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NATIONAL WATER RESOURCES STUDY, MALAYSIA

SECTORAL REPORT

VOL. 16

WATER SOURCE AND HYDROPOWER DEVELOPMENT PLANNING

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COMPOSITION OF THIS VOLUME

This Volume consists of two parts: Part 1 deals with the subject matters of Peninsular Malaysia and Part 2 is devoted to the States of Sabah and Sarawak.

ABBREVIATIONS

(1) Plan

FMP	:	First Malaysia Plan
SMP	:	Second Malaysia Plan
TMP	:	Third Malaysia Plan
4MP	:	Fourth Malaysia Plan
5MP	:	Fifth Malaysia Plan
6MP	:	Sixth Malaysia Plan
7MP	:	Seventh Malaysia Plan
NEP	:	New Economic Policy
OPP	:	Outline Perspective Plan
RESP	:	Rural Environmental Sanitation Program

(2) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance

MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries
MRRDB	:	Malaysia Rubber Research and Development Board
NDPC	:	National Development Planning Committee
NEB (LLN)	:	National Electricity Board
PORIM	:	Palm Oil Research Institute of Malaysia
PWD (JKR)	:	Public Works Department
RDA	:	Regional Development Authority
RISDA	:	Rubber Industry Small-holders Development Authority
RRIM	:	Rubber Research Institute of Malaysia
SEB	:	Sabah Electricity Board
SEBC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
SESCO	:	Sarawak Electricity Supply Corporation
UDA	:	Urban Development Authority

(3) International or Foreign Organization

ADAA	:	Australian Development Assistance Agency
ADB	:	Asian Development Bank
ASCE	:	American Society of Civil Engineers
FAO	:	Food and Agriculture Organization of the United Nations
IBRD	:	International Bank for Reconstruction and Development
ILO	:	International Labour Organization
IMF	:	International Monetary Fund
IRRI	:	International Rice Research Institute
JICA	:	Japan International Cooperation Agency
JSCE	:	Japan Society of Civil Engineers
MOC	:	Ministry of Construction, Japan
OECD	:	Organization for Economic Cooperation and Development
OECF	:	Overseas Economic Cooperation Fund, Japan
UK	:	United Kingdom
UNDP	:	United Nations Development Program

UNSF	:	United Nations Special Fund
US or USA	:	United States of America
US/AID	:	United States Agency for International Development
USBR	:	United States Bureau of Reclamation
WHO	:	World Health Organization
WMO	:	World Meteorological Organization

(4) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
CIF	:	Cost, Insurance and Freight
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
FOB	:	Free on Board
FSL	:	Full Supply Level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
HWL	:	Reservoir High Water Level
LWL	:	Reservoir Low Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SITC	:	Standard International Trade Classification
SS	:	Suspended Solid
V	:	Volume
W	:	Width

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 1 km^2 = 0.386 sq.mile	1 sq.ft = 0.0929 m^2 1sq.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^2
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

Exchange Rate
(as average between July and December 1980).

$1 = M$2.22
¥100 = M$1.03

PART 1

PENINSULAR MALAYSIA

SECTORAL REPORT

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PART 1 Peninsular Malaysia

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1. INTRODUCTION

The objective of the National Water Resources Study is to recommend an comprehensive and integrated approach of water resources development and use plans and improvement of legal and administration system to ensure efficient use of water and other natural resources for the target year of 1990 and 2000 based on the national short and long term development policy.

In the study process, identification survey of the present and future problems and needs in water resources development and use was done at first, and the present conditions of the use of water resources and water-related facilities and the results of interview survey with the officials were compiled in the Sectoral Report, Water Resources Engineering.

The objective of this report is to project and to evaluate the future problems and needs through the whole Malaysia with unified methodology and criteria, and to recommend the comprehensive and optimum development countermeasures for the year 1990 and 2000.

This report presents at first projection of water demand and supply balance between surface water resources and withdrawal of water demand, which was simulated by a computer data processing system by Basin or specified area in the year 1990 and 2000. Secondary alternative multi-purpose water source development plans, which comprised domestic and industrial water supply, agriculture and irrigation, flood control and river maintenance, groundwater, and hydropower generation, were made taking into account watershed management, inland fishery, inland navigation, water-related recreation, water pollution abatement, aqua-ecology and people's amenity. The optimum development and use plans for 1990 and 2000 were made in trial and error process taking the comments of the officials into account, but only the final results are presented in this report. Environmental quality and adverse effects due to construction of dams and reservoirs were also identified not only qualitatively but also partially quantitatively.

2. WATER DEMAND AND SUPPLY BALANCE PLANNING

2.1 Methodology for Planning

2.1.1 Alternatives

The objective of water demand and supply balance planning is to provide water source facilities, such as dams, headworks, barrages and water diversion facilities in order to turn out the basin water deficit in the target year to be zero or surplus under uniform design criteria.

Water source facilities have been planned under the principles as follow:

(1) Demand of surface water be supplied by natural river runoff as practically as possible;

(2) The river minimum maintenance flow be kept all the year at least to maintain water depth, flow velocity, water quality, channel stability, aquatic eco-system, fishery, navigation, operation and maintenance of intakes and river facilities, sea water repulsion, prevention of estuary clogging by silting, conservation of groundwater, prevention of riparian land and people's amenity;

(3) Water deficit be replenished with regulated surface water by dams or water diversion facilities under a given risk of drought level; and

(4) Alternative water source facilities be formulated only in the river basins where the river utilization ratio becomes larger than or equal to 10%. The river utilization ratio is the ratio of annual source water demand to annual mean natural runoff in a Basin.

If the water deficit, which is projected in Section 2.4, cannot be replenished with regulated water, the minimum maintenance flow would be reduced or a river water would be dried up and eventually water demand would not be satisfied with different risk of drought level. However, quantity and frequency of water deficit will be minor if utilization ratio of river water is very low. Dam facilities will not be necessarily required if reduction of the minimum maintenance flow is minor. The result of water demand and supply balance analysis showed that the peak water withdrawal for domestic and industrial water supply and irrigation scheme was generally less than a half of the desirable minimum maintenance flow when the utilization ratio of river water was less than 10%.

Three alternatives were accordingly prepared for water demand and supply balance planning taking into account the river utilization ratio, the minimum maintenance flow and three different risk of drought level.

Alternatives	Guaranteed Risk of Drought Level	Minimum Maintenance Flow
B1	1/N	Q97%
B2	2/N	Q97%
B3	4/N	Q97%

1/N, 2/N and 4/N mean the driest, the second and the third severe drought respectively in N year simulation record period. The simulation period is 19 years from 1961 to 1979 in case of Peninsular Malaysia. Q97% means the desirable minimum maintenance flow which has been assumed to be the daily mean discharge with the probability of exceedence of 97%. The given condition is that no water deficit is permitted under given risk of drought level if the river utilization ratio is larger than or equal to 10%, but no water source facilities are provided if the ratio is less than 10%. In other words, the minimum maintenance flow is not fully guaranteed and no replenished water is provided for any drought in river basins where utilization of river water is minor.

2.1.2 Planning criteria

The risk of water demand and supply balance has been evaluated by Basin in terms of the total annual deficit, and the required regulated water source has been planned by Basin by alternative with the following planning criteria.

(1) Data used

(A) Map

Location of dam sites, catchment area, reservoir storage volume, reservoir surface area, elevation of structures and water surface and dimension and works quantities of structures (dams, barrages, canals, tunnels, roads) were all measured in the maps of 1/63,360 scale. The minimum contour interval is different in respective map. It is 50 feet (15.25 m) or 100 feet (30.5 m) in plane and 50 feet, 100 feet or 200 feet in mountainous area. The error limit of the measured values, therefore, is not necessarily constant.

(B) Discharge

The daily discharge of less than 0.1 m^3/s could not be measured. The annual discharge were compiled from daily discharge and therefore the annual discharge of less than 3 x 10^6 m^3/y may be within the range of error.

(2) Priority of development

Priority of developing potential sites has been determined based on the following preference:

(a) nearest river system,

(b) nearest sites to the location of demand,

(c) higher investment efficiency, and

(d) storage capacity be large enough to meet the demand (required net supply capacity).

(3) Requirement of developed regulation water

The requirement of developed regulation water is composed of required net supply capacity and compensation discharge for shutdown at a site.

The required net supply capacity is expressed in annual basis (unit: 10^6 m^3/y). It is assumed to be 1.2 times of the estimated water deficit for the basin where seasonal variation of water demand is large, like major irrigation area or 1.1 times for the basin where constant rate of water demand is anticipated through a year, like domestic and industrial water demand area. The surplus capacity of 10% or 20% of the estimated deficit is assumed in order to adjust the discrepancy between constant draft operation and variable draft reservoir operation because the storage capacity required for the net supply capacity is estimated using the constant draft curves.

The compensation discharge, which is required for avoiding shutdown of discharge and maintaining the minimum water requirement in downstream of a dam site, is assumed to be 20% of the annual inflow at the catchment of a site (theoretically this varies depending on the river conditions).

(4) Return flow

Net water withdrawal is used for the basin water balance if the intake of irrigation or water supply is in the effective area; accordingly, return flow is taken into account. The total source water demand is used if the location is in the ineffective area.

(5) Extension of target year

Ultimate target of the net supply capacity was set for the year 2000 but the capacity has been extended up to the demand of the year 2005 when the required capacity of 2000 is extremely smaller than the possible maximum net supply capacity of a site.

(6) Development efficiency

The active storage (Vs) which is required for yielding the required regulation developed water (Wdt) is estimated by using development efficiency (Ed) as follows:

Active storage (Vs) = Wdt/Ed

Development efficiency is given by

Ed = developed water (draft)/active storage capacity

The development efficiency is obtained from the non-dimensional storage-draft curves.

(7) Active storage and dead storage

The storage capacity is defined as:

Gross storage capacity (Vg) = Active storage capacity (Vs) + Dead storage volume (Vd)

The maximum active storage capacity is assumed to be around 70% of the annual inflow at a dam site. Dead storage volume is assumed to be 2.0 x sedimentation volume of 100 years. If the maximum gross storage is limited by the physical possible maximum capacity (topographic constraint). The active storage is given as; Vs = Vg - Vd.

The sedimentation volume is assumed to be 20,000 - 60,000 $m^3/km^2/$ 100 years for Peninsular Malaysia as listed in Table 1.

(8) Freeboard

The freeboard from the full supply level (F.S.L or H.W.L) to the dam crest elevation is assumed to be at least 3.0 m.

(9) Investment efficiency

Investment efficiency of water resources development (EI) is used for evaluation and screening the best dam sites from the potential dam sites.

The investment efficiency is given as:

$$EI = Ed \times Es \times \frac{1}{Cd}$$

$$= \frac{Wd}{Vs} \times \frac{Vs}{Vd} \times \frac{Vd}{CD}$$

$$= \frac{Wd}{CD}$$

where, Ed: Water development efficiency
Es: Storage efficiency
Cd: Development cost per unit dam volume
Wd: Developed water (or net supply capacity)
Vs: Active storage capacity
Vd: Volume of dam body
CD: Development cost = dam construction cost + cost of water diversion facilities including O&M cost

(10) Non-dimensional storage curves

Non-dimensional storage-draft curves were made by constant draft operations for the selected 11 key stations. The 5-day mean natural discharges of 19 years period from 1961 to 1979 were used under cycle period concept. The 19 year record was repeated two times connecting the record of 1961 to the end of 1979 in order to find the largest storage requirement which could fall in the period between the end of 1979 and the beginning of 1961.

The non-dimensional storage-draft curves are shown by key station in Figures 3-5.

2.1.3 Criteria of cost estimates

(1) Construction cost

Construction cost is composed of

(a) direct cost,

(b) engineering and administration: assumed to be minimum 10% of the direct cost depending on the project scale,

(c) land acquisition and resettlement, and

(d) Physical contingency: assumed to be 30% of the total of a, b and c.

(2) Construction period and disbursement schedule

All the construction period is assumed to be 5 years. The disbursement schedule of 5 years is assumed to be 10% of the total cost for the first year, 20% for the second year, 30% for the third year, 30% for the fourth year and 10% for the fifth year.

(3) Estimate of direct cost

The standardized values shown in Tables 2-6 are used for estimation of direct cost of dams, tunnels, canals, pipelines, pumping stations, and access and relocation roads. These values are made from the data obtained in the cost survey (see Sectoral Report, Water Resources Engineering).

2.2 Water Demand and Supply Balance Analysis

2.2.1 Calculation model of water balance analysis

The purpose of the water demand and supply balance analysis is to project and evaluate the water balance of the whole Peninsular Malaysia by Basin with uniform criteria.

Water demand and supply balance is projected for the 41 Basins at the target years, 1990 and 2000 in the following procedure. The daily mean discharge records of the selected 53 gauging stations were examined and 11 reliable consecutive daily discharge records were selected at first (see Sectoral Report, Meteorology and Hydrology). The measured daily mean discharges of 11 gauging stations are converted into the natural daily mean discharge taking into account the water withdrawal of irrigation, domestic and industrial water supply and reservoir regulation effect during the measured period. The water demand and supply balance is estimated by each 5-day period in order to visualize the seasonal fluctuation clearly, especially for irrigation demand. The daily mean discharge records therefore were compiled in 5-day mean discharge records. The 11 natural 5-day mean discharge records at the gauged river basins were projected to the ungauged river basins of similar hydrogic condition in proportion to the basin runoff (rainfall minus loss). The net water withdrawal in the target year, which corresponds to the projected water demand excluding the return flow, is estimated for each Basin. The minimum river maintenance flow is also taken into account. The water demand and supply balance is evaluated in terms of water deficit. The water deficit is given by the sum of the natural 5-day mean discharge and the sum of all the water withdrawal and the minimum river maintenance flow. That is, the water deficit (DTj) is given by the following formula:

$$DTj = NFj + RT - (MT + AT) - QM$$

where, DTj: Water deficit in the given j Basin, 5-day mean (m^3/s)

NFj: Natural 5-day mean discharge in the given j Basin (m^3/s)

RT : Regulated flow in the projected year (1990 and 2000), reservoir operated discharge and diversion water (m^3/s) in j Basin

MT : Net domestic and industrial water withdrawal in the projected year (m^3/s) in j Basin

AT : Net irrigation water withdrawal in the projected year (m^3/s) in j Basin

QM : Minimum river maintenance flow (m^3/s) in j Basin

DTj is the average water deficit in the given period of 5 days (Δt). The total water deficit of the j Basin (TDTj) during a certain period (t) is therefore given by

$$TDTj = \int^{t} DTj \cdot \Delta t$$

MT and MW were projected in the Sectoral Report, D&I Water Supply. AT and AW were projected in the Sectoral Report, Irrigation Water Demand.

The regulated flow in the projected year (RT) is assumed to be zero in order to figure out the condition when no regulation reservoir is provided for the target year.

The total water deficit of the j Basin (TDTj) during a certain period (t) is consequently given by

$$TDTj = \int^{t} DTj \cdot dt$$
$$= \int^{t} (NFj - MT - AT - QM)\ dt$$

The calculation output (deficit) is shown by plus (+) when the value (DTj) is minus (-). The surplus is expressed in minus.

The 5-day mean discharge (NFj) is more precisely given as:

$$NFj = \text{Natural flow in the given j Basin } (m^3/s)$$
$$= N_5 \times \left(\frac{A_{ij}}{A_{oj}} \times \frac{R_{ij}}{R_{oj}} \times \frac{f_{ij}}{f_{oj}}\right)$$

where, N_5 : MF_5 + MW + AW + RF
= Natural 5-day mean discharge at the standard gauging station (m^3/s)

MF_5: Measured flow at the standard gauging station, 5-day mean discharge which is compiled from daily discharge (m^3/s)

MW : Net domestic and industrial water withdrawal in the measured period (m^3/s)

AW : Net irrigation water withdrawal in the measured period (m^3/s)

RF : Regulated flow in the measured period (m^3/s)

A_{oj}: Effective catchment area at the gauging station of the j Basin (km^2)

A_{ij}: Effective catchment area of the j Basin at the i point of the water balance calculation (km^2), the catchment area at the river mouth is defined as A_{1j}

R_{oj}: Annual mean basin rainfall for the gauging station (mm/y) of the j Basin

R_{ij}: Annual mean basin rainfall for the catchment at the i point of the water balance calculation of the j Basin (mm/y)

f_{oj}: Mean runoff coefficient for the gauging station of the j Basin

f_{ij}: Mean runoff coefficient for the catchment at the i point of the water balance calculation of the j Basin

2.2.2 Basin division and effective area

(1) Basin division

The Peninsular Malaysia were divided into 41 divisions of "Basins" for the purpose of engineering study. The Basin number, the name of Basin, the catchment area of each Basin are shown in Table 7. These Basins are shown in Fig. 1. The administrative divisions of the 11 States are shown in Fig. 2.

The Basin boundaries were delineated and the catchment area was measured on the map of 1/500,000 scale based on the following criteria:

(a) The Basin boundary is watershed;

(b) Each Basin is a river system or a group of river systems; and

(c) If an international boundary crosses a river basin, it is adopted as a Basin boundary.

(2) Effective area of Basin

An area of a Basin of which surface water can be practically used for the purpose of domestic and industrial water supply and irrigation schemes is defined as 'Effective Area' in this study. That is, the Basin catchment was divided into effective and ineffective areas. The border between effective and ineffective area is denoted as a broken line (--------) in Figs. 6-13. It is assumed that no intrusion of sea water was observed in the upstream of the border. This line was drawn based on the information from DID and PWD and study reports. The effective area is shown in Table 7.

The definition of the border line is assumed more precisely as follows:

(a) The upstream catchment from the lowest end sites of dams headworks, barrages or intakes for irrigation, water supply and/or hydropower be effective;

(b) The area of the large scale irrigation schemes of which the return flow cannot be used, for example the flow which is planned to be directly discharged to the sea, be ineffective;

(c) The area of the drainage schemes of which the return flow cannot be used depending on the direction of drainage channels, the location of rivers and the topography be ineffective;

(d) The swamp area of which discharge cannot be used because of inadequacy of water quality and/or topographic conditions be ineffective; and

(c) If the area is fallen outside the above-mentioned four categories and is located within 5 km along the coastal line, it be ineffective.

2.2.3 Minimum river maintenance flow

Two cases of the minimum river maintenance flow have been established as alternatives. One is the desirable minimum maintenance flow which has been assumed to be the daily mean discharge with the probability of exceedence of 97% (Q97%). The other is the essential minimum maintenance flow which has been assumed to be the daily mean discharge with the probability of exceedence of 99% (Q99%). Table 8 shows the assumed minimum maintenance flow in the effective area by Basin.

Q97% and Q99% are the discharges with probability of exceedence of 97% and 99% of the daily mean discharge series of the record period (19 years) respectively. No missing data was interpolated for the probability calculation.

2.2.4 Water demand and supply system diagrams

All the Basins, rivers, demand centers of cities, districts and irrigation schemes and supply facilities are expressed in models under uniform criteria as shown in the Water Demand and Supply System Diagrams of Figs. 14 - 31 in order to clarify the spatial condition of demand and supply balance.

The location of the major intakes is assumed to be the demand center of cities and major irrigation schemes if the exact intake sites are known. The location of demand center of district is assumed to be the gravity center of a district area. The gravity center of an area of minor irrigation schemes is assumed to be the demand center of a minor irrigation scheme when exact intake sites are unknown.

Numbering of notation system is applied for States (Table 9), Basins (Table 7), Prospective cities (Table 10), Districts (Table 11) and Irrigation major and minor schemes in order to show in the system diagrams and to process the data by a computer system.

2.3 Preliminary Evaluation of Water Demand and Supply Balance

2.3.1 Water balance of natural water resources

Table 12 shows the basin mean annual rainfall and runoff by Basin which were estimated in the Sectoral Report, Meteorology and Hydrology.

The annual hydrologic water balance among rainfall, evepotranspiration, deep percolation and surface runoff are estimated by Basin and by State as set out in Tables 13 and 14 respectively. Table 15 shows the assumed state share of catchment area in a Basin which is used for estimation of the state hydrologic water balance. The balance of Peninsular Malaysia is complied as follows:

	Total Catchment Area (km^2)	Unit	Mean Rainfall	Mean Evapo-transpiration	Mean Deep Percolation*	Mean Surface Runoff
Whole Peninsular Malaysia	131,680	mm	2,426	1,155	155	1,116
		10^9 m^3/y	319.4	152.1	20.4	146.9
		%	100.0	47.6	6.4	46.0
Whole East Malaysia	197,299	mm	3,398	1,051	224	2,123
		10^9 m^3/y	670.4	207.4	44.1	418.9
		%	100.0	30.9	6.6	62.5

Remarks; *: Denotes groundwater recharge

The values of Sabah and Sarawak are shown for comparison. The deep percolation was estimated in the Sectoral Report, Groundwater Resources.

2.3.2. River utilization ration in 1990 and 2000

The river utilization ratio, which is the ratio of the annual source water demand to annual surface runoff in effective area, are estimated by Basin for the year 1990 and 2000 in order to imagine the future conditions of supply capacity of surface water (i.e. river water). The results are shown in Table 16 for the case of target economic growth and Table 17 for the case of lower economic growth.

The source demand of domestic and industrial water supply was projected in the Sectoral Report, Domestic and Industrial Water Supply. Therein the D&I water demand was projected with the following conditions:

(a) all the urban water demand be supplied by surface water both for 1990 and 2000, and

(b) for rural water supply, groundwater be used at first in the following order of priority;

i) non-piped rural domestic water
ii) piped rural domestic water
iii) rural manufacturing water

and the ceiling of groundwater development is assumed to be 10% of the safe yield capacity. If the groundwater is used up to the limit, the remainder of rural water demand be supplied by surface water.

The demand in the ineffective area is assumed to be diverted by pipelines or canals from the effective area.

The irrigation water demand was estimated assuming the same crop yield for both cases of target and lower economic growth in the Sectoral Report, Irrigation Water Demand.

The Basins of which river utilization is projected to be higher than 10% in 1990 and 2000 under the condition of the target economic growth are respectively as follows;

Year	Basin No.
1990	1, 2, 3, 4, 5, 6, 7, 9, 11, 15, 17, 18, 19, 20, 24
2000	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 15, 17, 18, 19, 20, 23, 24, 40

2.4 Water Demand and Supply Balance in 1990 and 2000

The water demand and supply balance of each 5 days has been computed using 5 day discharge data for 19 years (N = 19) for the target year of 1990 and 2000. The 5 day water deficit has been summed to monthly and annual deficit, and the largest annual deficit (i.e. the most severe drought, drought level 1/N) in N year period, the second (2/N), the third (3/N), the fourth (4/N) and the fifth (5/N) are tabulated with the year occurred in Tables 18 (Target case) and 20 (Lower case) for 1990 and Tables 19 (Target case) and 21 (Lower case) for 2000. The desirable minimum maintenance flow (Q97%) is applied for these cases.

The structural measures of water source facilities are planned only for the Basins of which water utilization ratio is larger than or equal to 10%. The deficit of the Basins with water utilization of less than 10% is also estimated for comparision purpose.

3. WATER SOURCE DEVELOPMENT PLAN

3.1 Water Demand and Supply Balance Alternatives

3.1.1 Problem area with regard to surface water development

The 14 regions set out below are identified as problem area where the river utilization ration will be higher than or equal to 10% in the whole basin or locally in 2000 and water shortage is projected (See Table 16).

1) Perlis, Kedah and Pulau Pinang Region; Basins 1, 3, 4, 5, 6, 7

2) Pulau Langkawi; Basin 2

3) Kerian and Kurau river basins; Basins 8 & 9

4) Kinta Valley (Ipoh) in Basin 10

5) Bernam and Tengi river basins (Tanjong Karang irrigation scheme), Basins 11 & 12

6) Kelang Valley; Basins 13, 14, 15 and 16

7) Sepang river basin (Port Dickson); Basin 17

8) Linggi river basin (Selemban); Basin 18

9) Melaka-Muar Region; Basins 19, 20 and 21

10) South Johor Region; Basins 23, 24 and 25

11) Anak Endau river (Sawah-Endau irrigation scheme) in Basin 28

12) Kuantan river basin; Basin 31

13) Kemasin, Kelantan and Golok river basins; Basins 39, 40 & 41

14) Golok plain (Golok irrigation scheme) in Basin 41

3.1.2 Alternative water source development plans

Alternative water source facilities are planned for the problem regions identified in Section 3.1.1 so that the required regulation capacity (i.e. required supply capacity) can be replenished by the net supply capacity of the existing facilities and the additional net supply capacity of the newly proposed source facilities by the target year.

The net supply capacities of the reservoirs which were in operation, under construction, or commissioned at the beginning of 1981 are assumed to be the existing net supply capacity in the alternative planning. The major features of dams and reservoirs which are assumed to be existing facilities are listed in Tables 22 and 23. The capacity of very small facilities are assumed to be negligible.

Alternatives B1, B2 and B3 are planned by Basin or Sub-basin as a minimum unit with the planning criteria which are presented in Section 2.1. The basin plans are extended to multi-basin plans by integration of basin plans depending on the conditions. Possible combination of reservoirs and diversion facilities of canals, pipelines and tunnels is studied for each alternative based on the present and proposed inter-basin water usage program shown in Table 24.

The optimum development plans are proposed for each alternative for each problem region as set out in Tables 25 - 36 for alternative B1, Tables 37 - 48 for alternative B2 and Tables 49 - 59 for alternative B3. Inter-basin water diversion is proposed for the following problem regions.

Problem Region	Basin No.	Diversion Facilities	Basin Transfer (Basin No.)
Perlis, Kedah and	3	Jeniang diversion (barrage & canal)	Kedah 5 to 3
Pulau Pinang Region	10	Rui diversion (tunnel)	Perak to Kedah 10 to 5
Kelang Valley	13	Selangor diversion (pipeline)	Selangor 13 to 15
	16	Semenyih diversion (pipeline)	Selangor 16 to 15
	30	Kenaboi diversion (tunnel)	N. Sembilan to Selangor 30 to 16-15
	30	Perting diversion (tunnel)	Pahang to Selangor 30 to 13-15
	30	Kongkoi diversion (tunnel)	N. Sembilan to Selangor 30 to 16-15
Melaka-Muar Region	21	Muar diversion (barrage & canal)	Johor to Melaka 21 to 19 & 20
	30	Bera diversion (canal) (for Alternative B1 only)	Pahang to N. Sembilan 30 to 21
Sepang River Bain (Port Dickson)	30	Teriang diversion (pipeline)	N. Sembilan 30 to 17

(Cont'd)

Problem Region	Basin No.	Diversion Facilities	Basin Transfer (Basin No.)
South Johor Region	23	Teberau diversion (barrage & pipeline)	Johor 23 to 23 & Singapore
	24	Semangar diversion (canal)	Johor 24 to 23
	24	Johor diversion (barrage & canal)	Johor 24 to 24
	25	Sedili diversion (canal & pipeline)	Johor 25 to 24
Kemasin, Kelantan and Golok River Basins	39	Kemasin diversion irrigation canal	Kelantan 40 to 39
	41	Golok diversion irrigation canal	Kelantan 40 to 41

The location of proposed water source facilities including dams and diversion facilities are shown in Figs. 6 to 13 for the alternatives B1 which cover also the location of the alternatives B2 and B3.

Location of cities, irrigation schemes and dams and route of diversion canals, pipelines and tunnels are drawn by a simplified model as shown in Figs. 14 to 31 (see Section 2.2.4).

3.2 Recommended Water Source Development Plans

3.2.1 Selection of drought level for recommended plans

As is in Section 3.1.2 alternative water source facilities are planned with the same risk of drought level for each alternative plan. No distinction is made among irrigation schemes, domestic and industrial water supply, rural water supply or hydropower generation. The risk of failure (or water shortage) of the alternative B1 (drought level 1/N) is least, but the development cost is highest; that is, water rate becomes high.

In Malaysia, the facilities for domestic and industrial water supply have been designed for the drought having the recurrence interval of 30-50 years depending on the policy of each State. Irrigation schemes have been planned for the drought with the recurrence interval of 5 years.

The recurrence interval (or probability) of each drought level is estimated in Table 60. The probability of exceedence of the alternative B1 is estimated to be 1/20 - 1/38. For the alternatives B2 & B3 it is estimated to be 1/10 - 1/12.7 and 1/5 - 1/5.4 respectively.

The following risk level, accordingly, are applied to the recommended water source development plans taking into account regional peculiarity, purpose of major water demand, river utilization ratio, cost-benefit and development priority:

1) The net supply capacity of water source facilities be determined against the most severe drought ever recorded (i.e. 1/N drought level) for a river system where demand for domestic and industrial water supply is predominant (corresponding to Alternative B1);

2) It be determined against the fourth severe drought ever recorded (i.e. 4/N) for a river system where irrigation water demand is predominant (corresponding to Alternative B3);

3) Provided that structural measures of water source be required only if the river utilization ratio is larger than or equal to 10%.

3.2.2 Recommended water source development plans

The water demand and supply balance programs set out in Tables 61-70 and Figures 32-37 are recommended for the problem regions.

The construction schedule and major features of the recommended water source development plans, which fulfil the water demand and supply balance programs, are presented in Tables 81-92 and Tables 93-104 for the case under the lower economic growth. The location of the recommended water source facilities including dams and water diversion facilities are shown in Fig. 38-45.

The required net supply capacities adopted for the recommended water demand and supply programs are estimated in the following procedure.

1) The required supply capacity is determined to replenish the basin water deficit listed in Tables 18 and 19 by Basin basis where water demand is limited inside a Basin at first.
The required supply capacity, which is expressed in annual basis is assumed to be 1.2 times of the estimated water deficit for the basin where seasonal variation of water demand is large, like predominant irrigation area or 1.1 times of the dificit for the basin where constant rate of water demand is used through a year, like predominant domestic and industrial water demand center as defined in Section 2.1.2.

2) If the water demand is locally concentrated on a certain area in a Basin and if the demand (or deficit) can not be fulfilled by a Basin plan, the deficit in the specified sub-basin is estimated independently and the required supply capacity is obtained in the same procedure.
The region of the specified sub-basins, the catchment area and the projected withdrawal within the sub-basins are set out in Tables 105 and 106.

3) If the basin water deficit can not be fulfilled by the potential basin supply capacity independently or if inter-basin water usage is operated in a Basin (see Table 24), integrated water deficit is estimated for the combined basins. The surplus water demand or deficit in a water tight basin is superimposed on a water abundant basin depending on the boundary conditions.

4) The deficit estimated by integrated basin water usage is allocated for each basin in proportion to the individual deficit in Tables 18 and 19 or basin source demand depending on the boundary conditions taking into account each predominant drought level.

The breakdown of the required supply capacity is shown in Tables 71 - 80 by region basis.

Groundwater development is studied as an alternative water source which is comparable with surface water in the Sectoral Report, Groundwater Resources.

The fundamental planning conditions and technical features of the recommended water source facilities are summarized by each problem region as set out below.

(1) Perlis, Kedah and Pulau Pinang region

The river utilization ratio of the rivers in this region is estimated to be 54% in Basin 1, 74% in Basin 3, 26% in Basin 4, 12% in Basin 5, 43% in Basin 6 and 54% in Basin 7 respectively in the year 2000. The annual source water demand is presented in Table 16. In Basins 1, 3 and 5 the irrigation water demand is predominant and the design drought level of 4/19 is applied to the recommended plan. In Basins 4, 6 and 7 the domestic and industrial water demand is predominant and the design drought level of 1/19 is applied. The inter-basin water usage program in this region is shown in Table 24. The correlation among demand centers and water source and diversion facilities is expressed in a model as shown in Fig. 16. The required supply capacity and the recommended water demand and supply balance program are shown in Table 61 and Fig. 32.

The recommended construction plan is composed of the Timah Tosoh dam in the Perlis river, the Badak-Temin, Sari, Durian and Ahning dams in the Kedah river, the Beris dam and the Jeniang Transfer including the Naok and Reman dams in the Muda river and the Rui dam and a diversion tunnel in the upstream reaches of the Preak river in the State of Perak. The Jeniang Transfer consists of the Jeniang weir in the main stream of the Muda river, the Naok and Reman reservoirs of pumping flood water in the tributary of the Muda river and the transfer canal system to the Muda irrigation project and the Merbok river basin. The net supply capacity of the Jeniang transfer is estimated to be some 350×10^6 m^3/y. The net transferable water from the Rui dam is estimated to be 140×10^6 m^3/y. The Rui dam guarantees the compensation discharge including the river maintenance flow for the upper reaches of the Perak river. The Pong hydropower station of 2MW (private company) will be submerged by the Rui reservoir and the replacement cost is accounted for the project cost. A potential power about 4MW can be developed by the head difference at the outlet of the Rui diversion tunnel and, thus the power demand of the Pong station and the minor reduction of the secondary energy at the Kenering and Chenderoh power station in the Perak river could be compensated.

The major features and the construction schedule of the recommended water source facilities are presented in Table 81. The major features of the existing dams and barrages in Basins 3, 5, 6 and 7 are listed in Tables 22 and 23. The location and the route of the recommended dams and diversion facilities are shown in Fig. 38. The location of the alternative water source facilities is shown in Fig. 6.

Fig. 46 shows the schematic correlation among natural runoff, source water demand, withdrawal, return flow (demand minus withdrawal) and minimum river maintenance flow under the hydrological condition with recommended design drought level in the year 2000 by Basin in the Perlis, Kedah and Pulau Pinang region. The seasonal variation of runoff surplus and water deficit (the shaded portion) can be observed and the deficit is planned to be replenished by the recommended water source facilities consisting dams which store the runoff surplus in flood season and discharge it during the deficit season and water diversion facilities which aim to transfer water from the water abundant Basin to the water tight Basin.

(2) Pulau Langkawi

The river utilization ratio of the Pulau Langkawi is estimated to be 10% in the year 1990 and 11% in the year 2000. The irrigation water demand is predominant and the design drought level of 4/19 is adopted for the recommended plan. The source water demand is presented in Table 16. The required supply capacity and the recommended water demand and supply balance program is shown in Table 62 and Fig. 32.

The recommended construction plan is composed of the Aver Tawar dam and the Ulu Melaka dam. The major features and the construction schedule of the recommended water source facilities are presented in Table 81. The location of the two dams is shown in Fig. 38. The location of the alternative water source facilities is shown in Fig. 6.

(3) Kerian and Kurau river

The river utilization ratio of the Kerian river (Basin 8) and the Kurau river (Basin 9) is projected to be 3% and 46% respectively in the year 2000. In Basins 8 and 9 the irrigation water demand is predominant and the design drought level of 4/19 is applied. The annual source water demand is presented in Table 16. Inter-basin water diversion is operated for the Kerian irrigation project (23,490 ha) from Basin 8 to Basin 9. The Kerian irrigation project area is mostly located in the northwest coast of the State of Perak, but 1,504 ha of the total area is located in the State of Pulau Pinang. The Bukit Merah dam in the Kerian river and the Kerian barrage are in operation for irrigation. The correlation among demand centers and water source and diversion facilities is expressed in a model as shown in Fig. 18. The required supply capacity and the recommended water demand and supply balance program are shown in Table 63 and Fig. 33.

Construction of the Kerian dam is recommended in the Kerian river, which flows along the state boundary between the state of Kedah and the state of Perak. The major features and the construction schedule are presented in Table 82. The major features of the existing dam and barrage are listed in Tables 22 and 23. The location is shown in Fig. 39. The location of the alternative water source facilities is shown in Fig. 7.

(4) Kinta valley

The river utilization ratio of the Perak river is estimated to be 10% in the year 2000. The irrigation water demand is predominant as a whole and the design drought level of 4/19 is adequate for the Perak river. The annual source water demand of domestic and industrial water supply and irrigation is presented in Table 16. The demand will be fulfilled if the Temengor, Kenering and Bersia hydropower dams are fully commissioned and operated adequately. The major features of the three hydropower dams are listed in Tables 22 and 23. The desirable minimum river maintenance flow (Q97%) is assumed to be 52.3 m^3/s at the boundary of effective catchment area near the estuary (see Section 2.2.3).

The problem area is the Kinta Valley, the upper catchment of Ipoh. The river utilization ratio is estimated to be 19% at the upstream of Ipoh in the year 2000. The demand of domestic and industrial water supply is predominant and the design drought level of 1/19 is applied. The correlation among water demand centers and water source facilities in the Perak river basin is drawn in a model as shown in Fig. 18. The rquired supply capacity and the recommended water demand and supply balance program are shown in Table 64 and Fig. 33.

Construction of the Kinta (B) dam is recommended in the upstream reaches of the Kinta river, the tributary of the Perak river. The major features and the construction schedule are presented in Table 83. The location is shown in Fig. 39. The location of the alternative water source facilities is shown in Fig. 7.

(5) Bernam and Tengi river basins

The river utilization ratio of the Bernam river (Basin 11) and the Tengi river (Basin 12) is estimated to be almost constant as 23 - 24% and 1% respectively from 1990 to 2000. The irrigation water demand is predominant in this area and the design drought level of 4/19 is applied. The annual source water demand is presented in Table 16. Inter-basin water transfer for the Tanjong Kerang irrigation scheme in the State of Selangor is in operation from the Bernam Weir in Basin 11 to Basin 12. The Bernam river lies along the state boundary between the State of Perak and the State of Selangor. The correlation among demand centers and water source and diversion facilities is drawn in a model as shown in Fig.20. The required supply capacity and the recommended water demand and supply balance program is shown in Fig. 34. No additional water source facilities are recommended because the supply capacity of the peat swamp in Tanjong Karang area is evaluated to be more than $92x10^6$ m^3/y and is assessed to be enough for the 4/19 design drought level. The supply capacity of the peat swamp is under investigation by DID and if it is assessed to be not enough, additional dam construction would be required.

The major features of alternatives B1 and B2 are shown in Table 28 and 40 respectively. The location of the alternative water source facilities is shown Fig. 8.

(6) Kelang valley

The Kelang valley is composed of the Federal Territory (Kuala Lumpur), Petaling Jaya, Shah Alam and Kelang and is in the Kelang river basin (Basin 15).

The river utilization ratio of the Kelang river is projected to be 99% in the year 2000, and that of the vicinity river basins is projected to be 1% in Basin 13 (Selangor), 5% in Basin 14 (Buloh) and 6% in Basin 16 (Langat). The demand of domestic and industrial water supply is predominant and the share is almost 100% in Basins 13, 14 and 15. The share of the domestic and industrial water is about 50% in Basin 16. The annual source water demand is presented in Table 16. The design drought level of 1/19 is applied to this region. The water source area is limitted to the catchment area of about 340 km^2 at upstream of Kuala Lumpur, and thus the domestic and industrial water is transfered by a pipeline system from Basin 16 to Basin 15 at present as shown in Table 24. The correlation among demand centers and water source and diversion facilities is expressed in a model as shown in Fig. 20. The required supply capacity and the recommended water demand and supply balance program are shown in Table 65 and Fig. 34.

The Kelang Gates dam and the Langat dam are in operation. The major features of the existing dams are listed in Tables 22 and 23.

The recommended construction plan is composed of the Selangor dam and the Batang Kali dam in Basin 13, the Batu dam and the Gombak dam in Basin 15, the Semenyih dam in Basin 16 and the Kenaboi dam, the Perting dam and the Kongkoi dam in the Pahang river (Basin 30). The Batu dam is under design stage. The Semenyih dam is under construction and the water is planned to be transferred from the Langat river to the Kelang valley. The Selangor dam is planned to transfer the water from Basin 13 to Basin 15 by a pipeline system. The Kenaboi dam and the Kongkoi dam are located in the State of Negeri Sembilan and the water is planned to be diverted through a tunnel system from Basin 30 to Basin 16 and a pipeline system from Basin 16 to Basin 15. The Perting dam is located in the State of Pahang and the water is planned to be diverted through a tunnel system from the upper reaches of the Pahang river and to the upper reaches of the Selangor river and finally from Basin 13 to Basin 15 by a pipeline system.

The major features and the construction schedule of the foregoing recommended water source facilities are presented in Table 84. The location and route of these facilities are shown in Fig. 40. The location of the alternative water source facilities is shown in Fig. 8.

Fig. 47 shows the schematic correlation among natural runoff, source water demand, withdrawal, return flow (demand minus withdrawal) and the minimum river maintenance flow under the hydrological condition with recommended design drought level in Basins 13, 15 and 16 in the year 2000.

The water dificit (the shaded portion) is larger than the runoff surplus in the Kelang river and the runoff surplus is aboundant in the Selangor and Langat rivers. The deficit is planned to be replenished by the recommended water source facilities consisting dams and water diversion facilities.

Though the portion of return flow is extremely large in the Kelang river as a whole as shown in Fig. 47, the return flow can not be practically used for water supply in the downstream of Kuala Lumpur.
The deficit, therefore is calulated for the sub-basin at the upstream of Kuala Lumpur neglecting the returnflow; that is, the withdrawal is assumed to be the same as the source water demand (see Table 105).

(7) Sepang river basin

The river utilization ratio of the Sepang river (Basing 17) is projected to be 51% in the year 2000. The major water demand is the domestic and industrial water supply for Port Dickson and the design drought level of 1/19 is adopted for the recommended plan. The annual source water demand is presented in Table 16. The required supply capacity and the recommended water demand and supply balance program are shown in Table 66 and Fig. 35. The water demand and supply system diagram is shown in Fig. 22.

The recommended construction plan is composed of the Teriang and Gelami dams in the upper reaches of the Pahang river in the State of Negeri Sembilan and a pipeline transfer system of about 90 km from the Teriang sites to Port Dickson. The teriang and Gelami dams guarantee the compensation discharge including the minimum river maintenance flow for the upper reaches of the Pahang river as the Kenaboi, Kongkoi and Perting dams do.

The major features and the construction schedule of the recommended facilities are presented in Table 85. The location is shown in Fig. 41. The location of the alternative water source facilities is shown in Fig. 8.

(8) Linggi river basin

The river utilization ratio of the Linggi river (Basin 18) is projected to be 15% in the year 2000. The problem area is the upper catchment of Selemban. The river utilization ratio of the sub-basin with the catchment area of 163 km^2 is estimated to be 34% in the year 2000. The major water demand is the domestic and industrial water supply and thus the design drought level of 1/19 is adopted. The required supply capacity and the recommended water demand and supply balance program are shown in Table 67 and Fig. 35.

Construction of the Terip dam is recommended in the upstream reaches of the Liggi river. The major features and the construction schedule of the Terip dam are presented in Table 86. The location is shown in Fig. 41. The location of the alternative water source facilities is shown in Fig. 8.

(9) Melaka-Muar region

The river utilization ratio of the rivers in this region is estimated to be 48% in the Melaka river (Basin 19), 23% in the Kesang river (Basin 20) and 9% in the Muar river (Basin 21) in the year 2000. The annual source water demand is shown in Table 16. The design drought level of 1/19 is applied to Basins 19 and 20 and that of 4/19 is applied to Basin 21. Water transfer from Basin 21 to Basins 19 and 20 is proposed and the correlation among demand centers and water source and water diversion facilities is shown in Fig. 22. The required supply capacity and the recommended water demand and supply balance program are shown in Table 68 and Fig. 35.

The Durian Tunggal dam is in operation for water supply in the Melaka river. The Asahan dam, which is located in the Muar river in Johor, is operated for water supply to Melaka. The major features of these dams are listed in Tables 22 and 23.

The recommended construction plan is composed of the Muar dam, the Palong dam and the Muar barrage and diversion canal. The Muar dam is located in the State of Negeri Sembilan and the Palong dam is located over the State border between the State of Negeri Sembilan and the State of Pahang. The Muar barrage is installed near the estuary of the Muar river in the State of Johor and the water is transferred by a canal system from the barrage to Basin 19 in the State of Melaka and Basin 20 which is mostly shared by the State of Melaka and the State of Johor.

The major features and the construction schedule of the recommended water source facilities are presented in Table 87. The location and the route are shown in Fig. 41. The location of the alternative water source facilities is shown in Fig. 9.

(10) South Johor region

The river utilization ratio of the rivers in this region is projected to be 15% in Basin 23 (the Pontian Kechil, Sekudai, Teberan and other rivers) and 19% in the Johor river (Basin 24). The source water demand, which is mostly for domestic and industrial water supply to Johor Bahru and Singapore, is shown in Tables 16 and 106. The Basin 23 is divided into three parts, Sub-basin 23A (the Benut river), Sub-basin 23B (the Pontian Kechil, Pontian Besal, Pulai and Sekudai rivers) and Sub-basin 23C (the Teberau river). The Basin 24 is divided into two parts, Sub-basin 24A (the catchment at the proposed Johor barrage) and Sub-basin 24B (the remainder of Basin 24). For the detailed water demand and supply balance analysis, the demand of Johor Bahru is charged on the Sub-basin 23C and the demand of Singapore which is projected to be 319×10^6 m^3/y in 1990 and 407×10^6 m^3/y in 2000 is charged on the Sub-basin 24A. The total supply capacity for Singapore of the existing three dams, the Gunong Pulai dam, the Pontian Kechil dam and the Pulai III dam is assumed to be 7 x 10^6 m^3/y and is charged on the Sub-basin 23B. The design drought level of 1/19 is applied to the Sub-basins 23C and 24A. Water transfer from Basins 24 and 25 to Sub-basin 23C and Singapore is proposed and the correlation among demand centers and water source and diversion facilities is shown in Fig. 24. The required supply capacity and the recommended water demand and supply balance program are shown in Table 69 and Fig. 36.

The recommended construction plan is composed of the Semangar dam, the Linggiu dam and the Pengeli dam in the tributaries of the Johor river, the Sedili dam in the Sedili Besar river, the Johor barrage and transfer canal in the main stream of the Johor river, the Semangar diversion canal from Sub-basin 24A to Sub-basin 23C, the Sediri diversion canal and pipeline system from Basin 25 to Sub-basin 24A and the Teberau barrage and transfer pipeline system from Sub-basin 23C to Johor Bahru and Singapore. The Linggiu dam requires construction of a saddle dam in the Jengeli river.

The major features and the construction schedule of the foregoing recommended facilities are presented in Table 88. The location and route are shown in Fig. 42. The location of the alternative water source facilities is shown in Fig. 10.

Fig. 47 shows the schematic correlation among natural runoff, source water demand, withdrawal, return flow and the minimum maintenance flow under the hydrological condition with the recommended design drought level in Basins 23 and 24 in the year 2000.

(11) Anak Endau river basin

The river utilization ratio of the Endau river (Basin 27) is projected to be 7% as a whole basin in the year 2000. The Sawah Endau irrigation project is however planned in the Anak Endau river, the tributary of the Endau river and the river utilization ratio becomes locally high. The Anak Endau river is in the State of Pahang but the Endau river lies along the State boundary between the State of Pahang and the State of Johor about 25 km from the river mouth. The Anak Endau dam, the Kemelai dam and the Anak Endau weir are under construction for this project. The major features and the construction schedule of these recommended facilities are presented in Table 89. The location is shown in Fig. 43.

(12) Kuantan river basin

The river utilization ratio of the Kuantan river (Basin 31) is projected to be slightly less than 10% in the year 2000. The major demand is for the domestic and industrial water supply to Kuantan. The Kuantan barrage is under construction to protect water supply intakes from the sea water intrusion at about 10 km upstream from the river mouth. The construction schedule is shown in Table 90 and the location is shown in Fig. 43.

(13) Kemasin, Kelantan and Golok river basins

The river utilization ratio of the Kemasin river (Basin 39), the Kelantan river (Basin 40) and the Golok river (Basin 41) is projected to be 3%, 10% and 4% in the year 2000 respectively. The major water demand is for the North Kelantan, Kembu and Kemasin Semerak irrigation schemes and the minor irrigation schemes in this area. The annual source water demand is presented in Table 16. The inter-basin water usage from Basin 40 to Basins 39 and 41 is proposed as shown in Fig. 30. The demand increase ($28x10^6$ m^3/y) for the domestic and industrial water supply in Basin 39 is planned to be transferred from Basin 40. The irrigation demand for the Kembu and Kemasin Semerak irrigation schemes in Basin 39 is planned to be diverted from Basin 40. A part of the irrigation demand for the minor schemes in Basin 41 is also planned to be diverted from Basin 40. The required supply capacity and the recommended water demand and balance program which fulfills the design drought level of 4/19 are shown in Table 70 and Fig. 37. The water source facilities are not required until around the year 2000 in accordance with the river utilization ratio, but the Nenggiri dam is recommended to be commissioned by 1988 under the hydropower development program (see Section 4.2). It is consequently recommended that the Neuggiri dam is planned as a multipurpose development which integrates hydropower development and water source development.

The Nal dam, which is under study by DID, is proposed in the Nal river in the tributary of the Kelantan river for replenishing the irrigation water demand in this area locally.

The major features and the construction schedule of the recommended facilities are presented in Table 91. The location is shown in Fig. 45.

(14) Golok plain

An international committee has been established for developing the Golock river, which flows along the international boundary between the State of Kelantan and Thailand. The Golok dam has been proposed to fulfill the irrigation water demand because the river utilization ratio will become high locally, while the ratio of the Golok river is projected to be 4% as a whole in the year 2000.

The major features and the construction schedule of the Golok dam is presented in Table 92. The location is shown in Fig. 45.

3.3 Potential Dam Sites and Features of Proposed Dams

3.3.1 Potential Dam Sites in Peninsular Malaysia

Two hundred and twenty one dam sites were selected as potential sites in Peninsular Malaysia for this study. The total catchment area of Peninsular Malaysia is 131,680 km^2 and, thus one site is found in average catchment area of about 600 km^2. Of the 221 sites, 139 sites were identified in the previous study reports (see references in the Sectoral Report, Water Resources Engineering, Part 1) and 72 sites were newly found by the study team. All the sites were confirmed in the maps of 1/63,360 scale and the catchment area, reservoir surface area and works quantities were measured in the same maps and used for the study of alternative water source development plans.

The name of dam sites, catchment area, annual inflow at each site and the State which each site belongs to are compiled by Basin in Tables 107 - 112. The location of these sites is shown in Figs. 6 - 13.

3.3.2 Features of proposed dams

Tables 113 - 158 show the major features of proposed dams, such as net supply capacity, active storage, gross storage, reservoir surface area and breakdown of project cost. The values which are not available are kept as blank.

4. HYDROPOWER DEVELOPMENT

4.1 Power Demand Forecast

The future power demand in Peninsular Malaysia was projected up to 2000 by NEB as shown in Table 159. The annual power demand is projected to be 23,080 GWh with the maximum power of 3,780 MW in 1990 and 51,820 GWh with the maximum power of 8,600 MW in 2000. The average annual growth rate of the energy production is estimated to be 10.4% in the period from 1980 to 1990 and 9.4% in the period from 1980 to 2000. The load factor of the power system are anticipated to be not changed greatly through the forecast period and the value is estimated to be from 68% to 70%. (see Sectoral Report, Power Market, Part I)

The maximum power demand per capita is estimated in Table 160. The maximum power demand is estimated for the case of the lower economic growth by multiplying the maximum power demand per capita under the lower economic growth by the projected population and the result is shown in Table 161.

4.2 Recommended Hydropower Development Plans

The potential hydropower sites, of which installed capacity was estimated to be larger than or equal to 5 MW was selected from potential dam sites. The installed capacity was estimated with single purpose hydropower operation which is independent on the instream water usage. No run-of-river hydropower generation was studied except the Pergau sites.

The hydropower development plan was made to fulfill the preliminary hydropower development program which had been prepared and proposed by NEB in 1980 and the power demand forecast by NEB (Table 159) taking into account the minor modification made by NEB in 1981.

In this study 13 hydropower projects shown in Table 162 has been recommended; that is, 1 in the Trengganu river, 8 in the Pahang river and 4 in the Kelantan river. Eleven sites of these 13 sites, except Jelai and Tanum-1 sites, coincide the sites selected in the NEB preliminary hydropower development plan. The installed capacity and the development program planned by NEB has been adopted for these sites.

The hydropower development plan under the lower economic growth has been recommended as shown in Table 163 taking into account the maximum power demand forecasted for the case of lower economic growth (Table 161).

The major technical features of the recommended hydropower schemes are roughly estimated and presented in Tables 164 to 176, which compile gross storage, active storage, full supply level, reservoir surface area, dam height, installed capacity, annual energy, rated head and breakdown of the project cost. The values which are not available are kept as blank.

4.3 Criteria for Estimating Power Output

The installed capacity of generator and the annual energy are estimated by the following simplified criteria.

(1) Installed capacity

The installed capacity (power output) of generator (P) is given as:

$$P = 9.8 \cdot C \cdot Q \cdot He \quad \text{(kW)}$$

where,
- C : Composite efficiency of generating equipment (assumed to be 0.8)
- Q : Turbine discharge (m^3/sec)
- He: Effective hydraulic head (m)
  $= F.S.L. - \frac{2.5}{4} (F.S.L. - L.W.L.) -$ Riverbed elevation
- F.S.L.: Full supply level (m) corresponds to the water level for the active storage capacity
- L.W.L.: Low water level (m)
  $= F.S.L. - \frac{1}{3} (F.S.L. -$ Riverbed elevation)
  If the low water level is calculated to be lower than the dead water level, the water level was assumed to be the same as the dead water level which corresponds to the sedimentation volume of 100 years with the safety factor of 2.0.

The daily generation time is assumed to be 9 hours/day. The maximum active storage capacity is assumed to be the storage which can yield the annual draft of 100% of the annual inflow at a dam site. If the maximum gross storage is limited by topographic constraint, the active storage capacity is governed by the possible maximum gross storage capacity.

(2) Annual energy

The annual energy (Ea) is given as:

$$Ea = P \cdot T \quad \text{(kWh)}$$

where,
- P: Installed capacity (kW)
- T: Annual generation time (h)

The project cost is estimated in accordance with the criteria of cost estimates in Section 2.1.3.

4.4 Economic Benefit of Hydropower Development

4.4.1 Methodology

Economic benefit to be derived from power generation by the proposed hydropower projects is estimated based on the least-costly alternative power facilities cost criteria. As the alternatives, the following power plants are considered and economic comparison is made based on the price level at the end of 1980.

Alternatives	Unit Capacity (MW)
Oil-fired thermal	350 & 600
Gas-fired thermal	350 & 600
Coal-fired thermal	350 & 600
Nuclear	1,200
Combined cycle	200

For the proposed hydropower projects in Peninsular Malaysia, oil-fired thermal plant of 350 MW unit capacity is selected based on the results of the economic comparison, taking into account the projected total power demand in Peninsular Malaysia that is to be covered by a single power system, type and unit capacity of the power plants planned by NEB and other relevant matters.

4.4.2 Economic power benefit

(1) Power (kW) value

On the basis of the economic construction cost of 350 MW oil-fired thermal plant, annual equivalent cost required for producing the anticipated power is estimated for the discount rates of from 6% to 20% with the following assumptions:

(a)	Economic construction cost	M$1,120/kW
(b)	Construction period	3 yrs
(c)	Economic life	25 yrs
(d)	Salvage value	10%
(e)	Insurance (% of construction cost)	0.6%
(f)	Fixed O&M (% of construction cost)	1.85%

The annual equivalent costs per kW are estimated to be M$141.3 at 8% discount rate, M$187.5 at 12% and M$241.5 at 16%.

For the calculation of the kW value, adjustment factor of hydropower to the thermal power is calculated to be 1.24 as shown in Table 177.

The kW values, thus estimated, are as follows:

Discount Rate (%)	kW Value (M$/kW)
8	175.4
12	232.7
16	299.7

(2) Energy (kWh) value

The annual equivalent cost required for generating the projected energy is the sum of fuel cost and variable O&M cost of the 350 MW oil-fired thermal plant, which is calculated at M$0.1186/kWh with the following assumptions:

(a) Fuel consumption — 0.247 lit/kWh

(b) Oil price — M$75.5/barrel (US$34/barrel)

(c) Variable O&M (% of fuel cost) — 2.25%

For the calculation of the kWh value, adjustment factor of hydropower to the thermal power is calculated at 1.028 as shown in Table 177. The kWh value is estimated at M$0.1219/kWh.

(3) Economic power benefit

The total power benefit of each hydropower project is estimated for each discount rate as follows:

Total annual power benefit = Installed capacity x kW value
+ Annual energy output x kWh value

The annual equivalent of economic benefit at 8% discount rate for each hydropower project is shown in the Sectoral Report, Vol. 17, Public Expenditure and Beneficial and Adverse Effects.

5. BENEFICIAL AND ADVERSE EFFECTS DUE TO WATER SOURCE AND HYDROPOWER DEVELOPMENT

5.1 Parameters Showing Beneficial and Adverse Effects Due to Water Source and Hydropower Development

The beneficial and adverse effects due to the alternative water source development for water demand and supply balance programs and hydropower development are evaluated from the standpoint of national economic development, environmental quality and social well-being as set out below:

1) National economic development

   (a) economic benefit

   (b) economic cost

   (c) economic internal rate of return

2) Environmental quality

   (a) beneficial effect; safe river maintenance flow period

   (b) adverse effect; possible reduction in kind of fish immediately downstream of dams and barrages (number of sites)

3) Social well-being

   (a) beneficial effect;

   . safe water supply period

   . drought damage ratio

   (b) adverse effect

   . number of people to be removed for construction of water source and hydropower facilities

   . land compensation and resettlement

The beneficial and adverse effects on all the sectors are evaluated for the whole Malaysia in the Main Report, Vol. 2. It is evaluated by State basis in the State Reports (Vols. 1 - 10) and the detailed evaluation is made for each sector by project basis in the Sectoral Report, Public Expenditure and Beneficial and Adverse Effects. In this chapter the calculation procedure and results of the effects due to water source development and hydropower development are independently presented.

5.2 National Economic Development

The beneficial and adverse effects of the alternatives on the national economic development account are calculated as the annual equivalent of economic benefits and costs, assuming a discount rate of 8% for an evaluation period of 50 years between 1981 and 2030.

The prices of internationally traded goods and services are estimated based on the World Bank projection to 1990, or the international market price in December, 1980. The prices of locally traded goods and services are the normalized price in December, 1980. The transfer payments such as tax and local contractors' profit are deducted from all prices. The ratio of transfer payment to the financial cost is assumed to be 20% of financial cost referring to the ratio of tax revenue to GDP at purchasers' price in 1980 in 4MP.

The supply capacity required for multipurpose development scheme is allocated to domestic and industrial water supply and irrigation water supply in proportion to the demand.

The domestic and industrial water supply benefit is estimated based on the least-costly alternative facilities cost criteria. A construction schedule of dams to meet the required supply capacity which is allocated to domestic and industrial water supply is prepared, assuming the least costly dams among those which are not proposed for the alternative. The cost of the above-mentioned dams and the proposed intake, conveyance, treatment and distribution system is regarded as the benefit of domestic and industrial water supply without drought damage.

So far as the hydrological condition in 19 years from 1961 and 1979 is assumed, all water deficit can be met by Alternative B1 in the Basins with the river utilization of more than 10%. On the other hand, there may be a certain water deficit in the cases of Alternatives B2 and B3.

There should be established a rule for the emergency operation against the drought in which both the rate of water withdrawal and rate of river maintenance flow should be sustained as much as possible and the river flow should be kept not below the essential river maintenance flow. Herein a simplified rule is assumed that water withdrawal for use continues until the river flow lowers to the essential river maintenance flow after water withdrawal and thereafter the water withdrawal is reduced so that river flow no longer lowers. Consequently the reduction in supply for domestic and industrial water demand and irrigation water demand was calculated through the 19-year period of 1961 to 1979 for Alternatives B2 and B3, allowing low flow after the water withdrawal to be equal to the essential river maintenance flow. The reduction in benefit was calculated assuming that it is proportional to the reduction in the supply. The drought damage ratio is estimated in Section 5.3.2 for this purpose.

The economic internal rate of return (EIRR) is calculated as the discount rate with which the present worth of benefit equals to that of cost.

All the results for the national economic development account are compiled in the Main Report (Vol. 2), the State Reports and the Sectoral Report (Public Expenditure and Beneficial and Adverse Effects).

The benefit of the hydropower development is described in Section 4.4.

5.3 Environmental Quality and Social Well-being

5.3.1 Safe river maintenance flow period

The river maintenance flow is the requisite for the conservation of river environment and adequate water use. The effect on the river maintenance flow is evaluated by the safe river maintenance flow period defined as follows:

The period when the desirable river minimum maintenance flow (the daily mean discharge with the probability of exceedence of 97%, Q97%) is sustained under the most severe drought ever recorded (1/N), provided 100% water supply is guaranteed.

The calculation model of the safe river maintenance flow period is shown in Table 178. The safe river maintenance flow is calculated for the both conditions before (without structural measures) and after (with structural measures) the structural measures of water source facilities are provided. The results of the alternatives B1 - B3 are shown in Table 179 for the year 1990 and Table 180 for the year 2000. The results of the recommended plan are shown in Table 182 for 1990 and Table 183 for 2000. The value with structural measures are compared with the value without structural measures under 1/N drought level to show the rate of improvement. Table 181 shows the values without structural measures under different drought level, 1/N, 2/N and 4/N for the 41 Basins. The results of recommended plan under the lower economic growth are presented in Table 184 for 1990 and Table 185 for 2000.

5.3.2 Safe water supply period and drought damage ratio

The safe water supply period is defined as follows:

The period when water supply is guaranteed 100% but the river minimum maintenance flow is reduced to the essential minimum maintenance flow (the daily mean discharge with the probability of exceedence of 99%, Q99%) under the most severe drought ever recorded (1/19).

The drought damage ratio is defined as follows:

The ratio of total amount of water shortage in 19 years to the total amount of developed water including river minimum maintenance flow (Q97%) and withdrawal of all the sectors in 19 years in percent, provided alternative structural measures are given.

The calculation model of the safe water supply period and the drought damage ratio is shown in Table 178.

The safe water supply period is estimated for the both conditions before (without structural measures) and after (with structural measures) the structural measures of water source facilities are provided. The results of the alternatives B1 - B3 are shown in Table 179 for the year 1990 and Table 180 for the year 2000. The results of the recommended plan are shown in Table 182 for 1990 and Table 183 for 2000. The value with structural measures is compared with the value without structural measures under 1/N drought level to show the rate of improvement. Table 181 shows the values without structural measures under different drought level, 1/N, 2/N and 4/N for the 41 Basins. The results of recommended plan under the lower economic growth are presented in Table 184 for the year 199 and Table 185 for the year 2000.

The drought damage ratio is estimated for the case with structural measures and the results of alternatives B1 - B3 are shown in Table 186. Table 187 shows the results of recommended plans under the both target and lower economic growth in the year 1990 and 2000.

5.3.3 Resettlement and effects on aqua-ecology

The number of people to be removed for the purpose of construction of proposed water source and hydropower development facilities is calculated as adverse effect.

If a dam or a barrage is constructed, some species of fish would disappear within a certain length of river stretch immediately downstream of the dam reflecting an adverse effect on ecological system, though such adverse effect could be compensated by possible cage culture in the created reservoir. The number of dam or barrage sites is counted as the adverse effect.

These results are compiled in the Main Report, the State Reports and the Sectoral Report (Public Expenditure and 'Beneficial and Adverse Effects).

The land compensation and resettlement cost is accounted for the project cost. Table 188 shows the standard land compensation and resettlement cost used in this study.

5.4 Number of Proposed Facilities and Manpower Requirement

The number of proposed water source facilities (i.e. dams and barrages) and hydropower projects (dams) is counted as of the commission year of the facilities and is compiled in the period of Malaysia Plan from 5MP (1986 - 1990) to 7MP (1996 - 2000) as listed in Table 189 for alternative source facilities, Table 190 for recommended water source facilities and Table 191 for recommended hydropower dams.

The manpower, which is required for construction, operation and maintenance of the proposed facilities is also counted in terms of the number of the required staff. The results are compiled in Malaysia Plan by alternative or recommended plan as shown in Tables 192 - 196 for water source facilities and Table 197 for hydropower dams.

The grade of government staff is classified into 4 from A to D based on the information from the Government of Malaysia. The number of staff requirement for a project is assumed as set out below:

Grade	Construction	Operation and Maintenance
(i) Water source facilities (dams)		
A; Engineer	1	1
B; Technical assistant	1	1
C; Technician	2	1
D; Others	3	4
Total	7	7
(ii) Hydropower dams		
A; Engineer	1	1
B; Technical assistant	2	2
C; Technician	2	1
D; Others	3	4
Total	8	8

REFERENCES

1. VEN TE CHOW (Editor-in-Chief), HANDBOOK OF APPLIED HYDROLOGY, MacGraw-Hill, 1964, pp8.28 - 8.29

2. EPU, KEDAH-PERLIS WATER RESOURCES MANAGEMENT STUDY, Final Report (revised), YIS & RE, Vols. 1 - 5 July 1980

3. GOM, STUDY OF WATER RESOURCES MANAGEMENT IN THE PAHANG TENGGARA REGION, Final Report, MACE & etal, 1981

VOL. 1	EXECUTIVE SUMMARY
VOL. 2	WATER RESOURCES - Needs & Development Potential
VOL. 3	WATER RESOURCES - Quality Control & Management

Remarks; The other reports referred in Phase II Study are compiled in the Sectoral Report, Water Resources Engineering, Part 1.

TABLES

Table 1 SEDIMENTATION VOLUME AND DEAD STORAGE VOLUME

Applied Basin No.	Annual Specific Sediment Load ($m^3/Km^2/Year$)	100 year Sedimentation Volume ($m^3/Km^2/100Y$)	Assumed Dead Storage Volume (m^3/Km^2)
1∿9	150	15,000	30,000
10∿17	300	30,000	60,000
18∿29	100	10,000	20,000
30∿39&41	150	15,000	30,000
40	200	20,000	40,000

Table 2 STANDARD DIRECT COST FOR DAMS AND BARRAGES

(A) DAM

Assumptions

1) Dam type	Rockfill dam
2) Typical cross section	Slope of upstream and downstream: 4 Foundation excavation: 10-30 m depending on height of dam Crest width: 10 m Free board : 3.0 m

Direct cost

Unit cost	Volume of dam
US$20/$m^3$:	2 million m^3 or larger
US$25/$m^3$:	between 0.5 and 2 million m^3
US$30/$m^3$:	0.5 million m^3 or less

(US$1.00 = M$2.22)

Direct unit cost includes those of dam, spillway, diversion, intake and other appurtnant structures.

The unit cost was based on the actual construction cost of some dams in Nepal, Jordan, Indonesia and Malaysia from 1978 to 1980.

(B) Barrage/weir

M$1,450/m per m^3/s of 100-year maximum discharge capacity.

Table 3 STANDARD DIRECT COST FOR TUNNELS

Assumptions

1) Type — Pressure or free flow tunnel with concrete lining

2) Typical cross section — Circular type with lining thickness of 0.12 D (diameter)

Flow velocity was assumed at 2 m/sec.

3) Unit cost — Unit cost was expressed as construction cost per meter length of tunnel for some selected flow capacities.

The unit cost was estimated as a sum of excavation and concrete lining cost.

Excavation cost = US$40/$m^3$
Concrete lining = US$100/$m^3$

These costs were also based on the actual construction cost of the dam projects referred in dam cost estimate.

Direct cost

Flow capacity	Q	(m^3/s)	5	10	20	30
Dia	D	(m)	1.78	2.52	3.57	4.37
Excavation per meter	E	(m^3/m)	4.64	8.69	17.84	26.71
Concrete per meter	C	(m^3/m)	1.47	3.70	7.83	11.71
Cost						
Excavation		(US$/m)	185.6	347.6	713.6	1,068.4
Concrete		(US$/m)	147.0	370.0	783.0	1,171.0
Total unit direct cost		(US$/m)	332.6	717.6	1,496.0	2,239.4

Table 4 STANDARD DIRECT COST FOR OPEN CANALS

Assumptions

1) Type — Open canal with side lining

2) Typical cross section — Side slope : 1 : 2.5
Bottom : 3 h (h: design depth)
Allowance : 1.0 - 1.5 m
Flow velocity: 1.0 m/sec

3) Unit cost — Unit cost was expressed as construction cost per meter length for some selected flow capacity.

The unit cost was estimated as a sum of excavation and lining cost.

Excavation: US\$5/m^3
Lining : US\$80/m^3

Direct cost

Flow capacity	Q (m^3/s)	5	10	20	30
Depth	H (m)	0.95	1.35	1.9	2.3
Allowance	F (m)	1.0	1.0	1.2	1.5
Excavation	E (m^3/m)	15	23	42	62
Concrete	C (m^3/m)	1.53	2.18	3.07	3.72
Cost: Excavation	(US\$/m)	75	115	210	310
Concrete	(US\$/m)	122.4	134.4	245.6	297.6
Total unit direct cost	(US\$/m)	197.4	289.4	455.6	607.6

Table 5 STANDARD DIRECT COST FOR PIPELINES

Assumptions

1) Type — Steel pipeline

2) Cross section — Flow velocity: 2 m/sec
Thickness : minimum 8 mm

3) Unit cost — Unit cost was expressed as construction cost per meter length for some selected flow capacities.

Unit cost of materials per weight was estimated at US$5,400/ton which included steel material, erection and civil foundation cost.

Direct cost

Discharge	Q (m^3/sec)	1	2	3	5	10
Dia	D (m)	0.80	1.13	1.38	1.78	2.52
Thickness	T (mm)	8	10	10	10	12
Weight	W (kg/m)	159	280	342	446	740
Cost per meter	(US$/m)	859	1,512	1,847	2,408	3,996

Table 6 STANDARD DIRECT COST FOR PUMP STATIONS AND ACCESS AND RELOCATION ROADS

(A) Pump station

Assumptions

1) Type — Horizontal double suction volute pump

2) Unit cost — Unit cost was expressed as construction cost for some selected combination of suction head and discharge.

The pump cost included pump, motor and base structures.

Civil cost was assumed 100% of the pump cost.

Direct cost

Discharge	Q (m^3/min)	50	50	50	100	100	100	200	200
Head	H (m)	20	40	90	20	40	90	20	40
Motor capacity	(kW)	230	550	1,250	480	980	2,200	1,100	1,850
Pump cost	(US$$10^3$)	75	110	190	165	215	470	340	595
Civil cost	(US$$10^3$)	75	110	190	165	215	470	340	595
Total cost	(US$$10^3$)	150	220	380	330	430	940	680	1,190

O&M cost

Energy: M$10/kWh

Maintenance including operators: 1% of the total construction cost/year

(B) Single lane access road and relocation road

Assumptions

1) Type — Single lane rural class

Direct cost

Access road including pavement: M$300,000/km

Pavement only : M$100,000/km

2) Relocation road : M$300,000 - M$800,000/km

Table 7 BASIN DIVISION AND CATCHMENT AREA

No.	Basin	Catchment Area (km^2)	Effective Area (km^2)
1	Perlis	790	550
2	Pulau Langkawi	475	350
3	Kedah	3,695	2,510
4	Merbok	520	340
5	Muda	4,300	4,200
6	Perai	895	600
7	Pulau Pinang	300	220
8	Kerian	1,420	1,360
9	Kurau	3,255	1,155
10	Perak	14,700	13,555
11	Bernam	3,335	2,325
12	Tengi	565	420
13	Selangor	1,820	1,685
14	Buloh	560	295
15	Kelang	1,425	1,150
16	Langat	1,815	1,800
17	Sepang	640	260
18	Linggi	1,420	1,310
19	Melaka	1,010	775
20	Kesang	705	675
21	Muar	6,595	6,170
22	Batu Pahat	2,600	2,250
23	Pontian Kechil	2,660	1,800
24	Johor	3,250	2,490
25	Sedili Besar	1,820	1,495
26	Mersing	880	465
27	Endau	4,740	4,350
28	Rompin	4,285	3,730
29	Bebar	1,895	570
30	Pahang	29,300	27,650
31	Kuantan	2,025	1,635
32	Kemaman	2,570	2,245
33	Paka	850	815
34	Dungun	1,875	1,760
35	Marang	760	650
36	Trengganu	4,650	4,600
37	Setiu	1,035	875
38	Besut	1,230	940
39	Kemasin	1,020	310
40	Kelantan	13,100	12,600
41	Golok	895	835
Total		131,680	113,770

Table 8 MINIMUM RIVER MAINTENANCE FLOW IN EFFECTIVE AREA

Basin No.	Effective Catchment Area (km^2)	Balance Point (km)	Q97%		Q99%	
			$m^3/s/100\ km^2$	m^3/s	$m^3/s/100\ km^2$	m^3/s
1	550	12	0.418	2.3	0.309	1.7
2	350	Unspecified	0.657	2.3	0.457	1.6
3	2,510	15	0.570	14.3	0.406	10.2
4	340	12	0.618	2.1	0.441	1.5
5	4,200	10	0.667	28.0	0.476	20.0
6	600	15	0.750	4.5	0.533	3.2
7	220	Unspecified	0.727	1.6	0.500	1.1
8	1,360	7	0.750	10.2	0.537	7.3
9	1,155	45	0.675	7.8	0.485	5.6
10	13,555	70	0.386	52.3	0.203	27.5
11	2,325	53	0.671	15.6	0.447	10.4
12	420	15	0.810	3.4	0.667	2.8
13	1,685	32	1.16	19.6	0.950	16.0
14	295	15	0.746	2.2	0.610	1.8
15	1,150	29	0.913	10.5	0.748	8.6
16	1,800	44	0.878	15.8	0.717	12.9
17	260	12	0.846	2.2	0.692	1.8
18	1,310	3	0.191	2.5	0.046	0.6
19	775	5	0.155	1.2	0.039	0.3
20	675	4	0.119	0.8	0.059	0.4
21	6,170	20	0.133	8.2	0.100	6.2
22	2,250	3	0.200	4.5	0.151	3.4
23	1,800	8	0.644	11.6	0.522	9.4
24	2,490	42	0.566	14.1	0.458	11.4
25	1,495	16	0.649	9.7	0.528	7.9
26	465	14	0.817	3.8	0.667	3.1
27	4,350	25	0.694	30.2	0.561	24.4
28	3,730	40	0.536	20.0	0.434	16.2
29	570	49	0.737	4.2	0.596	3.4
30	27,650	44	0.517	143.0	0.170	47.1
31	1,635	13	0.709	11.6	0.557	9.1
32	2,245	5	1.03	23.1	0.811	18.2
33	815	2	0.908	7.4	0.712	5.8
34	1,760	10	1.17	20.6	0.926	16.3
35	650	6	1.25	8.1	0.985	6.4
36	4,600	1	1.34	61.5	1.06	48.6
37	875	6	1.14	10.0	0.903	7.9
38	940	17	1.12	10.5	0.883	8.3
39	310	35	1.55	4.8	1.19	3.7
40	12,600	31	1.31	164.5	1.02	128.7
41	835	8	1.68	14.0	1.31	10.9

Remarks; Q97%, Q99% = The daily discharge with the probability of exceedance of 97% and 99% respectively.

Table 9 NUMBERING OF STATES

State No.	Name of State	State No.	Name of State
1	Perlis	7	Melaka
2	Kedah	8	Johor
3	Pulau Pinang	9	Pahang
4	Perak	10	Trengganu
5	Selangor	11	Kelantan
6	Negeri Sembilan	12	Sabah
		13	Sarawak

Table 10 NUMBERING OF PROSPECTIVE CITIES/TOWNS

No.	Name	No.	Name	No.	Name
C1	Kangar	C41	Keluang	C123	Yong Peng
C2	Alor Setar	C42	Mersing	C124	Pekan Nanas
C3	Sungai Petani	C43	(Kuala Rompin)	C125	Jementah
C4	Kulim	C44	(Pekan)	C126	Ulu Tiram
C5	Butterworth/Perai	C45	Temerloh/Mentakab	C127	Senai
C6	Bukit Mertajam	C46	Bentong	C128	Kelapa Sawit
C7	(Sungai Bakap)	C47	Kuantan	C129	Masai
C8	Georgetown	C48	Jerantut	C130	Mentakab
C9	(Bayan Lepas)	C49	Raub	C131	Teriang
C10	Taiping	C50	Kuala Lipis	C132	Ulu Trengganu
C11	Kuala Kangsar	C51	Chukai	C133	Kuala Krai
C12	Sg. Siput Utara	C52	Dungun	C134	Kadok
C13	Ipoh	C53	Kuala Trengganu	C135	Gua Musang
C14	Batu Gajah	C54	Tanah Merah	C136	Rantau Panjang
C15	Kampar	C55	Kota Bahru	C137	Pt 1
C16	(Lumut)	C56	Peringat	C138	Pt 2
C17	Telok Anson	C57	Pengkal Kalong	C139	Pt 3
C18	Tapah	C58	Pasir Mas	C140	Pt 4
C19	(Bidor)	C59	(Tumpat)	C141	Pt 5
C20	(Kuala Selangor)	C101	Jitra	C142	Pt 6
C21	Kuala Kubu Baru	C102	Gura Chempedak	C143	Pt 7
C22	Kelang	C103	Yen	C144	Pt 8
C23	Shah Alam	C104	Tikan Batu	C145	Pt 9
C24	Petaling Jaya	C105	Air Itam	C146	Pt 10
C25	W. Persekutuan ((Kuala Lumpur))	C106	Tg. Tokong	C147	Pt 11
		C107	Gelugor	C148	Pt 12
C26	Kajang/Semenyih	C108	Tg. Bunga	C149	Pt 13
C27	(Banting/Jenjerom)	C109	Kg. Pmtg Kuching	C150	Pt 14
C28	Port Dickson	C110	Perai	C151	Pt 15
C29	Seremban	C111	Baru Mambang	C152	Pt 16
C30	Kuala Pilah	C112	Bagan Serai	C153	Pt 17
C31	Melaka	C113	Jelapang	C154	Pt 18
C32	Segamat	C114	S. Buloh	C155	Pt 19
C33	Tangkak	C115	Semenyih	C156	Pt 20
C34	Muar	C116	Ampang		
C35	Batu Pahat	C117	Serdang Baru		
C36	(Air Hitam)	C118	Bahau		
C37	Pontian Kechil	C119	Tampin		
C38	Kulai/Senai	C120	Kelebang		
C39	Johor Bahru	C121	Bukit Baru		
C40	Kota Tinggi	C122	Labis		

Remarks; In the water demand and supply system diagram a city is denoted as [2].

( ): Omission

Table 11 NUMBERING OF DISTRICTS

No.	Name	No.	Name	No.	Name
D 1	Perlis	D27	Batang Padang	D54	Mersing
D 2	Langkawi	D28	Sabak Bernam	D55	Rompin
D 3	Kulang Pasu	D29	Kuala Selangor	D56	Pekan
D 4	Padang Terap	D30	Ulu Selangor	D57	Temerloh
D 5	Kota Setar	D31	Gombak	D58	Bentong
D 6	Pendang	D32	Kelang	D59	Kuantan
D 7	Yan	D33	Petaling	D60	Jerantut
D 8	Sik	D34	Federal Territory ((W. Persekutuan))	D61	Raub
D 9	Kuala Muda	D35	Ulu Langat	D62	Lipis
D10	Baling	D36	Kuala Langat	D63	Cameron Highlands
D11	Kulim	D37	Sepang	D64	Kemaman
D12	Bandar Baharu	D38	Port Dickson	D65	Dungun
D13	Seberang Perai Utara	D39	Seremban	D66	Marang
D14	Seberang Perai Tengah	D40	Jelebu	D67	Ulu Trengganu
D15	Selatan	D41	Kuala Pilah/Jempol	D68	Kuala Trengganu
D16	Timur Laut	D42	Rembau	D69	Besut
D17	Barat Daya	D43	Tampin	D70	Ulu Kelantan/ Kuala Krai
D18	Perak Hulu/Selama = Perak Hulu	D44	Utara	D71	Pasir Puteh
D19	(Selama)	D45	Melaka Tengah	D72	Machang
D20	Kerian	D46	Selatan	D73	Tanah Merah
D21	Larut & Matang	D47	Segamat	D74	Bachok
D22	Kuala Kangsar	D48	Muar	D75	Kota Bharu
D23	Kinta	D49	Batu Pahat	D76	Pasir Mas
D24	Perak Tengah	D50	Pontian	D77	Tumpat
D25	Dinding	D51	Johor Bahru		
D26	Perak Hilir	D52	Kota Tinggi		
		D53	Keluang		

Remarks; In the water demand and supply system diagrams a district is denoted as ③.

( ): Omission

Table 12 MEAN ANNUAL RAINFALL AND RUNOFF BY BASIN IN PENINSULAR MALAYSIA

Basin No.	Effective Area (km^2)	Mean Annual Rainfall (mm/yr)	Mean Annual Runoff (10^6 m^3/yr)	Unit Mean Annual Runoff (10^6 $m^3/yr/km^2$)	Meam Annual Runoff Depth (mm)
1	550	1,903	465	0.846	846
2	350	2,500	455	1.301	1,301
3	2,510	2,274	2,837	1.130	1,130
4	340	2,433	426	1.253	1,253
5	4,200	2,528	5,569	1.326	1,326
6	600	2,780	893	1.488	1,488
7	220	2,700	311	1.413	1,413
8	1,360	2,790	2,037	1.498	1,498
9	1,155	2,634	1,560	1.350	1,350
10	13,555	2,342	12,848	0.948	948
11	2,325	2,490	2,564	1.103	1,103
12	420	2,142	347	0.826	826
13	1,685	2,498	1,992	1.182	1,182
14	295	2,068	222	0.752	752
15	1,150	2,246	1,070	0.930	930
16	1,800	2,207	1,604	0.891	891
17	260	2,176	224	0.860	860
18	1,310	2,082	1,204	0.919	919
19	775	1,910	583	0.752	752
20	675	1,778	358	0.530	530
21	6,170	1,796	3,849	0.624	624
22	2,255	2,088	2,095	0.929	929
23	1,800	2,521	1,940	1.078	1,078
24	2,490	2,395	2,362	0.949	949
25	1,495	2,534	1,632	1.091	1,091
26	465	2,795	632	1.359	1,359
27	4,350	2,601	5,046	1.160	1,160
28	3,730	2,343	3,340	0.895	895
29	570	2,659	695	1.219	1,219
30	27,650	2,127	24,238	0.877	877
31	1,635	2,629	1,691	1.034	1,034
32	2,245	3,097	3,369	1.501	1,501
33	815	2,923	1,082	1.327	1,327
34	1,760	3,309	3,013	1.712	1,712
35	650	3,414	1,181	1.816	1,816
36	4,600	3,549	8,974	1.951	1,951
37	875	3,273	1,466	1.676	1,676
38	940	3,239	1,544	1.642	1,642
39	310	2,795	532	1.715	1,715
40	12,600	2,558	18,522	1.470	1,470
41	835	2,966	1,580	1.892	1,892

Table 13 HYDROLOGIC WATER BALANCE AMONG RAINFALL, EVAPOTRANSPIRATION, DEEP PERCOLATION AND SURFACE RUNOFF BY BASIN

Unit: 10^9 m^3/year

Basin No.	Basin Name	Catchment Area (km^2)	Rainfall	Evapo-transpiration	Ground-water Recharge	Surface Runoff
1	Perlis	790	1.50	0.74	0.09	0.67
2	P. Langkawi	475	1.19	0.54	0.03	0.62
3	Kedah	3,695	8.40	3.52	0.70	4.18
4	Merbok	520	1.27	0.54	0.08	0.65
5	Muda	4,300	10.87	4.75	0.42	5.70
6	Perai	895	2.49	0.87	0.29	1.33
7	P. Pinang	300	0.81	0.36	0.03	0.42
8	Kerian	1,420	3.96	1.55	0.28	2.13
9	Kurau	3,255	8.57	2.72	1.46	4.39
10	Perak	14,700	34.43	18.56	1.93	13.94
11	Bernam	3,335	8.30	3.42	1.20	3.68
12	Tengi	565	1.21	0.52	0.22	0.47
13	Selangor	1,820	4.55	2.19	0.21	2.15
14	Buloh	560	1.16	0.59	0.15	0.42
15	Kelang	1,425	3.20	1.69	0.18	1.33
16	Langat	1,815	4.01	1.97	0.42	1.62
17	Sepang	640	1.39	0.62	0.22	0.55
18	Linggi	1,420	2.96	1.56	0.09	1.31
19	Melaka	1,010	1.93	1.11	0.06	0.76
20	Kesang	705	1.25	0.80	0.08	0.37
21	Muar	6,595	11.84	7.14	0.58	4.12
22	Batu Pahat	2,600	5.43	2.41	0.60	2.42
23	Pontian Kechil	2,660	6.71	3.09	0.75	2.87
24	Johor	3,250	7.78	4.23	0.47	3.08
25	Sedili Besar	1,820	4.61	2.33	0.29	1.99
26	Mersing	880	2.46	1.16	0.10	1.20
27	Endau	4,740	12.33	5.91	0.92	5.50
28	Rompin	4,285	10.04	5.64	0.56	3.84
29	Bebar	1,895	5.04	1.92	0.81	2.31
30	Pahang	29,300	62.32	34.27	2.35	25.70
31	Kuantan	2,025	5.32	2.80	0.43	2.09
32	Kemaman	2,570	7.96	3.75	0.35	3.86
33	Paka	850	2.48	1.27	0.08	1.13
34	Dungun	1,875	6.20	2.81	0.18	3.21
35	Marang	760	2.59	1.11	0.10	1.38
36	Trengganu	4,650	16.50	6.73	0.70	9.07
37	Setiu	1,035	3.39	1.34	0.31	1.74
38	Besut	1,230	3.98	1.69	0.27	2.02
39	Kemasin	1,020	2.85	0.62	0.48	1.75
40	Kelantan	13,100	33.51	12.91	1.34	19.26
41	Golok	895	2.65	0.74	0.22	1.69

Remarks; Groundwater recharge denotes deep percolation.

Table 14 HYDROLOGIC WATER BALANCE BY STATE

Unit: 10^9 m^3/y

State	Rainfall	Surface Runoff	Groundwater Recharge	Evapo-transpiration
Perlis	2	1	0	1
Kedah	23	12	1	10
Pulau Pinang	3	2	0	1
Perak	50	22	4	24
Selangor	18	7	2	9
Negeri Sembilan	14	5	1	8
Melaka	3	1	0	2
Johor	45	19	3	23
Pahang	80	33	4	43
Trengganu	43	22	2	19
Kelantan	39	23	3	13
Peninsular Malaysia	320	147	20	153
Sabah	194	113	14	67
Sarawak	476	306	30	140
Malaysia	990	566	64	360

Remarks; Groundwater recharge denotes deep percolation.

Table 15 ESTIMATED STATE SHARE OF CATCHMENT AREA BY BASIN

Basin No.	Name of Basin	Catchment Area (km2) Total	State Concerned
1	Perlis	790	Perlis(775), Kedah(15)
2	P. Langkawi	475	Kedah(475)
3	Kedah	3,695	Kedah(3,670), Perlis(25)
4	Merbok & Others	520	Kedah(520)
5	Muda	4,300	Kedah(4,223), P. Pinang(77)
6	Perai & Others	895	P. Pinang(610), Kedah(285)
7	P. Pinang	300	P. Pinang(300)
8	Kerian	1,420	Kedah(455), P. Pinang(58), Perak(907)
9	Kurau & Others	3,255	Perak(3,255)
10	Perak	14,700	Perak(14,700)
11	Bernam	3,335	Perak(1,835), Selangor(1,500)
12	Tengi & Others	565	Selangor(565)
13	Selangor	1,820	Selangor(1,820)
14	Buloh & Others	560	Selangor(560)
15	Kelang	1,425	Selangor(1,425)
16	Langat	1,815	Selangor(1,386), N. Sembilan(429)
17	Sepang & Others	640	Selangor(290), N. Sembilan(350)
18	Linggi & Others	1,420	N. Sembilan(1,105), Melaka(315)
19	Melaka & Others	1,010	Melaka(850), N. Sembilan(160)
20	Kesang	705	Melaka(510), N. Sembilan(37), Johor(158)
21	Muar & Others	6,595	Johor(4,025), N. Sembilan(2,492), Melaka(3), Pahang(75)
22	Batu Pahat & Others	2,600	Johor(2,600)
23	Pontian Kechil & Others	2,660	Johor(2,660)
24	Johor	3,250	Johor(3,250)
25	Sedili Besar & Sedili Kechil	1,820	Johor(1,820)
26	Mersing & Others	880	Johor(880)
27	Endau	4,740	Johor(3,835), Pahang(905)
28	Rompin & Pontian	4,285	Pahang(4,277), Johor(8)
29	Bebar & Merchong	1,895	Pahang(1,895)
30	Pahang & Penor	29,300	Pahang(27,000), N. Sembilan(2,300)
31	Kuantan & Others	2,025	Pahang(2,025)
32	Kemaman & Others	2,570	Trengganu(2,570)
33	Paka	850	Trengganu(850)
34	Dungun	1,875	Trengganu(1,875)
35	Merchang & Others	760	Trengganu(760)
36	Trengganu	4,650	Trengganu(4,650)
37	Setiu & Others	1,035	Trengganu(1,035)
38	Besut & Keluang	1,230	Trengganu(1,225), Kelantan(5)
39	Kemasin & Semerak	1,020	Kelantan(1,020)
40	Kelantan & Others	13,100	Kelantan(13,100)
41	Golok	895	Kelantan(895)

Table 16 RIVER UTILIZATION RATIO BY BASIN IN 1990 AND 2000 UNDER THE CONDITION OF TARGET ECONOMIC GROWTH

Basin No.	Basin Name	Surface Runoff in Effective Area (1) (10^6 m^3/y)	1990 Source Demand (10^6 m^3/y) D&I	1990 Irrigation	1990 Total (2)	1990 Ratio (2)/(1) (%)	2000 Source Demand (10^6 m^3/y) D&I	2000 Irrigation	2000 Total (3)	2000 Ratio (3)/(1) (%)
1	Perlis	465	16	189	205	44	37	213	250	54
2	Pulau Langkawi	455	2	45	47	10	3	45	48	11
3	Kedah	2,837	52	1,878	1,930	68	132	1,972	2,104	74
4	Merbok	426	22	48	70	16	61	48	109	26
5	Muda	5,569	23	539	562	10	36	618	654	12
6	Perai	893	147	166	313	35	218	166	384	43
7	Pulau Pinang	311	95	30	125	40	136	31	167	54
8	Kerian	2,037	3	54	57	3	5	61	66	3
9	Kurau	1,560	108	518	626	40	206	518	724	46
10	Perak	12,848	208	932	1,140	9	375	957	1,332	10
11	Bernam	2,564	27	567	594	23	36	567	603	24
12	Tengi	347	3	0	3	1	3	0	3	1
13	Selangor	1,992	29	0	29	1	29	0	29	1
14	Buloh	222	8	0	8	4	11	0	11	5
15	Kelang	1,070	687	0	687	64	1,060	0	1,060	99
16	Langat	1,604	45	41	86	5	51	41	92	6
17	Sepang	224	71	3	74	33	111	3	114	51
18	Linggi	1,204	44	110	154	13	67	111	178	15
19	Melaka	583	56	169	225	39	104	177	281	48
20	Kesang	358	8	72	80	22	11	72	83	23
21	Muar	3,849	70	236	306	8	109	246	355	9
22	Batu Pahat	2,095	50	5	55	3	81	5	86	4
23	Pontian Kechil	1,940	158	6	164	8	280	6	286	15
24	Johor	2,362	350	1	351	15	457	1	458	19
25	Sedili Besar	1,632	5	0	5	0	5	0	5	0
26	Mersing	632	8	0	8	1	14	0	14	2
27	Endau	5,046	39	210	249	5	62	274	336	7
28	Rompin	3,340	30	126	156	5	58	126	184	6
29	Bebar	695	2	9	11	2	4	9	13	2
30	Pahang	24,238	108	585	693	3	235	818	1,053	4
31	Kuantan	1,691	55	13	68	4	155	13	168	9.9
32	Kemaman	3,369	10	18	28	1	30	18	48	1
33	Paka	1,082	0	3	3	0	0	3	3	0
34	Dungun	3,013	8	31	39	1	24	37	61	2
35	Marang	1,181	2	26	28	2	2	47	49	4
36	Trengganu	8,974	57	200	257	3	161	208	369	4
37	Setiu	1,466	2	42	44	3	2	59	61	4
38	Besut	1,544	3	148	151	9.8	3	148	151	9.8
39	Kemasin	532	18	0**	18	3	18*	0**	18	3
40	Kelantan	18,522	76	1,203**	1,279	7	293*	1,586**	1,879	10
41	Golok	1,580	5	49**	54	3	9	49**	58	4

Remarks; D&I: Domestic and Industrial Water Supply

* ; Demand increase after 1990 is planned to be diverted from Basin 40.

**; Demand is planned to be diverted from Basin 40.

Table 17 RIVER UTILIZATION RATIO BY BASIN IN 1990 AND 2000 UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Basin Name	Surface Runoff in Effective Area (1) (10^6 m^3/y)	1990 Source Demand (10^6 m^3/y) D&I	1990 Source Demand Irrigation	1990 Source Demand Total (2)	1990 Ratio (2)/(1) (%)	2000 Source Demand (10^6 m^3/y) D&I	2000 Source Demand Irrigation	2000 Source Demand Total (3)	2000 Ratio (3)/(1) (%)
1	Perlis	465	13	189	202	43	23	213	236	51
2	Pulau Langkawi	455	2	45	47	10	2	45	47	10
3	Kedah	2,837	53	1,878	1,931	68	87	1,972	2,059	73
4	Merbok	426	18	48	66	15	32	48	80	19
5	Muda	5,569	21	539	560	10	30	618	648	12
6	Perai	893	126	166	292	33	178	166	344	39
7	Pulau Pinang	311	84	30	114	37	112	31	143	46
8	Kerian	2,037	3	54	57	3	4	61	65	3
9	Kurau	1,560	89	518	607	39	141	518	659	9.5
10	Perak	12,848	171	932	1,103	9	267	957	1,224	10
11	Bernam	2,564	27	567	594	23	32	567	599	23
12	Tengi	347	3	0	3	1	3	0	3	1
13	Selangor	1,992	33	0	33	2	39	0	39	2
14	Buloh	222	8	0	8	4	10	0	10	5
15	Kelang	1,070	629	0	629	59	907	0	907	85
16	Langat	1,604	47	41	88	5	63	41	104	6
17	Sepang	224	61	3	64	29	79	3	82	37
18	Linggi	1,204	39	110	149	12	51	111	162	13
19	Melaka	583	67	169	236	40	72	177	249	43
20	Kesang	358	8	72	80	22	10	72	82	23
21	Muar	3,849	64	236	300	8	94	246	340	9
22	Batu Pahat	2,095	44	5	49	2	67	5	72	3
23	Pontian Kechil	1,940	140	6	146	8	216	6	222	11
24	Johor	2,362	305	1	306	13	425	1	426	18
25	Sedili Besar	1,632	5	0	5	0.3	8	0	8	0.5
26	Mersing	632	7	0	7	1	11	0	11	2
27	Endau	5,046	35	210	245	5	52	274	326	7
28	Rompin	3,340	18	126	144	4	43	126	169	6
29	Bebar	695	1	9	10	1	4	9	13	2
30	Pahang	24,238	92	585	677	3	177	818	995	4
31	Kuantan	1,691	48	13	61	4	111	13	124	7
32	Kemaman	3,369	8	18	26	1	15	18	33	1
33	Paka	1,082	1	3	4	0.4	1	3	4	0.4
34	Dungun	3,013	7	31	38	1	14	37	51	2
35	Marang	1,181	1	26	27	2	1	47	48	4
36	Trengganu	8,974	50	200	250	3	102	208	310	3
37	Setiu	1,466	2	42	44	3	2	59	61	4
38	Besut	1,544	3	148	151	9.8	3	148	151	9.8
39	Kemasin	532	16	0**	16	3	28 *	0**	28	5
40	Kelantan	18,522	65	1,203**	1,268	7	135 *	1,202**	1,338	7
41	Golok	1,580	5	49**	54	3	6	49**	55	3

Remarks; D&I: Domestic and Industrial Water Supply

* : Demand increase after 1990 is planned to be diverted from Basin 40

** : Demand is planned to be diverted from Basin 40

Table 18 ANNUAL DEFICIT BY BASIN IN 1990 UNDER THE CONDITION OF TARGET ECONOMIC GROWTH

Unit: 10^6 m^3/y

Basin No.	Drought Level 1/N Deficit	1/N Year	2/N Deficit	2/N Year	3/N Deficit	3/N Year	4/N Deficit	4/N Year	5/N Deficit	5/N Year
1	63.3	1968	52.4	1963	44.5	1979	33.3	1965	33.2	1967
2	14.7	1968	12.4	1963	8.8	1979	7.4	1962	6.3	1967
3	963.4	1963	902.7	1968	863.1	1968	761.1	1965	649.3	1979
4	13.9	1968	11.9	1963	8.0	1979	7.8	1962	7.5	1965
5	221.5	1963	193.1	1968	147.8	1965	113.9	1979	106.6	1962
6	100.9	1963	85.1	1968	63.9	1965	55.7	1964	45.3	1962
7	56.8	1963	50.7	1968	37.2	1979	36.9	1965	31.8	1962
8**	10.4	1965	7.1	1968	6.6	1963	6.0	1979	5.1	1962
9	260.6	1963	212.7	1968	130.7	1979	129.3	1962	127.3	1965
10**	182.7	1972	181.2	1973	166.3	1978	88.0	1971	69.8	1975
11	324.5	1978	86.9	1977	77.7	1970	76.3	1979	66.1	1961
12**	0.5	1978	0.4	1963	0		0		0	
13**	17.2	1978	12.7	1963	3.6	1979	0.1	1962		
14*	0.4	1978	0.3	1963	0		0		0	
15	101.7	1978	92.9	1963	63.1	1979	50.3	1965	45.2	1977
16**	33.3	1978	26.6	1963	13.9	1979	4.6	1977	3.3	1965
17	23.6	1978	21.8	1963	14.8	1979	11.8	1965	10.7	1977
18	44.2	1979	41.6	1963	26.2	1977	13.9	1961	9.9	1968
19	130.8	1979	121.5	1977	82.3	1963	72.8	1961	59.1	1978
20	25.6	1963	10.0	1965	2.9	1979	2.1	1968	2.0	1973
21**	139.0	1963	27.4	1965	14.9	1961	10.3	1962	8.4	1968
22*	51.1	1963	8.6	1965	8.4	1962	6.2	1961	4.7	1975
23*	215.2	1963	73.8	1962	69.9	1961	60.7	1968	48.2	1971
24	352.4	1963	142.9	1961	125.6	1962	112.1	1968	108.2	1971
25**	114.0	1963	37.9	1962	25.3	1968	22.2	1961	12.3	1976
26*	51.2	1963	17.3	1962	13.5	1961	12.9	1968	8.6	1971
27*	433.2	1963	132.8	1962	106.9	1961	93.5	1968	71.0	1971
28*	312.1	1963	86.1	1962	61.8	1961	52.2	1968	46.9	1971
29*	52.0	1963	17.5	1961	17.3	1962	12.8	1968	6.8	1971
30**	215.4	1965	73.8	1963	58.2	1979	52.7	1977	1.7	1969
31*	0.6	1969	0.4	1963	0		0		0	
32*	4.3	1969	1.9	1963	0		0		0	
33*	0.3	1969	0.2	1963	0		0		0	
34*	8.6	1969	4.4	1963	0.9	1972				
35*	4.9	1969	2.9	1963	1.0	1972	0.1	1961		
36*	53.2	1969	31.0	1963	19.9	1972	5.2	1961	2.0	1968
37*	4.7	1969	2.3	1963	0.7	1972	0		0	
38*	50.7	1972	41.5	1969	24.4	1963	9.1	1968	7.1	1961
39*	11.3	1963	5.4	1961	4.4	1969	1.8	1977	1.2	1962
40*	663.8	1963	291.7	1961	257.1	1969	180.5	1977	86.4	1962
41*	37.4	1963	19.0	1961	13.9	1969	7.0	1977	4.6	1962

Remarks; N = 19

* : The river utilization ratio is less than 10%.

**: The river utilization ratio is less than 10% but inter-basin water usage with water stress basins is operated or planned.

Table 19 ANNUAL DEFICIT BY BASIN IN 2000 UNDER THE CONDITION OF TARGET ECONOMIC GROWTH

Unit: 10^6 m^3/y

Basin No.	Drought Level 1/N Deficit	Year	2/N Deficit	Year	3/N Deficit	Year	4/N Deficit	Year	5/N Deficit	Year
1	86.7	1968	70.4	1963	58.7	1979	49.7	1967	48.7	1965
2	14.9	1968	12.6	1963	8.9	1979	7.5	1962	6.4	1967
3	1,144.0	1963	1,080.0	1964	1,061.8	1968	903.6	1965	822.5	1979
4	18.5	1963	17.9	1968	10.9	1979	10.6	1965	9.7	1962
5	280.4	1963	242.6	1968	188.7	1965	138.0	1979	133.2	1962
6	156.7	1963	136.6	1968	99.4	1965	91.3	1964	89.7	1979
7	81.8	1963	78.6	1968	61.4	1979	57.6	1965	53.5	1964
8**	10.8	1965	8.1	1968	7.3	1963	6.4	1979	5.8	1962
9	280.9	1963	231.6	1968	146.1	1979	143.1	1962	140.1	1965
10	192.5	1972	189.3	1973	180.5	1978	97.8	1971	75.3	1975
11	326.3	1978	87.8	1977	78.3	1970	76.9	1979	66.6	1961
12**	0.5	1978	0.4	1963	0		0		0	
13**	17.3	1978	12.7	1963	3.7	1979	0.1	1962	0	
14*	0.5	1978	0.4	1963	0		0		0	
15	168.0	1978	161.5	1963	116.2	1979	98.1	1965	87.5	1977
16**	33.7	1978	26.9	1963	14.2	1979	4.8	1977	3.4	1965
17	46.7	1978	44.7	1963	34.2	1979	28.4	1965	25.5	1977
18	48.6	1979	45.6	1963	30.1	1977	16.0	1961	11.0	1968
19	171.6	1979	164.3	1977	118.5	1963	96.7	1961	89.9	1978
20	26.3	1963	10.5	1965	3.3	1979	2.1	1968	2.1	1973
21**	161.3	1963	35.3	1965	23.1	1961	15.0	1962	11.0	1968
22*	67.9	1963	15.0	1965	11.8	1962	11.1	1961	6.5	1975
23	276.3	1963	114.5	1961	98.8	1962	88.9	1971	88.9	1968
24	414.3	1963	189.0	1961	153.1	1971	152.8	1962	141.7	1968
25**	114.3	1963	38.0	1962	25.4	1968	22.3	1961	12.3	1976
26*	54.9	1963	18.6	1962	15.6	1961	14.5	1968	10.2	1971
27*	553.7	1963	156.9	1961	155.5	1962	129.9	1971	113.0	1968
28*	318.9	1963	88.6	1962	65.0	1961	54.5	1968	49.8	1971
29*	52.5	1963	17.7	1961	17.5	1962	13.1	1968	7.0	1976
30**	225.3	1965	97.8	1977	90.5	1963	69.5	1979	8.0	1967
31*	7.9	1969	3.8	1963	2.0	1972	0.2	1961	0	
32*	5.8	1969	2.6	1963	0.1	1972	0		0	
33*	0.3	1969	0.2	1963	0		0		0	
34*	11.3	1969	6.1	1963	1.7	1972	0		0	
35*	8.9	1969	5.1	1963	5.0	1972	1.0	1961	0.4	1968
36*	76.0	1969	47.9	1972	43.9	1963	12.6	1961	6.0	1968
37*	6.9	1969	3.8	1963	1.5	1972	0.2	1961	0.01	1976
38*	50.7	1972	41.6	1969	24.4	1963	9.1	1968	7.2	1961
39*	11.3	1963	5.4	1961	4.4	1969	1.8	1977	1.2	1962
40	798.7	1963	406.6	1961	383.7	1969	300.3	1977	207.1	1972
41*	38.3	1963	19.0	1961	14.3	1969	7.3	1977	4.7	1962

Remarks; N = 19

* : The river utilization ratio is less than 10%.

**: The river utilization ratio is less than 10% but inter-basin water usage with water stress basins is operated or planned.

Table 20 ANNUAL DEFICIT BY BASIN IN 1990, UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: 10^6 m^3/y

Basin	Drought Level 1/N		2/N		3/N		4/N		5/N	
No.	Deficit	Year	Deficit	Year	Deficit	Year	Deficit	Year	Deficit	Year
1	62.5	1968	51.5	1963	44.0	1979	32.7	1967	32.6	1965
2	14.7	1968	12.4	1963	8.8	1979	7.4	1962	5.6	1961
3	1,040.3	1963	978.7	1964	942.0	1968	818.8	1965	720.4	1979
4	13.5	1968	11.3	1963	7.7	1979	7.6	1962	7.2	1965
5	220.8	1963	192.5	1968	147.3	1965	113.6	1979	106.3	1962
6	111.3	1963	94.3	1968	69.9	1965	62.1	1964	51.8	1979
7	50.9	1963	44.9	1968	32.4	1965	32.2	1979	28.2	1962
8**	10.4	1965	7.1	1968	6.5	1963	6.0	1979	5.1	1962
9	252.6	1963	205.4	1968	125.0	1979	124.0	1962	122.3	1965
10*	180.2	1972	179.2	1973	162.7	1978	85.6	1971	68.5	1975
11	322.4	1978	85.9	1977	76.9	1970	75.5	1979	65.5	1961
12**	0.5	1978	0.4	1963	0		0		0	
13**	17.5	1978	12.9	1963	3.8	1979	0.1	1962	0	
14*	0.3	1978	0.3	1963	0		0		0	
15	89.4	1978	80.0	1963	54.0	1979	41.3	1965	37.4	1977
16**	33.6	1978	26.8	1963	14.1	1979	4.7	1977	3.4	1965
17	18.2	1978	16.1	1963	10.7	1979	7.9	1965	7.3	1977
18	43.3	1979	40.6	1963	25.4	1977	13.6	1961	9.7	1968
19	125.0	1979	115.5	1977	77.3	1963	69.7	1961	55.1	1978
20	25.5	1963	9.9	1965	2.9	1979	2.1	1968	2.0	1973
21**	135.5	1963	26.2	1965	13.9	1961	9.7	1962	8.2	1968
22*	48.4	1963	7.8	1962	7.7	1965	5.5	1961	4.5	1975
23*	206.6	1963	70.3	1962	64.3	1961	56.8	1968	43.4	1971
24	326.8	1963	123.7	1961	114.9	1962	99.9	1968	89.5	1971
25*	114.1	1963	37.9	1962	25.3	1968	22.3	1961	12.3	1976
26*	50.6	1963	17.1	1962	13.2	1961	12.7	1968	8.3	1971
27*	432.8	1963	132.6	1962	106.7	1961	93.3	1968	70.8	1971
28*	309.2	1963	85.2	1962	60.5	1961	51.6	1968	45.7	1971
29*	51.6	1963	17.3	1961	17.2	1962	12.7	1968	6.8	1976
30*	214.6	1965	73.4	1963	57.9	1979	51.7	1977	1.6	1969
31*	0.5	1969	0.3	1963	0		0		0	
32*	4.2	1969	1.8	1963	0		0		0	
33*	0.3	1969	0.2	1963	0		0		0	
34*	8.5	1969	4.3	1963	0.8	1972	0		0	
35*	4.9	1969	2.7	1963	1.0	1972	0.1	1961	0	
36*	52.0	1969	30.2	1963	18.6	1972	4.9	1961	1.8	1968
37*	4.7	1969	2.3	1963	0.7	1972	0		0	
38*	50.6	1972	41.5	1969	24.4	1963	9.1	1968	7.1	1961
39*	10.8	1963	5.1	1961	4.0	1969	1.6	1977	1.1	1962
40*	633.5	1963	289.7	1961	255.0	1969	178.3	1977	85.3	1962
41*	37.3	1963	18.9	1961	13.8	1969	6.9	1977	4.6	1962

Remarks; N = 19

* : The river utilization is less than 10%.

**: The river utilization ratio is less than 10% but inter-basin water usage with water stress basins is operated or planned.

Table 21 ANNUAL DEFICIT BY BASIN IN 2000, UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: 10^6 m^3/y

Basin No.	Drought Level 1/N Deficit	Year	2/N Deficit	Year	3/N Deficit	Year	4/N Deficit	Year	5/N Deficit	Year
1	79.4	1968	63.4	1963	54.4	1979	45.0	1967	43.8	1965
2	14.8	1968	12.5	1963	8.9	1979	7.5	1962	6.4	1967
3	1,107.0	1963	1,043.5	1964	1,023.1	1968	871.6	1965	784.6	1979
4	14.8	1968	13.3	1963	8.7	1979	8.2	1965	8.2	1962
5	277.5	1963	240.4	1968	187.1	1965	136.8	1979	132.0	1962
6	136.5	1963	117.9	1968	85.8	1965	78.0	1964	72.4	1979
7	67.4	1963	62.0	1968	46.8	1979	45.5	1965	38.9	1962
8**	10.8	1965	8.1	1968	7.3	1963	6.3	1979	5.8	1962
9	257.1	1963	209.5	1968	128.2	1979	127.0	1962	126.1	1965
10**	185.8	1972	183.8	1973	170.8	1978	91.0	1971	71.4	1975
11	324.4	1978	86.9	1977	77.6	1970	76.2	1979	66.1	1961
12**	0.5	1978	0.4	1963	0		0		0	
13**	19.1	1978	14.0	1963	4.5	1979	0.2	1962	0.1	1977
14*	0.4	1978	0.3	1963	0		0		0	
15	139.4	1978	134.0	1963	92.6	1979	77.9	1965	69.0	1977
16**	37.4	1978	30.3	1963	16.6	1979	6.1	1977	4.9	1965
17	26.8	1978	25.4	1963	17.3	1979	14.2	1965	12.7	1977
18	45.7	1979	42.7	1963	27.5	1977	14.8	1961	10.3	1968
19	147.1	1979	138.7	1977	96.0	1963	82.6	1961	71.9	1978
20	26.1	1963	10.3	1965	3.1	1979	2.1	1968	1.9	1966
21**	153.9	1963	32.6	1965	20.3	1961	13.2	1962	10.2	1968
22*	60.2	1963	11.9	1965	10.2	1962	8.9	1961	5.6	1975
23	244.1	1963	90.4	1961	85.3	1962	73.7	1968	65.6	1971
24	396.4	1963	176.0	1961	144.7	1962	140.3	1971	133.2	1968
25**	115.4	1963	38.3	1962	25.8	1968	22.8	1961	12.6	1976
26*	52.9	1963	17.9	1962	14.5	1961	13.6	1968	9.3	1971
27*	551.7	1963	155.7	1961	154.7	1962	128.8	1971	112.3	1968
28*	315.0	1963	87.2	1962	63.2	1961	53.2	1968	48.1	1971
29*	52.2	1963	17.6	1961	17.4	1962	13.0	1968	6.9	1976
30**	222.4	1965	93.7	1977	89.2	1963	68.5	1979	7.3	1967
31*	3.6	1969	1.5	1963	0.2	1972	0		0	
32*	4.7	1969	2.1	1963	0		0		0	
33*	0.3	1969	0.2	1963	0		0		0	
34*	10.1	1969	5.3	1963	1.3	1972	0		0	
35*	8.8	1969	5.0	1963	4.8	1972	1.0	1961	0.4	1968
36*	63.4	1969	37.1	1963	31.7	1972	8.2	1961	3.4	1968
37*	6.9	1969	3.8	1963	1.5	1972	0.2	1961	0.01	1976
38*	50.6	1972	41.5	1969	24.4	1963	9.1	1968	7.1	1961
39*	13.6	1963	6.8	1961	5.8	1969	2.6	1977	1.7	1962
40*	754.9	1963	377.7	1961	348.5	1969	268.3	1977	178.8	1972
41*	37.9	1963	18.8	1961	14.1	1969	7.1	1977	4.6	1962

Remarks; N = 19
* : The river utilization is less than 10%.
**: The river utilization ratio is less than 10% but inter-basin water usage with water stress basins is operated or planned.

Table 22 ESTIMATED NET SUPPLY CAPACITY OF DAMS AND BARRAGES IN OPERATION AND UNDER CONSTRUCTION

Basin No.	Name of Facility	Catchment Area (km^2)	Active Storage Capacity ($10^6 m^3/y$)	Estimated Net Supply Capacity ($10^6 m^3/y$)	Remarks
3	Pedu Dam	171	864	780	
3	Petubeng Weir			-	MADA intake
3	Kedah Barrage			-	
5	Muda Dam	984	123	-	To Pedu dam
5	Muda Barrage	4,200		-	
6	Perai Barrage		(2)	-	U/C
7	Ayer Hitam Dam	25	(2)	30	/1
9	Bukit Merah Dam		(20)	76	Krian scheme
10	Temengor Dam	3,420	1,270	2,450	
10	Bersia Dam	3,600	10	350	U/C
10	Kenering Dam	5,540	70	1,170	U/C
10	Chenderoh Dam	6,653	66	540	
10	Jor Dam			0	
10	Mahang Dam			0	
12	Swamp (Natural)		(148)	92	Tg. Karang scheme
15	Kelang Gate Dam	76	32	53	
15	Damansara Dam			0	
16	Langat Dam	41	(30)	32	To K.Lumpur
19	Durian Tunggal Dam	71	18	48	
19	Melaka Barrage	690		-	
19	Ayer Keroh Weir			0	
20	Kesang Barrage			-	
21	Asahan Dam			0	To Melaka
21	Belembang Dam			0	
21	Gunong Ledang Weir			0	
21	Pengkalan Bukit Weir			0	
22	Batu Pahat Dam			0	
22	Semberong Dam	130	(13)	21	U/C
23	Machap Dam	78	(30)	0	
23	Sekudai Barrage			-	
23	Teberau Barrage			-	
23	Pontian Kechil Dam	12		-	To Singapore
23	Gunong Pulai Dam	6		7	To Singapore
23	Pulai III Dam	2		-	To Singapore
24	Lebam Dam	19	3	10	
24	Layang Dam	31	(36)	33	U/C
26	Tenglu Mersing Dam			0	
27	Labong Dam			0	
30	Abu Bakar Dam	183		0	To Basin 10
31	Kuantan Barrage			0	U/C
36	Kenyir Dam	2,600	7,400	4,010	U/C
38	Besut Weir			0	
38	Tenang Weir			0	
40	Plau'ur Diversion Dam			0	To Basin 30
41	Bukit Kuang Dam			0	

Remarks; /1: Including supply from other sources
TB: Tidal barrage, ( ): Assumed, U/C: under construction

Table 23 PURPOSE, STATE AND ORGANIZATION CONCERNED OF DAMS AND BARRAGES IN OPERATION AND UNDER CONSTRUCTION

Basin No.		Purpose	State	Organization concerned
3	Pedu Dam	IR	Kedah	MADA
3	Petubeng Weir	IR	Kedah	MADA
3	Kedah Barrage	TB	Kedah	DID
5	Muda Dam	IR	Kedah	MADA
5	Muda Barrage	TB (WS)	P. Pinang	PWA
6	Perai Barrage	TB (Drainage)	P. Pinang	DID
7	Ayer Hitam Dam	WS + HY	P. Pinang	PWA
9	Bukit Merah Dam	IR	Perak	DID
10	Temengor Dam	HY + FM	Perak	NEB
10	Bersia Dam	HY	Perak	NEB
10	Kenering Dam	HY	Perak	NEB
10	Chenderoh Dam	HY + FM	Perak	NEB
10	Jor Dam	HY	Perak	NEB
10	Mahang Dam	HY	Perak	NEB
12	Swamp (Natural)	IR	Selangor	DID
15	Keland Gate Dam	WS + FM	Selangor	DID & SWW
15	Damansara Dam	WS	Selangor	SWW
16	Langat Dam	WS	Selangor	SWW
19	Durian Tunggal Dam	WS	Melaka	MWB
19	Melaka Barrage	TB	Melaka	MWB
19	Ayer Keroh Weir	WS	Melaka	MWB
20	Kesang Barrage	TB	Melaka, Johor	DID
21	Asahan Dam	WS	Melaka	MWB
21	Belembang Dam	WS	Johor	PWD
21	Gunong Ledang Weir	-	Johor	PWD
21	Pengkalan Bukit Weir	-	Johor	PWD
22	Batu Pahat Dam	FM (WS)	Johor	PWD
22	Semberong Dam	FM + WS	Johor	DID & (PWD)
23	Machap Dam	FM + WS	Johor	DID & (PWD)
23	Sekudai Barrage	TB	Johor	DID
23	Teberau Barrage	TB	Johor	DID
23	Pontian Kechil Dam	WS	Singapore	SUB
23	Gunong Pulai Dam	WS	Singapore	SUB
23	Pulai III Dam	WS	Singapore	SUB
24	Lebam Dam	WS	Johor	PWD
24	Layang Dam	WS	Johor	PWD
26	Tenglu Mersing Dam	WS	Johor	PWD
27	Labong Dam	IR	Johor	DID
30	Abu Bakar Dam	HY	Pahang	NEB
31	Kuantan Barrage	TB (WS)	Pahang	PWD
36	Kenyir Dam	HY + FM	Trengganu	NEB
38	Besut Weir	IR	Pahang	DID
38	Tenang Weir	-	Trengganu	PWD
40	Plau'ur Diversion Dam	HY	Kelantan	NEB
41	Bukit Kuang Dam	-	Kelantan	DID

Remarks; WS: Domestic and industrial water supply, IR: Irrigation,
FM: Flood mitigation, HY: Hydropower, TB: Tidal barrage

Table 24 INTER-BASIN WATER USAGE PROGRAM

Basin No.	Inter-Basin Water Usage
1	Inter-basin water diversion for Muda Scheme for Basin 3 to Basin 1
2	
3	Inter-basin water diversion from Basin 5 (Muda dam) to Basin 3 (Pedu dam)
4	
5	Domestic and industrial water supply from Basin 5 (Muda river) to Basins 6 & 7 (P. Pinang)
6	
7	
8	Inter-basin water diversion for Kerian irrigation project from Basin 8 to Basin 9
9	
10	To Perlis, Kedah & P. Pinang region
11	Inter-basin water diversion for Tanjong Karang irrigation project from Basin 11 to Basin 12
12	
13	To Kelang Valley
14	
15	Domestic and industrial water supply from Basin 16 to 15 (Kuala Lumpur)
16	
17	
18	
19	
20	
21	To Melaka water supply

Basin No.	Inter-Basin Water Usage
22	
23	Domestic and industrial water supply from Basins 23 and 24 (agreement) to Singapore
24	
25	
26	
27	
28	
29	
30	From upstream reaches to Basins 15 (Kelang Valley) and 17 (Port Dickson)
31	
32	
33	
34	
35	
36	
37	
38	
39	Inter-basin water diversion for irrigation project from Basin 40 to Basins 39 and 41
40	
41	

Remarks; ◄—— Inter-basin water usage in operation in 1982
◄--- Proposed inter-basin water usage

Table 25 WATER SOURCE DEVELOPMENT PLANS FOR THE STATES OF PERLIS, KEDAH AND PULAU PINANG, ALTERNATIVE B1

(1) DAM

Location				Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construc-tion Cost ($M\$10^6$)	Construc-tion Period
State**	Basin No.	Facilities	Purpose					
(i) Perlis, Kedah and Pulau Pinang Region								
Perlis	1	Arau dam	IR	50	37	36	25	1983-1987
Perlis	1	Timah-Tasoh dam	WS,IR,FM	150	6	20	14	1989-1993
Kedah	3	Ahning dam	WS,IR	120	116	100	70	1983-1987
Kedah	3	Badak-Temin dam	IR	114	137	95	34	1983-1987
Kedah	3	Sari dam	IR	61	73	51	31	1986-1990
Kedah	3	Durian dam	IR	75	88	63	35	1989-1994
Kedah	4	4-A dam	WS,IR	16	15	21	17	1985-1989
Kedah	5	Naok-Reman dams	WS,IR	-	-	350	123	1983-1987
Kedah	5	Beris dam	WS,IR	115	21	75	25	1983-1987
Kedah	5	Tawar-Muda dam	WS,IR	135	21	75	37	1985-1989
Kedah	5	Legong dam	WS,IR	44	44	45	32	1985-1989
Kedah	5	Weng dam	WS,IR	37	37	38	27	1985-1989
Kedah	5	Charock Teber dam	WS,IR	38	38	39	27	1985-1989
Kedah	5	Chiak dam	WS,IR	23	23	24	17	1986-1990
								U/C(Phase I)
P. Pinang	6	Mengkuang Phase I & II	WS	4	24	24	55	1981-1985
Perak	10	Rui dam	WS,IR	215	313	163	796	1983-1987
(ii) Pulau Langkuawai								
Kedah	2	Aver Tawar dam	IR	11	8	10	219	1985-1989
Kedah	2	Ulu Melaka dam	IR	7	3	6	15	1985-1989
Kedah	2	Nylor dam	IR	4	0.5	2	8	1985-1989

(2) DIVERSION FACILITIES

Basin No.	Diversion Facilities	Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/s)	Construction Cost ($M\$10^6$)	Construc-tion Period
1	Pumping from the Muda irrigation canal	Kedah Perlis 3 to 1	3.1	*	1983-1987
3	Jeniang diversion barrage and canal	Kedah 5 to 3	21.1	included in Naok-Reman dams	1983-1987
10	Rui diversion tunnel	Perak Kedah 10 to 5	10.5	(15)	1983-1987
6	Pipe line	Kedah P. Pinang 5 to 6	7.5	*	1985-1989
6	Pipe line	Kedah P. Pinang 5 to 6	1.3	*	1986-1990
6	Pipe line	Kedah P. Pinang 5 to 6	1.2	*	1991-1995
7	Pipe line	Kedah P. Pinang 5 to 7	4.3	*	1985-1989
7	Pipe line	Kedah P. Pinang 5 to 7	1.1	*	1986-1990
7	Pipe line	Kedah P. Pinang 5 to 7	0.5	*	1992-1996

Remarks; IR: Irrigation; WS: Water supply; FM: Flood Mitigation;
U/C: Under Construction; *: Cost included in other distribution facilities
Construction cost = Financial cost at 1980 constant price
**: The state where the facilities are located.
( ): Included in dam cost

Table 26 WATER SOURCE DEVELOPMENT PLAN FOR KERIAN AND KURAU RIVER BASINS, ALTERNATIVE B1

(1) DAM

Location: State**	Location: Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
Kedah/Perak	8	Kerian dam	WS, IR	112	208	134	1,356	1985-1989
Kedah/Perak	8	Sira dam	WS, IR	29	32	47	178	1985-1989
Kedah/Perak	9	9-A(2) dam	WS, IR	-	-	15	18	1990-1994

(2) DIVERSION FACILITIES

Basin No.		Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/s)	Construction Cost (M$$10^6$)	Construc-tion Period
8	Kerian diversion tunnel	Perak 8 to 9	10	*	1985-1989
		Perak Pinang 8 to 6	-	*	-

Remarks; IR: Irrigation, WS: Water supply
Construction cost: Financial cost at 1980 constant price
* : Cost included in irrigation facilities
**: The state where the facilities are located

Table 27 WATER SOURCE DEVELOPMENT PLAN FOR KINTA VALLEY, ALTERNATIVE B1

(1) DAM

Location: State*	Location: Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
Perak	10	Kinta (B) dam	WS	155	53	55	364	1985-1989

Remarks; Construction cost is the financial cost at 1980 constant price.
IR: Irrigation, WS: Water Supply
* : The state where the facilities are located

Table 28 WATER SOURCE DEVELOPMENT PLAN FOR BERNAM AND TENGI RIVER BASINS, ALTERNATIVE B1

(1) DAM

Location: State*	Location: Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
Perak	11	Geling dam	IR	56	30	32	89	1985-1989
Perak	11	Bil dam	IR	26	13	15	74	1985-1989
Perak	11	Sungkai dam	IR	193	161	100	530	1985-1989
Perak	11	Hypothetical	IR	-	-	153	811	1985-1989

Remarks; IR: Irrigation, Construction cost: Financial cost at 1980 constant price.
* : The state where the facilities are located

Table 29 WATER SOURCE DEVELOPMENT PLAN FOR KELANG VALLEY, ALTERNATIVE B1

(1) DAM

Location: State*	Location: Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construc-tion Cost ($M\$10^6$)	Construc-tion Period
Selangor	13	Selangor dam	WS	201	270	186	541	1985-1989
Selangor	13	Batan Kali dam	WS	49	72	45	76	1985-1989
Selangor	15	Batu dam	WS	50	28	39	80	1983-1987
Selangor	15	Gombak dam	WS	87	28	60	28	1986-1990
Selangor	16	Semenyih dam	WS	54	42	44	80	U/C1982-1985
N. Sembilan	30	Kenaboi dam	WS	118	136	83	237	1988-1992
Pahang	30	Perting dam	WS	88	119	59	214	1994-1998
N. Sembilan	30	Kongkoi dam	WS	54	69	33	224	1992-1996

(2) DIVERSION FACILITIES

Basin No.	Diversion Facilities	Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/s)	Construc-tion Cost ($M\$10^6$)	Construc-tion Period
13	Selangor diversion pipeline	Selangor 13 to 15	15	**	1985-1989
16	Semenyih diversion pipeline	Selangor 16 to 15	-	**	U/C1981-1985
30	Kenaboi diversion tunnel	N. Sembilan Selangor 30 to 16-15	5	11	1998-1992
30	Perting diversion tunnel	Pahang Selangor 30 to 13-15	4	6	1994-1998
30	Kongkoi diversion	N. Sembilan Selangor 30 to 16-15	2	2	1992-1996

Remarks; *: The state where the facilities are located
WS: Water supply, U/C: Under construction
Construction cost is the financial cost at 1980 constant price.
**: Cost included in water supply distribution facilities

Table 30 WATER SOURCE DEVELOPMENT PLAN FOR SEPANG RIVER BASIN ALTERNATIVE B1

(1) DAM

Location: State	Location: Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construction Cost (M\$$10^6$)	Construction Period
N. Sembilan	30	Teriang dam	WS	60	105	42	225	1985-1989
N. Sembilan	30	Gelami dam	WS	58	9	18	27	1990-1994

(2) DIVERSION FACILITIES

Basin No.	Diversion Facilities	Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/s)	Construction Cost (M\$$10^6$)	Construction Period
30	Teriang diversion pipe line	N. Sembilan 30 to 17	Stage 1: 3 Stage 2: 1	525 300	1985-1989 1990-1994

Remarks; WS: Water supply
Construction cost is the financial cost at 1980 constant price.

Table 31 WATER SOURCE DEVELOPMENT PLAN FOR LINGGI RIVER BASIN, ALTERNATIVE B1

(1) DAM

Location: State	Location: Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6 m^3/y$)	Construction Cost (M\$$10^6$)	Construction Period
N. Sembilan	18	Terip dam	WS,IR	23	43	41	21	1985-1989

Remarks; IR: Irrigation; WS: Water supply
Construction cost is the financial cost at 1980 constant price.

Table 32 WATER SOURCE DEVELOPMENT PLAN FOR MELAKA-MUAR REGION, ALTERNATIVE B1

(1) DAM

Location: State	Location: Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity (10^6m^3/y)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
N. Sembilan	21	Muar dam	WS,IR	209	36	37	20	1990-1994
Johor	21	Palong dam	WS,IR	316	140	107	27	1985-1989
N. Sembilan/ Pahang	30	Bera dam	WS	258	171	180	21	1985-1989

(2) DIVERSION FACILITIES

Basin No.	Diversion Facilities	Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/s)	Construction Cost (M$$10^6$)	Construc-tion Period
21	Muar diversion barrage & canal	Johor Melaka 21 to 19&20	15	160	1985-1989
30	Bera diversion canal	30 to 21	13	32	1985-1989

Remarks; IR: Irrigation; WS: Water supply;
Construction cost is the financial cost at 1980 constant price.

Table 33 WATER SOURCE DEVELOPMENT PLAN FOR SOUTH JOHOR REGION, ALTERNATIVE B1

(1) DAM

Location: State	Location: Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity (10^6m^3/y)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
Johor	24	Semangar dam	WS	160	137	123	54	1985-1989
Johor	24	Linggiu dam	WS	237	203	182	25	1985-1989
Johor	24	Pengeli dam	WS	143	65	84	30	1989-1993
Johor	25	Sedili dam	WS	227	124	164	18	1985-1989

(2) DIVERSION FACILITIES

Basin No.	Diversion Facilities	Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/s)	Construction Cost (M$$10^6$)	Construc-tion Period
23	Teberau diversion barrage	Johor 23 to 23 & Singapore	35	9*	1985-1989
24	Semangar diversion barrage & canal	Johor 24 to 23	35	36	1985-1989
24	Johor diversion barrage & canal	Johor 24 to 24	27	25	1985-1989
25	Sedili diversion canal & pipe line	Johor 23 to 24	10	83	1985-1989

Remarks; IR: Irrigation; WS: Water supply
Construction cost is the financial cost at 1980 constant price.
*: excluded the cost of distribution pipe line for water supply

Table 34 WATER SOURCE DEVELOPMENT PLAN FOR ANAK ENDAU RIVER BASIN, ALTERNATIVE B1

(1) DAM

Location State	Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^3m^3/y$)	Construction Cost (M$$10^6$)	Construction Period
Pahang	27	Anak Endau dam	IR	36	38	33	76	U/C1983-1987
Pahang	27	Kemelali dam	IR	44	47	41	30	U/C1983-1987
Pahang	27	Anak Endau weir	IR	-	-	-	*	U/C1983-1987

Remarks; IR: Irrigation
Construction cost is the financial cost at 1980 constant price.
*: Cost included in irrigation facilities

Table 35 WATER SOURCE DEVELOPMENT PLAN FOR KUANTAN RIVER BASIN

(1) DAM

Location State	Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6m^3/y$)	Construction Cost (M$$10^6$)	Construction Period
	31	Kuantan Barrage	WS	-	-	-	20	U/C1981-1985

Remarks; WS: Water supply; U/C: Under Construction
Cosntruction cost is the financial cost at 1980 constant price.

Table 36 WATER SOURCE DEVELOPMENT PLAN FOR KEMASIN, KELANTAN AND GOLOK RIVER BASINS, ALTERNATIVE B1

(1) DAM

Location State	Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity ($10^6m^3/y$)	Construction Cost (M$$10^6$)	Construction Period
	40	Nengirri dam	WS,IR	3,940	201	960	243	1995-1999

(2) DIVERSION FACILITIES

Basin No.	Diversion Facilities	Basin Transfer (Basin No.)	Diversion Discharge Capacity (m^3/y)	Construction Cost (M$$10^6$)	Construction Period
39	Kemasin diversion irrigation canal	Kelantan 40 to 39	1990: 11.7 2000: 18.0	*	-
41	Golok diversion irrigation canal	Kelantan 40 to 41	1990: 10.3 2000: 24.2	*	-

Remarks; WS: Water supply; IR: Irrigation; HY: Hydropower
Construction cost is the financial cost at 1980 constant price.
*: Cost of hydropower generation is borne by the hydropower development plan.