140.7
2	Taliair Pdg. Melangit	Sg. Abi	260	G	—	4.7	-	-	1962-1964	164.3
3	Taliair Kg. Belukar	Sg. Padang Malau	70	G	—	1.6	-	-	1972-1972	7.9
4	Taliair Kbg. Badak	Sg. Abi	73	G	—	1.6	-	-	1973-1973	8.5
5	Taliair Batu Pahat	Sg. Batu Pahat	38	G	—	0.9	-	-	1972-1972	4.3
6	Sg. Santan/Daboi Darat	Sg. Padang Malau	1,051	G	—	-	-	-	1967-1973	410.7
7	Sungai Repoh	Sg. Jerneh	272	G	—	-	-	-	1968-1972	245.2
8	Taliair Pdg. Siding	Sg. Arau	297	G	—	4.5	-	-	1960-1961	133.0
9	Taliair Kuala Tunggang	Sg. Arau	146	G	—	3.1	-	-	1972-1975	149.9
10	Alur Melaka	Sg. Arau	533	G	—	1.7	-	-	1975-1975	30.5
11	Pdg. Telela	Sg. Cempa		G	—	2.4	-	-	1973-1973	10.5
12	Titi Tinggi	Sg. Mata Air	81	G	—	-	-	-	1975-1975	18.6
13	Kampong Parit	Sg. Chuping	161	G	—	-	-	-	-1982	-
14	Jalan Abi/Sg. Kurung Batang	Sg. Kurang Batang	105	G	—	-	-	-	-1982	-
15	Sungai Pelarit	Sg. Pelarit	455	G	—	-	-	-	-1982	-
16	Ban Seberang Remei	Rainfed	323	C/D	—	-	-	6.6	1960-1961	187.5
17	Ban Bukit Tok Poh	Rainfed	25	C/D	—	-	-	1.9	1972-1973	27.1
18	Ban Wang Bintong	Rainfed	246	C/D	—	-	-	6.5	1963-1964	149.1
19	Taliair Bukit Tau	Rainfed	94	C/D	—	1.2	-	-	1973-1973	4.7
20	Alor Baroh	Rainfed	232	C/D	—	5.3	-	-	1975-1975	41.2
21	Kok Kelong	Rainfed	56	C/D	—	1.1	-	0.3	1973-1973	33.6
22	Keganaan Air Hujan	Rainfed	2,661	C/D	—	-	-	-	—	-

Remarks; G: Gravity irrigation scheme, C/D: Control drainage scheme

Table 6 INVENTORY OF MINOR IRRIGATION SCHEMES MAINTAINED BY DID IN KEDAH IN 1982 (1/2)

No.	Name of Scheme	District	Water Source	Scheme Area (ha)	Type of Scheme	Pump Capacity or Gate Size	Length of Irrigation Canal (km)	Length of Drainage Canal (km)	Length of Bund (km)	Construction Period	Construction Cost (M$10^3)
1	Sidam Kanan	Kulim	Sg. Muda	453	P	0.28 m^3/s x 3	11.8	10.3	-	1966-1972	649.6
2	Sidam Kiri	Kuala Muda	Sg. Muda	202	P	0.17 m^3/s x 3	4.5	4.8	-	1968-1970	396.0
3	Pulai	Baling	Sg. Ketil	239	P	0.68 m^3/s x 3	5.7	-	-	1969-1971	338.4
4	Pekula	Kuala Muda	Sg. Muda	1,780	P	1.27 m^3/s x 3	22.0	7.7	7.2	1963-1970	1,699.5
5	Kg. Binjal	Kg. Pasu	Sg. Wang Perah	172	G	ø900 x 2	3.4	-	-	1962-1964	125.1
6	Bendang Raja Janing	Pdg. Terap	Sg. Janing	137	G	ø900 x 2	5.6	-	-	1963-1964	104.5
7	Sg. Gelam	Kuala Muda	Sg. Bujang	154	G	ø610 x 1	2.8	-	-	1961-1962	51.9
8	Kg. Iboi	Baling	Sg. Kupang	186	G	ø610 x 1	4.8	-	-	1961-1962	116.9
9	Kg. Tawar	Baling	Sg. Tawar	45	G	ø610 x 1	2.0	-	-	1962-1964	41.8
10	Simpang Empat	Baling	Sg. Baling	28	G	ø610 x 1	2.8	-	-	1959-1961	69.5
11	Ulu Bakai	Baling	Sg. Bakai	75	G	ø610 x 1	3.8	-	-	1963-1965	78.3
12	Kg. Parit	Sik	Sg. Jeneri	192	G	ø610 x 1	3.6	3.7	-	1960-1961	44.9
13	Kg. Ulu/Kelang Batu	Bandar Baharu	Sg. Jejawi	24	G	ø610 x 2	1.3	-	-	1963-1964	34.2
14	Sg. Seluang	Kulim	Sg. Seluang	28	G	ø610 x 1	3.9	-	-	1963-1965	96.9
15	Tanjung Sik	Sik	Sg. Sik	91	G	ø760 x 2	3.7	3.7	-	1968-1970	136.0
16	Ban Merbok	Kuala Muda	(Rainfed)	1,530	C/D	—	-	30.9	30.9	1962-1963	1,336.9
17	Kota Bukit Meriam	Kuala Muda	(Rainfed)	1,453	C/D	—	-	6.8	2.9	—	275.0
18	Kg. Badang	Baling	Sg. Hulu Tawar	75	G	ø900 x 1	3.3	-	-	1972-1974	117.8
19	Jemerli	Kulim	Sg. Jemerli	121	G	—	-	12.1	-	1967-1969	467.3
20	Otak Kerbau	Kulim	Sg. Tarak/ Sg. Selarong	197	G	ø1,220 x 1 ø900 x 1	9.3	11.4	-	1972-1975	488.7
21	Lembah Bata	Kubang Pasu	Sg. Temin/ Sg. Bata	324	G	ø1,220 x 1 ø900 x 1	10.5	-	-	1972-1975	480.5
22	Kg. Ruat	Yan	Sg. Ruat	25	G	(600 x 600) x 2	-	-	-	1976-1976	62.3

Table 7 INVENTORY OF MINOR IRRIGATION SCHEMES MAINTAINED BY DID IN KEDAH IN 1982 (2/2)

No.	Name of Scheme	District	Water Source	Scheme Area (ha)	Type of Scheme	Pump Capacity or Gate Size	Length of Irrigation Canal (km)	Length of Drainage Canal (km)	Length of Bund (km)	Construction Period	Construction Cost (M$10^3)
23	Singkir Darat/ Sg. Pei	——	Sg. Singkir	291	G	ø900 x 2	-	2.8	2.8	1971-1974	721.2
24	Kulim	Kulim	Sg. Ular/ Sg. Keladi	155	G	ø610 x 2	8.1	-	-	1974-1976	415.6
25	Terat Batu	Kulim	Sg. Muda	28	P	0.07 m^3/s x 2	1.4	-	-	1973-1974	62.1
26	Kg. Luar	Baling	Sg. Legong	97	G	ø610 x 1	2.2	-	-	1974-1976	322.9
27	Selarong Panjang	Kulim	Sg. Merbok/ Sg. Badak/ Sg. Selarong	41	G	ø610 x 3	2.0	-	-	1975-1975	84.6
28	Baker Bata, Yan	Yen	Sg. Raga	40	G	ø900 x 1	1.6	-	-	1977-1978	139.9
29	Ulu Sedim (Siputeh)	Baling	Sg. Siputch	79	G	ø610 x 1	3.5	-	-	1974-1976	162.6
30	Merbau Pulas	Kulim	Sg. Sedim	95	P	0.12 m^3/s x 2	4.7	-	-	1975-1980	287.0
31	Pinang Tunggal	Kuala Muda	Sg. Muda	241	P	0.28 m^3/s x 3	6.9	10.1	3.6	1975-1979	759.2
32	Paya Rawa	Pendang	Muda Canal	109	P+CHO	ø900 x 1 0.07 m^3/s x 1	3.6	-	-	1976-1979	286.8
33	Lemban Bata II	Kubang Paso	——	931	G+P	——	-	-	-	——	1,687.5
34	Kg. Landak	Baling	Sg. Ketil	40	P	0.14 m^3/s x 2	2.2	-	-	1977-1979	196.2
35	Sg. Memplam	Baling	Sg. Mempelam	36	G	ø840 x 1	3.5	3.0	-	1979-1980	275.7
36	Pdg. Pusing/ Bt. Murai	Pendang	Muda Canal	367	CHO	——	12.7	4.6	-	1979-1981	2,500.0
37	Sg. Badong	Kuala Muda	Sg. Merbok Kecil	77	G	ø610 x 1	2.3	-	-	1978-1981	220.4

Remarks; G: Gravity irrigation scheme, P: Pumping irrigation scheme, C/D: Control drainage scheme, CHO: Constant head orifice (on the Muda main canal)

Table 8 INVENTORY OF MINOR IRRIGATION SCHEMES MAINTAINED BY DID IN PULAU PINANG IN 1982

No.	Name of Scheme	Water Source	Scheme Area (ha)	Type of Scheme	Pump Capacity or Gate Size	Length of Irrigation Canal (km)	Length of Drainage Canal (km)	Length of Bund (km)	Construction Period	Construction Cost (M$10^3)
(Seberang Perai)										
1	Sungai Muda	Sg. Muda	7,115	P	—	183.1	64.0	14.0	1955-1973	4,331.0
2	Pinang Tunggal	Sg. Muda	1,496	P	—	38.2	10.9	-	1962-1966	1,497.0
3	Sungai Jarak	Sg. Icreh/Sg. Jarak	789	P+G	—	33.6	6.2	-	1962-1973	1,575.2
4	Tasek Glugor	Sg. Kreh	221	P	—	8.1	-	-	1967-1973	500.1
5	Jarak Tengah	Sg. Jarak	105	P	—	1.0	1.8	2.9	1967-1973	125.8
6	Sungai Kulim	Sg. Kulim	3,663	G	—	77.4	43.8	-	1971-1982	2,608.9
7	Manchang Bubok	Sg. Junjong	136	G	—	8.4	7.2	-	1952-1956	156.0
8	Julu	Sg. Julu	244	P	—	-	-	-	—	733.9
9	Sungai Renjau	Sg. Perangin	20	G	—	-	-	-	1964-1965	16.7
10	Kuala Tasek	Sg. Junjong	18	P	—	1.0	1.2	-	1962-1967	46.2
11	Tasek Junjong	Sg. Junjong	195	G	—	-	-	-	—	73.3
(Balik Pulau)										
12	Sungai Pinang	Sg. Penang	601	G	—	8.9	14.7	6.4	—	569.8
13	Sungai Burong	Sg. Burong	525	G	—	10.5	12.6	6.7	—	426.9

Remarks; G: Gravity irrigation scheme, P: Pumping irrigation scheme

Table 9 LIST OF CONTROL STRUCTURE WITH DISCHARGE RECORD IN MADA AREA

Structure No.	Name	Flow Capacity (m^3/s)	Commanding Area (ha)	Distance from Pelubang (km)
1	Pelubang-N	76.7	50,400	0
2	Pelubang-C	77.4	45,400	0
3	Offtake ACX	27.7	16,954	7.98
4	Jitra	47.2	30,600	7.98
5	Offtake LBX	15.8	10,599	24.03
6	Lana Bulu	28.5	18,943	24.03
7	Arau	20.6	14,771	36.23
8	Offtake CCRBX1	7.4	3,657	5.73
9	Jabi	65.3	38,877	8.58
10	Senara	61.0	36,224	20.86
11	Guar Kepayang-C	29.3	17,917	26.20
12	Guar Kepayang-S	27.3	15,512	26.20
13	Offtake CCRBX10	5.4	2,181	33.81
14	Tokai	15.5	8,986	37.40
15	Pondok Chegar	-	13,672	33.30
16	Junun	24.4	12,222	43.87
17	Guar Chempedak	15.1	10,936	50.51

Table 10 MONTHLY ACTUAL DISCHARGE AT CONTROL STRUCTURES (1/3)

PELUBANGN2 (01)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	48.40	190.97	139.59	59.80	57.06	25.38	9.03	4.63	0.22	6.95	104.00	646.03
1977	77.07	50.17	159.69	115.09	19.02	25.84	20.56	1.83	0.00	3.13	2.68	143.90	619.00
1978	40.90	1.46	1.73	0.01	0.00	3.31	18.65	11.63	18.59	27.72	19.83	24.95	168.78
1979	3.51	71.14	135.21	79.15	38.09	30.04	3.15	0.33	10.43	8.82	8.84	88.83	477.55
1980	91.18	32.94	68.59	51.16	24.52	10.27	8.27	10.66	12.30	9.40	9.01	31.68	359.19
1981	103.80	37.23	74.73	31.40	31.66	52.03	27.01	33.72	22.72	70.67	51.87	80.80	577.61
1982	98.61	22.25	4.51	19.24	48.11	30.78	8.20	12.97	31.60	60.41	29.64	24.92	391.25
AVERAGE	59.30	37.54	90.78	62.24	31.40	29.93	15.89	11.45	14.32	25.77	12.69	71.30	462.77

PELUBANGE2 (02)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	71.07	181.41	99.91	4.24	61.38	8.54	3.27	12.69	0.30	7.00	96.31	546.03
1977	58.47	76.39	156.48	92.04	7.36	11.66	7.41	4.39	4.00	0.15	7.72	92.28	498.13
1978	14.48	0.09	3.16	0.15	0.00	1.07	3.99	4.36	9.75	7.47	4.23	3.74	52.49
1979	2.69	63.00	136.10	67.60	28.82	13.74	21.09	11.34	10.51	35.44	28.75	77.57	496.66
1980	71.92	36.81	68.48	69.44	41.97	13.51	10.66	3.23	7.46	7.03	6.84	21.29	338.63
1981	88.57	27.50	64.53	52.08	55.54	46.69	24.10	34.71	21.77	38.88	17.22	81.46	553.05
1982	86.55	23.03	4.03	22.89	32.20	28.85	17.73	27.96	5.63	17.52	11.21	22.92	300.51
AVERAGE	63.24	42.27	87.74	54.87	24.30	25.53	13.36	12.75	10.25	15.26	11.85	56.51	464.04

ACE 2 (03)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	25.59	67.85	51.93	23.94	29.91	19.78	13.27	30.66	52.00	43.15	48.62	406.50
1977	30.65	17.87	59.12	39.54	12.17	5.56	8.85	11.19	16.31	32.01	16.94	57.08	307.08
1978	15.43	0.79	0.55	0.00	0.00	3.84	8.66	7.38	35.15	61.71	39.16	15.87	188.34
1979	0.66	24.87	48.16	31.80	21.27	19.82	5.94	5.03	17.72	20.50	33.55	32.92	254.24
1980	33.87	5.67	29.96	30.81	14.25	11.99	5.13	14.79	23.65	55.27	43.81	26.17	295.39
1981	36.24	6.34	34.55	11.46	33.12	30.77	16.23	10.53	24.62	36.34	38.54	34.40	313.13
1982	38.70	13.72	0.00	10.57	39.22	21.41	25.67	10.94	32.99	48.58	46.61	23.11	311.32
AVERAGE	21.93	13.55*	34.31	25.16	20.57	16.47	12.87	10.42	25.87	40.92	37.40	34.00	359.72

JITRA 2 (04)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	36.69	122.26	94.97	55.85	44.66	35.72	17.28	23.31	38.95	42.39	86.67	596.54
1977	57.15	38.28	105.32	88.33	20.14	34.24	23.50	8.45	13.05	35.02	31.01	96.61	551.08
1978	43.26	3.87	7.41	6.72	14.85	6.95	20.52	11.83	20.42	32.01	26.59	25.42	219.86
1979	4.66	56.64	91.65	55.71	34.06	30.30	24.31	20.39	44.05	15.82	55.16	66.27	499.00
1980	60.18	37.41	48.56	42.66	32.72	22.21	13.74	21.04	19.42	49.52	43.51	38.59	429.58
1981	81.05	37.87	49.15	29.30	41.10	48.03	36.04	39.19	15.08	54.12	21.86	69.17	521.96
1982	77.88	26.28	6.84	26.92	44.61	28.08	24.42	12.37	32.21	69.62	75.97	32.26	457.46
AVERAGE	46.31	33.58	61.60	49.23	34.76	30.64	25.47	18.65	23.93	42.15	42.33	59.28	519.31

LOK 2 (05)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	3.41	40.72	22.27	11.53	12.93	15.36	7.36	8.99	16.88	16.56	25.51	181.52
1977	17.58	7.55	27.18	22.73	6.40	7.07	5.05	2.80	6.94	21.61	17.86	29.79	172.57
1978	11.87	0.58	1.35	1.09	2.87	2.75	6.56	4.66	6.31	7.21	5.19	7.83	58.05
1979	1.80	19.29	30.75	23.46	19.64	11.37	11.30	8.02	22.61	6.91	16.00	22.55	193.49
1980	18.15	12.94	14.35	14.20	9.88	8.51	2.39	5.12	7.35	22.31	19.19	13.28	147.67
1981	24.18	13.05	14.34	9.74	13.05	14.48	8.88	10.65	7.57	14.21	7.66	19.91	157.71
1982	20.93	7.68	2.12	8.90	20.28	9.67	12.14	5.03	14.69	31.39	32.05	14.31	179.15
AVERAGE	13.50	9.19	18.69	14.62	11.92	9.53	8.81	6.23	10.64	17.22	16.36	19.03	229.92

LANABULU 2 (06)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	15.50	55.00	43.58	29.65	14.68	7.73	3.44	3.43	8.24	9.16	35.86	225.23
1977	20.23	21.67	54.04	40.99	6.98	15.80	11.26	1.03	1.37	6.05	6.08	48.70	234.21
1978	23.93	1.33	1.06	1.54	6.88	2.36	30.91	5.29	12.29	23.14	23.62	15.53	127.80
1979	0.50	30.05	52.37	26.32	11.19	11.40	5.93	7.38	15.52	3.19	25.27	27.11	216.23
1980	31.03	17.03	29.47	15.26	12.79	8.36	5.07	8.47	8.92	17.53	14.93	17.25	186.07
1981	41.36	18.20	27.36	15.13	23.54	25.41	15.74	17.22	6.34	28.67	9.09	30.66	258.73
1982	38.05	7.77	3.55	12.22	24.65	11.91	9.53	3.97	13.50	33.62	35.42	13.82	207.61
AVERAGE	22.16	15.94	31.84	22.15	16.52	12.85	9.45	6.67	8.77	17.18	17.65	26.84	240.86

Table 11 MONTHLY ACTUAL DISCHARGE AT CONTROL STRUCTURES (2/3)

ARAU (07)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	14.82	38.78	36.43	29.39	13.49	15.19	5.09	16.50	24.86	19.18	31.24	245.78
1977	20.85	22.50	44.20	32.67	10.82	12.99	11.76	5.72	10.31	13.98	10.64	41.47	237.91
1978	20.83	2.10	2.06	2.79	9.16	5.31	15.56	4.55	22.11	29.19	28.48	16.82	158.95
1979	1.44	27.03	41.36	24.04	13.98	9.75	14.40	13.18	19.44	11.32	33.21	25.86	234.99
1980	25.01	19.14	29.65	18.08	13.40	12.23	4.15	14.12	16.55	28.61	23.87	16.52	221.32
1981	29.23	16.04	25.52	14.82	24.52	18.69	8.78	11.50	7.70	24.15	13.42	26.84	221.20
1982	26.19	4.30	2.75	14.20	25.28	10.59	16.95	5.65	19.42	40.59	39.13	16.87	221.91
AVERAGE	17.65	15.13	26.33	20.46	18.08	11.86	12.40	8.66	15.98	24.67	23.99	25.09	254.70

CERROX 3 (08)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	11.59	10.38	5.16	0.01	4.37	0.00	0.00	2.23	0.00	0.00	4.77	38.51
1977	1.18	6.39	11.22	6.28	0.56	0.80	0.00	0.58	0.02	0.00	0.22	6.89	34.13
1978	1.55	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	1.64
1979	0.61	12.45	8.42	2.73	0.00	0.00	0.00	0.41	0.83	3.76	0.23	2.12	31.55
1980	1.05	6.67	8.29	1.86	1.82	0.34	0.01	0.00	0.74	2.77	0.88	0.41	24.85
1981	2.38	7.21	11.72	0.74	2.48	2.35	2.06	4.66	4.17	2.91	0.00	6.00	46.68
1982	4.79	0.00	1.28	4.66	4.96	1.56	4.40	1.42	0.01	3.44	2.26	2.71	31.27
AVERAGE	1.62	6.34	7.33	3.03	1.40	1.35	0.92	1.01	1.14	1.84	0.51	3.27	58.16

JABI 3 (09)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	51.68	125.65	72.36	4.73	41.36	5.84	0.48	7.95	0.08	4.29	66.59	383.01
1977	29.37	45.37	124.09	77.52	5.22	8.08	6.13	2.15	1.58	0.02	5.79	74.10	399.42
1978	8.65	0.03	3.57	0.25	0.01	0.38	2.49	2.47	10.89	9.43	4.60	3.95	46.90
1979	2.22	42.46	109.15	57.59	26.73	50.10	27.25	14.60	9.60	29.85	26.76	70.61	426.92
1980	68.65	24.69	46.09	44.47	40.54	15.14	7.97	2.54	4.07	4.70	5.25	19.85	283.95
1981	82.68	23.74	46.31	52.95	61.72	45.09	21.43	35.87	20.30	59.36	20.30	69.80	517.56
1982	80.73	30.92	5.20	22.62	35.89	31.97	21.32	28.24	6.95	15.52	13.06	19.91	312.34
AVERAGE	38.90	34.13	65.72	46.82	24.98	22.02	13.20	12.05	8.76	14.14	11.46	46.40	348.04

SEMARA 3 (10)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	33.05	112.57	68.30	4.02	46.77	6.12	0.53	7.48	0.15	3.68	59.74	360.40
1977	26.82	66.25	106.87	76.85	5.66	8.52	7.80	4.39	2.98	0.53	5.47	69.60	381.53
1978	13.03	0.07	2.66	0.16	0.02	0.30	2.00	2.82	11.06	8.72	4.78	4.66	50.28
1979	1.66	61.79	96.41	57.82	27.65	10.75	27.69	16.16	9.98	30.04	26.72	62.02	408.28
1980	59.62	22.74	45.46	40.81	37.67	13.83	6.60	1.64	4.24	1.82	5.16	18.56	258.14
1981	75.85	24.51	44.96	47.36	58.23	41.60	22.36	32.63	21.32	35.84	20.38	67.56	490.60
1982	75.66	31.16	4.71	23.99	37.55	34.97	24.80	30.65	8.51	19.48	14.23	21.62	327.34
AVERAGE	35.77	34.22	59.09	45.04	24.37	22.10	13.88	12.69	9.37	13.80	11.49	43.39	376.94

GUARGEBY 3 (11)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	30.83	48.51	27.26	0.93	16.57	1.44	0.35	4.53	0.35	0.35	26.48	157.81
1977	7.90	39.32	48.01	28.73	0.44	1.40	2.17	0.90	1.32	0.53	2.02	30.20	162.92
1978	3.19	0.02	1.04	0.05	0.02	0.19	0.35	1.09	4.58	2.91	0.91	0.41	14.76
1979	1.08	29.05	36.76	15.08	9.05	3.32	3.04	1.42	4.43	13.42	9.00	26.08	153.70
1980	16.66	13.00	33.61	11.49	10.08	4.07	0.00	0.00	1.43	0.41	0.97	6.23	97.94
1981	26.36	14.81	30.78	13.55	19.69	13.19	9.56	13.67	18.43	14.78	9.43	27.19	211.42
1982	24.95	6.77	3.65	22.01	19.79	14.24	10.74	13.39	5.39	14.00	8.71	6.74	150.40
AVERAGE	11.44	19.12	28.91	16.88	8.57	7.57	3.90	4.40	5.73	6.66	4.49	17.62	188.84

GUARKEEPS 3 (12)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	12.54	45.56	27.29	1.66	14.97	4.14	0.47	1.50	0.26	3.40	23.45	135.24
1977	14.13	12.91	42.47	34.01	3.75	4.54	3.16	2.09	1.33	0.53	1.36	27.53	147.82
1978	5.34	0.01	1.23	0.04	0.02	0.43	0.78	0.75	4.22	4.84	3.45	3.18	24.49
1979	0.11	2.16	36.96	31.22	12.42	4.07	17.17	10.06	3.05	8.59	11.99	25.65	163.42
1980	34.44	5.47	3.65	16.98	18.11	7.11	4.86	1.50	1.40	1.45	2.24	8.41	105.62
1981	22.15	1.65	2.95	12.48	19.22	10.11	4.46	6.54	0.46	10.96	4.23	14.70	109.90
1982	31.85	12.50	0.86	0.12	13.78	13.95	9.49	11.25	3.48	4.31	4.59	10.52	116.68
AVERAGE	15.46	6.75	19.10	17.45	9.85	7.88	6.29	4.66	2.21	4.42	4.47	16.21	141.72

Table 12 MONTHLY ACTUAL DISCHARGE AT CONTROL STRUCTURES (3/3)

GERRIO 3 (13)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	5.55	9.32	5.74	0.21	5.00	0.00	0.00	1.37	0.00	0.00	5.50	32.71
1977	0.43	9.71	9.91	4.56	0.17	0.01	0.00	0.55	0.00	0.00	0.09	6.08	31.49
1978	0.00	0.02	0.43	0.00	0.01	0.47	0.09	0.00	0.00	0.00	0.00	0.00	0.71
1979	0.00	0.78	10.10	3.30	1.64	0.00	1.12	0.00	0.46	4.31	0.57	5.33	27.61
1980	4.50	0.25	1.41	7.23	2.10	0.38	0.10	0.08	0.13	0.00	0.33	1.35	17.78
1981	7.74	1.61	1.13	5.26	4.43	1.91	3.73	2.09	0.33	3.81	1.06	4.73	37.61
1982	4.68	2.87	0.05	0.03	3.42	2.81	3.90	2.26	1.14	0.55	0.06	0.26	22.04
AVERAGE	2.46	2.97	4.58	3.73	1.71	1.51	1.28	0.71	0.69	1.21	0.30	3.32	46.52

TOKAIREG 4 (14)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	21.95	32.05	16.84	1.26	5.34	1.55	0.53	1.95	0.92	0.55	13.64	96.57
1977	4.29	25.52	30.03	14.75	0.49	0.80	0.59	0.65	1.70	2.02	1.23	16.57	98.65
1978	0.49	0.50	0.69	0.02	0.03	0.00	1.84	1.09	5.14	3.39	1.33	0.47	14.78
1979	1.95	28.37	24.66	9.53	5.07	3.54	2.26	2.60	3.19	4.90	7.53	12.37	105.96
1980	7.91	13.05	28.47	5.51	4.53	2.18	0.01	0.00	0.99	0.11	0.30	2.43	65.49
1981	12.83	11.06	27.02	5.58	8.14	4.37	1.83	6.76	14.39	7.49	8.80	14.44	122.72
1982	11.39	1.26	2.59	19.70	11.56	7.52	3.64	4.61	2.97	10.58	6.00	5.84	87.68
AVERAGE	5.55	16.53	20.79	9.99	4.44	3.39	1.67	2.52	4.33	4.20	3.65	9.60	90.63

FONDOECHES (15)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	15.14	46.26	24.31	2.66	14.09	4.77	1.03	2.36	1.17	3.99	22.61	138.40
1977	12.94	15.47	46.55	33.20	4.02	4.79	2.87	2.45	2.48	1.12	1.92	26.62	154.42
1978	5.56	0.00	1.72	0.36	0.16	0.44	2.01	1.51	6.50	6.28	6.52	3.91	34.97
1979	0.10	3.01	44.36	36.29	14.43	5.80	19.72	14.50	6.06	8.78	14.04	26.55	193.62
1980	38.65	6.51	5.25	20.86	19.92	8.98	2.94	2.32	1.91	2.03	4.19	9.80	123.36
1981	40.31	5.92	5.44	27.37	29.90	20.35	8.12	14.24	0.95	18.92	7.69	31.95	219.16
1982	35.40	17.26	5.62	0.01	13.01	12.02	8.94	9.38	3.61	4.75	4.77	9.34	119.91
AVERAGE	18.99	9.05	21.60	20.34	12.02	9.50	7.05	6.49	3.38	6.15	6.16	18.68	152.35

JUBUB (16)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	5.72	20.28	11.72	1.87	6.56	2.10	1.17	6.12	4.27	3.13	9.00	71.93
1977	6.81	15.05	41.78	28.73	3.58	3.75	1.80	3.23	6.43	6.79	2.01	20.53	138.66
1978	3.17	0.00	0.67	0.00	0.23	5.30	3.20	1.10	8.47	8.40	7.64	2.96	41.12
1979	0.01	2.04	36.95	30.66	13.40	6.14	19.44	12.67	4.65	7.64	12.84	20.39	166.83
1980	35.28	7.97	3.76	24.90	19.61	7.70	3.92	4.24	5.37	7.51	8.04	9.10	137.20
1981	34.89	3.65	4.82	23.61	28.87	18.41	6.40	12.20	0.34	14.57	6.42	25.91	183.09
1982	23.75	14.65	0.74	0.34	15.89	7.45	6.57	7.10	5.23	6.06	9.60	8.38	105.67
AVERAGE	14.65	6.72	15.57	17.14	11.89	7.90	6.15	5.96	5.27	7.89	7.70	14.18	142.38

GUAR CHEMP (17)

UNIT : M**3/10**6

YEAR	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1976	0.00	8.82	34.52	18.03	3.85	8.28	4.32	2.22	13.10	8.60	5.25	15.51	122.50
1977	9.50	10.52	32.44	23.12	1.76	1.90	1.70	3.03	5.37	8.37	1.69	16.99	116.31
1978	2.52	0.00	0.68	0.07	0.67	0.36	2.64	1.19	7.70	9.02	7.70	3.15	35.68
1979	0.00	1.35	26.82	24.40	8.92	4.19	16.66	11.20	4.58	7.34	15.04	14.77	135.09
1980	26.71	6.99	2.25	13.01	10.86	5.97	1.53	2.98	4.56	5.35	5.91	4.85	90.96
1981	33.14	4.48	4.99	27.22	29.31	20.15	8.40	14.38	0.68	18.44	6.70	23.89	191.56
1982	19.47	12.15	0.36	0.06	12.62	5.55	5.65	5.31	3.75	5.98	7.28	7.03	85.20
AVERAGE	13.05	6.33	14.58	15.13	9.68	6.63	5.84	5.76	5.65	9.02	7.07	12.31	131.38

Table 13 ACTUAL IRRIGATION SUPPLY IN MADA AREA (1/2)

District	Off Take No.	Off Take Name	Irrigation Area	(ha)	Year	Irrigation Supply (10^6 m^3) Main	Off	Total
I	7	Arau	Main	14,471	1976/77	134.93	139.37	274.30
			Off	13,279	1977/78	99.33	117.71	217.04
					1978/79	125.07	-	-
					1979/80	133.98	116.69	250.67
					1980/81	114.82	107.63	222.45
					1981/82	95.60	110.83	206.43
					1982/83	-	134.84	-
					Average	117.29	121.18	238.47
II	3	ACX	Main	16,954	1976/77	222.55	206.68	429.23
			Off	16,679	1977/78	136.56	136.43	272.95
					1978/79	157.42	-	-
					1979/80	144.23	124.02	268.25
					1980/81	168.48	129.93	298.41
					1981/82	162.32	160.66	322.98
					1982/83	-	188.60	-
					Average	165.26	157.72	322.98
II	5	LBX	Main	10,599	1976/77	93.07	110.17	203.24
			Off	10,599	1977/78	88.45	71.23	159.68
					1978/79	47.63	-	-
					1979/80	99.16	104.32	203.48
					1980/81	92.36	61.45	153.81
					1981/82	73.08	78.14	151.22
					1982/83	-	101.65	-
					Average	82.29	87.83	170.12
III	8	CCRBX1	Main	3,657	1976/77	14.57	19.92	34.49
			Off	3,119	1977/78	8.76	19.42	28.18
					1978/79	12.87	-	-
					1979/80	14.66	11.56	26.22
					1980/81	14.39	12.32	26.71
					1981/82	17.87	24.01	41.88
					1982/83	-	18.07	-
					Average	13.85	17.55	31.40
III	13	CCRBX10	Main	2,181	1976/77	17.01	20.27	37.28
			Off	1,860	1977/78	6.19	15.20	21.39
					1978/79	0.78	-	-
					1979/80	15.32	16.16	31.48
					1980/81	11.16	11.30	22.46
					1981/82	17.28	17.83	35.11
					1982/83	-	13.61	-
					Average	11.29	15.73	27.02

Table 14 ACTUAL IRRIGATION SUPPLY IN MADA AREA (2/2)

District	Off Take No.	Off Take Name	Irrigation Area	(ha)	Year	Irrigation Supply (10^6 m^3) Main	Off	Total
IV	14	Tokai	Main	8,986	1976/77	46.87	55.57	102.44
			Off	8,585	1977/78	22.51	47.31	69.82
					1978/79	40.45	-	-
					1979/80	48.95	47.66	96.61
					1980/81	27.72	40.70	68.42
					1981/82	43.77	67.70	111.47
					1982/83	-	52.59	-
					Average	38.38	51.92	90.30
IV	17	Guau Chempedak	Main	10,936	1976/77	62.48	71.22	133.70
			Off	8,953	1977/78	34.86	63.95	98.81
					1978/79	28.92	-	-
					1979/80	75.23	92.19	167.42
					1980/81	54.27	40.60	94.87
					1981/82	81.33	104.25	185.58
					1982/83	-	33.30	-
					Average	56.18	67.59	123.77

Table 15 ACTUAL IRRIGATION SUPPLY IN DEPTH IN MADA AREA (1/2)

District	Off Take No.	Off Take Name	Irrigation Area	(ha)	Year	Irrigation Supply (mm) Main	Off	Total
I	7	Arau	Main	14,771	1976/77	932	1,050	1,982
			Off	13,279	1977/78	686	886	1,572
					1978/79	864	-	-
					1979/80	926	879	1,805
					1980/81	793	811	1,604
					1981/82	661	835	1,496
					1982/83	-	1,015	-
					Average	810	913	1,723
II	3	ACX	Main	16,954	1976/77	1,313	1,239	2,552
			Off	16,679	1977/78	805	818	1,623
					1978/79	929	-	-
					1979/80	851	744	1,595
					1980/81	994	779	1,773
					1981/82	957	963	1,920
					1982/83	-	1,131	-
					Average	975	946	1,921
II	5	LBX	Main	10,599	1976/77	878	1,039	1,917
			Off	10,599	1977/78	835	672	1,507
					1978/79	449	-	-
					1979/80	936	984	1,920
					1980/81	871	580	1,451
					1981/82	689	737	1,426
					1982/83	-	959	-
					Average	776	829	1,605
III	8	CCRBX1	Main	3,657	1976/77	398	639	1,037
			Off	3,119	1977/78	240	623	863
					1978/79	352	-	-
					1979/80	401	371	772
					1980/81	393	395	788
					1981/82	489	770	1,259
					1982/83	-	579	-
					Average	379	563	942
III	13	CCRBX10	Main	2,181	1976/77	780	1,090	1,870
			Off	1,860	1977/78	284	817	1,101
					1978/79	-	-	-
					1979/80	702	869	1,571
					1980/81	512	608	1,120
					1981/82	792	959	1,751
					1982/83	-	732	-
					Average	614	846	1,460

Table 16 ACTUAL IRRIGATION SUPPLY IN DEPTH IN MADA AREA (2/2)

District	Off Take No.	Off Take Name	Irrigation Area	(ha)	Year	Irrigation Supply (mm) Main	Off	Total
IV	14	Tokai	Main	8,986	1976/77	522	647	1,169
			Off	8,585	1977/78	251	551	802
					1978/79	450	-	-
					1979/80	545	555	1,100
					1980/81	308	474	782
					1981/82	487	789	1,276
					1982/83	-	613	-
					Average	427	605	1,032
IV	17	Guau Chempedak	Main	10,936	1976/77	571	795	1,366
			Off	8,953	1977/78	319	714	1,033
					1978/79	264	-	-
					1979/80	688	1,030	1,718
					1980/81	496	453	949
					1981/82	744	1,164	1,908
					1982/83	-	372	-
					Average	514	755	1,269

Table 17 ESTIMATED NET IRRIGATION SUPPLY IN MADA AREA

Unit: mm

Year	Off Season Paddy					Main Season Paddy				
	I	II	III	IV	Av.	I	II	III	IV	Av.
1976/77	1050	1160	807	723	948	(932)	(1146)	541	549	545
1977/78	886	761	695	634	736	(686)	(817)	256	288	273
1978/79	-	-	-	-	-	(864)	(744)	-	(348)	-
1979/80	879	837	557	797	776	(926)	(884)	513	623	572
1980/81	811	702	475	463	611	(793)	(947)	437	411	423
1981/82	835	875	841	980	889	(661)	(854)	602	628	616
1982/83	1015	1064	636	490	811	-	-	-	-	-
Average	913	900	669	681	795	(810)	(899)	470	500	486

Remarks; (1) Net irrigation supply for main season paddy in Districts I and II is not included in calculation of average figure.

(2) Irrigation area used for calculation of average figure is as follows:

District	Off Season		Main Season	
	Area (ha)	%	Area (ha)	%
I	16,962	18.8	(18,529)	-
II	30,137	33.4	(31,901)	-
III	18,572	20.6	20,893	46.0
IV	24,533	27.2	24,533	54.0
Total/Av.	90,204	100.0	95,856	100.0

Table 18 CALCULATION OF CONVEYANCE LOSS IN THE MUDA MAIN CANAL

Canal	Calendar Year	Total Flow (10^6 m^3/y) Inflow	Loss	Conveyance Loss (%)
Northern canal	1977	619	113	18.3
	1978	169	23	13.6
	1979	478	55	10.5
	1980	359	69	19.2
	1981	578	76	13.1
	Average			14.9
Central canal	1977	498	44	8.0
	1978	52	2	3.8
	1979	497	20	4.0
	1980	339	14	4.1
	1981	553	41	7.4
	Average			5.5

Table 19 ACTUAL IRRIGATION WATER SUPPLY FOR MINOR IRRIGATION SCHEMES (1978 - 1982)

Name of Scheme	Pump Capacity (cusec)	Pump Nos.	Irrigation Area (ha) Main	Irrigation Area (ha) Off	Annual Supply (mm)
Sg. Muda	200	1	5,240	4,970	2,314
	100	3			
Sidam Kanan	10	3	453	453	1,703
Sidam Kiri	6	3	202	202	1,510
Pulai	8	3	239	239	1,833
Pekula	45	3	1,780	1,731	2,293
Average					1,931

Table 20 CONVERSION RATIO FOR CALCULATION OF SPECIFIC RUNOFF

River Basin	Sub-Basin No.	Catchment Area (km^2)	Basin Rainfall (mm)	Conversion Ratio	Key Station
Perlis	PL1	341	1,898	1.016	Timah-Tasoh
	PL2	317	1,856	0.934	"
	PL3	225	1,996	1.206	"
Kedah	KD1	1,343	1,880	0.916	Lengkuas
	KD2	365	2,043	1.207	"
	KD3	345	2,280	1.629	"
	KD4	503	2,156	1.408	"
	KD5	974	2,417	1.873	"
	KD6	63	2,973	2.865	"
Muda	MD1	984	2,103	0.900	Jeniang
	MD2	756	2,296	1.130	"
	MD3	812	2,400	1.254	"
	MD4	895	2,354	1.199	"
	MD5	569	2,786	1.714	"
	MD6	559	2,354	1.199	"
	MD7	263	2,692	1.602	"
Perai	PR1	258	2,576	0.825	Ara Kuda
	PR2	453	2,337	0.659	"
	PR3	300	2,673	0.893	"

Table 21 ESTIMATED 5-DAY MEAN DISCHARGE IN 1/5 DROUGHT YEAR AT KEY STATION

Unit: $m^3/s/100\ km^2$

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Timah-Tasoh												
1-5	0.93	0.33	0.13	0.07	0	0.27	0.20	0.27	2.33	1.60	2.07	3.40
6-10	0.73	0.33	0.13	0.07	0	0.27	3.20	0.87	1.13	1.27	1.40	2.20
11-15	0.60	0.27	0.07	0.07	0.07	0.27	6.73	0.87	2.33	1.13	1.33	5.67
16-20	0.53	0.20	0.07	0	0.07	0.27	1.40	0.40	2.47	1.00	5.87	2.93
21-25	0.47	0.20	0.07	0	0.40	0.27	0.53	0.33	1.47	1.40	2.93	6.40
26-End	0.40	0.13	0.07	0	0.40	0.20	0.33	6.67	2.47	2.73	2.40	3.27
Lengkuas												
1-5	1.57	0.75	0.39	0.17	0.13	0.32	0.13	0.10	0.98	1.56	2.82	1.43
6-10	1.37	0.69	0.35	0.16	0.13	0.26	0.12	0.12	1.42	5.98	2.31	1.23
11-15	1.18	0.61	0.31	0.15	2.42	0.21	0.12	0.13	0.84	7.81	2.15	1.03
16-20	1.03	0.54	0.28	0.15	2.17	0.18	0.11	1.77	1.41	2.81	2.02	0.87
21-25	0.91	0.48	0.24	0.14	0.65	0.16	0.11	1.63	1.35	4.76	1.85	0.73
26-End	0.83	0.43	0.20	0.14	0.39	0.14	0.11	0.57	2.66	3.28	1.65	0.62
Jeniang												
1-5	2.63	1.12	0.83	0.55	1.12	1.47	0.63	1.47	1.30	5.77	3.35	3.11
6-10	2.30	1.06	0.77	0.82	1.10	1.30	0.60	1.18	1.80	4.02	3.51	2.87
11-15	1.95	1.00	0.72	0.80	0.93	1.06	0.56	1.83	2.56	3.43	3.37	2.55
16-20	1.64	0.95	0.67	0.79	3.58	0.83	0.53	1.98	2.76	3.13	3.61	2.19
21-25	1.40	0.92	0.63	0.73	1.85	0.72	0.49	1.59	5.47	2.39	3.51	1.85
26-End	1.23	0.89	0.58	0.61	1.55	0.66	1.11	1.43	5.52	3.24	3.33	1.55
Ara Kuda												
1-5	2.87	1.47	1.40	2.17	4.50	1.94	0.85	1.16	4.57	5.89	9.53	5.81
6-10	2.79	1.40	1.63	2.33	2.33	1.78	0.85	1.09	3.41	3.33	5.97	6.05
11-15	2.71	1.32	1.47	2.17	2.25	1.55	0.85	3.10	3.02	9.92	5.89	6.82
16-20	2.02	1.40	1.40	2.09	3.18	1.55	6.82	2.48	2.95	9.38	15.66	15.58
21-25	1.55	1.32	1.32	2.17	2.09	1.47	3.72	5.27	2.95	10.85	17.83	22.95
26-End	1.55	1.32	2.87	2.79	2.02	1.40	1.55	4.81	8.99	12.87	8.37	10.08

Table 22 CALCULATION OF MAXIMUM IRRIGABLE AREA PER UNIT CATCHMENT AREA BY SUB-BASIN

Unit: ha/km^2

River Basin	Key Station	No. of Sub-Basin	Rainfall Zone No.	Irrigable Area Main	Irrigable Area Off
Perlis	Timah-Tasoh	PL1	1	6.3	0.8
		PL2	1	5.8	0.7
		PL3	1	7.5	1.0
Kedah	Lengkuas	KD1	2	6.6	0.9
		KD2	2	8.7	1.2
		KD3	4	10.9	1.8
		KD4	3	10.1	1.4
		KD5	4	8.6	2.1
		KD6	5	20.6	2.9
Muda	Jeniang	MD1	6	15.0	2.3
		MD2	6	18.9	2.8
		MD3	6	20.9	3.1
		MD4	6	20.0	3.0
		MD5	7	28.6	6.7
		MD6	8	20.0	2.6
		MD7	5	26.8	5.1
Perai	Ara Kuda	PR1	8	27.5	5.5
		PR2	8	21.9	4.4
		PR3	9	29.7	6.0

Table 23 MINIMUM CATCHMENT AREA AT INTAKE SITE REQUIRED FOR FEASIBLE IRRIGATION DEVELOPMENT

Unit: km^2

River Basin	No. of Sub-Basin	Rainfall Zone No.	Minimum Catchment Area
Perlis	PL1	1	12.5
	PL2	1	14.3
	PL3	1	10.0
Kedah	KD1	2	11.1
	KD2	2	8.3
	KD3	4	5.6
	KD4	3	7.1
	KD5	4	4.8
	KD6	5	3.4
Muda	MD1	6	4.3
	MD2	6	3.6
	MD3	6	3.2
	MD4	6	3.3
	MD5	7	1.5
	MD6	8	3.8
	MD7	5	2.0
Perai	PR1	8	1.8
	PR2	8	2.3
	PR3	9	1.7

Table 24 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF PERLIS

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
1	Sungai Siran	Sg. Kechor	01	G	175	0	175	0	175	0	175	0
2	Taliair Pdg. Melangit	Sg. Kechor	01	G	260	0	260	0	260	0	260	0
3	Taliair Kg. Belukar	Sg. Kechor	01	G	70	0	70	0	70	0	70	0
4	Taliair Kbg. Badak	Sg. Kechor	01	G	73	0	73	0	73	0	73	0
5	Taliair Batu Pahat	Sg. Temenggong	01	G	38	0	38	0	38	0	38	0
6	Sg. Santan/Doboi Darat/Alor Sena	Perlis River	01	G	1,051	0	1,051	0	1,051	0	1,051	1,051
7	Sungai Repoh	Sg. Jejawi	01	G	272	0	272	0	272	0	272	0
8	Taliair Pdg. Siding	Sg. Arau	01	G	297	0	297	0	297	0	297	297
9	Taliair Kuala Tunggang	Sg. Arau	01	G	146	0	146	0	146	0	146	146
10	Alur Melaka	Sg. Arau	01	G	320	0	320	0	320	0	320	320
11	Pdg. Telela	Sg. Perlis (I)	01	G	213	0	213	0	213	0	213	0
12	Titi Tinggi	Sg. Tasoh	01	G	81	0	81	0	81	0	81	0
13	Kampong Parit	Sg. Gial	01	G	161	0	161	0	161	0	161	0
14	Jalan Abi/Sg. Kurung Batang	Sg. Kechor	01	G	105	0	105	0	105	0	105	0
15	Sungai Pelarit	Perlis River/Sg. Timah	01	G	455	0	455	0	455	0	455	235
16	Ban Seberang Remei		01	C/D	323	0	323	0	323	0	299	0
17	Ban Bukit Tok Poh		01	C/D	25	0	25	0	25	0	25	0
18	Ban Wang Bintong		01	C/D	246	0	246	0	246	0	246	0
19	Taliair Bukit Tau		01	C/D	94	0	94	0	94	0	94	0
20	Alor Baroh		01	C/D	232	0	232	0	232	0	232	0
21	Kok Kelong		01	C/D	56	0	56	0	56	0	56	0
22	Keganaan Air Hujan		01	C/D	2,661	0	2,661	0	2,661	0	1,222	0
23	Kg. Masjid	Sg. Tasoh	01		-	-	-	-	-	-	24	24
24	Kemajuan Tanah Tasoh	Sg. Tasoh	01		-	-	-	-	-	-	28	15
25	Kg. Belukar Inum	Sg. Gial	01		-	-	-	-	-	-	32	16
26	Kg. Hutan Lembah	Sg. Gial	01		-	-	-	-	-	-	28	19
27	Kg. Rambai	Sg. Arau	01		-	-	-	-	-	-	33	33
28	Ban Seberang Remei	Sg. Temenggong	01		-	-	-	-	-	-	24	12
29	Kg. Paya Besar	Perlis River	01		-	-	-	-	-	-	438	438
30	Kg. Kechor Behor Ampiang	Perlis River	01		-	-	-	-	-	-	306	306
31	Tanah Pinggir Muda	Muda Northern Canal	01	P	-	-	-	-	-	-	550	550
Total					7,354	0	7,354	0	7,354	0	7,354	3,462

Table 25 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF KEDAH (1/6)

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
1	Sidam Kanan	Muda River	08	P	453	453	510	510	510	510	510	510
2	Sidam Kiri	Muda River	06	P	202	202	264	264	264	264	264	264
3	Pulai	Sg. Ketil	06	P	239	239	239	239	239	239	239	239
4	Pekula	Muda River	08	P	1,780	1,731	1,825	1,825	1,825	1,825	1,825	1,825
5	Kg. Binjal	Sg. Temin	02	G	172	0	172	0	172	0	172	0
6	Bendang Raja Janing	Sg. Janing	02	G	137	57	137	57	137	57	137	57
7	Sg. Gelam	Sg. Merbok	05	G	154	154	154	154	154	154	154	154
8	Kg. Iboi	Sg. Ketil	06	G	186	186	186	186	186	186	186	186
9	Kg. Tawar	Sg. Ketil	06	G	45	45	45	45	45	45	45	45
10	Simpang Empat	Sg. Ketil	06	G	28	28	28	28	28	28	28	28
11	Ulu Bakai	Sg. Sedim	07	G	75	61	75	61	75	61	75	61
12	Kg. Parit	Sg. Jeneri	06	G	192	192	192	192	192	192	192	192
13	Kg. Ulu/Kelang Batu	Sg. Jawi	08	G	24	16	47	16	47	16	47	16
14	Sg. Seluang	Sg. Jarak	08	G	28	28	-	-	-	-	-	-
15	Tanjung Sik	Sg. Chepil	06	G	91	91	91	91	91	91	91	91
16	Ban Merbok	Sg. Merbok	05	C/D	1,530	0	1,530	0	1,530	0	1,530	0
17	Kota Bukit Meriam	Muda River	08	C/D	1,453	-	-	-	-	-	-	-
18	Kg. Badang	Sg. Sedim	07	G	75	75	75	75	75	75	75	75
19	Jemerli	Sg. Sedim	07	G	121	0	-	-	-	-	-	-
20	Otak Kerbau	Sg. Jarak	08	G	197	0	-	-	-	-	-	-
21	Lemban Bata	Sg. Temin	02	G	324	150	324	150	324	150	324	324
22	Kg. Ruat	Sg. Ruat	05	G	25	25	43	43	43	43	43	43
23	Singkir Darat/Sg. Pei	Sg. Singkir	05	G	291	0	291	0	291	0	291	0
24	Kulim	Sg. Kulim	08	G	155	91	155	91	155	91	155	91
25	Terat Batu	Muda River	08	P	28	28	28	28	28	28	28	28
26	Kg. Luar	Sg. Ketil	06	G	97	61	181	61	181	61	181	61
27	Selarong Panjang	Sg. Sedim	07	G	41	0	-	-	-	-	-	-
28	Bakar Bata, Yan	Sg. Belida	05	G	40	40	67	67	67	67	67	67
29	Ulu Sedim (Siputeh)	Sg. Sedim	07	G	79	49	114	49	114	49	114	49
30	Merbau Pulas	Sg. Sedim	07	P	95	34	95	34	95	34	95	34
31	Pinang Tunggal	Muda River	08	P	241	241	241	241	279	279	279	279
32	Paya Rawa (Region I)	Sg. Pendang Muda Central Canal	04	P+CHO	109	109	210	210	210	210	210	210
33	Lemban Bata II	Sg. Temin	02	G+P	931	648	1,090	648	1,090	648	1,090	1,090
34	Kg. Landak	Sg. Ketil	06	P	40	40	40	40	40	40	40	40
35	Sg. Mempelam	Sg. Sedim	07	G	36	36	67	37	67	36	67	36
36	Pdg. Pusing/Bt. Murai (Region I)	Muda Southern Canal	04	CHO	367	100	367	100	367	100	367	367
37	Sg. Badong	Sg. Merbok	05	G	77	65	77	65	77	65	77	65

Table 26 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF KEDAH (2/6)

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
38	Kota II	Muda River	08	P	-	-	1,460	1,460	1,460	1,460	1,460	1,460
39	Bakong/Lubok Boi	Muda Southern Canal	04	CHO	-	-	445	445	445	445	445	445
40	Tanjung Pari	Sg. Ketil	06	G	-	-	100	100	100	100	100	100
41	Sg. Tiak	Sg. Ketil	06	G	-	-	109	89	109	89	109	109
42	Titi Karangan	Sg. Sedim	07	G	-	-	225	68	225	68	225	68
43	Kg. Padang Meha/Pagar Museh	Sg. Sedim	07	G	-	-	150	120	150	120	150	120
44	Tanjung Besar	Sg. Chepir	06	P	-	-	172	172	172	172	172	172
45	Sg. Pering	Muda Northern Canal Sg. Perlis (II)	03	G+P	-	-	366	290	366	290	366	290
46	Kurung Hitam	Sg. Perik	02	G+P	-	-	105	105	105	105	105	105
47	Carok Kejal	Sg. Kejai	02	G	-	-	101	0	101	0	101	0
48	Padang Kerbau	Sg. Pendang Muda Central Canal	04	G+P+CHO	-	-	850	347	850	347	850	347
49	Sg. Lampan/Rambai	Muda Central Canal	04	CHO	-	-	222	222	222	222	222	222
50	Sg. Nawa/Gajah Mati	Muda Central Canal	04	CHO	-	-	535	500	535	535	535	535
51	Kg. Pantai Perai/ Kg. Serukam	Muda River	08	P	-	-	259	259	259	259	259	259
52	Sg. Teloi	Sg. Chepil	06	G+P	-	-	71	71	71	71	71	71
53	Padang Cicak	Muda River	06	G+P	-	-	81	53	81	53	81	81
54	Che Kedo/Putat	Muda Northern Canal	03	P	-	-	299	299	299	299	299	299
55	Sg. Gelong	Muda Northern Canal	03	P	-	-	194	194	194	194	194	194
56	Guar Ginu	Muda Central Canal	04	CHO	-	-	63	63	63	63	63	63
57	Kg. Banggol Berangan	Sg. Sedim	07	P	-	-	-	-	80	80	80	80
58	Kg. Tembak	Sg. Tembak	06	G	-	-	-	-	120	60	120	60
59	Lubok Kiab	Muda River	06	P	-	-	-	-	58	58	58	58
60	Kg. Sg. Limau/ Carok Bemban	Sg. Ketil	06	P	-	-	-	-	77	77	77	77
61	Kg. Matang Durian	Sg. Sedim	07	P	-	-	-	-	81	77	81	77
62	Kg. Selarong	Sg. Sedim	07	G	-	-	-	-	93	93	93	93
63	Kg. Guar Cempedak/ Kuala Badak	Sg. Tembak	06	G	-	-	-	-	133	133	133	133
64	Kg. Lanjut	Muda Central Canal	04	CHO	-	-	-	-	177	177	177	177
65	Kg. Kemumbong	Muda River	06	P	-	-	-	-	55	55	55	55
66	Pantai Cicak	Muda River	06	P	-	-	-	-	36	36	36	36
67	Sg. Perigi/Sg. Setar	Muda Southern Canal	04	P	-	-	-	-	47	47	47	47
68	Kg. Kubang Bemban	Sg. Tekai	02		-	-	-	-	32	18	32	18
69	Kg. Kerasak	Sg. Tekai	02		-	-	-	-	20	20	20	20
70	Kg. Nako	Sg. Jelutang	02		-	-	-	-	30	15	30	15

Table 27 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF KEDAH (3/6)

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
71	Kg. Tok Tanai	Sg. Pdg. Terap	02		-	-	-	-	28	28	28	28
72	Kg. Pd. Pak Tam	Sg. Pdg. Terap	02		-	-	-	-	36	36	36	36
73	Kg. S. Sari	Sg. Pdg. Terap	02		-	-	-	-	24	24	24	24
74	Kg. Padang	Sg. Pendang	04		-	-	-	-	40	20	40	20
75	Kg. Pdg. Serai	Sg. Pendang	04		-	-	-	-	52	26	52	26
76	Baker Arang	Sg. Pendang	04		-	-	-	-	79	79	79	79
77	Kg. Menerong	Kedah River	02		-	-	-	-	56	56	56	56
78	Kg. Cf. Setul	Sg. Temin	02		-	-	-	-	20	20	20	20
79	Kg. Langsat	Sg. Temin	02		-	-	-	-	40	31	40	31
80	Kg. Lubok Ipoh	Sg. Temin	02		-	-	-	-	20	10	20	10
81	Kg. Pdg. Halban	Sg. Temin	02		-	-	-	-	20	20	20	20
82	Kg. Belantek	Sg. Sok	06		-	-	-	-	35	35	35	35
83	Kg. Surau	Sg. Sok	06		-	-	-	-	26	26	26	26
84	Kg. Paya	Sg. Beris	06		-	-	-	-	30	30	30	30
85	Kg. Banggul	Sg. Jeneri	06		-	-	-	-	27	27	27	27
86	Kg. T. Belit	Sg. Chepil	06		-	-	-	-	55	55	55	55
87	Kg. Namek	Sg. Chepil	06		-	-	-	-	110	110	110	110
88	Sg. Cajad	Sg. Cajad	06		-	-	-	-	40	20	40	20
89	Kg. Kaki Bukit	Sg. Ketil	06		-	-	-	-	70	35	70	35
90	Kg. Baubak	Sg. Ketil	06		-	-	-	-	46	46	46	46
91	Kg. Terabak	Sg. Ketil	06		-	-	-	-	34	34	34	34
92	Sg. Tebing Tinggi	Sg. Ketil	06		-	-	-	-	28	28	28	28
93	Kg. Lahar	Sg. Ketil	06		-	-	-	-	116	116	116	116
94	Kg. Pdg. Geh	Sg. Ketil	06		-	-	-	-	63	63	63	63
95	Landang Wrong Jee	Merbok River	05		-	-	-	-	40	40	40	40
96	Kg. Paya Serdang	Sg. Jarak	08		-	-	-	-	63	63	63	63
97	Kg. Sira	Sg. Kulim	08		-	-	-	-	27	27	27	27
98	Sg. Kesai	Sg. Kesai	02		-	-	-	-	-	-	20	10
99	Kg. Lubok Merbau	Sg. Tok-Khomis	02		-	-	-	-	-	-	20	10
100	Kg. Nam Rok	Sg. Tekai	02		-	-	-	-	-	-	20	10
101	Bt. Batu Bertangga	Sg. Tekai	02		-	-	-	-	-	-	21	21
102	Kg. Pdg. Tok. Bakong	Sg. Tekai	02		-	-	-	-	-	-	30	10
103	Belukar Luas	Sg. Tekai	02		-	-	-	-	-	-	20	10
104	Kg. Pakra	Sg. Tekai	02		-	-	-	-	-	-	20	20
105	Kg. Pdg. Hassan	Sg. Pdg. Terap	02		-	-	-	-	-	-	20	10
106	Kg. Seberang	Sg. Pdg. Terap	02		-	-	-	-	-	-	50	50
107	Sg. Kik	Sg. Pdg. Terap	02		-	-	-	-	-	-	36	18
108	Sg. Iboi	Sg. Pdg. Terap	02		-	-	-	-	-	-	86	86
109	Kg. Banggul Setia	Sg. Pdg. Terap	02		-	-	-	-	-	-	48	48

Table 28 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF KEDAH (4/6)

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
110	Kg. Raja	Sg. Pdg. Terap	02		-	-	-	-	-	-	64	64
111	Kg. Berdang	Sg. Janing	02		-	-	-	-	-	-	20	10
112	Kg. Tengah	Sg. Perik	02		-	-	-	-	-	-	44	30
113	Kg. Nai Teh	Sg. Alor Yai	02		-	-	-	-	-	-	40	20
114	Kg. Bt. Hijau	Sg. Timas	04		-	-	-	-	-	-	46	23
115	Kubor	Sg. Pendang	04		-	-	-	-	-	-	20	11
116	Kg. Baharu	Sg. Pendang	04		-	-	-	-	-	-	34	17
117	Kg. Whatt Luar	Sg. Pendang	04		-	-	-	-	-	-	28	14
118	Kg. Whatt Tong Perok	Sg. Pendang	04		-	-	-	-	-	-	38	19
119	Kg. Bendang Lanjut	Sg. Pendang	04		-	-	-	-	-	-	20	10
120	Kg. Bt. Payong	Sg. Pendang	04		-	-	-	-	-	-	26	13
121	Kg. Pdg. Tok Sedau	Sg. Pendang	04		-	-	-	-	-	-	24	24
122	Kg. Panjong	Sg. Pendang	04		-	-	-	-	-	-	50	50
123	Kg. S. Jagong	Sg. Pendang	04		-	-	-	-	-	-	80	40
124	Kg. Bendang Raja	Sg. Pendang	04		-	-	-	-	-	-	60	30
125	Kg. Kayu Bangun	Sg. Pendang	04		-	-	-	-	-	-	36	18
126	Kg. Pinang	Kedah River	02		-	-	-	-	-	-	54	54
127	Kg. Tanjong	Kedah River	02		-	-	-	-	-	-	96	96
128	Padang Terap	Kedah River	02		-	-	-	-	-	-	36	36
129	Kg. Kubang Aring	Sg. Temin	02		-	-	-	-	-	-	20	16
130	Kg. S. Buloh	Sg. Temin	02		-	-	-	-	-	-	20	10
131	Sg. Mati	Sg. Temin	02		-	-	-	-	-	-	30	15
132	Kg. Pdg. Panjang	Sg. Temin	02		-	-	-	-	-	-	36	18
133	Kg. Jeragan	Sg. Temin	02		-	-	-	-	-	-	104	104
134	Kg. Kubang Chenok	Sg. Perlis (II)	03		-	-	-	-	-	-	32	16
135	Kg. Rumput Minyak	Muda Northern Canal	03		-	-	-	-	-	-	20	20
136	Kg. Seberang Paya	Muda Central Canal	04		-	-	-	-	-	-	20	20
137	Kg. Lubok Ular	Muda Southern Canal	04		-	-	-	-	-	-	38	38
138	Kg. Tok Kau	Muda Southern Canal	04		-	-	-	-	-	-	20	20
139	Kg. Banggul Batu	Sg. Sok	06		-	-	-	-	-	-	31	31
140	Kg. Landai	Sg. Sok	06		-	-	-	-	-	-	24	24
141	Kg. Banggul Berangan	Sg. Sok	06		-	-	-	-	-	-	36	18
142	Kg. S. Batang	Sg. Beris	06		-	-	-	-	-	-	44	22
143	Kg. Betong	Sg. Kerik	06		-	-	-	-	-	-	24	24
144	Kg. Bt. Hangus	Sg. Jeneri	06		-	-	-	-	-	-	35	26
145	Sg. Begia	Sg. Begia	06		-	-	-	-	-	-	24	20
146	Kg. Charok Gnong	Sg. Chepil	06		-	-	-	-	-	-	56	56
147	Kg. Lubok Besar	Sg. Chepil	06		-	-	-	-	-	-	70	38
148	Kg. Tupai	Sg. Chepil	06		-	-	-	-	-	-	60	30

Table 29 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF KEDAH (5/6)

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
149	Kg. Melayu Paya Terendam	Sg. Chepil	06		-	-	-	-	-	-	105	61
150	Kg. Hujong Bandar Sek	Sg. Chepil	06		-	-	-	-	-	-	72	40
151	Bt. Selambau	Sg. Cajad	06		-	-	-	-	-	-	36	18
152	Kg. Charok	Sg. Tembak	06		-	-	-	-	-	-	48	24
153	Kg. Charok Kelian Salang	Sg. Tembak	06		-	-	-	-	-	-	30	15
154	Kg. Gua Tinggi	Sg. Tembak	06		-	-	-	-	-	-	20	20
155	Kg. Ketengga	Sg. Ketil	06		-	-	-	-	-	-	20	20
156	Kg. Bt. Ketil	Sg. Ketil	06		-	-	-	-	-	-	30	30
157	Kg. Lubok	Sg. Ketil	06		-	-	-	-	-	-	58	58
158	Charok Puteh	Sg. Ketil	06		-	-	-	-	-	-	52	10
159	Kg. Charok Bunting	Sg. Ketil	06		-	-	-	-	-	-	20	16
160	Kg. Dusun Gani	Sg. Ketil	06		-	-	-	-	-	-	42	21
161	Kg. Baharu	Sg. Ketil	06		-	-	-	-	-	-	56	56
162	Kg. Charok Ketil	Sg. Ketil	06		-	-	-	-	-	-	152	76
163	Kg. Assam Jawa	Sg. Ketil	06		-	-	-	-	-	-	68	34
164	Kg. Telok Teduri	Sg. Ketil	06		-	-	-	-	-	-	28	14
165	K. Charok Bemban	Sg. Ketil	06		-	-	-	-	-	-	28	14
166	Kg. Kumbang Panjang	Sg. Ketil	06		-	-	-	-	-	-	40	20
167	Kg. Tok Dollah	Sg. Ketil	06		-	-	-	-	-	-	36	18
168	Kg. Rambong	Sg. Ketil	06		-	-	-	-	-	-	20	10
169	Kg. Charok Pendiat	Sg. Ketil	06		-	-	-	-	-	-	26	26
170	Kg. Kangar	Sg. Ketil	06		-	-	-	-	-	-	48	48
171	Kg. Pak Bong	Sg. Ketil	06		-	-	-	-	-	-	30	30
172	Kg. Setang	Sg. Ketil	06		-	-	-	-	-	-	38	19
173	Kg. Ketumbar	Sg. Ketil	06		-	-	-	-	-	-	70	39
174	Kg. Besah	Sg. Ketil	06		-	-	-	-	-	-	24	12
175	Kg. Paya Besah	Sg. Ketil	06		-	-	-	-	-	-	36	18
176	Kg. Terona	Sg. Sedim	07		-	-	-	-	-	-	48	48
177	Kg. Ulu Sedim	Sg. Sedim	07		-	-	-	-	-	-	46	46
178	Kg. Ulu Badang	Sg. Sedim	07		-	-	-	-	-	-	50	27
179	Kg. Pdg. Belon	Sg. Sedim	07		-	-	-	-	-	-	65	65
180	Kg. Merbok Bagan Sena	Sg. Sedim	07		-	-	-	-	-	-	68	34
181	Kg. Turus Gading	Sg. Sedim	07		-	-	-	-	-	-	30	30
182	Sg. Kejai	Sg. Sedim	07		-	-	-	-	-	-	56	47
183	Kg. S. Bakong	Sg. Sedim	07		-	-	-	-	-	-	40	40
184	Kg. Jeneri	Muda River	06		-	-	-	-	-	-	23	23
185	Kg. Pdg. Kawan	Muda River	06		-	-	-	-	-	-	24	24
186	Kg. Masjid Baharu	Sg. Merbok	05		-	-	-	-	-	-	65	40
187	Kg. S. Pasir	Sg. Merbok	08		-	-	-	-	-	-	22	11

Table 30 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF KEDAH (6/6)

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
188	Kg. Peng Lebai Man	Sg. Merbok	08		-	-	-	-	-	-	44	22
189	Kg. Selarong	Sg. Jarak	08		-	-	-	-	-	-	48	48
190	Kg. Kebun Tembakau	Sg. Jarak	08		-	-	-	-	-	-	43	43
191	Ladang Ambika	Sg. Jarak	08		-	-	-	-	-	-	30	30
192	Kg. Keladi	Sg. Kulim	08		-	-	-	-	-	-	100	100
193	Ladang Lim Boon Chye	Junjong (II)	08		-	-	-	-	-	-	20	20
194	Kg. Ayer Puteh	Junjong (II)	08		-	-	-	-	-	-	35	35
195	Kg. Relau	Sg. Jawi	08		-	-	-	-	-	-	26	26
Total					10,158	5,275	14,767	10,463	17,069	12,587	21,136	16,492

Table 31 LIST OF MINOR IRRIGATION SCHEMES IN THE STATE OF PULAU PINANG

Unit: ha

Scheme No.	Scheme Name	Water Source	Rainfall Zone	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
1	Sungai Muda	Muda River	08	P	7,115	7,115	7,115	7,115	6,950	6,950	6,950	6,950
2	Pinang Tunggal	Muda River	08	P	1,496	1,496	1,496	1,496	1,463	1,463	1,463	1,463
3	Sungai Jarak	Sg. Kerah, Sg. Jarak	08	P+G	789	789	789	789	769	769	769	769
4	Tasek Glugor	Sg. Kerah	08	P	221	221	221	221	262	262	262	262
5	Jarak Tengah	Sg. Jarak	08	P	105	105	105	105	98	98	98	98
6	Sungai Kulim	Sg. Kulim	08	G	3,663	3,663	3,663	3,663	3,369	3,369	3,369	3,369
7	Manchang Bubok	Sg. Junjong (II)	08	G	136	136	136	136	136	136	136	136
8	Julu	Sg. Junjong (I)	08	P	244	159	244	159	244	159	244	159
9	Sungai Renjau	Sg. Junjong (II)	08	G	20	20	20	20	20	20	20	20
10	Kuala Tasek	Sg. Junjong (II)	08	P	18	18	18	18	24	24	24	24
11	Tasek Junjong	Sg. Junjong (II)	08	G	195	195	195	195	167	167	167	167
12	Kg. Kepala Gajan	Sg. Junjong (II)	08	G	-	-	-	-	66	66	66	66
13	Sungai Pinang	Sg. Pinang, Sg. Ruso	09	G	601	0	601	0	601	0	601	0
14	Sungai Burong	Sg. Kongs/Sg. Burong/ Sg. P. Petong	09	G	525	202	525	202	525	202	525	202
Total					15,128	14,119	15,128	14,119	14,694	13,685	14,694	13,685

Table 32 AREA AND NUMBER OF IRRIGATION SCHEMES BY RIVER BASIN (1/3)

Unit: ha

	1982			1985			1990			2000		
	Nos.	Main	Off	Nos.	Main	Off	Nos.	Main	Off	Nos.	Main	Off
I. Perlis River Basin												
-1 Main River	(2)	1,286	0	(2)	1,286	0	(2)	1,286	0	(4)	2,030	2,030
-2 Tributary												
Sg. Tasoh	(1)	81	0	(1)	81	0	(1)	81	0	(3)	133	39
Sg. Timah	(1)	220	0	(1)	220	0	(1)	220	0	(1)	220	0
Sg. Jejawi	(1)	272	0	(1)	272	0	(1)	272	0	(1)	272	0
Sg. Kechor	(5)	683	0	(5)	683	0	(5)	683	0	(5)	683	0
Sg. Temenggong	(1)	38	0	(1)	38	0	(1)	38	0	(2)	62	12
Sub-total	(9)	1,294	0	(9)	1,294	0	(9)	1,294	0	(12)	1,370	51
-3 Other Rivers												
Sg. Gial	(1)	161	0	(1)	161	0	(1)	161	0	(3)	221	35
Sg. Arau	(3)	763	0	(3)	763	0	(3)	763	0	(4)	796	796
Sg. Perlis (I)	(1)	213	0	(1)	213	0	(1)	213	0	(1)	213	0
Sub-total	(5)	1,137	0	(5)	1,137	0	(5)	1,137	0	(8)	1,230	831
Total for I	(16)	3,717	0	(16)	3,717	0	(16)	3,717	0	(24)	4,630	2,912
II. Kedah River Basin												
-1 Main River	(3)	96,232	90,365	(11)	98,065	92,463	(14)	97,845	92,678	(22)	96,779	93,479
-2 Tributary												
Sg. Kesai	(0)	-	-	(0)	-	-	(0)	-	-	(1)	20	10
Sg. Tok Khamis	(0)	-	-	(0)	-	-	(0)	-	-	(1)	20	10
Sg. Tekai	(0)	-	-	(0)	-	-	(2)	52	38	(7)	163	109
Sg. Jelutang	(0)	-	-	(0)	-	-	(1)	30	15	(1)	30	15
Sg. Bdg. Terap	(0)	-	-	(0)	-	-	(3)	88	88	(9)	392	364
Sg. Janing	(1)	137	57	(1)	137	57	(1)	137	57	(2)	157	67
Sg. Kejai	(0)	-	-	(1)	101	0	(1)	101	0	(1)	101	0
Sg. Perik	(0)	-	-	(1)	105	105	(1)	105	105	(2)	149	135
Sg. Alor Yai	(0)	-	-	(0)	-	-	(0)	-	-	(1)	40	20
Sg. Temas	(0)	-	-	(0)	-	-	(0)	-	-	(1)	46	23
Sg. Pendang	(1)	44	44	(3)	810	307	(6)	981	432	(17)	1,397	678
Sub-total	(2)	181	101	(6)	1,153	469	(15)	1,494	735	(43)	2,515	1,431

Table 33 AREA AND NUMBER OF IRRIGATION SCHEMES BY RIVER BASIN (2/3)

Unit: ha

	1982			1985			1990			2000		
	Nos.	Main	Off	Nos.	Main	Off	Nos.	Main	Off	Nos.	Main	Off
-3 Other Rivers												
Sg. Perlis (II)	(0)	-	-	(1)	76	0	(1)	76	0	(2)	108	16
Sg. Berida	(1)	40	40	(1)	67	67	(1)	67	67	(1)	67	67
Sg. Temin	(4)	1,427	798	(3)	1,586	798	(7)	1,686	879	(13)	1,896	1,658
Sub-total	(5)	1,467	838	(5)	1,729	865	(9)	1,829	946	(16)	2,071	1,741
Total for II	(10)	97,880	91,304	(22)	100,947	93,797	(38)	101,168	94,359	(81)	101,365	96,651
III. Muda River Basin												
-1 Main River	(12)	15,988	15,939	(15)	17,952	17,924	(18)	17,668	17,640	(20)	17,715	17,715
-2 Tributary												
Sg. Sok	(0)	-	-	(0)	-	-	(2)	61	61	(5)	152	134
Sg. Beris	(0)	-	-	(0)	-	-	(1)	30	30	(2)	74	52
Sg. Kerik	(0)	-	-	(0)	-	-	(0)	-	-	(1)	24	24
Sg. Jemeri	(1)	192	192	(1)	192	192	(2)	219	219	(3)	254	245
Sg. Begia	(0)	-	-	(0)	-	-	(0)	-	-	(1)	24	20
Sg. Chepil	(0)	91	91	(3)	334	334	(5)	499	499	(10)	862	724
Sg. Cajad	(0)	-	-	(0)	-	-	(1)	40	20	(2)	76	38
Sg. Tembak	(0)	-	-	(0)	-	-	(2)	253	193	(5)	351	252
Sg. Ketil	(7)	635	599	(9)	928	788	(16)	1,362	1,187	(37)	2,284	1,796
Sg. Sedim	(7)	522	255	(7)	801	443	(10)	1,055	693	(18)	1,458	1,030
Sub-total	(15)	1,440	1,137	(20)	2,255	1,757	(39)	3,519	2,902	(84)	5,559	4,315
-3 Other Rivers												
Sg. Ruai	(1)	25	25	(1)	43	43	(1)	43	43	(1)	43	43
Sg. Singkir	(1)	291	0	(1)	291	0	(1)	291	0	(1)	291	0
Merbok River	(2)	231	219	(2)	231	219	(3)	271	259	(6)	402	332
Sub-total	(4)	547	244	(4)	565	262	(5)	605	302	(8)	736	375
Total for III	(31)	17,975	17,320	(39)	20,772	19,943	(62)	21,792	20,844	(112)	24,010	22,405

Table 34 AREA AND NUMBER OF IRRIGATION SCHEMES BY RIVER BASIN (3/3)

Unit: ha

	1982			1985			1990			2000		
	Nos.	Main	Off	Nos.	Main	Off	Nos.	Main	Off	Nos.	Main	Off
IV. Perai River Basin												
Sg. Jawi	(1)	24	16	(1)	47	16	(1)	47	16	(2)	73	42
Sg. Jarak	(3)	330	133	(1)	105	105	(2)	161	161	(5)	282	282
Sg. Kulim	(2)	155	91	(2)	155	91	(3)	182	118	(4)	282	218
Sg. Junjong (I)	(1)	244	159	(1)	244	159	(1)	244	159	(1)	244	159
Sg. Junjong (II)	(4)	369	369	(4)	369	369	(5)	413	413	(7)	468	468
Total for IV	(11)	1,122	768	(9)	920	740	(12)	1,047	867	(19)	1,349	1,169
V. Pinang Island	(5)	1,126	202	(5)	1,126	202	(6)	1,126	202	(6)	1,126	202
Grand Total	(73)	121,820	109,594	(91)	127,482	114,682	(134)	128,850	116,272	(242)	132,480	123,339

Table 35 IRRIGATION AREA OF THE MUDA IRRIGATION PROJECT

Unit: ha

Year	Season	Irrigation District I	II	III	IV	Total
1982	Main	18,500	31,900	20,900	24,500	95,800
	Off	17,000	30,100	18,600	24,500	90,200
1985	Main	18,500	31,700	20,800	24,400	95,400
	Off	17,000	30,100	18,600	24,400	90,100
1990	Main	18,400	31,600	20,600	24,300	94,900
	Off	17,000	30,100	18,600	24,300	90,000
2000	Main	18,200	31,200	19,600	24,000	93,000
	Off	17,000	30,100	18,600	24,000	89,700

Table 36 PROJECTED IRRIGATION AREA BY STATE/MADA

Unit: ha

State/MADA	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
Perlis:								
Gravity/Pump	3717	0	3717	0	3717	0	5180	3462
C/D	3637	0	3637	0	3637	0	2174	0
Total	7354	0	7354	0	7354	0	7354	3462
MADA:								
Gravity	95800	90200	95400	90100	94900	90000	93000	89700
Kedah:								
Gravity/Pump	7175	5275	13237	10463	15539	12587	19606	16492
C/D	2983	0	1530	0	1530	0	1530	0
Total	10158	5275	14767	10463	17069	12587	21136	16492
P. Pinang:								
Gravity/Pump	15128	14119	15128	14119	14694	13685	14694	13685
Grand Total:								
Gravity/Pump	121820	109594	127482	114682	128850	116272	132480	123339
C/D	6620	0	5167	0	5167	0	3704	0
Total	128440	109594	132649	114682	134017	116272	136184	123339

Remarks; C/D: Control drainage scheme

Table 37 PROJECTED IRRIGATION AREA BY RIVER BASIN

Unit: ha

River Basin	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
Perlis								
Minor: Gravity /Pump	3717	0	3717	0	3717	0	4630	2912
: C/D	3637	0	3637	0	3637	0	2174	0
Sub-total	7354	0	7354	0	7354	0	6804	2912
Kedah								
MADA	95800	90200	95400	90100	94900	90000	93000	89700
Minor: Gravity /Pump	2080	1104	5547	3697	6268	4359	8365	6951
Sub-total	97880	91304	100947	93797	101168	94359	101365	96651
Muda								
Minor: Gravity /Pump	17975	17320	20772	19943	21792	20844	24010	22405
: C/D	2983	0	1530	0	1530	0	1530	0
Sub-total	20958	17320	22302	19943	23322	20844	25540	22405
Perai	1122	768	920	740	1047	867	1349	1169
P. Pinang	1126	202	1126	202	1126	202	1126	202
Total	128440	109594	132649	114682	134017	116272	136184	123339

Remarks; C/D: Control drainage scheme

Table 38 LIST OF MINOR IRRIGATION SCHEMES TO BE IRRIGATED BY MUDA MAIN CANAL

Unit: ha

No.	Name of Scheme	Type of Scheme	1982 Main	1982 Off	1985 Main	1985 Off	1990 Main	1990 Off	2000 Main	2000 Off
Perlis										
31	Tanah Pinggir Muda	P	-	-	-	-	-	-	550	550
Kedah										
32	Paya Rawa	P + CHO	65	65	100	100	100	100	100	100
36	Pdg. Pusing/ Bt. Murai	CHO	367	100	367	100	367	100	367	367
39	Bakong/Lubok Boi	CHO	-	-	445	445	445	445	445	445
45	Sg. Pering	P	-	-	290	290	290	290	290	290
48	Padang Kerbau	P + CHO	-	-	150	150	150	150	150	150
49	Sg. Lampan/Rambai	CHO	-	-	222	222	222	222	222	222
50	Sg. Nawa/Gejah Mati	CHO	-	-	535	500	535	535	535	535
54	Che Kedo/Putat	P	-	-	299	299	299	299	299	299
55	Sg. Gelong	P	-	-	194	194	194	194	194	194
56	Guar Ginu	CHO	-	-	63	63	63	63	63	63
64	Kg. Lanjut	CHO	-	-	-	-	177	177	177	177
67	Sg. Perigi/Sg. Setar	P	-	-	-	-	47	47	47	47
135	Kg. Rumput Minyak	CHO	-	-	-	-	-	-	20	20
136	Kg. Seberang Paya	CHO	-	-	-	-	-	-	20	20
137	Kg. Lubok Ular	CHO	-	-	-	-	-	-	38	38
138	Kg. Tok Kau	CHO	-	-	-	-	-	-	20	20
Total			432	165	2,665	2,363	2,889	2,622	3,537	3,537

Remarks; P : Pumping irrigation scheme
G : Gravity irrigation scheme
CHO: Control head offtake

Table 39 COMPARISON OF CALCULATION METHOD FOR IRRIGATION WATER DEMAND FOR SMALL SCALE IRRIGATION SCHEME (1/2)

	Kedah-Perlis Development Study (Sep 1978)	Kedah-Perlis W.R. Management Study (Jan 1981)	Kedah/Perlis Irrigated Agriculture Intensification Study (Mar 1982)	Upgrading of I&D Schemes in P. Pinang (Apr 1982)
1. Cropping Schedule (days)				
1) Nursery period	25		25	25
2) Growing period				
- Main season paddy	125		95	115
- Off season paddy	110		95	100
2. Calculation Basis	Monthly		Peak only (10-day)	10-day
3. Presaturation Requirement		No theoretical background is shown.		
1) Presaturation period (days)				
- Main season paddy	21 to 30		15	30
- Off season paddy	21 to 30	Figures supplied from MADA are used.	30	30
2) Calculation method	?		DID Inf. Paper No.2	DID Inf. Paper No.2
3) Saturation+Standing water (mm)				
- Main season paddy	?		150	100
- Off season paddy	?		250	150
4. Evapotranspiration (ET)				
1) Reference ET	Pan evaporation		Grass evaporation	Grass evapo.
2) Crop coefficient	Assumed (Fig. 8)		Assumed (Fig. 8)	Assumed (Fig. 8)
5. Percolation Rate (mm/d)	?		0.25 - 5.0	2.0
6. Effective Rainfall	?		USDA Method 50mm = 76% 100mm = 65% 200mm = 54% 300mm = 45%	PS = 75% or less LP = 60% CG = 50%
7. Irrigation Efficiency (%)				
1) Conveyance (Main+Secondary)	88		-	85
2) Application (Tertiary)	77		-	80
3) Overall irri. efficiency	68		65	68

Table 40 COMPARISON OF CALCULATION METHOD FOR IRRIGATION WATER DEMAND FOR SMALL SCALE IRRIGATION SCHEME (2/2)

	Perlis Integraged Area Development Study (Mar 1982)	National Water Resources Study (Oct 1982)	P. Langkawi Surface Water Resources Study (Oct 1982)
1. Cropping Schedule (days)			
1) Nursery period	25	25	
2) Growing period			
- Main season paddy	100	120	
- Off season paddy	100	120	
2. Calculation Basis	Monthly	Monthly	Monthly
3. Presaturation Requirement			
1) Presaturation period (days)			
- Main season paddy	20	30	20
- Off season paddy	20	30	20
2) Calculation method	-	DID Inf. Paper No.2	-
3) Saturation + Standing water (mm)			
- Main season paddy	100	150	250
- Off season paddy	150 Add 100mm after transplanting	150	300
4. Evapotranspiration (ET)			
1) Reference ET	Grass evaporation	Open water evaporation	Grass evaporation
2) Crop coefficient	Assumed (Fig. 8)	Field measure-ment (Fig. 8)	Assumed (Fig. 8)
5. Percolation Rate (mm/d)	2.0	3.0	3.0
6. Effective Rainfall	PS = 40% CG = 70%	R ≦ 200mm: 60% of R R > 200mm: (R-200) x 0.3 + 120	70%
7. Irrigation Efficiency (%)			
1) Conveyance (Main+Secondary)	80	-	80
2) Application (Tertiary)	75	-	75
3) Overall irri. efficiency	60	55	60

Table 41 AVERAGE MONTHLY RAINFALL BY RAINFALL ZONE

Unit: mm

Rainfall Zone No.	Rainfall Station Name	Rainfall Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Arau	6402007	41	40	107	177	210	171	165	207	273	294	235	92	2,012
2	Kuala Nerang	6206035	43	38	119	184	223	137	139	176	262	316	209	102	1,948
3	Stn. Kajicuaca	6204039	44	53	100	187	255	182	187	218	301	321	214	100	2,162
4	Stn. Keretapi	6004045	48	58	86	174	260	214	248	243	370	358	235	95	2,389
5	Ibu Bekalan Tupah	5704057	64	65	136	231	296	265	272	277	417	483	294	147	2,947
6	Sik	5807067	62	64	109	205	249	168	202	210	288	381	266	114	2,318
7	Ladang Bagan Sena	5406081	107	90	192	275	270	184	230	240	341	456	336	219	2,940
8	Ladang Malakoff	5404041	79	74	129	192	199	158	196	209	341	392	280	155	2,404
9	Pintuair Bagan	5302002	78	94	158	225	258	184	210	261	376	486	270	132	2,732

Table 42 CLASSIFICATION OF TYPE OF IRRIGATION SCHEDULE

Classification	Type of Irrigation Schedule								
	A	B	C	D	E	F	G	H	I
Application									
Muda project	o	o	o	o	o	o	o	-	-
Minor schemes	-	-	-	-	-	-	-	o	o
No. of staggering schedule	5	10	6	8	7	4	5	4	4
Planting method	T	T	T	T	T	DS	DS	T	T
Growth period (d)	135	135	145	145	135	140	130	140	150
Growing season									
Main season	o	o	-	-	-	-	-	o	-
Off season	-	-	o	o	o	o	o	-	o
Tertiary development	o	x	o	x	x	o	o	-	-
Presaturation period (d)	20	40	20	40	40	-	-	30	30

Remarks; T: Transplanting, DS: Direct sowing

Table 43 IRRIGATION AREA BY TYPE OF IRRIGATION SCHEDULE FOR MADA AREA IN 1982

Unit: ha

Type	Irrigation District I	II	III	IV	Total
Main Season					
B2	-	-	-	2,980	2,980
B3	-	-	-	2,980	2,980
B4	3,050	3,340	3,540	2,980	12,910
B5	3,050	6,070	4,590	3,910	17,620
B6	4,370	6,070	5,590	5,090	21,120
B7	4,370	7,140	2,060	2,100	15,670
B8	2,340	7,140	2,060	2,100	13,640
B9	1,320	1,070	2,060	1,180	5,630
B10	-	1,070	1,000	1,180	3,250
Total	18,500	31,900	20,900	24,500	95,800
Off Season					
E1	-	1,680	1,080	-	2,760
E2	1,340	1,680	1,080	1,070	5,170
E3	4,880	3,970	2,640	2,020	13,510
E4	4,880	8,420	4,920	5,760	23,980
E5	3,530	6,750	3,840	4,700	18,820
E6	2,370	2,300	2,270	1,300	8,240
E7	-	-	2,270	350	2,620
G1	-	-	-	770	770
G2	-	1,100	-	6,470	7,570
G3	-	2,100	-	2,060	4,160
G4	-	2,100	500	-	2,600
Total	17,000	30,100	18,600	24,500	90,200

Table 44 IRRIGATION AREA BY TYPE OF IRRIGATION SCHEDULE FOR MADA AREA IN 1985

Unit: ha

Type	Irrigation District I	II	III	IV	Total
Main Season					
A3	1,700	2,250	1,150	1,650	6,750
A4	1,700	2,250	1,550	1,650	7,150
A5	-	-	400	-	400
B2	-	1,650	1,700	3,370	6,720
B3	1,700	4,550	1,700	3,370	11,320
B4	2,970	6,780	4,800	4,850	19,400
B5	4,440	6,780	4,800	4,850	20,870
B6	4,430	5,120	3,100	3,090	15,740
B7	1,460	2,220	1,500	1,470	6,650
Total	18,400	31,600	20,700	24,300	95,000
Off Season					
C2	1,040	1,000	-	-	2,040
C3	1,030	1,000	1,000	1,150	4,180
C4	1,030	1,000	1,000	1,150	4,180
D1	-	1,770	1,140	1,170	4,080
D2	1,050	2,910	1,140	2,520	7,620
D3	3,220	4,330	1,130	2,520	11,200
D4	3,220	4,320	2,310	3,700	13,550
D5	3,210	4,310	3,390	3,690	14,600
D6	2,050	4,310	3,380	3,690	13,430
D7	1,050	2,540	2,240	2,530	8,360
D8	-	1,410	1,070	1,180	3,660
F1	-	650	400	500	1,550
F2	-	650	400	500	1,550
Total	16,900	30,200	18,600	24,300	90,000

Table 45 IRRIGATION AREA BY TYPE OF IRRIGATION SCHEDULE FOR MADA AREA IN 1990

Unit: ha

Type	Irrigation District I	II	III	IV	Total
Main Season					
A1	1,850	1,680	1,980	-	5,510
A2	1,850	1,680	1,980	2,200	7,710
A3	1,850	3,870	2,570	2,900	11,190
A4	1,850	3,870	2,570	700	8,990
B1	-	-	-	1,740	1,740
B2	-	-	-	3,360	3,360
B3	940	2,900	1,700	3,350	8,890
B4	2,200	5,130	3,300	3,350	13,980
B5	3,670	5,130	3,300	3,350	15,450
B6	2,730	5,120	3,300	3,350	14,500
B7	1,460	2,220	-	-	3,680
Total	18,400	31,600	20,700	24,300	95,000
Off Season					
C1	1,200	1,100	1,100	1,100	4,500
C2	2,200	2,140	2,400	1,100	7,840
C3	2,200	2,130	2,400	1,100	7,830
C4	-	1,030	1,300	1,100	3,430
D2	-	1,420	-	3,660	5,080
D3	2,170	2,560	1,830	3,660	10,220
D4	3,470	3,610	2,910	3,650	13,640
D5	3,460	3,600	2,250	3,650	12,960
D6	1,000	3,590	2,240	2,530	9,360
D7	-	3,590	1,070	1,350	6,010
D8	-	1,130	-	-	1,130
F1	600	1,620	550	700	3,470
F2	600	1,620	550	700	3,470
F3	-	1,060	-	-	1,060
Total	16,900	30,200	18,600	24,300	90,000

Table 46 IRRIGATION AREA BY TYPE OF IRRIGATION FOR MADA AREA IN 2000

Unit: ha

Type	Irrigation District I	II	III	IV	Total
Main Season					
A1	2,070	2,740	2,130	2,500	9,440
A2	4,440	8,540	5,130	5,200	23,310
A3	6,980	11,530	7,790	8,300	34,600
A4	4,910	8,790	5,650	8,300	27,650
Total	18,400	31,600	20,700	24,300	95,000
Off Season					
C1	1,200	2,800	1,100	2,770	7,870
C2	3,520	5,900	3,970	5,600	18,990
C3	3,660	4,800	4,310	4,450	17,220
C4	2,490	4,800	2,990	3,090	13,370
C5	1,330	3,400	1,430	3,090	9,250
F1	1,200	3,200	1,100	1,750	7,250
F2	2,350	3,200	2,400	2,650	10,600
F3	1,150	2,100	1,300	900	5,450
Total	16,900	30,200	18,600	24,300	90,000

Table 47 IRRIGATION AREA BY TYPE OF IRRIGATION SCHEDULE FOR MINOR IRRIGATION SCHEMES

Unit: ha

Scheme	Type	1982/1985	1990/2000
Sg. Muda	H1 & J1	1,186	1,158
	H2 & J2	2,372	2,317
	H3 & J3	2,372	2,317
	H4 & J4	1,185	1,158
	Total	7,115	6,950
Sg. Kulim	H1 & J1	611	562
	H2 & J2	1,221	1,123
	H3 & J3	1,221	1,123
	H4 & J4	610	561
	Total	3,663	3,369
Pinang Tunggal	H1 & J1	499	488
	H2 & J2	499	488
	H3 & J3	498	487
	Total	1,496	1,463
Jarak	H1 & J1	263	256
	H2 & J2	263	256
	H3 & J3	263	257
	Total	789	769
Other Minor Schemes	H2 & J2	(50%)	(50%)
	H3 & J3	(50%)	(50%)
	Total	(100%)	(100%)

Table 48 10-DAY CROP COEFFICIENT BY VARIETY

Period after Transplanting (d)	135-day Variety	145-day Variety
0 - 10	1.01	1.01
- 20	1.06	1.06
- 30	1.16	1.16
- 40	1.29	1.28
- 50	1.38	1.36
- 60	1.44	1.42
- 70	1.45	1.44
- 80	1.42	1.45
- 90	1.31	1.41
- 100	1.16	1.31
- 110	1.00	1.16
- 120	Drainage	1.00
- 130	Drainage	Drainage
- 140	-	Drainage

Table 49 OPEN WATER EVAPORATION

Unit: mm/d

	Kangan	Alor Setar	Simpang Tiga	Bumbong Lima	Penang	Average
Jan	4.6	4.9	5.2	5.5	5.1	5.1
Feb	5.5	5.4	6.1	6.5	5.5	5.8
Mar	5.8	5.7	6.0	6.1	5.7	5.9
Apr	5.4	5.8	5.6	5.1	5.6	5.5
May	4.9	5.0	5.0	4.9	4.9	4.9
Jun	4.6	4.8	4.5	4.4	4.9	4.6
Jul	4.6	4.7	5.0	4.7	4.7	4.7
Aug	4.7	4.7	4.8	4.5	4.7	4.7
Sep	4.7	4.8	4.7	4.6	4.7	4.7
Oct	4.5	4.4	4.3	4.4	4.5	4.4
Nov	4.3	4.3	4.2	4.2	4.5	4.3
Dec	4.3	4.2	4.3	4.5	4.4	4.4
Average	4.8	4.9	5.0	4.9	4.9	4.9

Table 50 10-DAY OPEN WATER EVAPORATION

Day	J	F	M	A	M	J	J	A	S	O	N	D
Daily Evaporation (mm/d)												
1 - 10	4.8	5.6	5.9	5.6	5.1	4.7	4.7	4.7	4.7	4.6	4.4	4.3
11 - 20	5.1	5.8	5.9	5.5	4.9	4.6	4.7	4.7	4.7	4.5	4.3	4.4
21 - End	5.4	5.9	5.8	5.3	4.8	4.6	4.7	4.7	4.7	4.4	4.3	4.5
Average	5.1	5.8	5.9	5.5	4.9	4.6	4.7	4.7	4.7	4.4	4.3	4.4
10-day Evaporation (mm)												
1 - 10	48	56	59	56	51	47	47	47	47	46	44	43
11 - 20	51	58	59	55	49	46	47	47	47	45	43	44
21 - End	59	47	64	53	53	46	52	52	47	48	43	50
Total	158	161	182	164	153	139	146	146	141	139	130	137
										Annual Total		1,796

Table 51 EVAPOTRANSPIRATION OF PADDY BY TYPE OF IRRIGATION SCHEDULE (1/4)

Unit: mm

Month		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Jul	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-
Aug	1	47	7	7	-	-	47	-	-	-	-	-	-	-	-	-
	2	47	47	7	7	-	47	47	-	-	-	-	-	-	-	-
	3	53	52	52	7	7	52	52	52	-	-	-	-	-	-	-
Sep	1	50	48	47	47	7	47	47	47	47	-	-	-	-	-	-
	2	55	50	48	47	47	48	47	47	47	47	-	-	-	-	-
	3	61	55	50	48	47	50	48	47	47	47	47	-	-	-	-
Oct	1	64	59	53	49	47	53	49	47	46	46	46	46	-	-	-
	2	65	62	58	52	48	58	52	48	46	45	45	45	45	-	-
	3	70	69	65	62	56	66	62	56	51	49	48	48	48	48	-
Nov	1	62	64	63	61	57	63	61	57	51	47	44	44	44	44	44
	2	56	61	62	62	59	62	62	59	56	50	46	43	43	43	43
	3	-	56	61	62	62	61	62	62	59	56	50	46	43	43	43
Dec	1	-	-	56	61	62	56	61	62	62	59	56	50	46	43	43
	2	-	-	-	58	63	-	58	63	64	63	61	57	51	47	44
	3	-	-	-	-	67	-	-	66	71	73	72	69	65	58	53
Jan	1	-	-	-	-	-	-	-	-	64	68	70	69	66	62	56
	2	-	-	-	-	-	-	-	-	-	67	72	74	73	70	66
	3	-	-	-	-	-	-	-	-	-	-	77	84	86	85	80
Feb	1	-	-	-	-	-	-	-	-	-	-	-	73	80	81	81
	2	-	-	-	-	-	-	-	-	-	-	-	-	76	82	84
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	62	67
Mar	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77

Table 52 EVAPOTRANSPIRATION OF PADDY BY TYPE OF IRRIGATION SCHEDULE (2/4)

Unit: mm

Month		C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	D7	D8
Feb	1	7	-	-	-	-	-	56	-	-	-	-	-	-	-
	2	7	7	-	-	-	-	58	58	-	-	-	-	-	-
	3	47	7	7	-	-	-	47	47	47	-	-	-	-	-
Mar	1	59	59	7	7	-	-	59	59	59	59	-	-	-	-
	2	60	59	59	7	7	-	60	59	59	59	59	-	-	-
	3	68	65	64	64	7	7	68	65	64	64	64	64	-	-
Apr	1	65	59	57	56	56	7	65	59	57	56	56	56	56	-
	2	70	64	58	56	55	55	70	64	58	56	55	55	55	55
	3	72	68	62	56	54	53	72	68	62	56	54	53	53	53
May	1	72	69	65	59	54	52	72	69	65	59	54	52	51	51
	2	71	70	67	63	57	52	71	70	67	63	57	52	50	49
	3	77	76	75	72	68	62	77	76	75	72	68	62	56	54
Jun	1	66	68	68	67	64	60	66	68	68	67	64	60	55	50
	2	60	65	67	66	65	63	60	65	67	66	65	63	59	53
	3	-	60	65	67	66	65	-	60	65	67	66	65	63	59
Jul	1	-	-	62	66	68	68	-	-	62	66	68	68	67	64
	2	-	-	-	62	66	68	-	-	-	62	66	68	68	67
	3	-	-	-	-	68	73	-	-	-	-	68	73	75	75
Aug	1	-	-	-	-	-	62	-	-	-	-	-	62	66	68
	2	-	-	-	-	-	-	-	-	-	-	-	-	62	66
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	68

Table 53 EVAPOTRANSPIRATION OF PADDY BY TYPE OF IRRIGATION SCHEDULE (3/4)

Unit: mm

Month		E1	E2	E3	E4	E5	E6	E7	F1	F2	F3	F4	G1	G2	G3	G4	G5
Feb	3	-	-	-	-	-	-	-	47	-	-	-	-	-	-	-	-
Mar	1	-	-	-	-	-	-	-	59	59	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	59	59	59	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	64	64	64	64	-	-	-	-	-
Apr	1	-	-	-	-	-	-	-	57	56	56	56	-	-	-	-	-
	2	55	-	-	-	-	-	-	58	56	55	55	55	-	-	-	-
	3	53	53	-	-	-	-	-	62	56	54	53	53	53	-	-	-
May	1	51	51	51	-	-	-	-	65	59	54	52	51	51	51	-	-
	2	49	49	49	49	-	-	-	67	63	57	52	49	49	49	49	-
	3	54	53	53	53	53	-	-	75	72	68	62	54	53	53	53	53
Jun	1	50	48	47	47	47	47	-	68	67	64	60	50	48	47	47	47
	2	53	49	47	46	46	46	46	67	66	65	63	53	49	47	46	46
	3	59	53	49	47	46	46	46	65	67	66	65	59	53	49	47	46
Jul	1	65	61	55	50	48	47	47	62	66	68	68	65	61	55	50	48
	2	68	65	61	55	50	48	47	-	62	66	68	68	65	61	55	50
	3	75	75	72	67	60	55	53	-	-	68	73	75	75	72	67	60
Aug	1	67	68	68	65	61	55	50	-	-	-	62	67	68	68	65	61
	2	62	67	68	68	65	61	55	-	-	-	-	62	67	68	68	65
	3	-	68	74	75	75	72	67	-	-	-	-	-	68	74	75	75
Sep	1	-	-	62	67	68	68	65	-	-	-	-	-	-	62	67	68
	2	-	-	-	62	67	68	68	-	-	-	-	-	-	-	62	67
	3	-	-	-	-	62	67	68	-	-	-	-	-	-	-	-	62
Oct	1	-	-	-	-	-	60	65	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	59	-	-	-	-	-	-	-	-	-

Table 54 EVAPOTRANSPIRATION OF PADDY BY TYPE OF IRRIGATION SCHEDULE (4/4)

Month	Main Season Paddy				Month	Off Season Paddy			
	H1	H2	H3	H4		J1	J2	J3	J4
Aug 1	-	-	-	-	Mar 1	59	-	-	-
2	47	-	-	-	2	59	59	-	-
3	52	52	-	-	3	64	64	64	-
Sep 1	47	47	47	-	Apr 1	57	56	56	56
2	48	47	47	47	2	58	56	55	55
3	50	48	47	47	3	62	56	54	53
Oct 1	53	49	47	46	May 1	65	59	54	52
2	58	52	48	46	2	67	63	57	52
3	66	62	56	51	3	75	72	68	62
Nov 1	63	61	57	51	Jun 1	68	67	64	60
2	62	62	59	56	2	67	66	65	63
3	61	62	62	59	3	65	67	66	65
Dec 1	56	61	62	62	Jul 1	62	66	68	68
2	-	58	63	64	2	-	62	66	68
3	-	-	66	71	3	-	-	68	73
Jan 1	-	-	-	63	Aug 1	-	-	-	62
2	-	-	-	-	2	-	-	-	-
3	-	-	-	-	3	-	-	-	-

Table 55 10-DAY FIELD IRRIGATION REQUIREMENT FOR THE MUDA IRRIGATION PROJECT IN 1982

Unit: lit/s/ha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation District I												
1.	0.52	0.22	0	0	0.06	0.71	0.55	0.50	0.45	0.40	0.29	0.61
2.	0.52	0.16	0	0	0.06	0.71	0.55	0.50	0.45	0.40	0.29	0.61
3.	0.52	0.11	0	0.01	0.07	0.71	0.55	0.50	0.45	0.40	0.29	0.61
Irrigation District II												
1.	0.76	0.41	0.03	0	0.55	0.64	0.47	0.46	0.39	0.34	0.33	0.57
2.	0.76	0.32	0	0.10	0.55	0.64	0.47	0.46	0.39	0.34	0.33	0.57
3.	0.76	0.22	0	0.10	0.70	0.64	0.47	0.46	0.39	0.34	0.33	0.57
Irrigation District III												
1.	0.69	0.32	0.05	0	0.36	0.64	0.43	0.41	0.45	0.32	0.30	0.60
2.	0.69	0.24	0	0.08	0.36	0.64	0.43	0.41	0.45	0.32	0.30	0.60
3.	0.69	0.18	0	0.08	0.51	0.64	0.43	0.41	0.45	0.32	0.30	0.60
Irrigation District IV												
1.	0.53	0.25	0.05	0	0.53	0.55	0.42	0.54	0.39	0.25	0.30	0.54
2.	0.53	0.19	0	0.28	0.53	0.55	0.42	0.54	0.39	0.25	0.30	0.54
3.	0.53	0.13	0	0.28	0.55	0.55	0.42	0.54	0.39	0.25	0.30	0.54

Table 56 10-DAY FIELD IRRIGATION REQUIREMENT FOR THE MUDA IRRIGATION SCHEME IN 1985

Unit: lit/s/ha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation District I												
1.	0	0	0.81	0.76	0.47	0.67	0.41	0.05	0.53	0.24	0.39	0.32
2.	0	0	1.11	0.65	0.47	0.65	0.24	0.17	0.34	0.24	0.46	0.07
3.	0	0.26	0.98	0.55	0.59	0.55	0.08	0.41	0.24	0.26	0.53	0
Irrigation District II												
1.	0	0	0.91	0.87	0.50	0.72	0.44	0.04	0.57	0.26	0.44	0.34
2.	0	0	1.10	0.72	0.51	0.70	0.27	0.19	0.39	0.26	0.50	0.10
3.	0	0.39	0.99	0.58	0.64	0.59	0.10	0.45	0.26	0.29	0.58	0
Irrigation District III												
1.	0	0	0.81	0.81	0.50	0.71	0.43	0.04	0.52	0.23	0.38	0.31
2.	0	0	1.15	0.67	0.48	0.67	0.25	0.16	0.35	0.23	0.45	0.08
3.	0	0.22	1.05	0.58	0.62	0.59	0.08	0.41	0.23	0.26	0.53	0
Irrigation District IV												
1.	0	0	0.92	0.79	0.47	0.68	0.39	0.04	0.51	0.22	0.36	0.34
2.	0	0	1.08	0.70	0.47	0.58	0.22	0.14	0.36	0.22	0.43	0.10
3.	0	0.35	0.91	0.55	0.61	0.54	0.08	0.35	0.22	0.24	0.50	0

Table 57 10-DAY FIELD IRRIGATION REQUIREMENT FOR THE MUDA IRRIGATION PROJECT IN 1990

Unit: lit/s/ha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation District I												
1.	0	0	0.85	0.80	0.49	0.70	0.43	0.05	0.55	0.25	0.41	0.33
2.	0	0	1.16	0.68	0.49	0.68	0.25	0.18	0.36	0.25	0.48	0.07
3.	0	0.27	1.03	0.58	0.62	0.58	0.08	0.43	0.25	0.27	0.55	0
Irrigation District II												
1.	0	0	0.85	0.81	0.47	0.67	0.41	0.04	0.53	0.24	0.41	0.32
2.	0	0	1.03	0.67	0.48	0.65	0.25	0.18	0.36	0.24	0.47	0.09
3.	0	0.36	0.92	0.54	0.60	0.55	0.09	0.42	0.24	0.27	0.54	0
Irrigation District III												
1.	0	0	0.77	0.77	0.47	0.67	0.41	0.04	0.49	0.22	0.36	0.29
2.	0	0	1.09	0.64	0.46	0.64	0.24	0.15	0.33	0.22	0.43	0.08
3.	0	0.21	1.00	0.55	0.59	0.56	0.08	0.39	0.22	0.25	0.50	0
Irrigation District IV												
1.	0	0	0.90	0.78	0.46	0.67	0.38	0.04	0.50	0.22	0.35	0.33
2.	0	0	1.06	0.69	0.46	0.57	0.22	0.14	0.35	0.22	0.42	0.10
3.	0	0.34	0.89	0.54	0.60	0.53	0.08	0.34	0.22	0.24	0.49	0

Table 58 10-DAY FIELD IRRIGATION REQUIREMENT FOR THE MUDA IRRIGATION PROJECT IN 2000

Unit: lit/s/ha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation District I												
1.	0	0	0.83	0.77	0.48	0.69	0.42	0.04	0.53	0.24	0.40	0.32
2.	0	0	1.13	0.66	0.47	0.66	0.24	0.17	0.35	0.24	0.46	0.07
3.	0	0.26	0.99	0.56	0.60	0.57	0.08	0.42	0.24	0.26	0.53	0
Irrigation District II												
1.	0	0	0.82	0.78	0.46	0.65	0.40	0.03	0.51	0.23	0.39	0.31
2.	0	0	1.00	0.65	0.46	0.63	0.24	0.17	0.35	0.23	0.46	0.08
3.	0	0.35	0.90	0.52	0.58	0.53	0.09	0.41	0.23	0.26	0.52	0
Irrigation District III												
1.	0	0	0.74	0.74	0.46	0.66	0.40	0.04	0.47	0.21	0.36	0.29
2.	0	0	1.06	0.62	0.45	0.63	0.23	0.15	0.32	0.21	0.42	0.08
3.	0	0.21	0.97	0.53	0.57	0.55	0.07	0.37	0.21	0.23	0.48	0
Irrigation District IV												
1.	0	0	0.87	0.76	0.45	0.64	0.36	0.04	0.48	0.21	0.34	0.32
2.	0	0	1.04	0.67	0.45	0.62	0.21	0.13	0.34	0.21	0.41	0.10
3.	0	0.34	0.86	0.53	0.58	0.51	0.08	0.33	0.21	0.23	0.48	0

Table 59 10-DAY FIELD IRRIGATION REQUIREMENT FOR MINOR IRRIGATION SCHEMES

Unit: lit/s/ha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall Zone 1												
1.	0	0	0	1.00	0.55	1.15	0.90	0	0.65	0.20	0.35	0.90
2.	0	0	1.30	0.75	0.75	1.15	0.70	0	0.65	0.20	0.35	0.90
3.	0	0	1.30	0.65	0.75	1.15	0.50	0	0.65	0.20	0.11	0.60
Rainfall Zone 2												
1.	0	0	0	0.85	0.30	1.20	0.90	0	0.65	0.15	0.45	0.90
2.	0	0	1.30	0.70	0.30	1.20	0.70	0	0.65	0.15	0.45	0.90
3.	0	0	1.30	0.55	0.95	1.00	0.50	0	0.65	0.15	1.10	0.65
Rainfall Zone 3												
1.	0	0	0	0.85	0.40	1.05	0.90	0	0.65	0.30	0.35	0.90
2.	0	0	1.30	0.75	0.40	1.05	0.65	0	0.65	0.30	0.35	0.90
3.	0	0	1.30	0.60	0.60	1.05	0.40	0	0.65	0.30	1.20	0.65
Rainfall Zone 4												
1.	0	0	0	0.85	0.40	1.00	0.70	0	0.65	0	0.40	1.00
2.	0	0	1.40	0.70	0.40	0.85	0.55	0	0.65	0	0.40	1.00
3.	0	0	1.40	0.65	0.65	0.85	0.40	0	0.65	0	1.00	0.65
Rainfall Zone 5												
1.	0	0	0	0.85	0.45	1.10	0.90	0	0.65	0.15	0.60	0.90
2.	0	0	1.30	0.75	0.45	1.00	0.70	0	0.65	0.20	0.50	0.90
3.	0	0	1.30	0.65	0.80	0.90	0.50	0	0.65	0.50	1.00	0.60
Rainfall Zone 6												
1.	0	0	0	0.75	0.60	0.90	0.75	0	0.65	0	0.30	0.85
2.	0	0	1.30	0.75	0.60	0.90	0.75	0	0.65	0	0.30	0.85
3.	0	0	1.30	0.80	0.60	0.90	0.60	0	0.65	0	0.30	0.50
Rainfall Zone 7												
1.	0	0	0	0.45	0.60	1.05	0.80	0	0.65	0	0.30	0.85
2.	0	0	1.10	0.45	0.50	0.85	0.70	0	0.65	0	0.40	0.85
3.	0	0	1.10	0.76	0.60	0.85	0.60	0	0.65	0	0.65	0.65
Rainfall Zone 8[1]												
1.	0	0	0	0.60	0.35	0.75	0.60	0	0.60	0	0.30	0.95
2.	0	0	1.30	0.75	0.50	0.75	0.60	0	0.60	0	0.30	0.95
3.	0	0	1.30	0.85	0.80	0.75	0.40	0	0.60	0	0.75	0.75
Rainfall Zone 9												
1.	0	0	0	1.00	0.50	1.05	0.90	0	0.70	0.35	0.30	0.95
2.	0	0	1.30	0.80	0.70	1.05	0.70	0	0.70	0.35	0.30	0.95
3.	0	0	1.30	0.70	0.90	0.90	0.40	0	0.65	0.35	0.75	0.75

Remarks; Excluding Sg. Muda, Sg. Kulim, Pinang Tunggal and Jerak schemes

Table 60 10-DAY FIELD IRRIGATION REQUIREMENT FOR SG. MUDA, SG. KULIM, PINANG TUNGGAL AND JARAK SCHEMES

Unit: lit/s/ha

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sg. Muda Scheme in 1982/1985												
1.	0.81	0.71	0.57	0.54	0.43	0.57	0.56	0.40	0.23	0.29	0.23	0.83
2.	0.81	0.71	0.57	0.54	0.43	0.57	0.56	0.40	0.23	0.29	0.23	0.83
3.	0.81	0.72	0.57	0.54	0.43	0.57	0.56	0.40	0.23	0.29	0.23	0.83
Sg. Kulim Scheme in 1982/1985												
1.	0.13	0	0.23	1.05	0.66	0.78	0.73	0.11	0.49	0.32	0.36	0.95
2.	0	0	0.70	0.87	0.60	0.82	0.57	0.11	0.65	0.06	0.60	0.78
3.	0	0	1.04	0.74	0.67	0.78	0.32	0.27	0.65	0.17	0.84	0.45
Pinang Tunggal and Jarak Schemes in 1982/1985												
1.	0	0	0.47	0.95	0.61	0.83	0.70	0	0.65	0	0.48	0.95
2.	0	0	0.93	0.79	0.60	0.81	0.43	0.22	0.65	0.11	0.71	0.61
3.	0	0	1.15	0.70	0.74	0.76	0.22	0.32	0.65	0.22	0.95	0.27
Sg. Muda and Sg. Kulim Scheme in 1990/2000												
1.	0.13	0	0.22	0.97	0.61	0.73	0.67	0.10	0.46	0.30	0.33	0.88
2.	0	0	0.65	0.81	0.56	0.76	0.53	0.11	0.60	0.05	0.56	0.73
3.	0	0	0.97	0.69	0.62	0.73	0.30	0.25	0.60	0.15	0.78	0.41
Pinang Tunggal and Jarak Schemes in 1990/2000												
1.	0	0	0.43	0.88	0.57	0.77	0.65	0	0.60	0	0.45	0.88
2.	0	0	0.87	0.74	0.55	0.75	0.40	0.20	0.60	0.10	0.67	0.57
3.	0	0	1.06	0.65	0.69	0.70	0.20	0.30	0.60	0.20	0.88	0.25

Table 61 IRRIGATION DIVERSION REQUIREMENT BY SCHEME (1/6)

Unit: 10^6 m^3

No. of Scheme	Name of Scheme	1982	1985	1990	2000
I.	Perlis State				
1	Sungai Siran	1.6	1.6	1.5	1.5
2	Taliair Pdg. Melangit	2.4	2.4	2.2	2.2
3	Taliair Kg. Belukar	0.6	0.6	0.6	0.6
4	Taliair Kbg. Badak	0.7	0.7	0.6	0.6
5	Taliair Batu Pahat	0.4	0.4	0.3	0.3
6	Sungai Santan/Daboi Darat/Alor Sena	9.5	9.5	8.9	25.2
7	Sungai Repoh	2.5	2.5	2.3	2.3
8	Taliair Pdg. Siding	2.7	2.7	2.5	7.2
9	Taliair Kuala Tunggang	1.3	1.3	1.2	3.6
10	Alur Melaka	2.9	2.9	2.7	7.8
11	Pdg. Telela	1.9	1.9	1.8	1.8
12	Titi Tinggi	0.7	0.7	0.7	0.7
13	Kampong Parit	1.5	1.5	1.4	1.4
14	Jalan Abi/Sg. Kurung Batang	1.0	1.0	0.9	0.9
15	Sungai Pelarit	4.1	4.1	3.8	7.6
16*	Ban Seberang Remei	-	-	-	-
17*	Ban Bukit Tok Poh	-	-	-	-
18*	Ban Wang Bintong	-	-	-	-
19*	Taliair Bukit Tau	-	-	-	-
20*	Alor Baroh	-	-	-	-
21*	Kok Kelong	-	-	-	-
22*	Keganaan Air Hujan	-	-	-	-
23	Kg. Masjid	0	0	0	0.6
24	Kemajuan Tanah Tasoh	0	0	0	0.5
25	Kg. Belukar Inum	0	0	0	0.5
26	Kg. Hutan Lemban	0	0	0	0.5
27	Kg. Rambai	0	0	0	0.8
28	Ban Seberang Remei	0	0	0	0.4
29	Kg. Paya Besar	0	0	0	10.6
30	Kg. Kechor Behor Ampiang	0	0	0	7.4
31	Tanah Pinggir Muda	0	0	0	13.4
Total for Item I		33.8	33.8	31.3	98.6
II.	Muda Irrigation Project				
	MADA District-I	285.7	293.7	307.2	297.2
	MADA District-II	581.3	558.9	521.4	503.7
	MADA District-III	342.6	332.4	315.4	301.3
	MADA District-IV	411.4	406.8	399.1	382.5
Total for Item II		1,621.1	1,591.8	1,543.0	1,484.7

Remarks; *: Control drainage scheme

Table 62 IRRIGATION DIVERSION REQUIREMENT BY SCHEME (2/6)

Unit: 10^6 m^3

No. of Scheme	Name of Scheme	1982	1985	1990	2000
III.	Kedah State				
1	Sidam Kanan	9.7	10.9	10.2	10.2
2	Sidam Kiri	4.7	6.2	5.5	5.5
3	Pulai	5.6	5.6	5.0	5.0
4	Pekula	37.5	39.2	36.4	36.4
5	Kg. Binjal	1.6	1.6	1.5	1.5
6	Bendang Raja Janing	2.2	2.2	2.0	2.0
7	Sg. Gelam	4.0	4.0	3.7	3.7
8	Kg. Iboi	4.3	4.3	3.9	3.9
9	Kg. Tawar	1.1	1.6	0.9	0.9
10	Simpang Empat	0.7	0.7	0.6	0.6
11	Ulu Bakai	1.5	1.5	1.3	1.3
12	Kg. Parit	4.5	4.5	4.0	4.0
13	Kg. Ulu/Kelang Batu	0.4	0	0.6	0.6
14	Sg. Seluang	0.6	0.6	0	0
15	Tanjung Sik	2.1	2.1	1.9	1.9
16*	Ban Merbok	-	-	-	-
17*	Kota Bukit Meriam	-	-	-	-
18	Kg. Badang	1.6	1.6	1.5	1.5
19	Jemerli	0.9	0	0	0
20	Otak Kerbau	1.6	0	0	0
21	Lemban Bata	5.4	5.4	5.0	7.6
22	Kg. Ruat	0.6	1.1	1.0	1.0
23	Singkir Darat/Sg. Pei	2.9	2.9	2.7	2.7
24	Kulim	2.5	2.5	2.3	2.3
25	Terat Batu	0.6	0.6	0.6	0.6
26	Kg. Luar	1.7	2.4	2.0	2.0
27	Selarong Panjang	0.3	0	0	0
28	Bakar Bata, Yan	1.0	1.7	1.6	1.6
29	Ulu Sedim (Siputeh)	1.3	1.6	1.5	1.5
30	Merbau Pulas	1.2	1.2	1.1	1.1
31	Pinang Tunggal	5.2	5.2	5.6	5.6
32	Paya Rawa (Region I)	2.5	4.9	4.5	4.5
33	Lemban Bata II	18.9	20.4	18.9	25.5
34	Kg. Landak	0.9	0.9	0.8	0.8
35	Sg. Mempelam	0.8	1.0	1.0	1.0
36	Pdg. Pusing/Bt. Murai (Region I)	4.6	4.6	4.3	7.9
37	Sg. Badong	1.8	1.8	1.7	1.7
38	Kota II	0	31.3	29.1	29.1
39	Bakong/Lubok Boi	0	10.4	9.6	9.6
40	Tanjung Pari	0	2.3	2.1	2.1

Remarks; *: Control drainage scheme

Table 63 IRRIGATION DIVERSION REQUIREMENT BY SCHEME (3/6)

Unit: 10^6 m^3

No. of Scheme	Name of Scheme	1982	1985	1990	2000
41	Sg. Tiak	0	2.2	2.0	2.3
42	Titi Karangan	0	2.7	2.5	2.5
43	Kg. Padang Meha/Pagar Museh	0	2.9	2.7	2.7
44	Tanjung Besar	0	4.0	3.6	3.6
45	Sg. Pering	0	8.0	7.4	7.4
46	Kurung Hitam	0	2.7	2.5	2.5
47	Carok Kejal	0	0.9	0.9	0.9
48	Padang Kerbau	0	12.4	11.5	11.5
49	Sg. Lampan/Rambai	0	5.2	4.8	4.8
50	Sg. Nawa/Gajah Mati	0	11.9	11.6	11.6
51	Kg. Pantai Perai/Kg. Serukam	0	5.6	5.2	5.2
52	Sg. Teloi	0	1.7	1.5	1.5
53	Padang Cicak	0	1.5	1.3	1.7
54	Che Kedo/Putat	0	7.5	7.0	7.0
55	Sg. Gelong	0	4.9	4.5	4.5
56	Guan Ginu	0	1.5	1.4	1.4
57	Kg. Banggol Berangan	0	0	1.6	1.6
58	Kg. Tembak	0	0	1.6	1.6
59	Lubok Kiab	0	0	1.2	1.2
60	Kg. Sg. Limau/Carok Bemban	0	0	1.6	1.6
61	Kg. Matang Durian	0	0	1.6	1.6
62	Kg. Selarong	0	0	1.9	1.9
63	Kg. Guar Cempedak/Kuala Badak	0	0	2.8	2.8
64	Kg. Lanjut	0	0	3.8	3.8
65	Kg. Kemumbong	0	0	1.1	1.1
66	Pantai Cicak	0	0	0.8	0.8
67	Sg. Perigi/Sg. Setar	0	0	1.0	1.0
68	Kg. Kubang Bemban	0	0	0.5	0.5
69	Kg. Kerasak	0	0	0.5	0.5
70	Kg. Nako	0	0	0.5	0.5
71	Kg. Tok Tanai	0	0	0.7	0.7
72	Kg. Pd. Pak Tam	0	0	0.8	0.8
73	Kg. S. Sari	0	0	0.6	0.6
74	Kg. Padang	0	0	0.6	0.6
75	Kg. Pdg. Serai	0	0	0.8	0.8
76	Kg. Bakar Arang	0	0	1.7	1.7
77	Kg. Menerong	0	0	1.3	1.3
78	Kg. Cf Setul	0	0	0.5	0.5
79	Kg. Langsat	0	0	0.8	0.8
80	Kg. Lubok Ipoh	0	0	0.3	0.3
81	Kg. Pdg. Halban	0	0	0.5	0.5
82	Kg. Belantek	0	0	0.7	0.7
83	Kg. Surau	0	0	0.5	0.5
84	Kg. Paya	0	0	0.6	0.6
85	Kg. Banggul	0	0	0.6	0.6
86	Kg. T. Belit	0	0	1.1	1.1

Table 64 IRRIGATION DIVERSION REQUIREMENT
BY SCHEME (4/6)

Unit: 10^6 m^3

No. of Scheme	Name of Scheme	1982	1985	1990	2000
87	Kg. Namek	0	0	2.3	2.3
88	Sg. Cajad	0	0	0.5	0.5
89	Kg. Kaki Bukit	0	0	1.0	1.0
90	Kg. Baubak	0	0	1.0	1.0
91	Kg. Terabak	0	0	0.7	0.7
92	Sg. Tebing Tinggi	0	0	0.6	0.6
93	Kg. Lahar	0	0	2.4	2.4
94	Kg. Pdg. Geh	0	0	1.3	1.3
95	Landang Wrong Jee	0	0	1.0	1.0
96	Kg. Paya Serdang	0	0	1.3	1.3
97	Kg. Sira	0	0	0.5	0.5
98	Sg. Kesai	0	0	0	0.3
99	Kg. Lubok Merbau	0	0	0	0.3
100	Kg. Nam Rok	0	0	0	0.3
101	Bt. Batu Bertangga	0	0	0	0.5
102	Kg. Pdg. Tok. Bakong	0	0	0	0.4
103	Belukar Luas	0	0	0	0.3
104	Kg. Pakra	0	0	0	0.5
105	Kg. Pdg. Hassan	0	0	0	0.3
106	Kg. Seberang	0	0	0	1.2
107	Sg. Kik	0	0	0	0.6
108	Sg. Iboi	0	0	0	2.0
109	Kg. Banggul Setia	0	0	0	1.1
110	Kg. Raja	0	0	0	1.5
111	Kg. Berdang	0	0	0	0.3
112	Kg. Tengah	0	0	0	0.8
113	Kg. Nai Teh	0	0	0	0.6
114	Kg. Bt. Hijau	0	0	0	0.7
115	Kubor	0	0	0	0.3
116	Kg. Baharu	0	0	0	0.5
117	Kg. Whatt Luar	0	0	0	0.4
118	Kg. Whatt Tong Perok	0	0	0	0.6
119	Kg. Bendang Lanjut	0	0	0	0.3
120	Kg. Bt. Payong	0	0	0	0.4
121	Kg. Pdg. Tok Sedau	0	0	0	0.5
122	Kg. Panjong	0	0	0	1.1
123	Kg. S. Jagong	0	0	0	1.2
124	Kg. Bendang Raja	0	0	0	0.9
125	Kg. Kayu Bangun	0	0	0	0.5
126	Kg. Pinag	0	0	0	1.3
127	Kg. Tanjong	0	0	0	2.3
128	Padang Terap	0	0	0	0.8
129	Kg. Kubang Aring	0	0	0	0.4
130	Kg. S. Buloh	0	0	0	0.3
131	Sg. Mati	0	0	0	0.5
132	Kg. Pdg. Panjang	0	0	0	0.6

Table 65 IRRIGATION DIVERSION REQUIREMENT
BY SCHEME (5/6)

Unit: 10^6 m^3

No. of Scheme	Name of Scheme	1982	1985	1990	2000
133	Kg. Jeragan	0	0	0	2.4
134	Kg. Kubang Chenok	0	0	0	0.5
135	Kg. Rumput Minyak	0	0	0	0.5
136	Kg. Seberang Paya	0	0	0	0.4
137	Kg. Lubok Ular	0	0	0	0.8
138	Kg. Tok Kau	0	0	0	0.4
139	Kg. Banggul Batu	0	0	0	0.6
140	Kg. Landai	0	0	0	0.5
141	Kg. Banggul Berangan	0	0	0	0.5
142	Kg. S. Batang	0	0	0	0.6
143	Kg. Betong	0	0	0	0.5
144	Kg. Bt. Hangus	0	0	0	0.6
145	Sg. Begia	0	0	0	0.4
146	Kg. Charok Gnong	0	0	0	1.2
147	Kg. Lubok Besar	0	0	0	1.0
148	Kg. Tupai	0	0	0	0.8
149	Kg. Melayu Paya Terendam	0	0	0	1.6
150	Kg. Hujong Bandar Sek	0	0	0	1.0
151	Bt. Selambau	0	0	0	0.5
152	Kg. Charok	0	0	0	0.7
153	Kg. Charok Kelian Salang	0	0	0	0.4
154	Kg. Gua Tinggi	0	0	0	0.4
155	Kg. Ketengga	0	0	0	0.4
156	Kg. Bt. Ketil	0	0	0	0.6
157	Kg. Lubok	0	0	0	1.2
158	Charok Puteh	0	0	0	0.5
159	Kg. Charok Bunting	0	0	0	0.4
160	Kg. Dusun Gani	0	0	0	0.6
161	Kg. Baharu	0	0	0	1.2
162	Kg. Charok Ketil	0	0	0	2.1
163	Kg. Assam Jawa	0	0	0	0.9
164	Kg. Telok Teduri	0	0	0	0.4
165	K. Charok Bemban	0	0	0	0.4
166	Kg. Kumbang Panjang	0	0	0	0.5
167	Kg. Tok Dollah	0	0	0	0.5
168	Kg. Rambong	0	0	0	0.3
169	Kg. Charok Pendiat	0	0	0	0.5
170	Kg. Kangar	0	0	0	1.0
171	Kg. Pak Bong	0	0	0	0.6
172	Kg. Setang	0	0	0	0.5
173	Kg. Ketumbar	0	0	0	1.0
174	Kg. Besah	0	0	0	0.3
175	Kg. Paya Besah	0	0	0	0.5
176	Kg. Terona	0	0	0	1.0
177	Kg. Ulu Sedim	0	0	0	0.9
178	Kg. Ulu Badang	0	0	0	0.7

Table 66 IRRIGATION DIVERSION REQUIREMENT BY SCHEME (6/6)

Unit: 10^6 m^3

No. of Scheme	Name of Scheme	1982	1985	1990	2000
179	Kg. Pdg. Belon	0	0	0	1.3
180	Kg. Merbok Bagan Sena	0	0	0	0.9
181	Kg. Turus Gading	0	0	0	0.6
182	Sg. Kejai	0	0	0	1.0
183	Kg. S. Bakong	0	0	0	0.8
184	Kg. Jeneri	0	0	0	0.5
185	Kg. Pdg. Kawan	0	0	0	0.5
186	Kg. Masjid Baharu	0	0	0	1.2
187	Kg. S. Pasir	0	0	0	0.3
188	Kg. Peng Lebai Man	0	0	0	0.6
189	Kg. Selarong	0	0	0	1.0
190	Kg. Kebun Tembakau	0	0	0	0.9
191	Ladang Ambika	0	0	0	0.6
192	Kg. Keladi	0	0	0	2.0
193	Ladang Lim Boon Chye	0	0	0	0.4
194	Kg. Ayer Puteh	0	0	0	0.7
195	Kg. Relau	0	0	0	0.5
Total for Item III		136.8	263.4	289.5	374.8
IV. P.	Pinang State				
1	Sungai Muda	164.6	164.6	141.6	141.6
2	Pinang Tunggal	32.8	32.8	29.8	29.8
3	Sungai Jarak	17.3	17.3	15.7	15.7
4	Tasek Glugor	4.7	4.7	5.2	5.2
5	Jarak Tengah	2.3	2.3	2.0	2.0
6	Sungai Kulim	80.5	80.5	68.7	68.7
7	Manchang Bubok	2.9	2.9	2.7	2.7
8	Julu	4.1	4.1	3.8	3.8
9	Sungai Renjau	0.4	0.4	0.4	0.4
10	Kuala Tasek	0.4	0.4	0.5	0.5
11	Tasek Junjong	4.2	4.2	3.3	3.3
12	Kg. Kepala Gajan	0	0	1.3	1.3
13	Sungai Pinang	5.7	5.7	5.4	5.4
14	Sungai Burong	8.3	8.3	7.8	7.8
Total for Item IV		328.2	328.2	288.1	288.1
Grand Total (I to IV)		2,119.9	2,217.1	2,152.0	2,246.1

Table 67 IRRIGATION DIVERSION REQUIREMENT BY RIVER BASIN (1/4)

Unit: 10^6 m^3

River System	River Basin	1982	1985	1990	2000
Perlis	Main Stream	11.7	11.7	10.8	49.3
	Tributary				
	Sg. Tasoh	0.7	0.7	0.7	1.8
	Sg. Timah	2.0	2.0	1.9	1.9
	Sg. Jejawi	2.5	2.5	2.3	2.3
	Sg. Kechor	6.2	6.2	5.7	5.7
	Sg. Temenggong	0.4	0.4	0.3	0.5
	Sub-total	11.8	11.8	10.9	12.2
	Other River				
	Sg. Gial	1.5	1.5	1.4	2.4
	Sg. Arau	6.9	6.9	6.4	19.4
	Sg. Perlis (I)	1.9	1.9	1.8	1.8
	Sub-total	10.3	10.3	9.6	23.6
Total for Perlis River System		33.8	33.8	31.3	85.1

Table 68 IRRIGATION DIVERSION REQUIREMENT BY RIVER BASIN (2/4)

Unit: $10^6 \cdot m^3$

River System	River Basin	1982	1985	1990	2000
Kedah	MADA Area	1,621.1	1,591.8	1,543.0	1,484.7
	Main Stream	6.1	58.9	61.4	84.9
	Sub-total	1,627.2	1,650.7	1,604.4	1,569.6
	Tributary				
	Sg. Kesai	0	0	0	0.3
	Sg. Tok Khamis	0	0	0	0.3
	Sg. Tekai	0	0	1.0	3.0
	Sg. Jelutang	0	0	0.5	0.5
	Sg. Bdg. Terap	0	0	2.1	8.8
	Sg. Janing	2.2	2.2	2.0	2.3
	Sg. Kejai	0	0.9	0.9	0.9
	Sg. Perik	0	2.6	2.5	3.3
	Sg. Alor Yai	0	0	0	0.6
	Sg. Temas	0	0	0	0.7
	Sg. Pendang	1.0	11.4	13.7	20.4
	Sub-total	3.2	17.1	22.7	41.1
	Other River				
	Sg. Perlis (II)	0	0.7	0.7	1.2
	Sg. Berida	1.0	1.3	1.6	1.6
	Sg. Temin	25.9	27.4	27.5	40.8
	Sub-total	26.9	29.4	29.8	43.6
Total for Kedah River System		1,657.3	1,697.2	1,656.9	1,654.3

Table 69 IRRIGATION DIVERSION REQUIREMENT BY RIVER BASIN (3/4)

Unit: 10^6 m^3

River System	River Basin	1982	1985	1990	2000
Muda	Main Stream	357.6	400.3	357.8	359.2
	Tributary				
	Sg. Sok	0	0	1.3	2.9
	Sg. Beris	0	0	0.6	1.2
	Sg. Kerik	0	0	0	0.5
	Sg. Jemeri	4.5	4.5	4.6	5.2
	Sg. Begia	0	0	0	0.5
	Sg. Chepil	2.1	7.8	10.4	15.9
	Sg. Cajad	0	0	0.5	1.0
	Sg. Tembak	0	0	4.4	5.9
	Sg. Ketil	14.3	19.4	25.8	40.4
	Sg. Sedim	7.7	13.1	16.7	24.1
	Sub-total	28.6	44.8	64.3	97.6
	Other River				
	Sg. Ruai	0.7	1.1	1.0	1.0
	Sg. Singkir	2.9	2.9	2.7	2.7
	Merbok River	5.7	5.7	6.3	8.4
	Sub-total	9.3	9.7	10.0	12.1
Total for Muda River System		395.5	454.8	432.1	468.9

Table 70 IRRIGATION DIVERSION REQUIREMENT BY RIVER BASIN (4/4)

Unit: 10^6 m^3

River System	River Basin	1982	1985	1990	2000
Perai	Sg. Jawi	0.4	0.6	0.6	1.1
	Sg. Jarak	4.4	2.2	3.2	5.6
	Sg. Kulim	2.5	2.5	2.8	4.8
	Sg. Junjong (I)	4.1	4.1	3.8	3.8
	Sg. Junjong (II)	7.9	7.9	8.2	9.4
Total for Perai River System		19.3	17.3	18.6	24.7
P. Pinang		14.0	14.0	13.1	13.1
Total		2,119.9	2,217.1	2,152.0	2,246.1

Table 71 SUMMARY OF IRRIGATION DIVERSION REQUIREMENT BY RIVER SYSTEM BY STATE

Unit: 10^6 m^3

State	River System		1982	1985	1990	2000
Perlis	Perlis:	Main Stream	12	12	11	49
		Tributary	12	12	11	12
		Sub-total	24	24	22	61
	Other Rivers		10	10	10	24
	Kedah (MADA Canal)		0	0	0	13
	Total		34	34	32	98
Kedah	Kedah:	Main Stream				
		MADA	1,621	1,592	1,543	1,485
		MADA Canal	6	59	60	66
		Minor	0	0	1	6
		Sub-total	1,627	1,561	1,604	1,557
		Tributary	3	17	23	41
		Sub-total	1,630	1,668	1,627	1,598
	Muda:	Main Stream	58	100	97	98
		Tributary	29	45	64	98
		Sub-total	87	145	161	196
	Perai		5	3	4	11
	Other Rivers		36	39	40	55
	Total		1,758	1,855	1,832	1,860
P. Pinang	Muda		300	300	261	261
	Perai		14	14	14	14
	P. Pinang		14	14	13	13
	Total		328	328	288	288
Grand Total			2,120	2,217	2,152	2,246

Table 72 TYPICAL CONSTRUCTION COST FOR MINOR IRRIGATION SCHEMES IN 1982

	Pantai Perai	Sungai Tiak	Guar Ginu
Type of Scheme	Pumping	Gravity	CHO
Irrigation Area (ha)	259	109	63
Construction Cost ($M\$10^3$)			
1) Direct Construction Cost			
Intake facilities	575	242	20
Canal facilities	1,390	526	400
Others	45	37	35
Sub-total	2,010	805	455
2) Land Acquisition	240	45	45
3) Physical Contingency	675	255	150
Total	2,925	1,105	650

Remarks; CHO: Control head offtake

Table 73 ASSUMED CONSTRUCTION COST PER HA FOR MINOR IRRIGATION SCHEMES IN 1982

Unit: M$/ha

	Gravity & Pumping	Control Head Offtake
Direct Construction Cost		
Intake facilities	2,300	400
Canal facilities	5,500	5,500
Others	400	400
Sub-total	8,200	6,300
Land Acquisition	600	600
Physical Contingency*	2,700	2,100
Total	11,500	9,000

Remarks; *: Physical contingency is assumed to be 30% of direct construction cost and land acquisition.

Table 74 CONSTRUCTION COST FOR IRRIGATION DEVELOPMENT (1/5)

Unit: M$10^3

Scheme No.	Scheme Name	Type of Scheme	4MP	5MP	6MP	7MP
I.	Perlis					
23	Kg. Masjid		-	-	276	0
24	Kemajuan Tanah Tasoh		-	-	-	322
25	Kg. Belukar Inum		-	-	368	0
26	Kg. Hutan Lembah		-	-	-	322
27	Kg. Rambai		-	-	380	0
28	Ban Seberang Remei		-	-	-	276
29	Kg. Paya Besar		-	-	5,037	-
30	Kg. Kechor Behor Ampiang		-	-	2,346	1,173
31	Tanah Pinggir Muda	P	-	-	-	6,325
	Total for Perlis		0	0	8,407	8,418
II.	Kedah					
1	Sidam Kanan	P	572*	0	0	0
2	Sidam Kiri	P	741*	0	0	0
4	Pekula	P	220*	0	0	0
13	Kg. Ulu/Kelang Batu	G	326*	0	0	0
22	Kg. Ruat	G	145*	0	0	0
26	Kg. Luar	G	1,355*	0	0	0
28	Bakar Bata, Yan	G	119*	0	0	0
29	Ulu Sedim (Siputeh)	G	808*	0	0	0
31	Pinang Tunggal	P	0	437	0	0
32	Paya Rawa (Region I)	P+CHO	1,498*	0	0	0
33	Lemban Bata II	G+P	1,801**	0	0	0
35	Sg. Mempelam	G	280**	0	0	0
38	Kota II	P	8,900**	0	0	0
39	Bakong/Lubok Boi	CHO	1,800**	0	0	0
40	Tanjung Pari	G	600**	0	0	0
41	Sg. Tiak	G	850**	0	0	0
42	Titi Karangan	G	1,750**	0	0	0
43	Kg. Padang Meha/ Pagar Museh	G	1,050**	0	0	0
44	Tanjung Besar	P	1,200**	0	0	0
45	Sg. Pering	G+P	3,850**	0	0	0
46	Kurung Hitam	G+P	600**	0	0	0
47	Carok Kejal	G	580**	0	0	0
48	Padang Kerbau	G+P+CHO	7,500**	0	0	0
49	Sg. Lampan/Rambai	CHO	1,430**	0	0	0
50	Sg. Nawa/Gajah Mati	G+CHO	3,000**	0	0	0
51	Kg. Pantai Perai/ Kg. Serukam	P	2,250**	0	0	0
52	Sg. Teloi	G+P	800**	0	0	0
53	Padang Cicak	G+P	750**	0	0	0
54	Che Kedo/Putat	P	2,500**	0	0	0
55	Sg. Gelong	P	2,100**	0	0	0

Remarks; *: Ref. 3 **: Information from DID

Table 75 CONSTRUCTION COST FOR IRRIGATION DEVELOPMENT (2/5)

Unit: M$10^3

Scheme No.	Scheme Name	Type of Scheme	4MP	5MP	6MP	7MP
56	Guan Ginu	CHO	500**	0	0	0
57	Kg. Banggol Berangan	P	-	650**	0	0
58	Kg. Tembak	G	-	1,000**	0	0
59	Lubok Kiab	P	-	500**	0	0
60	Kg. Sg. Limau/Carok Bemban	P	-	650**	0	0
61	Kg. Matang Durian	P	-	600**	0	0
62	Kg. Selarong	G	-	700**	0	0
63	Kg. Guar Cempedak/Kuala Badak	G	-	1,100**	0	0
64	Kg. Lanjut	CHO	-	1,600**	0	0
65	Kg. Kemumbong	P	-	500**	0	0
66	Pantai Cicak	P	-	350**	0	0
67	Sg. Perigi/Sg. Setar	P	-	250**	0	0
68	Kg. Kubang Bemban		-	368	0	0
69	Kg. Kerasak		-	230	0	0
70	Kg. Nako		-	345	0	0
71	Kg. Tok Tanai		-	322	0	0
72	Kg. Pd. Pak Tam		-	414	0	0
73	Kg. S. Sari		-	276	0	0
74	Kg. Padang		-	460	0	0
75	Kg. Pdg. Serai		-	598	0	0
76	Kg. Bakar Arang		-	909	0	0
77	Kg. Menerong		-	644	0	0
78	Kg. Cf Setul		-	230	0	0
79	Kg. Langsat		-	460	0	0
80	Kg. Lubok Ipoh		-	230	0	0
81	Kg. Pdg. Halban		-	230	0	0
82	Kg. Belantek		-	403	0	0
83	Kg. Surau		-	299	0	0
84	Kg. Paya		-	345	0	0
85	Kg. Banggul		-	311	0	0
86	Kg. T. Belit		-	633	0	0
87	Kg. Namek		-	1,265	0	0
88	Sg. Cajad		-	460	0	0
89	Kg. Kaki Bukit		-	805	0	0
90	Kg. Baubak		-	529	0	0
91	Kg. Terabak		-	391	0	0
92	Sg. Tebing Tinggi		-	322	0	0
93	Kg. Lahar		-	1,334	0	0
94	Kg. Pdg. Geh		-	725	0	0
95	Landang Wrong Jee		-	460	0	0
96	Kg. Paya Serdang		-	725	0	0
97	Kg. Sira		-	311	0	0
98	Sg. Kesai		-	-	230	0
99	Kg. Lubok Merbau		-	-	-	230
100	Kg. Nam Rok		-	-	230	0

Remarks; **: Information from DID

Table 76 CONSTRUCTION COST FOR IRRIGATION DEVELOPMENT (3/5)

Unit: M$10^3

Scheme No.	Scheme Name	Type of Scheme	4MP	5MP	6MP	7MP
101	Bt. Batu Bertangga		-	-	242	0
102	Kg. Pdg. Tok Bakong		-	-	-	345
103	Belukar Luas		-	-	-	230
104	Kg. Pakra		-	-	-	230
105	Kg. Pdg. Hassan		-	-	230	0
106	Kg. Seberang		-	-	575	0
107	Sg. Kik		-	-	414	0
108	Sg. Iboi		-	-	989	0
109	Kg. Banggul Setia		-	-	-	552
110	Kg. Raja		-	-	-	736
111	Kg. Berdang		-	-	-	230
112	Kg. Tengah		-	-	506	0
113	Kg. Nai Teh		-	-	460	0
114	Kg. Bt. Hijau		-	-	-	529
115	Kubor		-	-	230	0
116	Kg. Baharu		-	-	-	391
117	Kg. Whatt Luar		-	-	322	0
118	Kg. Whatt Tong Perok		-	-	437	0
119	Kg. Bendang Lanjut		-	-	230	0
120	Kg. Bt. Payong		-	-	-	299
121	Kg. Pdg. Tok Sedau		-	-	-	276
122	Kg. Panjong		-	-	-	575
123	Kg. S. Jagong		-	-	-	920
124	Kg. Bendang Raja		-	-	690	0
125	Kg. Kayu Bangun		-	-	-	414
126	Kg. Pinag		-	-	-	621
127	Kg. Tanjong		-	-	1,104	0
128	Padang Terap		-	-	-	414
129	Kg. Kubang Aring		-	-	230	0
130	Kg. S. Buloh		-	-	230	0
131	Sg. Mati		-	-	345	0
132	Kg. Pdg. Panjang		-	-	-	414
133	Kg. Jeragan		-	-	-	1,196
134	Kg. Kubang Chenok		-	-	368	0
135	Kg. Rumput Minyak		-	-	180	0
136	Kg. Seberang Paya		-	-	-	180
137	Kg. Lubok Ular		-	-	342	0
138	Kg. Tok Kau		-	-	-	180
139	Kg. Banggul Batu		-	-	357	0
140	Kg. Landai		-	-	-	276
141	Kg. Banggul Berangan		-	-	414	0
142	Kg. S. Batang		-	-	506	0
143	Kg. Betong		-	-	-	276
144	Kg. Bt. Hangus		-	-	-	403
145	Sg. Begia		-	-	-	276
146	Kg. Charok Gnong		-	-	644	0

Table 77 CONSTRUCTION COST FOR IRRIGATION DEVELOPMENT (4/5)

Unit: M$10^3

Scheme No.	Scheme Name	Type of Scheme	4MP	5MP	6MP	7MP
147	Kg. Lubok Besar		-	-	805	0
148	Kg. Tupai		-	-	-	690
149	Kg. Melayu Paya Terendam		-	-	1,208	0
150	Kg. Hujong Bandar Sek		-	-	-	828
151	Bt. Selambau		-	-	-	414
152	Kg. Charok		-	-	552	0
153	Kg. Charok Kelian Salang		-	-	-	345
154	Kg. Gua Tinggi		-	-	-	230
155	Kg. Ketengga		-	-	-	230
156	Kg. Bt. Ketil		-	-	-	345
157	Kg. Lubok		-	-	-	667
158	Charok Puteh		-	-	598	0
159	Kg. Charok Bunting		-	-	-	230
160	Kg. Dusun Gani		-	-	483	0
161	Kg. Baharu		-	-	-	644
162	Kg. Charok Kechil		-	-	1,748	0
163	Kg. Assam Jawa		-	-	-	782
164	Kg. Telok Teduri		-	-	-	322
165	K. Charok Bemban		-	-	322	0
166	Kg. Kumbang Panjang		-	-	-	460
167	Kg. Tok Dollah		-	-	414	0
168	Kg. Rambong		-	-	230	0
169	Kg. Charok Pendiat		-	-	-	299
170	Kg. Kangar		-	-	-	552
171	Kg. Pak Bong		-	-	345	0
172	Kg. Setang		-	-	-	437
173	Kg. Ketumbar		-	-	805	0
174	Kg. Besah		-	-	-	276
175	Kg. Paya Besah		-	-	-	414
176	Kg. Terona		-	-	552	0
177	Kg. Ulu Sedim		-	-	529	0
178	Kg. Ulu Badang		-	-	575	0
179	Kg. Pdg. Belon		-	-	748	0
180	Kg. Merbok Bagan Sena		-	-	782	0
181	Kg. Turus Gading		-	-	-	345
182	Sg. Kejai		-	-	-	644
183	Kg. S. Bakong		-	-	-	460
184	Kg. Jeneri		-	-	-	265
185	Kg. Pdg. Kawan		-	-	-	276
186	Kg. Masjid Baharu		-	-	748	0
187	Kg. S. Pasir		-	-	-	253
188	Kg. Peng Lebai Man		-	-	-	506
189	Kg. Selarong		-	-	552	0
190	Kg. Kebun Tembakau		-	-	-	495
191	Ladang Ambika		-	-	345	0

Table 78 CONSTRUCTION COST FOR IRRIGATION DEVELOPMENT (5/5)

Unit: M$10^3

Scheme No.	Scheme Name	Type of Scheme	4MP	5MP	6MP	7MP
192	Kg. Keladi		-	-	-	1,150
193	Ladang Lim Boon Chye		-	-	-	230
194	Kg. Ayer Puteh		-	-	403	0
195	Kg. Relau		-	-	-	299
	Total for Kedah		49,875	23,371	23,249	23,281
III.	Pulau Pinang					
4	Tasek Glugor	P	0	472	0	0
10	Kuala Tasek	P	0	69	0	0
12	Kg. Kepala Gajan	G	0	759	0	0
	Total for Pulau Pinang		0	1,300	0	0
	Grand Total		49,875	24,671	31,656	31,699

Table 79 SUMMARY OF INVESTMENT COSTS

Unit: M$10^6

	4MP	5MP	6MP	7MP
Minor Schemes				
Perlis	0	0	8.4	8.4
Kedah	49.9	23.4	23.3	23.3
P. Pinang	0	1.3	0	0
Sub-total	49.9	24.7	31.7	31.7
MADA	128.7	171.0	268.9	268.9
Total	178.6	195.7	300.6	300.6

Table 80 OPERATION AND MAINTENANCE COST IN KEDAH IN 1982

Scheme No.	Scheme Name	Type of Scheme	Irrigation Area (ha)	O&M Cost Total (M$10^3)	O&M Cost Unit Cost (M$/ha)
1	Sidam Kanan	P	453	110	243
2	Sidam Kiri	P	202	60	297
3	Pulai	P	239	51	213
4	Pekula	P	1,780	310	174
6	Bendang Raja Janing	G	137	5	36
7	Sg. Gelam	G	154	24	156
8	Kg. Iboi	G	186	13	70
9	Kg. Tawar	G	45	21	467
10	Simpang Empat	G	28	8	286
11	Ulu Bakai	G	75	11	147
12	Kg. Parit	G	192	30	156
13	Kg. Ulu/Kelang Batu	G	24	4	167
14	Sg. Seluang	G	28	2	71
15	Tanjung Sik	G	91	25	275
16	Ban Merbok	C/D	1,530	137	90
17	Kota Bukit Meriam	C/D	1,453	112	77
18	Kg. Badang	G	75	8	107
19	Jemerli	G	121	5	41
20	Otak Kerbau	G	197	25	127
21	Lembah Bata	G	324	60	185
22	Kg. Ruat	G	25	3	120
23	Singkir Darat/Sg. Pei	G	291	13	45
24	Kulim	G	155	35	225
25	Terat Batu	P	28	27	964
26	Kg. Luar	G	97	9	93
27	Selarong Panjang	G	41	1	24
29	Ulu Sedim (Siputeh)	G	79	20	253
30	Merbau Pulas	P	95	40	421
31	Pinang Tunggal	P	241	58	241
34	Kg. Landak	P	40	29	725
35	Sg. Mempelam	G	36	6	167

Table 81 OPERATION AND MAINTENANCE COST IN PULAU PINANG IN 1982

Scheme No.	Scheme Name	Type of Scheme	Irrigation Area (ha)	O&M Cost Total (M$10^3)	O&M Cost Unit Cost (M$/ha)
1	Sungai Muda	P	7,115	1,210	170
2	Pinang Tunggal	P	1,496	428	286
3	Sungai Jarak	P+G	789	158	200
4	Tasek Glugor	P	221	76	344
5	Jarak Tengah	P	105	26	247
6	Sungai Kulim	G	3,663	920	251
7	Manchang Bubok	G	136	37	272
8	Julu	P	244	72	295
9	Sungai Renjau	G	20	7	350
10	Kuala Tasek	P	18	18	1,000
13	Sungai Pinang	G	601	68	113
14	Sungai Burong	G	525	92	175

Table 82 CLASSIFICATION OF MANPOWER

Grade	Category
A	Engineer, Superscale F Engineer, Superscale G Engineer, Senior Timescale Engineer, Timescale Quantity Surveyor
B	Technical Assistant, Special Grade Technical Assistant, Timescale
C	Special Grade Technician Timescale Technician Draftsman Grade I Draftsman Grade II
D	Stenographer Clerk Storekeeper
E	Typist Junior Clerk Junior Storekeeper Office Boy Drivers I.M.G.

Table 83 EXISTING MANPOWER IN MADA AND STATE DID

Unit: Persons

State/MADA	Grade A	Grade B	Grade C	Grade D	Date of Information
State DID					
Perlis	1	4	17	259	1982
Kedah	13	13	56	348	1982
P. Pinang	4	10	47	678	1982
Sub-total	18	27	120	1,269	
MADA	22	12	83	1,075	1982
(Water management)	(8)	(4)	(36)	(415)	
Total	40	39	203	2,344	

Table 84 ASSUMED CALCULATION STANDARD FOR MANPOWER REQUIREMENT FOR MINOR IRRIGATION SCHEMES

Unit: person/10^3/ha

Grade		Construction	O&M
A	Engineer	0.5	0.5
B	Technical Assistant	1	1
C	Technician	4	5
D	Others	8	50

Table 85 ESTIMATED MANPOWER REQUIREMENT FOR IRRIGATION DEVELOPMENT IN THE STATE OF PERLIS

Unit: Persons

Category	4MP	5MP	6MP	7MP
Construction				
Engineer	0	0	1	1
Technical Assistant	0	0	1	1
Technician	0	0	3	3
Others	0	0	6	6
Total Staff	0	0	11	11
O&M				
Engineer	0	0	0	1
Technical Assistant	0	0	0	1
Technician	0	0	0	4
Others	0	0	0	37
Total Staff	0	0	0	43
Construction and O&M				
Engineering	0	0	1	2
Technical Assistant	0	0	1	2
Technician	0	0	3	7
Others	0	0	6	43
Total Staff	0	0	11	54

Table 86 ESTIMATED MANPOWER REQUIREMENT FOR IRRIGATION DEVELOPMENT IN THE STATE OF KEDAH

Unit: Persons

Category	4MP	5MP	6MP	7MP
Construction				
Engineer	1	1	1	1
Technical Assistant	2	2	2	2
Technician	7	9	8	8
Others	15	18	16	16
Total Staff	25	30	27	27
O&M				
Engineer	0	2	3	5
Technical Assistant	0	5	7	9
Technician	0	23	35	45
Others	0	230	346	447
Total Staff	0	260	391	506
Construction and O&M				
Engineering	1	3	4	6
Technical Assistant	2	7	9	11
Technician	7	32	43	53
Others	15	248	362	463
Total Staff	25	290	418	533

FIGURES

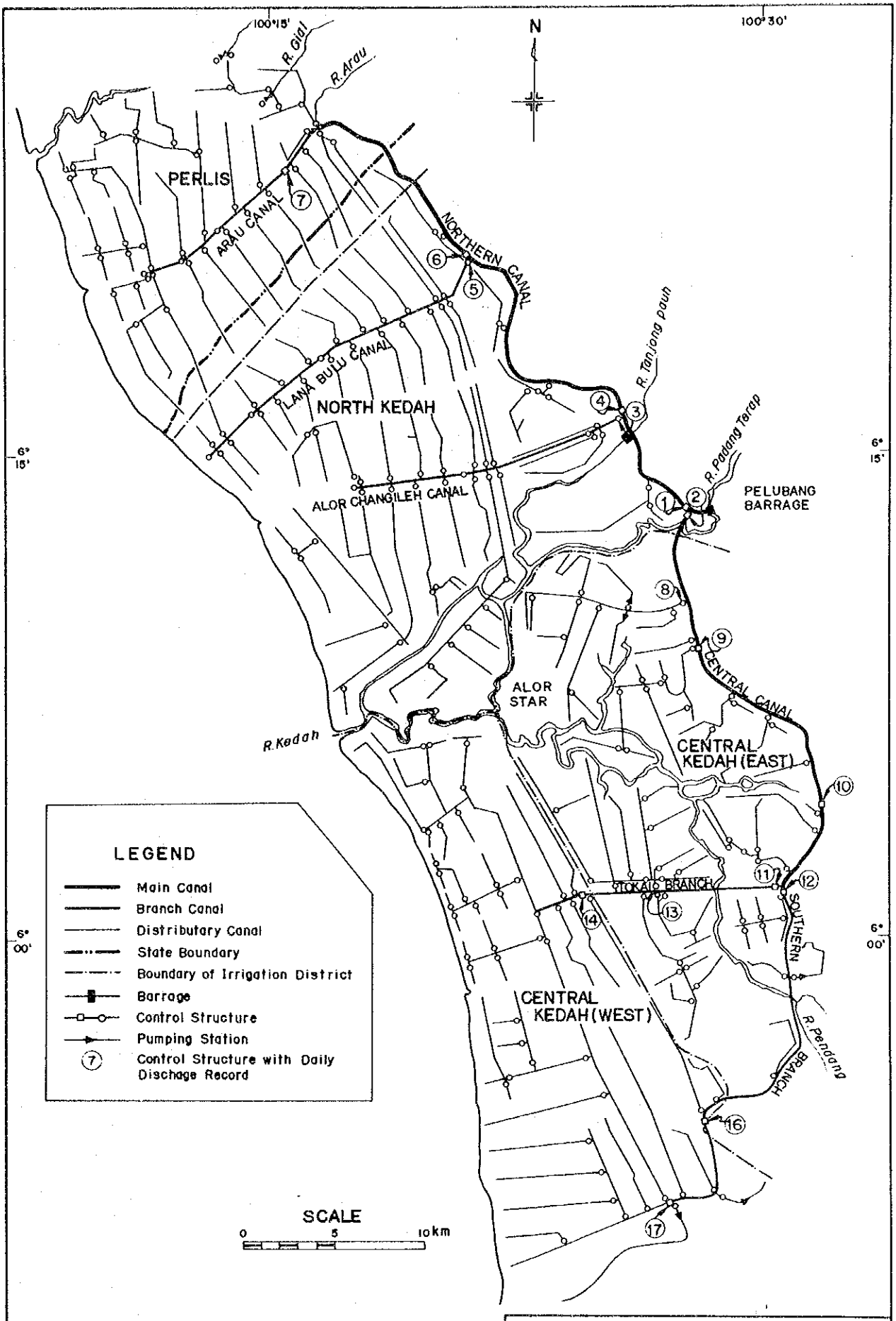

Fig. 1 Irrigation Canal System of the MADA Area

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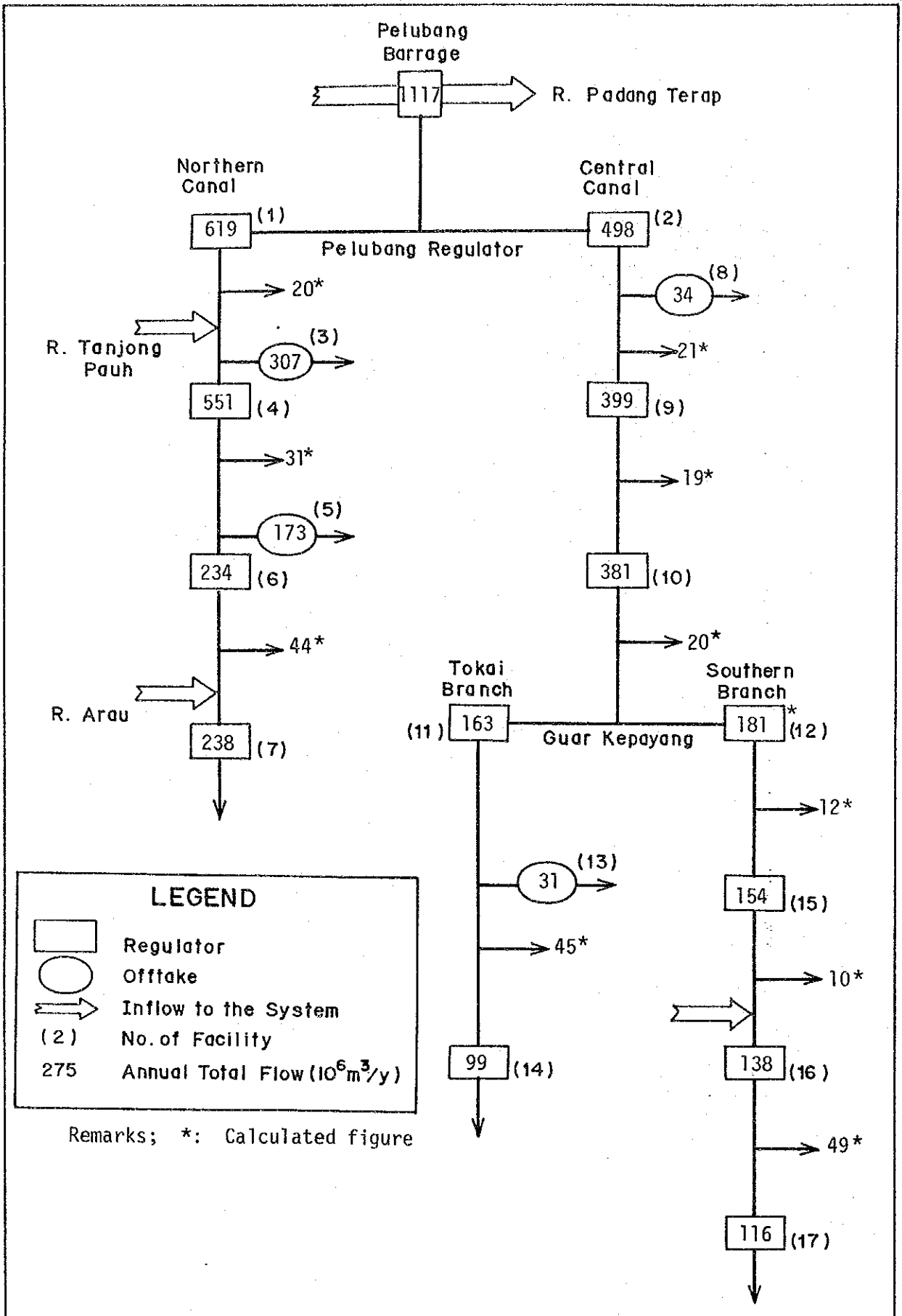

Fig. 2 Annual Total Flow in the Muda Irrigation Canal System in 1977

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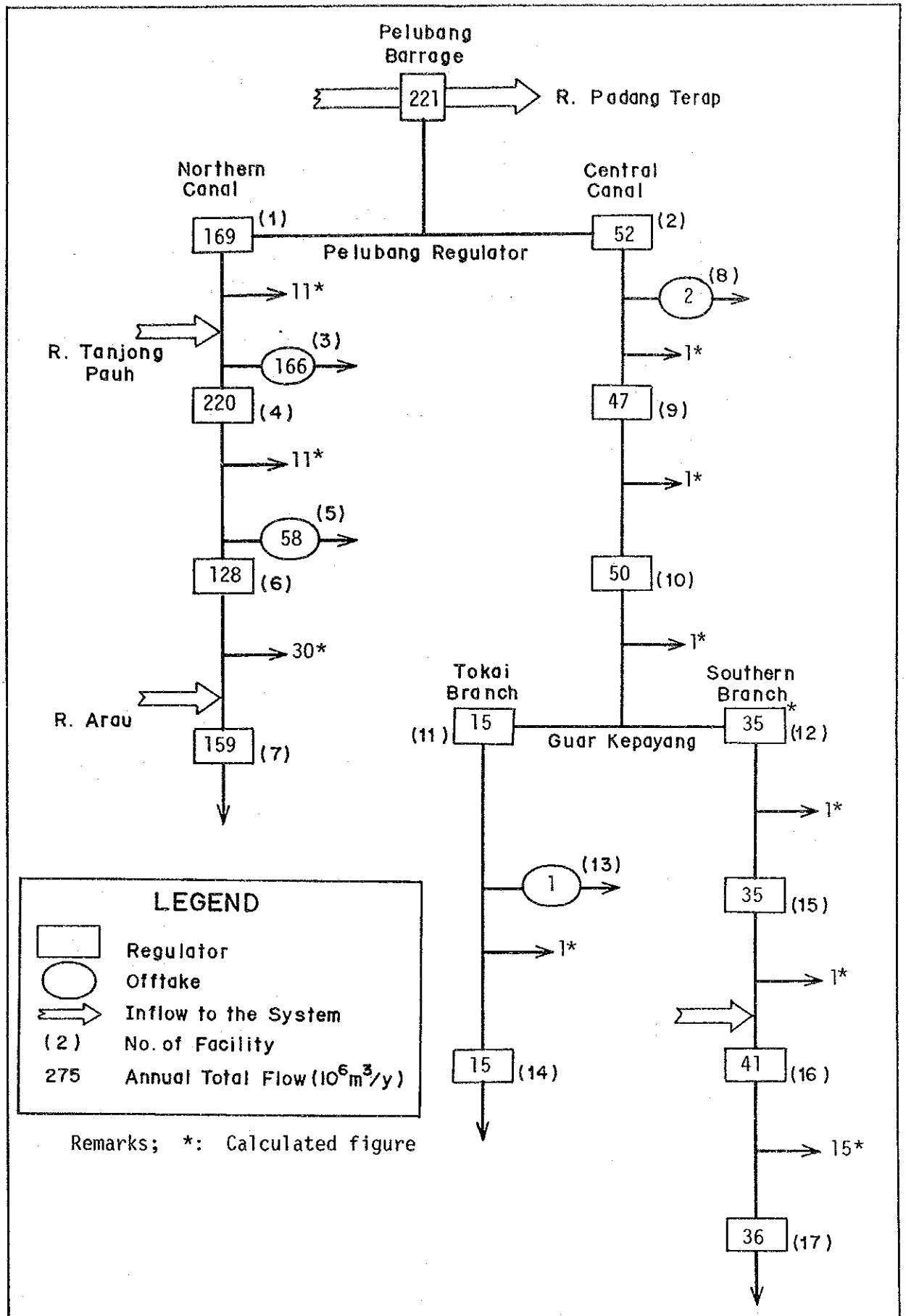

Fig. 3 Annual Total Flow in the Muda Irrigation Canal System in 1978

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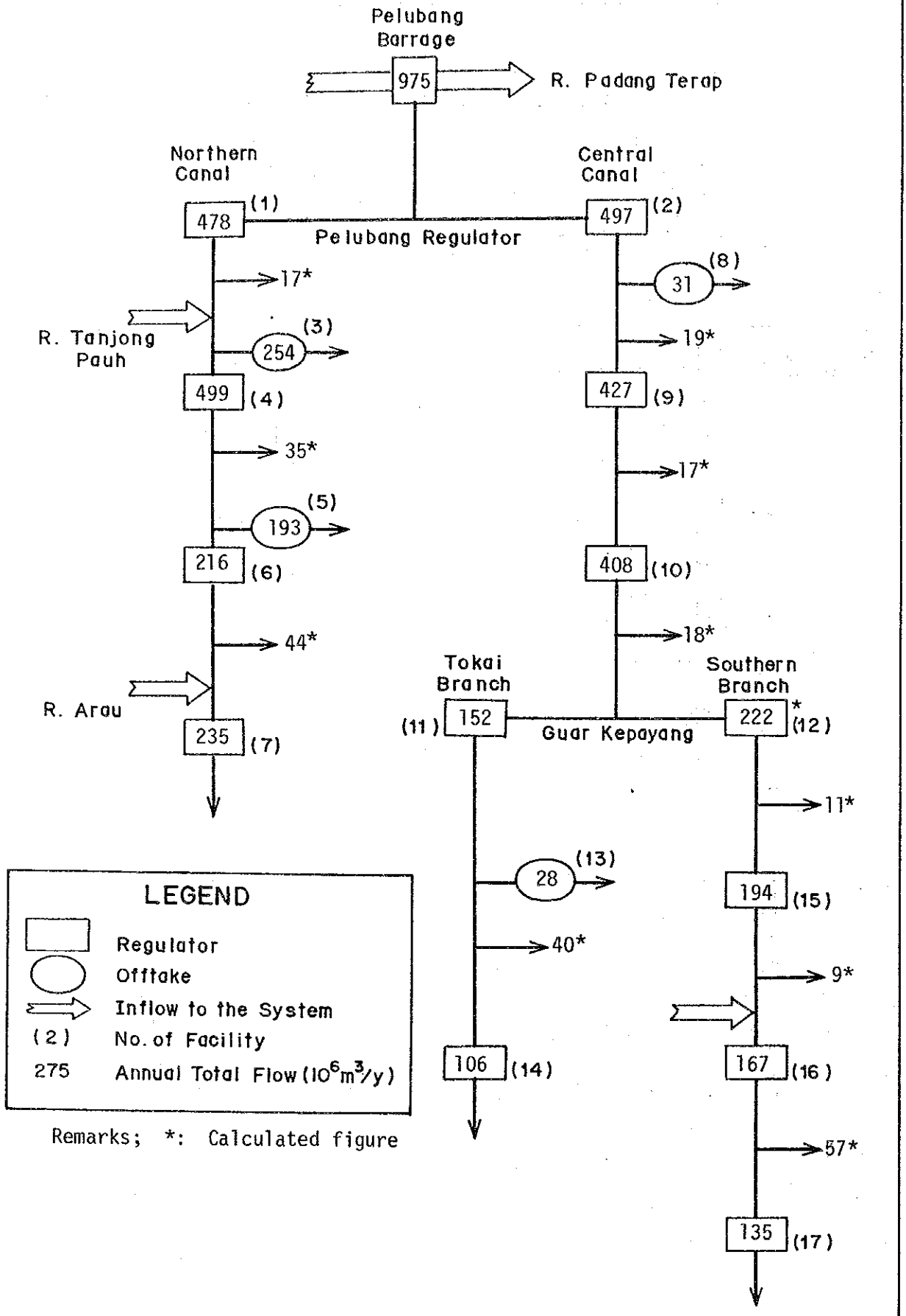

Fig. 4 Annual Total Flow in the Muda Irrigation Canal System in 1979

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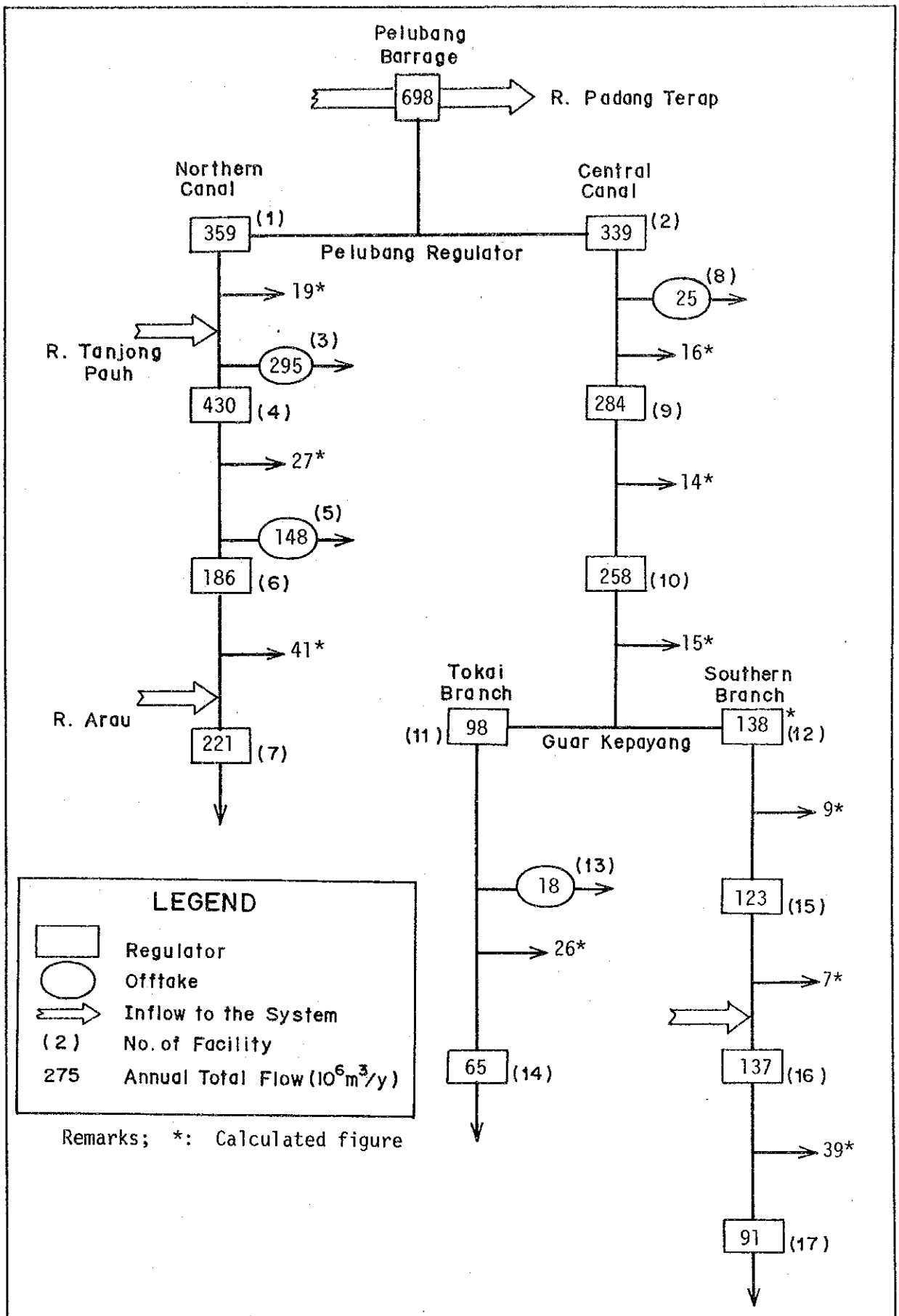

Fig. 5 Annual Total Flow in the Muda Irrigation Canal System in 1980

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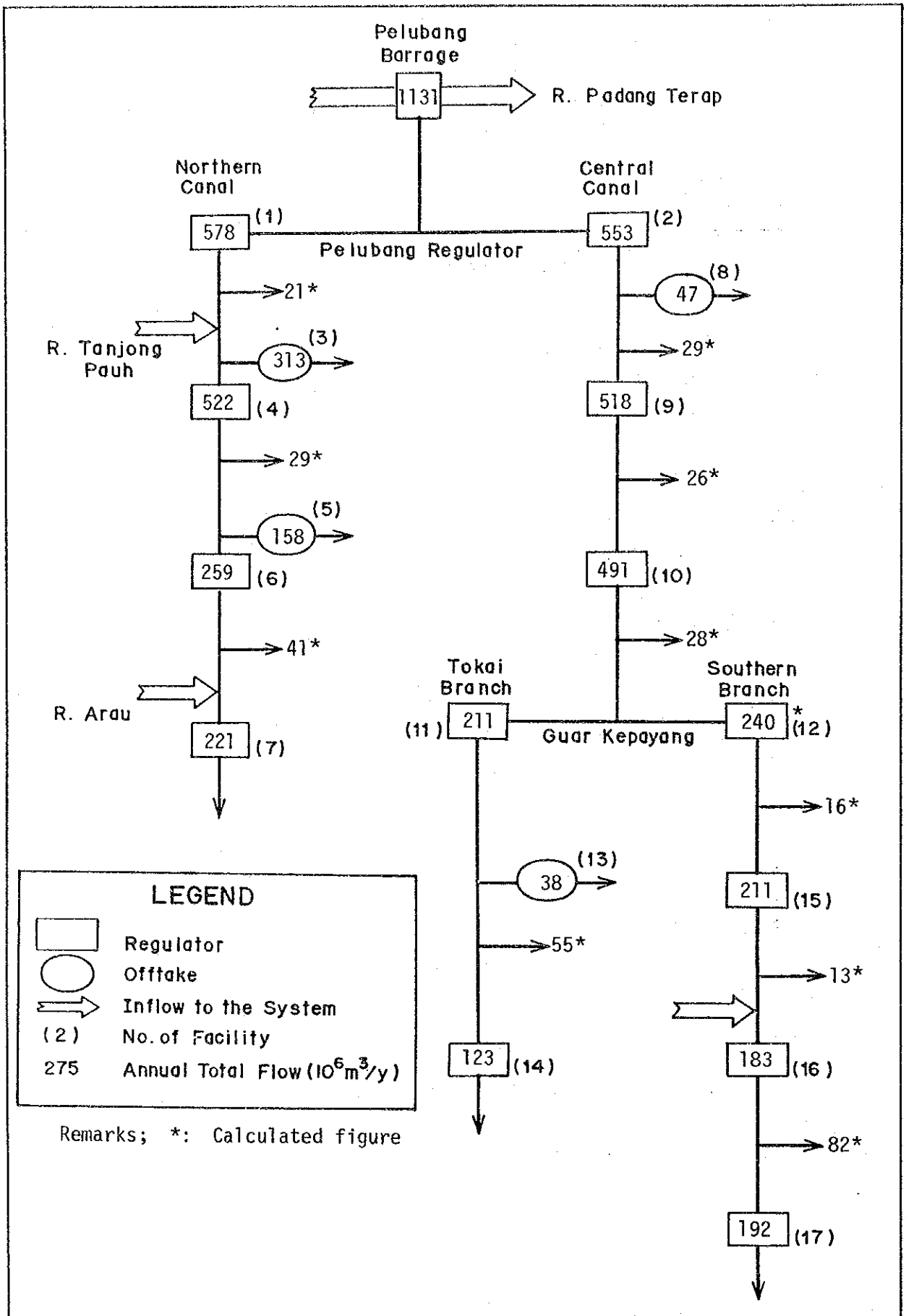

Fig. 6 Annual Total Flow in the Muda Irrigation Canal System in 1981

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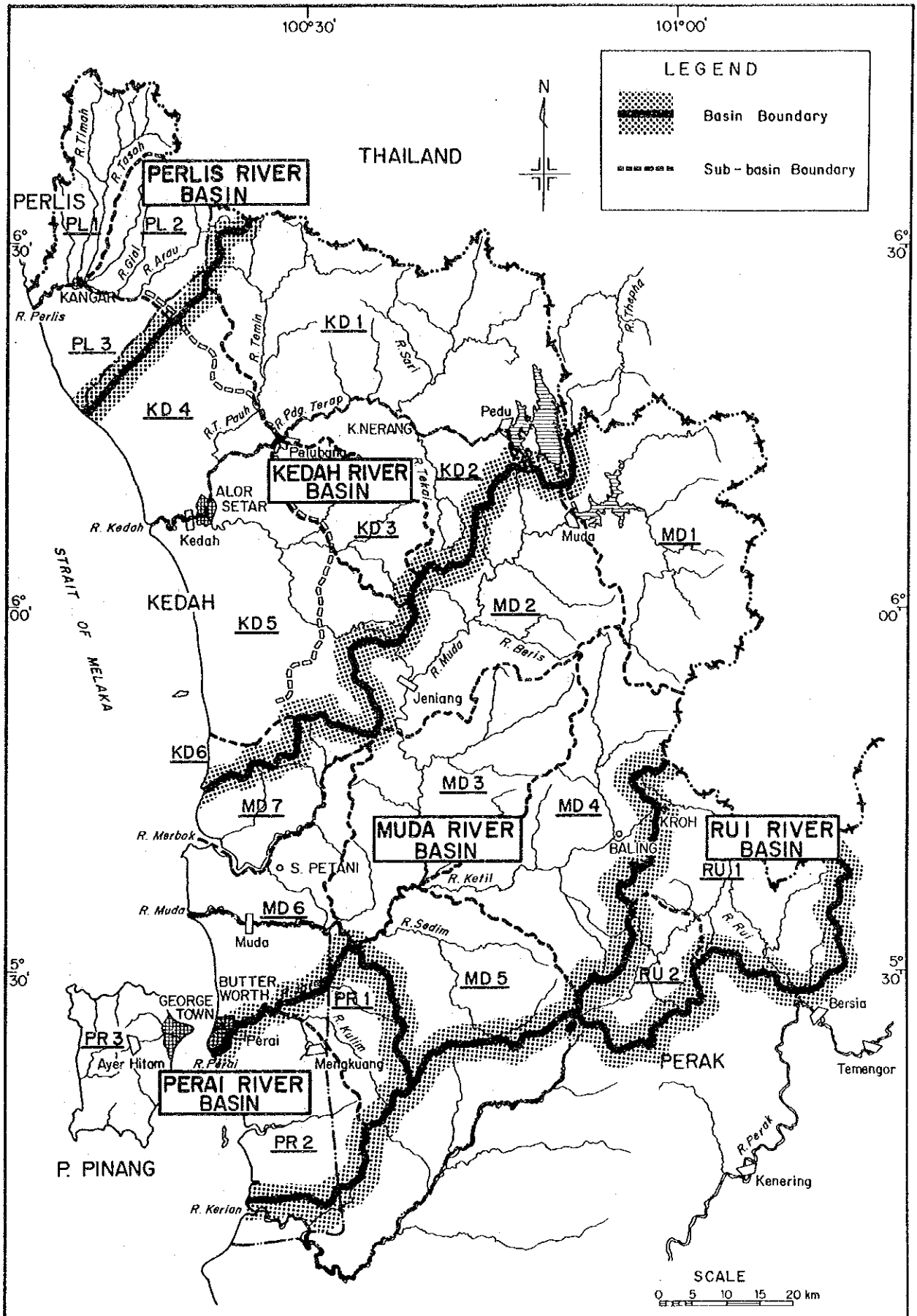

Fig. 7 Basin Boundary

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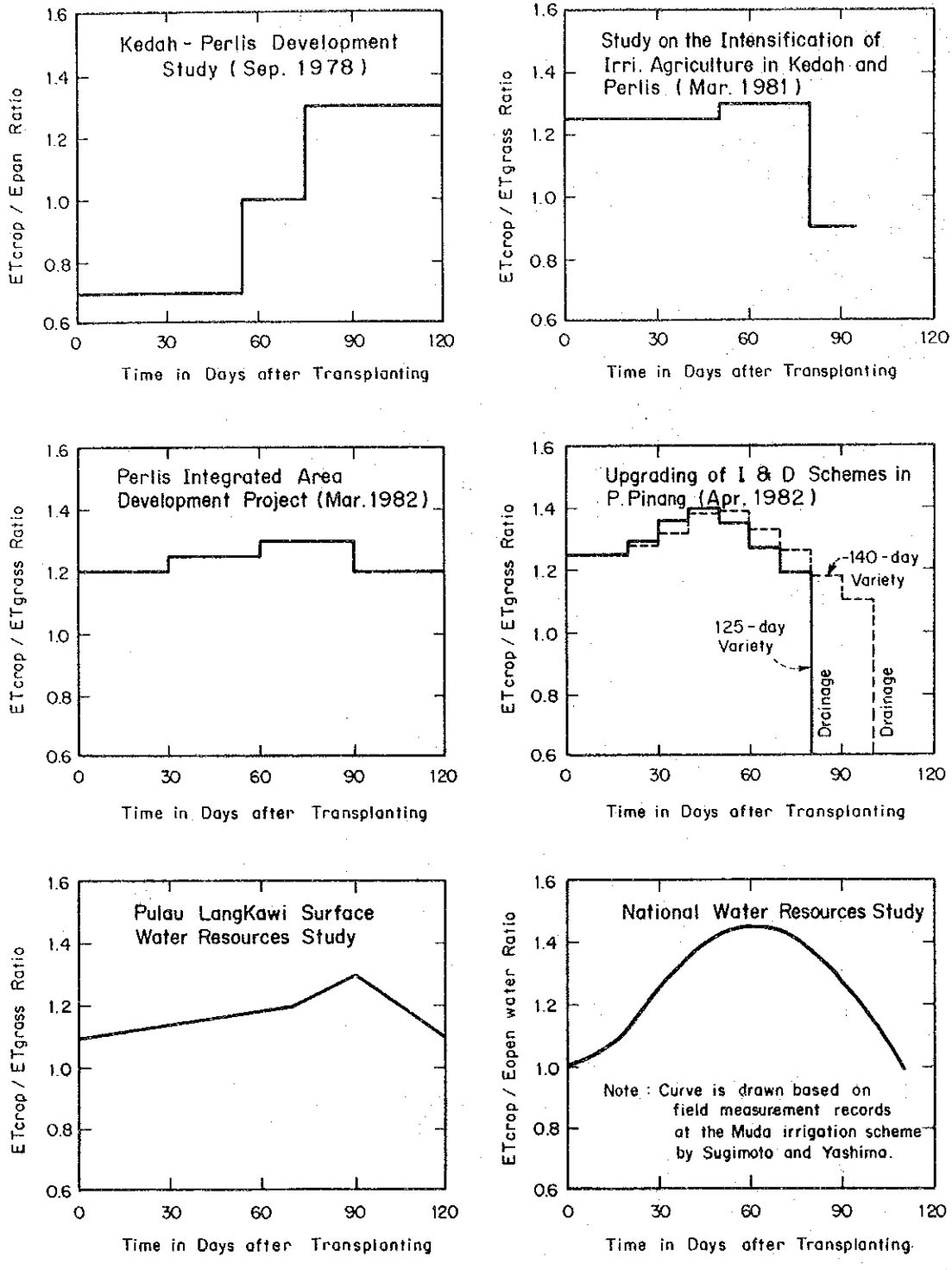

Fig. 8 Comparison of Crop Coefficient Used in the Previous Studies

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