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NATIONAL WATER RESOURCES STUDY MALAYSIA

SECTORAL REPORT

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GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

SECTORAL REPORT

VOL. 9

DOMESTIC AND INDUSTRIAL WATER SUPPLY

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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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

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SPECIAL ABBREVIATIONS

D Water Demand	:	Domestic water demand
M Water Demand	:	Manufacturing water demand i.e., water demand of manufacturing industries
I Water Demand	:	Water demand of manufacturing industries, tin mines, palm oil mills and rubber factories
D&I Water Demand	:	D water demand and I water demand
C.D.	:	Customer demand
S.D.	:	Source demand
UA Ratio	:	Unaccounted-for water ratio
TP Ratio	:	Treatment plant water use ratio
PCDU	:	Per capita daily water use
lpcd	:	Liter per capita per day
NUMW	:	Net unit manufacturing water use
FFB	:	Fresh fruit bunch
DRC	:	Dry rubber concentrate
MIDA	:	Malaysian Industrial Development Authority
PUB	:	Public Utilities Boards of the Government of Singapore
RESP	:	Rural Environmental Sanitation Program
O&M	:	Operation and maintenance

1. INTRODUCTION

This Sectoral Report presents a study on domestic, and industrial water demand (D&I water demand) in 1985, 1990 and 2000 in the 41 river basins in the 11 States of the Peninsular Malaysia to be supplied either from surface or ground water resources either through public supply system or private.

This study was made to serve the following objectives:

(1) to analyse the water balance in each basin and thereafter to draw up water resources development plans as well as D&I water supply development plans in case there exist deficits in river basins; and

(2) to estimate pollutant loads generated in association with D&I water use.

To meet the above objectives, source demand (S.D.) either at wells or river intake points as well as customer demand (C.D.) was estimated. Water demand was classified into (1) domestic water demand including commercial and public water use (D water demand), (2) water demand of manufacturing industries (M water demand), (3) tin mines water demand, (4) palm oil mills water demand, (5) rubber factories water demand, and (6) water supply to Singapore, considering their growth trends, locations and the strength and characteristics of effluent. D water demand and manufacturing water demand were classified into urban and rural demands. All the demands were estimated as gross demands without deducting return flows.

In making the analysis, necessary data were gathered through the relevant ministries and agencies of the Government of Malaysia, state and district authorities and interviews with people in private sector. Some foreign statistics were also referred to for the Sectoral Study including Japanese industrial water use statistics. Major references and data sources are listed in the last page of the text of this Sectoral Report.

2. PRESENT CONDITION OF D&I WATER SUPPLY AND USE IN PENINSULAR MALAYSIA

2.1 Organization

Public water supply in the 11 states in Peninsular Malaysia is administered by the following public organizations:

(1) PWD Waterworks Department and Water Authorities

(a) State Public Works Departments in the States of Perlis, Kedah, Johor, Pahang, Trengganu and Kelantan,

(b) State Waterworks Departments in the States of Perak, Selangor and Negeri Sembilan, and

(c) Pulau Pinang Water Authority and Melaka Water Authority

(2) Rural Environmental Sanitation Program (MOH)

In principle, PWD, Waterworks Departments and Water Authorities supply water to urban area and the adjacent including suburban and rural areas. Water supplied by the public water supply organizations is usually treated through coagulation and sedimentation, rapid gravity filtering or pressure filtering and chlorination process. The reticulation systems are connected to individual taps and public standpipes in the urban area. In the rural area, however, house connection is rather seldom. Water sources are usually surface flow.

In the States of Perlis, Kedah, Johor, Pahang, Trengganu and Kelantan, state PWDs administer public water supply. Waterworks Departments in Perak, Selangor and Negeri Sembilan belong to the State Governments and prepare separate financial statements for water supply in line with commercial accounting. Pulau Pinang and Melaka Water Authorities are state statutory bodies and practise commercial accounting. Water Supply Divisions of the state PWDs are obliged to adopt commercial accounting system in the future in compliance with the State Water Supply Fund Act which came into force in June 1980. The timing is at the discretion of each state government.

Through RESP, untreated water is supplied with the technical and financial assistance of MOH to the isolated rural area that will not be reached by PWD water supply systems within the coming 5 years. Main water source is groundwater. House connection is rather seldom.

2.2 PWD Water Supply and Use

Water supply by State PWDs, Waterworks Departments and Water Authorities (hereinafter called PWD water supply) in Peninsular Malaysia has been rapidly improved in recent years. About 598 x 10^6 m^3/y of water was supplied in 1978 in terms of treatment plant output compared with 426 x 10^6 m^3/y in 1975 (Tables 1 and 2).

The population served by PWD water supply system increased by 1.1×10^6 people p.a. or at the average growth rate of 6.4% p.a. reaching 6.5×10^6 people in 1978 from 5.4×10^6 people in 1975 (Ref. 1). Of the total served population, 3.9×10^6 people (60%) lived in urban area and 2.6×10^6 people (40%) lived in rural area in 1978.

PWD water supply per capita in each state varies very much as shown in Table 3. Average domestic supply per capita in Peninsular Malaysia was 181 lit/d in 1978. Average total PWD water supply including all the uses was 250 lit/d.

Water use data by purpose of use is obtainable by analysing revenue records in the light of past and present water tariff. Since water tariff is usually based on domestic comprising residential and part domestic/part commercial, and commercial use comprising trade and water use by manufacturing industries water use data is obtainable under this classification. In case of Selangor State, more detailed data has been obtained (Tables 4 to 8).

In all the states, residential use is dominant among all the uses. However, in a few areas, commercial water use was comparable or even exceeded household use. For example, in Petaling Jaya of Selangor State, commercial use exceeded residential use already in 1975. In Kelang district, they were comparable (Table 5).

Unaccounted-for water is defined as the balance between the total quantity of water supplied or treatment plant output and the total quantity of water metered, which comprises the followings:

(1) Leakage from service reservoirs, mains, service connections,

(2) Operation of hydrants and flushing mains,

(3) Losses due to metering inefficiency, and

(4) Unauthorized connection.

UA ratio (unaccounted-for water ratio) is defined as unaccounted-for water divided by treatment plant output. UA ratios of the states in Peninsular Malaysia were high in general with 27% and 28% in 1975 and 1978 for Peninsular Malaysia, respectively (Tables 1 and 2). Except Pulau Pinang State, UA ratio exceeded 20% in 1978. As seen in the tables, UA ratio was not improved from 1975 to 1978.

Treatment plant use is defined in this Sectoral Study as the amount of treatment plant water use for its own operation and loss between intake point and treatment plant. TP ratio (treatment plant water use ratio) is defined as the ratio of treatment plant use thus defined to the quantity of water abstracted at intake point. According to the information obtained from PWD, it lies in the range of 2-5% (Ref. 2). In this study, the ratio was assumed at 5%.

In 1978, there were 216 water supply intakes for pipe water in Peninsular Malaysia. The total capacity of the treatment plants was 1,262 x 10^3 m^3/d excluding Pulau Pinang and Melaka States in terms of normal operation capacity (Table 2).

The major portion of the PWD water supply has been for residential use for all the states in Peninsular Malaysia, even if its share varies according to state (Tables 4 to 8). However, classification adopted by state PWDs, Waterworks Department and Water Authorities is different from that defined in this Sectoral Study and the figures of domestic water use under the definition adopted in this Sectoral Study could be only approximation.

Up to now, no separate system for manufacturing water supply has been completed. Households, shops and factories share public water supply.

Only commercial water use data which include both trade use and use of manufacturing industries, is available with regard to the use of water supplied by public systems. No separate account is obtainable for manufacturing water use.

2.3 Rural Environmental Sanitation Program

Isolated rural areas have been supplied untreated water through RESP with the technical and financial assistance of MOH. This type of water supply is herein tentating called MOH water supply. Village people assist projects implementation by providing labor and operation and maintenance of the water supply facilities are carried out by them. From 1970 through 1980, 2,875 projects in total were implemented under RESP, providing 554,000 people with water as shown in Table 9 (Ref. 57).

2.4 Processing Water Use in Palm Oil Mills and Rubber Factories

Palm oil processing plants are in operation in all the states in Peninsular Malaysia except Perlis State in 1980. They totaled 128 in number and consumed more than 13 x 10^6 m^3/y (Table 10).

Rubber processing plants are working in all the states in Peninsular Malaysia except Perlis State in 1980. They totaled 206 in number and consumed about 19 x 10^6 m^3/y (Table 10).

2.5 Tin Mines Water Use

Except Kelantan State, tin mining is in operation in all the states in Peninsular Malaysia (Table 11). Number of tin mines as well as total production volume, however, has remained almost constant these years as shown in Table 12 (Ref. 3).

No statistical data are available about the actual water use of tin mines. Number of tin mines given water licenses and quantity of water allowed to be taken by licenses are the only data obtainable for water use of tin mines. In 1980, total number of tin mines given water licenses amounts to 127 or about 14% of the total. Total quantity of water allowed to be taken totaled 456 x 10^6 m^3/y (Table 11).

2.6 Water Supply to Singapore

According to the Agreement between the Government of Johor State and the Government of Singapore, Johor State shall supply raw water to PUB (Public Utilities Board of the Government of Singapore) (Ref. 4). The raw water is to be treated by PUB. The maximum quantity of treated water is fixed not exceeding 1.13 x 10^6 m^3/d. The quantity of treated water supplied to Singapore during 1970-1979 period is given in Table 13.

2.7 Water Tariff, Revenues and Expenditures

Within each state, same water tariff is applied regardless urban or rural. Water tariff for the 11 states in Peninsular Malaysia as of December 1978 is tabulated in Tables 14 to 17. Historical water charges for the States are given in Table 18.

Revenues and expenditures of the Water Supply Divisions of state PWDs, Waterworks Department and Water Authorities in 1978 are given in Table 19. Total revenues and recurrent expenditures are about balanced in most of the state.

3. WATER DEMAND PROJECTION AND SUPPLY TARGET SET BY PWD

In preparation of 4MP, PWD has projected the water demand for PWD water supply including domestic, manufacturing, commercial and other uses for 1990 (Table 20). According to this projection, total water demand in Peninsular Malaysia will grow to 1,321 x 10^6 m^3/y in 1990 in terms of treatment plant output at the average growth rate of 6.4% p.a. Among all uses, domestic water demand which comprises residential, religious institutions, charitable organizations and public standpipes will be the biggest with 834 x 10^6 m^3/y for Peninsular Malaysia excluding Perak State for which data is not available. Among states, Selangor State claims the biggest quota with 392 x 10^6 m^3/y demand or about 30% of the total. Supply capacity is planned to increase to 1,367 x 10^6 m^3/y, which is 3.5% bigger than the projected demand.

4. PUBLIC WATER SUPPLY PROJECTS DURING 4MP

4.1 Continuation and New Large-Scale Projects by PWD

4.1.1 Urban water supply projects

Public water supply projects contemplated to be implemented during 4MP period by State PWDs, Waterworks Departments and Water Authorities are given hereunder.

(1) Ahning Water Supply Project, Stage I (New)

This project calls for the construction of the following facilities:

(a) a raw water intake and a pumphouse,

(b) a treatment plant with the capacity of 90.9×10^3 m^3/d,

(c) 2 high level reservoirs with the capacities of 18.2×10^3 m^3 and 9.1×10^3 m^3, respectively,

(d) 3 balancing reservoirs with the capacities of 9.1×10^3 m^3 (1 reservoir) and 4.6×10^3 m^3 (2 reservoirs), and

(e) Trunk mains.

The project is the first stage of the 4-staged project and is scheduled to be completed by 1984 at the estimated capital cost of M\$60 x 10^6.

A total of 275×10^3 people in the northern part of Kedah State will benefit from the project. With the implementation of the fourth stage, at least 85% of the rural people in the area will have access to water by 1990 (Ref. 45).

(2) Kedah Tengah/Selatan Water Supply Project (New)

This project calls for the construction of the following facilities:

(a) raw water intake and a pumphouse,

(b) a treatment plant with the capacity of 54.5×10^3 m^3/d,

(c) high level reservoirs and service reservoirs, and

(d) raw water mains and trunk mains.

The project is scheduled to be completed in 1984. The capital cost is estimated at M\$29 x 10^6.

When completed, about 175×10^3 people in central and southern portion of Kedah State as well as the industrial estates in Tikam Batu, Bakar Arang and Lunas will benefit (Ref. 45).

(3) Muda River Water Project, Phase 2B (New)

This project is a continuation of Phase 2A of the Muda River Water Project which contemplates to supply a reliable yield of 455 x 10^3 m^3/d for the use in Pulau Pinang State.

The Phase 2B project involves the construction of the following facilities:

(a) 2 service reservoirs with the capacities of 4.6 x 10^3 m^3 and 27.3 x 10^3 m^3 respectively, and

(b) trunk mains.

The project, the capital cost of which is estimated at M$13 x 10^6, will augment water supply to meet the rapidly growing demand in Seberang Perai due to the intensive housing development and industrial growth (Ref. 45).

(4) Mengkuang Pumped Storage Project, Phase I (New)

This project is the first phase of the 2 phased project. The main objective of the whole project is to ensure that adequate water supply will always be availed for the Muda River Water Project which will be expanded to produce a reliable output of 455 x 10^3 m^3/d.

The 2 phased project comprises the construction of an earth fill dam and a reservoir with a full storage capacity of 23.7 x 10^6 m^3 at the Mengkuang river, pumping stations as well as water mains for conveying water from the Mengkuang reservoir to the Dua river treatment plant. Water will be conveyed from the Kulim river and the Muda river by pumping during high flow periods to the reservoir. The stored water will be released to the Dua treatment plant during low flow periods in the Muda river.

The Phase I with a storage capacity of 14.6 x 10^6 m^3 at Mengkuang reservoir is to be started during 4MP and completed at the end of 1983. The capital cost is estimated at M$40 x 10^6 (Ref. 45).

(5) Perak Selatan and Perak Hilir Water Supply Project, Stage I (New)

This project consists of the following components:

(a) laying a raw water pipeline to the treatment works at Tapah,

(b) laying a high pressure treated water main to Changkat Jong and to Parit Dayong,

(c) construction of treatment works of 90.0 x 10^3 m^3/d, and

(d) construction of reservoir.

The project is scheduled to be started at the end of 1980 and to be completed at the end of 1983. The capital cost is anticipated at M$48.4 x 10^6.

With the project, it is expected that entire urban population within the Perak Hilir district as well as the population in Tapah, Bidor and Temoh in the Batang Patang district will be served by treated water by 1990, whilst 95% of the rural population in supply area will have access to pipe water by 2000 (Ref. 45).

(6) Batu River Water Supply Project (Continuation)

The main components of this project comprise:

(a) construction of a reservoir in Batu river by DID,

(b) laying supply pipelines,

(c) construction of treatment works with the capacity of 113.7 x 10^3 m^3/d,

(d) construction of 2 service reservoirs with the capacity of 13.6 x 10^3 m^3, respectively, and

(e) construction of a water tank with capacity of 27.3 x 10^3 m^3.

Detailed design has been started. The project is expected to be completed in late 1982. The capital cost is estimated at M$28 x 10^6.

The main objective of the project is to meet the rapidly growing demand mainly in Sungei Tua, Selayang, Jinjang and Gombak in Selangor State where many housing and industrial development projects are going to be implemented (Ref. 45).

(7) Semenyih River Water Supply Project, Stage I (New)

The capacity of the existing water supply facilities in the Kelang valley in Selangor State including those under development, will be able to meet the future demand only up to 1985. Semenyih River Water Supply Project Stage I has been formulated to augment water supply to the cities of Petaling Jaya, Shah Alam, Kelang and the Federal Territory.

The main components of the project are as follows:

(a) construction of a 42.7 m high earth dam with the gross storage of 61.8 x 10^6 m^3,

(b) construction of an intake works,

(c) construction of treatment works with the capacity of 272.8 x 10^3 m^3/d,

(d) construction of 2 terminal reservoirs with the capacity of 45.5 x 10^3 m^3 and 22.7 x 10^3 m^3, respectively, and

(e) construction of 3 balancing reservoirs with the capacity of 11.4×10^3 m^3 each.

The project is scheduled to be completed in the middle of 1984 at an estimated capital cost of M$291 x 10^6 (Ref. 45).

(8) Benus River Water Supply Project (Continuation)

The primary aim of this project is to augment the water supply from the Kelang Gates Dam in Selangor State by conveying water from the Benus River in Pahang State over a ridge which separates the states. The water will be lifted up more than 270 m (Static) by pumping in 2 stages. The main pumphouse to be located at Janda Baik village will pump uo 27.3×10^3 m^3/d to a 1.6×10^3 m^3 suction tank to be located in the Lentang Forest Reserve.

The project is scheduled to be completed by the end of 1981. The capital cost is estimated at M$4.5 x 10^6 (Ref. 45).

(9) Terip River Water Supply Project, Stage I and Stage II (New)

This project consists of the following components:

(a) construction of an earth dam with a height of 32 m at the initial stage and 38.1 m at the final stage and a reservoir at the Terip River,

(b) conveyance of water from the reservoir to the Linggi River,

(c) construction of a treatment plant, and

(d) laying trunk mains to the Seremban municipal water supply system.

The stage I scheme will be implemented during the 4MP period, from 1981 through 1984 at the estimated capital cost of M$40.2 x 10^6. The stage II is scheduled to be carried out after 4MP period, 1991-1994.

Stage I works are designed to supply 41.8×10^3 m^3/d of treated water to the districts of Port Dickson and Seremban in Negeri Sembilan State (Ref. 45).

(10) Durian Tunggal Water Supply Project, Phase II (Continuation)

The main purpose is to increase the production capacity of the treated water supply in Melaka State by 54.6×10^3 m^3/d for meeting the water demand up to 1990.

The main components of the project comprise:

(a) installation of additional pumps in the existing raw water pumphouse,

(b) laying of an additional raw water pipeline,

(c) increasing the capacity of Bertam treatment works from 18.2×10^3 m^3/d to 72.7×10^3 m^3/d,

(d) construction of service reservoirs, and

(e) laying trunk and distribution mains throughout the State.

The completion is scheduled at the end of 1982 at the estimated cost of M$32.7 x 10^6 (Ref. 45).

(11) West Johor Water Supply Project, Phase II (New)

This project is multi-objective, aiming at the following:

(a) eliminating ground water logging due to flat topography by improving drainage systems, and

(b) constructing a dam and thereby to mitigate flood damage and to augment water supply.

The water supply component which consists of the Bekoh scheme and the Semberong scheme will increase water supply to the districts of Segamat, Muar and Batu Pahat in Johor State by strengthening the Yong Peng treatment plant capacity to 45.5×10^3 m^3/d and constructing a new treatment plant with the capacity of 45.5×10^3 m^3/d (Ref. 45).

(12) Greater Kuantan Water Supply Project (New)

This project involves the construction of:

(a) an intake structure and a pumping station at Kuantan river,

(b) a barrage to cut off sea water intrusion which is now at design phase, and

(c) treatment works.

The capital cost of the project is estimated to M$78.1 x 10^6.

The project has been proposed in view of the current rapid build up of urban and industrial facilities in the Kuantan region in Pahang State. The served area will consists of:

(a) Gambang,

(b) west of Kuantan,

(c) new port area at Gebeng,

(d) right bank of the Kuantan river proposed for agricultural development, and

(e) new fishing port and airport at Tanjung Lumpur.

This project intends to construct a dual water supply system to satisfy varied water quality requirement by domestic and industrial water users. At present, 4 options are proposed and the decision on choice of options has yet to be finalized. In case of Option 4, 111 x 10^3 m^3/d of untreated water and 75 x 10^3 m^3/d of treated water will be supplied to the served area (Ref. 45).

(13) Kota Bharu Water Supply Project (Continuation)

This project is designed to provide with 45.5 x 10^3 m^3/d of treated water by exploiting groundwater. Trunk mains will be constructed to serve the whole district of Kota Bharu in Kelantan State.

This project is a continuation project from the TMP. The commencement of the project is scheduled in 1983. The capital cost is expected to be M$29.4 x 10^6 (Ref. 45).

4.1.2 Rural water supply projects

In line with the Government policy of eradicating poverty and restructuring society as well as to cope with the rapid industrial growth, a number of rural water supply projects to be implemented by state PWDs, Waterworks Departments and Water Authorities have been drawn up.

(1) Rural water supply projects in Negeri Sembilan State (New)

To satisfy the growing water demand in the rural areas, a number of existing treatment plants will be expanded. Upgrading of old treatment plants, pump houses and trunk mains will also be carried out for extending rural water supply. The total capital cost of these projects is estimated at M$54 x 10^6.

Through these projects, the percentage of rural people receiving treated water supply is expected to increase to 76% in 1985 (Ref. 45).

(2) Rural water supply projects in Pahang State (New)

A total of 46 schemes will be implemented in this project covering the districts of Jerantut, Raub, Bentong, Temerloh, Cameron Highlands. Pekan, Kuantan and Lipis and the Pahang Tenggara Region. These schemes in general involve the construction of reservoirs, treatment plant works and laying pipelines. The total capital cost of the project is estimated at M$103 x 10^6.

It is expected that some 700 x 10^3 people will benefit from this project. By 1985, the percentage of rural people having access to pipe water supply will increase to 70% (Ref. 45).

(3) Rural water supply projects in Kelantan State (New)

These projects involve the following activities:

(a) development of new rural water sources,

(b) improvement and extension of existing rural schemes, and

(c) extension of major schemes.

Through these projects, approximately 1,600 km of water supply pipeline will be laid. The total capital cost of these projects is estimated at M$48 x 10^6.

It is estimated that an additional 300 x 10^3 people will benefit from these projects. In consequence, the percentage of rural population served by potable water will increase to 60% (Ref. 45).

4.2 Rural Environmental Sanitation Program

According to the preliminary plan for 4MP, about 780,000 people in the isolated rural area will be covered by RESP and provided untreated water during the 4MP period in addition to 554,000 people currently covered by the program as shown in Table 21 (Ref. 58). Relatively undeveloped states including Perlis, Kedah and the east coast states will be the major beneficiaries, accounting for about 73% of the increment.

5. PROJECTION OF D & I WATER DEMAND

5.1 General

Domestic and industrial water demand is divided into 5 categories, i.e., (i) Domestic including commercial and public, (ii) Manufacturing, (iii) Tin mines, (iv) Palm oil mills and (v) Rubber factories because of the following reasons:

(1) Household, commercial and public water demands have strong correlation with the size of population;

(2) Gross output and water demand of manufacturing industries are not necessarily proportional to the size of population;

(3) As it will be proved to be the case, the manufacturing water demand is likely to grow much faster than the others as manufacturing industries expands rapidly;

(4) Though their shares in the total water demand are small, it is more appropriate to separate the water demands of the tin mines, palm oil processing plants and rubber processing plants, to serve for river water quality study.

Considering the location of demand generation, D water demand (domestic water demand) and manufacturing water demand are classified into 2 categories as follows:

(1) Demand in cities/towns; and

(2) Demand in rural areas

Where, cities/towns are defined as gazetted areas with equal to or more than 10,000 population and rural areas with less than 10,000 population. All the other demand centers comprising palm oil mills, rubber factories and tin mines are located in rural areas.

The cities/towns and districts defined in this Study are shown in Table 22 and 23, respectively. Administrative division is given in Fig. 1.

Domestic water demand is partly met by public supply systems and partly by private. In urban area, state PWDs, Waterworks Departments and Water Authorities are responsible for public water supply. In rural area, the responsibility is borne by the above water supply organizations and RESP (MOH).

Part of manufacturing water demand is satisfied by PWD water supply systems. The rest is met by private facilities.

All of the palm oil mills, rubber factories and tin mines are presumably dependent on direct abstraction of surface water and private wells for their water supply.

For PWD water supply, the following target was set to reduce UA ratio (unaccounted-for water ratio) for 1985 during the Senior Water Engineers' Conference (Ref. 25).

Supply Area	UA ratio (%)
Individual Supply District	less than 20
Individual State	less than 25
Overall % for Peninsular Malaysia	less than 20

However, the set target seems not practicable, considering the current high UA ratio in Peninsular Malaysia and the ratio in Japan. (Tables 1 and 2, Ref. 5). It is assumed that the 20% target will be achieved in 1990 and will remain constant until 2000. For these cities/towns which already achieved the target of 20% in 1978, the ratio in 1978 was assumed to remain constant up to 2000 (Table 24). TP ratio (treatment plant water use ratio) was assumed at 5% of the quantity of water abstracted at intake point.

Source demand (S.D.) is obtained as follows:

$$S.D. = C.D./(1-UA\ Ratio) \times (1-TP\ Ratio)$$

For the water supply other than State PWDs, Waterworks Departments and Water Authorities, UA ratio was assumed nil since intake points and consumption points of water are closely located and S.D. was assumed to be equal to C.D.

Projected D & I water demand includes that for surface water as well as groundwater. Although available data for water source of the current water uses are rather limited, the following assumptions were made, considering the required quality of water for each purpose and other factors:

(1) Water demand to be generated in urban area is fully dependent on surface water;

(2) Water demand of palm oil mills, rubber factories and tin mines is met by surface water; and

(3) In the rural area, groundwater resources are allocated to domestic and manufacturing uses according to the following priority order until they are estimated to be exhausted:

1st	Private domestic
2nd	Public domestic
3rd	Manufacturing

5.2 Projection of Domestic Water Demand

5.2.1 Methodology

Domestic water demand for public supply and private was projected for cities/towns and the rural areas in the 41 basins in Peninsular Malaysia. Customer Demand (C.D.) for treated water was obtained for each area as follows:

Treated Water Demand = Population x Service Factor x PCDU
(Per Capita Daily Use)

Accordingly C.D. for private water was estimated for each area as follows:

Private Water Demand = Population x (1-Service Factor) x PCDU

S.D. can be obtained based on C.D., UA ratio and TP ratio as stated in Section 5.1.

5.2.2 Population projection

Population projection for cities/towns and rural areas in 1985, 1990 and 2000 and that under the lower economic growth made in Sectoral Report Socio-Economy was used for estimating domestic water demand as shown in Tables 25 to 36 and in Tables 37 to 48 under the condition of lower economic growth.

5.2.3 Projection of service factor

The 1980's is the United Nations Water and Sanitation decade and it is proclaimed that all the inhabitants be served by water by public systems and sewerage systems by 1990. However, though the Government of Malaysia is going to put great efforts for improving the water supply condition in the coming years, the target seems too ambitious, considering the past achievements.

Service factors of cities/towns were determined based on their population size, taking into account the service factor for 1990 for the urban areas projected by PWD. Service factor in 2000 was assumed to be 100%, considering the strong desire and financial capability of the Government of Malaysia. The projected service factor is shown in Table 49. The projected service factor under the condition of lower economic growth was projected similarly but the service factor targets were assumed to be attained with 5 years delay as shown in Table 50.

Service factors of the rural areas, which is covered by PWD water supply systems and RESP of the states were determined based on the PWD target for 1990 as well as the past achievement and preliminary program for 4MP of RESP with some modification, assuming the service factor of 100% in 2000 as shown in Table 51. The service factors under the condition of lower economic growth were estimated, assuming 5 years delay for achieving the 100% target as shown in Table 52.

5.2.4 Projection of per capita daily use

Though some data is available on the historical per capita daily use in Peninsular Malaysia, they are based on different water use categories from these adopted in this Study (Table 3). Though state PWD's and, Waterworks Departments and Water Authorities have made projections for per capita daily use for the future, they are based on different water use categories. Moreover, no correlation can be observed between population sizes of the cities and the projected per capita daily use figures.

Per capita daily use in Peninsular Malaysia was, therefore, projected considering its co-relation with per capita GDP of the country based on the data given in Tables 53 and 54. Projected per capita daily use for cities/towns and rural area thus estimated is shown in Table 55. Per capita daily use under the condition of lower economic growth was projected similarly as shown in the same table.

Per capita daily use for private domestic use was assumed at 40 liters up to 2000.

5.2.5 Projected served population

Based on the projected population and the service factor, it is estimated that in the urban area population served by PWD water supply systems will grow at the average growth rate of 4.5% p.a. during 1980 - 2000 period and the entire urban population will be served by PWD systems in 2000. In the rural area, population served by PWD system will increase at the rate of 2.7% p.a. Population served through RESP (MOH) will increase at the rate of 4.7% p.a. In 2000, the entire population in the rural area will be covered either by PWD or through RESP (MOH). Served population in 1980, 1985, 1990 and 2000 is given in Tables 56 to 60.

Under the condition of lower economic growth, the urban served population will grow at the average growth rate of 3.5% p.a. and 98% of the total urban population will be served by PWD water supply sytems. Rural population served by PWD will increase at the rate of 3.8% p.a. Rural population served through RESP (MOH) will increase at the rate of 5.7% p.a. In 2000, 98% of the total rural population will be covered either by PWD or through RESP (MOH). Served population in 1980, 1985, 1990 and 2000 is given in Tables 61 to 65.

5.2.6 Projected domestic water demand

Total pipe water demand was projected to grow rapidly reflecting the followings:

(1) Population increase;

(2) Rapid improvement of service factor; and

(3) Increase of per capita daily use

SD of the total domestic water demand for PWD supply in Peninsular Malaysia will grow at the average growth rate of 6.7% p.a. during 1980-2000 period, reaching 1.7×10^9 m^3/y in 2000, of which 73% will be generated in urban area and the rest in rural area.

Among the cities/towns, Bandaraya KL claims the biggest quota of 295×10^6 m^3/y or 24% of the total urban demand in 2000. Petaling Jaya comes next with 111×10^6 m^3/y or 9% of the total.

Among the 41 basins, the biggest demand will be generated in Basin 15 with 523×10^6 m^3/y or 31% of the total.

The total demand for RESP (MOH) water supply will grow at the average growth rate of 8.5% p.a. during 1980-2000 period, reaching 46×10^6 m^3/y in 2000.

Reflecting the sharp improvement of public water supply, the private water demand in Peninsular Malaysia will sharply decline from the estimated 55×10^6 m^3/y in 1980 or about 10% of the total domestic water demand to 13×10^6 m^3/y in 1990 and diminish in 2000 when 100% service factor target will be attained.

D water demand as a whole will reach 1.8×10^9 m^3/y or 41% of the total water demand in Peninsular Malaysia in 2000.

Projected domestic water demand is given in Tables 66 to 93.

Under the lower economic condition, SD of the total demand for PWD water supply in Peninsular Malaysia will grow at the average growth rate of 5.8% p.a. during 1980-2000 period, reaching 1.5×10^9 m^3/y in 2000, of which 65% will be generated in urban area and the rest in rural area.

Among the cities/towns, Bandaraya KL claims the biggest quota of 211×10^6 m^3/y or 22% of the total urban demand in 2000. Petaling Jaya comes next with 89×10^6 m^3/y or 9% of the total.

Among the 41 basins, the biggest demand will be generated in Basin 15 with 410×10^6 m^3/y or 28% of the total.

The total demand for RESP (MOH) water supply will grow at the average growth rate of 9.0% p.a. during 1980-2000 period, reaching 50×10^6 m^3/y in 2000.

Reflecting the sharp improvement of public water supply, the private water demand in Peninsular Malaysia will rapidly decline from the estimated 55 x 10^6 m^3/y in 1980 or about 10% of the total domestic water demand to 21 x 10^6 m^3/y in 1990 and diminish in 2000 when 100% service factor target will be attained.

D water demand as a whole will reach 1.5 x 10^9 m^3/y or 46% of the total in 2000.

Projected domestic water demand is given in Table 94 to 114.

5.3 Projection of Manufacturing Water Demand

5.3.1 Methodology

According to the projection made in Socio-Economic Study, production of manufacturing industries Malaysia will rise sharply. In terms of gross output value, it will be more than 6 times as big in 2000 as in 1980 in real terms. The share of each manufacturing industries will drastically change. In 1980, food industry was the biggest with 32% share. Machinery industry came next with 19%. Chemical industry was the third with 13% share. In 2000, machinery industry will be ranked in the first place with 33% share. Chemical industries will come next with 16% share each. Water use of each industry is expected to change sharply with the change of manufacturing process as well as the introduction of water saving technology. Projection methodology shall be able to estimate M water demand under these conditions with accuracy.

The time span and the expanse of area to be covered by the demand projection is huge. It should cover as long as 20 years and as many as 11 states or the whole of Peninsular Malaysia. Projection method shall be selected paying due attention to these characteristics.

Up to date, the following methodologies are used in general for estimating the future M water demand (Refs. 29 & 44):

(1) Per capita method;

(2) Percentage of domestic demand method; and

(3) Per acreage method

In the first methodology, there lies a basic assumption that as population becomes larger, the production value of manufacturing industries will become bigger and so the M water demand. However, this is not necessarily the case. Population growth depends on whether or not the expanding industries are labor-intensive. Population might grow because of increased labor opportunities in service sector. Further, labour-intensive industries are not necessarily the water-intensive ones.

If per capita M water demand is fixed for the future, M water demand can grow only at the growth rate of population. During 1980 - 2000 period, population in Peninsular Malaysia is expected to increase by 48% whereas manufacturing production value will be augmented by nearly 540%. Though M water demand does not increase proportion to the production value, it is not likely that manufacturing water demand grow as low as the population growth rate.

In order to employ different per capita figures for the future, an elaborate projection for manufacturing production will be a prerequisite. Further, the production value increase must be interpreted in terms of the per capita M water demand increase, which deemed to be difficult as well as inaccurate.

Based on the second methodology, M water demand will go together with the population growth, service factor improvement and per capita daily use increase. Because of similar reasons for the first methodology, this methodology cannot be justified.

In order to project M water demand for the future by means of the third metholodology, the following figures must be projected in the first place:

(1) Total acreage of factory sites in each area; and

(2) Unit water use per acre of factory site

Only limited information is available for short-range development of industrial sites in specific areas and no long-range plan, which stretches up to 2000 for whole Peninsular Malaysia, is not in existence. Limiting the development in industrial estates, information is still only available up to 1985. Further, information on the industrial estates alone is deemed insufficient because about 46% of the total industrial projects approved by MIDA during 1971 - 75 period was located outside the estates (Ref. 26).

Manufacturing water use varies according to the type of industry. To estimate the unit water use per acre of factory site, therefore, the types of industries must be predetermined. Water use is expected to change as manufacturing process alters in each industry and water-saving technology is introduced. This must also be taken into account to project the unit water use per acre of each factory site.

Though theoretically this method is justifiable, its application is better to be limited to the projection for specific areas for relatively short time period considering its complexity as well as the difficulty in obtaining the required data.

Considering all these, projection method of M water demand in the whole Peninsular Malaysia up to 2000 was selected. The projection is made, according to the adopted methodology, based on the following figures:

(1) Gross output values of manufacturing industries in 1985, 1990 and 2000 estimated Socio-Economic Study; and

(2) NUMW (net unit manufacturing water use) for producing unit gross output value for each industrial classification.

M water demand in terms of C.D. will be obtained as the sum of water demand of each industrial classification that is obtained as the product of gross output value and NUIW. S.D. for manufacturing water is obtained as follows:

$$S.D. = C.D./(1 - UA\ Ratio) \times (1 - TP\ Ratio)$$

The methodology is explained further in the subsequent sections.

5.3.2 Projection of gross output value

Gross output value of the states in 1985, 1990 and 2000 has been projected in Socio-Economic Study. Gross output value of cities/towns were obtained by assuming the ratio of gross output value of each city/town to that of the state where the city/town lies based on the actual ratio in 1974 and the propective economic structure of cities/towns. Gross output value of the rural area in each district can be estimated by deducting the gross output values of the cities/towns which lie in each state from that of the state.

The assumed gross output value ratios of cities/towns and rural area to state are given in Tables 115 to 118. These under the condition of lower economic growth are given in Table 119 to 122.

5.3.3 Net unit manufacturing water use

Manufacturing water use was estimated based on NUMW (net unit manufacturing water use) by industrial classification, excluding the recyclic water use.

Industrial classification was determined based on the current Malaysian Industrial Classification as well as Japanese Industrial Classification.

NUMW declines as the recyclic water use develops. The industrial water use data of Japan from 1962 to 1974 show that the NUMW remained almost constant after 1970. During the period of 1980 - 1990 as well as the period of 1990 - 2000, manufacturing industries in Peninsular Malaysia are expected to make sharp growth, accompanying the modernization of manufacturing technology including water use. It was assumed that, therefore, NUMW in Peninsular Malaysia in 1990 will reach the values of Japan in 1970. The projected NUMW is shown in Table 123. Malaysian data in the recent years are also shown in the table for reference.

5.3.4 Projected manufacturing water demand

M water demand was projected to rise sharply due to the expanding manufacturing industries.

SD of the total manufacturing water demand for PWD supply in Peninsular Malaysia will grow at the average growth rate of 7.4% p.a. during 1980-2000 period, reaching 1.3×10^9 m^3/y in 2000, of which 87.1% will be generated in urban area and the rest in rural area.

Among the cities/towns, Petaling Jaya claims the biggest quota of 140×10^6 m^3/y or 12.1% of the total urban demand in 2000. Bandaraya K.L. comes next with 87×10^6 m^3/y or 7.5% of the total.

Among the 41 basins, the biggest demand will be generated in Basin 15 with 285×10^6 m^3/y or 21% of the total.

Private water demand of manufacturing industries also mark rapid increase with the average growth rate of 7.4% p.a. during 1980-2000 period, reaching 1.2×10^9 m^3/y in 2000, of which 97.2% will be generated in urban area and the rest in rural area.

Manufacturing water demand as a whole will reach 2.5×10^9 m^3/y or 58% of the total water demand in Peninsular Malaysia in 2000.

The projected manufacturing water demand is shown in Tables 66 to 93.

Under the condition of lower economic growth, SD of the total manufacturing water demand for PWD supply in Peninsular Malaysia will grow at the average growth rate of 5.3% p.a. during 1980-2000 period, reaching 0.9×10^9 m^3/y in 2000, of which 85.4% will be generated in urban area and the rest in rural area.

Among the cities/towns, Petaling Jaya claims the biggest quota of 122×10^6 m^3/y or 15.8% of the total urban demand in 2000. Bandaraya K.L. comes next with 76×10^6 m^3/y or 9.8% of the total.

Among the 41 basins, the biggest demand will be generated in Basin 15 with 250×10^6 m^3/y or 27.6% of the total.

Private water demand of manufacturing industries also mark rapid increase with the average growth rate of 5.3% p.a. during 1980-2000 period, reaching 0.8×10^9 m^3/y in 2000, of which 97.0% will be generated in urban area and the rest in rural area.

Manufacturing water demand as a whole will reach 1.7×10^9 m^3/y or 52% of the total water demand in Peninsular Malaysia in 2000.

The projected manufacturing water demand is shown in Tables 94 to 114.

5.4 Projection of Processing Water Demand in Palm Oil Mills and Rubber Factories

5.4.1 Methodology

The processing schedule of palm oil and rubber was projected for each mill and factory in the Sectoral Report Agricultural Study as shown in Table 124. The processing water demand of palm oil mills and rubber factories was projected based on this estimated processing schedule multiplied by the estimated unit water use per unit production of palm oil and rubber.

5.4.2 Palm oil mills water demand

The processing water demand per unit production of palm oil was estimated at 0.8 m^3 per one ton of fresh fruit bunch (FFB) of oil palm based on the data provided by DOE and SLDB.

The total processing water demand in palm oil mills in Peninsular Malaysia was projected to grow at the average growth rate of 4.8% p.a. during 1980-2000 period to reach 17 x 10^6 m^3/y in 2000. Among the 41 basins, Basin 30 claims the biggest share of 22.4%, requiring about 4 x 10^6 m^3/y of processing water in 2000. The projected water demand of palm oil mills is shown in Tables 66 to 9.3.

5.4.3 Rubber factories water demand

The processing water demand per unit production of rubber was estimated at 18 m^3 per one ton of dry rubber concentrate (DRC) based on the data provided by DOE and SLDB.

The total processing water demand in rubber factories in Peninsular Malaysia was projected to grow at the average growth rate of 2.0% p.a. during 1980-2000 period to reach 40 x 10^6 m^3/y in 2000. Among the 41 basins, Basin 6 claims the biggest share of 10.0%, requiring about 4 x 10^6 m^3/y of processing water in 2000. The projected water demand of rubber factories is shown in Tables 66 to 93.

5.5 Projection of Tin Mines Water Demand

No statistical data are available for the actual water use of tin mines. Number of tin mines given water licenses and quantity of water allowed to be taken by licenses are the only data available for water use of tin mines.

As stated in Section 2.5, number of tin mines as well as total production volume in Peninsular Malaysia has remained almost constant these years. The total production in the future is likely to remain as well (Ref. 28).

Under these circumstances, the water demand of tin mines in Peninsular Malaysia up to 2000 was assumed to be 456 x 10^6 m^3/y which is equal to the total quantity of water allowed to be taken by water licenses in 1980. That under the condition of lower economic growth was assumed to be the same.

Of 41 basins, tin mine water demand will be generated in 14 basins. Basin 10 is by far the biggest water user among them, claiming 293 x 10^6 m^3/y (64.4% of total). Basin 16 is the second with 87 x 10^6 m^3/y and Basin 15 is the third with 28 x 10^6 m^3/y. These three basins together accounts for 89.7% of the total demand. Tin mine water demand in the basins is shown in Table 125.

The proportion of tin mine water demand to the total water demand in Peninsular Malaysia will drop steadily from 39.0% in 1980 to 10.5% in 2000 and 14.0% in 2000 under the condition of lower economic growth.

5.6 Estimate of Required Water Supply to Singapore

During 1970-1979 period, quantity of treated water supplied to Singapore increased at the average rate of 4.8% p.a. Assuming that the quantity will grow at the same rate as the historical one and treatment plant use of 5% of the raw water supplied, the total volume of raw water to be abstracted from Basins 23 and 24 will reach 316 x 10^6 m^3/y in 1990 and exceed the limit, 414 x 10^6 m^3/y (1.14 x 10^6 m^3/d) by 2000. The quantity in 2000, therefore, was assumed to be 414 x 10^6 m^3/y.

Under the condition of lower economic growth, it was assumed that the quantity will increase at the rate of 3.3% p.a., taking into account the difference of the GDP growth rates for the two cases.

The quantity of raw water to be abstracted from Basins 23 and 24 for the two cases is given in Table 126.

5.7 Projected D & I water Demand

Total D&I water demand excluding tin mines water use and supply to Singapore in Peninsular Malaysia was projected to grow at the rate of 6.8% p.a., reaching 2.4 x 10^9 m^3/y in 1990 and 4.3 x 10^9 m^3/y in 2000. Domestic water demand will increase at the rate of 6.1% p.a., reaching 1.8 x 10^9 m^3/y in 2000. Industrial water demand excluding tin mines water use will increase at the rate of 7.2% p.a., reaching 2.6 x 10^9 m^3/y in 2000.

Water demand for public water supply including untreated water supply through RESP (MOH) was projected to expand rapidly at the rate of 7.0% p.a., reaching 3.1 x 10^9 m^3/y or 71.3% of the total D & I water demand in 2000.

Among the cities/towns, Bandaraya K.L. Claims the biggest quota of 469 x 10^6 m^3/y or 19.5% of the total urban demand in 2000. Petaling Jaya comes in the second place with 391 x 10^6 m^3/y or 16.3% of the total.

Among the 41 basins in Peninsular Malaysia, Basin 15 requires 1.1 x 10^9 m^3/y or 25.2% of the total D & I water demand in 2000.

The projected D & I water demand is shown in Tables 66 to 93 and illustrated in Fig. 2. Projected volume of water to be supplied by State PWDs, Waterworks Departments and Water Authorities and that under RESP (MOH) is shown in Fig. 3.

Under the condition of lower economic growth total D & I water demand excluding tin mines water use in Peninsular Malaysia was projected to grow at the rate of 5.3% p.a., reaching 2.1 x 10^9 m^3/y in 1990 and 3.3 x 10^9 m^3/y in 2000. Domestic water demand will increase at the rate of 5.3% p.a., reaching 1.5 x 10^9 m^3/y in 2000. Industrial water demand will increase at the rate of 5.2% p.a., reaching 1.8 x 10^9 m^3/y in 2000.

Water demand for public water supply including untreated water supply through RESP (MOH) is projected to expand sharply at the rate of 5.7% p.a., reaching 2.4 x 10^9 m^3/y or 73.9% of the total D & I water demand in 2000.

Among the cities/towns, Bandaraya K.L. claims the biggest quota of 364 x 10^6 m^3/y or 14.7% of the total urban demand in 2000. Petaling Jaya comes in the second place with 333 x 10^6 m^3/y or 13.4% of the total.

Among the 41 basins in Peninsular Malaysia, Basin 15 requires 0.9 x 10^9 m^3/y or 27.8% of the total D & I water demand in 2000.

The projected D & I water demand is shown in Tables 94 to 114 and illustrated in Fig. 4. Projected volume of water to be supplied by state PWDs, Waterworks Departments and Water Authorities and that under RESP is shown in Fig. 5.

6. PLANNING OF PUBLIC WATER SUPPLY FACILITIES

6.1 General

The main objective of planning public water supply facilities in this Study is to form an outline cost estimate of construction and O & M of the facilities in order to give a rough idea on the public fund requirement. Planning was carried out based on the existing data and information including 4MP available in Malaysia as well as in the advanced countries based on standardized methods (Ref. 1, 2, 5, 18, 19, 21, 22, 29-44, 49-51, 54, 55, 57, 58, 60). Where detailed water supply study was already conducted, the results were utilized to the maximum extent possible. Detailed investigation and study should, therefore, be conducted to formulate the framework and evaluate the feasibility of the water supply projects before starting construction of the projects.

Study results for water source facilities including dams and reservours, barrages and diversion facilities are not found in this report but given in the Sectorel Report Water Source and Hydropower Development Planning.

It was assumed that water source for urban bulky water supply was surface flow except for Kota Bahru considering the following factors:

(1) No detailed information for the groundwater availability in Peninsular Malaysia is obtainable.

(2) Many instances of ground subsidence and water quality deterioration due to groundwater over-exploitation have been reported in many countries.

It was also assumed that for manufacturing water supply public sector plans and constructs facilities only up to trunk mains, leaving these for distribution and reticulation systems to private developers. The cost for the distribution and reticulation systems was assumed to be borne by the private.

In this Study, the following classification for the water supply facilities was adopted:-

(1) Intakes and raw water and treated water mains including intake and booster pumps.

(2) Treatment plants

(3) Distribution and reticulation systems including elevated tanks, distribution ponds and pumping stations.

6.2 Intakes and Raw and Treated Water Mains

The quantity of water to be abstracted at the raw water intakes was estimated by the following formula:

Quantity of raw water (SD) = CD/(1 - UA ratio)/(d - TP ratio) x K

where UA ratio (unaccounted - for water ratio) is usually 0.2 except the cities/towns given in Table 24 and TP ratio (treatment plant water use ratio) is 0.05. K is the coefficient to adjust seasonal fluctuation of water demand which was determined at 1.1.

Water mains were assumed to be constructed along the existing public roads. Location of intakes and mains was determined considering the following factors based on 1 to 63,300 scale map:

(1) Topography between the demand centers and intakes;

(2) Existing road networks; and

(3) Distance of sea water intrusion from the river mouth.

Mortal-lined ductile cast iron pipes of the following diameters was considered for water mains:-

Pipe Diameter (m/m)
600
900
1,200
1,350

Diameter was so selected that the maximum water velocity was below 3 m/s and minimum velocity was above 0.3 m/s in the case of raw water mains and below 3 m/s in the case of treated water mains.

Medium head water pumps of 20 to 50 m head were considered, assuming one stand-by unit per three units. Capacity of the intake and booster pumps where needed was determined based on the topography of the selected water mains route.

6.3 Treatment Plants

In order to purify the raw water for drinking and other uses, the following treatment processes were assumed:-

(1) Coagulation and sedimentation

(2) Rapid gravity filtering or pressure filtering

(3) Chlorination

Sedimentation pond capacity was determined at one third of the maximum daily water demand. The area of the sand filtration pond, was determined, assuming 120 m/d filtration rate.

Treatment own use was assumed at 5% of the treated water.

6.4 Distribution and Reticulation systems

Networks of 300 m trunk lines interval and 100 m branch lines interval were considered for distribution and reticulation pipeline systems. Mortal-lined ductile cast iron pipes of 300 to 500 mm diameter for trunk lines and 100 to 300 mm diameter pipes for branch lines were assumed to be used, depending on the magnitude of the water demand.

Distribution ponds and distribution and reticulation pipelines were designed considering the hourly fluction of water demand. The capacity of the distribution pond was determined as equal to half the maximum daily demand. The pipelines diameters were determined so that 130% of the maximum daily demand could be distributed. Elevated tank capacity was determined as equal to the maximum hourly demand.

Electric powered horizontal double suction volute pumps of the following characteristics were assumed to be employed:-

(1)	Head	H = 20 - 100 m
(2)	Flow rate	Q = 10 - 200 m^3/min
(3)	Power	L = 40 - 400 kW

The water pump was designed so that 130% of the maximum daily water demand can be distributed. Their capacity was determined so that water pressure inside the pipes be kept in the range of 1.5 to 4 kg/cm^2, taking into account the pipe diameters.

7. CONSTRUCTION COST AND O&M COST FOR PUBLIC WATER SUPPLY SYSTEMS

7.1 Construction Cost

7.1.1 General

Construction cost (investment cost) was estimated in the four categories as follows:

(1) direct construction cost,

(2) engineering service and administration cost,

(3) land acquisition cost, and

(4) physical contingency.

Engineering service and administration cost was assumed at 10% of the direct construction cost. Physical contingency was assumed at 30% of the total of (1) through (3).

Costs of equipments, materials and labor locally available were estimated at 1980 end price level based on the data obtained from PWD and the relevant previous reports (Refs. 21, 29 - 44, 49 - 53). In order to update the costs, the following escalation rates were assumed (Sectoral Report Water Source and Hydropower Development Planning):

1976 through 1978	0% p.a.
1979 through 1980	27% p.a.

The costs for internationally traded goods and services were estimated based on the international market price at 1980 end or the World Bank projection up to 1990 where applicable (Ref. 56).

Construction cost for public water supply projects widely varies depending on the topography, geology, land value, capacity and size of the facilities and the like. In this Study, however, standardized unit construction cost was assumed for all the projects.

7.1.2 PWD public water supply systems for urban area

State PWDs, Waterworks Departments and Water Authorities provide urban population with treated water.

Construction cost for raw and treated water mains comprises i) pipe and valve cost and, ii) civil works cost. The water mains were assumed to be constructed along the public roads and no land acquisition cost was assumed to be required. The unit direct construction cost for water mains is shown in Table 127.

The construction cost for pump stations comprises the costs for pumps including generators and pump houses, land acquisition and other relevant equipments. One stand-by pump unit was assumed per 3 pump units. The estimated construction cost is shown in Table 128.

Based on the past contract prices in Malaysia updated by the past escalation trend, unit direct construction cost for treatment plant was estimted at M$640/$m^3$/d of treatment capacity comprising M$175/$m^3$/d of treatment plant equipments with a generating set and M$465/$m^3$/d of civil works. Land acquisition cost was estimated at M$10 per m^3/d of capacity, assuming required area of 1,000 m^2 per 1,000 m^3/d of capacity and unit land acquisition cost of M$10/$m^2$ (Table 129).

Construction cost for distribution and reticulation systems comprises i) pipe and valve cost, ii) pump cost, iii) distribution pond and elevated tank costs, and iv) land acquisition cost. The unit direct construction cost was estimated as shown in Table 130.

Reinforced concrete reservoir was assumed as distribution pond. The unit direct construction was estimated at M$220 per m^3 of capacity. M$640 per m^3 of capacity was assumed for elevated tanks.

Distribution and reticulation pipelines were assumed to be constructed along the public roads and no land acquisition cost was to be necessitated. Land acquisition cost for distribution ponds was estimated at M$15 per m^3/d of capacity, assuming required area of 0.15 m^2 per m^3/d of capacity and unit land acquisition cost of M$100/$m^2$ (Table 129).

7.1.3 PWD water supply systems for rural area

State PWDs, Waterworks Departments and Water Authorities supply treated water to the rural inhabitants using either surface water resources or groundwater depending on the topography and availability of the resources. Unit direct construction cost for PWD water supply systems in the rural area was assumed at M$2,180 per m^3/d of supply capacity in case raw water was abstracted from surface flow based on the unit direct cost for PWD water supply for urban area, taking into account the difference of the supply capacities.

In case groundwater is exploited for water supply, unit direct construction cost of M$725 per m^3/d of supply capacity was assumed based on the construction costs for tube wells under various geological conditions given in Sectoral Report Groundwater Resources with the following assumptions:

(1) Raw groundwater is used without any purifying treatment; and

(2) Served population gets water from public hydrants.

7.1.4 Public water supply systems through RESP in rural area

According to the data obtained from MOH, principal water source for RESP has been groundwater during the past decade in Peninsular Malaysia (Ref. 55). The unit direct construction cost for public water supply systems was assumed, therefore, equal to that for PWD groundwater supply for the rural area, i.e., M$725 per m^3/d of supply capacity.

7.2 O&M Cost

For PWD water supply, O&M cost (recurrent expenditure) was assumed at 2% of construction cost based on the recurrent expenditure (O&M cost) for water supply recorded by state PWDs and other water supply organizations as well as the corresponding figures in the advanced countries (Refs. 9, 10, 12).

Rural water supply systems under RESP (MOH) are operated and maintained by the beneficiaries and O&M cost was assumed nil.

7.3 Estimated Cost

The estimated investment cost (construction cost) together with the treatment capacity for PWD supply and source demand for RESP (MOH) supply by city/town and rural areas by MP is given in Sectoral Report Public Expenditure and Beneficial and Adverse Effects.

8. CONSTRUCTION COST AND O&M COST FOR PRIVATE WATER SUPPLY

8.1 Construction Cost and O&M Cost

8.1.1 Construction Cost

The unit construction cost for the distribution systems for manufacturing water supply to be implemented by private concerns were assumed to be identical with that for public water supply.

The unit construction cost for water supply for palm oil mills and rubber factories was assumed at M$790 per m^3/d of supply capacity based on the data obtained from SLDB.

The unit cost for private water supply for domestic use was estimated at M$45 per m^3/d of water fetched based on the expenditure on tools to get water from nearby water sources.

8.1.2 O&M Cost

O&M cost was assumed at 2% of the construction given in the previous section.

8.2 Estimated Cost

The estimated construction cost (investment cost) required for private water supply by basin by MP is given in Sectoral Report Public Expenditure and Beneficial and Adverse Effects.

9. ECONOMIC BENEFIT AND COST FOR D&I WATER SUPPLY

9.1 Economic Construction Cost and O&M Cost

9.1.1 Economic construction cost

Economic construction cost (investment cost) for PWD water supply was estimated by deducting the transfer payment from the financial cost. The transfer payment including taxes and local contractors' profit was assumed at 20% of the financial cost.

Unit economic construction cost for rural public water supply through RESP (MOH) was estimated at M$1,580 per m^3/d of supply capacity, taking into account the economic value of the labor provided by the rural inhabitants for the construction. Unit economic construction cost for water supply for palm oil mills and rubber factories was estimated at M$630 per m^3/d of supply capacity by deducting transfer payment from the financial construction cost based on the data obtained from SLDB. That for private water supply for domestic use was assumed at M$90 per m^3/d based on the expenditure on tools and economic cost of labor of the rural inhabitants to fetch water from nearby water sources.

9.1.2 Economic O&M cost

Economic O&M cost was assumed at 2% of the economic construction cost given in the previous section.

9.2 Economic Benefit

Economic benefit to be derived from water supply including both public and private ones for domestic and industrial uses was estimated by the equivalent economic cost of the least-costly alternative facilities.

For the water source facilities including dams and diversion facilities, various alternatives were planned and the least-costly alternative was selected. In case the source facilities serve for multiple purposes, appropriate cost attributable to D&I water supply was considered as alternative cost. With regard to the rest of the water supply facilities comprising intakes, water mains, treatment and distribution facilities, no alternatives were considered, i.e., least-costly alternative cost is identical with that of the proposed facilities.

9.3 Estimated Economic Benefit and Cost

Annual equivalents of economic benefit and cost for D&I water supply at the discount rate of 8% with the study period of 50 years by basin are given in Sectoral Report Public Expenditure and Beneficial and Adverse Effects.

10. MANPOWER REQUIREMENT

10.1 Methodology for Manpower Estimate

Manpower requirement in the water supply organizations including Water Supply Divisions in State PWDs, Waterworks Departments and Water Authorities was estimated for the 1981 - 2000 period. Only the manpower for the management offices and construction offices required for the construction and O&M of water supply facilities proposed in this Study was considered, excluding the staffs at the headquarters.

For 4MP period, manpower requirement for O&M was estimated nil because demand for public water supply up to 1985 would be met by the ongoing water supply projects which are not included in the proposed projects.

The following papers and publications were studied to work out appropriate staffing levels for the O&M and implementation of the proposed projects:

(a) Proposal for New Posts for 1982, Selangor Waterworks Department (Ref. 59),

(b) Preparatory Paper for 4MP, PWD (Ref. 60), and

(c) Comparative Staffing Levels in the Waterworks Organization, PWD (Ref. 61).

The current staffing levels in the water supply organizations in the advanced countries were also taken into account.

The manpower classification given in Table 131 was adopted in line with the current practice in Malaysia. The formula adopted for O&M (management offices) and construction (construction offices) are given in Table 132.

10.2 Estimated Manpower

The estimated manpower required for public water supply in Peninsular Malaysia is given in Sectoral Report Public Expenditure and Beneficial and Adverse Effects.

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